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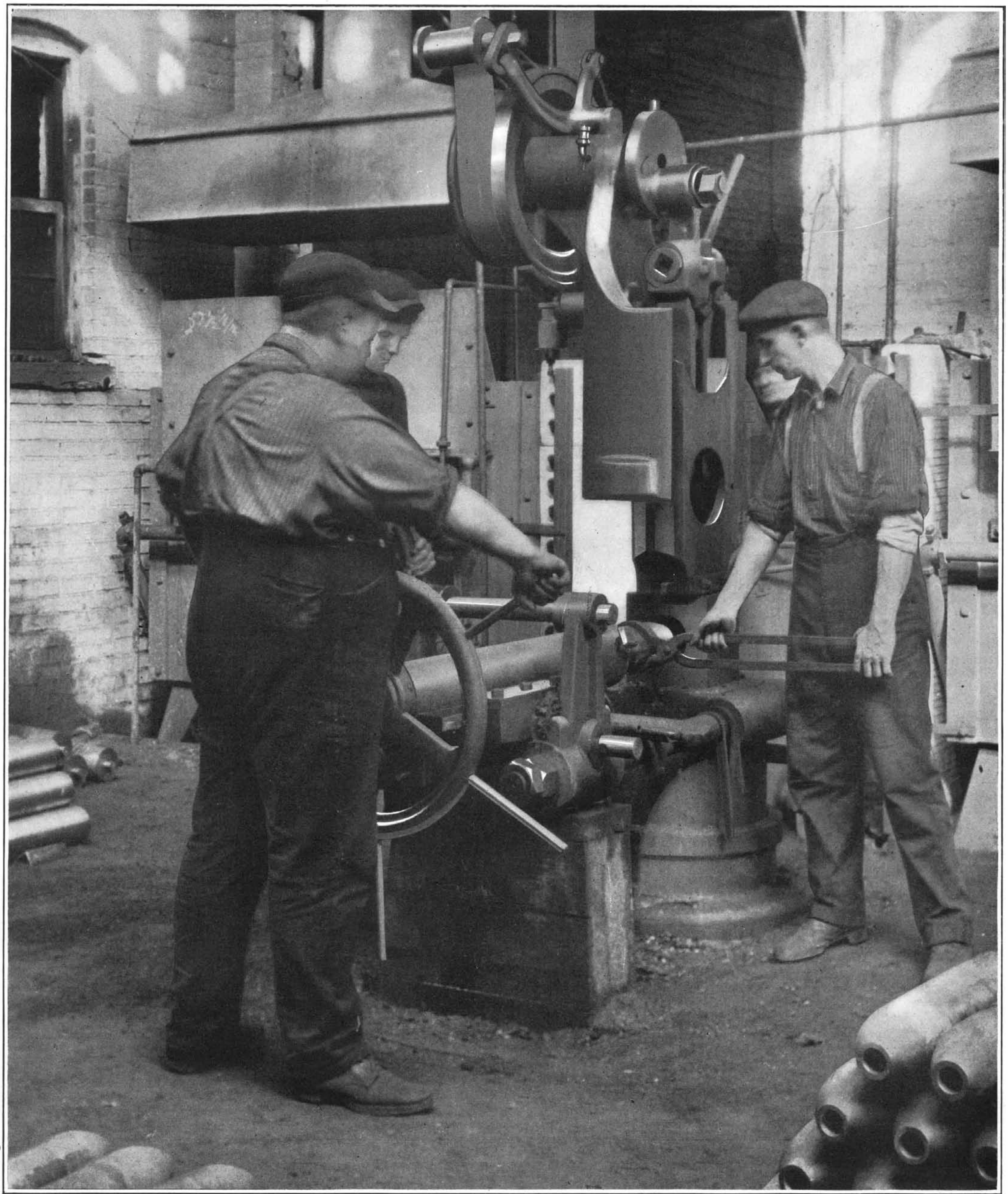

Photo by courtesy of *Machinery*

Nosing-in the end of high-explosive shells with a power hammer.

HIGH-EXPLOSIVE SHELLS.—[See page 212.]

# Food Selection—I*

## For Rational and Economical Living

By C. F. Langworthy †

THERE are a number of factors which should be taken into account when one discusses diet with reference to its adequacy and economy and to the satisfaction which it gives. Among these are a knowledge of local markets and standards of food quality; wise selection of food; preparation and cookery; and the planning of meals, or, as it is so commonly called, "menu-making." The last of these is by far the most important, and will therefore be discussed at the greatest length, though the others logically precede it.

By a knowledge of markets is meant not only knowledge of the location of butchers, grocers and other dealers in food in one's neighborhood or town, but also a good idea of the reliability of the different dealers, the quality of the goods which they offer, the relation of the cash or credit systems of selling to their prices, and other such things. To be complete it should also include some understanding of the production and distribution of food materials; such information, for instance, as would lead the housekeeper to purchase local-grown goods when possible, not only because they may be fresher, but also because of the difference in their favor of transportation charges and hence of price. With respect to the quality of foods, the housekeeper should know, for instance, how to distinguish old and young poultry, and tough, overfat or overripe meats; she should know the relative merits of wilted and fresh vegetables, being able to tell when the former can be freshened or when they include too much inevitable waste to be economical. Other illustrations might be cited, but these are sufficient to show what is meant. A knowledge of markets and of quality of food products as related to final value calls for a wide range of information, much of which can be taught and some of which must be gained by experience.

Wise choice of foods involves possession of other lines of information and experience which enables the housekeeper to purchase to good advantage. She must realize that out-of-season foods, like strawberries or green peas in January, will be more expensive, and no more nutritious, than the same foods in early summer, while foods which are uncommon at all times, like fresh mushrooms, will be more expensive than cabbage or carrots, which they closely resemble in nutritive value. She may select according to her circumstances, but she should do so "with her eyes open," and not in the belief that the superior virtues belong necessarily to the rare or the unusual. Then, too, one must take into account the quantities which can be handled advantageously in the home. It is the part of wisdom to purchase in quantity those supplies which can be easily stored and kept without deterioration, while such purchase would be decidedly unwise in the case of perishable foods, or if there are no proper storage facilities. One must take into account further the ability of the person who cooks to make acceptable dishes from the foods supplied. If she does not know how to make a palatable pot roast or similar dish from a tough cut of beef and does know how to broil a steak well, there may be some economy in choosing the steak. The suitability, with respect to the needs of the individual family, of the food purchased, is another important consideration. Thus, a good deal of waste comes from the purchase of meats which give too large cuts for the family tastes. For instance, if the chops purchased are so large that the individual portion which would be served (usually one large or two small chops) is larger than the eater's average appetite, part of the meat may be left on the plate and thrown away. The housekeeper, therefore, should take pains to provide materials which can be served in portions to "fit" the family tastes.

The relative amount of time, labor and fuel which is required in preparing foods for the table has a decided influence upon actual as compared with apparent cost. The busy housekeeper who wishes to prepare breakfast quickly may recognize this when she pays a higher price per pound for some ready-to-eat cereal, which at most only requires to be warmed before serving, instead of buying a breakfast cereal costing less per pound, but which must be cooked for several hours. If she prefers a cereal which needs longer cooking, she should know that she can begin to cook it when the evening meal is prepared, and finish it either in the fireless cooker or while she is preparing breakfast the next morning. The more she appreciates and acts upon such considerations, the more likely she is to provide a satisfactory diet and which is also an economical one.

Cookery and other matters pertaining to the preparation of food for the table are particularly important from the standpoint of economy and satisfaction. Here, as elsewhere, knowledge of the "art of dressing food," to use an old phrase, is very important. It may be learned by experience (usually at much cost), or from the mother or other members of one's family, as has been the rule in the past, or, like other arts, it may be learned in school, as is increasingly the case under the changed conditions of the present day. The housekeeper needs such knowledge, whether she applies it herself, or whether she directs some one else. If, in addition to the art of cookery, she understands relative food values and other technical matters pertaining to food and its uses, her task of providing a rational diet will be the easier.

She should not be parsimonious in her household management, neither should she be extravagant, and to this end she should understand and practice rational economy. She must realize, for instance, that a large amount of garbage means needless waste, due to carelessness, to excessive purchase, to overgenerous service, to poor cooking, or to menus which do not please the members of the family.

She should be familiar with economical practices and usages and with practical ways of saving materials, having wisdom to make use of those which are really worth while and to avoid those which merely seem economical. As an illustration, it is possible to be economical in the use of fat and yet keep up a good standard of living. This implies careful use of the fats purchased for the table and for cooking, and also the use of fats commonly thrown away. The proper "salvage" and use of chicken fat, rendered suet, bacon fat, and other fats commonly wasted, which are, so to speak, by-products of raw materials or of cookery, will enable her to economize in the amount of butter and other fats purchased as such. She may take a hint from the commercial baker, who realizes that stale bread and cake, dried and ground, can replace about one fourth of the flour used in making many kinds of cookies, cakes, and other foods. She must appreciate the importance of careful preparation of food materials and recognize that thin paring of fruits and vegetables is less wasteful than careless paring, and that soaking dried foods like navy beans, dried peaches, etc., before cooking them economizes fuel by lessening the time of cooking required. She must know that it is possible to make palatable yet economical dishes by extending the flavor of some more expensive food through a fairly large proportion of a cheaper food of blander flavor, as is done when a small amount of meat is combined with a large proportion of potatoes, carrots, and other vegetables in making a meat stew. On the other hand, she should see that it is poor economy to use a pint of cream and several eggs to save a cupful of cold boiled rice or farina which might better go into the soup kettle.

The last factor, namely, the planning of meals, is very important and places a great responsibility upon the housekeeper, since it determines whether or not the diet provides the body with all the materials it requires. It is a problem which is often well solved by the housekeeper on the basis of empirical or other knowledge, but which is almost certain to be wrongly solved if such knowledge is lacking. Certainly, it is one regarding which there is much ignorance and many misconceptions. At one extreme are those, and they probably represent the great majority, who consider their meals only in reference to palatability—a selection which may be rational if they have learned good food habits, and fortunately, there is much empirical teaching on food habits which is sound. At the other extreme are those who heed all the fantastic statements they come across regarding specific medicinal or even semi-magic virtues ascribed to certain foods, who place their hopes in some particular type of food material, or who fear lest they may suffer by "eating incompatibles," and so on through the long list of dietetic fads and fancies. Many, however, are not long deceived, their common sense warning them that, if such doctrines were true and important, the race could hardly have survived its alleged dietary indiscretions. Between these extremes stand a rapidly increasing number who seriously desire to understand and apply the principles of dietetics as they are now expounded by the more generally accepted authorities.

A fundamental principle is that the diet, considered for any reasonable length of time, must supply a great variety of chemical substances combined in different ways for the "structural" needs of the body, and also must supply it with energy-yielding substances with which it may perform internal and external work. It seems apparent that a varied diet, reasonably generous in amount, is more likely to meet the body needs than one restricted or unvarying in its make up or scant in quantity. The more knowledge and judgment used in its selection, the better the diet is likely to be.

In discussing diet, the expression "balanced ration" is often used, no doubt because it occurs so often, and to such good purpose, in discussions of animal feeding. Those who employ the term should remember that the feeder of livestock not only selects the kind of food which the horse or the steer is to eat, but measures the quantity. The housekeeper, the physician, and the nurse do this for the infant and sometimes for the person who is ill or otherwise compelled to live under circumstances in which the diet is definitely controlled. The housekeeper does not do this when under normal conditions she provides a meal for her family to select from and eat of at will. Such freedom of choice is compatible with rational living and should for the best ends be accompanied by rational food habits which can be early taught in childhood, or, if need be, acquired later in life. Therefore, the term "balanced" is, and is likely to remain, inaccurate for general discussions of dietetics, and the term "well-selected" should be given the preference.

The character of the meals which the housekeeper will provide is determined largely by racial and regional influences and also by fashion. In the United States the general character of the diet is like that in the British Isles, with many minor modifications contributed by the other races which go to make up our population. Thus, we have meat with potatoes and one or more other vegetables and a dessert for the simple dinner, with the addition of soup and salad for a more elaborate one. As an example of foreign influence may be cited the serving of macaroni and cheese as one of the vegetables at dinner, or the use of sauerkraut with pork.

The influence of fashion or custom is shown in such a matter as the preference for a meal of a given type; for instance, the continental breakfast of rolls and coffee in comparison with the English breakfast of jam, toast, eggs or meat, and tea, or the American breakfast of which fresh fruit and breakfast cereal so commonly form a part, usually accompanied by more hearty foods. We may prefer one type or another, because we have always known it or because we have learned to like it, but the whole matter is chiefly one of custom; and it is the same way with other meals. Fashion also governs quite largely the choice and the combinations of foods for a given meal; for instance, there is no inherent reason why peas instead of string beans should be served with lamb, or why we should serve apple sauce with pork and currant jelly with mutton rather than the other way around. We instinctively follow conventions, but we must not overlook the importance of so following our preference that we get distinct variety from meal to meal and from day to day. The housekeeper who thinks about such matters will realize that serving sweet potatoes, white potatoes, Hubbard squash, and boiled rice at the same meal shows "poverty of invention," since she will realize that they are somehow alike, even if she does not know that all are characterized by the presence in relatively large proportion of carbohydrates. Nor would she be happier in her choice if she served such a combination of green vegetables as spinach, asparagus, cabbage, and cauliflower, since all are similar members of the green vegetable group. Most palates would be better pleased if she had scattered her dishes through several days, having white potatoes and spinach, for instance, on one day; asparagus and sweet potatoes on another day; and so on through the almost endless number of combinations of which the food list permits; and had included in the menu such other types as seed and fruit vegetables (green beans and peas, tomatoes, cucumbers, green corn, melons, and so on). Not only would this be more pleasing to the person with discriminating taste, but it would also be more desirable from the standpoint of the rational selection of foods, since a person would be more likely to secure all of the food constituents which he needed from a mixed meal than from one of such sameness.

Furthermore, a survey of the available data on the subject of meals leads us to believe that it is possible

* *The Scientific Monthly.*

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to classify them into two distinct types (though admittedly this is only a very rough division), namely, those which, for want of a better term, may be called the "hotel" or "restaurant" type and those which may be called the "family" type. In the former the principal dish chosen is likely to be a meat order, which may carry with it a moderate serving of potato and which is supplemented chiefly by bread and butter and possibly dessert, and less often a green salad, but which usually does not include a generous order of vegetables. In the second, or "family type," of meals the amount of meat served is likely to be smaller and the proportion of vegetables served very much larger, with dessert and bread and butter as well. If we follow the rapidly gaining theory that foods like meat, which yield an acid residue when assimilated, should be accompanied by a generous amount of foods like vegetables and fruits, which yield a distinctly alkaline residue when assimilated, the wisdom of the so-called household type of meal is apparent. We shall find also, if we consider its chemical composition and energy value, that it is more likely than the other type to supply in reasonable proportion the necessary building and repair material and the energy-yielding substances required.

The number of meals taken in a day is significant chiefly as a convention or fashion. With the reasonably generous breakfast of the American family the lunch or supper is likely to be moderate and the dinner generous. On the other hand, it is natural enough that with the light breakfast of continental Europe there should go either the second breakfast and supper or the hearty lunch as well as the dinner. Apparently the number of meals taken does not greatly influence the amount eaten per day, for the man who goes without his breakfast is very likely to make up for it at dinner or supper, while the man who eats an early breakfast and then a second breakfast will be likely to take a moderate lunch or a light dinner. Good food habits do not permit of gluttony.

The housekeeper who tries to provide a varied menu should realize that in general variety can be secured in two ways, either by using a considerable number of dissimilar food materials or by using varied methods of cookery with a smaller number of food materials. While both methods have their uses and both should be taken advantage of, it is well to remember that the first is the one more likely to provide variety from a chemical standpoint.

As regards the amount of food required, satisfaction and rational living demand that the amounts provided should be adequate, while economy demands that the amount should not be so great as to lead to over-eating or to needless waste. It may seem generous to serve a person more than he can eat, but it is not wise, since it means material left on the plate, only to be thrown away. It is better to give a smaller serving and offer a second helping. Proper care in such matters as well as in the selection and preparation of food should mean a considerable saving. The possibility of saving is made clear by the fact that the waste observed in studies of several hundred American families ranged from practically nothing to 20 per cent of the food purchased.

It is also apparent that good dietary habits are important. These can be taught and are best learned in childhood. We should not allow children to grow up with whims, fancies and aversions respecting their food. They can be taught to like all the ordinary foods, and this should be done unless it becomes apparent (and this rarely happens) that some particular article of diet is distinctly harmful because of an idiosyncrasy toward it.

For the guidance of the food expert (dietitian or other specially trained worker), dietary standards have been proposed which show the proportion of protein and energy which the daily diet should supply. Such dietary standards are designed as guides for home and institution management, and should not be confused with expressions of physiological requirement. In quantitative discussions and in comparisons, one should always distinguish clearly between "food purchased," "food eaten" and "food digested," and should take the further precaution not only to compare like things, but to compare them on a uniform basis. The basis most often selected for comparing dietaries is the food or diet of "a man in the period of full vigor weighing 150 pounds and engaged in moderate to active muscular work," and factors for computing the requirement of men, women and children in other circumstances in terms of this standard have been worked out. These precautions should always be taken in comparing the results of dietary observations, experiments and studies; otherwise, avoidable confusion results. If they are so taken into account many of the seeming differences of opinions which sometimes lead to divergent conclusions will be found non-existent. When all precautions are taken for accuracy in comparisons and discussions, differences in the amounts of protein and energy found in the diet of different persons and different races are still apparent, as well as differences of opinion as to the amount of nutrients and energy required or desirable. Such differences of opinion, however, are not so great as one might expect, and one may well conclude, from a survey of the dietary studies of different races available, that persons of like age, sex and work, given an opportunity to select, instinctively choose diets showing, when reduced to uniform terms, a decided similarity with respect to the protein and energy they supply. This is not surprising when one recalls that all reasonably normal men possess bodies and possibilities of using them which do not vary within such very wide limits. A steam engine of a given size and type will require the same amount of fuel of a certain kind in Asia as would a duplicate engine in America, for the production of a like amount of power, and why should this not be true of the human engine as well?

A large number of dietary studies made in the United States considered in comparison with the other large number made elsewhere have led to the conclusion that not far from 100 grammes of protein per day, along with 3,000 to 3,500 calories of energy, represents, for the typical man (in the period of full vigor, engaged in moderate to active muscular work), the quantities which the food purchased should supply. We have not as yet been able to test with any degree of certainty the protein optimum though data on the subject are abundant enough to indicate that the suggested value represents common race habits. With energy the case is different, for it is possible with the respiration calorimeter to test the accuracy of the value suggested in any given dietary standard. Such tests show that the values given above are in accord with actual measurements of the energy expenditure of individuals under the specified circumstances of work and rest.

A consideration of the results of American experiments and other data has led us to conclude that with our ordinary food habits, involving, as they do, the use of a considerable variety of foods in reasonably liberal quantities, one is justified for many purposes in discussing dietetics on the basis of energy only, since a diet which supplies 3,000 to 3,500 calories of energy per man per day, as ours so very commonly does, almost inevitably supplies the needed protein, ash, and other constituents also. Particularly is this the case where one takes pains to include in the diet a reasonable amount of milk, green vegetables and fruit. If we accept this conclusion as rational, it enables us to go ahead without controversy until the time comes when we have more abundant knowledge of the kinds and quantities of protein we need, of the functions of mineral elements and the best ways to meet our body needs for them, and of the nature of vitamines or other regulatory substances.

It is no new thing to realize that although empirical knowledge and experience may lead to really good results, it is easier to achieve them if there is also special knowledge and training. Thinkers and writers in the past have given their time and attention to the problems of dietetics and have left us much which is interesting and useful. That we can discuss the problems more fully and more adequately at the present time is due to the great progress made in biology, physics, chemistry, medicine and other sciences. The question comes, how can we best translate the results of scientific investigation for the housekeeper's benefit? It was natural enough that at first we should try to do this in laboratory terms and expect the housekeeper to learn them. As a result, books, pamphlets, charts, etc., have been provided for her which in many cases cannot be understood without special training, and for this time and opportunity are only too often lacking. Later has come the realization that, while the specialist who follows home economics as a profession needs wide and varied technical knowledge, the woman who practises the art of housekeeping chiefly needs, aside from the skill which she gains by experience, simple statements of facts and definite methods by which she may obtain desired results. With this realization has come the attempt to formulate more simple and pedagogically correct methods of instruction, and to provide illustrative material in pictorial or graphic rather than tabular and diagrammatic form. It starts with materials and facts familiar to the housekeeper and, as far as possible, applies standards which have been tested in practical as well as experimental use. Its advocates believe that by thus bringing practice and theory into direct and vital connection, their teaching is more likely than either the scientific or the empirical method of instruction not only to result in more rational housekeeping, but also to supply the element of culture which raises any labor to an occupation.

*(To be concluded.)*

## Long-Heads, Square-Heads, and Short-Heads

Since the almost entire disappearance from ethnology of the Aryans and the merging of the Celts in the Alpine stock of Central Europe, the old race divisions have practically vanished. It would, indeed, seem, in view of the now accepted doctrines as to the distribution of the long-headed and short-headed races throughout Europe, that the French are half Germans, the Germans half Celts, the Anglo-Saxons mainly Scandinavians, the Celtic Fringe not Celtic at all but Iberian. Even the Basques would seem to have ceased to be a homogeneous racial relic, and to be Iberians or Alpines according as they live south or north of the Pyrenees. Not a little of the Germanization of the older ethnologists may be said to have been due to the teachings of Max Müller, whose assiduously preached Aryans, emanating from a vague plateau in Central Asia, were virtually Germans. He was followed by Bergmann, among others, with his Scythian ancestry of the Slavonic and Teutonic races, and among ourselves by such brilliant historians as Stubbs and Freeman, who traced the institutions of our Anglo-Saxon ancestors to the German forests and to their denizens as described in the "Germania" of Tacitus. Historians such as Coote, with his theory of Roman influences, and anthropologists have for many years been fighting counter to these doctrines. By the aid of craniometry it is now pretty well established that Europe is at most divided between two or three strata of races—the dolichocephalic, the mesocephalic, and the brachycephalic. The dolichocephalic are the oldest, and are pre-Aryan. On the high authority of Ripley, Keith, Chalmers Mitchell, and others we now know that the dolichocephals or long-heads, coming originally from the northern shores of Africa, have encircled Europe to the northwest as far as Finland. The short-heads are at most only a zone or offshoot in Central Europe of some race derived from Asia, and are perhaps the Aryans or Aryan Celts. They brought with them from beyond the Black Sea the Sanskritic language-drift, cremation, and the use of metals. That peculiar and, to our taste, unpleasing type of German head, which looks square and is exemplified by the portraits of Von Hindenburg, may be said to be in type Alpine. It is in appearance, if not in fact, brachycephalic, and its squareness may be the origin of the word *boche*—a French argot word meaning blockhead (see Rigaud's "Argot Moderne," 1888). This type of German probably owes his aspect to original brachycephaly, aided by sexual selection. He is rather Bavarian than Prussian, but the type, so common in the German army, is found throughout the empire. Primitive peasant women marry the type of man voted handsome by their fellows. A fleshy-necked, short-headed type has probably always set Gretchen adoring. The Basque, as Prof. Ripley points out, has often a long head behind his peculiar but not unpleasing brachycephalic type of face, and sometimes the Teutonic square-head *may* be really long. Proverbial wisdom is favorable to the long-headed man, who is held to be sagacious, whereas the bullet-headed man is the dunderhead, the ignoble creature, the barbarian. "He would have whipped poor bullet-head, so they called the negro," says DeFoe in "Colonel Jack" (1722). And the seventeenth century "Dictionary of the Canting Crew" speaks of "a dull silly fellow" as "bullet-headed." The French have some fifteen idiomatic sayings referring to the head, but in only one case do we find an allusion to its shape. They say "C'est une tête carrée" in reference to an obstinate fellow. According to Ripley, people do not, as a rule, pay regard to the shape of the head, despite the above citations. The long-headed Greeks of antiquity made their statues brachycephalic. It is a question, indeed, whether the broad-heads are in any way inferior to the long-heads in intellectual achievement or the capacity for civilization. And this being so, it would be wiser for the Anglo-Saxon to pride himself on the excellent use that during the centuries he has made of culture-drifts, which have given him freedom and other benefits, rather than on the shape of his skull.—*The Lancet.*

## Removing Rust From Nickel

First smear the rusted place with grease and rub it well in; this in itself frequently will remove a great deal of the rust. Allow the grease to remain for several hours and then remove it with a rag which has been dipped in ammonia. This usually will remove all traces of the rust. If, however, a stubborn spot or two remains wipe it with a little dilute hydrochloric acid. The acid should be used very quickly and with care, otherwise it will remove the nickel as well as the rust. When all the rust has disappeared wash the place where the treatment was applied thoroughly with clean water, and then use a metal polish.—*The Spatula.*

# High-Explosive Shells*

## Ammunition Used in Modern Rapid Fire Guns

THE common high-explosive shell which is used chiefly for the destruction of fortifications did not come into general use until the latter part of the sixteenth century. About that time hollow balls of cast iron were filled partly with black gunpowder and partly with a slow-burning composition that was ignited by several different types of fuses. These shells did not give very satisfactory results. An improvement was later made that consisted in fitting into the shell a hollow forged iron or copper plug filled with slow-burning powder. The early shells were spherical in shape and were fired from smooth-bored guns (not rifled). They were used in this manner up to about 1871.

Upon the advent of the rifled gun, sabots were fastened to the base of the spherical shell and took the rifling grooves in the gun. These were usually made of wood and the rim was covered with sheet iron, steel or copper. When the first types of high-explosive shells burst, they broke into comparatively large pieces, and did not have a very destructive effect. Later developments consisted in making the shells from cast or forged steel and filling them with high-explosives such as lyddite, melenite, shimose, etc., instead of common black gunpowder. These shells were sometimes cast in sand molds head downward from steel of the proper composition to give the required strength. They were then annealed by leaving them in a furnace for a sufficient length of time to bring them to a red heat, after which they were removed and allowed to cool gradually in the air. The interior of the cast shell was seldom machined, except at the base end for the insertion of the base fuse, and the exterior was either ground or finished in a lathe and grooved at the base to form a seat for the driving band.

There are four types of shells in use at the present time that may be said to be high-explosive. The first, but not the most common, known as the high-explosive shrapnel shell, combines the principles of both the high-explosive shell and the common shrapnel shell, and has been used by some governments within the past four or five years. In this shell the head or fuse carries a high-explosive charge and the matrix surrounding the bullets is a high-explosive material capable of being detonated by the detonation of the fuse. This projectile carries a combination time and percussion fuse and a base charge of black powder. For use as a common shrapnel, the fuse and bullets are expelled without any detonation, the matrix serving to produce smoke as in the common shrapnel. The head or fuse continues in flight and detonates upon impact, causing considerable damage, and is capable of destroying the shield used in protecting a field gun. In the event that the fuse is set to explode upon impact, the high-explosive material in the head and the matrix in the shell detonate together, thus giving the effect of a high-explosive shell. The explosive commonly used in the head and as a matrix in this class of ammunition is trinitrotoluol which is used in connection with fulminate of mercury or other similar materials necessary to start the detonation.

High-explosive shells are made at present in a variety of shapes and sizes, ranging all the way from 1.4 inch to 16 inches in diameter and from 1 to 2,400 pounds in weight. The high-explosive shells used by various governments also differ considerably in construction. For instance, the American government uses a solid-point nose shell. This shell is almost the same in construction as the armor-piercing shell, and can be used, of course, against light armored cruisers or the upper works of heavily armored ships. The shell is provided with a rifling band near the base and also with an inserted bronze plug in which the base type of fuse is held. The type of fuse used varies in accordance with the use to be made of the shell. For instance, in mountain guns, howitzers, and mortars, a centrifugal type of fuse is generally used, whereas for high-velocity field guns a ring-resistance fuse is generally employed. The cartridge case and primer held in the base are similar in construction to those used on shrapnel shells. This type of high-explosive shell explodes upon impact only and the cavity is filled with an explosive called explosive "D" from its inventor Lieut.-Col. B. W. Dunn. This is also sometimes known as "dunnite." Dunnite is not a sensitive explosive and consequently it requires considerable shattering effect to detonate it. In order to accomplish this, quite a heavy detonating charge is used. The detonating composition is made of picric acid in various portions or T. N. T. (trinitrotoluol).

The British 18-pound high-explosive shell is provided with very thick walls and carries a charge of high-explosive, generally lyddite. A nose fuse instead of a base fuse is used and the fuse operates on percussion only. In order that the lyddite be satisfactorily detonated, the fuse has an extension known as a gaine which continues down into the cavity of the shell for quite a distance. This gaine is filled with three different detonating materials, each successive one being more powerful than the last. In other words, this shell is set off by what is known as the delay-action fuse. This allows the shell to penetrate fortifications or earthworks before it is detonated, and consequently enables the explosion to have a much more destructive effect than if it took place instantaneously upon impact. This particular size of high-explosive shell is generally made from bar stock, and in order to avoid chances of piping, a gas plug is inserted in the base of the shell as shown. The cartridge case and primer held in the base are the same as those used on the shrapnel shell.

The now famous French 75-millimeter high-explosive shell is made from a forging having comparatively thin walls, and it is hardened and heat-treated to increase its elastic limit and tensile strength. It also carries a delay-action fuse in the nose that is of interesting construction, as will be described later. The cavity in the shell is generally filled with a high-explosive known as melenite, the base of which is picric acid. The melenite which is used in the cavity of the shell itself is poured in while in a liquid form and solidifies upon cooling. The exploder, extending from the end of the fuse into the explosive, is filled with melenite in powder form. The characteristics of the detonator and bursting charge have to be similar in order that the greatest possible shattering effect may be produced. The fuse used in this shell is also of the delay-action type and enables the projectile to penetrate earthworks or fortifications before detonation takes place. The cartridge case is similar to that used on the shrapnel shell and is filled with smokeless powder (nitrocellulose) in stick form.

The Russian 3-inch high-explosive shell is made from a forging that is heat-treated before or after machining, depending on the practice followed. This must have an elastic limit of not less than 62,000 pounds per square inch and a tensile strength of 118,000 pounds per square inch. This shell also carries a detonating fuse in its nose that differs considerably from any of the fuses previously described. This fuse is not of the delay type, but is practically instantaneous and detonates the high-explosive material in the shell upon impact. The cartridge case carries a heavy charge of smokeless powder—generally nitrocellulose—and also a primer in the base end somewhat similar in construction to that used in the British shell. This projectile has a muzzle velocity of over 1,900 feet per second, and as the shell proper is heat-treated it has considerable destructive effect when the high-explosive contained within it is detonated.

ARMOR-PIERCING PROJECTILES.

Following the introduction of iron sheathing for

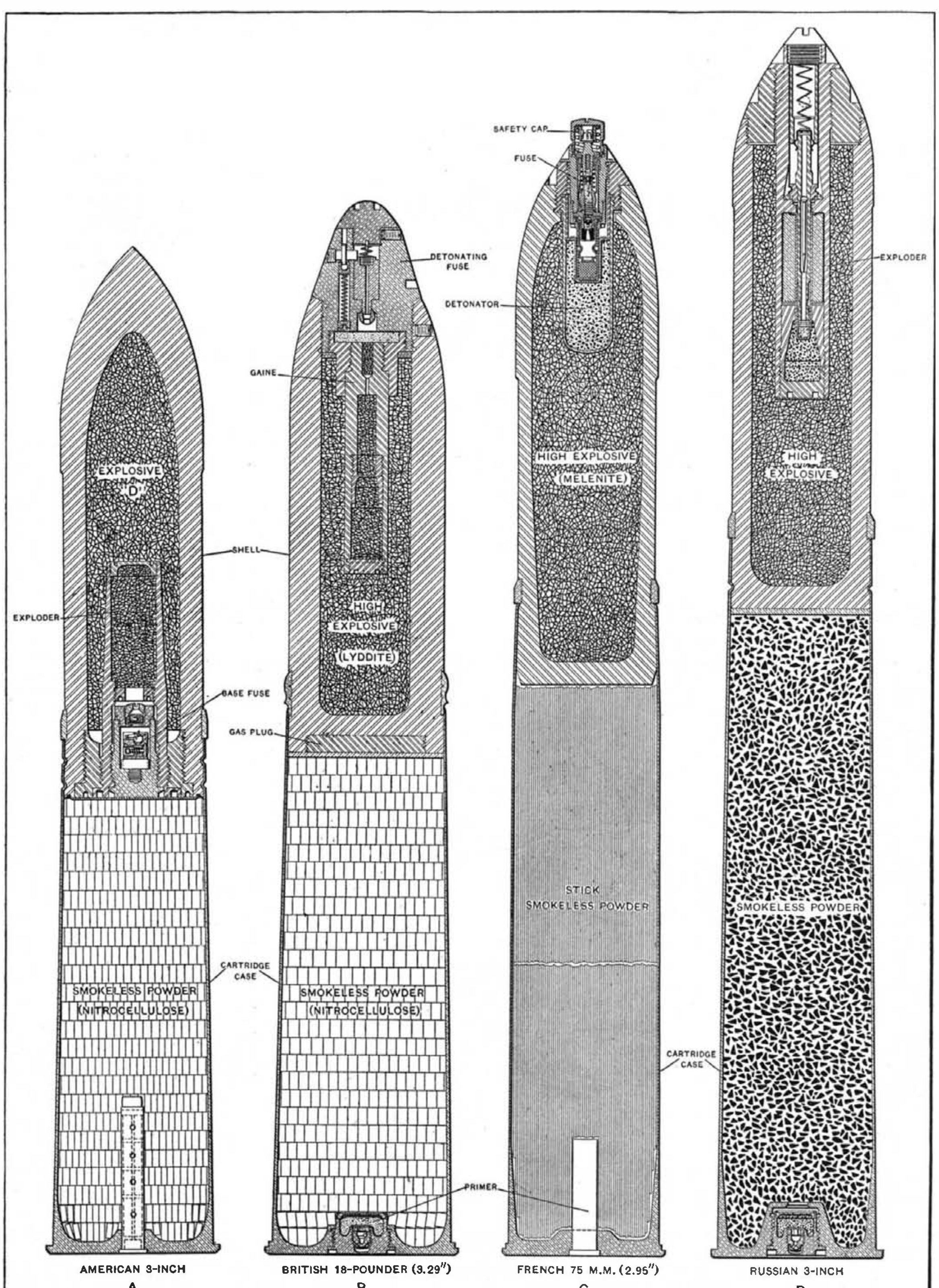



**Fig. 1.—Types of high-explosive shells now in use.**

* From an Article in *Machinery* by Mr. Douglas F. Hamilton, Associate Editor.

ships, it was found that the ordinary cast-iron high-explosive projectile did not readily pierce the plate, so that it became necessary to produce a projectile which would pierce the armor. This was accomplished by Sir W. Palliser, who invented a method of hardening the head of the pointed cast-iron shell. This was done by casting the projectile point downward and forming the head in an iron mold; the metal at the point being suddenly chilled became intensely hard, while the rest of the casting remained comparatively soft. The casting when partially cold was taken out of the mold and thrown down in the sand, where it was allowed to cool off gradually. These shells proved very effective against wrought-iron armor, but had little effect against steel armor plates. An improved shell was then devised which was made from forged steel with a point hardened so as to pierce the armor. This projectile is generally formed from steel containing both nickel and chromium, and sometimes tungsten. Armor-piercing shells are generally cast from a special mixture of chrome-nickel steel, melted in a crucible and afterward forged into shape. The shell is then thoroughly annealed, bored internally and turned on the exterior in a lathe. The heat-treatment consists in hardening the head of the projectile and tempering it in such a manner that the rear portion is reduced in hardness so as to render it extremely tough, whereas the point is extremely hard. There are two types of armor-piercing shells; one is known as a shot and is used for piercing armor, carrying a light bursting charge. The other is known as a shell; it carries a much heavier bursting charge, is longer, has thinner walls, and is much more destructive.

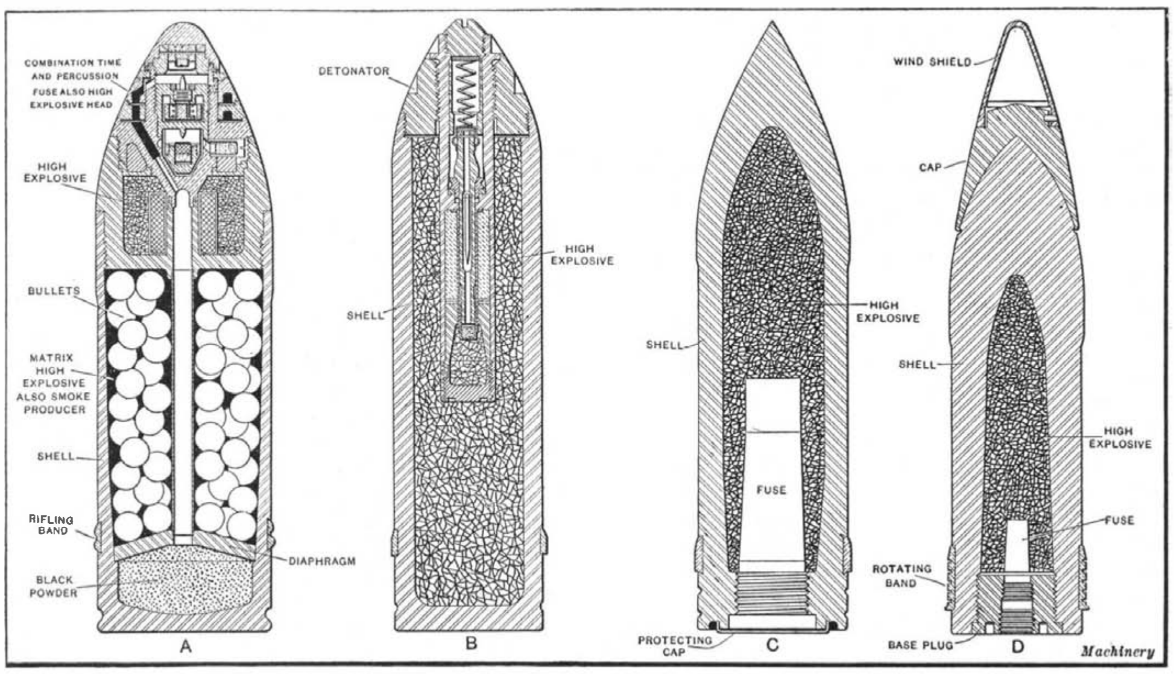
The armor-piercing shell is similar in shape to the common high-explosive shell, with the one exception that the walls are much thicker and the point of a still greater thickness. In order to greatly reduce the air resistance encountered in flight, armor-piercing shells are provided with a long pointed outer covering for the head. It was also found that if an armor-piercing shell having a hardened nose struck an armor plate with great force, the force of the blow shattered the head and made it ineffective. A soft steel cap was then placed on the shell; this gave the point support and greatly improved the chances of the projectile getting through a hard armor plate unbroken. One of the plausible theories advanced as to the ineffectiveness of an uncapped head is as follows: When an uncapped projectile strikes the extremely hard face of a modern armor plate the whole energy of the projectile is applied at the point, and the high resistance of the face of the plate puts the very small arc at the point of the projectile to a stress greater than the metal can resist. The point is therefore broken or crushed and the head of the projectile is flattened. This greatly reduces the penetrating power and results in the point of the projectile practically being welded to the armor plate. When a capped projectile strikes a hard plate, the resistance of the plate is distributed over a greater area, and, in addition the point is supported by the soft metal cap. Consequently, the point is not deformed and passes through the plate.

The specifications for the test governing the manufacture of armor-piercing projectiles are very stringent and require that the shell perforate a hard-face armor plate as thick as the caliber of the projectile without breaking the point. In other words, a 6-inch projectile is required to completely perforate a 6-inch armor plate and pass through it in an unbroken condition.

At present there are two general methods of manufacturing high-explosive shells. One is to make the shell from bar stock, removing the excess material to form the cavity by means of high-power drilling machines, whereas the other is to forge the shell to approximately the correct shape. Until within the last few years, cast-iron shells were used quite extensively; these were cast in sand molds, using a core to form the cavity. Great difficulty, however, was experienced in obtaining a casting free from flaws and other imperfections, and this method has generally been superseded by either the forged or bar stock shell. When the shell is made from bar stock, it is usually found necessary to fit a gas plug in the base end to eliminate any chances of piping. At present cast-iron shells are still used for target practice.

High-explosive shells are made in three distinct types as has been already mentioned. They are those with a solid base carrying a nose fuse, those with a solid nose carrying a base fuse, and those with an open nose and base carrying a nose fuse. If the shell is intended to carry a nose fuse, the base end is shaped in forging by the press and the nose subsequently formed to shape by a nosing-in die. In small shells of about 2 inches diameter, the nose when red-hot can be spun over in the lathe by properly formed tools. However, it is usually closed in by a press. For base fuse shells, the nose is produced by the forging machine and the base is subsequently formed by pressing the metal to the required shape.

One method of performing the nosing operation is shown in the cover illustration, in which a special power hammer is employed. For this work four men are required. One rotates the shell on its axis; another feeds the shell into the hammer dies, which are solid and of the right shape; the third operates the hammer, and the fourth man takes the nosed-in shell out of the hammer and brings another one to the machine ready to be operated on. The noising-in is started with light blows, so as to make the metal flow as evenly as possible; the blows are then increased in severity until the shell has received about twenty-five blows, which is ordinarily sufficient to complete the operation. The production is thirty an hour.




*A,* American 3-inch high-explosive shrapnel shell which combines the principles of a high-explosive and a common shrapnel shell; *B,* Russian medium-caliber high-explosive shell; *C,* shell used in coast defense and field guns; *D,* an armor piercing shell with delay-action fuse base, soft steel cap and wind shield.

## Turbine Blading

In the early days of steam turbine construction there were two chief, sharply defined types of steam turbines, which, subsequently, were adopted into extensive commercial use. These can be described as the (*a*) reaction turbine and (*b*) impulse turbine. The most prominent example of the first type is the one invented by the Hon. Sir C. A. Parsons (1884), and now commonly described as the Parsons turbine. The present leading example of the second type is that invented by Mr. Curtis of New York (1896), and now usually known as the Curtis turbine. The Curtis turbine was, however, not the first successful impulse machine, for this honor belongs to one patented by Dr. de Laval in 1889, which was a representative of the "one stage" form of this type—that is, the simplest possible form. Although the Curtis turbine was not the first of its type, yet it has been the one most extensively developed, and since 1902 has been widely utilized both in America and Great Britain.

At the present time, owing to the freedom of use produced by the expiration of basal patents, it is frequently the case that turbines do not belong entirely to either of these pure types, but are combined forms, containing elements of both. When considering the question of suitable material for blading during the early and sharply differentiated period, it was of primary importance to take into account the special requirements imposed by the particular type of machine being designed. In combined machines, if the individual portions are of large power, it is still considered advantageous to give each portion separate consideration with respect to the nature of the blading materials; but this is probably mainly due to the fact that there is at present no perfectly satisfactory and universally applicable material available. It is, however, now becoming clear that, apart from the purely commerical question of available economy in first cost, a blading material which answers the requirements of modern high-speed impulse turbines working with highly superheated steam will also meet those of reaction turbines. It will be noticed that the above fact, once it is acknowledged as established, will simplify the blading problem considerably.

It evidently follows that the first manufacturer who is successful in producing at a reasonable cost really satisfactory blading material for modern impulse turbines will have the whole world of turbine manufacturers as possible customers. This means the possibility of building up an enormous business, and it should be an incentive to strenuous research in this branch of the non-ferrous metals industry.

With the object of indicating to manufacturers the chief practical conditions which influence the selection of a material suitable for the blading of a high-speed turbine, driven by superheated steam, Mr. W. B. Parker presented at the recent autumn meeting of the Institute of Metals a series of specifications for alloys suitable for this extremely important purpose, showing that on the adoption of proper materials and manufacturing processes depended the very life of the operators of those turbines, particularly in warships.

Brass, probably the first non-ferrous alloy to be used for turbine blading, is shown to be quite unsuitable in modern superheated steam turbines, and copper, zinc, lead, tin and aluminium are at once ruled out. Nickel appears worthy of consideration, while cobalt "should certainly receive attention from blading manufacturers."

Tungsten is not mentioned, but it would certainly seem that this metal is as worthy of consideration as cobalt. Tungsten will probably prove to be the metal that will make possible the gas turbine, for no other metal that is practicable commerically has the power of resisting continuously the enormously high temperatures that are to be met with in the gas turbine. The temperatures in a superheated steam turbine never approach those reached in a gas turbine, so if tungsten will "stand up" in the latter—as it does—it should undoubtedly give satisfactory results.

It is in alloys of two or three metals that Mr. Parker sees the greatest potentialities, and one gathers that he regards alloys of the copper-aluminium-manganese series to be especially promising. In fact, he believes that these, and alloys of the copper-aluminium-nickel series, "foreshadow rivals for the special alloy steels now utilized for the most highly heated and stressed portions of the rotating blading."

These special alloy steels are being used from the sheer need for something which possesses naturally a good limit which is not too seriously annealed or "let down" by prolonged exposure to the highest temperatures.

None of these steels are perfectly satisfactory, because one trouble common to them is their natural tendency to rust. Steel alloys will probably be employed for high-speed superheated steam blading until such time as likely complex non-ferrous alloys have had their possibilities in this direction properly worked out, though when this will be done Mr. Parker seems somewhat dubious, as he speaks of "the apathy displayed toward the constant employment of scientific help and up-to-date methods of controlling metallic products." Steel manufacturers are, however, exempt from this sweeping condemnation, being praised for the spirit in which, when any trouble does happen to occur with their steel alloy blading, they "meet the complaint and tackle the problem of removing it," which they do effectively.

What non-ferrous metal-makers have to aim at is to produce a material in a physically stable condition, which must then possess a proportionality limit of over sixteen tons per square inch and a tensile strength exceeding the proportionality limit by not less than 100 per cent, and an elongation not under 10 per cent. The proportionality limit should remain constant within 10 per cent of its "cold" value over the range of temperature from 100 deg. Cent. (212 deg. Fahr.) to 450 deg. Cent. (842 deg. Fahr.)

Manufacturers have no light task in front of them. Their responsibility, especially to the public, is great, for it must be remembered that a single unsatisfactory blade among the tens of thousands used in the modern steam turbine may suffice to cause most serious damage. —*The London Daily Telegraph.*

# Photo-Chemistry*

## Research in Relation to the Reactions Caused by Light

By Harry A. Curtis, Ph.D.

EVERYONE has observed that light may bring about, or at least hasten, certain chemical actions. That growing plants require sunlight, that wall-paper fades, that laundered linen is whiter when dried in direct sunlight, that our hands and faces tan in the summer, these are facts of photo-chemistry too evident to be overlooked. To a lesser degree the photo-chemical processes of photography are known to the layman, but the modern science of photo-chemistry is known only to a few investigators. It may, therefore, be of some interest to the readers of this journal to consider the broad outlines of a branch of chemistry which offers great promise of becoming vastly important to man.

It is not the purpose of the present paper to trace the development of the science of photo-chemistry, but rather to summarize the results which research in this field has yielded and to point out certain large problems which are now occupying most attention.

To discuss a highly specialized branch of any science in language which shall not be so technical as to bewilder the average reader of a scientific journal, and yet not lose that precision which a special nomenclature brings to any science, is no easy task. The attempt will be made in this article to steer a happy middle course between the inaccuracies which inhere in a popular discussion of a technical subject and the formidable language behind which every science finally takes refuge from popular attack.

The term photo-chemistry has unfortunately become associated with the better known word photography. It must, therefore, be pointed out here that photography is but one branch of a very much wider science, photo-chemistry. Photo-chemistry has been defined as the study of the effect of light on chemical reactions, the term light being used in its broader meaning to include the infra-red and ultra-violet regions of the spectrum.

Visible light includes waves of radiant energy whose lengths[1] lie roughly between 800μμ and 400μμ. This range is but a very short piece of the total spectrum of radiant energy, which is now known to extend from waves less than a millionth of a millimeter long up to those having a length of several hundred miles. It is instructive to give in Table I the various parts of this spectrum which have been investigated to date.

TABLE I—SPECTRUM OF RADIANT ENERGY.

| Wave-Length. | Name of Wave. | Investigator. |
|---|---|---|
| 0.01μμ to 1μμ | Röntgen or X-rays | Röntgen, 1895 |
| 1μμ to 100μμ | Uninvestigated | .............. |
| 100μμ | Shortest ultra-violet | Schumann, 1893 |
| 200μμ | Ultra-violet rays | Cornu, 1878 |
| 200μμ to 400μμ | Ultra-violet ryas | Ritter, 1801 |
| 400μμ to 800μμ | Visible rays | Newton, 1666 |
| 800μμ to 1μ | Ultra-red rays | Herschel, 1800 |
| 1μ to 10μ | Heat rays | Langley, 1886 |
| 10μ to 61.4μ | Heat rays | Rubens, 1896 |
| 108μ | Heat rays | Rubens, 1910 |
| 218μ and 343μ | Heat rays | Rubens, 1911 |
| 343μ to 1 mm | Uninvestigated | .............. |
| 4 mm | Shortest electrical waves | Lampa, 1895 |
| 6 mm | Electrical waves | Lebedew, 1895 |
| 1 cm. to 10 m. | Electrical waves | Hertz, 1889; Lodge, 1890; Righi, 1894 |
| 10 m. to 1 km. | Electrical waves | Feddersen, 1892 |
| 1 km. to 100 km. | Electrical waves | Tesla |
| 100 km. to 1,000 km. | Electrical waves | Lodge, 1888 |

It will be seen in Table I that if the visible portion of the spectrum be called unity, then the total range represented in the table will be $2.5 \times 10^{14}$. To get an idea of the magnitude of this ratio, suppose the length of the visible spectrum to be a meter. Then the total length represented would span the distance from earth to sun about 170 times. It is probable that radiant energy of every wave length will be found to have an effect on chemical reactions. As yet, however, research in this line has been almost completely limited to the visible and ultra-violet parts of the spectrum, to heat rays, and, in very recent years, to a few scattered investigations in the region of very short waves.

AVAILABLE SOURCES OF LIGHT.

Our greatest source of light is, of course, the sun. Prof. Luther estimates that the sun delivers continuously to the earth about 200,000,000,000 horse-power, which is about 1,000,000 times more than is generated by all the engines on earth. Of this enormous quantity of energy, plants utilize a small portion, part is reflected away from the earth, and the balance is dissipated as heat. To store up and utilize a larger part of this energy with which the sun floods the earth is one of the dreams of photo-chemists.

While it is probable that any successful commercial process of photo-chemistry must utilize sunlight, it has been found that sunlight is a most unsatisfactory source of light for purposes of photo-chemical research. The difficulty is, of course, that the intensity of the sunlight is never constant for more than a few minutes at a time. Aside from this, the earth's atmosphere filters out the shorter waves of light, the very ones which are the most effective in most photo-chemical processes.

Of the various artificial sources of light, only a few are of sufficiently high intensity to be used in photo-chemical studies. The electric arc has sufficient intensity, but is difficult to keep burning steadily. The same difficulty is met with in the case of the electric spark, although several successful pieces of research have been accomplished, using the spark as a light source. The Nernst glower burns steadily, and gives a continuous spectrum, but the light is not rich in the short waves. By far the most successful lamps for purposes of photo-chemical research are the mercury-vapor lamps. These are easy to operate, and give an intense light which is very rich in short waves. The spectrum of the light emitted is, of course, discontinuous. This is an advantage where it is desired to carry out research using monochromatic light, for if the light be spread out with a prism, any particular line may be used as a light source by simply screening off the rest of the spectrum. Where all the light is to be used, the spectrum may be enriched by replacing the mercury with an amalgam.

If the shorter waves of the mercury-vapor light are to be utilized, however, the lamp may not be constructed of ordinary glass, for this is not transparent to waves shorter than about 350μμ. Many attempts have been made to prepare glass which should be more transparent to the shorter waves. These attempts have been successful to the extent that glass has been produced at the Jena works having a transparency extending to nearly 250μμ. This, however, only partially solves the problem. There are indeed very few materials which do possess the desired properties. The lower limits of transparency of a number of common materials are given in Table II.

TABLE II—THE LOWER LIMITS OF TRANSPARENCY.

| | |
|---|---|
| Flint Glass | One centimeter thickness transmits from 50 to 80 per cent at 350μμ Less than 1 per cent is transmitted at 305. |
| Uviol Glass | Lower limit at 253μμ. |
| Fluorite | One centimeter thickness transmits 83 per cent at 186μμ and the transparency is still high at 100μμ. |
| Rock Salt | Transparency is high at 186μμ. |
| Quartz | Transmits 96.2 per cent at 222μμ and 67.2 per cent at 186μμ; at beyond 186μμ the transparency falls off rapidly. |
| Calcite | Less transparent than quartz for short waves. |
| Mica | Strongly absorbs the short waves. |
| Water | Transparency is high at 193μμ. At 186μμ it is less transparent than is quartz. |
| Glycerine | Transparency is high at 240μμ. |
| Canada Balsam | Transparency is high at 330μμ. |
| Gelatine | Transparent down to 257μμ. |
| Air | Transparency is high at 194μμ; at 186μμ the absorption is very high, and no waves shorter than 165μμ are transmitted. |

Of these materials, quartz is the one best adapted, and since the methods of working quartz have been developed, this material has found wide use in photo-chemical research, both in the manufacture of lamps and of all sorts of reaction vessels.

THE MEASURING OF LIGHT.

The problem of measuring light in photo-chemical research is one which differs radically from the measuring of light for ordinary illuminating purposes. In the latter it is the visual result which is in question, and therefore any of the visual photo-meters may be applied. In photo-chemistry, however, the problem is usually to determine the rate at which radiant energy is being delivered to the reaction vessel. This at once eliminates all visual photo-meters, for the human eye is not equally sensitive to light waves of all lengths. It is most sensitive to yellow-green light, and is, of course, blind to the ultra-violet which is so active photo-chemically. Many chemical photo-meters, or actionometers as they are called, have been invented, but all of them have the same fault in that they are not equally sensitive to light of all wave-lengths. Ignorance of this fact has rendered of little value much of the early work in photo-chemistry.

One of the instruments most used for measuring light intensity in modern photo-chemical research is the thermopile. This instrument is based on the well-known fact that when radiant energy falls upon a junction between two different metals, that part of the energy which is absorbed heats the junction and will cause a current of electricity to flow from the one metal to the other through an external circuit. If a delicate galvanometer be included in the circuit, the current may be measured, and by comparing this current with that produced by a radiation of known intensity, the total radiation from any source may be measured. The radiation of known intensity is obtained from a so-called "black-body" radiator. Stefan discovered empirically, and Boltzmann derived by thermodynamic reasoning the law now known as the Stefan-Boltzmann law, which states that the total radiation from a perfectly black body is proportional to the fourth power of the absolute temperature. Stated algebraically $S = CT^4$, where $S$ is the total radiation, $T$ the absolute temperature, and $C$ a natural constant having a value approximating $1.71 \times 10^5$ ergs per square centimeter per second. It is, of course, not possible to construct a "perfectly black body," in the sense here used, but the deviation of certain actual radiators from the ideal is negligible.

Another instrument often used to measure radiant energy is the radiomicrometer. In this instrument a thermopile and small circuit are suspended by a fine fiber between the poles of a magnet. When light falls upon the thermopile, a small electrical current flows through the circuit and the suspended system is turned by the magnetic field as in the D'Arsonval galvanometer, the effect being magnified by an optical lever.

TYPES OF PHOTO-CHEMICAL REACTIONS.

In general it may be said that light is capable of bringing about every type of chemical reaction. The number of photo-chemical reactions now known is far too large to allow a consideration of each one individually. We shall, therefore, only point out a few examples under each type of reaction.

*Oxidation Reactions.*—*a*. Lead sulphide is oxidized to lead sulphate by light and air:

$$PbS + 2O_2 = PbSO_4$$

*b*. Sulphur dioxide is partially oxidized to sulphur trioxide by light and oxygen:

$$2SO_2 + O_2 \rightleftarrows 2SO_3$$

*Reduction Reactions.*—Silver salts, iron salts, mercury salts, bismuth salts, etc., are reduced by light, the metal being liberated in some cases, in others a salt corresponding to a lower valence of the metal being formed. The ordinary process of blue-printing involves the photo-reduction of an iron salt.

*Polymerization.*—*a*. Under the influence of light oxygen is converted partially into ozone, the equilibrium between the oxygen and the ozone depending upon the temperature and the intensity of the light used.

$$3O_2 \rightleftarrows 2O_2$$

*b*. In organic chemistry a great many polymerizations have been accomplished by means of light. As a simple example we may cite the conversion of cyanogen into paracyanogen:

$$x(CN)_2 = (CN)_2x$$

*Depolymerization.*—Ozone is partially decomposed into oxygen, the decomposition proceeding until the equilibrium point has been reached as in the formation of ozone from oxygen.

*Allotropic Changes of the Elements.*—Under the influence of light sulphur which is soluble in carbon disulphide, so-called Sλ, is converted into sulphur which is insoluble in carbon disulphide, so-called Sμ.

Likewise yellow phosphorus is converted into the red modification at a very much higher rate than occurs in the dark.

*Isomeric Changes.*—Light is especially active in bringing about isomeric changes in organic chemistry. For example, maleic acid becomes fumaric acid under the influence of light, orthonitrobenzaldehyde becomes orthonitrobenzoic acid, isocrotonic acid becomes normal crotonic acid, cumaric acid becomes cumarin, etc.

Light may also bring about stereo-isomeric changes, as, for example, in nearly all the fulgides, where the change is usually accompanied by a change in color.

*Hydrolysis.*—Hydrolyses, especially in organic chemistry, are readily accomplished by light. Thus acetone and water react to form acetic acid and methane:

$$CH_3COCH_3 + H_2O = CH_3COOH + CH_4$$

Ethyl bromide yields alcohol and hydrobromic acid:

* A lecture delivered before the Teknik Club, Denver, and republished from the *Metallurgical and Chemical Engineer*.

[1] 1μ = 0.001 millimeter; 1μμ = 0.000001 millimeter.

$$C_2H_5Br + H_2O = C_2H_5OH + HBr$$

*Synthesis.*—*a.* Hydrogen and chlorine combine to form hydrogen chloride with explosive rapidity in direct sunlight:

$$H_2 + Cl_2 = 2HCl$$

*b.* Carbon monoxide and chlorine combine to form phosgene:

$$CO + Cl_2 = COCl_2$$

*c.* In organic chemistry a great many syntheses have been carried out by means of light, this method often affording a direct and simple means of carrying out reactions which may be accomplished only with much difficulty by other means.

It has long been known that the halogenation of organic compounds is much hastened by exposing the reaction mixture to sunlight. In this connection it is interesting to note that a close parallelism exists between halogenation at high temperatures and halogenation in sunlight.

*Decompositions.*—*a.* Light decomposes hydrogen iodide very readily in the presence of oxygen or air:

$$HI = H + I$$

*b.* Hydrogen peroxide is decomposed into water and oxygen:

$$H_2O_2 = H_2O + O$$

The rate of decomposition is greatly influenced by the presence of a trace of foreign substance in the solution, in most cases the solution becoming more stable upon the addition of the foreign substance.

*c.* Under the influence of light of short wave-length, most organic compounds are decomposed into simpler substances. In Table III are given the decomposition products of a number ofsimpl e organic compounds.

TABLE III—DECOMPOSITION PRODUCTS OF ORGANIC COMPOUNDS.

| Compounds. | Percentage of Products. | | | | | |
|---|---|---|---|---|---|---|
| | $CO_2$ | CO | $H_2$ | $CH_4$ | $C_2H_6$ | $C_4H_{10}$ |
| Methyl alcohol | 5 | 8 | 87 | .. | .. | .. |
| Ethyl alcohol | .. | 22 | 63 | .. | 15 | .. |
| Propyl alcohol | .. | 16 | 69 | .. | .. | 15 |
| Formaldehyde | 9 | 39 | 46 | 6 | .. | .. |
| Acetaldehyde | 5 | 39 | 33 | .. | 23 | .. |
| Propyl aldehyde | 6 | 37 | 37 | .. | .. | 20 |
| Formic acid | 59 | 21 | 19 | 1 | .. | .. |
| Acetic acid | 41 | 14 | 13 | 13 | 19 | .. |
| Propionic acid | 41 | 15 | 15 | 15 | .. | 14 |
| Acetone | .. | 49 | .. | 5 | 46 | .. |
| Acetone and water | 1 | 44 | .. | 9 | 46 | .. |

# Correspondence

*[The editors are not responsible for statements made in the correspondence column. Anonymous communications cannot be considered, but the names of correspondents will be withheld when so desired.]*

## The Phenomena of a Moving Automobile Wheel

To the Editor of SCIENTIFIC AMERICAN SUPPLEMENT:

May I request the privilege of adding a word in regard to the phenomena of a rolling wheel, as the matter is introduced in your columns in the issue of January 22nd, the SCIENTIFIC AMERICAN, No. 4 of Vol. CXIV.

In question No. 14,026, G. J. C. asks why the top of a fast-moving automobile wheel is transparent and the bottom is not. The answer as printed in the same article is very clearly put, but I ask, is it sufficient or wholly accurate? Will not, I say for example, any point temporarily on the top of the wheel be moving forward faster than the opposite point, not only "if referred to the ground" (as the answer states), but also if referred to any point or line or object? (Of course, we aren't considering its constant speed or rotation, the motion of various points being there referred to the center of the wheel.)

I respectfully submit, to be printed in your columns or elsewhere if convenient, this proposition of mine and outline of proof. It seems that this simple geometric figure and equation make more clear that fact of variation in velocity and solve one or two other questions not before discussed. Or else, on thinking this over, some better-informed person—yourself, for instance, or a scientific reader—will disprove it.

Proposition: "The velocity of any point on the circumference of a rolling body (a ball or wheel) is a variable one. For it is the resultant of two velocities, as its motion is of two motions, both in themselves constant, the rotary one, and the forward progress of the whole wheel."

As the wheel is not rotating on a stationary axis, but is rolling, the problem is to determine the construction and the equation (referred to two axes, a vertical and a horizontal one) of the curve or locus of a point on the circumference of a circle, when the circle is made to roll on a straight line. Take the line as "$X$-axis" and any one of the positions in which the tracing point $P$ is on this line as the origin $O$. Let $C$ be the center of the circle, and $r$ its radius. Now, with the circle in any representative position, as in Fig. 1, join the center to $P$ and to the point $T$, point of tangency. Also take $PD$ and $PE$ perpendicular to $OX$ and to $CT$ respectively, and represent by $\phi$ the circular measure of the angle $TCP$.

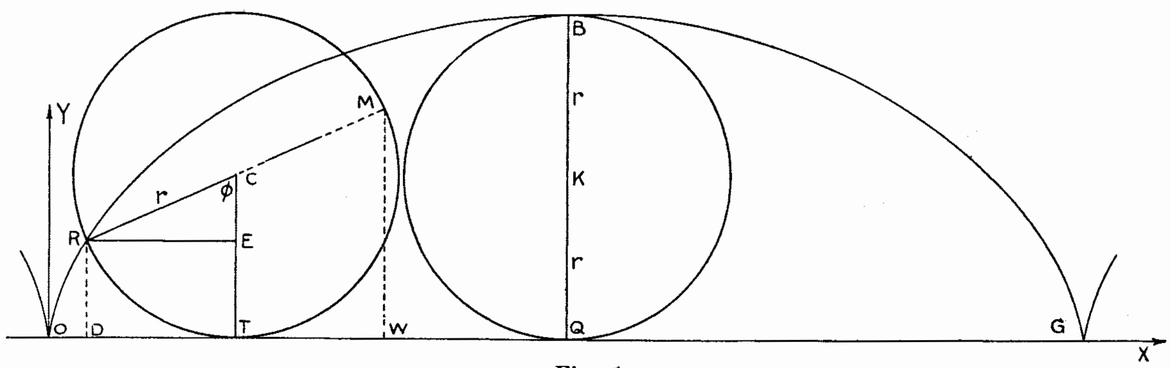



Fig. 1.

In Fig. 1 the position of the circle (center at $c$) is such that it would, if rolled back to the left, bring point $P$ in coincidence with the origin $O$.

$$\therefore OT = \text{arc } TP = r\phi.$$

Therefore if $x$ and $y$ express distance of $P$ from the axes $YO$ and $XO$, the co-ordinates of $P$:

$$x = OD = OT - PE = r\phi - r \sin \phi,$$

$$y = DP = TC - EC = r - r \cos \phi.$$

That is, the equations for the locus are:

$$x = r\ (\phi - \sin \phi), \text{ and } y = r\ (1 - \cos \phi).$$

And as $\phi$ increases from 0 to $2\pi$ (i. e., from zero to 360 degrees), $P$ follows the path indicated ($OBG$). The entire curve is this arch and repetitions of it.

We do not need a figure to realize that the common notion is wrong that a car moves only as far or fast as its tires do. It may seem a paradox to deny it. Yet it is clear that a point on the wheel's rim goes not only as far forward as the hub does, but has also its many revolutions around the hub. Hence the two paradoxical facts: first, that the tire moves on the average much faster than the axle; and second, any part of the tire must for half the journey be traveling slower than the hub or the whole machine.

We can see that Fig. 1 represents the path of any such point in all its consecutive positions. A significant fact appears that although the point never stops revolving, yet its forward motion once in each revolution is as though interrupted. It does not stop for any finite time, of course, but (see the point $G$!) the direction of the resultant motion is changed by 180 degrees from perpendicularly downward to perpendicularly upward. At that moment when the point is on the line (for no actual but only an infinitesimal period of time) its velocity is that of a simple rotating and not rolling body.

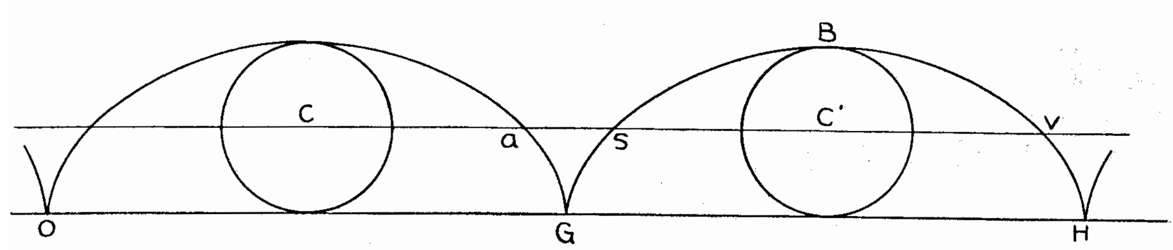



Fig. 2.

Now see the figure and think of the circle rolling, $P$ coming from $O$, and the radius $PC$ from the perpendicular line $OY$. For *in the length of time in which the circle as a whole (i. e., its center $C$) has moved forward the distance OT, and in which M, the point opposite P (and starting in line OY), has moved forward the distance $OT + DT$ or OW, in that length of time the point P has moved forward only the distance OD.* That means simply that, relative to the ground, the ratio of the distances traveled in the same time (less than for a quarter revolution) and measured straight ahead by the points $M$ and $P$ is as $OW$ is to $OD$. While the ratio of the distance moved over actually by the points in the same time (which means the ratio of their velocities) is of the same value approximately, inasmuch as $P$ has moved up (also rotating backward) through the curve $OP$, and $M$ has moved downward (with a forward rotation) over a curve longer than its projection $OW$.

Now notice that any point to get from $O$ to $G$, or the linear distance equal to the circumference ($2\pi r$) has to travel the curve $O.B.G.$ It cannot travel at a constant speed, since whenever it is above the level of the center the rotation is toward the right, the same as the direction of rolling, and its speed is the variable sum (or properly the resultant) of the two velocities; and since when below the level of the center the rotation is toward the left, and the real velocity is a sort of difference of two (with different directions than either and lower measure). For an actual case (see Fig. 2) the distance traveled by the end of a radius (or spoke of a wheel) from the time it faces ahead horizontally (in line of $Ca$) till it has rotated 180 degrees and faces the rear (in line of $C's$) will be the sum of the two cycloid arcs $aG$ plus $Gs$, while the distance traveled by the same in the same time to complete the 360 degrees of rotation is the arc $sBv$.

*Briefly, then, aGs is the path of a point in one half revolution; and sBv is the path of the one opposite it in the same time, or better, its own path continued in the next half revolution.*

*Postscript.*

Note I. The lowest part of the wheel never "rests" on the ground. Its downward motion (at $G$) is stopped, but the upward motion begins without the minutest fraction of time of interruption. Meanwhile the forward progression continues—and there is no backward movement of any point, no matter how slow the wheel rotates.

Note II. Notice the very sharp angle of change in direction (at $G$ and $H$), when for an instant (infinitesimal) the direction is parallel to what it was, and the angle grows out of zero degrees.

Note III. There is analogy between this and the change in direction at its highest point of a projectile shot straight upward; when (the action of gravity being as continuous as the rotation of the wheel) the body does not stop nor hesitate when its momentum is lost, but starts immediately to fall.

Note IV. Following is a much simpler instance (that of the wheel) of resultant motion. On a freight train moving 15 miles per hour, a man running from the caboose with a speed of 5 miles per hour has absolutely twice the forward velocity as a man who runs toward him from the engine with the same running speed.

Note V. The spokes of the automobile wheel, of course, as they converge at the hub tend to have there the same speed; but the great difference in the motion of their extremities gives rise to the commonly noticed phenomena (a fact, not an illusion) that the top of the wheel is the part most transparent.

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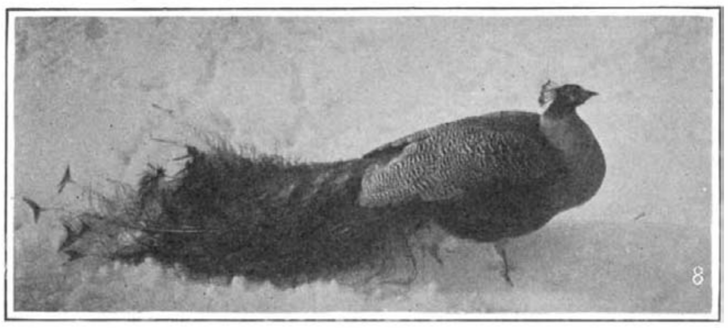
## Moving a Lighthouse

A NEW breakwater was built at Sheboygan, Wis., and it became necessary to establish a lighthouse upon it, to take the place of the one located on the old breakwater. It was decided that, as the existing structure was in excellent condition, it would be an economical plan to move it to the new location, and this was accomplished in the short time of three days. The structure was a cylindrical steel tower of a total weight of thirty tons, and it was transferred by means of timber-ways to a scow 120 feet long and 30 feet wide, which was towed to the new breakwater, where the tower was again transferred, and secured in its new position.




**Picturesque views in the national park.**

7, Main entrance on Connecticut Avenue; 8, A magnificent cock pea fowl in the snow; 9, The zebra house; 10, A Bactrian camel; 11, Pond for water birds; 12, a bull yak in combative mood.

# Some Noted Zoological Parks

## The National Zoological Park at Washington

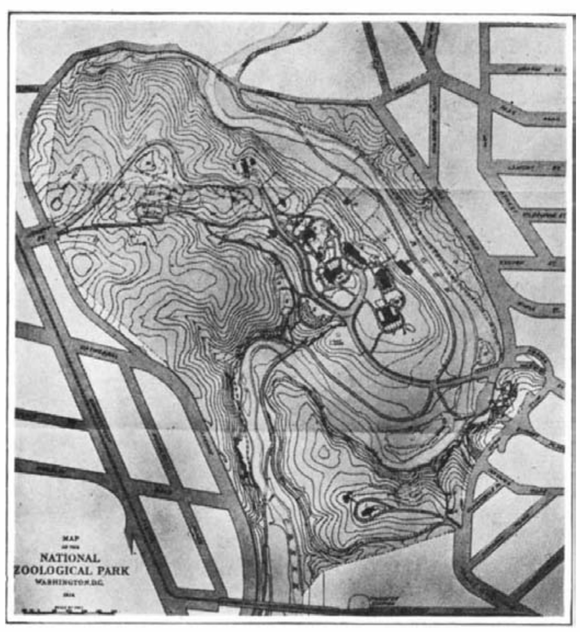
By R. W. Shufeldt

If there be one city in the United States more than another in which we should find an extensive, well-equipped and well-stocked zoological garden, Washington, the national capital, is that city; and, be it said to the credit of our Federal Government, this city is not lacking in that requirement. Our Republic, however, was nearly a century and a half old before any such enterprise worthy of the name was put on foot; as a matter of fact, Congress did not authorize the purchase of the land for such a purpose until the year 1890. When the Government did take action it was by no means in a niggardly and careless manner, for, appreciating the importance of the institution and what it meant in the way of being an added factor to the beauty of Washington—and Washington is one of the most beautiful cities in the world—Congress not only provided for a park for all time, of wide and ample extent, but it saw to it that the site was selected with the view of meeting each and all of the requirements in the premises.

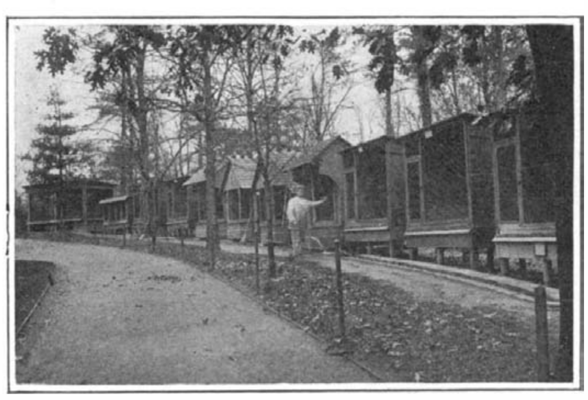
Nearly one hundred and sixty acres were chosen, and these, while close to the heart of the city at the time of the selection, included, topographically, every possible requirement demanded on the part of a park which was to be gradually converted into a collection of homes for the exhibition of animals of all kinds from all parts of the world. This came to be established as the National Zoological Park, and was placed under the direction of the Smithsonian Institution—the act providing that it was to be for the "instruction and recreation of the people."

Not over twenty years ago this entire piece of ground was practically on the very outskirts of the city, while at this writing (January, 1916) it is almost entirely and closely surrounded by many elegant houses, car lines and country residences, and may be said to be well within the residential part of the western city limits. Notwithstanding this, the lay of the land and its topography is of such a character that, when one chances to be in almost any part of this park, at any season of the year, one enjoys the constant sensation of being in some charming and varied country, situated many miles from any metropolis, or from even a country town. Rock Creek, running through it in a general southerly direction, is a stream of exceptional beauty and diversity of character. It has its falls, its deep pools, its slow and rapid currents, and its torrents—all of which are greatly to be desired in the waterway in a zoological park, for these very differences make swimming-pools for large mammals, otter ponds, beaver lakelets and streams, and many other necessities. Splendid timber, including a great variety of trees, is distributed in an ideal way throughout the entire acreage, grand, isolated trees, with plenty of underbrush and copse, all of which has been conserved and added to through the introduction of many shrubs, trees and conifers of great beauty and diversity.

In its entirety this park is a winding valley, through




which the stream passes as it sweeps around splendid hills. In some localities we are confronted by rugged cliffs, which are, in most cases, extremely picturesque, and in a few really imposing. The naturalness of a fair share of all this has been carefully preserved,



**Quarters for wild felines and canines.**

while the improved parts—areas for buildings, roadways and other purposes—merge into it almost imperceptibly, the lines of demarkation being scarcely noticeable, particularly during the open season, or when a mantle of snow in midwinter obliterates all dividing lines.

This part of Washington is now growing with marked rapidity, and the buildings of every class and kind are, as a rule, most substantial and imposing, so it is quite safe to say that within the next quarter of a century it will be hard for Washingtonians to realize that, as I write these lines, we find in this park a flock of *wild* turkeys, several coveys of quails or bob-whites, black and gray squirrels, wild rabbits, 'coons, mink, skunks, and only three years ago a flock of Canada geese (*Branta canadensis*), attracted by the presence of the tame ones, came down to join the latter in the pond where they were kept, remaining there for some time. In fact, they became quite tame, though they took to flight again when the migration season set in.

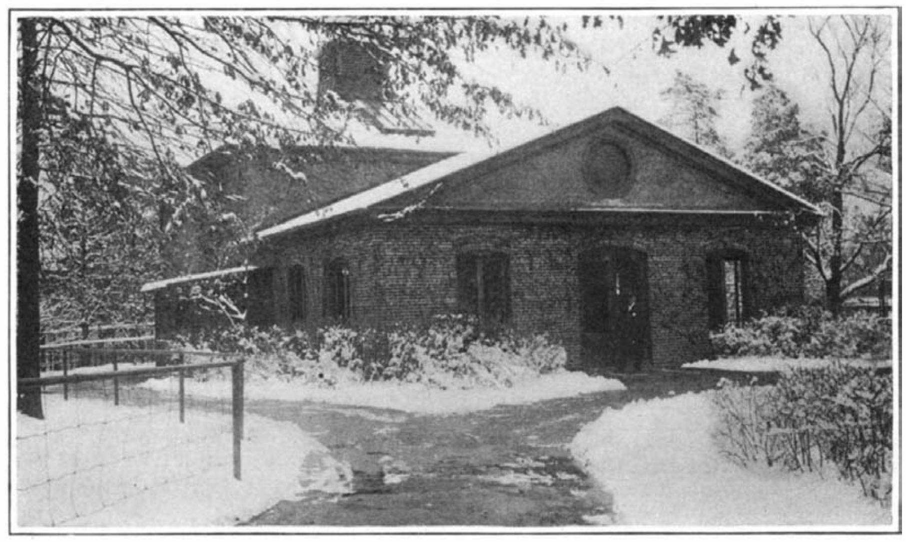
As will be seen in the plan of the grounds, the principal buildings of this park are to be found at the top of the lion-house hill, the structure named being one of the largest in the group. It contains several lions, tigers, leopards, hyenas, tapirs, hippopotamus, alligators, various reptiles and other animals—the big cats being able to pass out of their house quarters during the warmer parts of the year to outside cages of fair proportions, in order to enjoy the sun and a greater amount of exercise. This privilege should be extended to all other animals, but, unfortunately for them, it is not the case.

To the rear of the lion house we have the monkey house, a fairly good structure, in which we find some fifteen or sixteen species of apes, monkeys, macaques, chacma, baboon and so on. They are in cages of various sizes, and as well kept as is possible under the circumstances, but the place is too dark for the greater part of the year, and the ventilation is not of the best.

I may mention here that at the end of June, 1915, there were in this park 151 species of mammals, represented by 629 individuals; 185 species of birds, represented by 696 individuals, and 22 species of reptiles, represented by 72 individuals, making a total of only 358 species, represented by 1,397 individuals. Compared with many of the great zoological gardens of the world, this is not much of a showing. As a matter of fact, we find no fish in this collection, and no batrachians, with an entire absence of all invertebrata; indeed, there are no groups whatever represented here beyond mammals, birds and reptiles. It is simply astounding that there should not be a better representation at the National Zoological Park, at the capital of a nation of nearly a hundred millions of people.

But to return to the matter of buildings and enclosures that are maintained in this garden, perhaps no group is more indifferently cared for than the birds. The "bird house" is a wretched apology for a place to bring comfort and happiness to some fifty or sixty different species of birds. An elegant specimen of the harpy eagle, for example, is kept in this bird house; it has been there for a long time, in a cramped little cage where sunlight rarely enters, and where there is absolutely no room for exercise for a creature of this kind. In fact, this very bird house is, upon the whole, a disgrace to a zoological garden worthy of the name, and it should be replaced by one designed along lines making for the comfort, happiness and freedom of the creatures held captive in it. This particular building

A substantial monkey house.



The new elephant house.

reminds me of the story connected with the elephant house. The elephants were formerly kept *chained* in a miserable old wooden roundhouse for altogether too long a time. Indeed, conditions were so bad and so inhumane that it became the subject of general discussion in humanitarian circles in the city, whereupon several ladies so minded carried the question to Congress and pressed the passage of a bill for $20,000 to build a new elephant house. This was eventually cut down to $10,000, which passed—one Congressman remarking that $10,000 would build a house good enough for him to live in, consequently it ought to build one good enough for any elephant of his acquaintance.

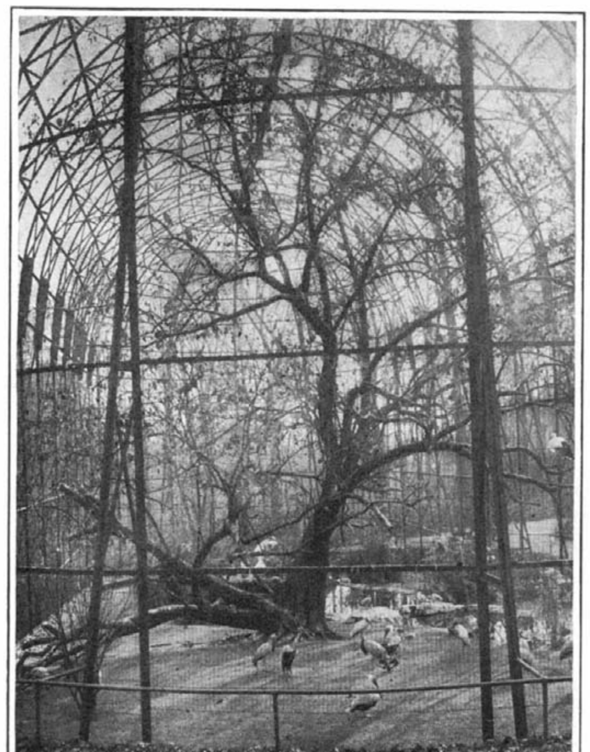
There are many sights which are really worthy of study, and which are not readily forgotten. For example, there are fully sixty peacocks at large upon the grounds, and it is by no means a rare thing to observe a dozen or fifteen of them in a flock, deliberately walking through the freshly fallen snow, several inches deep. It was in midwinter that I secured my picture of the main entrance to the park, here shown. The little lodge for the watchman is seen to the right of the sidewalk opening; the gate for vehicles, being much wider, is not in the view, and is to the left of the signboards shown. There are two or three other entrances to the park, but they are even less pretentious than this one. As a matter of fact, for a National Zoological Park, having an extent of between 160 and 170 acres, the entrances are most simple in character, to say the least.

A few of the animals kept in the park have almost as much freedom as they enjoy in nature; this is well illustrated in the case of some of the elk and the yak. I have seen hundreds of elk in nature, but I must say that I have never seen a pair appearing more natural or to better advantage than the old buck and doe in the illustration. The yaks have a fine range all to themselves; the old bull shown charged me three times before I secured this portrait, and he is shown in it as he appears when just turning to do it again. Fortunately, a strong wire fence prevented him from smashing my camera to bits—and perhaps from crippling the camerist into the bargain.

Not a few denizens of this park enjoy equally spacious tracts, or, rather, are confined in similarly roomy paddocks, such as many of the deer, the seals and otters, beavers that inhabit the beaver pond, and so on, while in other instances the cages are small, cramped and totally inadequate for the purposes for which they are used. A good series of examples of these latter are shown in one of the illustrations, while those for the bears and dogs (*Canidae*) are nearly as bad. Indeed, positive and continuous cruelty is inflicted upon some of the animals in this park; it is the duty of our citizens to call the attention of Congress to these matters, and through more generous legislation see to it that it is remedied.

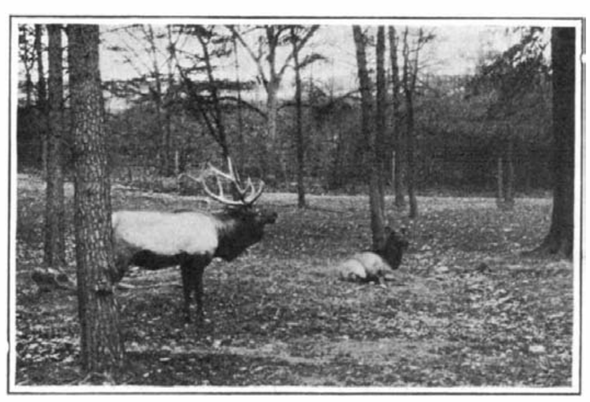
Not a few things are lacking in this National Zoological Park of ours, and it is high time attention was drawn to them, in that the Government may not only know of these needs, but that Congress may provide the means to supply them. In the first place, money, or part of a more generous appropriation from the general Government, should be set aside to publish a quarterly report upon the National Zoological Park, which should contain everything pertaining to the Garden. This quarterly report should be published in the best possible manner, and be thoroughly illustrated with both colored and plain plates, as well as by many text cuts, as the contained articles and sections demanded.

There is still another glaring deficiency in the work accomplished by our National Zoological Park: the fact that it issues no "Guide Book." Some such publication should appear annually; that is, such a booklet as is issued by the London "Zoo," the Cincinnati "Zoo" and not a few other parks and gardens of the kind. These guide books are of the greatest possible use; their issuance redoubles the value of a zoological garden as an educational center, and as an institution where representatives of not a few of the professions may obtain material for their work in the world's activities.



The big flying bird cage.

Having already mentioned the monkey house, I present here an exterior view of the building, which is seen to be most substantial and architecturally beautiful in many respects. It is of solid blue granite, with well-arranged outside cages for the use of the inmates in summer, and at such times in spring and autumn



The spacious elk paddock.

as it is not too cold for them in the open air. Monkeys are subject to quite a number of diseases when kept in zoological gardens, and some of those diseases are for the most part fatal to them. I may mention here that every zoological garden of any size, containing a sufficient number of animals to warrant it, should have its own hospital, equipped for the treatment of animal diseases of every possible nature. Connected with this there should be a full staff of veterinary practitioner, pathologist, attendants and others. This department is well taken care of in the Philadelphia Zoological Garden and elsewhere—a matter I have already touched on in my other published articles.[1]

The proper sustaining of such a department in a zoological garden is more economical than it is to have expensive animals die from lack of the necessary medical and surgical treatment, to say not a word as to what many of them suffer before such treatment is brought to their aid. Added to this, we must consider what a body of valuable and useful information is annually to be obtained from such a hospital or laboratory when properly and efficiently conducted.

In a park as large as this one there can be no particular reason for cramping certain animals so much. and it would seem that many now so confined could enjoy greater freedom. Unfortunately, not all of them are as well off as the Bactrian camel—a fellow who has so much ground to roam over that it took me nearly two hours to secure a picture of him.

There are few places where the inmates enjoy themselves more than they do in the enormous flying cage. This affair cost many thousands of dollars, and is so capacious that it allows almost perfect freedom within to quite a variety of species of birds, as pelicans, ducks, herons, ibises, gulls and not a few others. So big is this great cage that a large tree is enclosed within it, in which the night herons build groups of nests for their young. Pelicans fly up and down its length with ease, while others feed along the shore of the enclosed central pool.

We may now pass to a consideration of some of the departments that should form a part of the National Zoological Park, and be maintained at a constant and high state of efficiency. No one of these is more important than a prosectorial department, which should be under the direction of a prosector. He should have such assistants as are demanded to properly carry out the aims and purposes of the work to be performed. This consists in nothing more or less than the study of the anatomy of all the animals that die in the park, and, incidentally, as much as possible of their physiology while they live there.

In 1915 forty-one animals died and were lost to the collection of the park. What do we know of the anatomy and physiology of any of these animals? In some instances scarcely anything, in so far as their morphology is concerned, and still less of their physiology.

Connected with the above proposed prosectorial department there should be a library of anatomy and physiology and allied branches. When I say this I mean a library upon the anatomy of *all animals*, not simply upon the genus *Homo*, to which most of our American journals of anatomy are devoted, as though it were the alpha and omega of vertebrate morphology.

Then there should be a collection of specimens in the museum of this prosectorial department—skeletons and material in spirit for comparison. All this, and what else that is needed to complete such a department, should be quartered in a special and suitable building, amply large enough to meet all the demands of such research work. The entire system at the present time is both wasteful and unscientific, and a disgrace to a civilized nation commanding the finances there are at hand in the United States.

In addition to this prosectorial department there should be one entirely devoted to photography and other pictorial work. Here there should be another suitable building devoted to a photographic gallery and drafting rooms, fully equipped in every particular to photograph *scientifically* all the *new* animals that come

[1] Shufeldt, R. W., "The Laboratory of Comparative Pathology of the Zoological Society of Philadelphia," *Popular Science Monthly*, Vol. LXXXIV, No. 5, New York city, N. Y., May, 1914, pp. 507-513, Figs. 1-5.

Shufeldt, R. W., "Care and Exhibition of Animals in Zoological Gardens," *The Guide to Nature*, Vol. VII, No. 1, Sound Beach, Conn., June, 1914, pp. 13-15, Figs. 1 and 2.

into the collection. These photographs should be published in the semi-annual and illustrated report of the superintendent, in the best possible manner, and where photography cannot be well employed, a skillful artist should make hand drawings of the animals for the same volume or volumes. These drawings should be something after the order of those once made by a distinguished animal artist who visited the park at one time for the purpose, but not so idealized.[2]

There are many ways of adding to a zoological collection such as the one here being noticed, but space will not permit of my saying much about it. However, it may be pointed out that the consuls in foreign lands can often do a great deal in this direction, and our Government should not only call their attention to this matter, but it should fully extend to them the proper facilities for carrying it out. Then many living specimens may be brought home by animal collectors and duly deposited, but all this practically goes without the saying.

Coming to another point, it would seem to be highly desirable that, and after respectable entrances have been built, at least two days in the week should be set aside upon which gate money should be charged visitors to the park. This would bring in a good sum annually, adding at least something to the available finances for the park's maintenance, and having the effect of securing on those days a more select class of visitors.

Owing to the few day watchmen allowed by the Government, many of the rules governing a zoological garden are regularly violated. Personally, I have seen upon many occasions visitors giving candy, peanuts, bits of cake and other improper food to the animals through the bars or wiring of their cages. The result of this lack of proper guarding is very much to be deplored—to say the least.

Finally, I am of the opinion that one of the most objectionable features of this park is to allow it to be used at all seasons of the year as a playground for children, or a skating-rink and the like. It results in great damage to the grounds, the plants and the shrubs, to say nothing of the fact that guards are taken from other duties—from which they can not well be spared—and employed to watch the children in many localities on the grounds. Moreover, it throws a responsibility upon the authorities at the park in the event of accidents or drowning, which is not right from any view-point we may consider it. No one could be more in favor of ample and many public playgrounds for the city's children than I am, but a zoological garden is *not* the place for them. The Government should set aside other city areas for such purposes, in convenient localities and of ample proportions. These can then be properly policed and guarded as they should be, and given over entirely to the children for every sport they engage in.

[2] Seton, Ernest Thompson., "The National Zoo at Washington, a Study of Its Animals in Relation to Their Natural Environment," *The Century Magazine*, Vol. LIX, March, 1900; Vol. LX, May, 1900.

# Light and Illumination—II*

## A Survey of the History, Principles and Practice of Lighting

By Dr. Charles P. Steinmetz

Concluded from SCIENTIFIC AMERICAN SUPPLEMENT No. 2099, Page 194, March 25, 1916

IN RESPECT to the three metals mentioned, osmium proved very good as the illuminant in a lamp, but is too rare to be generally used. Tantalum gave good results, having a higher resistance than carbon, but has been superseded by tungsten because the melting point of the latter is much higher, and it can thus be run at a higher temperature, and it is now used in all lamps having metallic filaments. The so-called "Mazda" is a tungsten lamp. Since the tungsten lamp can be operated at a much higher temperature than any carbon lamp, a greater percentage of all the vibrations produced come within the visible three-quarter octave. The carbon lamp requires three watts per candle, while the tungsten lamp requires only one watt because with the carbon filament only three fourths per cent of the total vibrations are in the visible range, while with the tungsten burner we get about 2 per cent, or about three times the percentage.

Two per cent is, however, very little. Most of the vibrations are still outside the visible range, either too slow or too fast. So the further problem has been somehow to get a still higher operating temperature. In the carbon and tungsten lamps a vacuum has been used. Naturally the lamp having a carbon filament must at least be exhausted of air to prevent its combustion, but that is not the fundamental reason for the vacuum because the lamp bulb might be filled with a gas in which carbon will not burn, such as nitrogen, hydrogen, or argon. But to maintain the carbon filament in such a gas at the temperature it would have in a vacuum would require much more energy. By conduction and convection the gas will carry away a very large part of the energy supplied to the filament, which will be given up to the glass globe and dissipated uselessly, and therefore a much greater energy consumption is required, if the filament is to be maintained at the proper temperature. Without the extra supply of energy the filament would not attain a light-giving temperature. So the reason for the vacuum in incandescent lamps has been to avoid the enormous loss of energy through heat conduction and convection were the globe filled with a gas.

The use of a vacuum, however, is disadvantageous because it facilitates evaporation, and thus sets a lower and less efficient limit to the temperature to which in practice the filament should be raised, even though far below the melting or boiling point.

Now, the boiling point and rate of evaporation of water at other low temperatures depend upon the pressure. At ordinary atmospheric pressure water boils at 100 deg. Cent.; at higher pressure it will boil at higher temperature; and at lower pressure it boils at lower temperature. In a vacuum water may boil at the melting point of ice, and if the vacuum is excellent, no water will be present, the boiling point drops below the freezing point, and the ice passes directly into water vapor. If, likewise, in the incandescent lamp we can decrease the evaporation by lowering the boiling point, it follows that the vacuum is a disadvantage because, without the vacuum, evaporation and blackening would be very much less at the same temperature.

Now, suppose that instead of having a vacuum in a 100-watt tungsten lamp it is filled with inert gas, say, nitrogen at atmospheric pressure. To maintain the filament at the same temperature as before will require more energy because much of the heat is carried away by the gas, the pressure of which, however, will cause the evaporation to be much less, therefore the filament can be raised to a still higher temperature with an evaporation no greater than with a vacuum. The pressure has raised the boiling point and reduced the evaporation rate for equal temperatures.

Assume the evaporation in a vacuum to be such as to limit the life of the lamp to 1,000 hours at the temperature produced by 100 watts, then with nitrogen at atmospheric pressure we could use, say, 200 watts with the same rate of evaporation and blackening. But this would raise the temperature, so that while 100 watts will give 200 candles, 200 watts would give 600 candles, were it not that the nitrogen carries a lot of heat away from the filament. Consequently an additional 100 watts must be supplied to make up for this loss and raise the temperature sufficiently to give the 600 candles. In this way the candle power of the lamp has been increased from 200 candles with an expenditure of 100 watts to 600 candles for 300 watts with the same evaporation, blackening and life, which means an increase in efficiency over the vacuum lamp from one candle per watt to two candles per watt.

Now, suppose we take another lamp, say one requiring 20 watts with a vacuum. If filled with nitrogen, the temperature could be raised, probably not so high as to get six times as much light, because a 20-watt filament is so thin the evaporation that occurs, even at the lesser rate due to the pressure, would wear it away too fast. Furthermore, the percentage of energy lost through the gas is very much greater, because the surface of a thin filament in contact with the gas is much larger compared with its volume than in the large filaments of lamps of high candle power. Whether the loss of energy due to the gas will be more or less than the gain made by the higher temperature and higher efficiency depends upon the relation of surface to bulk of the filament. With a filament in the form of a closely wound helix, where there is a relatively small surface to carry away heat, the gain may be considerable. But with a straight filament of exceedingly small wire there may be only an insignificant gain, and even a loss. In the small "Mazda" lamp of 10 or 20 watts more would be lost than gained by filling the lamp with a gas. In the big units of 300 or 500 watts, very much more is gained than lost by using the gas. The gas filled lamp represents a compromise based on allowing a big loss by heat conduction and convection by the gas, which is more than compensated by the higher temperature permissible, because the rate of evaporation is kept down by the pressure of the gas.

All kinds of inert gases would not serve the purpose equally well. Other things being equal, obviously the gas having the lesser heat conducting and convecting capacity is the better. Thus nitrogen is much superior to hydrogen, and argon a little better than nitrogen. Therefore, while large lamps may be filled with nitrogen, in the smaller type of gas-filled lamps, say, 100-watt lamps, in which nitrogen would result in no appreciable gain, it pays to use argon.

In the gas-filled tungsten lamp, the efficiency is raised from the five watts per candle of the early carbon filament lamp of Edison to two candles per watt, an increase in the ratio of ten to one, due not only to the gas pressure keeping down the rate of evaporation and permitting a higher operating temperature, as before explained, but further to inherently different characteristics of the two materials, in that a greater proportion of all the vibrations emanating from tungsten, when at the same temperature as carbon, falls within the visible three-quarter octave. The radiations from tungsten in the "Mazda" lamp are thus to some extent favorably selective, compared with the radiations from the carbon filament.

True selective radiation was found out some years ago by Auer von Welsbach and utilized by him in greatly improving gas lighting. In investigating various elements he discovered that the rare oxides of some metals, as thorium and cerium, when heated to incandescence, give out much more light than materials in general, say, for example, carbon or platinum, at the same temperature. When platinum is heated to incandescence in a flame, it will emit visible radiations mainly in the yellow part of the spectrum. But place one of these rare oxides in the flame, and it will give a greenish-white light much stronger than the light from the platinum, and entirely beyond what would naturally be expected considering the temperature. Thus these materials have the curious property at flame temperatures of producing an abnormal number of vibrations of high frequencies falling within the visible three-quarter octave. Such oxides are in practice formed into a mantle, which is heated by a Bunsen flame, resulting in an increase of lighting efficiency much greater than is obtainable directly from gas. The high efficiency cannot be due to the temperature, because the temperature of a gas mantle is relatively low. The quality of the light corresponds in general to low temperature, and furthermore at no temperature could any merely radiating incandescent body give off just the same quality of light which these materials give. This was the first production of light not directly due to temperature but to some selective radiation, the nature of the materials resulting not in all kinds of vibrations, but more particularly in useful ones.

The question arises: Is it possible to gain the same advantage for the incandescent lamp that has been obtained in gas lighting from the Welsbach mantle by using some such selective material for the filament? This has been accomplished to some degree in the "Nernst" incandescent lamp, but the gain was insignificant compared to that obtained with the gas mantle. The reason is this: The temperature of a gas flame is comparatively low, consequently it alone gives little light. But by selective radiation or "luminescence," that is, light not directly dependent upon temperature effect, the added mantle at the same temperature gives, say, ten times as much light, thus increasing the efficiency ten times.

Now in the "Nernst" lamp the temperature is much higher than the gas flame, so that we obtain, say, twenty times as much light as from the gas flame. And since the mantle gives ten times as much light as the gas flame and the "Nernst" filament gives twenty times as much light as the gas, the increase in efficiency of the "Nernst" lamp, partly due to selective radiation and

* Presented at a joint meeting, Electrical Section, Western Society of Engineers, and Chicago Section, American Institute of Electrical Engineers, and reproduced from the *Journal* of the Western Society of Engineers.

partly to the higher temperature, is only 50 per cent. So the "Nernst" filament is more efficient than the carbon filament at the same temperature, but the increase is very small compared to the increase in the Welsbach mantle. The percentage of light added by luminescence in the "Nernst" filament is probably the same as that in the mantle, but the filament itself gives so much more light, due to the higher temperature alone, that eventually very little is gained. That is why the "Nernst" lamp did not show such a startling gain over the Welsbach mantle as compared with ordinary gas lighting, and further because it could not be heated to the increased temperature possible in the tantalum lamp and still higher temperature in the later tungsten lamp. The "Mazda" is much more efficient than the "Nernst" lamp, for while the "Nernst" lamp gains by higher luminescence, the tungsten lamp more than makes up for this by its higher temperature.

The only way to produce real selective vibration, corresponding with the note from the air column in an organ pipe, or from a violin string, is by causing vibration of the atom. But even here we get, not a single vibration, but a mixture of all the vibrations of which the atom is capable. Therefore it cannot be accomplished by means devised as one would build a piano, by an assemblage of wires of suitable lengths under proper tensions, because there are only a certain number of elements at command, and the atoms must be used as we find them, for we are powerless to modify them or their actions.

Solids and liquids are not available, because their atoms are so close together that they cannot vibrate freely. They may be compared to a heap of sand. While each grain, if separate, could send out its own vibrations and produce a separate color effect, in the heap all we get is a general sand color, a mixture of all those kinds of vibrations that are characteristic of sand particles. So a solid or a liquid can give no definite vibration of the spectrum, but only general vibrations of all kinds of frequencies, like the incandescent tungsten filament. Only the atoms of gas and vapor give spectrometric light.

Let us see which of the gases and vapors give a large percentage of visible rays. Atoms of the same material, for instance, mercury vapor, will give the same vibrations regardless of whether the temperature is high or low. With higher temperature the intensity will increase, but the frequency remains the same, just as with the violin string the note is the same whether the string is bowed heavily or lightly, only in the former case the intensity or volume of sound will be greater than in the latter, it will be louder. So with atoms of vapor, whether they be highly heated or not, whether a large or a small current is sent through them, they still keep the same frequency of vibrations, only more or less intense, and thus giving more or less light, although there will also be other vibrations too fast or too slow to come within the visible range.

In order to secure efficient lighting in this way, that is, by luminescence, we should select those chemical elements that happen to have a considerable percentage of their natural vibrations in the visible range. There are practically three of them: mercury, calcium and titanium. In mercury vapor the green colors predominate, in calcium the orange and red, and in titanium vapor the atomic vibrations have frequencies fairly well distributed over the whole visible range. With any one of them, under favorable conditions, as much as 20 per cent of the total radiation comes within the visible range, the three-quarter octave, which is several times more than can possibly be obtained from an incandescent body at any temperature, even at the temperature of the sun. There is, therefore, a possibility in this direction of an efficiency in lighting materially higher than is possible with incandescence.

This brings us to the final consideration of the question: What improvements are possible? Take the gas-filled "Mazda" lamp with which two candles per watt are obtained. Possibly the economy may be increased by going to a still higher temperature, close to the melting point of tungsten, and there is still quite a latitude permissible in this direction. It would mean higher gas pressure to keep the evaporation down, and a transparent globe of different composition than at present used because the gas would be very much hotter. Then the loss from heat conduction and convection under the greater gas pressure would be much increased. A better gas for the purpose than nitrogen might be used, perhaps argon. Possibly, an improvement up to three candles per watt could be obtained, but the prospect of any substantial gain is limited.

Another question is: Can we find a material, a metal, having a higher melting point than tungsten? Doubtless, it must be an element, because for chemical reasons the melting point of any compound of two materials must lie somewhere between that of either of the materials entering into it. For example, all tungsten compounds must necessarily have lower melting points than tungsten itself, all carbon compounds have lower melting points than carbon, and so on.

In conclusion, we may hope to increase the efficiency from two candles to three or four candles per watt by incandescence. In the case of the luminous spectrum produced by an electric current flowing through a gas or vapor there is no theoretical limitation because definite rates of vibration result. With the most efficient vapors, those of mercury, calcium or titanium, we can probably get something like eight to ten candles per watt under favorable conditions, an efficiency much higher than can ever properly be expected from incandescent radiation, but this is under the most favorable laboratory conditions, not as yet at all attainable in any arc lamp in commercial practice. It shows, however—and now we are considering theoretical possibilities—that within the range of luminescent lighting, exemplified in the vacuum tube, and in the luminous arc and flaming arc, there is no theoretical limitation of efficiency, while in incandescent lighting there is a limitation set by the unavoidable production of all kinds of vibration, of which the useful embrace only three quarters of an octave. By luminescence we may, as already stated, probably attain an efficiency of eight candles per watt, but should some new way of producing luminescence be discovered by which all the vibrations would have a frequency, say, between four hundred and six hundred millions of millions of cycles per second, about 50 candles per watt would be obtained. This can be done, because the firefly does it, but we do not yet know how he does it.

## Jupiter—The Solar King*

By George A. Russ

Could the ancient astronomer but view the starry hosts of heaven through the gigantic telescopes of to-days! How astonished he would be to penetrate into millions of miles of space and bring to view the wonders of the boundless sea, knowing that these objects are not, as he supposed, mere specks of light in the sky, but in reality other worlds, many of them giants compared to this little insignificant globe of ours.

And, like the ancient astronomer, many of us do not realize what wondrous things are those brilliant lights we see shining above us. For instance, take the planet Jupiter; what appears to us as a small speck of light is really one of the greatest wonders of the heavens. Its light is only inferior to that of the sun, and is so brilliant that it casts a shadow. This wonderful body is 483,000,000 miles, or over five times as far from the sun as the earth is, and its orbit is of such magnitude that its year is almost twelve of ours. Its rotary motion is so rapid that it is flattened at the poles and bulged at the equator, and if it were to rotate just a trifle faster it could not keep itself together, but would burst, and be spread broadcast on the skies like so much paint. The rapidity of its rotation is better understood when it is known that its year contains 10,455 days.

But as wonderful as these things are, they lack interest when the great size of Jupiter is taken into consideration. This monster of the heavens has a diameter of 88,000 miles, a circumference of 264,000 miles and a surface area of 23,232,000,000 square miles, or 121 times that of the earth; while its volume is 1,390 times and its mass 300 times that of our globe. In size it is second only to the sun, and easily dwarfs all the other planets put together; for were the whole of them combined in one mass, that mass would not weigh half as much as this colossal planet, and if it were cut up into 1,300 pieces, each piece would be larger than the earth.

Everything connected with Jupiter is so colossal that our utmost efforts fail to grasp a definite idea of the immense scale on which it is constructed. It is next to impossible to form an adequate idea of its great size by the use of figures as used in the science of astronomy. To grasp an idea of the dimensions of this huge planet we must compare it with something with which we are more or less familiar. To this end what will serve our purpose better than to increase, as it were, the size of our earth to that of Jupiter, for who is not familiar with the geography of our globe?

First, we find that the total area of our earth would be 22,232,000,000 square miles. Of this vast area 17,119,800,000 square miles would be occupied by the seas and oceans, leaving 6,292,000,000 square miles to be distributed among the continents, islands, etc.

The Pacific Ocean, the largest body of water on the globe, would cover an area of 6,734,860,000 square miles and the Challenger Deep, near the island of Gaum, the deepest depression of the earth's surface, would be 316,000 feet deep, while the Aldrich Deep, near New Zealand would be 309,500 feet deep and the Tuscarora Deep, east of Japan, would extend for 279,300 feet below the surface of the Pacific. A journey from San Francisco to Yokahama, Japan, would require a trip of 52,800 miles, and the fastest ocean liners would be considerably over three months in completing the voyage.

Asia, the largest continent, would stretch out over 2,029,291,000 square miles of territory, and the distance across this huge tract of land, from the Mediterranean Sea to Bering Strait, would be over 60,000 miles. Its coast line would be almost 355,000 miles in length, and if straightened out in a direct line would extend to the moon with 116,000 miles to spare.

China would have no fears of territorial aggression from Japan, as the little "Island Empire" would now be 19,602,000 square miles in extent, and there would be ample room for all the Japanese for hundreds of years to come. We find the Chinese Empire with an area of 512,435,000 square miles, while India would contribute 188,760,000 square miles to the 1,347,698,000 square miles that would go to make up the Empire of "John Bull."

Mt. Everest, the highest peak in Asia and the highest known point on the globe, would loom up a massive Sentinel, 319,000 feet in height, while many other summits of the Himalayas would exceed an altitude of over 60 miles.

Africa, with an area of 1,392,589,000 square miles, would be an interesting study indeed. We would find here some of the greatest rivers in the world, such as the Congo, 31,900 miles; the Niger, 28,600; Zambezi, 15,000, and the Nile, 37,900 miles in length. Here we would find the great Desert of Sahara, a barren waste of sand and rock, 242,000,000 miles in extent, while 14,000 miles to the south is the Victoria Nyanza, 3,218,600 square miles in area, and next to Lake Superior the largest body of fresh water on the globe.

Although the islands of the world would not offer us such comparisons as the continents, we may be interested to know that Borneo, the world's largest island, would have an area larger than Asia, Africa and North America combined, while Cuba would be a larger country than the United States, Mexico, Germany, Italy, France, Spain, Japan, Norway and Chili combined.

What a large, undeveloped body of land South America would be! Stretching a distance of 47,000 miles from Lake Maricabo to Cape Horn. Here we would find the lofty Andes, rising from the very seacoast, and extending the entire length of the continent with many of its peaks, such as Aconcagua, 238,690 feet; Sorata, 232,810 feet; Illimani, 211,500 feet; Sahama, 209,700, and Chimborazo, 206,960 feet in height, piercing the sky in all directions.

The largest river in the world, the mighty Amazon, rising in these mountains, would have a course 38,000 miles in length, with a drainage area of 302,500,000 square miles. Its width where it empties into the Atlantic would be over 2,000 miles, and the volume of water it discharges would be so great that the waters of the ocean would be freshened 500 miles from shore.

The great frozen land of the Midnight Sun would indeed be a barrier to all mankind, and no Polar expedition would ever be attempted amid the ice and snow as is now done. Greenland, the barren waste of ice and snow—the most absolute desert known in the world—would be 60,500 square miles in extent, and throughout this vast area, excepting a short strip near the coast, there would be no living thing, and in the interior, where the elevation would be 100,000 feet, the temperature, even in midsummer, remains, as now, below zero, and rain would never fall. The Great Muir Glacier of Alaska would rise 2,000 feet above the water, and extend 8,000 feet below, presenting a vast expanse of ice 700 miles long by 250 miles wide.

Our own country would be a country of "Magnificent Distances" and would, as now, contain some of the greatest natural wonders of the earth. A man traveling from New York to Chicago would grow weary of his 10,000-mile ride, while the 2,057-mile trip between Chicago and Rock Island would be quite an undertaking. Evanston would be located on an inland sea of 2,629,330 square miles, and would be 123 miles north of Chicago, while Milwaukee would be 850 miles away.

The Rocky Mountains would be 57,000 miles in length, and 37 of its peaks in Colorado alone would be more than 140,000 feet above sea level, while the lava deposits in our Western States would cover an area of 18,150,000 square miles.

The wonderful Yosemite Falls, which are famed the world over, would in one mighty leap make a descent of almost three miles.

The Mississippi-Missouri River with a length of 47,300 miles would drain 152,460,000 square miles of territory, and each year enough sediment would be poured from its mouth into the Gulf of Mexico to build a pyramid 121 miles square and 3,000 feet high.

As so many objects on this earth offer themselves for comparison, we could go on with our illustrations indefinitely, but enough has been said to give a fairly clear idea of the tremendous mass of matter contained in the greatest planet of the Solar System—Jupiter.

Rockford, Illinois.

* *Popular Astronomy.*

# Finding Your Way at Night Without a Compass*

## An Accomplishment Necessary for the Soldier, Explorer or Traveler

By Lieut.-Colonel W. A. Tilney, F.R.G.S., F.R.A.S.

WITH so much fighting now done at night, this art would appear to be most useful for soldiers to learn. The following is an account of its development and solution.

During the South African war I was often sent on long-distance night reconnaissances, and sometimes had Col. Benson, who led the attack at Magersfontein, as a companion. We noticed that the colonials, South Africans and natives were quite at home in the dark, whereas men from the British Isles were blind and helpless and lost their way when only a short distance from the column.

Col. Benson often told me about the attack at Magersfontein, and described the difficulties of a night attack when the operation depends on one man with a compass.

As an aeronaut in Ladysmith, I had plenty of opportunities of foreseeing the great power aeronautics would have in warfare in the future, and that most of the effective fighting would be done at night.

At that time the regulations described night operations as extremely hazardous, and warned the commander who undertook such operations that he did so at his own peril and was responsible for the results. Various expedients were suggested to enable the troops to keep their direction, such as that the route should be previously reconnoitered and marked by tins, pieces of paper and other devices; but how the reconnoitering party were to carry out this operation nobody has yet been able to understand. We found the colonials never required this artificial help, and could move about on a starlit night as easily as in daylight and as fast as the nature of the ground permitted, whereas our regulations laid it down that local guides should be procured, the route fixed by compass-bearing, and that the pace would rarely exceed two miles an hour.

With the whole operation dependent on the guide, and each individual blind and helpless in the dark, it is little wonder that the regulations described a night attack as extremely hazardous. We foresaw if only we could devise some simple method for finding our way at night, which could be easily learned by the rank and file of the army, it would have a far-reaching influence on night warfare. In 1903, on my return to England, I took up the problem of "How to make a simple and practical use of the heavens," and ascertained from various colonials, Basutos, Indians, and Arabs that they could instinctively read the heavens as a compass, this knowledge having been transmitted from father to son for generations.

My idea was to work out the exact movement and direction of the largest and most easily distinguishable lights in the heavens, so that the least educated had only to be able to recognize these signs by sight and their whereabouts would be known for every hour of the night. Thus, the dome of the heavens would be a compass.

In 1904 I went through a six months' course at the Royal Geographical Society, under Mr. Reeves, in the hope that we should be able to work out the positions of these various heavenly bodies, but found that the only means of doing so was by observation with a sextant or other instrument and the help of logarithms, etc.

Each observation and calculation took at least twenty minutes, so that to have made a calendar of the heavens by obervation was an absolute impossibility.

Some of the highest navigating authorities took a keen interest in the idea, and I am deeply indebted to Mr. Reeves, Captains Nansen, Scott, Armitage, Smith and Blackburn for the help they gave me.

It was not until 1907 that we were able to get star bearings mechanically with the help of an orthographic projection of a sphere. Mr. Reeves's astronomical compass originated from this method. In 1909 Capt. Blackburn, nautical adviser to the New Zealand government, sent me his A B C tables, and I then commenced to make a time table of direction stars for use in India. We found when the true bearing of various first magnitude stars was known, that it made all the difference to night operations; unfortunately we could arouse little official interest in the project, for anything to do with astronomy was considered too complicated for the average soldier.

However, in 1911 Capt. Weatherhead, naval instructor, Royal Navy, brought out a little book, with a foreword by Sir Robert Ball, in which he drew attention to the system I was then endeavoring to perfect, and, having received satisfactory reports from various cavalry regiments, I had every hope that the system would be of the utmost value to the army, if we could only get it well known before the European war cloud had burst. In 1912 it was amply proved that troops could march with ease, rapidity and precision on a starlit night, now that the largest stars were labeled in the heavens, and soldiers began to realize that the ability to make long-distance rapid night marches gave troops the power to strike an enemy from a distance, if necessary, across country, and that this system was an enormous improvement on old methods, especially in India and Egypt.

In June, 1913, being certain we were now on the straight road to overcome most of the difficulties connected with night operations, I made the double journey from Sialkot to Quetta to lecture to the Staff College, where I knew they would give the system a thorough good testing. The heat across the Sind Desert at this time of the year is terrible, and many of my friends warned me that such a journey at the hottest time of the year, with only four days' rest at Quetta, would tax the strongest constitution; but feeling sure that the great war was not far distant, and that in case of any trouble in India this new power to make rapid night marches *without the help of guide* would be of the utmost value, I made the journey.

Severe tests were carried out, and they reported: "We are perfectly certain that the system is a *most eminently sound one*," while the Indian Cavalry School reported: "The system has been tried at Saugor and has worked very well indeed. The students found no difficulty in determining the direction stars, and it is obvious that the faster the pace the truer is the direction." On my return to Sialkot, I realized that my friends' warning was true, and that unless I could get out of the heat I was done for. Fate decreed that I could not get home, and I almost died of heat stroke at Sialkot, so could not complete the tables for use in Europe till August, 1914, when Sir Douglas Haig wrote a foreword commending it to the notice of officers and men.

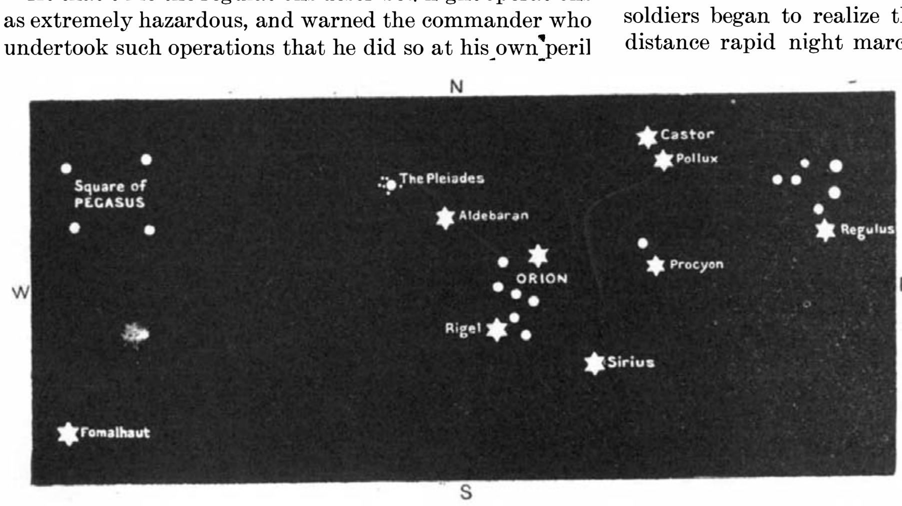



**Fig. 1.**

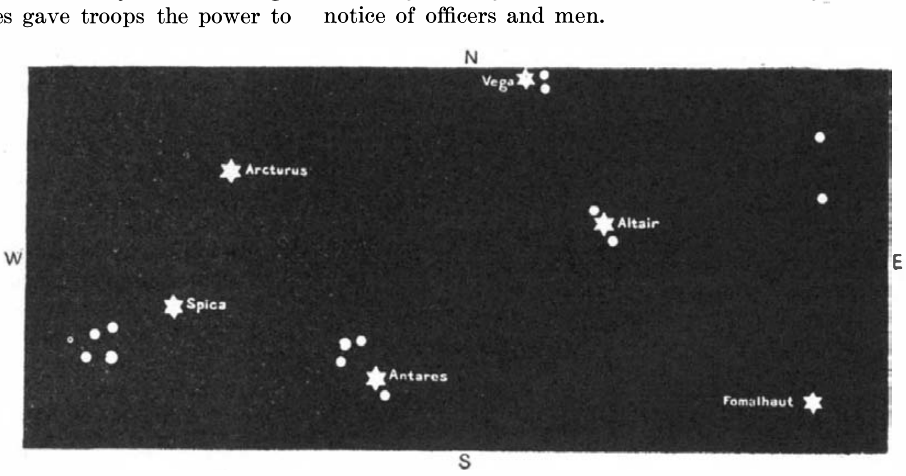



**Fig. 2.**

But it was too late, Armageddon had begun, and the work which I had hoped would be invaluable to the army in this crisis was of no avail. Many officers affirm it would have saved hundreds of lives and casualties had this natural method been known at the earlier stages of the war; so let us explain the system in a few words, and then see how it would have affected:

(*a*) The individual in open and trench warfare.

(*b*) Bodies of troops.

(*c*) How rapid night marches can be conducted with ease, rapidity and precision on a starlit night.

### THE SYSTEM.

Let us imagine fire balloons or beacons to be placed in the heavens north, east, south, west; it would then be easy enough to go in those directions. Similarly, if you wished to go, say, a hand's breadth, to the right or left of the beacons, you could easily do so. The stars mentioned in "Marching or Flying by Night Without a Compass" (published by Rees, 5 Regent Street, London, price 1*s*.) are the largest in the heavens and act as your fire balloons or beacons.

Now, if you put the front buttons of your coat on the North or other direction stars, your right and left breasts give you an angle of 45 degrees from the star and your shoulders a right angle. Also, it is only a matter of a little practice to be able to measure 15 degrees of horizon with your hand, so you can get any number of degrees to the right or left of your direction stars, and after a little practice it becomes second nature to recognize the points of the compass at sight, and you acquire the same sense of direction as bushmen, Arabs, and people who live far away from civilization.

The North Star, Altair, and Vega are all-sufficient night guides for the rank and file during the spring and summer. For autumn and winter, the North Star, the Sword and Belt of Orion, Procyon and Regulus.

### ITS INFLUENCE ON NIGHT OPERATIONS.

At the present moment almost every individual from the British Isles is blind and helpless at night.

Let us remove this helplessness and we shall:

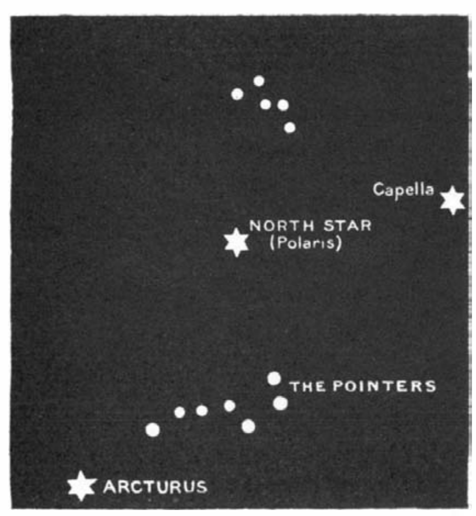
(1) Give him confidence and self-reliance when engaged in night operations.

(2) Give him a sense of direction, so that he will not fire or dig trenches in the wrong direction.

(3) Be able to send individuals on messages and all communications will be much facilitated.

(4) Slightly wounded men will not wander toward the enemy's lines.

(5) If we have to make an attack or retirement on a

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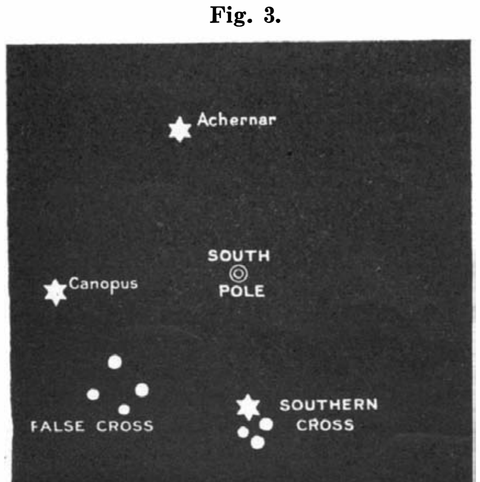


**Fig. 4.**

* A paper read before the Royal Society of Arts.

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First, we find that the total area of our earth would be 22,232,000,000 square miles. Of this vast area 17,119,-800,000 square miles would be occupied by the seas and oceans, leaving 6,292,000,000 square miles to be distributed among the continents, islands, etc.

The Pacific Ocean, the largest body of water on the globe, would cover an area of 6,734,860,000 square miles and the Challenger Deep, near the island of Gaum, the deepest depression of the earth's surface, would be 316,000 feet deep, while the Aldrich Deep, near New Zealand would be 309,500 feet deep and the Tuscarora Deep, east of Japan, would extend for 279,300 feet below the surface of the Pacific. A journey from San Francisco to Yokahama, Japan, would require a trip of 52,800 miles, and the fastest ocean liners would be considerably over three months in completing the voyage.

Asia, the largest continent, would stretch out over 2,029,291,000 square miles of territory, and the distance across this huge tract of land, from the Mediterranean Sea to Bering Strait, would be over 60,000 miles. Its coast line would be almost 355,000 miles in length, and if straightened out in a direct line would extend to the moon with 116,000 miles to spare.

China would have no fears of territorial aggression from Japan, as the little "Island Empire" would now be 19,602,000 square miles in extent, and there would be ample room for all the Japanese for hundreds of years to come. We find the Chinese Empire with an area of 512,435,000 square miles, while India would contribute 188,760,000 square miles to the 1,347,698,000 square miles that would go to make up the Empire of "John Bull."

Mt. Everest, the highest peak in Asia and the highest known point on the globe, would loom up a massive Sentinel, 319,000 feet in height, while many other summits of the Himalayas would exceed an altitude of over 60 miles.

Africa, with an area of 1,392,589,000 square miles, would be an interesting study indeed. We would find here some of the greatest rivers in the world, such as the Congo, 31,900 miles; the Niger, 28,600; Zambezi, 15,000, and the Nile, 37,900 miles in length. Here we would find the great Desert of Sahara, a barren waste of sand and rock, 242,000,000 miles in extent, while 14,000 miles to the south is the Victoria Nyanza, 3,218,600 square miles in area, and next to Lake Superior the largest body of fresh water on the globe.

Although the islands of the world would not offer us such comparisons as the continents, we may be interested to know that Borneo, the world's largest island, would have an area larger than Asia, Africa and North America combined, while Cuba would be a larger country than the United States, Mexico, Germany, Italy, France, Spain, Japan, Norway and Chili combined.

What a large, undeveloped body of land South America would be! Stretching a distance of 47,000 miles from Lake Maricabo to Cape Horn. Here we would find the lofty Andes, rising from the very seacoast, and extending the entire length of the continent with many of its peaks, such as Aconcagua, 238,690 feet; Sorata, 232,810 feet; Illimani, 211,500 feet; Sahama, 209,700, and Chimborazo, 206,960 feet in height, piercing the sky in all directions.

The largest river in the world, the mighty Amazon, rising in these mountains, would have a course 38,000 miles in length, with a drainage area of 302,500,000 square miles. Its width where it empties into the Atlantic would be over 2,000 miles, and the volume of water it discharges would be so great that the waters of the ocean would be freshened 500 miles from shore.

The great frozen land of the Midnight Sun would indeed be a barrier to all mankind, and no Polar expedition would ever be attempted amid the ice and snow as is now done. Greenland, the barren waste of ice and snow—the most absolute desert known in the world—would be 60,500 square miles in extent, and throughout this vast area, excepting a short strip near the coast, there would be no living thing, and in the interior, where the elevation would be 100,000 feet, the temperature, even in midsummer, remains, as now, below zero, and rain would never fall. The Great Muir Glacier of Alaska would rise 2,000 feet above the water, and extend 8,000 feet below, presenting a vast expanse of ice 700 miles long by 250 miles wide.

Our own country would be a country of "Magnificent Distances" and would, as now, contain some of the greatest natural wonders of the earth. A man traveling from New York to Chicago would grow weary of his 10,000-mile ride, while the 2,057-mile trip between Chicago and Rock Island would be quite an undertaking. Evanston would be located on an inland sea of 2,629,330 square miles, and would be 123 miles north of Chicago, while Milwaukee would be 850 miles away.

The Rocky Mountains would be 57,000 miles in length, and 37 of its peaks in Colorado alone would be more than 140,000 feet above sea level, while the lava deposits in our Western States would cover an area of 18,150,000 square miles.

The wonderful Yosemite Falls, which are famed the world over, would in one mighty leap make a descent of almost three miles.

The Mississippi-Missouri River with a length of 47,300 miles would drain 152,460,000 square miles of territory, and year enough sediment would be poured from its mouth into the Gulf of Mexico to build a pyramid 121 miles square and 3,000 feet high.

As so many objects on this earth offer themselves for comparison, we could go on with our illustrations indefinitely, but enough has been said to give a fairly clear idea of the tremendous mass of matter contained in the greatest planet of the Solar System—Jupiter.

Rockford, Illinois.

* *Popular Astronomy.*

true bearings and obviates the necessity to draw out the star-bearing and direction lines, as above described.

When no stars are visible, it enables you to proceed on true bearings as fast as the nature of the country permits.

So we have conquered most of the difficulties connected with night operations and, as Sir Douglas Haig says, the method has been tested and found successful. Another well-known authority remarks: "The system is exceedingly useful because it is so simple, and is just what was wanted in the army when so much fighting is done at night; it will be of the greatest service to others besides soldiers."

If these predictions are fulfilled, and it proves to be a real service to the army in this great crisis, those who have helped to perfect the system will be more than well rewarded.

# Flame Standards in Photometery*

## Conditions to Be Met and Facts Relating to Lamps Used

The need of a reliable standard to serve as a basis for the measurement of light has long been recognized, and in attempts to meet this need much ingenuity has been applied and a tremendous amount of labor has been expended. No standard yet produced has, however, shown such evident superiority as to obtain general acceptance. In France, Germany, and England different forms of flame standards have been recognized as primary standards, but no one of them has been considered entirely satisfactory.

In France the Carcel lamp, invented about 1800, was raised to the dignity of a standard largely as a result of its use as a convenient comparison lamp by Fresnel, although definite directions for its use were not published until 1862, and even those directions have had to be radically modified in recent years.[1] The later prestige of the lamp arose from the fact that Biolle practically defined his unit in terms of the Carcel, and in default of a reproduction of the Violle platinum standard, the French unit (the bougie décimale) adopted by the International Electrical Congress of 1889, was in practice maintained by the Carcel lamp, the candlepower of which was taken as 9.62 bougies décimales.

The Hefner lamp was proposed by von Hefner-Alteneck in 1884 and rapidly displaced the candles previously used in Germany. In 1893 the Physikalisch-Technische Reichsanstalt began to certify lamps of this type, and in 1895 the present German unit, called at first the Hefnerlicht and later the Hefnerkerze, was defined as the intensity of a Hefner lamp under certain atmospheric conditions.

The Harcourt 10-cp. pentane lamp, the final product of a series of pentane lamps devised by Vernon Harcourt and others, was adopted in 1898 for all tests made under the direction of the Metropolitan Gas Referees of London. Since some doubt existed regarding the reproducibility of the lamps, the Engineering Standards Committee defined its unit of candlepower as one tenth of the candlepower under standard conditions of a particular lamp kept at the National Physical Laboratory.

The defects of such standards are illustrated by the fact that for years after the three types were adopted in the respective countries there remained a considerable margin of uncertainty as to the relative numerical values of the three units. Several direct intercomparisons of the flame standards gave more or less discordant results, and no definite agreement was reached until a comparison of the units actually used in each of the national standardizing laboratories was obtained through measurements of groups of seasoned electric incandescent lamps carried from one laboratory to another. These measurements showed that within the limits of experimental error the units in use in France and in England were equal, while the Hefnerkerze was 0.9 as large as the others; and this simplicity of ratios made possible the agreement which has reduced the units of light to two, namely, the Hefnerkerze and the international candle of England, France, and America.[2]

The light unit of the Bureau of Standards has always been maintained by groups of electric lamps, because it has been believed that the unit once agreed upon could be so maintained with an accuracy considerably above that with which it could be reproduced by reference to any of the so-called reproducible standards at present in use. In other words, the incandescent lamps have really been employed as primary standards and the flame standards, which logically should play the part of primary standards, have been relegated to a subordinate position. For example, a given pentane lamp is not assumed to give 10 candles, but is compared with the electric standards and is assigned a value as a result of the comparison.

Although the electric lamps are very satisfactory as secondary standards, and although as empirical primary standards they may serve to maintain the unit of light constant for many years, yet there is a possibility of an appreciable drift in the value of the unit occurring sooner or later, if there is no photometric standard accurately reproducible from its specifications which is capable of serving as a reliable check upon the electric standards. Consequently, while the present unit may be considered as definitely and permanently adopted, there is need of a reproducible standard to preserve the value of that unit unchanged. There have been proposed several possible methods of constructing such standards which would be more rational than the essentially crude flame standards, but not one of them has yet been developed to a sufficient extent to be of any use as a permanent custodian of the unit, and none gives much promise of being able to supplant the flame lamps in the immediate future. It has, therefore, appeared worth while to make a study of the best types of flame lamps to see how closely they would reproduce in our laboratory the values adopted by international agreement and also to find whether their reliability as primary standards could be increased by any changes in construction or in operation.

Another reason for improving flame standards is their extensive use in gas photometry, to which they are in some respects better adapted than electric standards. At the suggestion of representatives of the gas industry, the Bureau of Standards some years ago took up the study of some of the more important flame standards with the hope of improving current practice in gas testing in American cities. We may anticipate our conclusion by saying that for such use the pentane lamp has appeared far superior to any of the others, and the results of the Bureau's experience have been incorporated in a special paper[3] for the guidance of those who may have occasion to use that form of lamp.

The present paper is intended to give some of the details of the experimental work done on lamps of various types which have found a more or less extensive use. The most important are the three primary flame standards mentioned above, and the modified form of the pentane lamp which is widely used in the United States, and only these four forms will be considered.

In any flame standard the lamp itself is not the standard but, along with the fuel and the air, it constitutes a means for producing the actual standard, the flame. In considering the property of reproducibility we have, therefore, to interpret the word in a double sense; we must consider the possibility of producing different lamps and different lots of fuel which are sufficiently like each other to give sensibly the same candlepower, and we must also take into account the exactness with which a given lamp can be made to reproduce the intensity of its flame at different times. In a secondary standard the second consideration is the one of chief importance. In a primary standard a high degree of reproducibility of this second kind is desirable but is not really indispensable provided the departures from normal value are not systematic; the property of first importance is the reproducibility of the lamp and the fuel

The excellent performance of the electric lamps makes it possible to test very accurately the qualities of various lamps, for we can not only measure the lamps from day to day and compare various lamps with each other with the certainty that the basis of comparison remains constant, but we can also determine whether lamps of each type give the same intensity as is found in other laboratories, and hence can form an opinion as to the possibility of an independent reproduction of the unit.

Besides the lamp and the fuel the third factor, the air, must be considered, for it affects the intensity of the flame very markedly. Oxygen is supplied by the atmospheric air drawn into the flame. With the oxygen go nitrogen, carbon dioxide, and water vapor, which are not needed for combustion and which cool the flame and reduce its intensity. If the air supplied to the flame varies in its composition, the rate of combustion is altered and the cooling effect of the inert gases varies. Fortunately the proportions of oxygen, nitrogen, and carbon dioxide in the open air are remarkably constant and are sensibly the same in different places, so that it is not difficult to obtain standard conditions in this respect if the photometer room has provision for a liberal continuous supply of fresh air.

The barometric pressure and the proportion of water vapor in the air are, however, variable, and it is not easy to control the variations so as to obtain normal conditions. Consequently, in order to determine the normal value of a flame standard, it is usually necessary to apply corrections for the departure of these two conditions from normal.

A possible explanation of the large differences between results obtained in different laboratories may be found in a direct effect of temperature on the candlepower. Changes of temperature and of humidity are closely related; the so-called humidity correction might really represent the combined effects of moisture and temperature changes. The relative variation of the two elements is probably not the same in different laboratories; for example, measurements made at the Bureau include a larger range of humidity than do those made at the National Physical Laboratory, while the range of indoor temperatures is probably about the same in the two laboratories, the average temperature at the Bureau being higher. We have not, however, been able to obtain any definite indication that changes of temperature within the usual laboratory range affect the candlepower of either the Hefner or the pentane lamp, and both Paterson and Butterfield, Haldane and Trotter have concluded that they do not affect the pentane lamp. It, therefore, appears unlikely that temperature effects will afford a solution of the difficulty.

It is perhaps worth noting that in case of insufficient ventilation there is a connection also between the humidity and the vitiation of the air, since the processes which exhaust the oxygen of the air usually produce considerable quantities of water vapor. If the arrangements are such that the thoroughness of the ventilation varies, there will be some tendency for the coincidence of high humidities with poor ventilation, for whenever the ventilation becomes insufficient the water vapor produced by the lamps and observers will increase the humidity. In a room where the flow of air depends on difference of temperature between indoor and outdoor air, still more serious effects might be produced by a systematic difference in the flow, which would probably be less in summer, and, if so, would tend to give fictitiously large values for the humidity effect. The room in which the present work has been done is supplied with air by a system of forced ventilation, assuring a flow independent of weather conditions. It was considered desirable to remove immediately from the room the air which rises about the lamp, carrying with it products of combustion, and this was accomplished by placing a hood above the lamp with a pipe leading to a ventilating outlet. That the ventilation was sufficiently good is shown by the fact that lamps burned continuously for several hours showed no decrease in intensity, and that a complete change of the air (obtained by placing a fan in an open window and blowing outdoor air through the room), caused no perceptible increase of candlepower.

### THE CARCEL LAMP.

In the discussion of correction coefficients no mention has been made of the Carcel lamp, because its performance is so erratic that no one has been able to determine any of its coefficients. Very few measurements on the lamp have been made at the Bureau, but those made have confirmed the conclusions reached by other observers in that the lamp never does reach a steady state, the intensity in different directions and with different chimneys varies considerably, shifting the chimney up or down a small distance often changes the candlepower by several per cent, and the departure of any one measurement from the mean value of the lamp is likely to exceed 2 per cent when the utmost care is taken to reproduce the conditions of burning. While the mean candlepower obtained happened to fall very near the normal value (9.62 international candles), no confidence could be felt in any value so determined, and it appeared useless to spend more time on the lamp.

### THE HEFNER LAMP.

The Hefner lamp has had a long and honorable career. Although it has some serious defects and requires much patience and skill and many observations to obtain accurate results, it nevertheless has some important merits. It if had not, it would not now be contesting for first place among primary flame standards, after the world has had more than a quarter of a century in which to replace it by a better one.

Its principal merits as a primary standard are its simplicity of construction and operation, ease of manipulation, portability, durability, and the excellent agreement of one lamp with another. Its defects are its small

*Abstracts from Scientific Paper No. 222 of the Bureau of Standards, by E. B. Rosa and E. C. Crittenden. This paper is a revision of one published in the *Transactions* of the Illuminating Engineering Society (Vol. 5, pp. 753–778; 1910), under the title "Report of progress on flame standards." More recent developments have not materially changed the conclusions then stated, and the present paper differs from the original in form more than in substance. Many additional measurements have been made, covering in all about 80 pentane lamps, but so far as the purposes of this paper are concerned the older data show the performance of the lamps as well as the newer results would.

[1] J. Gas Lighting, 99, p. 234; 1907.

[2] Circular of the Bureau of Standards, No. 15, on the "International unit of light."

[3] The Pentane Lamp as a Working Standard, this *Bulletin*, 10 pp. 391–415; 1913.

intensity, unstable flame, reddish color, and the difficulty of setting the flame at exactly the right height. For either a primary or a scondary standard these, it must be admitted, are serious objections.

The Reichsanstalt certifies Hefner lamps as correct if within 2 per cent of their standard. At the Bureau of Standards we have eight Hefner lamps—four made by one company and four by another—and all fall within this limit. Indeed, the maximum departure of any lamp from the mean of all is scarcely more than 1 per cent. However, a primary photometric standard is not entirely satisfactory so long as appreciable differences exist among a lot of lamps made to the same specifications. Accidental errors will, of course, occur in the measurements, but of these eight Hefner lamps, certain ones are regularly high and others regularly low, showing that the lamps are not as nearly identical in construction as they should be. This result is due to two things. In the first place, the specifications are not as precise as they should be, and in the second place there are in some lamps slight departures from the specifications. That the intensity of the flame may always be the same—under the same atmospheric conditions—it is necessary (1) that the fuel be uniform, (2) that the wick tube shall always be of the same material and dimensions, and (3) that the height of flame be constant. In comparing lamps, the same fuel and the same kind of wick are used in the different lamps, and comparisons are made with the same apparatus and practically in the same atmosphere, as they are used in succession by the method of substitution. Hence, the differences observed are due (1) to differences in flame height or (2) to differences in the effect of the wick tubes on the size or temperature of the flame.

The wick tube affects the flame in several ways. The bore should be 8 millimeters exactly, and this determines to some extent the size of the flame. This dimension is very accurately met in all the lamps. The thickness of the tube is specified to be from 0.14 to 0.17 mm. The tube conducts heat down to the liquid amyl acetate which saturates the wick, the top of which is from 1 to 3 mm. below the top of the tube, but it also conducts heat on down to the body of the lamp and dissipates more from its surface. The thicker the tube the more readily is the heat conducted, and hence with the thicker tube the top of the wick must be higher in the tube to give the correct flame height. Also, the thicker-walled tube cools the flame more, and, therefore, reduces its candlepower. Hence, the wick tube should be very accurately specified to insure reproducibility. A departure of one or two hundredths of a millimeter from the mean in the thickness of the wall of the wick tube might seem negligible, but its effect is not negligible. To insure strict reproducibility, the weight of the tube should be specified in addition to its bore and its length; the composition of the German silver of which the tube is made ought also to be specified, to insure uniform results. There is reason to believe that if the specifications were drawn closer and the construction were as exact as it might be, a considerable improvement in the reproducibility would result.

The fuel, amyl acetate ($C_7H_{14}O_2$), is readily obtained pure enough to satisfy the specifications. We have, however, received from a reputable chemical firm amyl acetate which was guaranteed by them to be pure, which did not conform to the specifications, and which gave a flame of slightly different intensity from amyl acetate fulfilling the specifications. Hence, the only safe way in precise work is to test the fuel before using it, or purchase only amyl acetate that has been tested with reference to its use in the Hefner lamp.

The flame height specified in the Hefner lamp is 40 mm., at which height it gives nine tenths of an international candle. An extended study has been made of the amyl-acetate lamps when burning at a flame height of 45 mm., at which height they give one international candle; at least those with Krüss sights give, on an average, one international candle. Taking the mean of all, the height should be about 45.25 mm. It is believed, however, that when the wick tube is more accurately specified, and the Krüss sights alone are employed, a flame height of 45.0 mm. will give very accurately one international candle.

There is no appreciable temperature-light coefficient to the Hefner lamp between the limits of temperature that are commonly employed. It is, however, steadier at from 15 deg. to 20 deg. Cent. than at higher temperatures. Hence, for work of highest precision a comparatively narrow range of temperature might well be specified.

### THE PENTANE LAMP.

The Harcourt pentane lamp presents a striking contrast to the Hefner. It is bulky, relatively complicated in construction, less portable, and less convenient in manipulation, more expensive in first cost and in fuel, and requires much better ventilation and a larger photometer room. On the other hand, its higher candlepower, steadier flame, and better color are very great advantages. As to reproducibility, it is easier to reproduce results with a given pentane lamp than with a Hefner lamp when both are operated under correct conditions, but there is a greater difference among different pentane lamps than among different Hefners.

No wick is used in the pentane lamp. The fuel (pentane, $C_5H_{12}$), is contained in an elevated reservoir or saturator. Air enters the inlet and mixes with the vapor of pentane as it passes over the liquid pentane through the maze into which the saturator is divided by vertical vanes, and this mixture flows down the supply pipe to the burner. In hot weather the pentane may evaporate so rapidly as to flow out through the inlet, and thus prevent the air from entering. In this case, only pentane vapor is fed to the flame. Air, heated by passing through the annular space between the inner and outer chimney, flows down through the hollow standard and into the central chamber below the burner. Thus the flame resulting from the combustion of the vapor of pentane as it issues from the ring of 30 holes in the steatite burner, is fed with prehated air within the flame, while it takes atmospheric air directly through its outer surface. The length of flame used is determined by the distance between the burner and the chimney, which is adjusted to be 47 mm. when cold, and the height of flame is controlled by the rate of supply of the fuel. The latter is regulated by a stopcock. The tip of the flame is viewed through a mica window in the lower end of the inner chimney, and must be watched and frequently regulated in work of the highest precision. When the flame is at the correct height its candlepower is a maximum. As in the case of the Hefner, the intensity of the flame depends upon the dimensions of the lamp, the composition of the fuel, the atmosphere in which it is burned, and the manipulation of the lamp, especially as regards regulating the flame height and screening the flame.

The specifications of the standard pentane lamp were carefully drawn, and have been closely followed by the several makers of the lamps, with, however, some variations in the American lamps. But that the specifications are not sufficiently exact and complete is shown by the fact that different lamps differ in candlepower appreciably. That is, different pentane lamps burning the same fuel, in the same atmosphere and operated by the same people, differ by as much as 2 or 3 per cent, quite independently of the errors of observation. It is not possible, therefore, to take the light of a pentane lamp as 10 international candles under the stated standard conditions. It may in any particular case be only 9.6 or 9.8 candles at standard humidity and barometric pressure, even when the fuel and all external conditions are right.

The total intensity of the light of the flame depends, of course, on its dimensions, and this is affected by the size of the burner. The specifications say that there shall be 30 holes (from 1.25 to 1.5 mm. in diameter), drilled in a circle in the steatite burner, the outside and inside diameter of which are 24 mm. and 14 mm., respectively. But the precise diameter of the ring of holes is not specified, and this is found to vary in different burners.

Of the three English lamps for which values are given in this paper all fulfill the specifications regarding burners, and all have the individual holes about the same size (1.35 mm. in diameter), but in the one which gave the low candlepower the diameter of the circle of holes was 2 per cent smaller than in the others. This was thought to be a possible explanation of the low value, but it has since been found that the effect on the candlepower does not exceed 0.5 per cent. A series of interchangeable burners, in which the variations were made even greater than the specifications permit, have been tested. In these the outer diameter of the circle of holes varies by 4 per cent, and the different burners have holes ranging from 1.1 mm. to 1.5 mm. in diameter; the combined effect of variation in holes and in size of circle is only about 1 per cent in candlepower. The reason that this effect is so small is probably to be found in the fact that the pressure on the vapor is very small, and the flow from the holes is so gentle that the vapor spreads so as to cover the whole top of the burner. Consequently, the size of the flame is determined more by the size and shape of the top of the burner than by the dimensions and location of the holes in it. Still, a closer specification of the latter would remove a source of small differences between lamps.

It is well known that a pentane lamp increases in candlepower for a time after lighting up, and that one should wait from 15 to 30 minutes before taking measurements. Four curves taken during the heating-up period of the lamp, show that the light increases to a maximum and then decreases to its steady value. This maximum is from 1.5 to 3 per cent above the final value, which is reached in from 15 to 30 minutes. The first two curves are for English lamps, which reach a steady condition in half the time required by the early American lamps whose performance is shown in the lower curves. These American lamps were of the type first made in this country, which had lower candlepowers than most English lamps, and the study of these heating curves led to the discovery of one cause of the low candlepower. The form of curves indicates the presence of two opposing influences, one tending to make the candlepower high and the other, which becomes effective a little later, tending to lower the candlepower. In the American lamp this second effect is greater than in the English form. These two opposing influences are simply the temperatures of the two columns which constitute the circulatory air system of the lamp. The chimney becomes hot first and a vigorous circulation is set up, making a strong draft up through the burner and thus broadening the flame. As the lamp standard, through which the air flows down, becomes warmer, the temperature difference of the two columns is less; the circulation is less vigorous, and the flame becomes slightly narrower.

Beneath the saturator is a flat radiating plate, which in the English lamps is brazed to the standard and serves to conduct heat away, thus keeping down the temperature of the down-flowing air. In the early American lamps this plate was considered primarily as a support for the saturator, and it was connected to the standard only by two bands. It, therefore, failed to function properly as a radiator of heat; the standard became too warm, so that the air flow was decreased and the candlepower lowered. Experimental tests showed that the substitution of a brazed plate for the loose one increased the candlepower by about 1 per cent, while freeing the plate from the standard, even without removing it entirely from the lamp, caused a reduction of the candlepower. In one case, the same American lamp gave 9.63 candles when the plate was not in contact with the standard and 9.75 in the regular condition. This suggests the possibility of an appreciable variation being introduced by accidental change of the contact between the plate and the standard. For this reason, as well as to bring the lamps nearer 10 candles, the brazed plate should be used.

Another detail of construction which makes a measurable difference in the same way is the connection between the bottom of the chimney and the standard. This should be of non-conducting material, but in the first American lamps it was made of metal, which conducted heat across to the standard and thereby reduced the candlepower. When these two faults of construction are remedied, as they have been in more recent lamps, the American form will reach a steady state in about 20 minutes after lighting. The newer lamps also give higher candlepowers than those shown in this paper.

By interchanging parts so far as possible, evidence has been obtained that the discrepancy between the English lamps studied is largely due to some difference in the air system, but, unfortunately for this work, the lamps are not intended to be taken apart and the parts are not interchangeable in general. Consequently the exact cause of the difference has not been found.

The candlepower of a pentane lamp can be appreciably increased by any method of cooling the standard. Even the introduction of a screen to cut off the radiation of heat from the flame to the standard makes a perceptible difference, and drafts of air blowing over the lamp probably porduce more effect through the disturbance of temperature conditions than by disturbing the flame directly. Precautions should, therefore, be taken to obtain a gentle and regular flow of air past the lamp when it is in use.

There is one feature which tends to make the American lamp higher in candlepower than the English form. This is the method of supporting the inner chimney. The chimney is set, when cold, 47 mm. above the burner, but the expansion on heating reduces the height. Since the chimney is supported near the bottom in the American lamp and at the top in the English, the reduction in height is less in the former type. The actual height when the lamps are burning has been found to be 46.7 mm. in one American lamp and 45.9, 45.8, and 45.7 mm., respectively, in three English lamps. Incidentally these variations suggest that if the lamp is to be a primary standard some better method of fixing the height is necessary.

Although many lamps of English and of American manufacture have been tested, none of them except a few very recent American lamps have shown a candlepower as high as that of the standard pentane lamp of the National Physical Laboratory. The maker of that lamp, from whom the bureau purchased two lamps, was unable to duplicate it exactly as to candlepower.

One of the difficult features of the use of pentane lamps is the fuel. In addition to the inconvenience of pentane being very volatile and explosive, its composition is variable, and as sometimes supplied does not conform to specifications. It is distilled from gasoline, its composition being made nearly uniform by repeated distillation. Besides the great difficulty in separating all the butanes ($C_4H_{10}$) and all the hexanes ($C_6H_{14}$), pentane itself ($C_5H_{12}$) exists in three separate forms, which have different boiling points. Two of these come within the range of temperature used in the final distillation, and in addition the distillation carries over more or less of

the substances which have higher boiling points. Hence, if pentane which complies strictly with the specifications be distilled it may be separated into three portions of appreciably different boiling points. This fractionation goes on in the saturator, and the photogenic value of the pentane changes to an appreciable extent in a few hours. The official specifications of the London Gas Referees direct that the residual pentane be emptied out of the saturator at least once in each calendar month. For work of the highest precision the authors find that it is desirable to do this every time the lamp is refilled and that this refilling be done frequently, not waiting until the pentane is nearly exhausted. This requires the rejection of a considerable fraction.

But while the value of a given lamp can be determined with so little uncertainty, the difference between lamps are very considerable. It is recognized in England that different pentane lamps differ in candlepower, so that the standard of the National Physical Laboratory is not that of any pentane lamp taken at random, nor the mean value of a group of lamps, but a particular pentane lamp. It remains to learn how to make different lamps agree as closely as a particular lamp will agree with itself.

CONCLUSION.

While much remains to be done on the pentane lamp to make it a thoroughly satisfactory flame standard, the authors believe that a much closer agreement between different lamps, and a little higher degree of reproducibility in the same lamp, is possible. For use as a practical standard in photometric measurements, and for use as a primary standard for fixing the unit of light, the same lamp should not be employed, and the specifications should be appreciably different. One would not think of employing an ordinary meter bar for a primary standard of length, or of using an ordinary precision resistance box for the reference standards of a national standardizing institution. No more should one think of using a pentane lamp that is not too good for a gas works or for ordinary photometric practice as a primary standard for fixing and maintaining the unit of light. There should be as much difference here as in other physical standards. Vernon Harcourt has rendered a great service to photometry and to the industries in developing his various pentane lamps, and the authors can not refrain from expressing their admiration for the thoroughness with which he worked in the pioneer days of precise photometry. His lamp has stood the test of use, and after years of criticism it remains the most practical flame standard we have. Nevertheless, the results of this study indicate that, at least as made at present, the pentane lamp can not be considered as a reproducible primary standard, its value in this respect being decidedly less than that of the Hefner lamp. If the principles of the present lamp are to be applied to the development of a primary standard, further improvement is necessary, not only in the construction of the lamp, but in its use as well. Instead of using the ordinary style of lamp, at any temperature and any humidity, with the pentane that satisfies ordinary requirements, there should be a lamp (or several lamps), built to very exact specifications, operated within very narrow limits of temperature and humidity, with pentane satisfying much more rigorous requirements as to density and boiling point, and an atmosphere maintained constant as to oxygen content with great care. With such painstaking procedure the unit of light can be fixed with either the Hefner or the pentane lamp with very considerable precision, sufficient at least to serve as a valuable check on the admirable electric standards now in use. It is with a view of contributing something to the working out of such precise specifications that the work of investigation at the Bureau will be continued.

## Sources and Collection of Rubber

In addition to the large quantity of rubber which is collected by natives from trees in the wild state, much is secured from plantations where rubber-bearing trees are cultivated according to scientific principles. This is generally known as "plantation rubber."

The principal rubber producing trees, the countries where they are most abundant, and the commercial names of the rubber they produce are as follows:

Hevea: Para rubber. Brazil, Peru, Bolivia.

Micandra: Mixed with Para. Brazil.

Manihot: Manicoba or Ceara. Brazil.

Castilloa: Caucho. Central America, Mexico, Brazil.

Ficus: Assam, Rangoon, Java, Penang. Found principally in southeastern Asia.

Funtumia: Gold Coast Lumps, Ivory Coast Lumps, Congo, Cameroon. Eastern and Central Africa.

Landolphia: Congo, Red and Black Kassi. Eastern and Central Africa.

Hancornia: Mangabeira. Brazil.

Under the heading of industrial rubbers is included crude rubber available in commercial quantities, where the percentage of rubber is small compared with the impurities present. In such cases a process of purification is necessary before the rubber is ready for manufacturing purposes. Only two are of sufficient importance to warrant mention, viz:

Dyera Costulata: Jelutong or Pontianak. Occurs principally in Java.

Parthenium Argentatum: Guayule. Mexico.

The most important wild rubber, both in quality and quantity produced, is the Hevea, from which is obtained the Para rubber. It is found in Brazil, Peru, and Bolivia.

Taking into consideration all the wild rubbers, Brazil is the most important rubber-producing country. Of lesser importance may be mentioned Central America, Mexico, Central and East Africa, Malaya, and Java.

The most striking phase of the crude rubber situation to-day is the tremendous growth of the plantation industry. The first experiments were started nearly 40 years ago, but it is only in the past 10 years that the cultivated rubber has become of commercial importance. In this short time the production of plantation rubber has grown from practically nothing until it is equal to that of the wild rubbers. Some idea of this growth may be gathered from the following table, which gives the production of plantation rubber in Ceylon alone:

CEYLON PLANTATION RUBBER.

| YEAR. | TONS. | YEAR. | TONS. |
|---|---|---|---|
| 1903 | 19 | 1911 | 3,200 |
| 1905 | 75 | 1912 | 5,500 |
| 1907 | 250 | 1913 | 8,000 |
| 1909 | 680 | 1914 | 14,500 |
| 1910 | 1,500 | | |

Practically all of the plantation rubber comes from Hevea trees, only a small part of the total production being obtained from trees of other species, such as the Castilloa, Ficus, etc.

Briefly stated, rubber is obtained in the following way: Incisions are made in the bark of the trees, and receptacles are placed under the incisions to collect the gradual flow of latex. The custom usually followed by natives is to coagulate or dry the latex by means of smoke or merely by exposure to the air. "Plantation latex" is coagulated by the addition of acid (generally acetic), after which the rubber is washed, sheeted, dried, and sometimes smoked. The smoking process has been adopted in an attempt to secure the valuable properties possessed by the wild rubbers, which are coagulated by smoking.

RUBBER SUBSTITUTES.

No true rubber substitute—that is, no material possessing all the properties of rubber—has yet been produced. Synthetic rubber is identical in composition, etc., with the crude rubber, and so cannot be called a substitute. It is not yet produced on a commercial scale. There are a number of so-called substitutes, however, that may be mixed with rubber to advantage in the production of certain articles.

The oil substitutes are of two kinds, namely, white substitute, produced by mixing corn, rapeseed, and cottonseed oils with sulphur chloride, and brown substitute, made by heating any of the above oils with sulphur.

The so-called mineral rubbers are either natural products, such as gilsonite, elaterite, etc., or the crude tar residue remaining after the distillation of petroleum. These substitutes are extensively used in the cheaper grades of insulated wire.

RECLAIMED RUBBER.

On account of the large amount of waste vulcanized rubber or scrap available, and the high cost of crude rubber, the reclaiming of rubber has assumed such proportions as to constitute an industry in itself. By "reclaimed rubber" is not meant devulcanized rubber, although in some cases much of the free sulphur is removed. No process has yet been developed by which the process of vulcanization can be reversed and crude rubber reclaimed.

The old method of reclaiming consisted in grinding the scrap and removing the fibers and particles of metal, and other waste material, after which the rubber was mixed with oil, heated in ovens, and sheeted. In a more modern process the fibrous materials are destroyed by treatment with acid, after which the scrap is heated in ovens.

In a third method, known as the alkali process, which is carried out on an extensive scale, the old rubber is ground between rolls, particles of iron are removed by magnets, and the ground material is screened. The rubber is then heated in iron vessels containing an alkali solution, by which means free sulphur is removed and the fibrous matter destroyed, after which it is thoroughly washed to remove the alkali and dried by steam coils. It is then mixed between rolls, without the addition of oil, and sheeted.

It is said that rubber reclaimed by this process from carefully selected scrap is superior to some of the lower grades of crude rubber.—*Circular No. 34, Bureau of Standards.*

## Proctor's Formula for Tanning Hides

To tan 10 kilogrammes of hides dissolve 9 kilogrammes of chrome alum in 90 liters of water at ordinary temperature, adding the alum by degrees. To this solution add 2.5 kilogrammes of crystallized sodium carbonate previously dissolved in 10 liters of water. Place 30 liters of this mixture in a vessel containing about 8 hectoliters of water. Add 7 kilogrammes of salt. Immerse the hides in this bath and turn them for half an hour, then gradually reinforce the bath by adding the rest of the chromic liquor.—*La Nature.*


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