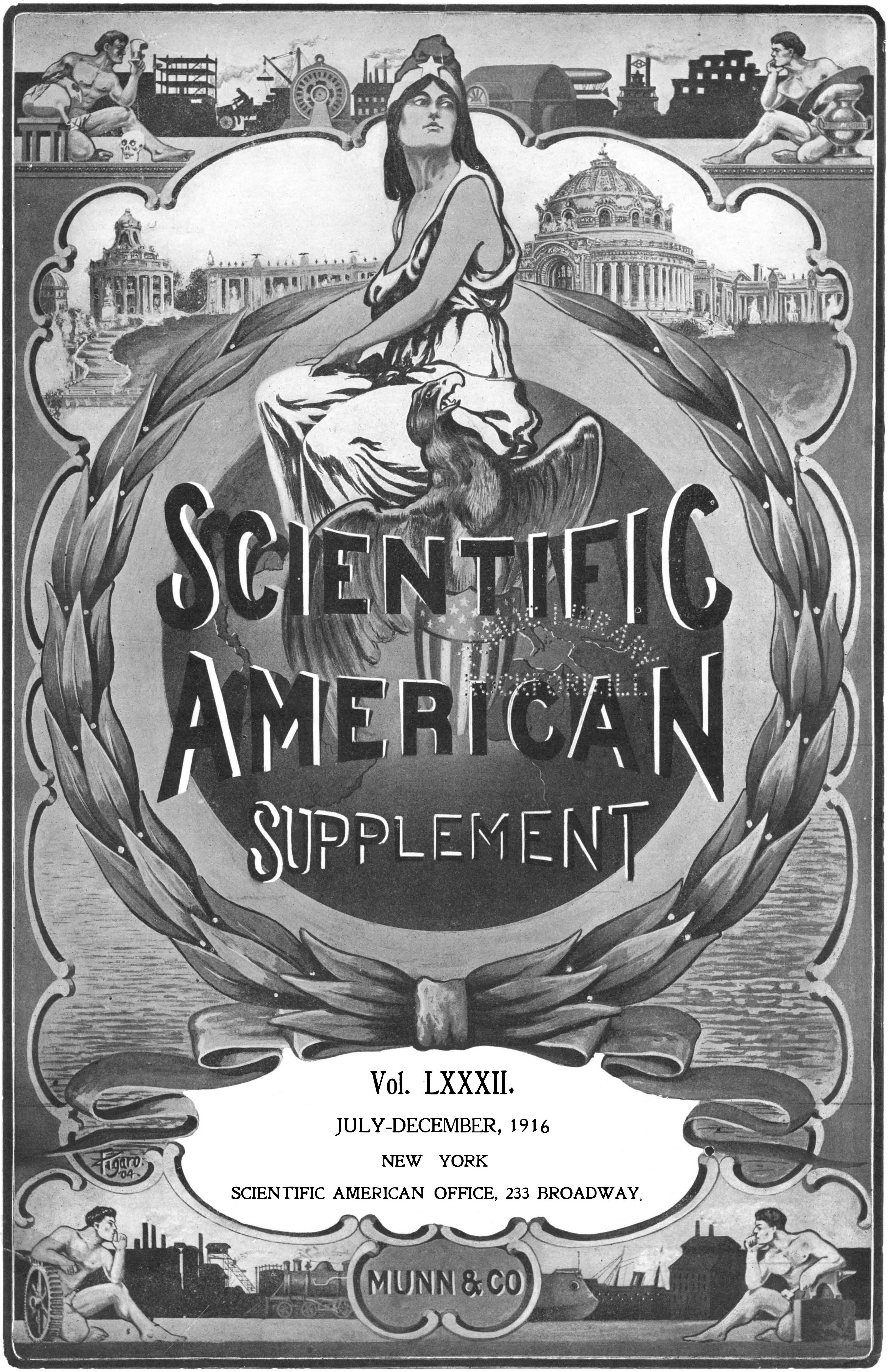

SCIENTIFIC AMERICAN SUPPLEMENT
Vol. LXXXII.
JULY-DECEMBER, 1916
NEW YORK
SCIENTIFIC AMERICAN OFFICE, 233 BROADWAY.
MUNN & CO
Figaro '04

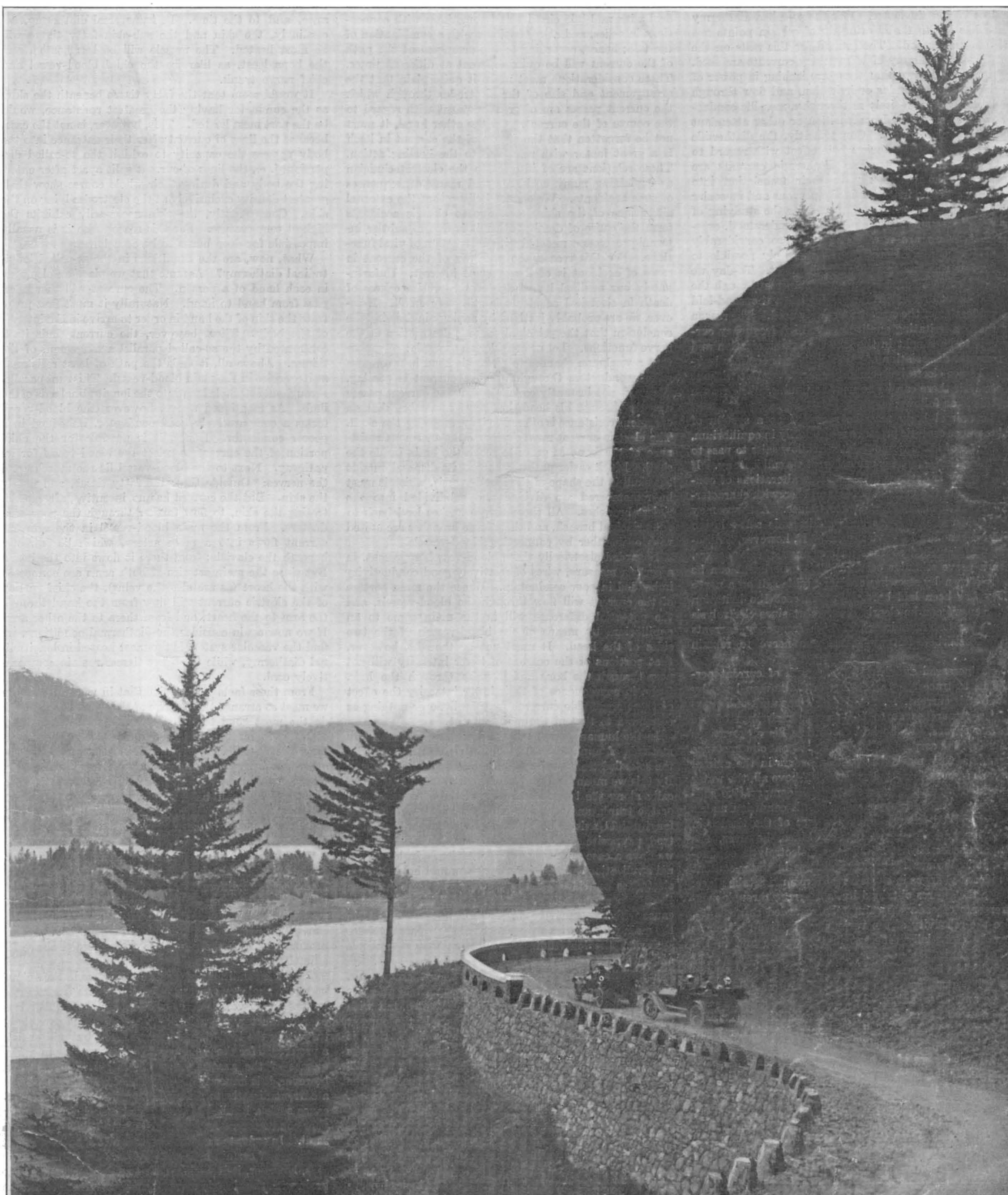
SCIENTIFIC AMERICAN SUPPLEMENT



VOLUME LXXXII ]
NUMBER 2113

NEW YORK, JULY 1, 1916

[ 10 CENTS A COPY
$5.00 A YEAR



A picturesque curve around the cliffs at Shepperd's Dell.

THE COLUMBIA RIVER HIGHWAY.—[See page 8.]

# The Human Body as an Electrical System

## Interesting Facts of Value Both to the Physician and the Electrician

By G. Bucky, M.D.

ALTHOUGH the electric current has long been used in medicine for purposes of healing, it is not until quite recently that there has been definite knowledge upon its various relations to the human body with regard to the conductivity of the latter. It is the so-called diathermy which has led to the clearing up of certain points not hitherto understood. The ground for this rests on the fact that in diathermy high frequency currents are used, and it is well known that these are lacking in power of specific electric stimulus or irritation, and flow through the human body precisely as through a metallic conductor without suffering decomposition or other attendant electrolytic phenomena. Consequently, the diathermic currents can develop their whole effect with regard to the evolution of heat. The diathermic currents are sensed by the body only in their translation into heat, but exert no irritation in the nervous and muscular system. Thus was the way opened for the studying of physiologic laws not hitherto precisely understood, especially since we are now enabled to use considerably stronger currents. Heretofore it was only possible to send a few milliamperes through the body. To-day we can send currents of three or more amperes through the body without danger of injury. This is a thousand-fold intensification of the currents formerly used. The reason for the non-irritating quality of the high frequency currents is to be sought in the fact that the ionization and consequent dissociation of salt solutions is entirely lacking. Hence electrolysis cannot occur. . . . But without electrolysis there can be no nerve stimulus. The reason for this is as follows:

The animal body may be regarded as a system of fluids whose osmotic pressure is ordinarily in equilibrium, i. e., none of these tissue-fluids will allow salts to pass to adjoining tissues. This osmotic rest we call isotony. If this isotony is destroyed there occur alterations of concentration in the various fluids, and therewith characteristic alterations in the separate tissues. A nerve may be considered merely as such an isotonic salt-solution with reference to its environment. If, however, the isotony be disturbed so that an exchange of salts occurs, then a nerve stimulus occurs. This experiment can be easily shown by strewing ordinary table salt on a nerve which has been laid bare, in which case the irritation of the nerve can be clearly seen. But since electrolysis is not an accompaniment of high frequency currents the undisturbed isotony causes the nerve to remain quiet. . . .

The increased and harmless strength of current permits us to trace the path taken in the human body by the electric current. . . . Wildermut has undertaken extensive researches as to the electric resistance of the various tissues, but he had to confine his observations exclusively to corpses. This is a significant circumstance because a very marked alteration occurs in the animal body as soon as death takes place. Above all, the water content of animal tissues alters with comparative suddenness when death supervenes. This condition makes itself observed externally by the loss of the tissues in elasticity and in circumference. Since, however, the animal tissues almost all represent electrolytic conductors, it is obvious that with a change in water-content significant changes in electric resistance must take place. Hence the figures obtained by Wildermut through measurements of cadavers cannot be regarded as absolute. Also the relativity of the various conductive resistances may be essentially different in the corpse and in the living organism. However, in spite of these sources of error highly interesting deductions can be derived from the Wildermut figures as to the pathway of the current in the animal organism.

The order of resistance in the animal tissues may be considered probably as follows: bones, fat, skin, muscle, nerve, blood and other bodily fluids. The bone possesses the highest degree of resistance, the fluid the lowest. It is now clear that according to the laws of electricity the chief part of the current traversing the body will flow through the tissues having the lowest degree of resistance, so far as anatomical relations permit. But it must be noted here, that the various tissues are arranged very differently in the body, so that we sometimes have to deal with multiple circuits and sometimes with connections in series, and at other times with a combination of the two; hence, according to the arrangement the path of the current will be quite different at different times. These considerations must make it quite plain that the arrangement and size of the electrodes through which the current passes are of great moment with regard to the course of the current. On the other hand, it must not be forgotten that the course of the current in itself is a great factor with reference to the healing action. These relations are of interest to the electrotechnician as explaining many accidents and many consequences of such accidents. We cannot believe that the external alterations of the skin, etc., due to electric accidents form the cause of death; rather it is due to subtler internal processes connected with destruction of vital functions. For this reason the pathway of the current in cases of accident is of the greatest interest. Unfortunately our medical knowledge of the precise causes of death in electrical accidents is still very small. However, we are probably justified by analogy in drawing the conclusion that the principal cause is destruction of the nerve functions. Let us consider an example: Suppose that a workman chances to place his head between two naked conductors through which a current is passing. We must not instantly conclude that the current passes directly through his head, but must remember that an enormous resistance is offered to its passage by the skull. The electric current must overcome the enormous resistance of the bone in order to reach the brain inside the skull. Much easier pathways are at its disposal outside the skull in the shape of the blood-vessels, which it must be remembered are divided and subdivided into the tiniest branches. All these tiny branches lead back to one principal branch, and these large branches are united with each other by connecting blood-vessels.

Regarded electrically these blood-vessels represent, in a certain measure, wires of relatively good conductivity imbedded in poor conductors. Hence the main portion of the current will flow through the blood-vessels, and the potential difference will in the main come to an equilibrium by means of the blood-vessels of the two sides of the head. It must not be thought, however, that portions of the current of lower intensity will not pass through the bone and likewise through the hair. Only, in consequence of their lower intensity the effect of these small side currents may be little or nothing as compared to that of the main current.

In the human body we must distinguish between two methods of application of the electric current, namely, the so-called transverse application and the longitudinal. By this we mean that one time the current is sent vertically along the longitudinal axis of the limb concerned or the trunk, and another time at a right angle to this longitudinal axis. If, for example, we place two electrodes opposite each other at the same height on an arm we have a case of transverse application. In longitudinal application, on the contrary, we would hold the two electrodes one in each hand. The difference between these two methods is of such enormous importance because with the transverse application we have to deal in the main with a series arrangement of the separate tissues and with the longitudinal application with a multiple arrangement.

Naturally this must be understood *cum grano salis*, since in the body we never have pure multiple or series circuits, but always a combination of the two, but with one of them always in preponderance. If the current passes across the longitudinal axis of a limb, then it must penetrate the skin on both sides. After that comes the fatty tissue under the skin, then the muscle, then the bone in the middle, and in the vicinity of the bone the principal blood-vessel and the principal nerve trunk.

Hence the current has first to overcome the great resistance of the skin and of the fat underneath the skin, after that it finds an easier passage through the muscle in series. It will certainly avoid passing through the bone since it can run along the side of the bone in multiple circuit. The blood-vessel and principal nerve trunk will be penetrated across the longitudinal axis only by a small portion of the current.

In order to obtain a very lucid comprehension of these relations let us consider only the so-called diathermy currents (high frequency current). In these we are able to estimate the resistance of the various tissues by the degree of heat evolved by the penetration of the current.

For Joule's law holds here, according to which the number of calories produced is directly proportional to the square of the strength of the current, to the resistance, and to the time. In transversal diathermy, accordingly, the skin and the sub-skin fatty tissue will be most heated. The muscle will be less heated, and the bone least, as likewise the chief blood-vessel and chief nerve trunk.

It would seem that the fatty tissue beneath the skin, as the conductor having the greatest resistance, would be the part most heated. This, however, is not the case, because the lines of current after their entrance into the body possess the capacity to exhibit the so-called dispersion; i. e., the lines of current split apart after entering the body and during their whole course show their greatest density exclusively at the electrodes lying on the skin. Consequently, the skin necessarily exhibits the highest temperature. For this reason also it is usually impossible for deep burns to be occasioned.

What, now, are the conditions in the so-called longitudinal diathermy? Assume that we place an electrode in each hand of a person. The current will thereupon pass from hand to hand. Naturally it must first penetrate the skin of the hand in order to arrive in the interior of the body. Then, however, the current finds itself confronted by the so-called parallel arrangement of the tissues. Above all, it finds the path of least resistance at its service in the main blood-vessel. This runs parallel throughout its whole length to the longitudinal axis of the limb. As mentioned above, however, the blood-vessel forms a comparatively good conductor, imbedded in a poorer conductor. Hence, it is possible for the chief portion of the current to select the blood-vessel for its pathway. Next to the blood-vessel lie the muscles and the nerves. Outside these the fatty tissue, and finally the skin. But the current has no incentive, after penetrating the skin, to flow farther through the poor conductors. From the main blood-vessel in the arm the current flows into a main artery, which lies directly beneath the clavicle; from there it flows into the heart. But since the main arteries of both arms are connected with the heart (as are also the veins), the chief portion of the electric current will flow from the hand through the arm to the heart, and from there to the other arm. If we now again consider the diathermal conditions, we find the vascular system is the most heated in longitudinal diathermy, while the other tissues remain comparatively cool.

From these facts we perceive that in various maladies we must so arrange the passage of the current that it will do the most good to the affected organ. If our main object is to reach the blood-vessels, then we must employ the so-called longitudinal diathermy; if, on the other hand, we wish to reach the muscles we must apply transversal diathermy. That conditions are really as thus depicted can be proved by animal experiment. We can measure the diathermy current in the body very simply and easily if we make use of a crossed thermo element.

Two sides of this are connected with a microvolt meter, the other two each bear a needle. These needles are inserted in the different parts of the animal's body. In this manner we can easily succeed in studying experimentally the division of the current in the animal's organism. The results of these measurements coincide approximately with the resistance series quoted above for animal tissues.

Thus the conditions of electric resistance in the animal body are analogous to that of a silver wire (represented by the blood-vessel) imbedded in a metal which is a poor conductor, e. g., lead. The current is capable of traversing the lead (i. e., the flesh, etc.) but will exhibit a preference for the silver wire (blood-vessel). In consequence of the anatomical arrangement of the tissues, however, it is impossible under the conditions to conduct a current directly to any given locality of the body, because such a locality is surrounded on all sides by very poor conductors. As mentioned above this is true of the skull. In order to reach some parts of the brain we must make use of certain artificial devices. In spite of such aids, however, it is not possible to reach all parts of the brain with the electric current; we are confined to certain limited and non-essential portions. . . .

Similar conditions obtain with the marrow of the bones. Here, too, the marrow is surrounded on all sides by the poor conductor, bone. It is almost impossible to cause electric currents of appreciable energy to penetrate directly into the interior of a bone. These conditions

NOTE.—While it has long been known that the human body is an electrical conductor, it is not generally realized that it must be regarded rather as an electrical system of conductors, rather than as a single conductor like an iron rod or copper wire. The various tissues of the body, bone, flesh, skin, blood, etc., possess each a specific degree of electrical resistance. Consequently, when a current of electricity passes through the body its path is devious. The conditions governing its passage are obviously of the highest interest to the physician wishing to make use of the current for remedial purposes. A knowledge of such conditions is likewise of vital importance to the electrician. We take pleasure in quoting from an article upon the subject by Dr. G. Bucky, which appeared not long ago in the *Elektrotechnische Zeitschrift* — for SCIENTIFIC AMERICAN SUPPLEMENT.

have led to the employment of a specific electrical technique, so-called auto-induction. In this method the electric current enters the animal body, not directly, by conduction, but indirectly, by induction.

For this purpose we make use of a coil of wire within which the patient, or the limb to be treated, is placed. When now a powerful current is made to flow through the coil, an induced current is created in the body. In this manner it is, therefore, possible to cause the flow of electric currents even in the brain or in other inaccessible organs. Since, however, for the employment of this method comparatively high primary currents are required in order to cause an appreciable current in the body of the person, and since on the other hand the apparatus at our disposal cannot be very large, for fear of being too expensive for the physician, only moderate results have as yet been obtained.

Another unsatisfactory circumstance is that the currents induced in the interior of the body by auto-induction can, naturally, be only eddy currents, those without definite direction.

A very interesting fact about the diathermy currents is the following: The animal body can support greater quantities of current of the undamped high frequency currents, if these be supplied intermittently to the body. In this connection the observation may be made that the organism can support almost twice as great a quantity of the intermittent current as of the continuous current when the current-break and current-interval are to each other as 1 : 2. The effect is increased by the intermittency of the diathermy currents.

It seems paradoxical to the electrotechnician that an interrupted current should develop a higher efficiency than a continuous current. But this is due to the fact that the skin is capable of supporting very high temperatures for brief intervals, even super-temperatures, which would produce the severest burns if longer continued. That these super-temperatures can be borne without injury is due to the regulation processes of the body. The regulating mechanism consists of the circulation of the blood and the throwing off of perspiration. By the circulation of the blood the heat is quickly carried away from the point of contact. The circulation operates, therefore, like a cooling system of running water. The exudation of sweat tends to prevent overheating of the point of contact by reason of the fact that its evaporation absorbs large quantities of the heat developed.

Another great advantage of the intermittent diathermy current is that it causes a more even warming up of all the adjacent tissues, that is, during the current interval the super-heated tissue has the chance to give off its excess heat by heat conduction to the surrounding parts. But since the number of calories is very considerably increased because the current-intensity is almost doubled, even those tissues which are but little warmed by a continuous current because of their resistance and their arrangement will have their temperature considerably raised by the intermittent current because of heat-conduction. This increase of heat heightens very considerably the therapeutic effect of diathermy. For this intermittent service special current-breakers, so-called "pulsators" are made.

The above exposition makes it clear that the physician who wishes to gain the greatest effects from the electric current must possess very considerable physical and technical knowledge.

It is hoped, finally, that these lines will make clear to the electrotechnician the reason for many puzzling accidents and their consequences.

## The Application of Scientific Methods to the Improvement of the Sugar Beet

An important memoir on the production of improved seeds of the sugar beet is published by M. E. Schribaux in the *Bulletin de la Société d'Encouragement*.[1] The memoir gives one of the best accounts that has yet appeared of the methods of selection which have proved so successful in improving the quality of the sugar beet during the past fifty years. It is to these improvements that the remarkable growth of the beet sugar industry is largely due. They provide an admirable illustration of what can be effected by applying rigorous scientific methods to agricultural practice and industry on the large scale, and demonstrate scientific control pushed to a limit which only a few years back would have been regarded as impracticable or even impossible. This can be best appreciated when it is stated that in selecting the best beet roots to be used as seed-producers, every single root which appears suitable on morphological or other grounds, is subjected to chemical analysis. Often more than 3,000 roots are analyzed each day; for this purpose a staff of three men, assisted by ten women or children, is necessary, and the price of each analysis works out at about four centimes.

The accompanying diagram (Fig. 1) shows at a glance the improvement that has been effected in the quality of the beet since it was first grown as a raw material of the sugar industry. During the interval from 1838 to 1870 seed growers confined their attention almost entirely to physical characteristics, such as form; these efforts were not without success, and led to the adoption of the type which, after its selection by Rabethge and Giesecke, became known as the *Klein Wanzleben*, from the district in Saxony in which it was grown. During this period, too, it was noticed that the largest roots are always the poorest, and a medium-sized root only was therefore aimed at. From 1838 to 1870, the increase in the percentage of sugar was but small, namely, from 8.8 to 10.1 per cent.

The second period of selection opened with the discovery by Louis de Vilmorin of the fact that, although the saccharine quality of the beet is a hereditary character, in order to maintain the improvement of the stock it is necessary to repeat the selection of the seed-bearing plants (*portegraines*) at frequent intervals. He created the celebrated race *Vilmorin améliorée* associated with his name, by adopting a strictly scientific control in place of the empirical one which had previously determined selection. To ascertain the richness in sugar of the mother plants Vilmorin at first floated the roots in baths of salt or sugar solutions of known specific gravity. This method was soon replaced by a process of ascertaining the density of the juice expressed from small sectors of the roots, and this, in turn, gave way to the polarimetric process which is now universally in use. The methods introduced by Vilmorin were adopted with great success between 1870 and 1890, especially in Germany; during this period of twenty years the sugar content was raised from 10.1 to 13.7 per cent.

Up to this date, however, attention was given only to direct heredity, selection being confined to the mother roots. The next great step in the improvement of the beet was introduced by taking into account the ancestral heredity of the seed-bearers, *pedigree* or *genealogical* selection being adopted. This method was defined by Vilmorin as follows: "It consists in valuing the different reproducing plants separately and individually, keeping the seeds produced by each apart, and determining by direct experiment the faculty of transmission which each plant enjoys." From 1898 to 1912, by this *individual* method of selection, aided and controlled by chemical analysis, the sugar content has been increased from an average of 15.2 to one of 18.5 per cent. Individual roots have contained from 26 to 27 per cent of sugar, and there is every reason to believe that the improvement of the beet is far from having reached its limit.

It is impossible here to do more than glance at the latest methods of working adopted by the seed-selecter. Each single root grown has its sugar content determined by a process which leaves it practically uninjured and suitable for planting after its character has been ascertained. The small sample of pulp is taken for analysis by means of a small rasp-drill which pierces the root about 2 centimeters below the base of the neck at an angle of about 45 degrees. Experience has shown that although the sugar content is very different in different zones, the particular section taken in this way corresponds with the *average* over the whole root; 4.065 grammes of the pulp so obtained (one-quarter the "normal" weight) are transferred to a 50 cubic centimeter measuring flask, and water, containing basic lead acetate, added, so as to make the volume about 40-45 cubic centimeters. After adjusting exactly to 50 cubic centimeters and

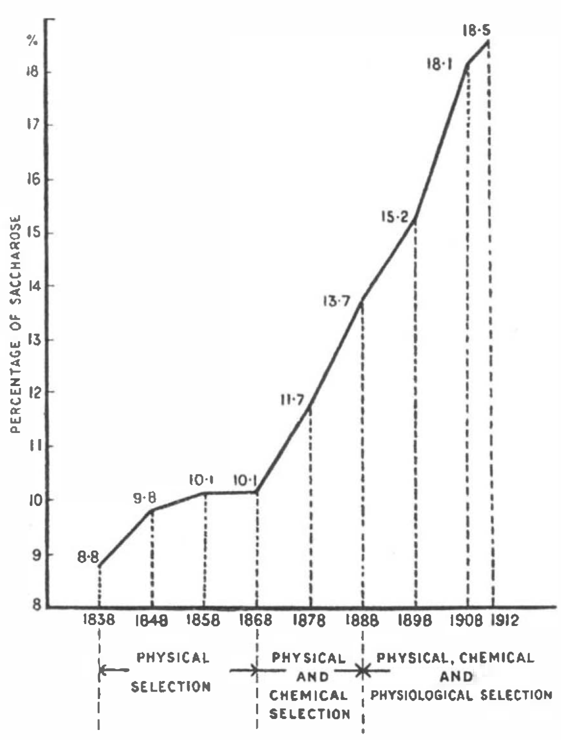



**Fig. 1.—Variation of richness in sugar of industrial sugar beets.**

filtering, the solution is examined in a 400 millimeter continuous-flow saccharimeter tube. In this way the percentage of sugar in the root is read off directly on the instrument.

As a result of the analysis the roots are divided after lifting into three classes: "mothers," "grandmothers," and "élites." Thus, in the case of the 1915 crop, mothers and grandmothers would be used to furnish commercial seed, the "mothers" in 1916, the "grandmothers" in 1918. The "élites" would, in 1916, give seed which, in 1917, would yield the supply of roots to be again subjected to selection.

From time to time the selecter comes across roots the characteristics of which stand out as abnormally desirable. Such plants are subjected to careful genealogical selection in order to ascertain whether their descendants show these qualities on even a greater scale. If so, these roots are made "heads of families" and are the starting-points of new and improved races. Progress in the future largely depends on discovering remarkable "heads of families." For such a result it is necessary, not merely for the operator to be skilled in selection, but he must work on enormous numbers of roots—several hundreds of thousands each year.

A field of future work, which as yet has scarcely been touched, lies in an attempt to avoid the injurious effect of cross-fertilization, which tends to retrogression of the race. Another rich opportunity for work is to be found in the adaptation of beet seed to local soils and climatic conditions. For this purpose it would be necessary to carry out the experiments with the seed plants in the localities where the main crops are subsequently raised for the sugar manufacturer.

One of the most promising directions for future work in improving the sugar beet is to be found in the asexual method of propagation suggested by Nowoczek and adopted with success by M. Gorain at Offenkerke and M. Helot at Noyelles-sur-Escaut. In this system multiplication is effected by grafts and buds in the individuals used to give the seed of the first generation of "heads of families" and "élites." Full details are given in M. Schribaux's paper of this system, which has the great advantage of rapidly increasing the number of the specially desirable individuals to be subjected to further selection.

Many other problems face the seed-selecter in France which are dealt with in considerable detail, more particularly that of the improvement of the germinative power of the seed and the best means of rapidly producing in France at the present time the necessary supply of high-grade seeds, which in the past were largely imported from abroad.—*W. A. D. in Nature.*

[1] "La production des graines de graines de betterave industrielles assurée par Lagriculture francaise." By E. Schribaux. (*Bull. Soc. d'Encouragement*, vol. cxxiv., No. 4, pp. 178-251.)

## Dryers for Photographic Work

Chloride of calcium is sometimes used to absorb moisture and keep certain photographic products dry, such as platinum paper or carbon paper, but a European photographer finds that ordinary cardboard of the heavy kind will act as a good drier. The card is used in rough sheet, it being well dried by heat and then wrapped in waxed paper so as to leave only the edge of the board free, so that it will not absorb moisture too quickly. The idea is a simple one and is found quite effective for preserving some kinds of paper and even plates which are apt to suffer from moisture. On the other hand, care should be taken regarding cardboard which serves for the usual photographic packing, for instance, with packets of sensitive paper, such as are in common use, for cardboard absorbs and carries with it great quantities of moisture, and may thus be a cause of accidents which cannot be traced. Of course, in the method mentioned above the card can be re-dried occasionally.

## Synthetic Indigo From China

Of the estimated annual consumption of synthetic indigo of 80,000,000 pounds, 95 per cent came from Germany before the war, and of this the Orient took nearly 70 per cent, China alone taking 50 per cent. To meet this demand large stocks were carried in China, and these have been drawn on by America since the home supply was exhausted, naturally at a considerable increase in price. This supply was of great assistance to American manufacturers, although some importers received choice Chinese mud dyed blue.

# Filipino Toys*

## How Our Young Island Wards Amuse Themselves

### By Alva R. Brane, Acting Div. Supt. Pampanga

CHILDREN shape toys after the implements, and games after the activities of their elders.

Perhaps the most pronounced characteristic of childhood is the desire for activity. This desire can be directed and the mind and the hand of the child trained by the judicious use of suitable toys. They should be of such a nature as to instill in the child a knowledge of and desire for the activities with which he is the most likely to be connected in his after life. Toys which create habits of industry should be provided, to the exclusion of other toys and games of chance.

Although at present there is a large importation of

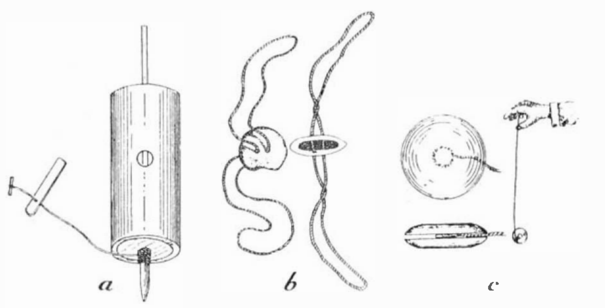



**Fig. 1.—(a) Whistling toy; (b) buzz saw; (c) yo-yo.**

foreign toys into the Philippines, one should not conclude that the habit of playing with toys was introduced by a foreign people. Long before toys were brought in there were native toys in use; and from time to time new ones have been devised.

While the Filipino child probably has as many playthings as have children of other countries, the native toy is much less noticeable, because it is seldom highly colored. The most numerous are the kites and tops, which may be seen almost any day during the dry season. In very common use also are other devices which will spin, contrivances for making a noise, dolls, and stilts. Fishes and curiously wrought animals are also sometimes seen. The toy wagons, carts, sleds, boats, fishspears, bows and arrows, stoves, and cooking utensils

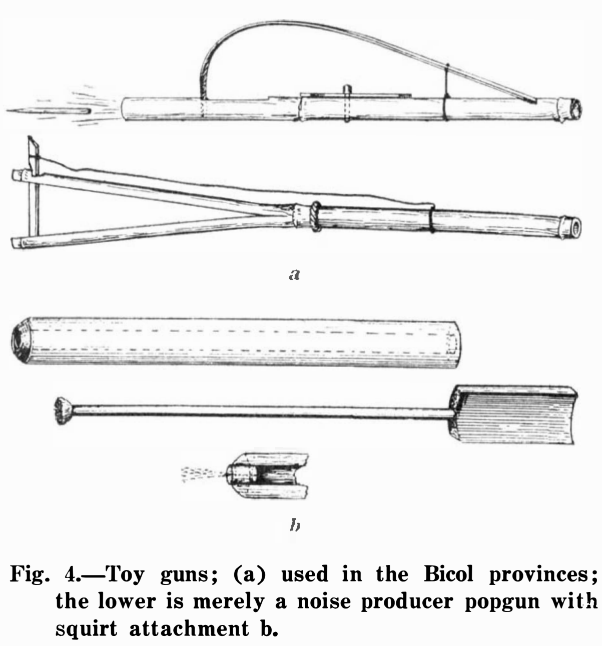



**Fig. 4.—Toy guns; (a) used in the Bicol provinces; the lower is merely a noise producer popgun with squirt attachment b.**

are, of course, patterned after the implements and utensils used in the homes.

There is still a strong tendency, even among the youngest children, toward games containing the element of chance. This might be overcome to a great degree by a more widely extended use of interesting toys.

It is notable that the chief differences between the Filipino toys and those of the Occident are accounted for by the differences in materials and in places of manufacture. The similarity existing between them and toys of other Oriental countries is brought about by the same influences. Likewise, the type is affected to a great extent by the environment, the Occidental toy being more mechanical than is the Oriental. Oriental toys are largely manufactured in the home, generally by the child himself and from such materials as bamboo, seeds, and abaca, which are cheap and easily obtained, while the Occidental toys are more generally made of metals and in factories.

While many of the Filipino toys are quite simple, some require considerable skill in manufacture and dexterity in manipulation. The degree to which this skill and dexterity are shown by the average Flipino boy but tends to emphasize the educational value of many of the toys which now exist and the need of an extension of the use, and a diversification and increase in the number, of present designs.

Of course nothing definite as to the origin of most of these toys can be given, though the people of Tolong, Oriental Negros, tell the following story of the introduction of the top: A long time ago a Spaniard living in that vicinity had a discussion with the leading men of the town regarding the shape of the earth and in illustrating the rotation of the earth used a top. The top was such a novelty that the people copied it, and it became a popular toy at once. The whistling top is said to have been originated by a people called Palao, who, hundreds of years ago, were supposed to have drifted to the shores of Samar from the islands far out

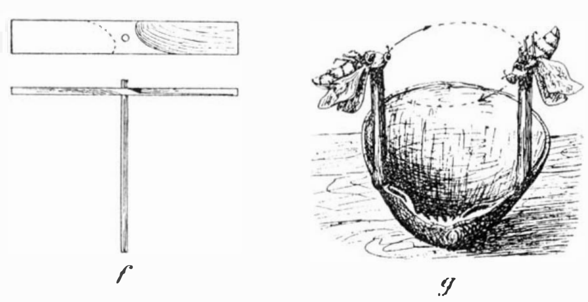



**Fig. 3.—(f) Aerial whirligig; (g) beetle merry-go-round.**

in the Pacific. Another story has been told concerning the introduction of stilts. The people desired to have some giants present at the town fiesta, so their priest taught two men to walk on stilts and exhibited them as giants. The boys, learning of the device, adopted it; and stilts have since become popular toys. In one section of the Philippines the sight of the boys playing with their tops is heralded by the old people as a sign of approaching hard times. But perhaps the prettiest

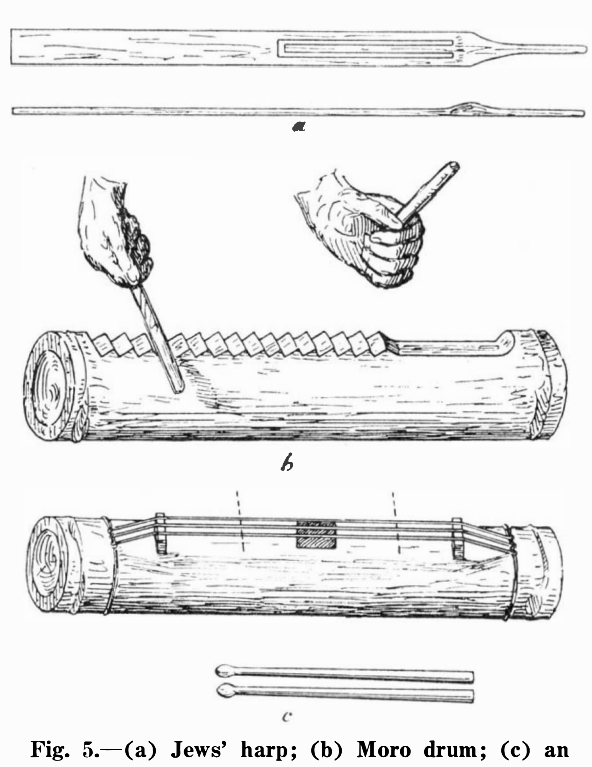



**Fig. 5.—(a) Jews' harp; (b) Moro drum; (c) an Ilocano drum.**

story is one that has come up from the South. The Moros have a custom of teaching their children to call their dolls datus and princesses, and to treat them with due respect. When the doll is broken or has become unserviceable, it receives a fitting burial or is allowed to float to sea in a gaily decorated toy vinta. The older people say this creates in the children the proper respect for the datus and princesses.

As birds derive their names in this country from the sounds they make, so also do many of the toys: as, for example, in the case of the names for popguns, rattles, and the various humming toys. It will be seen that, as a rule, the name of a toy differs in the different provinces. Sumpit (blowgun), pana (arrow), and yo-yo, however, are names very generally used throughout the islands. The word for a toy is frequently but a doubling of the word for the real thing. Such is the case with isda-isda (toy-fish), badil-badil (toy-gun).

There is evidently some commercial possibility in Filpino toys, for a patent was recently secured upon the yo-yo by a firm in the United States. This toy has been extensively manufactured in the Province of Rizal and in the Philippine School of Arts and Trades.

More or less detailed descriptions of certain of these toys are given herewith. All of them are manufactured locally, and many of them are of original design. A

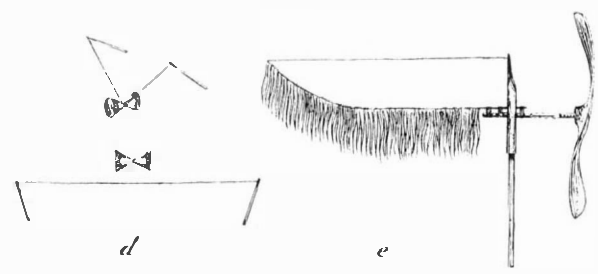



**Fig. 2.—(d) Diabolo; (e) wind wheel.**

few, however, are copied, or adapted to local conditions, as is the case with the diabolo and certain aerial toys. Imported toys are not superior to the toys manufactured here, unless in the matter of finish and uniformity. Many imported toys could be copied or altered and produced in the islands, thus affording a greater variety.

Kites—boradol (Bicol), sapisapi (Pangasinan), tanguri (Sulu), sarangola (Tagalog), nairot (Ilocano). Bamboo forms the frame-work, over which is spread and pasted Japanese paper of different colors. The kites vary from the large leaf to which has been attached a thread or an abaca fiber, to elaborate affairs, with or without humming attachments, made to represent various animals, birds, and insects.

Tops—talumpop (Sulu), camposo (Pangasinan), casing (Visayan). They are usually of hard wood into which has been driven a nail which is later sharp-

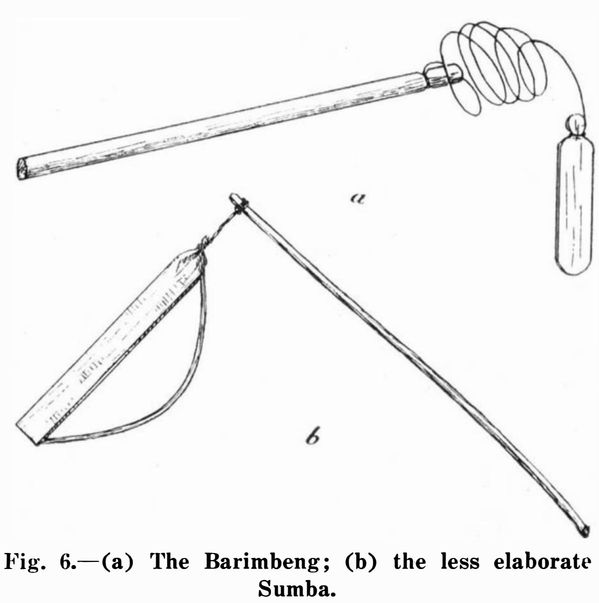



**Fig. 6.—(a) The Barimbeng; (b) the less elaborate Sumba.**

ened. The Sulu tops are often painted black, green, red, and yellow. It is doubtful if the children of any country use tops to a greater extent or handle them more skillfully than do Filipino children.

Whistling top: barimbao, canaocao (Pangasinan), sagodidaha-palao (Samar), Fig. 1, *a*. It is made of either a bamboo tube or the hardened rind of a wild squash.

Buzzsaw—barimbao, ugaog (Pangasinan) (Fig. 1, *b*). The large seed is made to revolve and produce a sound by short, quick pulls which cause the cord to twist and untwist.

Yo-yo (Fig. 1, *c*.)—Materials: hard wood and cord. This toy is thrown in such a manner as to cause the wheel to unwind and rewind the cord as it leaves the hand and returns. Considerable skill is required to operate it well.

Diabolo (Fig. 2, *d*)—The hourglass-shaped block of wood is balanced on a cord at each end of which is a short stick. By careful manipulation, the block is caused to spin, and may be tossed to quite a height and caught again on the cord.

*From the *Philippine Craftsman*. Acknowledgment is due to teachers in Pangasinan, Capiz, Ilocos, Norte, Pampanga, and Mindanao and Sulu for most of the information embodied in this article.

Windwheel (Fig. 2, *e*)—pipidao (Moro). This is used more often as a means of frightening away birds and animals than as a toy. Before matches came into general use, these wheels were used in starting fires.

Aerial Whirligig—balic-balic (Pangasinan); (Fig. 3 *f*). This toy is operated by revolving the handle rapidly between the hands. Upon being released the toy rises in the air. It is generally admitted to be an imitation of a Japanese toy.

Beetles' Merry-go-round—sibaoeng (Pang.), abal-abal (Ilocano); (Fig. 3 *g*). Two beetles are stuck to the softened ends of two tapers which are fastened to opposite sides of a medium-sized shell. Although illustrated here, a merry-go-round of this type is not recommended.

Whistles—Filipino children are as susceptible as are children of other countries to the charms of a toy whistle. The whistles are made from a number of different materials, but those made from a joint of rice straw or the petiole of the papaya leaf are, perhaps, the most common.

Guns—Philippine children have for their amusement all sorts of toy guns, three of which are shown in Fig. 4. The upper two are both known in Bicol as badil-badil. The squirt gun and the popgun are variously known as luthang in Visayan, palsoot in Ilocano, palpaltog in Pangasinan, sulparit in Pampanga, and timbuck in Moro. A wad of leaves is often made to serve the purpose of a cork for the popgun. In addition to the guns shown in the illustration are the blowgun and the lantaka (Samar Visayan). The latter is more like a real cannon than a toy. It is fired by igniting the gas given off from heated kerosene.

Jew's-harp (Fig. 5 *a*)—cubing (Moro), ab-afu (Igorot), curimbao (Ilocano). These are used by both young and old in the more remote districts, where they are frequently the only musical instruments. They are usually made of bamboo, though the ab-afu, the Igorot jew's-harp, is often made of brass. It differs from those of other sections in size, shape, and manner of operation. The ab-afu is made the length of a large-caliber cartridge, usually of a shape resembling a slipper sole, and has a string attached at each end.

Bamboo drums—Two types of these drums are in use. One (Fig. 5 *b*) is made by notching one side of a bamboo tube. This is the kagul. The Moro boys take it to the rice fields when they are guarding the rice against birds. It keeps the boys from going to sleep. While a stick is rubbed up and down on the notches, the other end of the tube is lightly struck with another stick. To understand better how difficult it is to play this instrument, take one pencil in your right hand and one in your left; move the right hand back and forth on the edge of the desk and with the left beat up and down, trying to keep time. Another type (Fig 5, *c*) is made by raising three strips of the outer part of the bamboo and placing a bridge under each end. If a narrow opening is made in the tube, just under the raised strips, a loud sound is produced when the strips are struck with the small sticks. Unless much care is taken, the strips will break at the ends. A cord is often wound around the bamboo at the ends of the strips, just outside the bridges.

Barimbeng, barioer-oer, banerber (Pangasinan) (Fig 6, *a*), sumba (Bicol); (Fig. 6, *b*). The handle is fastened by means of a cord, usually to a flat piece of wood, though sometimes to merely a doubled segment of a palm leaf. When this piece is made to revolve around the handle, a humming sound is produced.

Rattle careteket (Ilocano) (Fig. 7, *a*). Materials: wood, bamboo, and coconut shell. By moving the hand in a circle, the bamboo cylinder is made to revolve while the notched wheel remains stationary on the handle. As the springs on the side pass from cog to cog a loud noise is produced. This toy is in most common use during the week before Easter, though it is sometimes used at ball games. As a noise producer it has few equals. The sandirit (Pamp.), shown in Fig. 7, *b*, is another kind of rattle. It is operated by alternately pulling and loosening the cord, thus causing the spindle to revolve and wind and unwind the cord. The caling-caling is illustrated in Fig. 7, *c*. Small sea shells are suspended by cords from a bamboo ring. This is hung in the window and the wind causes the shells to strike together and rattle. This toy is common in many parts of Luzon.

Dolls (Fig. 8)—These dolls have hair made of black cotton yarn, eyes and mouth of black thread, bracelets and hair ornaments of tin. Whatever the reason may be, Filipino children seem to spend less time with dolls than do children in America. It is believed that the number of homemade dolls is greater than formerly.

Bows (pana) and arrows (busog) are fast disappearing as toys except among the mountain people. Pana is the common term for both bow and arrow.

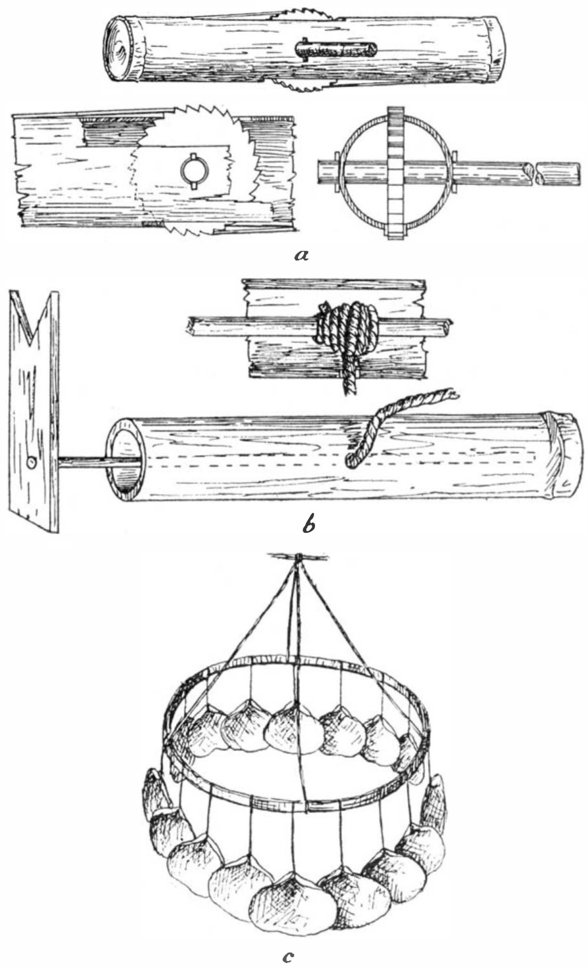



**Fig. 7.—(a) An Ilocano rattle; (b) a Pampagan rattle; (c) a rattle seen hanging in the windows in country districts.**

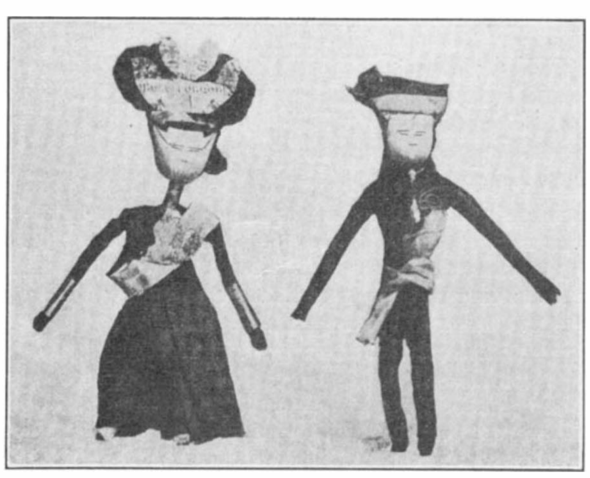


**Fig. 8.—Moro dolls (bay-bay) from Sulu.**

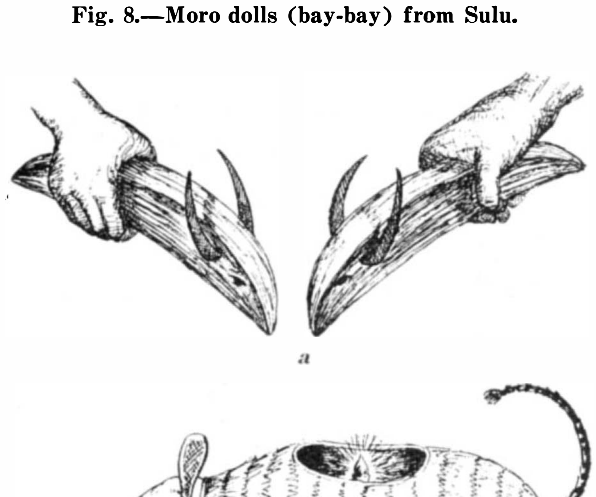



**Fig. 9.—(a) This is both a toy and a game, found among the Moros; (b) the "Rabbit" is one of the many Capiz toys.**

Fishes (isda-isda) and animals—The fishes are often carved out of wood and appropriately decorated. The fish is kept in position in the water by means of a stick passed through the center of the fish, perpendicular to its side. A cord, by which the fish is caused to dart through the water, is attached to one end of this stick. Carabao: Fig. 9,*a*. The body is made of coconut husk, while the horns are made of the shell. It is a Moro toy and is used in a game of the same name. The object of the game, which is a fight, is to break the horns of the opponent. The nose of each carabao must be kept on the ground during the fight. Toy animals, such as that shown in Fig. 9, *b*, are often made of a bamboo framework covered with paper, and the whole mounted on wheels. This toy has gone by the name of "conejo," the Spanish for rabbit, and is to be seen only on Christmas Eve. A great variety of toy animals made in this way bear the same name.

Stilts—Cadang-cadang (Pangasinan). These vary as to material and appearance. The simplest are half-coconut shells through the tops of which are passed strong cords long enough for the child to hold when standing erect. The others are usually of bamboo, though forked sticks are sometimes used.

### Action of Periodic Forces on Drops

The ingenious hydrodynamic experiments which the late Professor C. A. Bjerknes, of Christiania, brought before the scientific congresses held in connection with the Paris Exhibition of 1881, and which the late Mr. Augustus Stroh modified in an equally instructive and beautiful manner, have recently found a sequel. Bjerknes placed drums, covered with elastic membranes, in viscous liquids, and made the membranes vibrate by connecting the drums to reciprocating pumps. Stroh conducted similar experiments in air, and obtained the same apparent attractions between membranes vibrating in the same sense, and repulsions between membranes vibrating in opposite sense, in a manner analogous to magnetic and electric phenomena. Now K. Boedeker, of Göttingen, has extended these researches to drops of one liquid floating in another liquid of the same density (*Annalen der Physik*, vol. xlvi, page 503). The theory of the behavior of drops under periodic forces had partly been investigated by Rayleigh, by S. Webb in 1879, and by Kirchhoff. Experimentally little had been done except by Lenard and by Gundry, although the phenomena may play an important part in meteorology and atmospheric electricity, since the hollow or solid globules of water in mists and clouds are exposed to the action of the electromagnetic forces of radiation and electric discharges within electric and magnetic fields. After experimenting with anilin and benzol, Boedeker made his drops mostly of carbon tetrachloride (density, 1.59) and oil of turpentine (0.87), mixed in such proportions that the drops would float in water. The forces applied were electric (intermittent currents from an induction apparatus) or mechanical. In the latter case a pin attached to a pulsating membrane was dipped into a drop, which moved up and down with the pin, at the same time undergoing changes in shape. The shape changed from spherical to elliptical, conical or doubly conical, according to the frequency of the pulsations. The general rule was confirmed that two drops attracted one another when vibrating in the same phase, and repelled one another when in opposite phases; but for drops of very unequal size the rule did not hold. When two drops were between two plates, the one drop below the other, the pulsations would bring them to the same level, and vibrating drops would make drops at rest start oscillating. Particular interest attaches to the experiments made with very small drops of emulsions. These drops of $10^{-3}$ cenimeter diameter, were excited by resonance, the force having a frequency of 125,000 periods per second; the changes in shape were far too rapid to be recorded or even observed photographically, though this was possible with bigger drops. When two metallic plates, 2 millimeters or 3 millimeters apart, were lowered into the emulsion, and an electromotive force of 100 volts was applied, the minute drops coalesced to bigger drops, which formed a chain across the gap between the electrodes. The drops thus formed a coherer like metallic filings, but the chain broke up as soon as the current was interrupted, and this liquid coherer, therefore, automatically decohered itself, which metallic filings do not, of course. In investigating this interesting peculiarity further, Boedeker added electrolytes to the water, so as to have drops of an insulating material (the oil emulsion) in a conducting liquid. The addition of potassium chloride to the water did not give a good emulsion, the drops being too big; better results were obtained with ammonia. The presence of alkalies facilitates the formation of fine emulsion.—*Engineering.*

# The Rusting of Iron*

## And Some Methods For Its Protection

IRON rust is chemically a hydrated oxide of iron, or iron hydroxide, i. e., a compound of iron with oxygen and water. In 100 grammes of dried iron rust there are 52.3 grammes of iron, 22 grammes of oxygen, and 25.7 grammes of water. From this fact we may conclude that iron will rust only when in contact with water and oxygen. In the absence of either of these substances, no rusting is possible, as may be shown in practice. It is well known that iron in water is entirely free from rust as long as no oxygen is admitted to it. Similarly iron and steel may be protected from rust if calcium chloride is kept in the air where the metal is, for this takes the water out of the air.

According to the experiments of Spannrath, oxygen alone is not able to attack iron at ordinary temperatures. This furnishes a method of protecting fine instruments of steel, as, for example, surgical instruments, from rusting in an easy manner. A layer of dry calcium chloride is placed on the bottom of a glass vessel with an airtight glass cover, and the instruments are placed on a paper or wooden shelf in the vessel, sometimes after being dipped in strong alcohol to remove the last traces of moisture. The air of the atmosphere is able to promote rusting, and in the same light may be considered all organic and inorganic acids, even the weakest, all chlorine compounds of the metals and alkalies, as well as all water-absorbing or hydrated salts. Ordinary water from wells and springs, or rain water, is able to cause iron to rust very quickly. But if the water is first boiled, then cooled in the absence of air, iron placed in it will not rust, for the oxygen has been driven out by the boiling. But as soon as oxygen is allowed to enter the water, the process of rusting will begin at once. In this is to be found the explanation of the fact that an iron tea kettle does not rust inside while in active use, since the air is never allowed to remain in the water. But as soon as the kettle has been allowed to stand until air is absorbed by the water, rusting begins at the water-line.

The more oxygen there is in water, the faster will be the process of rusting in it. On this account cold water allows rusting to take place faster than hot water. Rain water is especially saturated with oxygen, and this is known to cause rusting most rapidly. The process of rusting may be considered as carried on by an agent, which is nothing else than a solution of oxygen in water. Carbonic acid has also a certain influence on the formation of rust, but in the process of rusting the carbonic acid is regenerated again and is not used up. The question now presents itself: how does it happen that a covering of rust often leads to such energetic rusting of the iron beneath? To explain this we need only consider the behavior of other metals. As is well known, zinc and lead can be exposed to the air without any protective coating; a fine coating is formed which adheres to the metal and protects it permanently from further action of the air. Even when the film is removed the natural process repeats itself and again covers the metal with a new protective coating, and the metal is not damaged. The process is wholly different with iron. Here the rust forms a porous mass covering the iron, which allows an uninterrupted access of oxygen to the iron beneath. The covering, on account of its porosity, attracts liquids to it, especially the water which is saturated with oxygen.

So the statement is verified that rust causes rusting. At the same time it must be remembered that the rust itself is not the cause of further rusting, but is only the carrier of the substances which promote the formation of rust. If there is no water in the rust, no further formation of it takes place. If the rust were not of such a porous character, it would also form a covering to protect itself, as is the case with lead, zinc, etc.

The gases in the smoke from locomotives are especially capable of causing rust. Such gases contain sulphur dioxide, which has an especially destructive action on iron, so that railroad bridges of iron construction have to be very carefully watched. Attempts have been made with some success to protect the beams of bridges with a coating of zinc (galvanized iron). By tests of long duration it has been found that the galvanized coating of the Göppinger Street bridge in Bavaria was completely destroyed in 35 years.

In the same way iron which is imbedded in fresh lime mortar is in a short time strongly attacked. The rust formation progresses rapidly into the interior, where it forms scale with the constituents of the mortar. These scales peel off very easily. The moisture within the mortar serves to supply the necessary water for the corrosion. Also the iron core alters its properties, in such a way as to decrease its strength, and brittleness and loss of tenacity are the results.

It is curious to observe the large increase in volume of rusted iron. Practically this is of considerable significance, for the increase in volume is often attended by a development of large forces. In heavy stone masonry which is reinforced with iron clamps and pins set in lime mortar, the stones have been known to be displaced by the rusting of the iron so far that a resetting of the masonry was required. Gypsum (plaster of Paris) favors the formation of rust in a most unusual manner. The case is quite different with cement, which acts as a protection against rusting in a very serviceable manner. Satisfactory results have been obtained by spreading a thin film of cement over the iron.

In general it may be said that knowledge on the problem of the corrosion of iron has not progressed very far, though the importance of the problem is beyond question. No good explanation has been obtained for the fact, observed in practical experience, that under similar conditions the progress of rusting takes place in an irregular way. Even on a single specimen of iron, corrosion takes place over different parts of it with quite different speeds. Probably the differences in the composition of the specimen are here the deciding factor, and its different densities. As is well known, rusting takes place in places which have been scratched or torn more than in neighboring places which have not been damaged.

Hydrochloric acid (muriatic acid) and common salt promote the rusting of iron to an extraordinary degree. Paper, in so far as it is used in packing iron, generally has a protective action. Sheet iron naturally fails before the destructive action of rusting more rapidly than massive iron. If sheet iron which has rusted through shows very small, almost invisible holes, it is safe to attribute the cause in this case to the presence of acids.

Specimens of rust show rather varied colors. Fresh iron rust has a bright yellowish-red color, which with increasing age gradually merges into dark brown, and finally brownish-black, without showing in the process any sudden changes of color. Iron rust which separates as a fine powder is mostly yellowish-red, similar to the iron oxide which occurs in nature. On account of the porous nature of rust, it may be easily removed, especially by treating it with petroleum. Rust soaks up the petroleum, and thereby loses its hardness and tenacity, and allows itself to be cracked off.

The question of rust prevention has an especial practical interest, and so some rust-preventing materials will be mentioned. It is practically impossible to keep iron away from the rust-forming agents, especially air—that is, oxygen, carbonic acid gas, moisture and acids—so that protective coatings are required. These fall into two general classes, those which give a permanent protection, and those which give only a temporary protection, and which allow rusting after a certain time. The latter class are important chiefly for the transportation of iron which is to be used at once, or which goes into protected places. Into the permanent class fall such agents as enamel, zinc plate (galvanized iron), tin plate, lead-covered metal, copper plating, and burnishing. As temporary protecting agents the following are used: Smearing with oil, grease, painting with oil color or asphalt paint, and rubbing with graphite. Enamel is a very efficient method of permanent protection, but it has the disadvantage of being too expensive, especially for large pieces, such as structural steel. The same may be said of metallic protective coverings of all kinds for larger pieces. When it is necessary to protect small objects from rust for a long time, a rapid drying solution of resin, a spirit enamel or a celluloid solution is most suitable and most reliable. But for iron construction this method is, of course, excluded. Here the best results may be obtained by oil paint, carefully applied, though there is a limit to the time over which such protection will be effective. The best paint yields after some years to the destroying action of the air, which makes it brittle, and finally blows it away as dust. The tearing off generally leaves the iron quite free, and here the rusting process begins at once. The normal life of good paint is between two and five years, but its permanence can be greatly increased if the drying of the paint is carried out at 50 to 60 deg. Cent. (120 to 140 deg. F.). for by this process the oil attains a much greater hardness and is then of longer resistance.

A paint or enamel which effectually prevents the formation of rust permanently has never been found, although such a thing would be valuable. It is therefore necessary to remove the coating of rust which is present before applying paint.

The removal of rust can be accomplished in many ways. Beside those mentioned with sand-paper, pumice, sand or other hard substance, wire brushes and corroding acid may be used. If the rust is removed with petroleum, grease or oil, it is absolutely necessary before any coat of paint is applied to take away carefully the last traces of the oily material, for otherwise the coat of paint cannot be properly applied, and will form bubbles on the iron. The firm adhesion of the paint to the iron is essential if any effective protection is to be expected of it.

The process of cleaning cast iron by immersing it in a bath of dilute hydrochloric or sulphuric acid, then cleaning it with warm water or lime water, is absolutely to be condemned, for there are small holes in the iron which retain firmly traces of the acid and give rise to rapid corrosion.

The larger the amount of varnish in a paint, the greater will be its protective action against rust. The use of linseed-oil varnish is especially important. Oil paints are not applicable in all cases; either the cost of the material may exclude it, or the working conditions may be unfavorable. Iron gas pipes buried in the earth cannot be painted on account of the expense, and here tar is commonly used; on sheet iron chimneys paint cannot be used, since it would peel off on cooling, and here, as in most cast-iron articles, tar is often suitable. Coal tar, or better, coal tar pitch, dissolved in benzine or petroleum, may be used. In cases in which tar is used, it is quite necessary to remove thoroughly the acid constituents of the tar before applying it, as otherwise, in place of rust protection, an aid to rusting is added.

Tar is not of very general applicability, for if it becomes warm it may flow away from the iron and leave it exposed. The same is true of asphalt, for which a solvent is required, and it has the further disadvantage of becoming brittle when cold, so that it is not generally used.

The number of means of preventing rust is very large, and, as is usual in such cases, most of them are useless. Of especial interest is the so-called iron color, which has as a basis iron oxide. Among the naturally occurring iron colors the most important is iron-minium, otherwise known as kidney ore, or hematite. It occurs in nature as hematite, mixed with various quantities of clay. There is a whole series of other iron colors, such as rouge, sparry iron ore, ordinary iron oxide, Caput mortuum, English red, Prussian red, and others in which some sulphur is present.

Graphite is also very good as a protective agent against rust, since it is not acted upon by any acid. The somewhat expensive minium, red lead, is also much used as an iron paint, and it is especially suited for painting railroad bridges, since when red lead acts chemically with the sulphurous gases from the locomotive smoke, it forms only products which are insoluble, in contrast to iron, which forms only soluble salts. An especialy important place under the protection of iron from rusting is taken by the so-called scale process (Barff's process). There is a long list of other substances which are used for this purpose, among which may be mentioned gum oils, linseed oil, hydroferrocyanic acid, silver dross, rubber graphite paint, and many oxide paints.

Normal conditions for the painting of iron have been worked out for almost all parts of the country. The underlying principle is generally the use of iron or lead oxide paint, but the conditions under which it is applied are various. All oil paints are generally applied in three coats. Painting in the open is in general to be avoided, if possible, and the iron must be thoroughly cleaned before painting, generally by the use of wire brushes. The painting must be carried out with sufficient time between coats for complete drying. Often the first coat is only linseed oil and lead oxide. For the second and third applications a thicker paint may be used. In some localities even a fourth coat is applied, or it is even required of contractors by law. In order to distinguish the last coat, this is generally made somewhat darker in color. If wooden members rest on iron construction, places where these touch are sometimes protected with a fourth coat of paint. Especial care is naturally given to bolts and rivets. If it is to be established clearly just what the process of rusting consists in, several problems must first be solved, and these problems are especially worthy of investigation.

* Translated for the SCIENTIFIC AMERICAN SUPPLEMENT from *Motorschiff und Motorboot.*

# Electro-Plating With Cobalt*

## Some Results of Experiments With a New Metal of Great Promise

IN 1842. Prof. Boetger pointed out that dense and lustrous deposits of nickel could be obtained, which, on account of their resistance to oxidation, great hardness, and elegant appearance, were capable of many applications. The outcome of this has been that during the last decade commercial plating with nickel has developed to be of very great magnitude. On the other hand, no plates of cobalt or of its alloys have ever been in extended commercial use. No doubt part of the reason is because of the difficulty of obtaining a supply of cobalt metal at an attractive price. On the other hand, for commercial plating where labor, overhead charges, the preparation of the surface to be plated, the difficulty of maintaining the bath, the amount of buffing, the current efficiency, and particularly the speed with which the work may be run through the baths, are so considerable a fraction of the cost of the finished work—the price of the metal to make up the anodes and the salts is by no means alone the determining fact or in the choice of that metal. Moreover, the speed of plating largely determines the hardness and other physical properties of the plate, which in turn determines the weight of metal required for satisfactory commercial tests.

A great many technical points in connection with the plating of cobalt have not been investigated; the corresponding investigations for nickel have been comparatively thorough. Before platers can adopt cobalt for many purposes, on a considerable scale, a number of questions must be answered by experiments.

Although numerous statements have been published in the past with regard to cobalt plating, the conclusions to be drawn from a survey of the existing literature and patents would lead one to be very skeptical as to the advantages of cobalt plating over nickel plating. It is noticeable, however, that the conditions for the production of good cobalt plates, as given by different authors, vary very greatly among themselves. Not only are the conclusions often diametrically opposite, but likewise the data from which conclusions are drawn.

Consider alone the question of the relative maximum current densities with which cobalt and nickel may be successfully plated. There is little or nothing in the literature relating to the solutions of cobalt which we have found in this laboratory to be most suitable for fast plating. If it can be shown to be practically feasible to plate cobalt from a bath at several times the speed that this is possible for nickel, other things being equal or in favor of the cobalt, this greater speed of turning out the work, with attendant economies, might offset a very considerable difference in the initial cost of the anodes and salts of the two metals. It must certainly appeal to anyone that if cobalt-ammonium sulphate, because of its very much higher solubility than nickel-ammonium sulphate, or for other reasons, may be used as a plating bath at very much higher current densities, with such a bath the plater may turn out work at correspondingly greater speed. Moreover, plating at greater speed will probably mean a harder and denser plate with consequent less weight of metal required.

A large number of plating experiments were undertaken at this laboratory with a view to studying the questions outlined above. Numerous types of cobalt baths were used and experiments performed with various concentrations of each solution.

Several cobalt solutions were found to be suitable for electro-plating with cobalt under the conditions of commercial practice. Among these are the following:

SOLUTION I B.

Cobalt-ammonium-sulphate, $CoSO_4.(NH_4)_2SO_4.6H_2O$, 200 grammes to the liter of water, which is the equivalent of 145 grammes of anhydrous cobalt-ammonium-sulphate, $CoSO_4.(NH_4)_2SO_4$, to the liter of water. Specific gravity = 1.053 at 15 deg. Cent.

SOLUTION XIII B.

Cobalt sulphate $CoSO_4$.....312 grammes.
Sodium chloride NaCl..... 19.6 "
Boric acid................ nearly to saturation
Water ................... 1000 c.c.
Specific gravity = 1.25 at 15 deg. Cent.

Cobalt plates from these solutions, on brass, iron, steel, copper, tin, German silver, lead and Britannia metal articles, of different shapes and sizes, deposited under conditions identical with those met with in general nickel plating practice, are firm, adherent, hard, and uniform. They may readily be buffed to a satisfactorily finished surface, having a beautiful luster, which, although brilliantly white, possesses a slightly bluish cast.

The electrical conductivity of these solutions is considerably higher than that of the standard commercial nickel solutions, so that other things being equal, they may be operated at a lower voltage for a given speed of plating.

Solution I B is capable of cobalt plating on the various sizes and shapes of objects met with in commercial practice at a speed at least four times that of the fastest satisfactory nickel solutions.

Solution XIII B is capable of cobalt plating on the various sizes and shapes of objects met with in commercial practice at a speed at least fifteen times as great as that of the fastest satisfactory nickel solutions.

Plates from both of these solutions on various stock pieces satisfactorily withstood the various bending, hammering and burnishing tests to which commercial nickel work is ordinarily submitted.

These two very rapid cobalt solutions are remarkable for their satisfactory throwing power. That is, they readily and satisfactorily deposit the cobalt in the indentations of the work.

These two rapid solutions operate at these high speeds in a perfectly still solution without agitation of any kind.

These solutions are both cleaner, that is, free from creeping salts and precipitated matter, than the standard commercial nickel baths.

The cobalt deposited at this rapid speed is very much harder than the nickel deposited in any commercial nickel bath. Consequently a lesser weight of this hard cobalt deposit will offer the same protective coat as a greater weight of the softer nickel deposit. Considering solution XIII B, operating at 150 amperes per square foot, on automobile parts, brass stampings, etc., a sufficient weight of cobalt to stand the usual commercial tests, including buffing and finishing, is deposited in one minute. With the best nickel baths, it takes one hour, at about 10 amperes per square foot, to deposit a plate equally satisfactory. Therefore, the actual weight of metal on the cobalt plate must be approximately one quarter that of the nickel.

For many purposes, under the condition of these rapid plating solutions, one fourth the weight of cobalt, as compared with nickel, is required to do the same protective work. Consequently, if nickel is worth 50 cents a pound, in the anode form, cobalt could be worth nearly $2 a pound, in the same form, to be on the same basis, weight for weight of metal. In addition there are other advantages of cobalt in saving of labor, time, overhead, etc.

A smaller plating room would handle a given amount of work per day with cobalt than with nickel.

With these very rapid plating solutions, by the use of mechanical devices to handle the work, the time required for plating, as well as the labor costs, may be tremendously reduced. Solution I B, and particularly Solution XIII B, are so rapid as to be revolutionary in this respect.

Obviously the cost of supplies, repairs, etc., would be less with cobalt plating than with nickel, as the size of the plant for a required amount of work is less

The voltage required for extremely rapid cobalt plating is greater than that for most nickel plating baths; it is not so great but that the machines at present in use may in general be operated. For the same speed of plating, the cobalt solution requires much the lower voltage.

For a given amount of work the power consumption for this rapid cobalt work is less than that for nickel. This is obvious, because the total amount of metal deposited in the case of cobalt is very much less, whereas the voltage at which it is deposited is not correspondingly greater.

Ornamental work on brass, copper, tin, or German silver would require only a one minute deposit. Even wares exposed to severe atmospheric influences, or friction, could be admirably coated with cobalt in solution XIII B in fifteen minutes. The tremendous possibilities of this solution are not to be completely realized unless mechanical devices are applied to reduce hand labor to a considerable extent.

Thick deposits from these solutions are vastly superior to any that we have seen produced from nickel solutions. The tendency to distort thin cathodes is less pronounced, while elcctrotypes and electrodes have been given a superior thick deposit in a most satisfactory manner. The lines were hard, sharp and tough and the surface smooth. Nickel does not equal cobalt for excellence of massive plates.

Many of these tests were passed upon by uninterested skilled mechanics, who invariably reported in favor of cobalt as above.

Both solutions I B and XIII B are substantially self-sustaining, once they are put into operating condition, and the amount of ageing required to do this is very much less for them than that for the present commercial nickel baths.

*From a report on experiments conducted at the School of Training, Queens University, Kingston, Ont., under the authority of the Dominion Government, and published by the Department of Mines, Canada.

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### Making Iridescent Skins on Artificial Pearls

SINCE the remotest antiquity the pearl has been one of the most highly prized gems with which mankind has sought to adorn himself and herself. The value of pearls is determined not merely by size and shape, but by the color of the "skin," as the outer layer is called. A pearl of the first water must possess not only a milky white luster and satiny sheen, but the subtle and delicate play of prismatic colors known as iridescence.

As is the case to-day with most valuable natural products, the art of making artificial substitutes is highly developed. Many of the best artificial pearls can with difficulty be distinguished from Orient pearls of the finest water. This is attested by one of the most daring attempts at robbery ever made in public and in daylight. A magnificent string of pearls was placed on exhibition at Christie's, the famous London auction house, previous to being put up for sale. A well-dressed woman came into the rooms several times and professed particular admiration for it, hanging over the case with gloating admiration. Finally, she asked the official guard to let her examine it outside the case, and while handling it managed to substitute an artificial replica, which her previous study had enabled her to have made.

A German scientist, R. E. Liesegang, has occupied himself recently with a minute study of the causes of iridescence in pearls and the best method of reproducing these artificially. We glean some interesting details in a report of his research given in the *Zeitschrift für die Keramischen, Glas-und verwandten Industrien.*

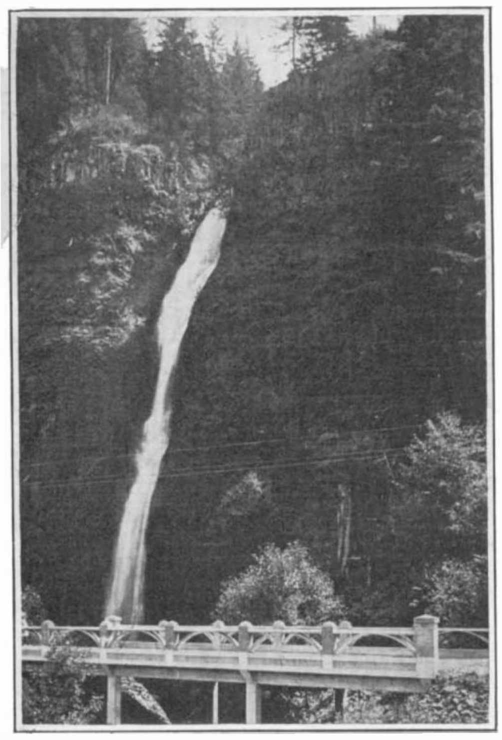
According to this, in one method of fabricating artificial pearls the glass is either coated with a thin layer of a solution of fish scales, or with mica dust previously treated with the fumes of salts of tin. This gives the color effect of a thin layer of uneven depth. "The iridescence of genuine pearls, however, resembles rather the spectral effect of the Rowland lattice, modified, naturally, by the curving surface. As a matter of fact the optical peculiarity of pearls, and particularly of the inside of mussel shells, is also conditioned by the ribbed surface. The essential iridescence of pearls, the 'water of the pearl' is caused by these superficial ribs, which are 0.008 millimeter apart. This is proved, for example, by the fact that if impressions be made on plastic substances by iridescent mussel-shells, these substances become iridescent through having their surfaces correspondingly ribbed by the pressure of the shells."

These experiments indicate that the aim of the artificial pearl maker should be to impress on the surface of the glass bead a "trellis" or "lattice" of corresponding fineness. Mr. Liesegang has shown that this may be done by a physico-chemical process which creates a minutely wrinkled film of the kind best suited to cause iridescence in reflected or transmitted light.

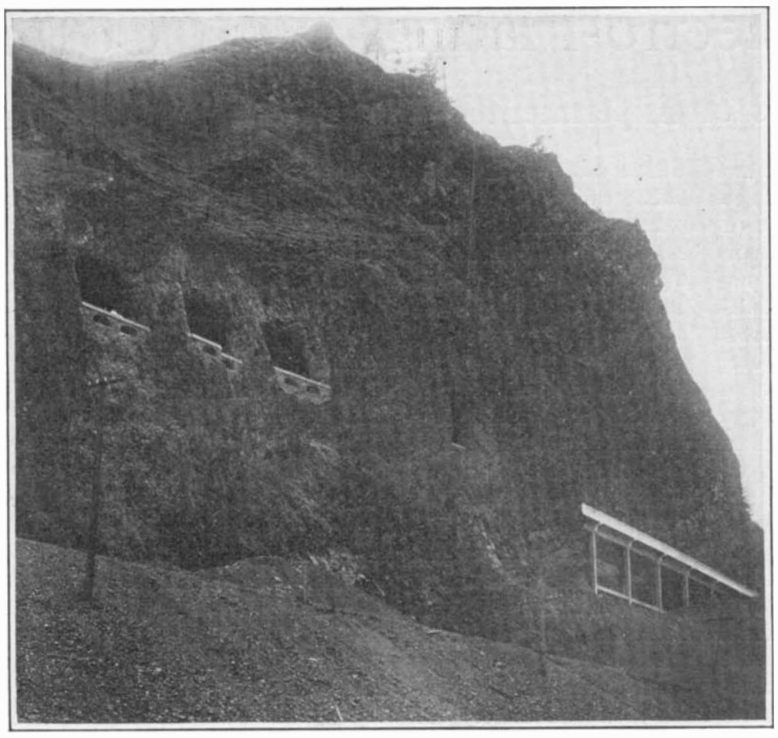
If, under given conditions, a drop of an aqueous solution of trinatrium-phosphate be placed on a still moist layer of gelatine, and the latter be slowly allowed to dry, there will appear, after a certain interval of time, a vividly iridescent ring surrounding the drop, and the iridescence will be retained when the film is entirely dry. It was first suspected that this was due to exceedingly minute rhythmic depressions, but closer research has shown that the iridescence is really caused by extremely fine parallel wrinkles in the gelatine surface.

"In order to create this wrinkling on round glass beads the phosphate solution must be made in some manner to diffuse in the gelatine coating of the beads, for if directly touched there will be no wrinkling.

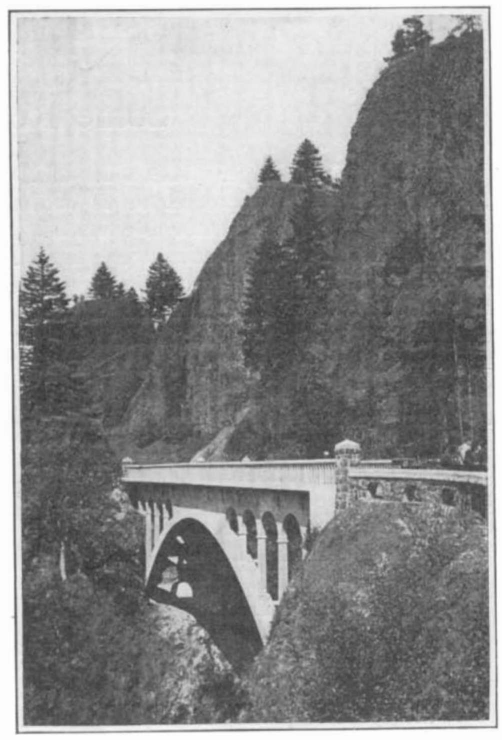
"In pierced beads this is easy to accomplish by means of a wick. If the pearl is not pierced then the iridescence necessarily fails at some point. In spite of extensive laboratory experiments, no receipe has thus far been found to give certainty to the effects of the process, since the gelatine is not a chemically uniform substance. But in these experiments we may see the beginning of methods which will give a more exact resemblance of the artificial to the natural pearl."



Horse-tail falls.



Observation windows in tunnel at Storm Cliff.



Shepperd's Dell.

# The Columbia River Highway

## A State Road That Is a Model of Artistic Engineering

Leading out of the city of Portland, and extending along the Columbia River, through scenery of unsual beauty and grandeur, the State of Oregon has constructed a sixty-mile stretch of highway that will stand as a model for engineering work of this kind, besides being an enterprise of considerable economic value, connecting up, as it does, a wide tract of country with the principal city of the State.

The region bordering on the Columbia River is rugged and mountainous, with long vistas of forest and river, affording a grand opportunity for the laying out of a route of unusual scenic features, and in locating the road every opportunity of adding to the attractiveness of a journey through the region has been studied and taken advantage of by the engineers. Wherever special construction work was necessary, such as bridges, viaducts or tunnels, the surrounding conditions were carefully studied, and great care was taken to secure harmonious and appropriate designs that would set off and enhance the natural beauties of the scenery. All of this is in striking contrast with similar works in other parts of this country, where the engineers appear to despise artistic effects, and consider only the bare technical side of the question to the exclusion of esthetic results that would meet with lasting public approval. Undoubtedly the severely commonplace and practical character of public works so generally seen in this country is the result of lack of appreciation and cultivated taste on the part of those in authority, together with a desire for economy; but where good judgment and skill prevail, the crude designs so often seen could have been converted into things of beauty at a surprisingly small cost, and would give correspondingly greater satisfaction to the public that pays for the work.

The bearing of these remarks may be appreciated by an inspection of the accompanying illustrations. In the picture on the first page it will be noted that the natural character of the forbidding cliff has been retained practically intact, while the rough retaining wall of the embankment, with its rough hewn guard posts, is in perfect harmony with the adjoining surfaces. Another view in the same vicinity, at Shepperd's Dell, gives an idea of the beautiful and appropriate bridgework that characterizes this unusual piece of road building. Again the idea of swinging the road around the summit of Crown Point, and affording a magnificent panorama of the surrounding country, was particularly appropriate. Here the elevation is 700 feet above the river, and a view extending between thirty and forty miles is afforded. In addition to the roadway a handsome parapeted promenade borders the brow of the heights, and, as will be noted in the picture, an ample parking space has been provided for vehicles within the loop of the road.

In several places there are charming cascades and waterfalls conveniently near to the main road, and paths have been provided leading to these points of interest for the convenience of tourists, many of them requiring special bridges. An example of the taste and thoroughness with which this thoughtful auxiliary work has been done is seen in the photograph taken at the Horsetail Falls.

The most notable feature of the entire highway, however, is the tunnel at Storm Cliff, shown in another illustration. Here a rugged promontory jutted out from the mountains bordering the river, and as a railway occupied all the available space at its foot, it was necessary to cut a way through the rocks. There was an old country road that won its devious way over the ridge by steep grades, one of them of 23 per cent, but it was not considered advisable to attempt its improvement, so preparations were made to attack the obstruction at a lower elevation. From the riverbank a cliff of solid rock arose abruptly for 500 feet, where there was a bench, or saddle, a few hundred feet wide, and above this the cliff arose to a height of 2,000 feet or more. From the bench men were lowered by ropes 200 feet to cut out niches in the face of the cliff for the engineers to work from, and they laid out the plans for a tunnel 400 feet long, approached by a 200 foot concrete viaduct of simple design. The notable feature of this tunnel is the series of wide observation windows that have been cut through the outer wall, after the manner of the famous Axenstrasse, in Switzerland, and the view from these windows, looking out across the broad Columbia River, and over into the State of Washington, is said to far surpass that of its notable prototype.

The Columbia River Highway is about sixty miles long, leading from Portland, Oregon, to Hood River. Throughout its length it has a width of 18 feet of substantial bitulithic pavement, and in no case does the grade exceed 5 per cent. It is an ideal scenic route, and eventually there is no doubt but that other connecting roads will be built to form an artery leading to the Eastern country. At present it forms a portion of a route that can be taken through the Yellowstone Park, and joining the Lincoln Highway at Cheyenne.

### Minor Products of Wood

Wood enters into the manufacture of various commodities, some of which are of experimental importance only at this time or have developed only in other countries.

#### OXALIC ACID.

When sawdust and caustic alkali are heated together at a temperature of 392 deg. and 494 deg. Fahr., decomposition of the sawdust occurs, with the formation of the oxalate of the alkali metal. One factory, at Bradford, Pa., is engaged in this industry, but no examination of the plant was made. From other sources, however, it is found that in a general way the process for making oxalic acid from wood consists, first, in the preparation of a solution of carbonates of sodium and potash, or of soda ash alone. This solution is treated with milk of lime, whereby caustic soda is formed, as follows:

$$Na_2CO_3 + Ca(OH)_2 = 2NaOH + CaCO_3.$$

After removal of the lime mud the caustic soda is evaporated in iron pans to a specific gravity of 1.35 and mixed with sawdust in the proportion of one part of sawdust to two parts of alkali. This mixture is next heated by superheated steam or hot air for an hour or more to a temperature not exceeding 494 deg. Fahr. The resulting melt is then treated with hot water and the solution filtered. Upon cooling, small crystals of sodium oxalate are formed, which are freed from the adhering liquid by centrifuging. To prepare pure oxalic acid from sodium oxalate, the latter is dissolved in hot water and milk of lime added, thus forming insoluble oxalate of lime:

$$Na_2(C_2O_4) + Ca(OH)_2 = 2NaOH + CaC_2O_4.$$

The oxalate of lime after separation from the caustic-soda liquor is washed and brought into lead-lined vessels and treated with dilute sulphuric acid, whereby decomposition takes place with the formation of oxalic acid in solution and calcium sulphate in the solid form, thus:

$$CaC_2O_4 + H_2SO_4 = H_2C_2O_4 + CaSO_4.$$

The oxalic-acid solution is then drawn off, evaporated to a high concentration, and crystallized.

Attention should be directed to the use of another method in Europe, as well as in the United States, in which carbon monoxide is passed into a solution of caustic soda, forming sodium formate, from which the oxalic acid is obtained. This method is apparently more satisfactory for the commercial production of oxalic acid than the older method in which sawdust is used.

#### WOOD FLOUR.

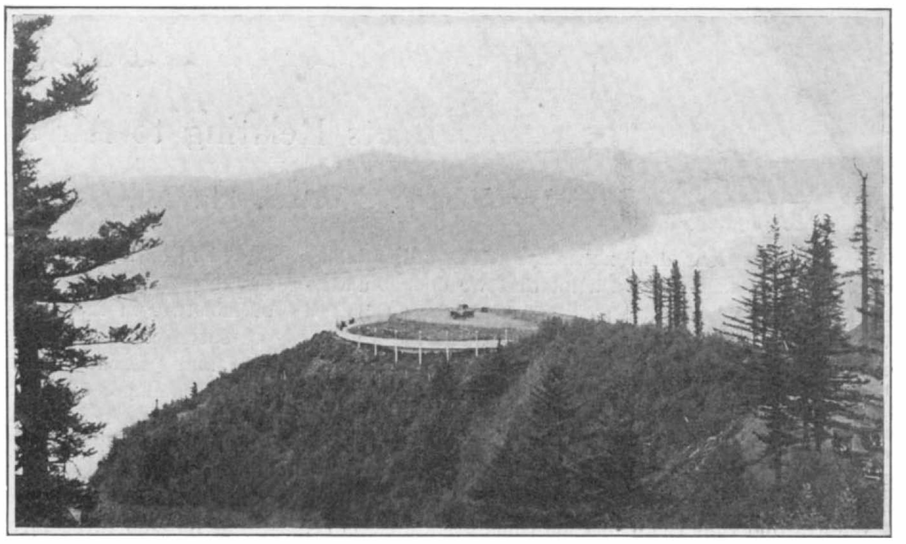
Wood is sometimes finely ground by mechanical means to yield a flour of such fineness as to render it an excellent absorbent for nitroglycerin in dynamite. Three plants are engaged in this industry in the United States.

The industry has attained much larger proportions in foreign countries, not less than twenty companies being located in Norway, Sweden, Germany, Scotland, and the Netherlands.

In the United States the raw material consists of round wood, slabs, and sawdust from white pine, small fir, and poplar. The wood is first chipped in cutters, or "hogs," after which it is screened and the uniform-sized chips then conveyed to grinders. The latter consist of two grindstones horizontally mounted on a shaft; the upper one being stationary. The grinders are operated by horizontal turbine water wheels and are direct connected. The chips are fed between the two surfaces of the stone and crushed into powder form. During the grinding just enough water is added to prevent firing. The ground wood passes next through a battery of grit gauze rotary screens, yielding wood flour of a fineness varying from 20 to 60 mesh, depending upon the use to which it is to be put. From the screens the wood flour is conveyed by a blower to the press house and baled, after which it is ready for shipment.

The cost of raw material is stated at $8 per cord for round wood, $5 per cord for slab wood, and $2.75 per ton for dry sawdust. Wood must be free from bark for use in this process. The power requirements are

View from Chanticleer Inn, on Columbia River Highway.



Crown Point and its grand panorama.

forty-five horse-power per ton per twenty-four hours. The labor cost is stated at $4.50 per ton, and the initial cost of plant at $13,000 per ton daily capacity. Besides its use as an absorbent, wood flour is used as a filler for linoleum and in the manufacture of certain grades of wall paper known as "oatmeal paper."

WOOD PLASTICS.

Wood enters into the composition of various molded or compressed bodies known as plastics, although this use of wood has not as yet been developed in this country into an industry of great importance. Wood for plastics is used in three forms—sawdust, wood pulp, and cellulose solutions.

Sawdust enters largely into the magnesia cement plastics used as artificial floorings, table tops, and tile. Sawdust and mineral filler are intimately mixed with magnesia, and the mixture moistened with a solution of magnesium chloride, molded into the desired form, and allowed to set for forty-eight hours, during which it hardens into a substance having many of the properties of both wood and stone. When the mixture is poured on glass slabs, the surface in contact with the glass becomes smooth and highly glazed.

The use of sawdust as a constituent of clay bodies that are burned into brick or tile is also of some importance. During the burning the sawdust is consumed, leaving the clay body more porous, lighter, and more valuable as an insulator. It is believed that this use of sawdust could be greatly extended in the manufacture of partition tile and clay products employed in cold-storage construction.

Sawdust and pulp are employed in the manufacture of plaster blocks, wood taking the place of sand. Such bricks, it is said, are durable, have considerable elasticity, and permit of nails being driven into them as readily as into wooden construction.

The briqueting of sawdust for fuel use has been attempted, and seems entirely feasible from the standpoint of producing a satisfactory fuel product. Such blocks, however, have not been able to compete in price with coal for equivalent heat units.

Wood pulp lends itself to the manufacture of certain types of plastics even more satisfactorily than sawdust. Of chief importance is the industry that has been developed in this country for the manufacture of fiber products, such as indurated ware and insulating conduits. Spruce and hemlock mechanical pulp and newspaper stock comprise the raw material. After thorough beating the pulp is deposited upon forms and by means of pressure and suction the pulp is molded into desired shapes and treated with various waterproofing coatings. Indurated ware consists largely of water pails, washtubs, utensils, and sanitary articles. For underground conduits the pulp is deposited on rolls, which are removed after drying and the pulp impregnated with bitumens such as asphalt or gilsonite. The use of bituminous conduits is rapidly increasing, the output of a single plant visited being reported at a carload per day of 10 hours.

The manufacture of yarn from paper pulp for use in textiles has been developed to some extent in European countries. The processes are patented,[1] one of the chief products being known as "silvalin." This is a wood yarn used by weavers in Germany for cloth, curtains, furniture cloth, carpet, and floor cloth. It is often mixed with other fiber, such as cotton, hemp, flax, wool, and jute, and such mixtures, it is said, can be cleaned by washing and boiling with soap and soda. In this country paper yarns have found their chief use in the manufacture of carpet matting.

Cellulose solutions are the basis of a large industry manufacturing vulcanized fiber and artificial silk. For the most part cotton cellulose is employed. One process, however, employs wood pulp. This is the viscose process, in which caustic soda and carbon disulphide are used to soften and partly dissolve the cellulose. While in the condition of a jelly it is forced through dies, and the resulting threads coagulated and spun into fabrics. Viscose silks are gaining rapidly in popularity, and in the opinion of American manufacturers will eventually displace the silks made from cotton cellulose by the introcellulose and copper ammonia methods.

Vulcanized fiber is made by treating cotton-cellulose paper with a zinc-chloride solution. This softens and renders the paper partly gelatinous. After washing and upon drying it is converted into a hornlke body that can be worked into many commodities, such as sprocket wheels, crank handles, trunk board, insulating pipes, fixtures, etc. It is reported that wood-cellulose paper enters into certain kinds of vulcanized fiber. The literature of cellulose plastics also describes[2] the preparation of viscoid masses from wood pulp that can be sawed, drilled, and worked in the lathe for the manufacture of articles similar to those made from vulcanized fiber.

Conferences with the technical men engaged in the manufacture of cellulose plastics and an examination of the literature on the subject lead to the belief that wood cellulose will enter largely into the manufacture of plastics in the future development of this industry.

NEEDLE OILS.

The leaves of small twigs of coniferous trees, such as cedar, hemlock, spruce, fir, and pine, contain volatile oils that can be readily obtained by steam distillation. The yield varies from 0.2 per cent to 0.5 per cent, depending upon the species and the time of the year when the leaves are cut.

The manufacture of needle oils is not an industry of any great magnitude. It is carried on by the farmers in the New England States, who sell the oil to wholesale drug houses and exporters. The distillation is carried on in small portable stills, often of wood. Direct steam is passed over the needles, and upon cooling the oil forms a layer on the surface of the water, from which it is separated and put into containers for shipment.

The principal production in the United States is from the leaves of the white spruce (*Picea canadensis*) and black spruce (*Picea mariana*), the annual quantity being estimated at 100,000 pounds. It is used in the manufacture of liniments, perfumes, and as a deodorizer. Its market price varies from 38 to 50 cents per pound. Hemlock oil from eastern hemlock (*Tysuga canadensis*) needles is often mixed with spruce oil and serves the same general uses. When kept separate it sells for 38 to 40 cents per pound.

Cedar-leaf oil is produced annually to the extent of 50,000 pounds. Its market price ranges from 40 to 70 cents per pound. It is used chiefly as an insecticide and for floor dressings and furniture polishes.

On the Pacific coast several commercial distilling establishments are producing eucalyptus oil from the leaves of the hardwood tree, *Eucalyptus globulus*. Eucalyptus oil is used in the arts and in medicine, and for such purposes has been imported largely from Australia. The oil from the California eucalyptus differs slightly from the same species grown in Australia, and this fact has retarded the extensive use of the domestic product. The yield is reported at 0.8 per cent of the total weight of the green leaves. It sells at 45 to 50 cents per pound.

The needle-oil industry, according to exporters and drug men, is not capable of any considerable extension. The quantity produced in the past has been ample to supply the domestic requirements, the variation in prices being due in part to overproduction and in part to the substitution of Siberian pine-needle oil, which can be bought in the New York markets, duty paid, for 18 to 30 cents per pound.—*Special Agents' Series No. 110, Bureau of Foreign and Domestic Commerce, U. S. Dept. of Commerce.*

[1] United States patents, Nos. 762914, 794516, 762640, 762641, 795776, and 776474.

[2] Bersch: Cellulose and Cellulose Products, pp. 154-155.

## The Brownian Movement

THE substance usually selected for exhibiting the mysterious phenomenon known as the Brownian movement is gamboge, on account of the facility it offers for obtaining extremely minute particles suspended in fluid. A much more brilliant effect is obtained with finely divided glass particles, and very little trouble is required to produce a beautiful slide showing the movement permanently and very effectively.

The following practical details may be of service to those who would like to experiment in this mysterious subject. Take a few pieces of thin glass—broken microscopic slide covers do very well—and place them in a glass mortar. One of the so-called "insulators" for pianos will serve, or a glass salt-cellar. A stone mortar is not suitable, as in the process of pounding minute fragments of the mortar mix in with the glass particles. For the same reason the pestle should be of glass, and the round knob of a glass-stoppered bottle may be used for the purpose. Half fill the mortar with water, and with pressure grind the glass as finely as possible. After grinding for a minute or two, pour away the milky water, so as to get rid of any chance impurities; fill up again with fresh water and resume the pounding. Use as much pressure as possible, and also as much patience as is at your command, for you are not likely to grind too finely. When patience is exhausted—say in half an hour—remove the pestle and allow the water to settle a little while. Then decant carefully about half the liquid into a wine glass. Cover this over and leave till next day. Then decant again, leaving the deposit behind. The fluid this time will be of an opalescent blue, owing to the extreme minuteness of the particles suspended in it. In another twenty-four hours a little will be precipitated, and a further decantation may be made. But this time the deposit may be saved, as it will probably be found that it consists of particles fine enough for our purpose. If not, the deposit of the next decanting will certainly be. Examine a drop under the microscope to test this, but it must be understood that dark-ground illumination and a strong light are absolutely essential to render the particles and their movement visible. Even an inch power objective will suffice if high-power eye-pieces are employed, but a higher power is desirable if the dark-ground condenser used will allow of it, which is not the case with the ordinary paraboloid.

If the experiment has been properly carried out the whole field should be a mass of glittering points of light oscillating in all directions continuously. A drop of the deposit which yields this effect may be carefully mounted with its fluid in a very shallow watertight cell in the ordinary way. To guard against gradual leakage, ring the cell with water-proof cement daily for several days in succession, so as to build up a good wall round the edges of the cover.

There are various theories as to the cause of the Brownian movement, any one of which would be plausible if it were not that they each contradict the others. No theory seems quite satisfactory, but into that question there is no need to enter in this communication, which is only intended as a practical exposition of a simple method of exhibiting the phenomenon in a permanent mount.—*Charles E. Benham, in the English Mechanic.*

# Modern Air

## Facts Relating to Air and Ventilation in Relation to Health

By John F. Norton, Ph. D. Asst. Prof. Massachusetts Institute of Technology

We hear a great deal nowadays about the relation of air to health. We read a lot that we do not understand in view of our own and our friends' experiences. We find much that appears to be contradictory in statements of those upon whom we look as authorities.

Somebody tells us that we should not be in the same room with persons having colds, diphtheria, whooping cough and other diseases, and then a recognized expert comes along with the statement that disease transmission through air is very limited.

We are told that the deal conditions are, for example, 68 deg. to 70 deg. F., 40 to 50 per cent humidity, and a movement of the air not sufficient to be felt as a draft, and we begin to wonder why we are told to live as much as possible in the open air, and why our friend who has had tuberculosis could possibly have been cured by an almost complete outdoor life. Someone tells us that a properly opened window gives the best ventilation for an office, while others try to convince us that an ozone machine is any great amount better.

Those of us who have made a study of the subject of air are not by any means ready to say that we know all about it, or that we can explain all the above apparent contradictions. There are, however, a number of facts about which we have definite knowledge. Some of these are known to the general public as well as to the scientist, but the general public is not always ready to give up its old traditions—for example, that sore throats are caused by leaky plumbing—and the scientist is too often unwilling to put his knowledge in such a form that it is either intelligible or convincing. Some of the present day facts and ideas are so directly opposed to what was firmly believed by our grandmothers that the whole subject of air has taken on a modern aspect which is so unlike the old that we might almost believe we are dealing with an entirely different sort of atmosphere. In fact, we are almost doing that in the modern home, office or hospital, so that we may perhaps be justified in speaking of "modern air."

Air is such a vital thing, a source of danger as well as a necessity, that it is worth while to know something about its relation to our own health and comfort. We can look at it from two standpoints, which amount to the same thing in the end.

First, what is the connection between air and the chance for getting any specific disease? Many diseases are due to the activities in the body of micro-organisms, which are living organisms of comparatively simple structure and yet have independent existence. The organisms act generally through the formation in the body of some poisonous non-living substance. The question is, What diseases may be transmitted through the air and what are the chances of getting them? This may be answered in a general way by saying that there is a possibility of infection in those diseases in which the germs are given off from the skin, nose or mouth—diphtheria, tuberculosis of the lungs, etc. Now, in most cases it is necessary to be quite close to the person having the disease, as the germs settle fairly quickly with dust particles or water droplets and die rapidly. The organisms of tuberculosis may, however, live for some time and enter the body with dust and dirt. It is a fact, therefore, that unless we are in contact with an infected person or are so close that we may receive spray from coughing or sneezing, we are in very little danger of getting disease germs from air. That this is true is also demonstrated by the tendency of some modern hospitals to treat the various infectious diseases in the same ward, care of course being exercised by the nurses and attendants so as not to spread any disease by acting as carriers between two patients.

The second question is this: What is the relation of the condition of air to general health and therefore to resistance toward disease?

Let us first consider the condition under which we are comfortable or uncomfortable. Hill has studied the average temperature and humidity of various health resorts and found that there is a relation between these two physical factors and bodily comfort. Where the temperature is high, 80 to 90 deg. F., the humidity should be low, 20 to 30 per cent. At 68 to 70 deg., the indoor temperature demanded by most of us, the humidity should be 50 per cent. When the temperature is low, 55 to 60 deg. F., a higher humidity is preferable, 65 to 70 per cent. These are, therefore, two of the important factors. In addition it is necessary to have some movement in the air. According to the most generally accepted ideas it is these three physical conditions of the air, temperature, humidity (i. e. the ratio of the amount of moisture in the air to the amount which would be present if the air were saturated at the same temperature and pressure) and motion, which influence our comfort and possibly our general health. If these conditions are not right we may feel tired, lazy, headachey, even nauseated, and under prolonged exposure our resistance to disease may be lessened with perhaps fatal results.

But how do these three factors act? By their effect on the rate of loss of heat from the body. Heat is lost in three ways: (1) Any substance, when passing from liquid to vapor, absorbs heat. Thus when liquid water on the surface of the body *evaporates*, heat is removed from the body. (2) If two substances at different temperatures are placed in contact with each other, for example, if a hot piece of iron is immersed in a pail of cold water, heat passes from the body of higher temperature to that of lower temperature, and this will continue until the bodies have the same temperature, provided no heat is supplied to or removed from the system. Thus the human body will *conduct* heat to the surrounding air when the temperature of the latter is less than 98.6 deg. Fahr. Heat may also be carried by *convection* currents. These two, conduction and convection, may be grouped together and called heat loss by *transmission.* (3) Heat may pass between two objects in the form of *radiant energy.* To sum up, heat may leave the animal body by *evaporation*, *transmission* and *radiation.*

The *amount* and *rate* of heat loss by these methods are directly influenced by the temperature, humidity and motion of the surrounding air.

Further explanation will serve to make this clearer. Evaporation will increase with increase of temperature, for the higher the latter the more rapidly will the air take up moisture. It will increase with decreased humidity, for the lower the humidity the greater will be the amount of moisture which the air can receive. Evaporation will increase with increased motion, because the air surrounding the body will be changing rapidly, thus allowing air of low moisture content to replace that which has taken up its share from the body.

Heat loss by transmission will be greater, the greater the difference of temperature between the body and the surrounding air. The human body differs from the illustration given by the hot iron in that its temperature remains practically constant, as heat is supplied by internal combustion as fast as it is given off. Since moist air is a better conductor of heat than dry air, transmission is aided by high humidity. Motion affects loss by this method as it does loss by evaporation, that is by continually bringing fresh air to the body. Motion also increases convection currents.

Radiation is doubtless influenced by these factors, but we have little knowledge concerning it.

The above brief discussion will give the principles involved. Indeed, no one can deal with exact quantities, for we have no data on which to make a quantitative statement. All we can say is that, according to the ideas in vogue, a comfortable or uncomfortable feeling is due respectively to the proper or improper loss of heat from the body, and that this loss depends upon the physical condition of the air.

But this explanation does not seem to fit all facts. for if it did, why not live indoors with air of a specified variety and be just as healthy as if we lived outdoors with the same air? There seems, therefore, to be some factor which we have not yet found, and which is just as vital as those discussed. There is certainly a stimulation about outdoor air which is absent indoors, and Hill has suggested a "factor of stimulation" which may be concerned. But it is something entirely apart from our present knowledge.

Let us, however, apply what we do believe, and increase our comfort and health by insisting upon being supplied with properly conditioned air, at least in schools, offices, halls, etc., where it is quite possible to furnish it at a reasonable expense.

Methods of temperature regulation of air, at least as far as heating is concerned, are too well known to need any description. Air is sometimes cooled in the summer—a proposition not so common as heating. The easiest way to do this is to pass the air through a stream or "curtain" of cold water. Where expense is of no importance, as should be the case in a hospital, pipes containing chilled brine may be employed, that is, the air should be passed through a refrigerator.

Methods for regulating the moisture contents of air may not be quite as familiar. The most important has already been referred to, that is, passing the air through a curtain of water formed by small streams from a large number of little nozzles. The humidity of the air after this treatment will be about 95%. In order to regulate the humidity in a room it is therefore only necessary to have the air passing through the water at a definite temperature. For example, if we wish to obtain a humidity of 60 per cent in a room with a temperature of 65 deg. Fahr., we must have the air in the humidifier at about 51 deg. The amount of moisture taken up at this lower temperature will be the proper amount to give the required humidity at the higher temperature. In factories another method of humidifying is sometimes used, i. e. spraying moisture from a wet revolving brush.

The proper movement of air through a room is not always an easy matter to realize, but it can usually be done with the exercise of sufficient care. Both downward and upward ventilation are used. It is quite useless to discuss here the relative merits of the two, as either can give good results. The ideal way would seem to be to admit the air through a large number of small openings, and this is sometimes done.

It is thus quite possible to get into a school or other building the kind of air we desire from a purely physical standpoint. What, then, about dust, street sweepings, bacteria and other "impurities"? These can also be removed by screens, or better, by air washers—the humidifiers we have just described. This disposes of any objectionable material from outside. But what about the material which gets into the air from people living or working in the room? It used to be supposed that the carbon dioxide given off from the lungs was poisonous, but this was shown to be false some time ago. It was also supposed that small organic particles known to be given off in the breath and from the skin were poisonous, but the latest work has thrown considerable doubt on this. However, these particles may be disagreeable, as many of them have an unpleasant odor. The most popular remedy for this has been the use of that most popularly discussed substance, ozone.

That ozone in sufficiently large amounts and in the presence of sufficient water is a good disinfectant is admitted, but under the conditions existing in a room and in amounts small enough not to be objectionable to the nose and throat, it is quite useless. But what of that? We have already said that disease transmission through the air is negligible. Is ozone, then, of use in removing odors? Ozone is also a strong oxidizing agent, and under the proper conditions can be made to oxidize the organic substances causing the odors, but here again it is necessary to have so much ozone present that it is irritating to most of us. The way to remove odors is to furnish a sufficient supply of clean air so that the obnoxious substances will be carried out of the room through the ventilators.

Sewer air is a thing of which many are afraid. While it is true that this is not the cleanest kind of air and that it is certainly not healthy to live in an atmosphere of it, still, no specific disease can be obtained from it. Gases from a leaky furnace, containing carbon monoxide, are far more common and more dangerous.

We have heard considerable during this winter of prevalent grippe about the dry air of our houses. Just how much effect this has is doubtful, as the normal healthy throat seems to be able to adjust itself to changes in humidity such as usually occur in a house. Over-heating makes one much more uncomfortable than too little moisture.

Our modern air, then, in schools, offices, public buildings and homes ought to be free from dust and odor, to have the proper physical characteristics and to be supplied in sufficiently large amounts. This modern air will play a distinct and highly important part in our efficiency. But at the same time we must not forget that other, probably unknown, effect of outdoor air in stimulating us for still better work. If we cannot get this in the daytime we can at least get it during sleep at night. The old-fashioned bad air included night air, the idea being recently expressed by a humorist in the only really funny newspaper column, in the following verse:

"Last night, friend wife in fresh air frenzy
Threw ope the window and in-flu-enzy."

## Dynamical Stability of Aeroplanes*

By Jerome C. Hunsaker

The first rational theory of the dynamical stability of aeroplanes is due to Bryan[1] whose work was extended and applied by Bairstow[2] with wind tunnel tests on models.

The utility of such tests in predicting the aerodynamical properties of a full size aeroplane is now well understood and the validity of this application has been repeatedly demonstrated. The late E. T. Busk of the Physical Staff of the Royal Aircraft Factory, England, applied Bairstow's model tests to the design of an aeroplane and recently succeeded in perfecting an inherently stable machine which could be flown "hands off. Neither the details of Busk's experiments nor of the type of aeroplane developed by him have been disclosed by the British War Office.

My present investigation of two different types of aeroplanes, one a standard military tractor with no claims to inherent stability in flight, the other a machine designed to possess some degree of inherent stability while departing as little as possible from standard practice as exemplified by the other, has for its object:

(*a*) To determine the aerodynamical constants for the two aeroplanes by means of model tests in the wind tunnel.[3]

(*b*) To apply the aerodynamical constants so found in the dynamical equations of motion for the full scale aeroplane in free flight and to examine the stability of the motion.

(*c*) To compare the stability, both lateral and longitudinal, of the two chosen types of aeroplane, with a view to tracing to the individual parts of each machine their effects upon the motion.

(*d*) To attempt to formulate general qualitative conclusions which may assist constructors of aeroplanes to avoid instability or to provide any desired degree of stability.

(*e*) To throw light upon the general problem of inherent dynamical stability.

*Stability Distinguished as Statical or Dynamical.*—An aeroplane in horizontal flight in still air must be driven at such speed and kept at such an inclination of wings to wind that the weight is just sustained. When in this normal attitude the aeroplane, if properly balanced, is in equilibrium. In a statical sense, this equilibrium is stable if righting moments are called into play tending to return the aeroplane to its normal attitude if by any cause it is deviated therefrom. In general, an aeroplane, if stable in a statical sense, will, when given an initial deviation, take up an oscillation which either may be damped out or may increase in amplitude. The aeroplane is dynamically stable if, and only if, these oscillations die out as time goes on, leaving the aeroplane in its original normal attitude. It is clear that statical stability must first be provided before the dynamical stability of a design can be examined.

The righting moments which tend to restore the aeroplane to its normal attitude are a measure of statical stability. If the statical stability is great, the period of the oscillations will be short and the motion violent, whereas an aeroplane should have a gentle motion of slow period heavily damped. An ocean liner of too great stiffness (large metacentric height) is not suitable for passenger or cattle carrying service; it is preferable in ship-design to give only enough metacentric height to insure that the vessel in never unstable and to damp the roll by generous bilge keels. In a similar manner the theory indicates that, in aeroplane-design, it is preferable to give just enough statical stability to insure that the aeroplane is never unstable and to make the oscillation dynamically stable by the use of generous damping surfaces and large wings.

The investigation is most conveniently discussed in two parts, the first dealing with the "longitudinal" motion involving pitching of the aeroplane and rising and sinking of its center of gravity combined with change of forward speed, and the second with the "lateral" motion, which involves side-stepping, or skidding, combined with rolling and yawing to the right and left.

*Longitudinal Motion.*—From the dynamical equations of motion for the full scale aeroplane written down with the aerodynamical co-efficients determined by tests on the models, the small oscillations about the equilibrium position are determined by three simultaneous linear differential equations with constant coefficients, of which the solution shows that the motion may be considered as composed of two oscillations, one of a period of the order of 2 seconds damped to half amplitude in 0.1 second, the other of period from 10 to 30 seconds not very strongly damped. The short oscillation appears never to be of importance in ordinary aeroplanes, but the long oscillation, being only moderately damped, may cause trouble, especially for an aeroplane that flies with a large angle of incidence for the wings.

The calculation of the period and damping of the long oscillation was repeated for several speeds from highest to lowest corresponding to small and large angles of incidence with the result shown in the following table:

| Aeroplane* | S | S | S | S |
|---|---|---|---|---|
| Velocity, miles-hour | 76.9 | 53.4 | 44.6 | 36.9 |
| Incidence of wings | 0.° | 30.° | 6.° | 12.° |
| Period, seconds | 34.7 | 17.6 | 15.8 | 10.56 |
| Damp 50 per cent, seconds | 8.1 | 11.0 | 13.1 | .... |
| Double amplitude, seconds | .... | .... | .... | 24.7 |
| **Aeroplane*** | **U** | **U** | **U** | **U** |
| Velocity, miles-hour | 79.0 | 51.8 | 47.0 | 44.2 |
| Incidence of wings | 1.° | 7.° | 10.° | 14.° |
| Period, seconds | 34.0 | 16.7 | 13.7 | 11.5 |
| Damp 50 per cent, seconds | 11.0 | 17.7 | 63.0 | .... |
| Double amplitude, seconds | .... | .... | .... | 24.7 |

* The letters S and U represent respectively the machine designed for inherent stability and a standard military tractor.

*Instability at Low Speed.*—It appears that the period becomes much more rapid at low speed, that at some critical speed the damping vanishes, and below this speed both aeroplanes become frankly unstable. This instability at extreme low speed is common to all aeroplanes and the only advantage of our "stable" aeroplane S is that its longitudinal motion is stable down to about 40 miles per hour while aeroplane U is stable only down to about 47 miles per hour.

A study of the relative magnitudes of the coefficients for these typical aeroplanes leads to the conclusion that longitudinal instability at low speed is due, first, to the decrease in damping of the tail surfaces on account of the low speed, and, secondly, to the decrease in rate of change of lifting force with change in attitude for high angles of incidence. The latter has a predominating effect on the damping of the long oscillation. Consequently, if an aeroplane is to be stable and land at a relatively slow speed, it must not operate at too great an angle of incidence. To sustain its weight it should therefore have a comparatively large wing area. The principal difference between aeroplanes S and U is that the former supports a weight of 3.55 pounds per square foot of wing area and the latter 5.2 pounds per square foot.

The following recommendations are made for an aeroplane to have its longitudinal motion damped at lower speeds than is usual in practice: (1) Provide large horizontal surfaces of long arm for damping the pitching. (2) Provide wings of such area that the slow speed does not require a great angle of incidence. Roughly the safe slow speed should not require more than 80 per cent of the maximum lift of the wings. (3) Keep the longitudinal radius of gyration small by concentrating the principal weights.

*Slowness in Pitching.*—It may be imagined that a dynamically stable aeroplane of rapid period might be so violent in its motion that the pilot would be shaken about to such an extent as to be hindered in the performance of his military duties of observation, gun-fire, or bomb dropping. It appears that the expression representing the period of the long oscillation contains certain predominating coefficients, and a consideration of their magnitude leads to the following conclusions: The natural period of pitching is increased by: (1) High speed of flight; (2) Large damping surfaces on the tail; (3) small angle of incidence; (4) Small righting moments.

*Lateral Motion.*—After measuring the aerodynamical coefficients, and the radii of gyration in roll and yaw, the dynamical equations for the asymmetrical or lateral motion may be set down. For small oscillations these reduce, as in the longitudinal case, to three linear differential equations with constant coefficients. The determinant formed from the coefficient may be factored by use of approximate methods and the motion may be compounded from that represented by each of three factors.

*Spiral Dive.*—The first factor may correspond either to a damped or to an amplified motion. At high speeds model S shows a subsidence damped to half amplitude in 10.4 seconds. At lower speeds this damping diminishes and at 37 miles per hour the motion becomes a divergence which doubles in amplitude in 7.2 seconds. Aeroplane U is spirally unstable at high speeds. Examination of the preponderating terms in the expression representing the motion shows that the aeroplane starts off on a spiral dive.

A simple relation may be obtained involving four of the aerodynamical coefficients which, if positive, insures that spiral instability of this kind is not present. It appears that spiral instability is caused by too much fin surface to the rear or too large a rudder and by not enough fin surface above the center of gravity. A proper adjustment is easily obtained without sacrifice of desirable flying properties. Aeroplane S has a small rudder and wing-tips raised about 1.6 deg.; aeroplane U has no rise to wing-tips nor vertical surface above the center of gravity and has a very deep body giving the effect of a rear vertical fin. These differences in design account for the respective stability and instability of the two machines.

*Rolling.*—The second factor in the equation of motion represents a rolling of the aeroplane which is so heavily damped by the wide spreading wings as to be ordinarily of no consequence. In the extreme case of a "stalled" aeroplane, the damping of the roll vanishes because the downward moving wing has no more lift than the other. Here we may expect trouble, and frequent accidents to stalled aeroplanes indicate that the pilot's lateral control by ailerons also becomes operative.

*Dutch Roll.*—The third element in the motion is a yawing to right and left, combined with rolling. The motion is oscillatory of period from 5 to 12 seconds, which may or may not be damped. The analogy to the "Dutch Roll" or "Outer Edge" in ice-skating is obvious. If the skater leans too far out on his swings he may fall, and in the same manner if the aeroplane bank too much a slight puff of wind may capsize it.

The motion of the Dutch Roll is stable provided there be sufficient vertical fin surface on the tail and not too much fin surface above the center of gravity. These requirements conflict with those previously stated for spiral stability and a compromise must be made. Overcorrection of spiral instability may produce instability in the Dutch Roll and *vice versa*. Fortunately, the damping of rolling by the wings is helpful in both cases, and it appears possible to obtain that nice adjustment of surfaces which will render both motions stable.

Model S was stable in the Dutch Roll at all speeds, having a period from 6 to 12 seconds, and the initial amplitude damped 50 per cent in from 1.5 to 6 seconds. Model U was stable in this respect except at low speed when it showed a period of 6 seconds and the initial amplitude was doubled in 8 seconds.

The following table summarizes the results obtained for the lateral motion:

| Aeroplane | S | S | S | U | U |
|---|---|---|---|---|---|
| Rise of wings | 1.63° | .... | .... | 0.0 | .... |
| Angle of incidence | 0.° | 6.° | 12.° | 1.° | 15.5° |
| Velocity, miles | 76.9 | 44.6 | 36.9 | 78.9 | 43.6 |
| Spiral Motion: | | | | | |
| Damp 50 per cent, seconds | 10.4 | 2.7 | .... | .... | 3.3 |
| Double, seconds | ..... | .... | 7.2 | 28.0 | .... |
| Dutch Roll: | | | | | |
| Period, seconds | 5.9 | 10.7 | 12.0 | 5.2 | 5.7 |
| Damp, 50 per cent, seconds | 1.4 | 1.3 | 6.0 | 1.8 | .... |
| Double, seconds | ..... | .... | .... | .... | 7.7 |

*General Conclusions.*—It is believed that the majority of modern aeroplanes are spirally unstable but stable in the Dutch Roll. Furthermore it appears to be a simple matter so to adjust surfaces that any aeroplane can be made completely stable without sacrifice in speed or climb. At extreme low speed an aeroplane must be unstable in its longitudinal motion but need not be unstable laterally.

The degree of stability to provide in a given case cannot be determined from mechanical considerations alone. For example, the comfort of the pilot must be a first consideration and for this reason the righting moments giving statical stability should be small; the period of the aeroplane can then be made relatively slow, and if the damping is adequate, the free oscillations will be stable.

The theory is applied here only to flight in still air. Obviously the air is never still, and the aeroplane must finally be judged from its behavior in gusts. An inherently stable aeroplane tends to preserve its normal attitude with relation to the relative wind, and if the velocity and direction of the relative wind change in an irregular manner, the stable aeroplane will tend to follow. The result will be to force on the aeroplane a motion which will be more violent the greater the statical stability. Consequently in rough air an aeroplane very stable statically is unsuitable as a gun platform and for many other military purposes.

Considerations of theory indicate that a slight degree of statical stability combined with the maximum of damping give an aeroplane slow periods of oscillation and a dynamically stable motion, with little ill effect upon performance or controllability.[4]

* Proceedings of the National Academy of Sciences.

[1] G. H. Bryan, "Stability in Aviation," Macmillan, 1910.

[2] L. Bairstow, "Technical Report of the Advisory Committee for Aeronautics," London, 1912–13.

[3] A description of the wind tunnel and the results of some experiments therein may be found in *Smithsonian Inst., Misc., Coll.*, 62 No. 4, 1–92 (1916).

[4] Full details of this investigation will be offered for publication in a forthcoming number of *Smithsonian Misc., Coll.*

# The Projecting Lantern*

## Its Principles Development and Operation

By John B. Taylor

Such consideration as can be given to the projecting lantern in part of an evening meeting must of necessity be brief and, in parts, disconnected. Books on the subject run to several hundred pages and I admit the omission of consideration of some phases on the subject. In fact, a number of treatises might be written without exhausting the field, for its different aspects include everything that the illuminating engineer may meet in any of his activities. Engineering (mechanical and electrical), chemistry, physics, optics, physiology and psychology—all these sciences are essential and each contributes its part in a greater or less degree. When all these divisions have been considered there still remains the artistic side, which is perhaps less tangible but quite as important.

The "magic-lantern" and the "magic-lantern exhibition," to select from the great confusion of names all relating to the same thing, has reached the stage where no home, school, church, theater or public gathering place of any kind is complete without one. In these places it serves for education, entertainment and as an aid to the world's business activities.

Educational uses of the lantern have changed from first to second place in the few years since the cinematograph exhibition or now familiar "movie," with its ramifications, has come to be such an enormous industry. There is an old bit of philosophy to the effect that a nation is molded and influenced more by its songs than by its laws. This I may parody by saying: Let me produce the "movies" of a nation and I care not who makes its laws. It is to be regretted that of the miles of film pictures shown daily, those devoted to instructing, educating and inspiring may be measured in feet.

Reference has just been made to the confusion of names for the apparatus which produces an enlarged image of a picture or object on a screen. The term "magic-lantern" was quite appropriate so long as the uses were mainly for mystifying and entertaining. The lantern was well developed before the art of photography. The apparent desire to eliminate the word "magic" after the apparatus was put to serious uses brought forth a number of terms[1], of which the poorest seems to have taken the deepest root. The misused term is "stereopticon."[2] There is nothing "stereoscopic" about it. The word "sciopticon" is now seldom used in this country, though it was well known some years ago and might well have been retained. "Projecting lantern," which term I use myself, is not the most desirable, as it should apply more properly to searchlights and apparatus for galvanometers, oscillographs and the like. Some inaccuracies and much confusion would be avoided by designating the apparatus as a "picture lantern" and the finished product as a "lantern picture." The terms are simple, shorter than many, accurate and sufficiently broad to cover all forms, whether adapted for transparent or opaque objects, vertical, horizontal or microscopic, separately or in any combination.

At present, probably over 99 per cent of lantern picture work is done with transparent photographic slides or films. As developed and practically standardized, the elements are the source of *light* (or radiant), the collecting and *condensing lens* (or system of lenses or reflectors), the *objective* (system of lenses forming the image of the slide) and the *housing* to confine stray light from the radiant. Whoever first added the condenser put the lantern essentially into its present form.

The first beginnings of the art must go to pre-historic times with shadow pictures on cave walls and ceiling with fire or pine torch as sources of light. The pictures were followed by inverted images in a crude "camera obscura," a light-tight box with a small hole serving in place of the later lens. As soon as a lens was added to take the place of the pin-hole, a *camera* was available and photography awaited only the light sensitive plate.

* A paper read at a meeting of the New York Section of the Illuminating Engineering Society, January 13th, 1916. Republished from the *Transactions* of the Society.

The Illuminating Engineering Society is not responsible for the statements or opinions advanced by contributors.

[1] Photo-electric lantern, solar lantern, stereopticon, sciopticon, diascope, episcope, epidiascope, megascope, aphgenscope, polyopticon, projecting lantern, dissolving lantern, projectoscope, radiopticon, balopticon, delineascope various "scopes" preceded by proper names, etc., not to mention any of the moving picture apparatus.

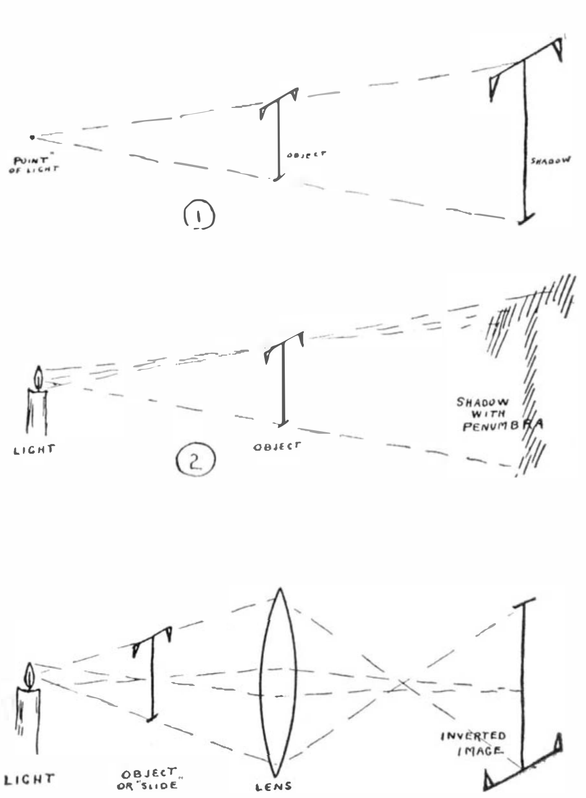
[2] Properly a "stereopticon" has to do with a pair of pictures taken from a slightly different view-point. Various devices may be used to present one of this pair to the right eye and the other to the left eye. The resulting appearance of relief or solidity is striking, but the added expense, complication and need for use by audience of special viewing devices have prevented any wide-spread use of such a properly called "stereopticon."

Inverting the *camera obscura* by enclosing the light source and object resulted in the "opaque projector." Many forms of this under various names have recently come on the market.

The picture lantern for opaque work is simpler than the lantern for transparencies, as the condenser may be omitted. Unless a translucent screen is used, with a lantern on one side and observers on the other sides, the image of the picture is reversed. For serious work and whenever there is reading matter, a mirror to correct this reversal is an essential. Compared with the lantern for transparencies, the condenser may be dropped and a mirror should be added.

The enlarged picture on the screen from a slide may be regarded as a shadow picture in which the condenser is the source of light of such a nature that each part of its surface radiates light in only one direction. These directions being symmetrical about an axis, there is produced a shadow on the screen of the picture on the slide, which is inverted; i. e., top becomes bottom and right becomes left. If the light could be the overworked hypothetical "point-source," and a well corrected lens system used as a condenser, the objective could be omitted.

A series of diagrammatic projection lanterns for transparent slides, proceeding from the simple shadow picture to the present standard arrangement, is shown in Figs. 1 to 7.




**Projection diagrams.**

Fig. 1 illustrates the ideal shadow picture with a "point-source" of light. Here the size of screen picture may be made as large or small as desired by regulating the distance between slide and the "point-source."

Fig. 2 illustrates the practical shadow picture in which the light or radiant has appreciable dimensions and must be sufficiently removed from the slide (or other object) to prevent heat damage. The lines of the screen picture are bordered with a penumbra—details cannot be shown sharply.

In Fig. 3 a lens has been added which occupies a definite position between the object and the screen. The penumbra is eliminated since the lens redirects the diverging radiation, i. e., the slide and screen are conjugate focal planes of the lens. Neglecting aberrations, the screen picture may be sharp; fine details may be shown. Unless the light source is an extended surface, the objective must be larger than the slide. This leads to a lens of almost impossible dimensions if the radiant is close to the slide (which is as it should be for efficient utilization of the light) and if the lens is a foot or two removed from the slide (which it must be to give a picture of not too great a size on the screen). Note also the inversion between the slide and the screen. This form of projection is used with the microscope where the small size of the object and the short distance to objective do not require lenses of impossible sizes.

Fig. 4 shows the addition of a condensing lens. This may be regarded as an extended light source—larger than the slide and close to it without burning it up—which permits the objective lens to be of reasonable dimensions. The radiant and objective are conjugate on the condenser. Thus the objective need be no larger than the image of the radiant which in practice is magnified two to six diameters. Besides thus directing the light into an objective lens of moderate dimensions, the condenser incidentally forms a fire-proof wall between the radiant and the slide. This is of greater importance in moving picture projection and microscopic work when the arc or other radiant would have to be extremely close to film or specimen in order to utilize any considerable flux of light.

Fig. 5. In a properly adjusted lantern using a carbon arc the objective may be removed entirely and still leave a recognizable screen picture of the same size and position. The hazy outlines result from size of light source and uncorrected condenser aberrations.

Fig. 6 is somewhat similar to Fig. 4. The condenser is made up of two pieces of glass mounted with convex surfaces inside and plane surfaces outside, which combination gives less serious aberrations than an equivalent single lens which must have great thickness. The most common objective if not taken directly from a portrait camera has been fashioned after the classical Petzval combination. This lens has a large aperture and covers satisfactorily the relatively small lantern slides. This type of lens became firmly established as a projecting lantern objective at the time when kerosene lamps with two or more large wicks were common sources of light. As the flame from such a lamp is partly transparent, a reflector as indicated increased the flux of light in the direction of the condenser. A large aperture objective was essential to utilize efficiently the large light source. On the camera these lenses were designated as one quarter size, one half size and full size, as applying to the size of the photographic plate. These objectionable terms, instead of essential information as to an equivalent focus and size of aperture, have long been given to the public by lens and lantern makers. Even after the extensive use of smaller and more brilliant sources of light have made possible the use of smaller and better corrected lens, the descriptive literature and lenses themselves are put out with no indication of optical length or breadth.

Fig. 7 is a typical diagram of the modern lantern. The source of light is a carbon arc. The condenser may be divided into two or three elements as here shown. With the three elements, the relatively thin meniscus of lesser diameter can be placed close enough to the arc to use an appreciably greater flux of light. The water-cell for absorbing much of the undesirable infra-red radiation is an essential part of every up-to-date lantern. It should be located between the condenser elements where the light flux is approximately parallel. The water-cell will be further considered a little later. The objective should be a well corrected lens of moderately large aperture. The modern photographic "anastigmats" are excellent, though expensive and often better than other parts of the apparatus and condition of operation justify.

The lantern for opaque cards, etc., is made to appeal strongly to the amateur in advertising literature. The results are frequently disappointing. The photograph, picture, drawing, page of book or other object is brightly illuminated. Of the light reflected from the object a small portion only is directed toward the objective. Occasionally specular reflection from parts of the object strike the lens and give extremely bright spots, making a disagreeable contrast with the darker portions. Two or more light sources or a divided beam is often the arrangement to reduce deep shadows of solid objects and to generally equalize contrasts. The lenses should be well corrected and of the largest possible aperture. This condition reduces the depth of focus, making the screen picture liable to blurring in parts. The large aperture requirement makes proper objectives very costly and therefore a lens of only moderate focal length is supplied or selected. The shorter focus means a larger screen picture with still further reduction in brightness. The opaque lantern must therefore be set closer to the screen in a position which is not always satisfactory. If provision is made for transparent slides in the same piece of apparatus a separate projection lens of even less focal length is provided so that the picture from the relatively small slide will appear at least as large as the opaque picture. (The slide picture should properly be larger.)

The short focus lens with a lantern close to screen is not the best arrangement for reasons other than convenience of location.

In selecting a lantern equipment for any situation

there are several interlocking factors. The screen position must be selected and the size of picture determined. Extremes in distances from observers should be avoided by placing a screen well back on the stage, or by removing some of the front rows of seats. The screen should be low to avoid discomfort from looking up.

The lantern should be back of the audience and as nearly as may be on a level with the center of screen. Unless the optic axis of the lantern is perpendicular to the screen, a distorted picture appears on the screen.

The screen should preferably be vertical, but a slight angle is permissible when the lantern cannot be placed on the proper level. A screen too much off the vertical is just as objectionable as a distorted picture.

Other things remaining the same, a smaller picture is brighter, and unless carried too far the greater brightness compensates in a measure for the reduction in size of details. The smaller picture appears better from the front rows; its center is lower, requiring less tilting of the lantern and therefore less distortion of the picture.

The further the lantern can be moved back the less the need of tilting and the less distortion. Long focus lenses are therefore indicated as generally desirable. A 6-inch e. f. lens has been supplied as a matter of course with many cheap and moderate priced lanterns, unless the purchaser is experienced and demands a lens better adapted to general conditions. The justification for this lens giving a larger picture with the lantern up front, passed with the waning of the kerosene lamp. If all the 6-inch objectives put out could be replaced with 10-inch objectives, and all those of 10-inch replaced with 18-inch, more satisfactory demonstrations would result.

With the size of the picture and the lantern distance fixed, the focal length of objective is determined. This in turn determines the proper focal length for that element of the condenser next to the slide. The focal length of the condenser element toward the radiant determines the flux of light that is utilized. The diameter of the condensing lenses should be ample to cover the slide without showing colored fringes or reduced illumination in the corners.

Theoretically a large radiant like the kerosene burner requires a greater diameter of condenser than does the carbon arc.

After the objective is placed in the position to focus the slide on the screen, the radiant is moved to the position which focuses its image in the center of the objective. It should be noted that changing the position of the radiant at the same time changes the light flux entering the system and passing through the condenser, slide, objective and on to screen. A change in objective to one of quite different focal length should be accompanied by a corresponding change of front element of condenser, so that the radiant may remain in its proper position.

Many expert operators and even some lantern manufacturers will argue that a more powerful light is needed to "throw" a picture from a properly designed and adjusted lantern 40 feet away than is needed for the same size picture with a proper lantern 20 feet away—as though the light became "tired" along the way.

In both cases the same flux of light is passed by the slide, directed toward the screen and spread over the same area. Unless the room is full of smoke, absorption of light in these distances is negligible. A demonstration with two pictures side by side or photometric readings on the two pictures should (but does not always) end the argument.

Nearly all the illuminants from the tallow candle to sunlight have served in lantern picture service; various forms of electric lights have been adopted. When electric energy is available, the carbon arc holds the field. The electric incandescent is widely used when a moderate amount of light is sufficient, as it has so many advantages. Where there is no current, the oxyhydrogen lime light (calcium light, or Drummond light) has long been pre-eminent. Also for small pictures or where great brilliancy is not necessary, acetylene serves well in the absence of electricity.

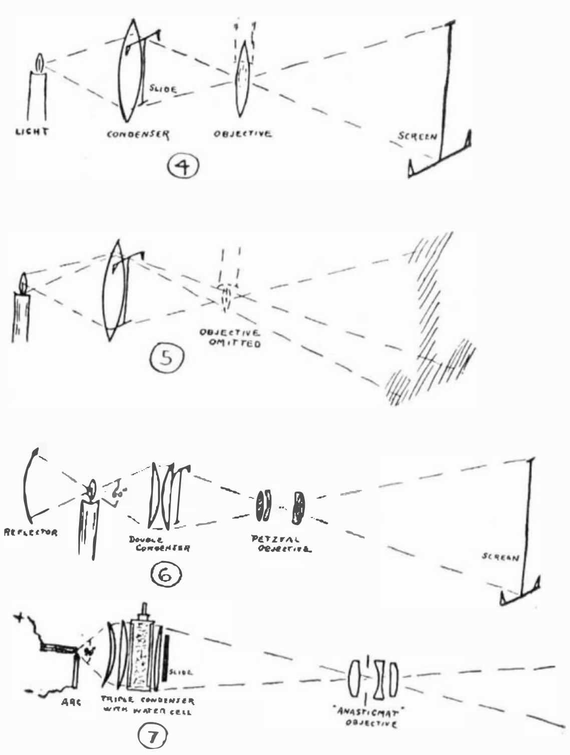
In appraising an old or possible new illuminant, the following points should be considered: Total light flux; light flux in useful direction; possibility of using reflector; "point-source" (size of radiant and intrinsic brilliancy); color; efficiency (undesirable heat production); ventilation required; ease of starting; steadiness of operation; quietness of operation; expense of operation; expense of replacements; life, reliability, fragility; safety; skill required to adjust and operate; bulk and weight; initial cost.

In this age of "regulation" it is surprising that legislatures, commissioners and censors have not meddled more with the requirements as to "minimum candle-power in the movies," etc.

Lantern slides are frequently shown with satisfaction where the illumination is ½ foot-candle or less in the clear whites of the pictures. On other occasions the reading may be found to be ten to twenty times as great. For moving pictures a brighter screen picture seems desirable, though in those cases where the same lamp is used for moving pictures and for regular lantern slides, the slides will be about twice as bright unless the current is cut down or some kind of absorbing screen interposed.

Many different surfaces and fabrics have been used as screens. Of these which should be opaque, some transmit and waste quite as much light as they reflect. Aluminium painted or other metal surfaced screens show the picture by light which is largely specularly reflected. These appear brilliant to the observer in a favorable position, but viewed from the side there is great unevenness. Photometric measurements may show as great variation as 5 or 10 to 1 and this condition is aggravated with the use of a short focus, wide angle objective. Under extreme conditions the side of a picture away from the observer may appear almost black. Such conditions are most common with translucent screens. The necessity for viewing the ground glass of a photographic camera nearly in the direction in which light is proceeding after leaving the lens is familiar to many. While the special translucent screens distribute better than the common ground glass ones, those demonstrations in which the lantern and spectators are on opposite sides of the screen are especially liable to uneven pictures. Apart from the greater straight line transmission inherent in the screen, the available space back of the screen usually calls for short focus lenses and the wide angle between the extreme ray on one side and line of vision of observer on the other side explains the many unsatisfactory results.

Familiarity breeds contempt, and more was expected of the lantern operator in the days when oxy-hydrogen




**Projection diagrams.**

lime lights in double or even triple lanterns were the order of the day at pretentious demonstrations or lectures. The pictures were skillfully dissolved; many ingenious mechanical slides were devised; the second and third lantern aided in producing special effects like sunrise and sunset, moonrise, lightning, rain, snow, etc. Experiments and demonstrations in chemistry and physics were shown enlarged on the screen; thermometers, galvanometers, etc., were specially constructed to fit the lantern.

The spectacular element is not overlooked in the popular moving pictures, but little seems to have been done lately in producing new experimental devices adapted for projecting. Even the older well worked out devices are frequently overlooked.

The water-cell has been referred to. Through omission of this or an equivalent heat absorbing device many valuable slides are ruined. Color slides of the autochrome variety are sensitive to heat on account of the varnish softening. Hand colored slides are more liable to fade through excessive heating. Microscopic slides and larger slides mounted after the same manner with balsams are easily damaged by overheating. Even the ordinary slides are frequently cracked or otherwise damaged by too rapid evaporation of moisture enclosed. The water-cell is admittedly an added care. Unless the water has been freed from air by boiling, bubbles appear which may show on the screen. The cells do not hold enough water to go through a usual exhibition without boiling. This means delay in changing cells or replacing water. However, until light is obtained efficiently with little or no heat, or other arrangements are devised for disposing of it, the water-cell is an essential of the complete lantern. The old idea that a solution of alum is better than plain clean water is a mistaken notion.

The standard size of slide in this country is 3¼ by 4 inches outside. The binding and mat reduce the actual picture size to about 2¾ inches high by 3 inches wide. There is thus considerable space at each side for labeling with data and names. How far this compensates for extra space and weight over the standard English slide of 3¼ inches square is a question. Though there is little excuse for the display of slides reversed, inverted, or reversed and inverted, such are frequently seen. The English slide may be shown in eight different positions, of which but one is right.

As a collection of slides is likely to come from many different sources and be handled by many different lantern operators, it is desirable that there should be standards for marking and arranging. The "spot" in the lower left-hand corner to prevent inversion and reversal has come to be quite generally recognized. But it is quite as important to tell at a glance if all the slides in a pile or in a case are right side up, etc. This can be readily done by suitable binding or labeling. It is also desirable that titles or data and name of maker or owner should appear in standard positions. Further, a box of slides handed to a lantern operator should carry some indication of the proper order of showing. Frequently the last is shown first.

The physiology of vision has an important bearing in connection with lantern pictures. This is frequently overlooked. The eye is many thousand times as sensitive after a period of darkness as at noon on a bright summer day. Astronomers, microscopists, photographers, and X-ray workers recognize this and frequently must wait a number of minutes in almost darkness for the eye to attain the sensitive state (sometimes called "twilight vision") before being able to proceed with the work in hand. In passing from the street with the glare of the sun from the pavement to the interior of a moving picture theater, although the click of the machine is heard, one may have difficulty in locating the screen at once. Until a whole reel has been shown the pictures will be pronounced very dim.

Besides this delay in acquiring visual sensibility other factors affecting the appearance of a picture are overlooked. The room is often only partly darkened; bright spots around doors and windows may be in the line of vision; the projecting lantern may be in the middle of the "audience;" bright spots often appear on walls, floor or ceiling, due to poorly designed ventilating openings in the lamp housing; perhaps there is no bellows or tube connecting the slide with the objective, in which case those who are back of the lantern suffer through having on the retina a bright spot from the back lens of the objective; also there may be appreciable illumination by scattered radiation from the uninclosed slide. An effort should be made to avoid marked contrast in slides.

Autochrome slides transmit about 10 per cent as much light as ordinary slides. If common slides and the color sildes are mixed, it is highly desirable to reduce the illumination for the common ones by cutting down the light or interposing diffusing or absorbing screens. A piece of ground glass between condenser and slide may be found about right. If the lens has an iris diaphragm this may be partly closed.

Some unsuccessful exhibitions of lantern slide color pictures on analysis show some or all of the following points overlooked: room not properly darkened; insufficient time for visual accommodation; lantern leaks light; screen not opaque; picture too large; slides too dense though satisfactory for viewing by hand; source of light insufficient or too yellow in color.

A careful lantern operator will never subject the spectators to the full light of the lantern on the screen without a slide in position. Many lanterns have no means for cutting off the light, except by a loose cap for the objective. This is usually lost or misplaced. A hanging cover is desirable for mechanical protection as well as for a light shield. An iris disphragm in the lens (so constructed as to close completely which the camera lens iris does not) is a desirable arrangement.

As to focusing, where possible this should be carefully done before the meeting and left untouched while showing the slides. The operator is usually too far from the screen to see details as well as others can and his eyes are likely to be dazzled by adjusting the light, etc. If he has an opera glass he can do better.

Time and space are lacking to do more than refer to moving picture lanterns. Optically these differ from the lantern slide arrangement in the distance between the condenser and the film. The lantern slide is close to the condenser, where the illumination is uniform more or less irrespective of shape and size of the light source. The moving film has a position approaching the enlarged image of the light source. The shape, size and evenness of this, therefore, become of importance and the aberrations of the condensing lenses may even be advantageous in blurring over and equalizing illumination.

DISCUSSION.

Mr. F. L. G. Kollmorgen: Some time last year I was called into consultation by a concern here making a transparent screen. They wanted to have a thoroughly satisfactory projection on such a screen and asked me to devise for them a special lens for their purpose. Obviously a transparent screen acts in an entirely different way from an ordinary screen which is illuminated in the direction from which the observer looks at it. In a

transparent screen the observer looks, as you might say, directly into the projecting lamp. If the screen were entirely transparent, say, a plate of glass, an observer in the center of the room would see absolutely nothing but the center of the picture bounded by the fully illuminated opening of the lens; an observer seated at one side of the room would see nothing except a part of the extreme edge of the picture bounded by the lens opening which, however, is now no longer circular but very much foreshortened; thus an observer at the side of the hall will get very much less light than one in the center even in the direct line of vision, owing to the lens aperture being cut down by the mount. If we make the screen partially transparent the amount of light in the line of direct vision is reduced and at the same time the remainder of the screen becomes partly self-luminous, but this luminosity decreases rapidly with the angular distance from the direct line of vision. It will thus be seen that an observer in the center of the hall may get a fairly good general picture in which, of course, the center is by far the brightest, while to an observer at the side of the auditorium the part in direct line of vision from the lamp to his eye will be the brightest but the other side of the picture will be so dark as to be practically invisible. I am of the opinion that this is a fault of all transparent screens that cannot be eliminated.

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Dr. H. Gage: I wish to make a few remarks on the way projection apparatus should be made. In the first place, the apparatus here demonstrated is a combined apparatus so arranged as to allow the use of all forms of projection interchangeably. If a person were to design a complete war vessel, he would like to combine in the same ship a dreadnought, a submarine and a flying machine, and we have something the same kind of compromise to make when we try to combine in one machine the four principal types of optic projection; the ordinary lantern slide projection, opaque projection, microscopic projection, and moving picture projection. The burden of my remarks is that the best design for opaque projection is essentially different from the best design for microscopic projection, for lantern slide projection or for the other forms.

This instrument is a good example of the design necessary for opaque projection. There is a searchlight to begin with, requiring about thirty amperes direct current to operate, which involves heavy wiring. With opaque projection, the light is diffusely reflected from the paper or other object in all directions; consequently, only a small percentage of it can get through the objective. Something like 3 per cent of the diffusely reflected light flux will go through a large sized objective. With opaque projection, one good way of calculating the possible illumination on the screen is to assume that the objective is completely filled with light, that is, it is considered as a light source, of the intrinsic brilliancy of the object illuminated. The illumination on the screen is proportional to the intrinsic brilliancy of the surface illuminated, multiplied by the area of the lens, and divided by the square of the distance from the screen. Hence, to secure good results with an opaque projector, bring the whole apparatus close to the screen, use a short focus objective of as large a diameter as it is possible to get, and use a searchlight to illuminate the object.

For ordinary lantern slide projection, the diagrams (Figs. 6 and 7) given by Mr. Taylor in his paper, show about the path of the rays through the apparatus. For moving picture projection, and microscopic projection, one must take into consideration the fact that the arc light can no longer be considered as a point source, but is an extended source, and that in moving picture projection it is necessary to illuminate an object slightly less than one inch wide and three quarters of an inch high, the illumination over the entire surface being even, in order to prevent streaks. In microscopic projection, as actually used in histology and embryology, the greatest flexibility of different microscopic powers is needed. The lecturer may wish to demonstrate during half of his lecture sections of the spinal cord, perhaps showing a diameter of fifty millimeters. There may be one or two of these sections in which he will want to go immediately from that large size down to a sixteen millimeter objective, or even an eight millimeter objective. This requires a convertible apparatus of a different sort, one which can be changed rapidly from a high power to a low power, rather than changed from microscopic projection to opaque or to lantern slide projection. The great requirement when showing microscopic specimens is ability to change rapidly from high power to low power. The cost of making this combined apparatus convertible from the ordinary lantern slide projector to the projection microscope without losing any of the flexibility required of the projection microscope is a good deal greater than to make two separate pieces of apparatus.

With all forms of projection, the direct current carbon arc is the best, but other light sources can be used, such, for example, as the tungsten, lime light, or acetylene. With microscopic projection, the only really satisfactory light source is the direct current carbon arc. With opaque projection, the object must receive an intense illumination, the direction from which this illumination comes being unimportant. Microscopic and moving picture projection use *directed* light, and the area and intrinsic brilliancy of the light source and the area of the objective play an important part. Where we have very small objectives, as in the microscopic case, it is impossible to get the light necessary for good projection, except with the most brilliant light source available. With moving pictures, the objectives are big enough so that it is possible to operate successfully with tungsten lamps of special type. Intrinsic brilliancy of arc and tungsten sources are given below.

TABLE I.—INTRINSIC BRILLIANCY OF SOURCES.

| | | Intrinsic Brilliancy Candle-power Per Square Centimeter. |
|---|---|---|
| Direct current arc | Solid carbons | 15,800 |
| | Cored carbons | 13,000 |
| Tungsten (Langmuir formula) | Absolute Temperatures. | |
| Highest temperature usable | 3,250° | 3,750 |
| Temperature of 20-ampere, gas-filled lamps | 2,850° | 1,225 |

This table shows that with the gas-filled lamps operating at highest efficiency practicable, the intrinsic brilliancy is less than one tenth that of the direct current carbon arc.

The intensity of screen illumination is a matter to which I have seen no references in any illuminating engineering papers. The results of some experiments made in Cornell several years ago are given below and may be taken for what they are worth, i. e., first approximations.

In a dark room with clear lantern slides 2.5 foot-candles would answer, while 5 foot-candles gave entirely satisfactory results. In a room lighted from the back with incandescent lamps enough to take notes, 0.7 foot-candle on the screen from the lights, and 6 foot-candles from the lantern gave good projection, that is, during a lecture to students, and there was plenty of light to spare. With the ordinary lantern slide, it is better to light the room dimly so that the students can take notes, than to have it absolutely pitch dark. With opaque projection, it is necessary to have the room pitch dark and work with a lower screen intensity. For moving picture films about 3 foot-candles are required.

TABLE II.—INTENSITY OF SCREEN ILLUMINATION.

| | | Foot-Candle. |
|---|---|---|
| (1) | In a perfectly dark room an illumination of 1 foot-candle is satisfactory for transparent microscopic specimens stained red | 1 |
| (2) | Dark room—lantern slides—2.5 foot-candles will do with reasonably clear slides | 2.5 |
| (3) | Dark room—five foot-candles entirely satisfactory | 5 |
| (4) | Room lighted from back with incandescent lamps enough to take notes: screen | 0.7 |
| | lantern | 6 |
| (5) | Room lighted from window at sides | 0.85 |
| | Room lighted from entire incandescents | 1.5 |
| | Fair results secured from lantern | 5.4 |
| (6) | Dark room, somewhat thick moving picture film—average illumination | 3.0 |

TABLE III.—MINIMUM AVERAGE ILLUMINATION GIVING SATISFACTORY MOVING PICTURE PROJECTION.

| | | Foot-Candles. |
|---|---|---|
| 1. | Tinted film | 2.7 / 3.9 |
| 2. | Yellow tinted film | 5.6 / 8.5 / 3.3 / 3.3 |
| 3. | Black and white dark film | 6.0 |
| 4. | Blue colored dark film | 26.2 |
| 5. | Black and white dark film | 25.5 |
| 6. | Hand colored film | 3.1 |
| 7. | Hand colored different part | 16.0 / 8.5 |
| 8. | Black and white dark film | 30.0 |
| | Maximum Illumination. | |
| 9. | Dark room and light film, too much screen illumination at | 75.0 |

The values for the average screen illumination are taken with the film removed and the shutter revolving.

I should like to see similar studies made of the conditions necessary for good projection, but made with greater thoroughness, in order that the illuminating engineer could be of greater service in planning the lighting of theaters and lecture rooms, and the installation of projection apparatus.

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Mr. L. C. Porter: Mr. Taylor has mentioned the increasing use of the incandescent lamp for the stereopticon. I want to say just a few words as to the primary differences between the stereopticon equipped with an arc lamp for a light source and equipped with an incandescent lamp.

The incandescent lamp has already, one might say, captured the field for home use, and small stereopticons and projectors for lecture service, due to its greater convenience, simplicity, safety and other well-known factors. In all probability it will, in the very near future, take a good deal of the larger work too. In fact, for motion picture projection, we are already able with an incandescent lamp to equal the results from a 50 ampere alternating current arc, or from a 25 ampere direct current arc.

A few of the primary differences are these: In the common form of projection lantern, we have two condensing lenses (Fig. A) and light from the focal point of

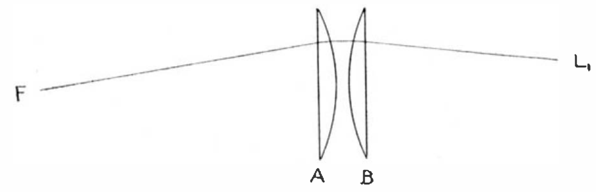


**Fig. A.**

lens *A* will be made practically parallel as it goes through. If you use an ordinary lamp filament, i. e., a filament as shown in Fig. B, a light ray $L^2$, coming from a point *P*, away from the focal point would be scattered when it went through the lenses and similarly from all other points outside the focus. For that reason the ordinary lamp filament cannot be used for projection. To get satisfactory projection, it is necessary to concentrate the filament as closely as possible around the focal point of the condenser.

In arc lamps, the light comes from the crater of the carbon. The distribution of light from such a crater is somewhat as shown in Fig. C; therefore, a condensing lens of tolerably long focal length will utilize a very large percentage of the total light, as shown by the shaded portion of Fig. C. On the other hand, if you put an

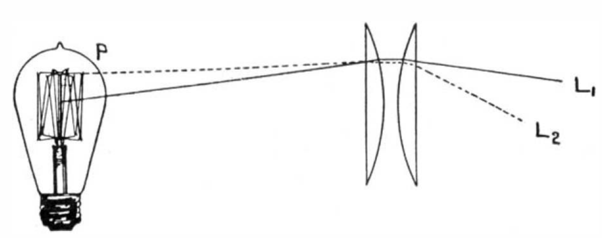


**Fig. B.**

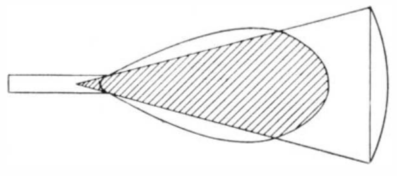

**Fig. C.**

incandescent lamp (which has, practically speaking, a spherical distribution, i. e., the candle-power is equal practically in every direction with the exception of under the base) at the same point of the arc, using the same condenser, you utilize a very small percentage of the total light flux, as shown by the shaded portion in Fig. D.

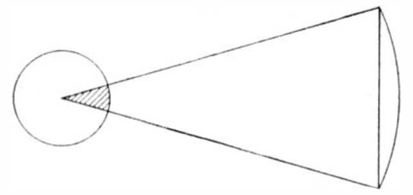

**Fig. D.**

Therefore, when one uses an incandescent light it is necessary to use a short focus condenser so that you utilize a larger percentage of the total light flux; and that can still further be increased by putting a spherical mirror back of it, as illustrated in Fig. E. With an arc light source the screen is practically an image of the center of the arc and that gives you a uniform field. With an incandescent, if the light source is exactly at the focal point, you get an enlarged image of the filament on the screen, which is more or less objectionable. To get rid

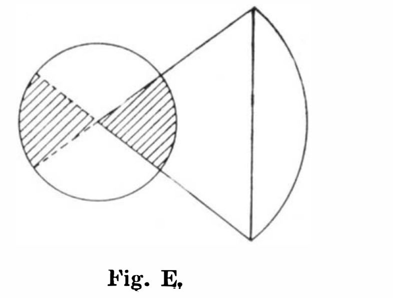

**Fig. E.**

of that it is necessary to move the light source a little out of focus, or use other means of breaking up the filament image.

In regard to Dr. Gage's figures, twenty-five foot-candles for moonlight work seems to me a little high. When one comes to night scenes, one wants to think of darkness. We found that we could get very good moonlight scenes with from six to ten foot-candles. According to Dr. Gage, I should estimate that about three to six foot-candles is considered good illumination on the screen in average moving picture work and we are able to obtain that from an incandescent light source.

Mr. M. Luckiesh: I believe this society should become more interested in vision as influenced by moving pictures. No doubt all of us while viewing motion pictures have experienced considerable visual discomfort from two chief sources of eye-strain, namely the brightness contrast of the highly illuminated screen amid relatively dark surroundings and the more or less evident flicker. The discomfort due to both of these causes can be lessened by illuminating the entire room slightly. In many cases I believe the illumination intensity on the screen is too great. However, if excessive intensity of illumination is available, I would suggest that considerable general illumination be provided. Where this is done the results are very satisfactory. Even in some cases the slight amount of light provided by the orchestra lamps makes the brightness contrast between the screen and its surroundings quite endurable compared with the condition when the orchestra lamps are unlighted. Sometimes, however, these lamps are very glaring.

Another point of interest which has received little attention is the relation of the illumination intensity on the screen to the conspicuousness of the flicker. It is well known that the critical flicker-frequency, or the frequency at which flicker disappears, increases slowly with the increase in the brightness of the surface which is being alternated against darkness. The flicker frequency has been shown to increase approximately proportional to the logarithm of the brightness. There is reason to believe that there is an optimum relation between illumination and the noticeability of flicker in moving picture projection which is not the condition found in some movie theaters. Another point of interest is found in the contour of the flicker or the wave-form of the brightness. I have shown, (*Physical Review*, 1914, vol. iv,, N. S. July, p. 1; *Electrical World* May 16th, 1914) that the critical frequency decreases as the change from light to dark becomes less abrupt. This and other points are of considerable interest in the design of moving picture projection apparatus. In fact, the "movies" present a comparatively unexplored field for those interested in the aims of this society.

## Power Situation in Germany and Austria During the War*

THE outbreak of the war and the disorganization of industrial enterprise following this event had a decided influence on power production and consumption all over Germany and Austria-Hungary. When war was declared and the government called in the military reserves, a great number of industries were suddenly deprived of their manual help and consequently were compelled to reduce production. Also the power industries, especially the central stations, were suffering from shortage of labor, and the immediate result was a general curtailment of service. This reduction in industrial activity all over the country, however, made the effects of power supply less felt, and the fact that just then the electric-light supply had to meet only the summer demand helped the central electrical supply stations to tide over their initial difficulties.

More difficult to deal with was the disorganization in the demand for power. While in normal times this demand is spread fairly evenly over the whole territory and the larger overland stations consequently can easily arrange their output, the demand ceased in certain districts with the outbreak of the war, while it became unexpectedly large in others. In sections where small industries prevailed there was little demand for power, while everywhere in the iron and steel and the machine-building industries the demand rose to such an extent that the existing stations were taxed to full capacity. New industries springing up as a result of the war, especially such products as had formerly been imported, soon brought new problems, which had to be solved at short notice. Later, the problem of raw materials and fuel added to the many difficulties under which power production had to be carried on.

All these problems were met as they arose, either by reorganization or by complete changes, and at the end of 1915 conditions had accommodated themselves to the war so that a fairly normal, even if not entirely satisfactory, operating system had been created.

ADJUSTMENT OF TRAMWAY LOAD.

The first months of the mobilization of the army, while taking away manual help from the stations, found added work for all those power stations that had to supply railroads and tramways, especially in those districts which were mostly affected by the mobilization and the carrying of troops. For instance, in the Rhineland, which is covered with a network of electric railways, a great demand for tramway facilities arose, making necessary the employment of all available rolling stock and also power. Not only were the tramways used largely for the transportation of troops, but they served also as feeders for the ordinary railways connecting the armament plants with the western front. As the system of power stations working in that neighborhood is closely interrelated, it was easy to organize the power supply in such a way that no difficulties arose. In all those districts the power supply to railways increased, but it became necessary to cut down tramway facilities in other directions, and nearly all the street-car systems in the larger cities began to curtail their service, thus making possible the employment of the stock in other places and lightening as well the work of the generating stations. Owing to the lack of men for running the cars as well as travelers to use them, this reduction could be carried out without undue hindrance to the service, which has been everywhere sufficient for the decreasing demand.

In some cases where there was competition between existing stations and overlapping, this competition ceased to exist. In Vienna, for instance, a considerable saving was gained by simply closing down the plant of the Allgemeine Oestereichische Elektrizitätsgesellschaft and coupling the whole service onto the Wiener Städtische Elektrizitätswerke, which not only brought cheaper operation of the service, but made the supply more effective.

With the progress of the war the shortage of labor in the power stations was somewhat relieved by measures taken by the government. Many industrial plants were closing down, and labor was set free which could be used somewhere else. Further, female labor, which formerly had been employed only in certain industries, began to spread, and we find machine shops, ammunition plants and other industrial enterprises employing a large number of women. In the central stations the shortage of skilled labor was not so easily remedied. By coupling together existing plants as previously mentioned, a saving was gained, but this was not sufficient, especially as power generation very soon became an important factor in industrial preparedness. Therefore power plants began to ask exemption for their leading employees, which was granted where necessary. The main difficulty was that the government itself became a large employer of skilled electrical labor, having many uses for such workmen in the field. The telephone plays an important part in military operations, trenches are lighted electrically, and electricity is used to charge the wire entanglements before the trenches. Nevertheless, the generating stations were able to secure sufficient assistance to keep their plants going, even if curtailments of power and light service became necessary.

ELECTRICAL PLANTS CLOSED DOWN.

In the middle of the year 1915, when it became evident that Germany and Austria would have to take steps to relieve the shortage of raw materials such as copper and nickel, which had formerly been imported, the closing down of electrical plants became more general. Where possible, concentration of power generation was resorted to, so as to set free the copper used in machinery and cables. In this way both countries were able to gain considerable quantities of copper. In Vienna, for instance, 480 tons of copper is said to have been recovered by using the cables of one of the closed plants. Moreover, in building new machines an effort has been made wherever possible to replace copper by iron or other metals.

However, it seems that the ordinary means of obtaining the desired metals were not sufficient, and in the autumn a new order appeared, making compulsory the registration of all kinds of unused electrical machinery. The committee that had this work in hand had authority either to destroy the machines so as to gain the copper and other desired metals or to order their rebuilding after plans that would recover as much of those metals as possible.

HANDLING REBUILT MACHINES.

The rebuilt machines were taken over by the distribution office for electrical machinery of the War Ministry, which acted as a kind of exchange, facilitating the distribution of all kinds of electrical machines to consumers who could make use of them. This system of machinery distribution has been applied to other machines, and it was possible to relieve in this way any arising shortage on one side without necessitating the building of new machines which, under the existing circumstances, would have been costly and have reduced still more the existing stocks of raw materials. The rebuilding of old machines and the construction of new ones without the use of copper was not always easy, and great difficulties were met in many instances. It is likely, however, that the knowledge thus gained will have some influence on the construction of power machinery in the future.

Another effect of the war on the electrical-power industry both in Germany and Austria has been curtailment of building activity, shortage of money for private and public enterprises having made impossible industrial expansion.

Coal was obtainable in sufficient quantity and for reasonable prices, but there existed some difficulty in shipping it to the spots where there was demand. There was also a shortage of oil for the Diesel motors, which was aggravated for some time, especially in Hungary, through the occupation of Galicia by the Russians. When the latter were driven out of the province, they destroyed much of the industrial property and set fire to several of the oil wells; but it seems that the electric-power stations in this district have fared rather well, and little of their property was destroyed.

Although lack of coal was felt less in Germany than in Austria, in the former country transportation facilities were somewhat irregular and generating stations were compelled to carry larger stocks than usual so as to meet any sudden stoppage. This has reopened the question of making a better use of the existing water reserves for generating purposes. Generally it seems, however, that Germany's water reserves will be of better use to industries in the form of an inland water-transportation system than for power generation. The present project of creating a government monopoly in power generation foresees the use of the now practically valueless peat reserves.

Germany and Austria-Hungary will have to economize, and they cannot economize better than by gaining the same results by the employment of cheaper means. So it is likely that many of the stations, having reduced their working expenses to the lowest possible standard, will continue their work under the same economic conditions after the war. This will set labor free in other directions.

*From *Power* (special correspondence.)

## The Gas Turbine Problem

THE problem of the gas turbine was discussed in a recent issue of *Zeitschrift Ges. Turbinenwesen* by A. Walter, who considers that it has been approached from a wrong point of view, and that the problem cannot be solved by connecting a turbine wheel to a combustion or explosion chamber. The combustion turbine offers a desirable continuity of action, but involves temperatures and gas velocities that are now and probably always will be prohibitive. Water injection, and other similar devices, reduce efficiency, and consequently the prospects in this direction are not promising. In considering the problem the following points must be kept in view: (1) A perfectly continuous constant-pressure process being impracticable, we should seek a process giving the greatest continuity practicable. (2) Vigorous cooling without too great expenditure of power and heat loss in the chamber and turbine should be sought. (3) Multiple wheel-and-drum action or reaction turbines are more efficient, durable and stronger than a simple velocity wheel. (4) Waste heat should be utilized in some other way than by a regenerator.

The writer suggests a new process, which is a modification of the ordinary constant-pressure system, the working being intermittent, but of long period. Air for combustion and cooling is taken continuously and at constant pressure to the combustion chamber. Due to constant pressure in the latter, the use of any standard type of turbine and effective cooling of the whole turbine is made possible. In the machine described, there are three combustion chambers built radially on to the wheel, two chambers being at work while the third cools. Each chamber has its own fuel and air supply, and each its own ignition. Pressure is equal in all three chambers, and the latter are connected to the turbine by expansion nozzles. Air entering the chamber which is cooling at any particular moment sweeps out burnt gas, expands in nozzles, and restores part of the energy consumption of the compressor in the shape of work done on the turbine wheel. Cooling is accentuated by expansion of the air through the nozzles. At the end of the cooling period the fuel valve is opened, an explosive mixture produced, burnt and expanded through the nozzles, to do work on the turbine. The advantages claimed for the new turbine are few working parts; improved expansion conditions in the nozzles, since no fall of pressure occurs in the combustion chamber on the completion of combustion; high thermal and mechanical efficiency; reduced gas velocity and revolutions per minute, and hence less severe stresses at high temperatures; favorable application as exhaust gas turbine; high overload capacity and good utilization of cooling air.

## The Culebra Slides at Panama

A masterpiece in technical reporting of facts is Governor Goethals's account of the Panama Canal slide situation. His statment carries clear conviction that the long chain of earth movements which mark the history of the canal has been handled in a capable, deliberately judging manner. Moreover, it inspires a fair degree of confidence in an early ending of serious slide trouble for the canal. The present two immense slips at Culebra, in the light of Governor Goethals's review, represent part of the final adjustment of the ground to its new slope and water conditions. Just as the thorough job of excavation done to clean up the Cucaracha slide of two years ago produced a result that upon a year's test of the permanent water conditions appears to be stable, so the removal of the present Culebra slides promises to bring quiet in this region also.

But in the matter of such earth movements as these, any definite prediction is little else than barefaced guesswork. Clays of landslip proclivities not only defy calculation, but are free from all regularity or habit of behavior by which guessing could be guided. Their performance inclines toward the unexpected. Brief reference to the nature of landslips will show convincingly that they form poor subjects for prediction and prophecy.

The classification of Panama slips given by Governor Goethals in the present report furnishes a good basis for such reference. His classification does not fall very far short of covering landslips in general. It is by no means the least valuable feature of the report.

First and simplest are slips of the kind discussed in the ordinary retaining-wall theory. These, however complex they may become, both as to physical facts and as to theory, are always of small size.

Second are the slides of the ship-launching type, where a natural slip-plane exists, on which the superincumbent mass begins to slide, under critical conditions of lubrication. Such slides are not exactly rare. They are slow-moving, and may be very large and exert enormous down-hill pressure on an obstacle. Governor Goethals says that the great Cucaracha slide was of this type.

Third are slips of the plastic-flow kind, a rare and highly unmanageable type. They are represented in the remarkable series of slips in valleys of the St. Lawrence River tributaries in Quebec—most notable of them the last, the slip which overwhelmed the village of Notre Dame de Salette in the Lievre valley in 1908. They are also represented in the recent subsidence of a large cement plant at Hudson, N. Y., as well as in the tipping of the Transcona grain elevator two years ago. According to the description of the Culebra slides, these too are of the plastic-flow type.

In these latter slips a clay-like subsoil becomes suddenly plastic—not to say semi-liquid—under certain conditions of moisture and pressure. The Quebec slides, as reviewed in *Engineering News* of May 27th, 1909, show the characteristic phenomena most clearly. In a typical instance, a flat river terrace, up to 60 feet high above water, developed surface cracks, and soon afterward a large section of the bank subsided suddenly, the material below bursting out from the bank while the upper strata in part dropped nearly vertically. The Quebec slides include one or two bottle-shaped slides, where the failure area was very narrow at the river bank, while back of the bank it spread laterally like a dock basin, and the material squeezed out by the subsidence flowed out through the narrow bottleneck break of the bank.

Practically nothing is known as to the particular soil qualities responsible for the plastic-flow slips. We do not even know that notorious landslip soils differ in any way from normal clays or silt soils. We do not know whether sand mixtures play a part. The necessary careful laboratory attack on the problem is still to come.

But that high moisture content plays a determining part is well recognized. All but one of the Quebec landslips occurred in the months of March to May, and the one exception came in October after several days of rain.

Similarly, we know well that pressure is a vital factor. In the Transcona elevator case, for instance, how clear is the picture of sudden breakdown of the subsoil, crushed under its normal load! The same soil carried the same load for a long time, with no yielding; but when some slight change in its nature—no doubt due to an increase of water content—occurred, quite suddenly the bed of clay failed, flowed away laterally against the counter pressure of the surrounding soil and destroyed the support of the building. Only because we call this a foundation failure is it any different from the landslips.

The compressive loads which caused the flows seem to have been such as occur under very moderate depths of overburden—sometimes as low as 30 feet, which would hardly exceed 1½ tons per square foot, or such as may be caused by a not unusual surface load, as the weight of the Transcona elevator, or of the stone storage pile of the Knickerbocker cement plant.

Considering the time just prior to any one of these slides, it is obvious that not only was there no warning, but every assurance could be drawn from long-continued permanence of conditions that the soil was stable. In the Quebec valleys, for instance, farms and villages existed many years on and near the ground which ultimately subsided and flowed out. Any prediction, certainly, would be for continued stability and quiet. The slip, of course, disproved it, and just as surely would make any future prediction in the same region valueless. As said earlier, predictions are guesswork.

At Culebra, while the plastic-flow character is evident from the description—and Governor Goethals himself makes a clear distinction between the Culebra or "break" type and the other slips at Panama—the situation is somewhat different, and by no means equally hopeless, from the predicting viewpoint. The flows that occurred there were relatively slow movements. The soils that crushed out under the superincumbent weight did not fail as suddenly or completely; they have no such narrow critical range as exhibited in other slides of this type. Adjustment should, therefore, be easier, and the permanence of the result should be more dependable.

The toe abutment of the slope is no more being cut away by canal-prism excavation. Water being already in the canal, there will be no further rise of ground-water. Moreover, the movement of the sliding ground relieved the soil stresses in large part, and with continuance of flow during excavation of the slide toe, a full opportunity is given for complete relief. Adjustment to the present saturation level may, therefore, be expected to be complete. Subsequent reduction of load by surface excavation, as a protective measure, is likely then to have greater effect than did the prior steam-shovel terracing in the same region, which consumed millions of dollars.

Removal of the slide, says Governor Goethals's report, is going on at the rate of 1,000,000 yards per month. The total earth to be excavated—only a small part of which is in the canal—is 10,000,000 yards. If the worst comes to the worst, if all the material slips into the prism, the canal will be closed a long time. The indications are in any event that the closure will continue a number of months.

The citizen as stockholder in the canal enterprise should accept this fact without complaint. Indeed, since the adjustment slip occurred so soon after the opening of the canal, he may feel fortunate in having the slip occur at this time, and under circumstances where the best method of removal can be applied systematically and thoroughly.—*Engineering News.*

## Cumberland Process of Preventing Corrosion

A paper recently read by Mr. J. F. Peter, at a meeting of the Institute of Marine Engineers, contains some interesting information on the Cumberland process of preventing the corrosion of boilers, condensers, and other metallic vessels and structures in contact with water or other corrosive liquids. The process has been referred to on several occasions in our columns, and is now being extensively adopted in this country, so that it will probably be familiar to most engineers. We may, however, mention that the principle upon which it depends for its action is the application of an electromotive force to overcome those produced by two dissimilar metals, or the same metal in different conditions, in contact with an electrolyte. This is accomplished by fitting one or more iron electrodes into the vessel to be protected and connecting them to the positive pole of a small dynamo, generating a continuous current at a pressure of about 8 volts. The iron electrodes are insulated from the vessel, to which the negative pole of the dynamo is electrically connected, so that a current flows from the iron electrode to the walls of the vessel while the apparatus is in use. This has the effect of confining the corrosion entirely to the iron electrodes, which are gradually eaten away, but which can be replaced at a trifling cost. The current is regulated by resistances and measured by an ammeter. In the case of boilers it has been found that the system not only prevents corrosion, but also prevents the formation of scale and removes any old-standing scale which may have been deposited before the apparatus was installed. The current necessary to afford complete protection in the case of a condenser is about 1 ampere for each 500 square feet of cooling surface, so that a condenser with 6,000 square feet of surface would require a current of 12 amperes. The energy required at 8 volts would therefore be 96 watts, and the cost at ½d. per kilowatt-hour would be 35s. per annum, running continuously. Six cast-iron electrodes, each weighing 20 pounds, would be used in such a condenser, and these would have to be renewed once a year, at a cost of about 15s. In boilers where the question of scale formation has to be considered a rather heavier current is necessary, and for ordinary marine boilers about 1 ampere is usually allowed to each 300 square feet of heating surface. If corrosion only has to be guarded against, a smaller current density can be used. A case is mentioned of a vessel having twelve Yarrow boilers, each with 4,125 square feet of heating surface, which it was found in practice could be completely protected from corrosion, and kept quite free from scale, with a current of 5 amperes per boiler, though when installing the system it had been decided to supply 14 amperes per boiler. The electrodes in each of these boilers consisted of two 7-foot lengths of 3 inches by ¾ inch bar-iron fitted in the steam drumjoint below the water level; their life will be considerably longer than two years.—*Engineering.*


# SCIENTIFIC AMERICAN SUPPLEMENT

**Founded 1876**

NEW YORK, SATURDAY, JULY 1st, 1916.

Published weekly by Munn & Company, Incorporated

Charles Allen Munn, President; Frederick Converse Beach, Secretary; Orson D. Munn, Treasurer; all at 233 Broadway, New York

Entered at Post Office of New York, N. Y., as Second Class Matter




### The Scientific American Publications

Scientific American Supplement (established 1876) per year $5.00
Scientific American (established 1845) . . . . " 3.00

The combined subscription rates and rates to foreign countries, including Canada, will be furnished upon application
Remit by postal or express money order, bank draft or check

**Munn & Co., Inc., 233 Broadway, New York**


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