# SCIENTIFIC AMERICAN SUPPLEMENT

Copyright 1916 by Munn & Co., Inc.

VOLUME LXXXI
NUMBER 2093

★ NEW YORK, FEBRUARY 12, 1916 ★

10 CENTS A COPY
$5.00 A YEAR

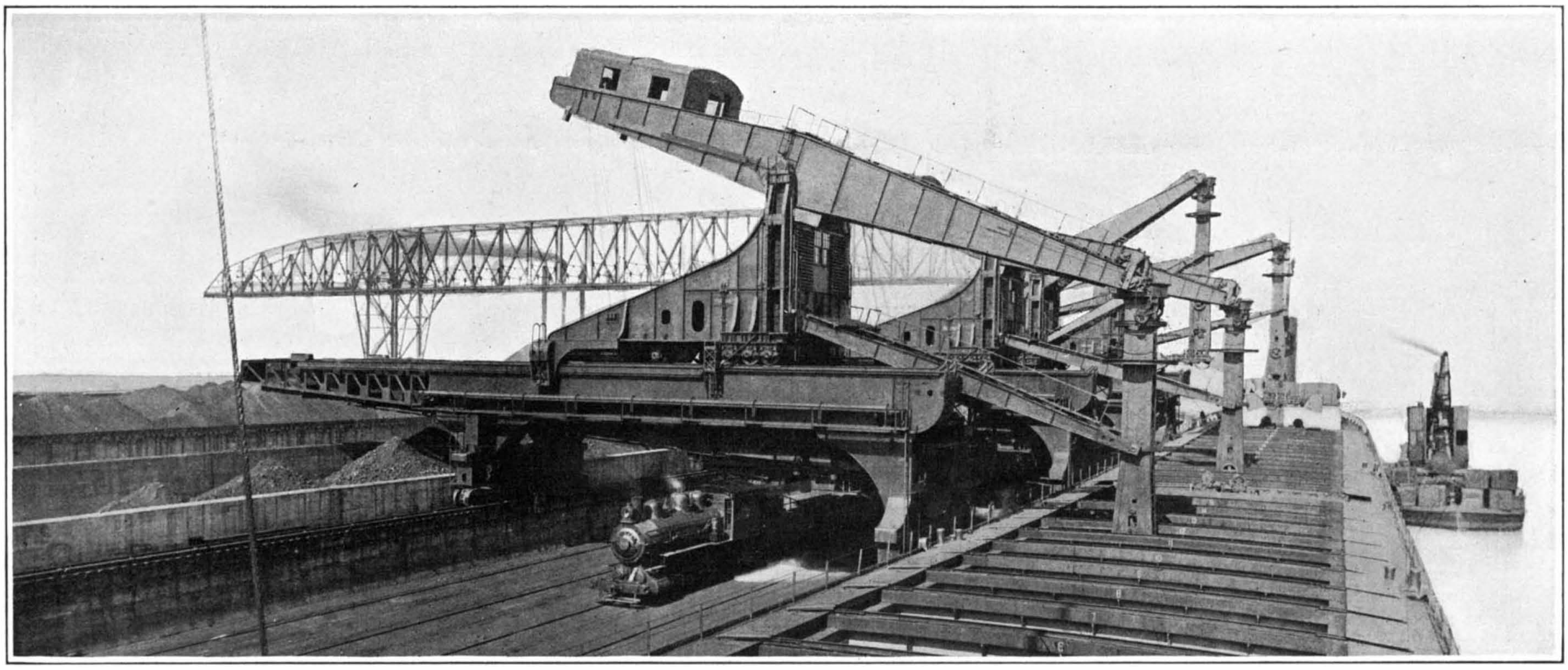
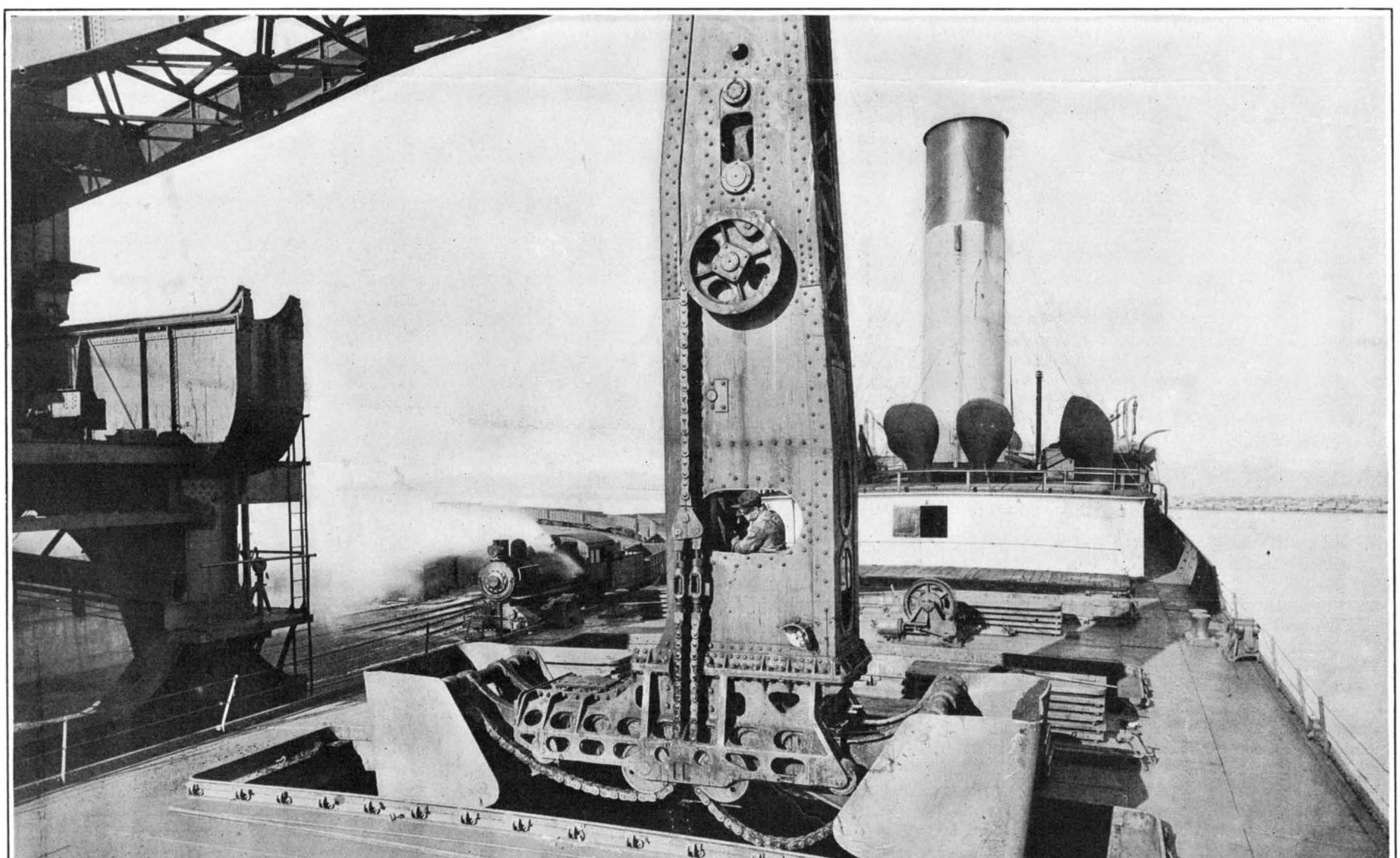



Fig. 7.—View of latest type of dock and ore-carrying vessel and most modern unloading machines equipped with 17-ton buckets.



The arm of an unloading machine, with bucket open, dropping into the hold of an ore carrier.

ORE UNLOADING ON THE GREAT LAKES.—[See page 104.]

# The Inner Life of Some Common Plants*

## The Chemical Faculties That Are Related to Their Growth, Color and Activity

By P. Q. Keegan, LL.D.

ORDER may to men's eyes be introduced into the world of plants by classification and naming, or the plant may be mechanically dissected and the histological parts thereof scanned through the magnifier in order to ascertain their particular form or relation to other parts of the structure; but a third method is to endeavor to discern and separate the chemical compounds which the vital energies of the plant produce, and are of service for the outcome of such visible or intangible phenomena as its size, weight, rate of growth, coloration, general activity, and duration of life. In fact, we can never understand the inner life of a plant until we know something about its chemical faculties, and whether it is really similar to or distinguishable from other plants by its power of producing certain organic compounds by virtue of the peculiar quality and strength of its physiological powers of assimilation and of deässimilation. All other features are of purely mechanical or fortuitous origin: this one alone uplifts the screen of mystery that enshrouds its manner of life, the precautions and forestallments necessary to its very existence and wellbeing, its glory and panoply of coloration, its powers of resistance either to the sultry tropical sun or to the piercing fangs of winter cold. But let me now put forward certain illustrations of this mode of view, the selection being made from some common familiar plants.

*Daffodil*.—This tenant of open woods and pastures exhibits deep-green leaves and large yellow flowers which develop almost under any conditions, because it needs no nitrate from the soil, its roots being infested by fungi, forming an association named "Mycorrhiza." It is perennial because there is a bulb underground, although its pollen germinates easily and with great regularity on the stigma with production of numerous germinable seeds. Its overground life is prolonged, for the leaves keep green long after the flowers have perished; while the scales of the bulbs, comparable to youngish rudimentary leaves, still support and sustain a considerable activity. Examined now chemically, we learn that the leaves are very difficult to dry, their 90 per cent of water being held with extraordinary constancy and tenancy. Now we know that water is essential to life, and hence the reason why these very watery organs keep green and living for an unusually lengthy period. The analysis indicates a physiological process of assimilation, producing very little starch, but abundant sugar (hence copious nectar) and plenty of mucilage, oil, and wax; and a process of deässimilation, producing abundant acids and some tannoid, along with a little saponin, and an alkaloid most probably a decomposition product thereof. No tannin is observed; hence, there is nothing but yellow, orange, and green colorations potent and deep; while the ash of the visible parts shows that a large amount of soluble alkaline salts, especially chlorides, are extracted from the soil for the needs of the plant. Altogether, then, we learn that the physiological processes in the case of the Daffodil are sluggish and imperfect, have little vigor or development, evolve little substance of an oxidative character, but potent in the way of a reductive property, which means that in this plant the oxygen of the surrounding air finds little chance of invigorating the living protoplasm of the tissues.

The Primrose, "first-born child of Ver," presents some interesting features. It is also what may be called a root-plant: its erect rhizome, with its broad cortex and narrow pith, finds out a damp clay on which to live and manufacture an abundance of starch and malic acid. It contains little tannin, but instead an emetic saponin (cyclamin), doubtless a decomposition product thereof. The leaves evolve abundance of wax and chlorophyll (the Primrose revels in the shade), but yet have no tannin, save later in their narrower parts and chief bundles; but there are abundant acids and mucilage and fugacious starch, together with an ample supply of mineral matters (ash), which may yield as much as 17.2 per cent of chlorine. The floral parts (pedicel and inflorescence) are conspicuous by the presence of carotin (at the base of the petal) and xanthophyll (toward its tip), which latter imparts a perfectly delicate coloration thereto (artists say it is really green). Here, too, do we find more tannin than in any other organ of the plant, and a tannin (it is regarded as a tannide by some chemists) of a very remarkable character. Thus, when boiled with dilute mineral acid it yields a solution and precipitate of a most beautiful red color—just the very tint, in fact, which we see staining the corolla of the cultivated Primulas in the winter time. Whence we see that the keen and passionate fervor of the poet with reference to the Primrose finds a justification in the revelations of the chemist; the secret source of colorific faculty is revealed, the gentle swaying of the petaled head that may be pure red or purple (but never blue) is faithful to the leaves as yet in rudiment of form or function; in short, the "rose," which from the prime derives its name, dreads not her annual funeral. The vitality is apparently fresh and juvenile; but, in fact, it is of sluggish temperament and of long prepardedness for the fierce battle with the elements, for it really belongs to a mountain genus—it is a plant of the hills.

In striking contrast to the foregoing is the plant known familiarly as the Cow Parsnip (*Heracleum Sphondylium*), found in hedges, hayfields, etc., which has been said to exhibit a rollicking vigor, a robustious growth beyond all English flowers; in fact, "the progress is forceful, the vigor ebullient, the triumph supreme." But what on earth may account for all this amazing exhibition? Need we state that no amount of naming, dissecting, natural selectioning, etc., will ever answer this question? The root is hard and fibrous, and contains abundant starch and mucilage, also a yellowish acrid resin and some sugar, but no tannin. The large leaves, which are highly chlorophyllous, contain much resin and fat-oil, with small quantities of tannoid and caffetannin: they produce great quantities of oxalate of calcium; the starch is fugitive and forms no reserve. The peculiarity of the plant, owing doubtless to its anatomical structure, is that the nitrate which it absorbs from the soil exerts a more than ordinary influence over its growth and development. It is known that different plants behave differently toward the nitrates of the soil; in some their growth is checked, but this is not the case with the Cow Parsnip. It appears that the nitrates of the soil, when they ascend the stem of a certain structure, increase the osmotic pressure (i.e., they communicate a swelling force to the cell sap), and this increases growth by acting, not merely as a mechanical force which stretches the cell-wall, but also as a stimulating irritant on the protoplasm. The latter, therefore, puts forth its greatest strength and vigor when especially the tissues are of a certain pliability and responsiveness. Nitrate is clearly detected by chemical methods in the stem and in the huge leaves. Moreover, the plant has air-spaces, interstices, and intercellulars in great variety and extent, so that the oxygen of the air is at liberty to play freely within the tissues. A rapid reformation of sugars, and so on, which increase the osmotic pressure and accelerate the growth, would serve to counteract the effect of a too liberal absorption of water from the soil.

Just at the beginning of autumn, when the moorlands get bleak and gray, and the fallow wolds and fields assume a sear and yellow aspect, we see, erect thereon, a stiff, picturesque, solitary weed with looped and curled leaves and an effusive crown of yellow flowers. This is the Ragwort (*Senecio Jacobaea*), and its loneliness on the soil is no indication that it has no relations; on the contrary, it may be regarded as a type repeated and represented by an enormous number of plants scattered broadcast over the face of the earth. But let us seek what it contains. The leaves are fortified by a considerable coating of wax, and much carotin and chlorophyll are produced thereby; also a tannoid capable of yielding brilliant "lakes" with salts of tin, alumina, and lead, some caffetannin, cane-sugar, resin, very much mucilage and oxalate of calcium, but no reserve starch. The mineral matters (ash) amount to 14.4 per cent in the dry leaf, and yield 9.6 per cent chlorine, 23.4 oxide of lime, 8.5 $SO_3$, 4.1 silica; and even from these figures we can learn that (unlike its congener, the Groundsel) its roots are infested by fungi, and that it absorbs no nitrates from the soil. Some biennials and perennials grow very rapidly in early spring, but the Ragwort is in no hurry, and flowers only in late July. The analysis also shows that it produces acids and resins rather than tannins; that is to say, its powers of deässimilation (oxidation) are limited; and there is also a tendency toward decomposition, as the presence of alkaloids or bitter principles evinces. The comparatively large dimensions and rigid posture of this plant indicate a great hold of water, which in turn depends on the great absorption of salts from the soil (the whole plant contains 23.3 per cent pure ash, according to Anderson), and an active transpiration of water vapor from the leaves, whose form and configuration are eminently adapted to the purpose. The type of root here is eminently fitted to absorb nourishing juices from the soil, and the leaves have a delicate cuticle, and are destitute of every protection against excessive evaporation. The superior colorific faculty of the plant is clearly evinced by the beautiful carmine-red tint which paints the epidermis of the lower portions of the stem.

The Marsh Cinquefoil (*Potentilla Comarum*), a tenant of marshes and the peat bog of mountains and meadow moors, may be taken as a type of the plants enrolled in the renowned order Rosaceae. It shuns a lime locality, and prefers a sandy one. Long roots spring from the stem, creep in the mud of pools and marshy places, and are surrounded by a thick, spongy mantle of thin-walled cells with broad intercellular air-passages, serving a supply of oxygen to these parts; no lignin, or true cork, is developed there. Moreover, the roots are infested by fungi (*Mycorrhiza*), which means that the plant is nourished by the organic nitrogenous matter of the soil, and contains no nitrates; hence, also it grows rather slowly. Like most of the Rosaceae, it is a pretty strong chemical plant, and its beautifully shaped leaves contain a good supply of carotin, wax, a crystalline hydrocarbon, and some fat-oil in the greener parts. As usual, also, a very notable amount of tannoid and tannin, precipitating gelatine, and tartar emetic are found. Not much free sugar, but large quantities of starch (especially at high noon), mucilage, pararabin, and oxalate of calcium are manufactured and stored up by the leaves. The ash of the overground parts yielded very little silica, and comparatively little phosphorus or sulphur (as befits a water-plant), but a large quantity of lime, iron, and manganese. The above analysis indicates immediately the powerful physiological activities of this type of rosaceous plant. Intense assimilation or chlorophyllian energy is attested by the abundance of starch and fatty matters, while the liberal outcome of tannin and acids (there is about 26 per cent carbonic acid in the ash) proves that the process of deässimilation (oxidation) is specially vigorous and complete. Moreover, the latter progresses near to perfection, for it is observed that the inner segments of the calyx, the petals, stamens, and styles are always suffused with a dark purple coloration, whence the plant has earned the designation of the "purple-wort." Most other wild rosacean plants, such as Burnet, Lady's Mantle, Avens, Tormentil and so on, contain chemical constituents very similar to those just reviewed.

The beautiful "Empress of the Lake" and the "Delight of the Waters"—the white Water-lily (*Nymphaea alba*)—has been thoroughly well studied as regards its morphology and internal anatomy, but the chemical outcome of its marvelous mode of life has been almost completely neglected. There are no cells with hard, thick walls (sclerenchyma) in the leaves or petioles, and their vascular bundles are arranged like those of the Monocotyledons, and with an extreme reduction of their woody portion (xylem), which is characteristic of water plants. Moreover, there are numerous empty air-spaces and canals, but no actual vessels fit for conducting sap. An examination of the leaves shows that they contain much wax, fat-oil, and carotin, but little chlorophyll and some resin; there is a moderate quantity of tannoid, and a tannin which is rare in nature, and is known as gallotannin. Its presence in a plant is a clear indication of considerable oxidizing agencies operative therein; it is, perhaps, also indicative of a no great amount of lignification being required for that particular species or organ wherein it exists. There is a moderate quantity of sugars (glucose and levulose), an enormous amount of a specially slimy mucilage, and a quite unusual amount of reserve starch, along with some pararabin and a crystalline substance, soluble in dilute acids, which is oxalate of calcium, connected with an undefined pectic substance encrusting the walls of the intercellular canals and stellate cells of the petioles and blades. The rhizome may be four inches thick, is spongy, horizontal, dark brown, and emits a great number of long, white, nourishing roots and rootlets, which have no root-hairs: it consists of a dense outer wall, a cortex full of large air-spaces, and a central core traversed in all directions by vascular bundles. The petioles and peduncles which spring from it may be up to over nineteen feet long. It prefers a peaty bottom, and requires a large amount of nitrates, rather than ammonia, as food; a fact which would serve to explain its presence in certain waters and its absence from others. The rhizome contains about 4 per cent fat and resin, 10 per cent tannin and its decomposition products, 6.25 per cent sugars, 20 per cent starch, 4 per cent proteid matter, 23.6 per cent crude fiber, and 5.5 per cent ash. There is an ill-defined, harmless alkaloid in all parts of the plant, except the seeds, strange to say. It will be gathered from the foregoing that the Water-lily is exceptionally rich in starch (even the seeds contain 47 per cent thereof); a fact which indicates an exceptional activity and plasticity of the protoplasm in connection, more espe-

* From *Knowledge*.

cially, perhaps, with the function of transportation and growth. In fact, the enormous force requisite to project the petioles and peduncles to the surface from several feet depth of water, not to mention the hauling back of the flower again to near the bottom where the seed ripens—all this must require immense food stimulus and factor, and an extraordinary adaptation of form and tissue to function. It appears, however, that in this case the oxygen of the air, and also of the water, imparts to the cells an activity whence they derive a power of action beyond the influence of free oxygen in a manner and to a degree quite unusual in ordinary land plants. In fact, the amount of proteids in the tissues and of phosphates and sulphates in the ash of all parts is relatively very small, and there are no nitrates in the foliar organs. Thus, by dint of chemical science we arrive at certain physiological conclusions quite contrary to those suggested by mere anatomy or class relationship.

That remarkable plant known as Good King Henry (*Chenopodium Bonus-Henricus*), that dogs the footsteps of humanity, may now be considered. It keeps severely to such stations as the roadsides and waste places near dwellings or ruins, and sometimes sheepfolds. The root and most of the stem have an abnormal structure, owing to a too small thickening growth. All these peculiarities of habitat, and so on, would be hopelessly inexplicable if no resort was made to chemistry. The analysis reveals vast richness in chlorophyll and carotin, a great accumulation of mucilage, much resin and salts of organic acids, but very little tannic matter or free sugar, and no reserve starch. It is, moreover, especially a strong nitrate plant; a circumstance which ensures to it a great root development, a rapidity of growth, a vegetative apparatus out of proportion to the reproductive capacity, and a sort of inevitable choice or selection of habitats where nitrogenous matters of a certain constitution only, and fitted to yield abundant nitrates to the roots, are specially produced and readily available.

# Munitions Profits

## Rejections of Defective Materials Prove Costly

Occasionally the veil is lifted from the processes of war munition manufacturing in this country and Canada and the public gets an insight into the difficulties met by numerous contractors for shells and ordnance. It is still early, however, for the different firms to see exactly where they are coming out in this new and varied business. It is known that in numerous cases deliveries of finished products have not been made on time, owing to delays which were not foreseen at the time contracts were signed. As to profits to be made, a distinct change of opinion is evident in some manufacturing quarters from that held when huge orders first were placed, and this change is toward a lower and not a higher basis.

The Canadian Car and Foundry Company recently obtained from the Russian Government a six months' extension on an order for $83,000,000 worth of shells, and may now ship their final consignment of 5,000,000 shells by August 1st instead of March 1st. It was a tremendous load that this concern took upon itself, largely from patriotic reasons. The largest order that Russia had ever placed outside her own confines before, it is said, was for 500,000 shells, this in Germany several years ago, and the time element was not so important then.

The Canadian management had to work on specifications drawn by the German manufacturers, and it seemed as though there would be no great difficulty in making shells rapidly when equipment had been installed. Events proved, however, that the specifications had to be altered, and considerable delay resulted from this work. Then more time was necessary than had been estimated for the outfitting of plants. The company's shipments are now reported to be on a satisfactory basis, but much of the task has to be done in 1916 that was intended for 1915.

CANADIAN EXPERIENCE NO EXCEPTION.

The experience of the Canadian Car and Foundry Company has not been the exception by any means among firms which set out to make something on a great scale that they had never made before. The Bethlehem Steel Corporation is understood to be up to date in deliveries, but there is a special reason for this. Mr. Schwab had been making ordnance and munitions for years before the war began. His plants were equipped and his men were trained. The Bethlehem organization was ready. Most of the other concerns had to prepare for the work after they got their orders.

The manufacture of shells and arms is conducted in secret. This is necessary because of obvious factors likely to impede or destroy operations. Not even a director of the Bethlehem Corporation, except those actively engaged in the work, can get past the guards at Bethlehem. Shell makers are almost as reluctant to talk about the work as they are to show it to the casual visitor. When they do they decline to be quoted by name. The man who is here quoted is an officer of a corporation which has been successful with its orders, yet had many difficulties to meet before things were set going right.

"The trouble with a lot of us," said he, yesterday, speaking of steel makers generally who took munition contracts, "was that we thought we had a blacksmithing job on hand. Instead it proved a task for a watchmaker. Imagine a batch of fifty shrapnel shell cases set up on a table, nicely polished and formed, seemingly ready for the guns in France. Along comes a British Government inspector with a small instrument in his hand which he inserts into the mouth of one of the shells. This instrument, a micrometer, measures the circumference of the case down to the thousandth part of an inch. If it fits smoothly, the whole group of shells is passed; if it does not fit, the shell cases are rejected.

"Now, it might seem to the layman no difficult task to forge the steel and turn the shells to the exact measurement in these days of scientific appliances. This is true in a sense, but still it requires a great deal of experience and skill to follow specifications. We can do it now, but it took time, and the experience was costly. Rejections have to be considered in two ways. In the first place, the time put in on a batch of shells thrown out is lost; also the chances are that much of the finished material is good for nothing except scrap. There is no method, of course, by which shell makers can tell yet the extent to which rejections have eaten into estimated profits, but it will prove to be a considerable sum in the case of many firms which took on munition contracts for the first time.

INSPECTION BEGINS EARLY.

"Inspections begin long before the shells come from the machine. There are no harder workers in the country to-day than the inspectors sent here by the English, French and Russian governments. From the time the molten iron comes from the blast furnace they are watching it. Step by step, as the raw material moves along through the different processes, tests are made by chemicals or instruments. A mass of steel bars may come from the rolls, representing one 'heat.' A chip is taken from a single bar and inspected. If it meets requirements, the bars are all passed; if it falls below par, all the bars are rejected.

"There have been stories of slipshod work, passed by inspectors with tendencies for graft. Don't believe them for a minute. I know nothing of conditions in other lines of purchase in this country for the allied governments, but I can say emphatically that the inspectors in munition factories are alert and unswerving in their duty. A dozen bad shells, you know, might cause the loss of hundreds of yards of trenches, and the men sent here are determined to see that no poor ammunition is sent across the sea if they can prevent it."

The munition maker declined to discuss the probable extent of profits.

"There are too many elements to be considered before one might make an estimate," he said, "and some are still hidden. It may be months after the contracts are completed before the contractors will know exactly what the work meant in dollars and cents. Plants have had to be built for this temporary task. Will they be of use afterward, or a liability when the war is ended? Hundreds of thousands of dollars have been invested in special lathes and other machinery which may have to be scrapped later. Labor costs have risen, and may rise further before the orders are filled.

"Some of these details were foreseen and counted upon when manufacturers figured on the contracts. Liberal estimates were made to cover unforeseen expenses, but there have been more costs of one sort and another than numerous contractors dreamed about. I may make one direct statement—profits from shell making, in my opinion, will not foot up to as high a total as many optimists thought they would a year ago."—*The New York Sunday Times.*

### Protection of Live Stock in Fields Against Lightning

The loss of live stock by lightning in some localities, especially in the Middle Western States, has been sufficient to cause considerable concern, and in many cases precautions have been taken to prevent it. The greater portion of the loss is caused by cattle drifting against wire fences during thunderstorms and being struck by lightning, which may be collected by the fence at a distance and brought to the herd with sufficient force to kill them. It is not often that cattle are killed by direct stroke unless it be under trees where they have gathered for shade and to fight flies during the excessively warm period which usually precedes a summer thunderstorm.

In many instances attempts have been made to obviate the danger from wire fences by the simple and inexpensive expedient of earthing the wires at intervals by means of an iron or copper wire stapled to the posts in contact with the fence wires and extending 3 or 4 feet (0.91 or 1.2 meters) into the ground. This, however, makes an earth connection of high resistance and is soon broken off or corroded away. A much more permanent, but also more expensive, earth connection is made with a post of galvanized iron with clamps for holding the wires, which is made especially for the purpose. These posts may be placed from 50 to 100 yards (45.7 to 91.4 meters) apart, according to the conditions of dampness of the soil. If the soil is dry, they should be placed rather close together, say at 50 yards (45.7 meters), in order that the resistance to earth may not be too high. If the soil is damp, they may be placed at 100 yards (91.4 meters), or even more. An excellent earth connection, which is less expensive than that obtained with the posts, can be obtained with one half or three quarter inch (1.27 or 1.9 centimeters) galvanized-iron pipe extending 5 or 6 feet (1.32 or 1.83 meters) in the ground and attached to each fence wire by wrapping with galvanized-iron wire. The pipe earths may be spaced at the same distances as the iron posts mentioned above.

To simply connect the fence to earth, however, is not sufficient. It is also necessary that the electrical continuity of the fence be broken up. This can be accomplished by inserting at intervals of 300 yards (274.2 meters), or so, 2 by 2 inch (5.08 by 5.08 centimeters) strips of hardwood a yard (0.914 meter) in length, to the ends of which the ends of the disconnected fence wires are made fast. In this manner a bolt of lightning striking any section of the fence will be confined in large measure, at least, to that section, and thus its transmission to a distant part of the fence will be prevented, even though the resistance of the earth connection is rather high. The strips of wood may be staggered in a vertical direction to a sufficient extent to make it not easy for stock to reach through the fence between the strips where there are no barbs to prevent it.

In the case of trees which it is desirable to preserve on account of the shade they afford to stock, the danger from lightning may be reduced by fencing around the trunk at a few feet from it and rodding the tree with a three eighths inch (6.95 centimeter) copper cable extending from the topmost branches to a sufficient depth in the ground to reach permanent moisture. Where trees are isolated and the vicinity is much frequented by stock, this may be a wise precaution.—*Technologic Papers No. 56 of the Bureau of Standards.*

### Heat Screen for Lenses

Means for preventing the overheating of condenser lenses for projection apparatus such as used in moving picture work, are provided in a recent patent. Formerly there was employed an absorbing trough near the lens, which contained a solution of a ferric salt. It was also found that a plate of glass containing iron salts could be used to advantage to absorb heat rays. The lens itself, however, must not be made of such glass, as the thick part would have a pronounced coloration which would absorb the light. Again, when a glass plate is used, it reflects light from its surface and thus causes a loss. The new method consists in building up a glass disk against the flat side of the condenser lens, so as to avoid reflection of light. It is not required to cement the plate to the lens, but the two can be well pressed together in a suitable mounting.

### A Ferry Operated by Trolley

According to the *Electrician*, there is an electrical ferry at Strassburg that receives its energy from an overhead trolley conductor. The boat is a flat raft, 45 feet long, with 20-foot beam, having a deckhouse on one side in which are installed the motor, control gear, and gearing. Resting on the bed of the lake is a ⅝-inch galvanized steel rope, which passes around a 3-foot hauling drum on the boat, and which also forms the return conductor. The trolley wire is of hard-drawn copper, 9 millimeters in diameter, stretched between two 30-foot lattice masts. The collector consists of a single light over-running wheel attached to the raft by a flexible insulated copper cable, the slack of which is taken up by an ingenious arrangement of hanging weights and pulleys suspended from loops in the cables.

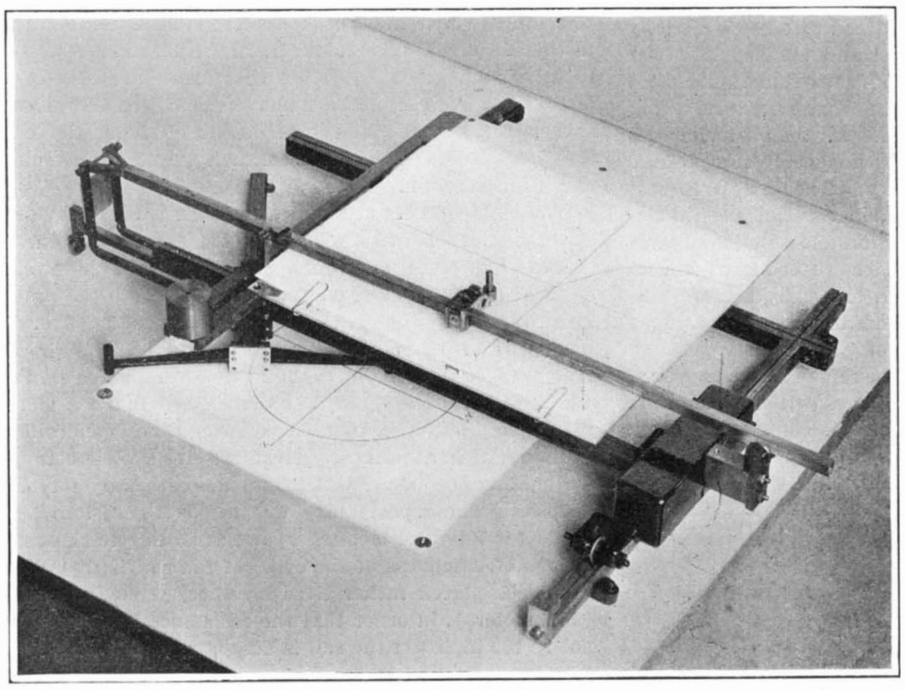


Fig. 4.—The differentiator as it appears when in use.

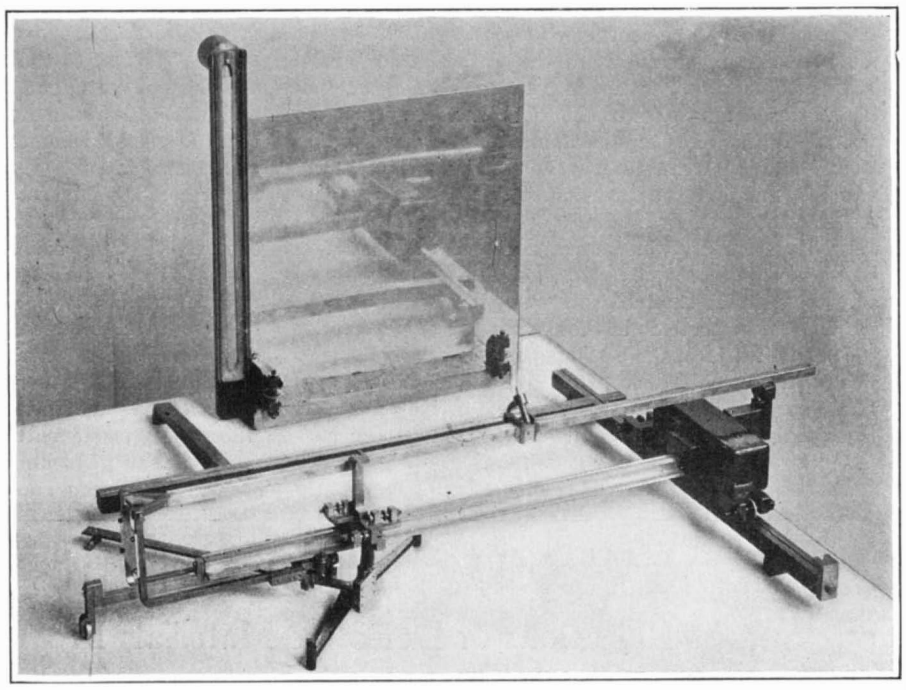


Fig. 5.—The differentiator with tangent bar and carriage turned up.

# A Differentiator

## An Instrument for Laying Out Curves in Engineering Problems

By Armin Elmendorf*

Mechanical integrating machines are familiar tools in nearly all engineering offices and laboratories where areas of irregular figures, such as indicator diagrams and road cross-sections, are wanted. Often it is desirable to obtain not only the magnitude areas but the area or integral curve of a given empirical curve.

If $AB$, Fig. 1, be the curve determined by the function $y' = f(x)$, then $y = \int f(x)dx$ is the equation of the integral curve $OD$ and the length of the ordinate $zv$ erected at any point $z$ to meet the integral curve is proportional to the area $H$ and is therefore a direct measure of this area. Machines, among which the Coradi integraph is the best known, are available to the investigator or engineer who desires such a graphical record of area.

Likewise, if $y = F(x)$ is the equation of the curve $OD$ then $y' = \frac{d[F(x)]}{dx}$ is the equation of the differential curve $AB$ and the length of the ordinate erected at any point to the differential curve $AB$ is proportional to $\frac{d[F(x)]}{dx}$. Inasmuch as $y = F(x)$, its derivative with respect to $x$ measures the slope of the tangent at any point $V$, that is, it shows the rate at which $y$ is changing with respect to $x$. If for example a curve be plotted between velocity of a starting train as ordinates and time as abscissae, then, as is well known, the rate at which the velocity changes, namely $\frac{dv}{dt}$, measures the acceleration, and it becomes possible by a simple computation (after allowing for friction loss) to determine the force exerted by the locomotive at any instant.

Many examples could be cited in which a knowledge of rate of change is of considerable value. Prof. J. Erskine Murray gives the following instances in which rates are of first importance[1]:

(1) Meteorological observations of temperature, pressure, humidity and rainfall.

(2) Terrestrial magnetic records.

(3) Experimental results in physics and chemistry which involve changes whether in time or in space.

(4) Statistics of population, mortality and immigration.

(5) Statistics of wages, prices, commerce.

(6) Medical records.

(7) Engineering calculations, such as the deduction of tractive force from a time and space or a time and velocity diagram.

Much experimental data that is left uncoördinated may be studied by plotting, and from the derivative of the plotted curve noting the changes that take place in the rates. Autographic records can be made of deflections against time for beams broken in impact, but such curves in themselves give very little information. It is only when they are differentiated that they become valuable, for then it is possible to determine the energy consumed up to any instant. Since the derived curve has velocity as ordinates, the energy absorbed by the beam is obtained from the relation $E = \frac{1}{2} m (v_1^2 - v_2^2)$ where $v_1$ is the velocity when the weight reaches the beam and $v_2$ is the velocity at the instant under consideration. A differentiation of the velocity-time curve yields in turn the acceleration-time curve from which the force exerted at any instant against the descending weight may be computed.

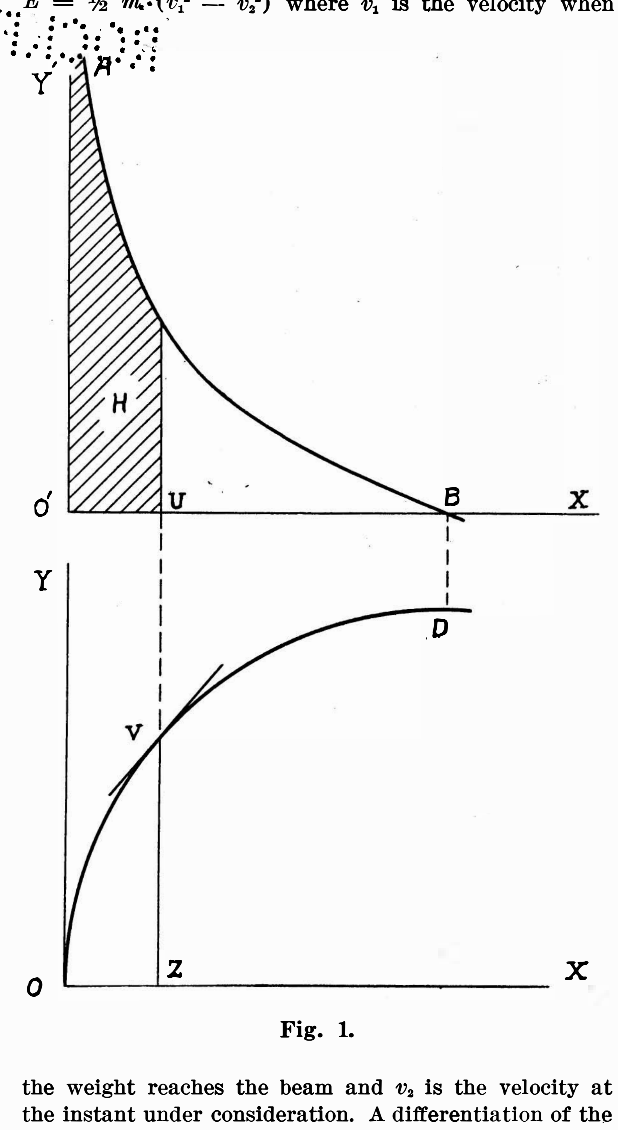



Fig. 1.

By the laborious process of drawing tangents to the given curve, computing the slope of these tangents, and then plotting the magnitudes of the slopes as ordinates, the differential curve of any empirical curve can be drawn. It is obvious that the error involved in this operation must be great, as it is the accumulated error of three steps—first, the drawing of the tangent; second, the computation of the slope, and, third, the plotting of the points.

The difficulty that lies in the design of a mechanical device to perform these operations has been in the getting of the true tangent. Prof. Murray recommends two black dots on a sheet of celluloid, placed so close together that the secant line which they determine is practically identical with the tangent. The adjusting of such dots until the tangent position is obtained may result in considerable error, as a little experimenting with the device will show. The machine illustrated in Fig. 4 uses a silver mirror for locating the tangent. When the mirror is placed exactly normal to the curve the image and the curve form a continuous unbroken line. Any slight deviation from the normal gives a break in this line at the point along the bottom edge of the mirror, where the image and the curve join. With a little practice a remarkable degree of accuracy can be obtained in setting the mirror.

Referring to Fig. 2, it will be seen that if the tangents and a series of horizontal lines of constant length $a$ be drawn from points on a given curve $MN$, and perpendiculars erected at the ends of these lines, the vertical distances from the horizontals to the points where the vertical lines cut the tangents measure the slope of the tangents at the various points. If $a$ be made unity then $BC$ represents the slope of the tangent at point (1) and $DE$ that of the tangent at (2), etc. That is, any vertical distance between the two curves $BDG$ and $CEF$ stands for the gradient of the tangent line at some point on the curve $MN$, and to get a graphical record of slope it is only necessary to plot these distances as ordinates to a fixed horizontal line. This may be accomplished by the simple device illustrated in Fig. 3.

For clearness, the curves shown in Fig. 3 are lettered to correspond to those of Fig. 2. The length $a$ on the link $L$ is the constant base and determines the scale to which the slope is drawn. $Q$ can move along the slot in the vertical bar $HI$ which in turn is constrained to horizontal motion by rollers at the base, fitting in suitable grooves. $Q$ also slides along the slot in the tangent bar $RS$, to which is attached the mirror $T$. $O$ and $P$ are free to move horizontally in the slot of the carriage $U$, but take this carriage along in vertical motion, with the result that as point $O$, the point of tangency traces the given curve, $Q$ traces the curve $CEF$ and $P$ the curve $DG$. Could the tangent bar be swung into a horizontal position the tracing point $I$ would be somewhere along the base line $XX$. In the position shown, $J$ has been drawn up through the distance $h$ equal to $QP$, the slope at the point $O$. The varying distance $h$ therefore measures the slope at points on the given curve and the curve $M'N'$ on the carriage is then the desired differential or slope curve.

From the previous discussion it follows that the curve $MN$ is the integral curve of $M'N'$, and any ordinate erected to it from the $X$-axis would represent the area bounded by the curve $M'N'$, the two co-ordinate axes, and the ordinate to the curve at the point corresponding to the ordinate to the integral curve.

* Instructor in Mechanics, University of Wisconsin.

[1] *Proceedings* of the Royal Society of Edinburgh, May, 1904.

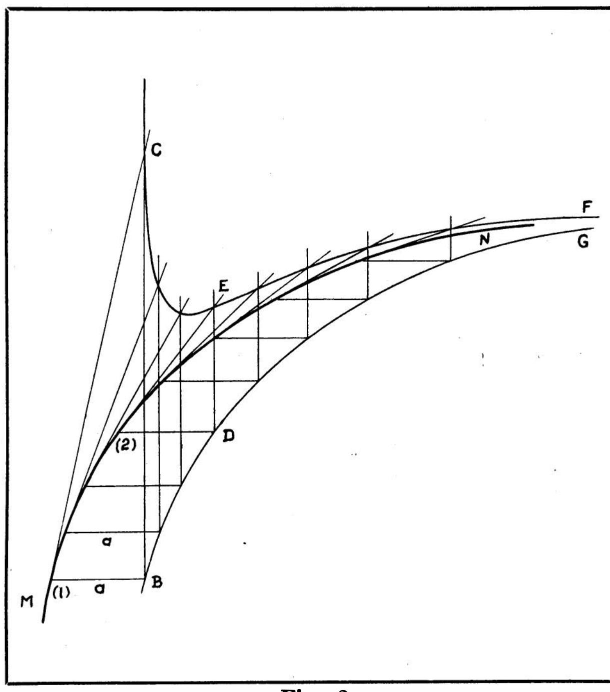



Fig. 2 .

With the foregoing description, Fig. 4 needs little explanation. The two grooves at right angles, the tangent bar, the carriage turned up in Fig. 5, and the mirror and image are all plainly shown. By means of the two superimposed rails, shown better in Fig. 5, it is possible for the point $Q$ of Fig. 3 to move under the point $P$, thereby accommodating negative slopes. The long, square tube to which the tracing pencil is fastened is graduated upon the upper face, enabling the operator to find the numerical value of the slope at any point as he proceeds in the construction of the differential curve. In the illustration the derived curve is that of the upper half circle.

The machine will take a maximum slope of about 4.5, which has been found satisfactory for all practical purposes, as the scale may be changed for any curve that has a greater slope. It has been successfully used for differentiating deflection-time curves from impact tests on wooden beams, to obtain velocity-time curves for the same and from these by a second differentiation acceleration-time curves. By means of the latter and the initial curve the relation between force and deflection curve, but for impact loading in place of deflection has been plotted, giving the common load deflection-curve, but for impact loading in place of static loading.

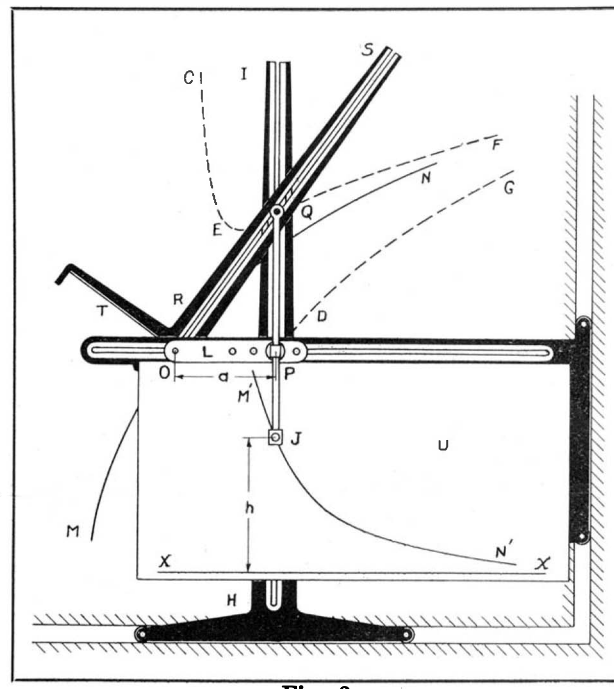



Fig. 3.

## Saving Sinking Ships

An interesting proposal brought forward by Messrs. Brunton Brothers, of St. Stephen's House, Westminster, for preventing the sinking of ships damaged below the water-line by collision or other means, depends on what seems at first sight the paradoxical expedient of pumping more water into them.

Supposing that a bow compartment has been injured and water is entering, their method is to pump the main circulating discharge water into a stern compartment, and fill it to a height above the water-line; the "head of water" thus created depresses the stern and raises the bows, the water in the bow compartment being then free to run out by the holes through which it entered until its level is the same as that of the outside sea. As this happens it becomes possible to discharge some of the water in the stern compartment, because only so much of it is required as will counterbalance the weight of the material of the bows, the water in the bow compartment open to the sea having no effective weight on the ship and forming, as it were, a part of the sea and not of the ship. The final result is that the vessel is brought to an even keel; her draught is greater than before the accident, but she contains less water than she did when she was down by the head with her bow compartment flooded.

Damage to the side is dealt with in a similar manner. Supposing that in a vessel having an inner skin or longitudinal bulkheads three of the starboard side compartments have been opened to the sea, then water would be pumped into one of the corresponding compartments on the port side, destroying buoyancy and adding weight until the list is counteracted. Careful and prompt regulation of the amount of water pumped in is essential, else the vessel will be liable to capsize toward the side opposite to that on which the damage was inflicted, and Messrs. Brunton claim to be able to keep the amount under exact control by means of valves like those employed in their hydraulic system of working watertight doors.

Before the war, their method was brought to the notice of a number of German naval architects, and it is thought that it may have been fitted in German warships, though without adequate means of regulation. This, it is suggested, may account for the fact that in some of the published photographs German ships are seen capsizing to port, although the damage has been to their starboard side. If the Brunton method has been adopted, it is useless to continue firing at the damaged side with the object of sinking the ship; compartments on that side are already open to the sea, and the shots, unless they pierce the longitudinal bulkheads, can do no further harm. The attack should, therefore, be continued on the other side. Similarly, if the forward compartments of a ship fitted with the Brunton arrangement are flooded, it is not only futile but even detrimental from the point of view of sinking her, to fire at her bows, since the only effect can be to knock away some more of their material and thus decrease their weight. The object should rather be to pierce the stern compartment and thus liberate the water which, by its counterbalancing effect, is holding the bows out of the water against the pull which gravity is exerting on the material of which they are composed.—*London Times Engineering Supplement.*

**Drying Blueprints.**—Makers of blueprints may be interested to know that a wet print can be wiped dry, or nearly so, with a common towel. This absorbs the water even faster than blotting paper and almost as fully.

## A New System of Cutting Gears

The wear on the surfaces of the gear teeth while in frictional engagement with each other is affected not only by the magnitude of the forces to be transmitted, but by the shape of the tooth profile on which depends the friction of the two-tooth surfaces working on each other.

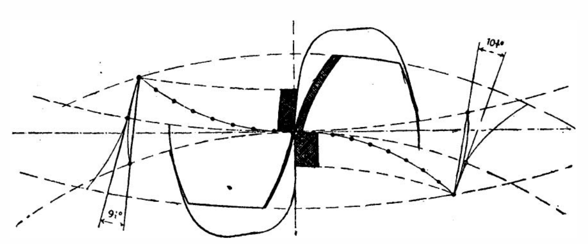


Fig. 1.—Cycloidal system.

For each definite tooth shape there must be a certain tendency to wear, i. e., with a tooth having a certain shape the wear in the unit of time must be greater, other conditions remaining the same, than in another profile. As long as the gears are new and the profile has not been altered by wear, that gear system must be the best which

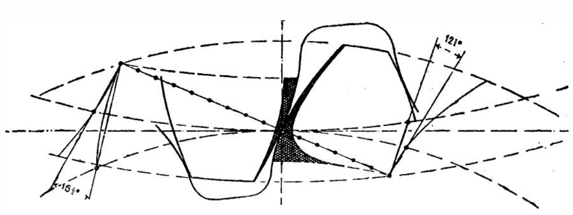


Fig. 2.—Involute system.

has most favorable conditions of grip, sliding friction and contact friction.

In the following figures showing different gear systems the tendency to wear of the new gear system is represented in the true proportion by shaded areas, the depth of the hatched areas extending over part of the tooth

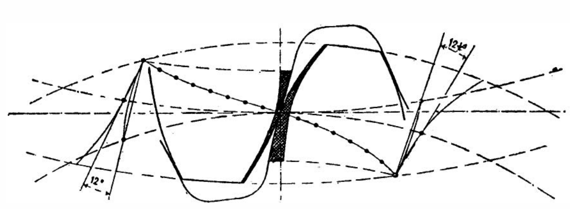


Fig. 3.—Ozoidal system.

profile corresponding to the magnitude of the theoretical wear coefficient resulting from the tooth profile. A comparison shows at once that the wear ratios are exceedingly unfavorable in the cycloidal gear system, especially at the base of the tooth, where the tendency to wear is ten times a large as at the apex of the tooth. A little more favorable and not showing the abrupt change of wear tendency on the pitch-line are the conditions as shown in the involute gear system (Fig. 2), but the tendency to wear is at places extraordinarily high. A far greater compensation of the tendency is shown in the ozoidal gear system recently developed by the firm of Friedrich Stolzenberg of Berlin-Reinickendorf (Fig. 3), which possesses a tooth profile with a contact line such as that sought for in cycloidal and evolute teeth. In this ozoidal gear system the disadvantages of other gear systems are avoided, and their advantages are retained, resulting in a very compact tooth profile with very large base, and very strong teeth even with small numbers of teeth, capable of withstanding up to 30 per cent more load than a normal evolute tooth. Since the conditions of sliding friction and contact friction, and, consequently, the tendency to wear of the ozoidal gear system, are very favorable, the "life" of the teeth is comparatively long, the profile remaining almost unchanged. The ozoidal gear system may be of value particularly in transmitting large powers in continuous service, but by its nature is also well adapted to all other conditions. The ozoidal gears are cut by means of special machines and tools by processes which are particularly adapted to the gear system and from which extraordinarily accurate gear profiles are obtained.—*Prometheus.*

## Acres of Tracing Cloth and Hogsheads of Ink

A large-sized filing cabinet will be needed by the Valuation Division of the Interstate Commerce Commission at Washington, D. C. The law requires every steam-railway carrier to file with the commission maps and profiles of its entire system. The maps are of standard size, 23 by 55 inches inside the border lines, on scales of 100, 200 or 400 feet = 1 inch. The profiles are 10 by 55 inches inside the borders and on a scale of 20 feet = 1 inch vertical and 400 feet = 1 inch horizontal.

It is estimated, according to F. C. Sheperd in a paper presented before the Boston Society of Civil Engineers, that the Boston & Maine Railroad will have to file about 3,000 maps and 750 profiles. The Boston & Maine Railroad comprises 2,300 miles of track. There is about 370,000 miles of track in the United States, and computing the number of maps required by the same ratio as on the Boston & Maine, we have 484,000 maps and 121,000 profiles.

These Government file maps must be on tracing cloth, which will require about 537,000 square yards (4,840,000 square feet) of plain tracing cloth and 67,000 square yards (600,000 square feet) of profile tracing cloth. As the railways will very likely not want to file the originals with the Government, tracing-cloth copies of the originals will have to be made, doubling the consumption of tracing cloth to 1,000,000 square yards and 130,000 square yards respectively—a total of 1,130,000 square yards.

*Engineering News* is informed from reliable sources that ordinary tracings require about one quart of black drawing ink to every 100 square yards of tracing cloth, so for these railway-valuation maps about 11,300 quarts of drawing ink will apparently be the quantity required.

## Mucilage for Paraffin Paper

According to the *Papermaker*, a suitable mucilage for paraffin and similar papers, which binds well and resists the weather, consists of a mixture of dextrine, rice-starch, acetate lacquer and beeswax. The proportions vary according to the character of the paper for which the mucilage is used. For normal paraffin paper of medium weight, the following mixture is used, heating being effected by direct steam, by a flame or a hot-plate: Dextrine 30 parts, rich starch 30 parts, acetate lacquer 20 parts, beeswax 20 parts. The mixture, well stirred, produces an extremely viscous, yet transparent, mass with good weather-resisting qualities.

# The Structure of the Atom—II*

## A Comprehensive Survey of the Development of Theories and the Present Situation

By Dr. K. Fajans

Concluded from SCIENTIFIC AMERICAN SUPPLEMENT No. 2092 Page 83, February 5, 1916

### ATOMIC WEIGHTS OF THE RADIOACTIVE ELEMENTS.

The Prout hypothesis was in its time tested by comparison with the atomic weights. To establish the present theory that helium is one of the constituents of the atom, such a test is of even more importance. This may be done for the three members of the radium-uranium series which have been obtained in a chemically pure condition, namely uranium, radium, and radium *G*. If an atom of an element loses one α-particle during its transformation, i. e., one helium atom, the atomic weight of the resulting element must be less than that of the parent element by the atomic weight of helium, 4.0. The emission of a β-particle, i. e., an electron, is accompanied by such a small loss in mass, that it is negligible.[8] Between uranium 1 and radium three α-transformations and two β-transformations are known to take place; these elements must therefore differ in atomic weight by 3.4.0 = 12.0 units. The atomic weight of radium is 226.0 (Hönigschmid, 1912), that of uranium 1 should therefore be 226.0 + 12.0 = 238.0, while a recent experimental determination gave[9] 238.2 (Hönigschmid, 1914), a value which differs from the theoretical by only a small amount. The calculation of an atomic weight of an element from the values for two other elements has become of considerable importance in these cases. The values for all the elements in the uranium-radium series have been calculated in this way and given (in parentheses) in Table 2. Of very special interest in this connection is the atomic weight of radium *G* so obtained, and its experimentally determined value.

It has been possible by the use of radioactive methods to follow the uranium-radium series as far as radium *F*. This element, named polonium by its discoverer Madame Curie (1898), decomposes with the loss of α-particles, without leaving any residue which could be demonstrated by radioactive means. It is assumed that the transformation product radium *G* does not decompose further, and is completely stable; i. e., it is the end-product of the uranium-radium series. If this is true, radium *G* must be present in uranium minerals: these have been present during the millions of years since the crust of the earth solidified, and during this time uranium and its accompanying elements must have been passing through a condition of perpetual, though very slow, decay. It was shown by Boltwood (1907) that all uranium minerals contain lead in amounts which, for minerals of the same geological period, i. e., of equal age, were proportional to the uranium content, while in minerals of different ages the lead increased in amount with the age of the mineral. This points strongly to the conclusion that *radium G* is nothing else than the well-known element *lead*. And since the half time period of uranium is known ($5 \times 10^9$ years) from a variety of phenomena, it is possible to calculate the *age of different minerals* from the ratio of lead to uranium.

Attempts to gain the support of atomic weight determinations for this hypothesis as to the chemical nature of radium *G* have been beset with difficulties. As is shown in Table 2, the atomic weight of radium *G* might be expected to be 206.0, while the actual atomic weight of lead is 207.2, a difference which far exceeds the experimental errors of the determination. The explanation of this contradiction has become possible, since a study of the chemical properties of the radioactive elements has led to the astonishing conclusion that there are elements which *have identical chemical properties, and which are yet of widely differing atomic weight.*

### ISOTOPIC ELEMENTS.

If a solution of radium *B*, which is easily identified by its radiations and the half time period of its decay, is mixed with a solution of a lead salt, it is not possible to separate the radium *B* from the lead by any known chemical process, while the addition of any one of the usual chemical elements to lead gives a mixture which is easily separated. It is possible to explain this only when it is assumed that the lead and radium *B* resemble each other in chemical properties to a remarkable extent. Aside from radium *B*, the other members of the radium series are also chemically identical with radium *D*, and the individual members of the thorium and actinium series show this same behavior. Now it has been shown in the calculations above that all of these elements have very different atomic weight; the atomic weight of radium *B* (214.0) is 7 units greater than that of lead (207.2). These results have raised the possibility (Russell, Fajans, Soddy, 1913) that perhaps the element in uranium minerals which acts like lead is an element *which shares all of the chemical properties of ordinary lead and yet has a different atomic weight*, namely, that of radium *G*.

Besides the evidence of Boltwood that radium *G* has the chemical properties of lead, we have to consider yet other evidence, since it is of significance for the question as to whether the atom is made of positive and negative electricity. On account of the extraordinary similarity in the chemical properties of the elements such as radium *B* and lead, it has been decided (Strömholm and Svedberg, 1909) to place them in the same position in the periodic system. In this way it has been possible to allot to all the radioactive elements equal significance in the periodic system (Fajans, Soddy, 1913). In such a position in the system we do not have a single element, as shown in the table, but a group (a constellation) of elements, which may therefore be called *isotopic* elements. As an example, the *lead constellation*, which comes in the position of lead (Pb) in the table, is shown:

TABLE 3.

| Name. | Atomic weight. |
|---|---|
| Radium *B* | 214.0 |
| Thorium *B* | 212.4 |
| Actinium *B* | (211.0) |
| Radium *D* | 210.0 |
| Thorium $D_2$ | 208.4 |
| Lead | 207.2 |
| Radium *G* | 206.0 |

All of the known radio elements distribute themselves in this way in the positions in Table 1 between uranium (*U*) and thallium (*Tl*). The groups of the periodic system to which the members of the uranium-radium series belong, as shown by their chemical behavior (column 4), are shown in column 5 of Table 2. By comparison between column 5 and column 2 it may be seen that the following series laws are true (Soddy, Fajans, 1911 and 1913). After each α-ray transformation the element is shifted into the second lower column from that of the parent element, and by each β-ray transformation into the next higher group. (For example, $\underset{IV\,a}{\text{Ionium}} \xrightarrow{\alpha} \underset{II\,a}{\text{Radium}}$, or $\underset{V\,b}{\text{Radium } E} \xrightarrow{\beta} \underset{VI\,b}{\text{Radium } F}$.) These two laws hold also for the actinium and thorium series. Since Radium *F* (polonium), on account of its chemical properties, belongs in the sixth group (*VI b*) in the next to last horizontal line of the periodic system, and since it undergoes transformation with the emission of α-rays, its transformation product, radium *G*, must belong in the fourth group (*IV b*), the lead constellation, i. e., it must have the chemical properties of lead.

These considerations led to the determination (Richards and Lembert, Hönigschmid and Miss Horovitz, Madame Curie, 1914) of the atomic weight of the "lead" from radioactive minerals, and it was, in fact, shown that this atomic weight was considerably lower than that of ordinary lead. It was also possible to obtain (Hönigschmid and Horovitz, 1914) from an especially pure uranium pitchblende a "lead" whose atomic weight was 206.0, which corresponds to the theoretical value for radium *G*.[10] *The lead found in uranium minerals is therefore not identical with ordinary lead, but is an isotope of it.* It is therefore called *uranium-lead*. In how far the properties of the isotopic elements agree may be seen from the comparisons of properties which especially characterize ordinary lead, such as solubility of the salts, electrode potential, and indeed spectrum, in none of which has the slightest difference been detected.

The atomic weight determinations mentioned above point to a new fact, that the *atomic weight of an element can be calculated from those of other elements*, and this constitutes *quantitative proof* of the assumption that *helium is a constituent of the radioactive elements.* It may also be stated with confidence that *there are elements with different atomic weights but extraordinarily similar (so far as known inseparable) chemical and spectroscopic properties.* The atomic weight does not, as was thought at the time of the discovery of the periodic system, absolutely condition the chemical properties of an element.

It is permissible to inquire whether or not many of the known elements consist of mixtures of chemically inseparable isotopes,[11] and whether their atomic weights are therefore merely average values. It is open to argument in the light of this hypothesis whether all of the elements may not be made up of helium and perhaps hydrogen[12] and whether all of the atomic weights of the known elements are not the sum of whole multiples of the atomic weights of these two fundamental substances.

### THE RUTHERFORD ATOMIC MODEL.

We have now to consider those conceptions as to the structure of the atom which are best suited to explain the observed facts. The most suitable of these is the Rutherford conception (1911) of the model atom, first developed by him from the behavior of α-rays when they penetrated solid substances, and later gradually adapted to the explanation of other phenomena.

According to this conception, the atom of any element consists of a positively charged central *nucleus* which is surrounded by *concentric rings of negative electrons.* In the neutral state the sum of the negative charges of the electrons is equal to the positive charge of the central nucleus. The nucleus has a very small radius, of the order of $10^{-12}$ centimeter, but the radius of the outer ring of electrons of the atom has a radius of about $10^{-8}$ centimeter. It must be assumed that the electrons are in rotation around this central core in order to explain how they may be separated from it in spite of the attractive force of its positive charge. An atom is therefore a small solar system. The chemical and many of the physical properties of the atom depend on the arrangement of the outer ring of electrons; for example, the *valence* of a metal depends on the number of electrons which may be easily separated from the outer ring. Also the conditions in the ordinary light spectrum depend upon the vibrations of the electrons in the outer ring. From what has been said it is evident that the mass of the atom is mainly combined with its positive charge, i. e., with the nucleus of the Rutherford atom. It is also plain that since radioactive processes are not influenced by any physical or chemical conditions which can be imposed, these processes are taking place in the nucleus of the atom, not in the outer ring. Therefore the α- and β-particles come from the nucleus of the radioactive atom.

As to the nature of the α-particle, Rutherford makes a very simple assumption: it is the positive nucleus of the helium atom, therefore the neutral helium atom consists of a positive nucleus with two elementary charges and two negative electrons. The hydrogen

* Translated for the SCIENTIFIC AMERICAN SUPPLEMENT from *Die Umschau.*

[8] Although no change in atomic weight takes place during β-ray transformation, the elements involved in it differ not only in radioactive properties, but, as will be shown later, there is also a marked difference in chemical behavior.

[9] The element uranium obtained from minerals consists of a chemically inseparable mixture of uranium 1 and uranium 2 (see following paragraph), so that the value experimentally determined for this element is influenced by the different atomic weights of these two elements, which differ by four units. But uranium 2 is a much shorter lived element than uranium 1, and the proportion of it in minerals is correspondingly smaller, so that the experimentally determined value for uranium is practically identical with that for uranium 1.

[10] If the mineral contains ordinary lead, which has been deposited with the uranium in the course of formation of the mineral deposit, this is naturally mixed with the radium *G* in the process of working up the mineral, and the value obtained lies between 206.0 and 207.2.

[11] It has not been shown that ordinary lead is not a mixture of radium *G* and another member of the lead constellation, Thorium $D_2$ (atomic weight 208.4). At least this assumption is worthy of serious thought.

[12] That helium is not only a constituent of the heavy radioactive elements, but probably also of other elements, may be seen from a glance at the first two lines of the periodic system; exactly as in the case of α-ray transformation, we see that the elements separated from each other by two groups have atomic weight differences of about 4.0. But even if the elements are considered as mixtures of isotopes, and the atomic weights as average values, lithium (atomic weight 7) could scarcely be made up *only* of helium, for then one of the elements of the lithium constellation must have an atomic weight of 4, i. e., must be helium, which is, of course, impossible. It is necessary, therefore, to assume some other constituent, and it is to hydrogen that we naturally turn.

atom is still simpler; namely, a positive nucleus with *one* elementary charge and a *single* negative electron. Then the positively charged hydrogen ion is nothing else than the positive electron, and this explains how it is that positive electricity is never found associated with masses smaller than that of the hydrogen atom. There are many other facts which favor these simple constitutions for the helium and hydrogen atoms, among which may be mentioned the fact that Bohr, with the aid of certain assumptions as to the nature of light radiation, has been able to explain the structure of the hydrogen spectrum.

Helium, as a whole atom, does not form a constituent of the other atoms; rather, its nucleus enters into their nuclei. The same idea must be applied to hydrogen as a component of other atoms. But besides helium and hydrogen nuclei, the nuclei of radioactive elements must contain electrons as well, since the $\beta$-ray transformations must also take place within the nucleus. The positive charge of the nucleus is, then, the algebraic sum of the positively and negatively charged constituents.

As to the *size of the positive charge of the nucleus* for different elements, van der Broek (1913) has advanced the following hypothesis: beginning with hydrogen as one in the periodic system, helium 2, lithium 3, and proceeding thus from element to element in the system, we obtain the *atomic numbers* of the elements, and at the same time the positive charge of the nucleus expressed as whole multiples of $e$. Shifting one position in the periodic system corresponds to a change in the nuclear charge of one elementary charge. (In Table 1 the atomic numbers of the elements are given beside the symbols for each element.) The shifts in position in the periodic system during $\alpha$- and $\beta$-ray transformations of radioactive elements lends strong support to the theory of van der Broek: after an $\alpha$-ray transformation, the nucleus of the resulting atom has two positive elementary charges less than the original atom; during a $\beta$-transformation the nucleus loses one negative charge, which has the same effect upon the total charge as if a positive charge had been gained. In agreement with this conception, during the first type of change, the element passes into the second lower column; during the latter type, into the first higher column of the periodic system. (See Table 2, column 6.)

This conception of the structure of the atom explains completely also the existence of isotopic elements: If uranium 1 undergoes an $\alpha$-transformation, and this is followed by two $\beta$-transformations, the uranium 2 nucleus has after these three transformations the same positive nuclear charge as uranium 1. But since the chemical properties depend primarily on the outer ring of electrons, and since the number and arrangement of these is primarily governed by the charge of the central nucleus, it follows that uranium 1 and uranium 2 must have similar chemical properties. Thus it may be seen that *the fundamental properties of the elements which are of primary importance do not depend on the atomic weight, but on the nuclear charge.* The nuclei of uranium 1 and uranium 2 are, of course, not identical, and this explains their different radioactive properties, for example, their different half-time values. This will exert a certain influence on the outer electrons, and hence on the chemical properties, but on account of the small dimensions of the nucleus compared to the radius of the "atom," this is so small that it has not yet been possible to observe it.

Whether the Rutherford atom will be as serviceable in explaining other physical and chemical facts as it has been in the foregoing pages can be determined only by the results to be obtained in the future.

## Agriculture in France During the War*

In common with all other industries in France agriculture has been deeply affected by the war, but it is most apparent that it is doing its full duty. The farmers have given without hesitation of their best blood to their country, and generously, and there have been few, if any, shirkers. Those whom their age has kept at the fireside, old men, youths and children, together with the women, have rivaled the soldiers in zeal and have not forgotten for a moment the mission of agriculture to nourish the nation, and to prevent the fertile soil from becoming waste land. It is well to review what has been done and to note what the prospects are for the future.

The war broke out in August, 1914, when the harvest, quite fully gathered in southern France, was in progress in other parts of the country. Thanks to the efforts of the population remaining at home and to the spirit that animated the people one and all, the gathering was finished, slowly to be sure, but under conditions practically normal. The invasion of the enemy into the north and northeastern portions of France involved the loss of the crops in a department where the harvests were greatest, but nevertheless the country has had available, according to the statistics of the Minister of Agriculture, 101,000,000 hectoliters (about 287,000,000 bushels) of grain. In consequence, the population then needed only a relatively small importation of foodstuffs.

Difficulties began, however, with the autumn harvests. Military requisitions had taken most of the horses, and the disturbance in transportation prevented the distributions necessary to operate under normal conditions. There was thus an inevitable reduction in the cultivated lands, somewhere about 2,000,000 acres, with about half a million more in the department occupied by the Germans. This loss was effected by the fall of 1914.

As the seasons succeeded one another the farms have been worked under less and less advantageous conditions. The calls to the colors, first for the classes of 1915 and 1916, then for territorials or militia, which in a number of sections had been undisturbed, reduced from day to day the available workers of the farms. The strength of those remaining pushed to its utmost has been able till summer to tide over any difficulties without much default.

But of course such matters cannot fail to have direct influence on the products of the land as a whole. The reports of the Minister of Agriculture show that nearly five million acres have now been withdrawn from cultivation, including the fields occupied by the enemy. These losses have been borne by different crops, about four million being in farms raising cereals. The loss in grain land is about two million; in hay farms about one million and one third, about 570,000 acres in potatoes, 860,000 acres in other vegetables, of which some 470,000 acres were for beets and brewers' stock.

To this great original cause of loss of product are added others, quite as sure, but not at once so obvious. The inability to prepare the land properly, the impossibility of securing proper quantities and kinds of fertilizer, the insufficiency of the available labor, are all of them factors to loss of efficiency and production below the normal. It is possible at this moment to know the full extent of the harvest, and the total production of grain has not passed 104,000,000 hectoliters (295,000,000 bushels) and that of hay not more than 79,000,000 hectoliters (4,000,000 tons). With reference to the grain the product per acre is less by about one sixth than the normal before the war, while the crop of hay is the smallest recorded for the past fifteen years. There will be a deficiency of perhaps one fifth of the normal requirements, but this is available at reasonable prices in other countries, and it is not likely that the cost of bread in France will be increased.

On this account the Government may well abandon the regulations, in some instances ill advised, that have been in force for perhaps a year to prevent scarcity. After the cereals potatoes form the principal alimentary crop. There has been a loss of land for this culture as already noted of 570,000 acres this year. The crop has been very variable, in many places normal but in others notably reduced, and in part by the natural enemies of the plants. The latter regions are quite extended. It would be unfortunate, however, to prophesy scarcity, when it is most probable that the prohibition of exportation, established early in the war, if rigorously attended to, will more than make up the deficiency.

The story is somewhat different when it comes to beets and other vegetables, especially those grown in the south of France. On account of the war the production of sugar reached only 330,000 tons in 1914, and will be less the present year. The growth of beets has been much affected and the various causes have cut production down to half its normal amount. The beet product for liquors is on a different basis, however, for all the alcohol is requisitioned in advance for military purposes.

With some exceptions the crop of fodder is good, in places, excellent, and this is important since it is necessary that the animals on which so much depends, should be well nourished. Despite the great demands of the military, these have been met during the year and will apparently be continually met in the future.

The vine occupies, as every one knows, a very important place among agricultural products in France, even the most important. Its culture demands the closest care and attention to combat the parasitic maladies and the insects that war against it. It was fatal, therefore, to have been obliged to withdraw men from the vineyards for the mobilization. In addition to this another trouble, an attack of unusual violence of mildew, occurred in the spring. The crop has been enormously reduced, but there is still the hope that the wine will prove of unusually high quality.

On the contrary, the apple crop has been unusually good in Brittany and Normandy, an abundance that is somewhat embarrasing, since the great annual export to Germany has ceased, and this it was that formerly cared for the surplus. The present proposition is to make military use of the fruit and its products. It is rather curious that at a time of the need of conservation of food products, the apples run some risk of rotting on the farms.

The details of the smaller garden vegetables are such that it is not easy to give a comprehensive survey of them all. It is true that there is great demand for them, and this will continue, for the military, fed as the men are on a diet largely of meat, will consume more vegetables to balance their ration. Efforts are in progress to increase this line of agriculture.

In conclusion it would appear that agriculture in France has been deeply disturbed by the war. The reaction has been energetic, to the honor of the farmers. The Government hastened to take measures to help them, and under the supervision of Fernand David, Minister of Agriculture, and his energetic collaborator, François Berthault, these measures have been reasonably successful. They included first rent concessions and co-operative workings for the mobilized men, then distribution of seeds, fertilizer, etc., in the villages of the invaded sections. Thanks to this aid in the departments of the Marne, Meuse, and Meurthe-et-Moselle, the cultivation of the fields has been kept up almost under the fire of the German shells. Then there has been temporary allotment of farms, and aid in the processes of cultivation, but the results have not always been of the best, for reasons of the disturbances.

To-day the situation is rather serious. In addition to the obstacles already noted there is now to be considered the indisposition of the farmer, wearied with almost superhuman toil, to remain on his land.

It is absolutely necessary to have the cultivation of the soil go on without interruption; it is necessary for the present and in equal measure at least for the future. Coercion of laborers will be powerless against the discouragements of the situation. What seems best to do is to organize in military fashion companies of farm hands and send them into different countrysides according to the needs. There are enough men available for such organizations, and it is merely necessary to act seriously and to act without delay.

* From La Nature.

## Induced Electromotive Force

According to the usual conception, the induced electromotive force in a conductor is located in the conductor, and is the cause of the induced currents that flow. If we regard the rate of change of the magnetic field cutting a circuit as the line integral of the electric force, we obtain a representation that leads to the same results for the electric field at points within the conductor, and besides this to a correct representation for points outside the conductor, for which points the first conception does not accord with the facts. Knowing that an electric field does exist outside the conductor, we are constrained to admit that the facts cannot be properly represented by an electromotive force situated in the conductor, and such an induced electromotive force cannot have an actual physical existence. The conditions obtaining in a circular copper ring surrounding a magnetic cylinder are analogous to those in a magnetic ring similarly linked with a current-carrying conductor, and in place of the lines of magnetic force $H$ in the latter case we have the lines of electric force $E$ in the former case. It would seem a retrograde step to speak of an "induced magnetomotive force" caused by the electric current, and there is no good reason for speaking of an "induced electromotive force" caused by the magnetic field, and the discarding of this mode of expression would be a scientific advance.—W. Rogowski, in *Archiv f. Elektrot.*

## A Gas Stove Lighting Device

An automatic device for lighting gas stoves is the subject of a French patent. It is specially adapted for use with the common one or two-place flat open gas stove with circular blue flame, over which is put the vessel for cooking. Besides the usual gas cock, there is fitted on after it a special cock which belongs to the device. From here a small tube projects into the gas burner, and the end of the tube has a small pilot flame which burns constantly, provided the main cock is kept open. The special cock is mounted with a set of levers in such way that the combination ends in a vertical projection or pin that projects somewhat above the stove base, so that when the vessel is placed on the stove it depresses the levers and turns on the gas, which is lighted by the pilot flame. A spring on the special cock restores to the first position after removing the vessel, and thus the gas is never kept lighted unnecessarily.

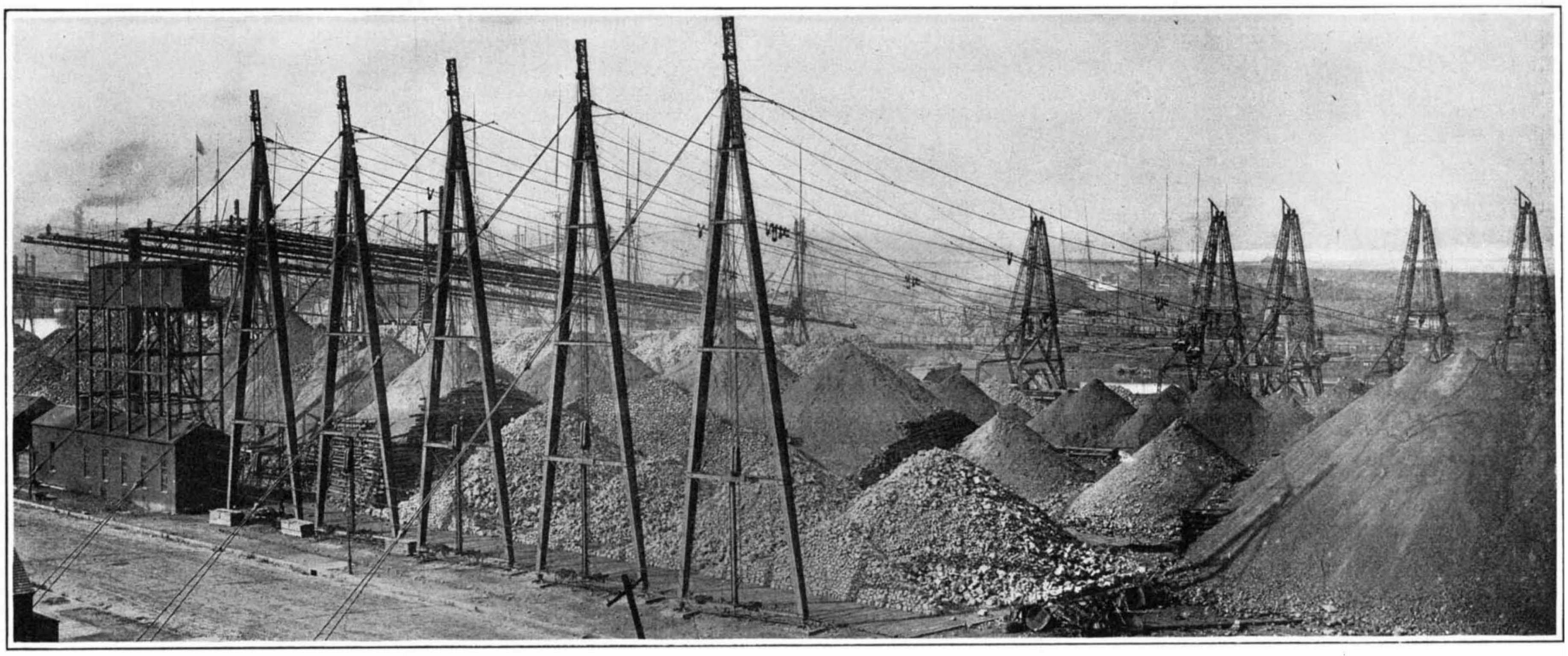


Fig. 1.—Cableways delivering direct from the vessel to the stock piles. The first form of unloading machine.

# Ore Unloading on the Great Lakes*

## How the Immense Shipments of Ore Compelled the Development of Great Machines

By J. H. Stratton

THE modern ore unloader, as developed at the present time, is used almost exclusively at the ports of the Great Lakes. There are few, if any, ocean ports at which the ore tonnage handled is great enough to warrant the installation of one of the large modern plants. There is also added difficulty to be overcome on account of the tides, so that the ore handled by the unloaders which we will consider comes from what is known as the Lake Superior District and is delivered to Lake Erie and Michigan ports.

The discovery of ore in that district dates back to 1844, although none of the ore was shipped down the Lakes previous to 1852, and at that time the Sault Ste. Marie canal and locks had not yet been built, the shipments were comparatively small (the first shipment being made in barrels), as all the ore had to be unloaded and hauled around the rapids by team and reloaded below the rapids. The opening of the canal to navigation in 1855 really marked the beginning of ore shipments, and the problem of ore unloading.

During the period from 1855 to 1866, the unloading was all done by hand without the assistance of steam or electric power, the early method being to install a staging in the hold of the vessel, upon which the ore was shoveled, to be re-shoveled again to the deck, and again re-shoveled into wheelbarrows and wheeled along gangplanks to the dock. At that time the average cargo of ore was about 300 tons, or less, and required four days to unload.

Later, as the quantity of ore to be handled increased, a block carrying a manila rope was fastened to the ship's rigging and a tub handling perhaps half or three fourths of a ton, attached to this rope. The rope was then run through another block, attached to the dock, and a horse hitched to the rope; when the tub was filled it was hoisted to the deck level by the horse walking forward along the dock. The contents of the tub were then dumped into wheelbarrows and wheeled to the dock, the tub being lowered into the hold of the vessel by backing the horse.

This primitive method of unloading was followed until 1867. At that time the firm of Bothwell & Ferris, who operated the N. Y., P. & O. dock, now the Erie Railway dock in the old river bed, employed about 40 horses in the work of unloading schooners.

Table I. shows the growth of the shipments from the Lake Superior region from 1855 to 1912. This has been arranged in four columns representing the four periods in which the different methods of ore unloading which we will consider, were developed. The first period, 1855 to 1866, was devoted to hand-work and the use of horses. The second, from 1867 to 1880, still used the hand-filled buckets, but the horses were replaced by steam power, the ore still being wheeled to the dock in wheelbarrows.

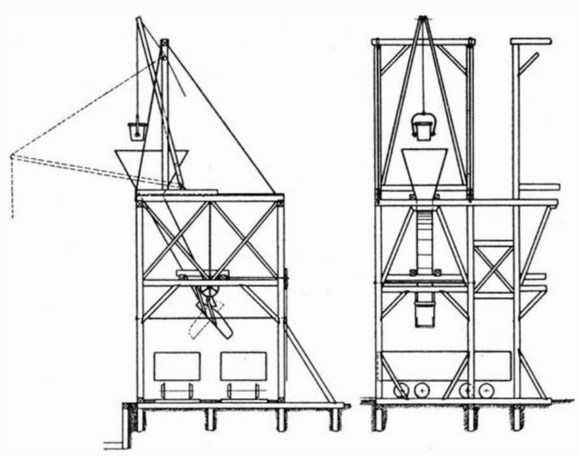


Fig. 2.—Champion ore hoist.

Early in 1867 Robert Wallace designed and built a 6-inch by 12-inch engine, geared to winding drums attached to a portable boiler, the whole being mounted on skids, making it self-contained, so that it could be moved along the dock to any desired position. The engine operated the rope and was arranged to hoist three tubs of ore at one time. This arrangement was so successful that a boat could be unloaded in a single day, and was the general method used for unloading ore until 1880. The cost of unloading in this manner must have been at least 40 or 50 cents a ton.

Such methods appear crude and inefficient when compared with our modern equipments, but when we consider the tonnage to be handled and the cost of installation, we must acknowledge that it answered its purpose admirably.

The period from 1881 to 1899 retained the hand-filled buckets, but the ore was delivered to cars or docks over cableway or bridge tramway, the tub or bucket being dumped directly into the cars or stock pile as required.

During all these periods, from 1855 to 1899, the unit of bulk in unloading was a shovel in the hands of a man. Beginning with 1900 the method changed to automatic unloaders, or the bridge equipped with an

* From a paper presented before the Cleveland Engineering Society and reproducd from the *Journal* of the Society.

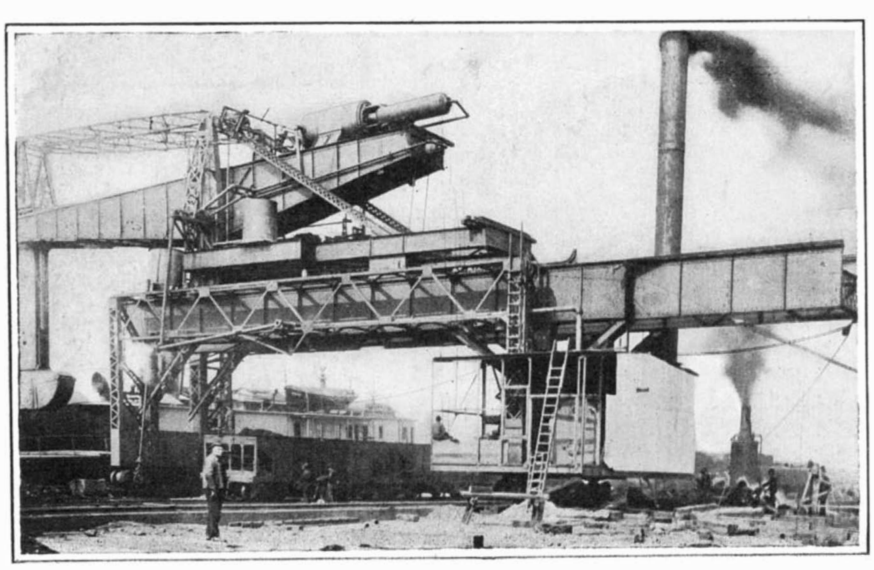


Fig. 4.—The first Hulett machine, using a grab bucket, and delivering to cars or stock pile.

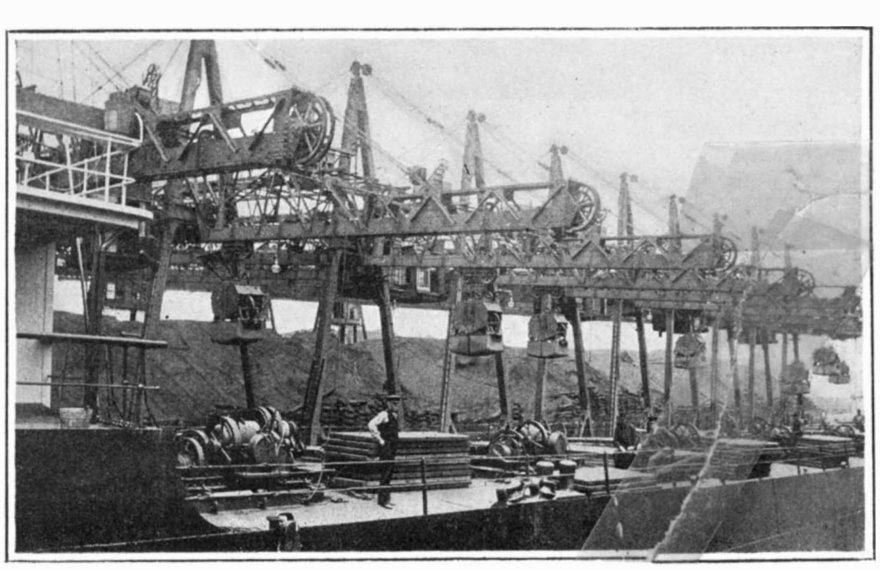


Fig. 6.—Ore bridges with two-ton excavating buckets. Also shows electric haulage rigs clamped to the hatches.

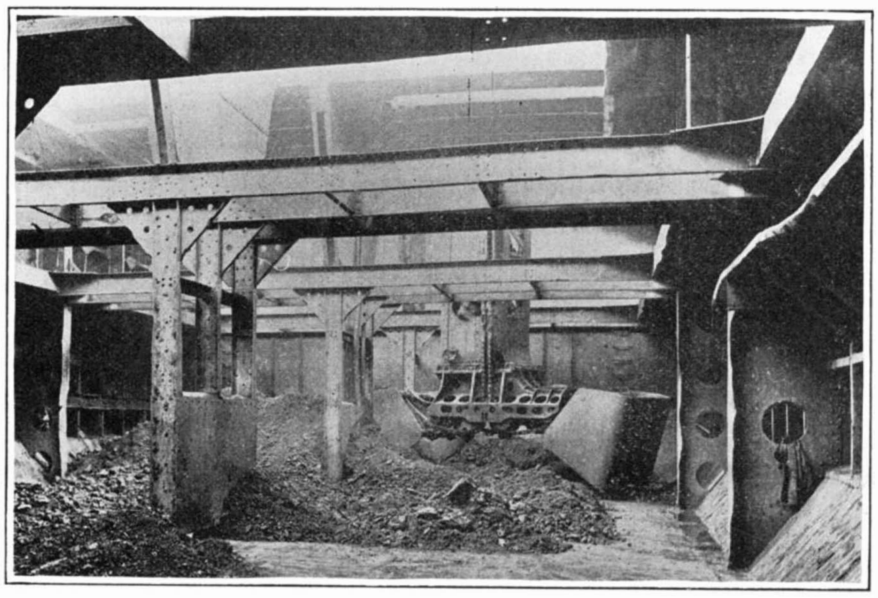


Fig. 9.—An unloader bucket in the hold of a vessel. When open it has a spread of 21 feet, 3 inches.

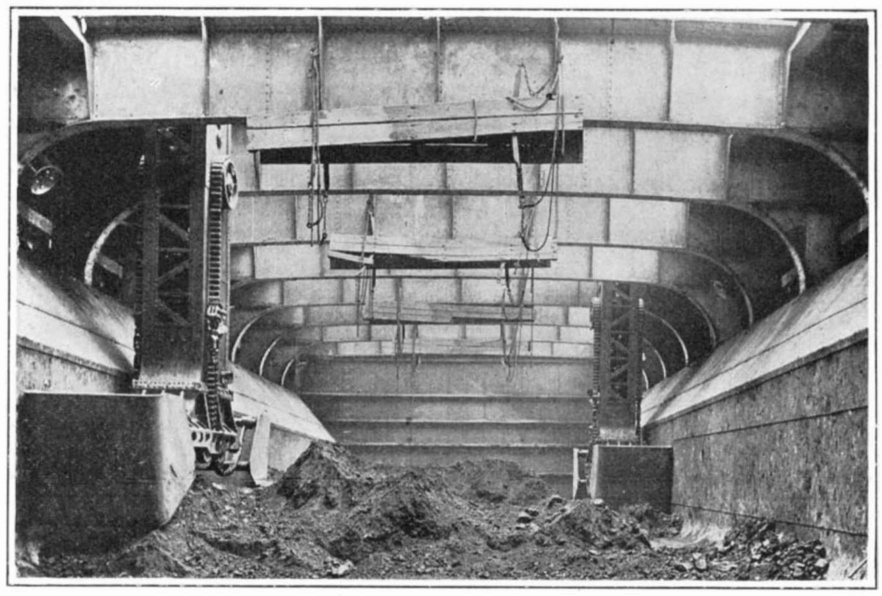


Fig. 10.—These giant buckets can gather up ore in every part of the hold of a modern ore-carrying vessel.

TABLE I.—RECORD OF LAKE SUPERIOR IRON ORE OUTPUT.

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 1855 | 1,449 | 1867 | 473,567 | 1881 | 2,307,005 | 1900 | 19,059,393 |
| 1856 | 36,343 | 1868 | 491,449 | 1882 | 2,965,419 | 1901 | 20,593,537 |
| 1857 | 25,646 | 1869 | 617,444 | 1883 | 2,352,840 | 1902 | 27,571,121 |
| 1858 | 15,876 | 1870 | 830,940 | 1884 | 2,518,693 | 1903 | 24,289,878 |
| 1859 | 68,832 | 1871 | 779,607 | 1885 | 2,466,642 | 1904 | 21,822,839 |
| 1860 | 114,401 | 1872 | 900.901 | 1886 | 3,565,144 | 1905 | 34,353,456 |
| 1861 | 49.909 | 1873 | 1,162,458 | 1887 | 4,762,107 | 1906 | 38,522,239 |
| 1862 | 124,169 | 1874 | 919,557 | 1888 | 5,063,877 | 1907 | 42,266,668 |
| 1863 | 203,055 | 1875 | 891,257 | 1889 | 7,292,643 | 1908 | 26,014,987 |
| 1864 | 243,127 | 1876 | 992,764 | 1890 | 9,003,725 | 1909 | 42,586,869 |
| 1865 | 236,208 | 1887 | 1,015,087 | 1891 | 7,071,053 | 1910 | 43,443,297 |
| 1866 | 278,796 | 1878 | 1,111,100 | 1892 | 9,072,241 | 1911 | 30,731,235 |
| | | 1879 | 1,375,691 | 1893 | 6,065,716 | 1912 | 48,500,000 |
| | | 1880 | 1,908,745 | 1894 | 7,748,312 | | |
| | | | | 1895 | 10,429,037 | | |
| | | | | 1896 | 9,934,828 | | |
| | | | | 1897 | 12,464,574 | | |
| | | | | 1898 | 14,024,673 | | |
| | | | | 1899 | 18,251,804 | | |

excavating bucket. The unit of bulk for unloading then became the excavating bucket, varying from 1½ to 10 tons in the earlier machine and 17 tons at the present time.

Table II. shows the amount of ore received at Lake Erie ports by years from 1906 to 1911. In addition to the figures shown in the table, there were unloaded in the year 1911 at South Chicago 3,685,100 tons, at Indiana Harbor 365,312 tons, and at Gary, Ind., 1,302,745 tons.

Table III. shows the average cargo of ore from 1895 to 1911. This table is a little surprising in view of the fact that we hear so much during the last few years about vessels of 10,000, 12,000 and 13,000 tons capacity. It indicates that there must be a large tonnage of ore still handled in boats carrying 5,000 or 6,000 tons each.

During the year 1880, the late Alex. E. Brown became interested in the problem of ore unloading, and as he brought to bear the force of a well-trained mind, it is not strange that this marked the beginning of great improvements in the existing method of ore unloading.

During the season of 1880 to 1881, Mr. Brown installed on the N. Y., P. & O. dock what I believe to be the first mechanical ore unloader to take the ore from the hold of the boat and deliver it either to cars or stock piles without rehandling. It consisted of two towers supporting a cableway, one tower being placed at the edge of the dock and having a hinged apron or boom that could be dropped down to carry the cable out over the boat, and the other being placed back of the stock pile. On the cable stretched between these towers traveled a trolley from which was suspended the bucket or tub carrying the ore. Several tubs were placed in the hold of the boat so that the shovelers could be filling one tub while a full one was being hoisted and delivered to car or the stock pile. Taking the ore from the hold of the vessel direct to the stock pile without stopping to reload or transfer the ore, resulted in a great saving of time, the speed depending upon the skill of the operator who did the hoisting, and the number of shovelers employed. This first installation consisted of three of these cableways. The hoisting was done by a 12-inch by 24-inch engine, geared to three drums, fitted with band friction clutch and brakes, so that each drum could be operated independently.

Fig. 1 shows a view of this cableway as rebuilt at a later date, and in addition shows in the background some bridge tramways. The dimensions of this cableway were: Total length, 383 feet; hinged projection over the vessel, 33 feet; height above dock of the back pier, 75 feet; of the front pier, 61 feet; height of cable at the front pier, 28 feet.

During the summer of 1882 there was installed on the docks of the Illinois Steel Company at South Chicago by Mr. Robert Aspin some ore-handling rigs known as the Champion Hoists, shown by diagram in Fig. 2, from which the operation will be quite clear. The bucket was lowered into the hold, hoisted and swung back over the dock by means of the shear legs, the ore dumped from the bucket into wheelbarrows or tramcars, and, in the later rigs, into hoppers with gates and chutes for delivering it into the cars. It is interesting to note that this method of unloading was so efficient that it was not replaced until 1906, at which time the docks were equipped with more modern machinery.

In 1884 Mr. McMyler applied the revolving derrick to ore unloading, using it to hoist the tubs of ore from the hold of the vessel and swing them over the car, or to a tramcar by which they were delivered to the stock pile. This was a very efficient means of handling small quantities of ore where it could be delivered directly into the cars. These derricks, fitted with excavating buckets, are still in use for unloading ore where only small quantities are handled.

Fig. 3 shows a typical scene on the ore dock at which two vessels, one of them a whaleback, or "pig," as they are sometimes called, are being unloaded. In the vessel you will notice there are seven bridges in operation, while in the whaleback there are five. By using a large number of units it was possible to unload a vessel very rapidly; one record being the unloading of a cargo of 1,980 gross tons—working 6 hatches with 9 men in each hatch, and delivering the ore from 50 to 150 feet back from the vessel—in 9 hours, or at the rate of 220 tons per hour. The cost of handling ore in this manner was from 18 to 22 cents per ton.

Fig. 3.—Scene at an ore dock. Five "bridges" are at work on the whaleback in the foreground, while seven bridges are clearing out the other vessel.

In general, this method of ore unloading was followed until 1900. Many improvements were made in the details of the machines, such as special hooks to facilitate the transfer of the hoist line from an empty to a full tub, as well as many other refinements, making what were then known as "fast plants."

The King Bridge Company, the McMyler Manufacturing Company, and others, each built some particular type of bridge, but they all depended upon men to shovel ore into the tubs, which were then hoisted by steam power and the ore dumped into car or stock pile.

After the development of the "Brown Hoist" the next radical improvement in ore unloading was made by G. H. Hulett, who, while associated with the Webster, Camp & Lane Machine Company, of Akron, Ohio, contracted with the Pittsburgh & Conneaut Dock Company in September, 1898, for the construction of the first Hulett Automatic Ore Unloader on their dock at Conneaut Harbor, Ohio. This unloader marked a radical change in methods, doing away with the shovelful as a unit of bulk and using a grab bucket of 10 tons capacity for the unit. While others had copied the "Brown" machine and had made minor improvements or changes in details, Mr. Hulett was the first to make a radical change in methods, his machine being a real invention and marking a new era in ore handling.[1]

The first Hulett machine was built as shown in Fig. 4, and consisted of a pair of girders supported upon towers or legs carrying the girders high enough to provide locomotive clearance; these girders span four tracks and in addition have a cantilever extending back to cover a small stock pile in a receiving pit or temporary receptacle. On top of the girder is a trolley carrying a walking beam from which depends the bucket leg; at the lower end of this leg the bucket is attached eccentric to the center of the leg. In operating, the bucket discharges into a conveyor car which travels between the girders, and the ore is

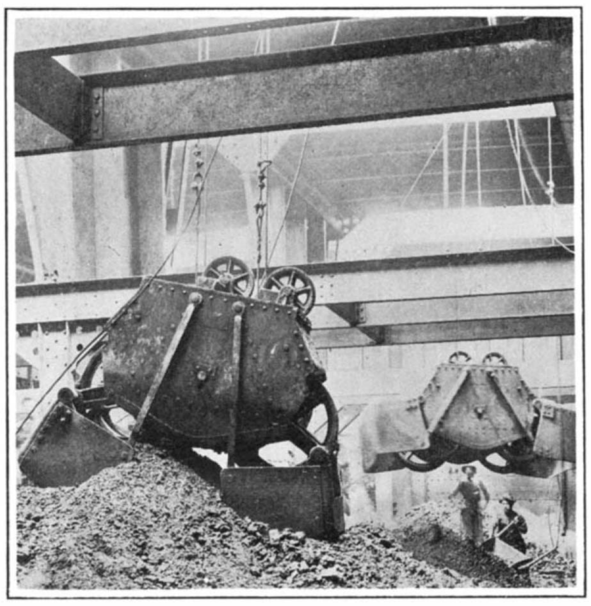


Fig. 5.—First type of excavating bucket used. Drag scraper in the background.

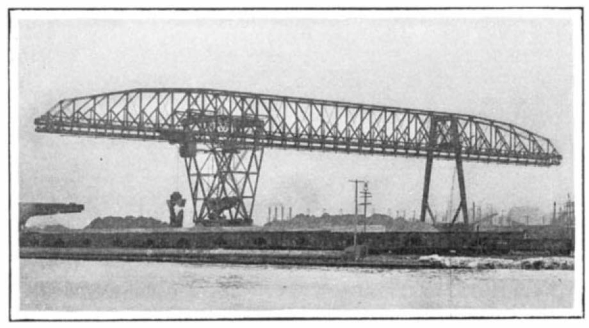


Fig. 8.—Handling ore in a storage yard by a bridge 606 feet long.

TABLE II.—IRON ORE RECEIPTS AT LAKE ERIE PORTS, GROSS TONS.

| | 1911 | 1910 | 1909 | 1908 | 1907 | 1906 |
|---|---|---|---|---|---|---|
| Toledo | 493,345 | 1,225,202 | 1,374,224 | 680,553 | 1,314,140 | 1,423,741 |
| Sandusky | ........ | ........ | 11,088 | ........ | 83,043 | 35,847 |
| Huron | 223,947 | 197,951 | 243,082 | 213,377 | 971,430 | 778,453 |
| Lorain | 2,937,605 | 2,884,738 | 2,796,856 | 2,286,388 | 2,621,025 | 2,191,965 |
| Cleveland | 4,584,211 | 6,344,943 | 6,051,342 | 4,240,851 | 6,495,998 | 6,604,661 |
| Fairport | 666,365 | 1,516,434 | 1,734,277 | 1,518,961 | 2,437,649 | 1,861,498 |
| Ashtabula | 6,359,131 | 9,620,638 | 8,056.941 | 3,012,064 | 7,521,859 | 6,833,352 |
| Conneaut | 6,931,278 | 6,309,548 | 7,007,834 | 4,798,631 | 5,875,937 | 5,432,370 |
| Erie | 289,400 | 942,592 | 1,235,057 | 828,602 | 2,294,239 | 1,986,539 |
| Buffalo | 2,802,976 | 4,704,439 | 5,002,235 | 2,835,099 | 5,580,438 | 4,928,831 |
| Detroit | 243,292 | 296,412 | 159,889 | ........ | ........ | ........ |
| Totals | 25,531,550 | 34,042,897 | 33,672,825 | 20,414,491 | 35.195,758 | 32.076 757 |

TABLE III.—AVERAGE CARGOES OF IRON ORE.

| | | | |
|---|---|---|---|
| 1895 | 1,800 | 1904 | 5,272 |
| 1896 | 2,202 | 1905 | 6,101 |
| 1897 | 3,556 | 1906 | 6,973 |
| 1898 | 3,517 | 1907 | 7,516 |
| 1899 | 3,803 | 1908 | 8,325 |
| 1900 | 3,783 | 1909 | 7,777 |
| 1901 | 4,459 | 1910 | 7,155 |
| 1902 | 4,899 | 1911 | 7,178 |
| 1903 | 5,668 | | |

delivered to cars on either of the four tracks, or to the stock pile under the cantilever. The bucket leg is carried on roller bearings and can be rotated through about seven eighths of a revolution. The bucket has sufficient spread, when open, to reach beyond the center of the space between hatches, which enables the operator to take out about 95 per cent of the ore without the use of shovels.

The first machines built were all operated by steam and hydraulic pressure. Later electricity combined with hydraulic pressure was tried, while at present nearly all machines of this type are operated entirely by electricity. The first bucket tried on these machines had backs of a circular shape, which were later changed to rectangular, and still later replaced by flat scoops or trays without backs.

The entire machine is arranged to travel along the dock so as to reach all the hatches without shifting the boat. All the functions of the machine are performed by hydraulic pressure except the traversing of the machine along the dock and the conveyor car haulage, a pair of steam engines being provided for these operations.

The power equipment consists of a 150 horse-power locomotive type boiler, a steam pump delivering water at a pressure of 1,000 pounds per square inch, and a steam accumulator having 50-inch steam cylinder, 21-inch water cylinder, and a stroke of 8 feet. The operator is located in the bucket leg directly over the bucket, and from this point controls the opening and closing of the bucket, rotating the bucket leg, hoisting and trolleying. One man is thus able to deliver the ore from the boat to the conveyor car. In addition there is required a fireman, and also an engineer to look after the moving of the machine along the dock and operate the conveyor car haulage.

[1] A grab bucket built by Hoover & Mason was used at South Chicago as early as 1899.

This machine marked a very radical change in the method of unloading ore. It was first tested out in 1899 and put into regular service in 1900. At the time this machine was put into service it was costing about 19 cents a ton to unload ore while with this machine it was possible to handle it for less than 6 cents a ton. While this machine was being developed F. E. Hulett designed and patented an excavating bucket that could be controlled entirely by ropes. A study of the ordinary clamshell bucket had shown that the action of the cutting edges of the bucket was not correct for digging ore. The edges of the bucket move approximately in an arc of a circle. In order to properly dig heavy ore it is necessary to give the open bucket a very wide reach and the first movement of the cutting edges should be approximately vertical, thus approximating the action of a shovel when digging.

This excavation bucket, Fig. 5, was first tried out in the spring of 1901 and proved so successful that during the fall of 1901 and spring of 1902, 72 standard ore-handling bridges and 10 revolving derricks were rebuilt and equipped with 1½-ton capacity buckets of this type; and while these buckets did not show so great a saving in the cost of unloading as did the 10-ton buckets, they made a material saving and were sometimes used to take out about 40 per cent of the cargo. The vessel was then moved to a dock equipped with the 10-ton unloaders for cleaning up, as the large machines could reach the ore between the hatches and clean up in better time. The smaller buckets necessitated so much shoveling to secure the ore between the hatches that to facilitate this work Max Andrews, of M. A. Hanna & Co., designed and built a special machine to expedite the moving of this ore within the reach of the excavating bucket. This machine consisted of a pair of drums operated by an electric motor. The drums were fitted with clutches and the operator could quickly start or stop either drum with the motor running at constant speed.

The ropes ran from the drums through snatch blocks to scrapers as shown in Fig. 5. Two men would drag the scraper back and hold it in position to dig the ore, and the machine operator would then throw in the clutch on the drum and drag the scraper loaded with ore within reach of the excavating bucket.

Fig. 6 shows a portion of a plant of 12 ore bridges equipped with 2-ton excavating buckets, and also shows the electric haulage rigs clamped to the hatches. Other buckets of this type were developed of capacities up to 5, and later 10 and 15-ton sizes, so that the standard system of unloading became either the Hulett Unloader of 10 to 17 tons capacity, or an excavating bucket.

While we may be inclined to look with pardonable pride upon the modern development of the ore unloader, we must not forget that the earlier machines did their work well, and were more efficient in handling the small quantities then required than the present machines would have been. It has required the united work of the shipbuilder, the dockbuilder and the shipper, with the builders of unloaders, to bring about the present condition.

Before the mining of the Mesaba ores, or the crushing of the hard ores, the excavating buckets of to-day would have had a hard time. It would be impossible for them to handle the large lumps of hard ore that were formerly shipped from the mines, but as this is all crushed before loading into the boats, the problem is much easier.

The latest and most modern ore dock on the lakes is the new dock of the Pennsylvania Company, put in operation during the last year, shown in Fig. 7. The storage yard has an area of 40 acres of reclaimed land. There is a concrete dock wall, 1,000 feet long, resting upon concrete piles. The storage pit walls are 800 feet long, providing a storage yard of 1,000,000 tons capacity. The dock wall and storage pit walls are connected by reinforced concrete ties spaced 20 feet centers and resting on a double row of piles.

The unloading equipment consists of 4 Hulett unloaders equipped with 17-ton buckets. These unloaders have a main span of 71 feet, spanning 4 railroad tracks and a cantilever 56 feet, which enables them to deliver the ore 116 feet from the face of the dock. At the water level the open bucket has a maximum reach of 65 feet 2½ inches from the face of the dock. The total weight of each unloader is about 730 tons. For delivering the ore to the main storage yard there is a large ore-handling bridge, Fig. 8, having a main span of 266 feet, and a cantilever at each end of 170 feet. In operation the ore is delivered by the 17-ton bucket to a 65-ton receiving hopper between the girders of the machine, from which it is drawn into a 50-ton larry car equipped with scales for weighing the ore as it is discharged into the car or stock pile. This larry car can discharge the ore into cars on either of the 4 tracks, or into the temporary stock pile under the cantilever, from which the bridge handles it to the main stock pile.

The unloader bucket is shown in the hold of a small boat in Fig. 9. When fully open the shells have a spread of 21 feet 3 inches, and, in addition, a telescopic motion of 3 feet.

Fig. 10 shows the bucket in the hold of one of the large ore-carriers and clearly shows how completely the buckets can gather up the ore. Frequently in cleaning up a boat the operator will gather a small quantity of ore and drop it in a pile, repeating the operation until he can secure a full load for the bucket.

The motors are of the following capacities: Walking beam hoist, 300 horse-power; trolley, 100 horse-power; bucket closing, 100 horse-power; bucket rotating, 35 horse-power; motor operating hopper gates and for moving the machine along the dock, 150 horse-power; larry travel, 150 horse-power; opening and closing larry gates, 35 horse-power. With these motors it is possible for the bucket to make a complete cycle in 50 seconds, and as the receiving hopper has a capacity of 65 tons, it is not necessary for the operator to wait for the larry car operator to draw out each bucketful. Since the larry car has a capacity of 50 tons and to properly load a car it must make two discharges, it is evident that it is not necessary to lose time in accurately judging the amount drawn from the receiving hopper.

The crew for operating each unloader consists of one operator in bucket leg for opening, closing and rotating bucket, and operating trolley; one operator in the larry for filling, weighing and discharging; in addition, the railroad company usually furnishes a check weighman in the larry. There is also one oiler required for each machine, and for the group of four machines there is usually employed one master mechanic and one electrician.

In cleaning up the boat there is an average of four shovelers for each machine during the final cleanup. Each of the four machines on the dock discharges into cars placed on one of the four lines of tracks spanned by the machine. Between each pair of tracks is a narrow-gage track on which runs an electric shunter especially designed for this work. In operation, the empty cars are delivered by locomotive within reach

of this shunter, which takes five empties on the tracks on each side of it, placing them under the two unloaders which it is serving. As each car is filled the shunter moves the line of five cars forward until all have been filled; it then delivers the loads to the outgoing end of the yard, where a locomotive takes them for making up into trains, the shunter returning for another string of empties.

As an indication of how thoroughly all the operations in connection with these unloaders are carried on with clock-like precision, I will cite one record which was made on August 20th, 1912, by the Superior Extension and New Union docks, at Ashtabula Harbor. During an operating day of twenty hours there was unloaded from eight boats a total of 70,000 tons. This required 1,319 cars for its transportation, or a car of ore every 55 seconds as an average, and, as this time included the moving of the boats to and from the dock, it is evident that there must have been the utmost precision and harmony in the operation of the entire equipment. Another record was made on August 12th, 1912, at Conneaut, where a cargo of 10,636 tons was unloaded in 2 hours and 52 minutes. So far as I know, this is the fastest unloading on record. The equipment on this dock consisted of four 5-ton Brown machines, four 10-ton and one 15-ton Hulett machines.

What the future may have in store for ore unloading I do not think any of us wish to prophesy. I do believe, however, that whatever improvements are made in ore handling in the future, if we are to make any great increase in capacity, it must come through some radical change as was made in the methods when the excavating bucket and the Hulett machine superseded the hand shovel.

The cost at the present time is approximately 6 cents a ton. The original Hulett unloader brought the price down to about that figure, although it varies at different plants; at some plants the cost is somewhat less than that; at others as high as 9 or 10 cents, depending on working conditions.

# Open Hearth Versus the Electric Furnace*

## In the Manufacture of Commercial Steel

By Sidney Cornell

THERE has been a great deal of discussion lately about the cost of making steel in the electric furnace in competition with the open-hearth furnace, and recently the assertion has been made that the electric furnace can compete with the open hearth in the manufacture of commercial steels on a large scale.

The electric furnace has successfully competed in quality and in cost with the crucible process, and in many instances can produce steel at a cost less than in the smaller converter or Tropenas process, and is being used for making small and special castings at a very good showing in cost. The assertion that the electric furnace can do all that the modern open-hearth furnace can do in large and organized plants, and on commercial steels, is open to doubt, and the folowing analysis of the facts may be of value in clearing up the situation. The matter must be considered from a commercial standpoint, and for the manufacture of steel for rails, structural shapes, merchant bar, etc., the problem is nothing more than a balance of detailed costs and investment. In order to do this the following table has been compiled from data from a year's operation of a large open-hearth plant in a well-known steel company, and compared with what is claimed to be practice obtainable in an electric furnace plant of the same capacity.

The following comparison is made from records for an open-hearth plant consisting of 80-ton furnaces, having a production of about 200 tons of ingots per day for each furnace, and compared with a 20-ton electric furnace having approximately the same capacity per day. This comparison must be made assuning that an electric furnace plant of some ten furnaces is substituted for a plant of open-hearth furnaces containing ten furnaces, each plant being equipped with the necessary auxiliary apparatus, mixers, scrap yards, cinder ladles, ingot equipment, tracks, etc.

The cost of a modern open-hearth plant with 80-ton units, is approximately $275,000 per furnace, including all auxiliary equipment, building, etc. The cost of a 20-ton electric furnace of the most advanced type is estimated at $500,000 per unit, and including the necessary electrical equipment. In connection with the electric furnace it is assumed that blast-furnace gas would be converted into electricity, and that modern practice cleans all blast-furnace gas, thus making the gas engine and equipment chargeable to the electric-furnace equipment, but not the gas-cleaning plant.

Table I is a tabulation of the materials necessary to make a ton of steel, and whether the electric or the open-hearth furnace is used or not, the quantity of raw materials is approximately the same. It is argued that the electric furnace can use inferior materials. Inferior materials necessarily are not in the most advantageous shape to handle, and often are more bulky than those of better quality, so that although in the auxiliary charge the electric furnace might use a slightly smaller quantity this would be offset in the more bulky principal materials, and accordingly more troublesome to handle.

The electric furnace will consume the same raw materials in the making of a ton of steel, the molds used will be the same, and the only credit will then be refractories and producer gas, from the tabulation of Table I.

In Table I the cost of rebuilding is included in the refractories cost, which is given totaled for the electric furnace, and the cost of power is taken at a low figure $0.007 per kilowatt-hours. In a commercial plant such as is under consideration, the labor distribution for the handling of the quantity of materials necessary to make each ton of steel will be the same for either type of furnace, and in this work organization of a force is as imperative for a plant of electric furnaces as for an open-hearth plant. Further, an electric-furnace plant, being part of a steel works, would have to bear its share of the non-producing departments, and accordingly Table II applies for both purposes.

TABLE I—MATERIALS CHARGED PER TON OF STEEL.

| Material. | Pounds per Ton of Steel. | Rate Cost per Pound. | Cost per Ton Steel Open Hearth. | Cost per Ton Steel Electric Furnace. |
|---|---|---|---|---|
| Hot metal | 872 | $0.005 | $4.360 | $4.360 |
| Cold pig | 376 | 0.005 | 1.880 | 1.880 |
| Chills | 17 | 0.008 | 0.136 | 0.136 |
| Molds | 15 | 0.010 | 0.150 | 0.150 |
| Castings (iron scrap) | 5 | 0.008 | 0.040 | 0.040 |
| Pit scrap | 64 | 0.007 | 0.448 | 0.448 |
| Ingot butts | 46 | 0.007 | 0.322 | 0.322 |
| Turnings | 41 | 0.005 | 0.205 | 0.205 |
| Sheet scrap | 99 | 0.006 | 0.594 | 0.594 |
| Miscellaneous steel scrap | 852 | 0.005 | 4.260 | 4.260 |
| Limestone | 119 | 0.0005 | 0.059 | 0.059 |
| Ferro-manganese | 16 | 0.020 | 0.320 | 0.320 |
| Ferro-silicon | 0.5 | 0.010 | 0.005 | 0.005 |
| Iron ore | 108 | 0.0012 | 0.129 | 0.129 |
| Fluorspar | 4 | 0.0009 | 0.003 | 0.003 |
| Coal | 4 | 0.0009 | 0.003 | 0.003 |
| Aluminium | 0.25 | 0.2000 | 0.050 | 0.050 |
| New molds (40 lb. per ton) | 25 | 0.010 | 0.250 | 0.250 |
| Cupola relining (dolomite) | ....... | ....... | 0.010 | 0.240 (total.) |
| Calcined dolomite | 105 | 0.0011 | 0.123 | |
| Magnesite | 3.5 | 0.010 | 0.035 | |
| Chrome ore | 1 | 0.009 | 0.009 | |
| Clay | 5 | 0.0006 | 0.003 | |
| Loam | 9 | 0.0005 | 0.004 | |
| Coke | 16 | 0.0014 | 0.022 | |
| Ladle brick | 0.9 | 0.010 | 0.009 | 0.009 |
| Stoppers | 0.012 | 0.010 | 0.0012 | 0.0012 |
| Sleeves | 0.214 | 0.028 | 0.0061 | 0.0061 |
| Nozzles | 0.021 | 0.010 | 0.0021 | 0.0021 |
| Rebuilding | ....... | ...... | 0.1400 | ...... |
| Produce gas | 5250 cf. | 10c M. cf. | 0.5250 | ...... |
| Electric power | 605 kw.-hrs. | 0.007 kw.-hrs. | ...... | 4.220 |
| Total | | | $14.1034 | $17.6924 |

TABLE II—LABOR COST IN MAKING STEEL.

| Function. | Item. | Cost per Ton of Steel. |
|---|---|---|
| General | General works | $0.092 |
| | Steam | 0.003 |
| | Water | 0.007 |
| | Electric light and power (for cranes, etc.) | 0.012 |
| | Yard switching | 0.045 |
| | Shops | 0.065 |
| Producing labor | Superintendent and foreman | 0.009 |
| | Clerks, timekeepers and weight-masters | 0.014 |
| Stocking | Unloading and handling from cars | 0.042 |
| | Filling boxes from bins | 0.015 |
| | Cranemen, etc., handling boxes | 0.019 |
| | Narrow-gage engineers, etc. | 0.013 |
| Charging | Charging machine men | 0.012 |
| | Pull-ups and cranemen | 0.009 |
| | Metal mixed labor | 0.020 |
| Melting | Melting and gas tending (or electrodes) | 0.170 |
| | Lining hot metal ladles | 0.006 |
| | Bottom making | 0.017 |
| Casting | Ladle lining and stopper setting | 0.040 |
| | Mold handling | 0.012 |
| | Scrap and cinder labor | 0.062 |
| All other | Ingot distribution | 0.004 |
| | Mold yard labor | 0.022 |
| | Scrap and cinder drop labor | 0.048 |
| | Inspcetion and stripping ingots | 0.001 |
| | Transportation | 0.035 |
| | Other general | 0.035 |
| | Total | $0.829 |

TABLE III—LABOR IN REPAIRS.

| Item. | Cost per Ton of Steel. |
|---|---|
| Narrow gage, ladles, etc. | $0.007 |
| Charging machines | 0.003 |
| All machinery except charging | 0.017 |
| Furnaces | 0.009 |
| Metal mixers | 0.005 |
| Grinders and all drying apparatus | 0.002 |
| Ingot stripper | 0.002 |
| Scrap drop | 0.001 |
| Buildings | 0.002 |
| Yards, sewers, etc. | 0.006 |
| Bins, tracks, trestles, etc. | 0.006 |
| Total | $0.060 |

Table III (Labor in Repairs) will also hold good as much for an electric-furnace plant as for an open-hearth plant, because as may be noted, the large portion of the charges are not for the furnace proper, and the furnace proper is a comparatively small item.

The fixed charges against the open-hearth furnace, costing $275,000 per unit, and figured at 16 per cent for interest, depreciation and taxes, becomes $0.610 per ton of steel produced. The cost of an electric-furnace plant of the same daily capacity is approximately $500,000 per unit, and including a 4,500-kilowatt electrical equipment per unit, which, assuming the same rate of depreciation as the open-hearth plant, carries a burden of $1.110 per ton of steel produced, using 16 per cent as per above.

The electric furnace consumes electrodes, and a figure of $0.340 per ton of steel is given as a fair average. In the induction type of furnace this would be eliminated, but with an increase in power consumption.

The summary of the situation is given in Table IV.

TABLE IV—SUMMARY.

| Item. | Open Hearth. | Electric Furnace. |
|---|---|---|
| Investment, per unit, 200 tons daily capacity | $275,000.0000 | $500,000.0000 |
| Interest, depreciation, etc., 16 per cent | 0.6100 | 1.1100 |
| Raw materials (Table I) | 14.1034 | 17.6924 |
| Plant overhead cost and producing labor (Table II) | 0.8290 | 0.8290 |
| Labor in repairs (Table III) | 0.0600 | 0.0600 |
| Electrodes | ........... | 0.3400 |
| Other overhead | 0.0100 | 0.0100 |
| Total cost per ton of steel | $15.6124 | $20.0414 |

There are some electric furnaces operating in this country of sufficient capacity to produce facts as to costs for the above comparison, but when an electric furnace operating on castings or special steels produces steel at a cost of approximately $20 per ton of steel, it is not logical to suppose that the same equipment can produce steel at a sufficiently low cost to compete with the open-hearth furnaces in the manufacture of commercial steels. All steel works produce scrap, which must be remelted and made of value, and the amount of raw materials consumed in the manufacture of steel must remain approximately the same, so that other figures enter into the calculation such as have been tabulated. Accordingly, until the large factor in the cost of making electric furnace steel—the cost of power—is reduced, the electric furnace cannot compete with the open-hearth in the manufacture of steels for rails, structural shapes, merchant bars, etc. In order to do so electrical energy must be produced at a cost lower than $0.001 per kilowatt hour and the present electrical equipment using blast furnace gas cannot do better than $0.007 per kilowatt hour.

* From *Metallurgical and Chemical Engineering.*

### Rice Bread

IT is found that an excellent bread can be made by incorporating about one fifth rice flour, according to experiments made in France, and such bread, according to Prof. Maurel, stands a good comparison. Since France now imports large quantities of wheat, there might be involved an economic question of much interest. On the other hand, M. Mesurer is occupied with preparing actual samples, and he had loaves with 18 per cent of rice baked in the ovens of a public institution. On examination, the bread proved of good taste and general qualities.

# An Anemometric Paradox*

## A Wind Motor That is Not Affected by the Direction of the Wind

By R. Villers

When a surface is inclined with respect to the direction of motion of the wind, but is constrained to move in a direction almost perpendicular to the wind, the latter compels the surface to move in a direction dependent upon the direction in which it is inclined. This is the principle of sail boats, wind mills, aeroplanes, etc. If the wind takes a direction diametrically opposite, that is, strikes the other face of the surface, the direction of movement of the latter is reversed unless one alters the direction of inclination of the surface, as is done in the case of sail boats. *A priori* it seems to be impossible to construct a surface having a fixed inclination that shall always be impelled in the same direction although the wind blow from diametrically opposite directions. Nevertheless, this paradox has been realized.

In building a wind motor having a vertical axle the problem is to construct a wheel having peripheral

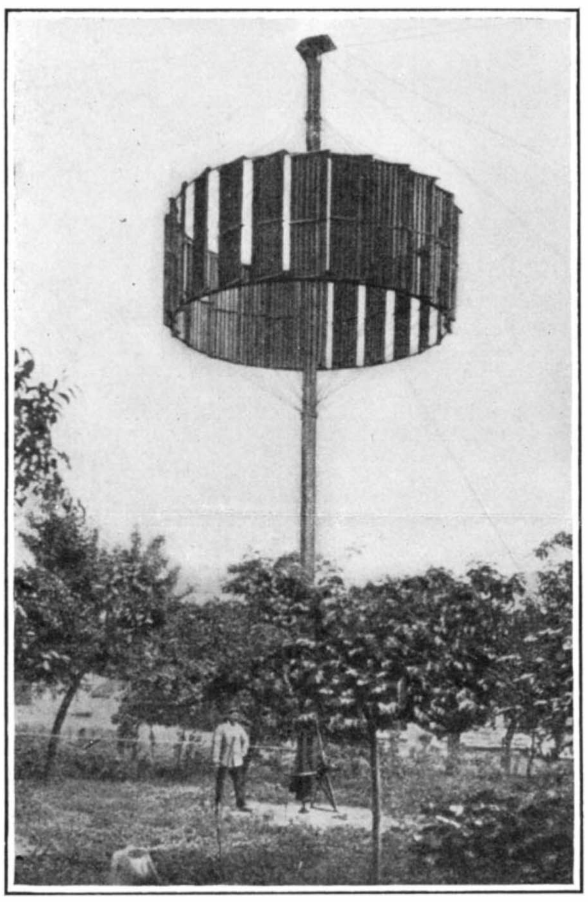


**Fig. 2.—General view of the wheel mounted at the summit of its mast.**

At the masthead are seen the guys and the cap which protects the collar at the top of the mast against the rain. One may also distinguish one of the two pulleys and ropes by means of which the wheel is raised and lowered. At the foot of the mast is seen the variable eccentric.

sails to receive the force of the wind. But in order to employ wheels of large diameters it was desired to combine the reaction of the wind entering the wheel with the reaction of the wind leaving the same (as though the wind acted but once against the wings, or both at the top and the bottom of the wheel).

It was therefore necessary that the wings should have a reaction perpendicular to the wind but always in the same direction, whichever face the wind struck against. This led to constructing each wing of several sheet-iron blades shaped like *abcd* in Fig. 1, and placed one behind the other as there shown.

Now, the wind *v*, in its effort to enter the wheel (see Fig. 1), passes between the blades and produces a reaction in the direction of the arrow *x;* while another wind *v'*, which tends to emerge from the wheel, slides along the general slope of each wing and causes a further reaction in the same direction *x*. (This same principle might be applied to sailing vessels or to other mechanisms utilizing the force of the wind.)

By reason of the angle of the section *ab* of each blade the wings also utilize the difference between the

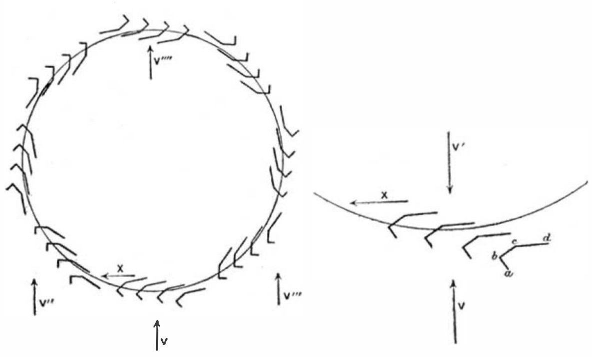


**Fig. 1.—Diagram of the double-acting wings.**

The diagram on the right shows the details of the curved blades. The wind *v* strikes the outside of the wheel and the wind *v'* strikes the inside. Both winds entering between the blades, cause a motion in the same direction. The diagram on the left shows the general construction of the wheel and the manner in which it utilizes the difference between the actions *v''* and *v'''*.

thrust of the wind *v''* (a following wind) and of the wind *v'''* (a head wind). Most of the vertical-axle wind motors (chimney pots, nightcap mills or Polish mills, advertising devices, etc.) utilize this difference alone, which cannot be very large, for in the active portion *v''* the blades suffer a slight mutual overlap in spite of the increased area they expose. Furthermore the head wind, *v'''*, adds its velocity as a brake on the speed of the wings against which it acts. Nevertheless, by utilizing the wind over the whole breadth of the wheel, an expanse that increases with the diameter of the wheel, and by utilizing it twice over, the total power developed is considerable.

Contrary to ordinary expectation and to the expectation of the inventor himself, the power-returns from this device are very high if the inclinations of the different elements are judiciously chosen. It is possible to so adjust things that the utilization areas exposed to the winds *v* and *v''* shall amount to about 9/10 of the diameter of the wheel. It is, of course, evident that the same effects are produced whatever the direction of the wind, so that the motor does not need to be oriented.

This very simple mechanism makes it possible to manufacture wind mills at a very low price. Everyone living in the country finds it more or less necessary to obtain water and to raise it, but very few have water power, steam engine or combustion motor available, while the wind is at the disposal of all. These new wind motors may therefore prove very useful to gardeners and to agriculturists. The house that is exploiting this patent under the name "Conqueror windmill" (*moulin à vent vainquer*), delivers a motor complete with mounting, pump, and piping, all ready to install for 600 francs ($120), or one-third the price of the usual systems.

One feature that favors this low price is that, if the space available is sufficiently large, the motor is simply mounted on a revolving mast which turns with it and is held at the top by guys, thus eliminating the steel tower. Experience has shown that this mounting works excellently. This arrangement offers the further great advantage of eliminating the otherwise necessary acrobatic feat of climbing to the top of the tower every week in order to inspect and oil the bearings. In fact, the only moving part at the masthead is a strong collar fitted to the mast and receiving a pivot to which the guys are attached. This collar is well covered, stores oil for several years and may be replenished from below by means of a pipe. Furthermore, the mill wheel may be lowered or raised on the mast by means of blocks and tackles, just as is the gasolier of the circus tents.

The action of the pump is regulated by an eccentric fixed on the mast near its foot. Perhaps the wind is very variable, or the pump a strong one, so that the motor will not move in weak winds, or the pump is small and in spite of the increased speed the motor makes but poor use of the enormous power of the high winds. It is therefore necessary to vary the strength of the pump with the variation in the wind. The firm of Mahiet in Bourges builds an eccentric which automatically increases its eccentricity as the

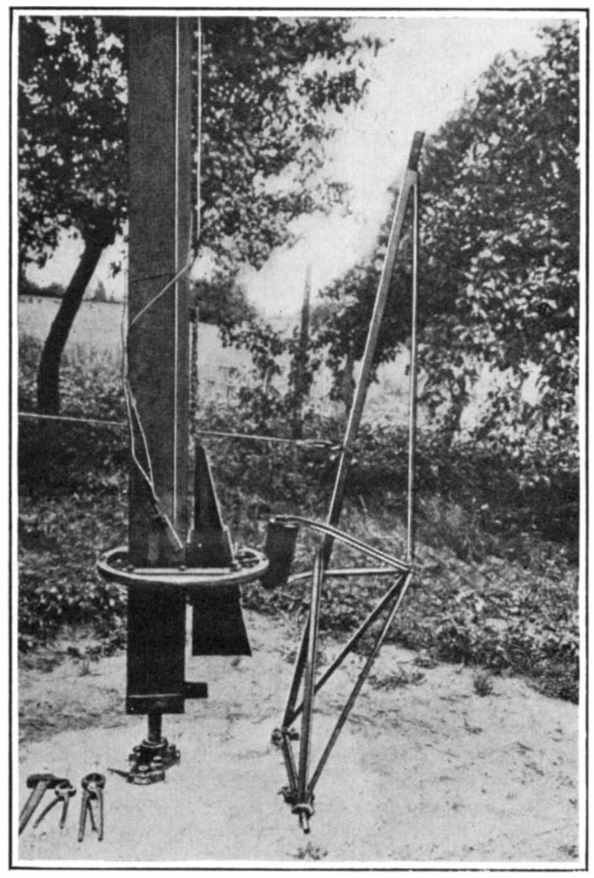


**Fig. 3.—Detail view of the variable eccentric and the oscillating lever.**

A steel wire attached to the oscillating lever (the latter held against the mast by the weight loaded on the pump-piston) operates the pump at any distance from the mill. Note the wedge whose ascent or descent regulates the eccentricity of the eccentric; it is itself regulated by a large ball-governor not shown in the figure.

speed increases, so that the action of the pump varies automatically through all strokes from one of 5 centimeters in a gentle breeze up to 1 millimeter for storm winds. This is a valuable advantage during the summer when irrigating fields or gardens, a single thunder squall may suffice to pump full large reservoirs. Furthermore, this device considerably increases the amount of water lifted during a year.

The motor may be regulated by throwing out the wings either automatically or at will, so that the wheel may be slowed down or stopped. The regulating attachment adds to the price, however, and it is not indispensable for the small models appropriate to gardeners. When it is desired to stop work it is sufficient to disconnect the pump and allow the mill to continue turning; nothing is thereby consumed or destroyed.

* From *La Nature*.

### Support for Violoncello

In order to keep the foot of the instrument from slipping upon the floor, a recent French invention calls for a socket support for the foot, the support being in the shape of a flat strip laid on the floor and connected to the leg of the chair. A simple ring will serve very well for the socket, in which the foot of the instrument is placed, and a second ring is put on the foot of the chair, the two rings being connected together by a strip of fabric. This latter can be in the shape of a sliding strip so as to be able to adjust the length between the instrument foot and the chair.

### Depolarization in Leclanche Cells

In a paper discussing this subject before the American Electrochemical Society, Messrs. Thompson and Crocker state that the polarization is not due to hydrogen, since the manganese dioxide completely prevents its liberation. It is due to the ammonia, which is liberated by the splitting up of the ammonium radical, combining with the water and forming ammonium hydroxide, and hence hydroxyl ions by dissociation; these hydroxyl ions bring about polarization. The dissociation of the ammonium hydroxide can be prevented by the addition of excess of ammonium chloride and the polarization thus diminished, but the best method is to add zinc chloride, which gives rise to complex zinc ammonia compounds, thus preventing, to a large extent, the formation of ammonium hydroxide and hence of hydroxyl ions.

# A High Efficiency Incandescent Lamp

## Steps in Its Development, and Principales of Operation

A NEW type of high efficiency incandescent electric lamp is described in a paper presented to the Institution of Electrical Engineers by Messrs. E. A. Gimingham and S. R. Millard. It seems that in 1913 experiments were started with a view to making a lamp having the usual characteristics of the ordinary incandescent lamp, but having as the source of light an arc having electrodes of tungsten or other refractory conductor burning in an inert gas such as nitrogen or argon. The first lamps constructed were made with the electrodes in contact, one being connected to an expansion strip of copper or other material having about the same coefficient of expansion. A spiral filament of tungsten, or molybdenum, was mounted close to the strip and connected in series with the arc circuit. To prevent the strip moving too far and the arc breaking, a thick wire was sealed into the glass support, this wire acting as a stop and maintaining the correct gap. For alternating current lamps the electrodes were constructed of fused tungsten, and were of equal size. In the case of one of the continuous-current lamps the positive electrode was made of a globule of fused tungsten, and the negative electrode consisted of a number of tungsten wires or filaments mounted in the form of a brush.

The parts were assembled as shown in Fig. 1, and sealed in an ordinary incandescent lamp bulb, which, after being exhausted of air, was filled with nitrogen at a pressure of, approximately, two thirds of an atmosphere. When connected to a continuous-current circuit through a resistance, the current passing through the coil *A* produced sufficient heat to cause the expansion strip *B* to warp, thus separating the electrodes *E E* and striking an arc between them. The temperature of the heating coil then dropped to a very dull red heat, due to the resistance introduced by the arc itself. The heat from the arc was more than sufficient to keep the expansion strip hard against the stop *F*, and thus to maintain the requisite length of gap. The

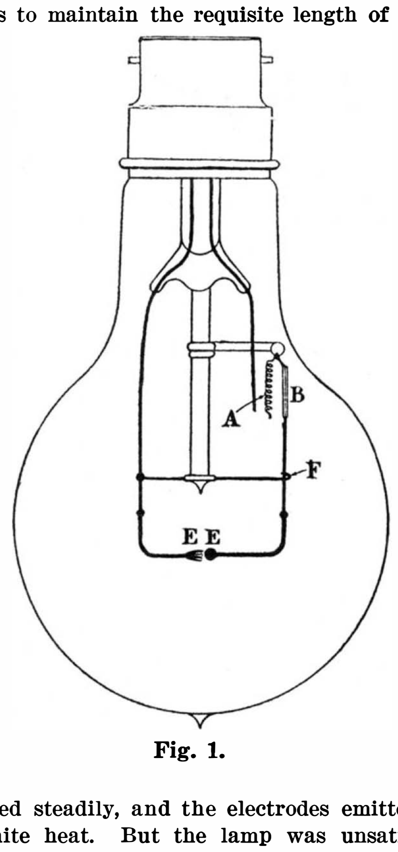


Fig. 1.

arc burned steadily, and the electrodes emitted an intense white heat. But the lamp was unsatisfactory. One trouble was that the electrodes tended to stick together, with the result that the expansion strip failed to separate them. Moreover, a considerable amount of spluttering took place, thus shortening the length of the lamp's life. Ultimately, however, a lamp was developed which had a life of over 100 hours.

Later the problem was attacked in a totally different way. It is well known from experiments made by Sir J. J. Thompson, Dr. Fleming, and others, that the filament in an incandescent lamp gives off a strong negative discharge, and if an additional electrode seated adjacent to the filament be charged to a positive potential a current passes between the filament and this electrode. This principle was applied in developing the new lamp. The first attempts were made with a view to constructing an alternating-current lamp, consisting of two small globules of tungsten fixed a definite distance apart. In order to break down the resistance within the arc gap a filament was mounted adjacent to the electrode; this filament, when made to glow brightly for a few seconds, acted as an ionizing agent, thus making the arc gap conducting. This ionizing circuit was connected in parallel with the arc through a single pole switch and resistance. To put the lamp into operation the ionizing circuit was completed for a few seconds, and then broken by means of the switch, the result being that an arc was momentarily struck between one of the electrodes and the filament, this being followed by an arc between both electrodes, the

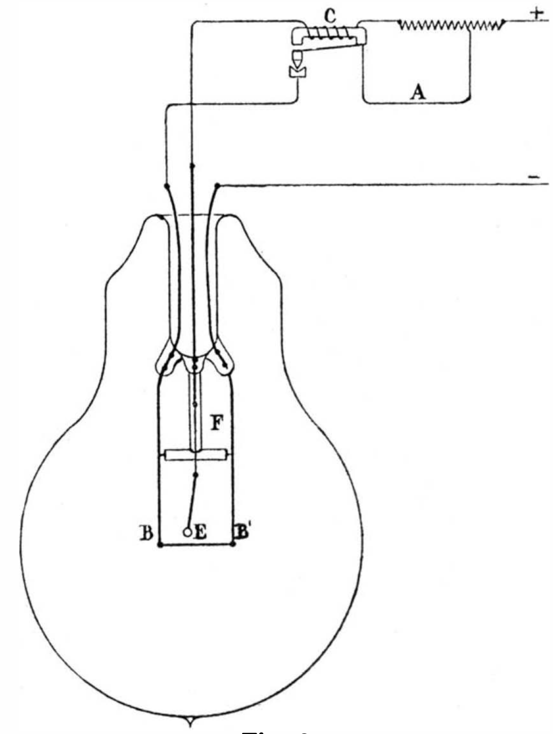


Fig. 2.

filament acting as the ionizer being then entirely cut out of the circuit. This lamp proved to be a great improvement upon the previous one. Attempts were made to construct a lamp for continuous-current circuits.

At first the construction was similar to that of the alternating current lamp, with the exception that the negative electrode was smaller. To put the lamp into operation the filament acting as the ionizer was brought to a high state of incandescence and then cut out of circuit by means of a switch in the positive lead. Difficulties, however, were experienced in inducing the arc to leave the tungsten filament ionizer and pass to the negative electrode. This trouble, it seems, was due to the difficulty of bringing the negative electrode to a temperature high enough to form an arc. In the alternating-current arc the electrode which momentarily formed the arc with the ionizer helped to form the arc proper, but with the continuous-current lamp the arc persisted in passing between the positive electrode and the ionizer. Later negative electrodes were made which the arc would strike, but it was considered necessary to provide thoroughly for the protection of the ionizer. It is well known that several refractory oxides possess to a very high degree the property of emitting electrons, and experiments were therefore made with mixtures and combinations of tungsten with zirconia, yttria and other oxides of the refractory class.

As a result of continued experiments a satisfactory filament having powerful ionization properties was evolved. It was found that if filaments were carefully made they were not destroyed by the action of the arc, and that they lasted considerably longer than a filament of pure tungsten, this being, no doubt, due to the difference in the physical state of the two filaments. Difficulties, however, still remained. The action of the arc naturally destroyed, after a time, the ionizing properties, and in some cases difficulties have been experienced in re-striking after the lamp has been in use for 200 hours. This deterioration of the ionizing properties of the filament, however, was only local, being merely around a short length directly opposite the anode. To overcome this a short length of expansion strip similar to that used in the lamp shown in Fig. 1 was linked between the anode and stem lead. A lamp constructed in this manner is shown in Fig. 2, which is a lamp suitable for working with continuous current. Three leads, it will be noticed, pass through the lamp stem. On one is mounted the electrode *E*, while the other two hold the filament acting as the ionizer *B* $B^1$. The positive main lead is divided into two circuits, one of which, *A*, passes through a resistance, and the contacts of the electro-magnetic switch C to one pole of the ionizer *B*, the other being taken through a resistance, and the coil on the electro-magnetic switch to the positive electrode of the arc circuit *E*. The negative main lead is connected to the remaining ionizer lead $B^1$. When the lamp is in operation the current first passes through the ionizer circuit, causing the filament to incandesce at a temperature sufficient to ionize the gas between it and the positive electrode. At first a small current flows in the arc circuit, this current rapidly increasing until the cut-out is operated. This breaks the ionizer circuit until the arc is struck, the striking being assisted by the removal of the ionizer circuit which previously shunted the arc circuit. The heat rising from the arc causes the expansion *F* to warp. and this moves the arc to another position on the ionizer.

On switching off the current the electrode returns to its original position, having left the inactive part and coming to rest opposite the still active portion of the ionizer. By this means the lamp may be restarted at any period of its life without difficulty. In this lamp practically the whole of the intense white heat emanates from a small globule of fused tungsten one tenth of an inch in diameter. Any size or shape of electrode may be made, the construction of the higher candle-power lamps being as shown in Fig. 3. Here the expansion strip is dispensed with, for with a powerful arc there is a greater tendency for the arc to pass across the shortest gap. In this case, after striking from the filament to the edge of the electrode, the arc rises to the thickened portion immediately opposite. As compared with the carbon arc lamp the new lamp is very simple. No regulating mechanism is necessary, and there is, therefore, a saving in the cost of production. The loss of light caused by the obstruction of the electrodes is small compared with that in the carbon lamp, and there is no trouble from flickering or arc wandering. Moreover, as the arc is completely enclosed, there is no danger from fire. No re-carboning is required, and the lamp needs no attention while it is in use.

The curve *A*, Fig. 4, shows the percentage variation of pressure with current, and it will be seen that the curve is similar to that of an ordinary arc, though it indicates that the stability is greater. The pressure

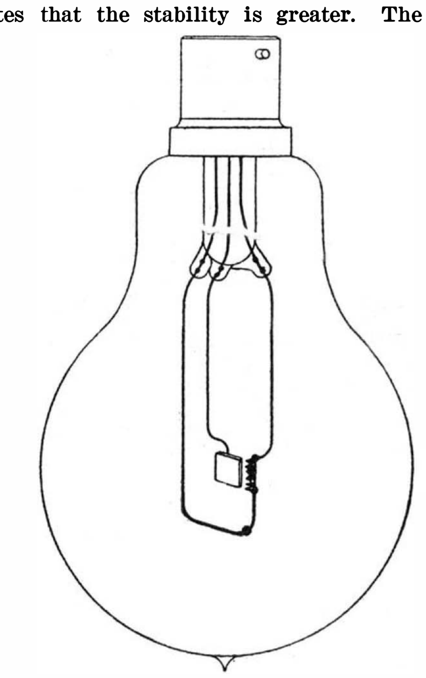


Fig. 3.

across the arc steadily decreases with an increase of current, and if continued until the spluttering point is reached the pressure suddenly drops. A representative efficiency curve is shown at *B*, which shows the efficiency for the normal working current to be 0.5 watt

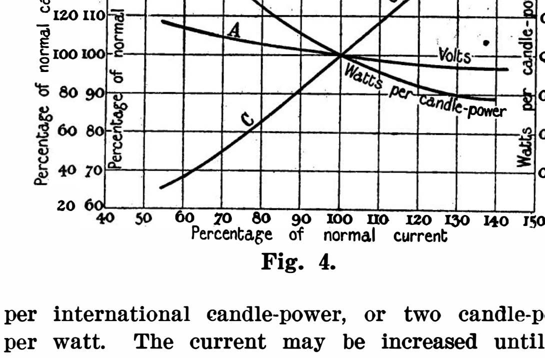


Fig. 4.

per international candle-power, or two candle-power per watt. The current may be increased until the tungsten reaches the sputtering point, at which the efficiency is 0.3 watt per candle-power, or 3.33 candle-power per watt. Curve *C*, in Fig. 4, shows the variation of candle-power with current.—*The Engineer*.

# Trade-Marks in the American Republic

## A Plea for the Ratification of the Buenos Aires Convention

The commercial importance of trade-marks has increased during the last forty years by leaps and bounds until to-day they constitute the largest asset of many commercial establishments. Their value in the United States has probably increased in about the same ratio as the number registered, which in 1871 was 486, and in 1915, 6,253.

This large increase in the number and value of trade-marks is attributable largely to two causes: First, the readiness with which they lend themselves to modern advertising methods. They are catchy, easily remembered guide posts which enable the purchaser to repeat every satisfactory buying experience and to avoid the repetition of every unsatisfactory one.

It has been said that trade-marks and advertising are the greatest forces in modern commercial transactions, and that working together their tendencies are to raise qualities and standardize them and to reduce prices and stabilize them.

Advertisements of trade-marked goods fill the daily papers, and magazine readers frequently find more space devoted to the exploitation of trade-marked goods than to the discussion of current topics.

The adage to the effect that "A rose by any other name would smell as sweet," and therefore that there is nothing in a name, has been displaced at least in the commercial world by the adage that "A good name is rather to be chosen than great riches."

The second cause for the large increase in the importance of trade-marks is the modern favorable attitude of the courts in practically all countries. This attitude, especially of equity courts, is based on their endeavor to encourage commercial integrity of producers and sellers. They recognize that a merchant who relies on his superior goods identified by a trade-mark is a benefactor to commerce.

A trade-mark is of no value until it is favorably and extensively known. To advertise it ordinarily requires large expenditure of money, and the property right acquired in the marks is of such a fugitive, intangible character that it is the subject of continual attack by pirates wishing to trade on the reputation of their honest competitors. The ever increasing frequency of communication between the American Republics will often extend the reputation of valuable trade-marks from one country to another and their combined efforts will be necessary to prevent trade-mark piracy.

A few concrete illustrations of what has already occurred on this line will show the evils to be overcome and the difficulties that will be encountered in applying the remedy.

One of the largest cereal manufacturers in the United States last year attempted to extend its trade to one of the South American countries, but found that an unscrupulous rival had preceded it by a few months and registered its most valuable mark, which it had been advertising at enormous expense for thirty years, thus shutting out its valuable trade built up under its home trade-mark.

A fifteen thousand dollar consignment of lead pencils from the United States to a Central American Republic was confiscated not long ago at the port of entry because they bore a trade-mark which infringed a trade-mark recently registered by a business rival in the receiving country, although the United States merchant had registered his United States mark twenty years before.

One of the largest manufacturers of motorcycles in this country whose trade-mark is his most valuable asset can not export to three other American Republics because a pirate knowing of the reputation of his goods in this country, had succeeded in registering his trade-mark in each of these countries.

One of the most valuable trade-marks in the tobacco business registered in the United States has very recently been registered by a rival of its owner in seven Central and South American countries.

The United States consul general at Buenos Aires writes:

"The appropriation of foreign trade-marks has reached a very serious state in recent years. . . . If an Argentine firm usurps the mark of a foreign manufacturer and registers it, then the real owner is helpless, for the new owner can take legal action against the real owner of the mark for imitating or fraudulent use of same. The rightful owner may even have his merchandise excluded from the market simply because it bears his own mark. It has happened that foreign manufacturers have had to leave the market after having spent much time and money in building up their business, or have had to pay an indemnity to a local firm which has been brazen enough to register a world-known mark."

These and many other similar incidents cry loudly for co-operation on the part of the American Republics to attempt to prevent this unfair competition in trade, and thus encourage honestly conducted commerce between these countries.

The difficulties to be overcome are serious, but not insurmountable. Probably the most serious arises from the nature of the trade-mark laws of the various Republics.

For the purposes of this paper these laws may be divided into what are technically known as, first, "attributive" laws, and, second, "declaratory" laws. The first create the exclusive rights in a mark usually by registration. Sometimes by simple announcement that a particular mark has been adopted. The second only provide for giving notice usually by registration of the rights already acquired by prior use of the mark. The right to the mark being based on the common law right of priority of adoption and subsequent continuous use.

The attributive or creative laws are in force in most of the Southern Republics, while the declaratory laws, which are based on the English common law, prevail in the Northern Republics. Both systems have their merits and demerits. The attributive system lends itself peculiarly to the frauds before enumerated, while the declaratory system is weak in not requiring notice to the public throughout the country of the adoption of a mark. These different systems give rise to difficulties in framing treaties for the better protection of trade-marks used in commerce between the American Republics.

Again, some of the American Republics refuse to recognize numerals as trade-marks, while in others they are registrable, and some of these countries require word trade-marks to be entirely fanciful, while others are more liberal in registering words descriptive of the goods. "Uneeda" for biscuits has been protected in the United States, while other countries have refused to protect this word as a trade-mark on the ground that it is only a mis-spelling of "you need a," an advertising phrase which any one may use. On the other hand, "Economy" has been refused registration in the United States, but allowed in other countries as a valid trade-mark. Still these are border line cases, and even the courts of the same country might differ as to the legality of such marks.

In the United States, under the statute of February 20th, 1905, nearly all words are registrable if they have been in use ten years prior to the passage of the statute. But there is no other American Republic that has a corresponding provision.

But the difficulties indicated are not insurmountable. The principles underlying trade-mark protection are quite similar in all the American Republics, and no reason exists why a treaty or convention may not be framed to cover the points of similarity and practically to prevent piracy of trade-marks of one country by dishonest traders of any other country.

Such a convention has been proposed by representatives from the American Republics and is as follows:

The United States of America, the Argentine Republic, Brazil, Chili, Colombia, Costa Rica, Cuba, Dominican Republic, Ecuador, Guatemala, Haiti, Honduras, Mexico, Nicaragua, Panama, Paraguay, Peru, Salvador, Uruguay, and Venezuela.

CONVENTION.

*Protection of Trade-Marks.*

ARTICLE I. The signatory nations enter into this convention for the protection of trade-marks and commercial names.

ART. II. Any mark duly registered in one of the signatory States shall be considered as registered also in the other States of the union, without prejudice to the rights of third persons and to the provisions of the laws of each State governing the same.

In order to enjoy the benefit of the foregoing, the manufacturer or merchant interested in the registry of the mark must pay, in addition to the fees or charges fixed by the laws of the State in which application for registration is first made, the sum of fifty dollars gold, which sum shall cover all the expenses of both bureaux for the international registration in all the signatory States.

ART. III. The deposit of a trade-mark in one of the signatory States produces in favor of the depositor a right of priority for the period of six months, so as to enable the depositor to make the deposit in the other States.

Therefore the deposit made subsequently and prior to the expiration of this period cannot be annulled by acts performed in the interval, especially by another deposit, by publication, or by the use of the mark.

ART. IV. The following shall be considered as trade-mark: Any sign, emblem, or especial name that merchants or manufacturers may adopt or apply to their goods or products in order to distinguish them from those of other manufacturers or merchants who manufacture or deal in articles of the same kind.

ART. V. The following cannot be adopted or used as trade-mark: National, provincial, or municipal flags or coats-of-arms; immoral or scandalous figures; distinctive marks which may have been obtained by others or which may give rise to confusion with other marks; the general classification of articles; pictures or names of persons without their permission; and any design which may have been adopted as an emblem by any fraternal or humanitarian association.

The foregoing provisions shall be construed without prejudice to the particular provisions of the laws of each State.

ART. VI. All questions which may arise regarding the priority of the deposit or the adoption of a trade-mark shall be decided with due regard to the date of the deposit in the State in which the first application was made therefor.

ART. VII. The ownership of a trade-mark includes the right to enjoy the benefits thereof and the right of assignment or transfer in whole or in part of its ownership or its use in accordance with the provisions of the laws of the respective States.

ART. VIII. The falsification, imitation, or unauthorized use of a trade-mark, as also the false representation as to the origin of a product, shall be prosecuted by the interested party in accordance with the laws of the State wherein the offense is committed.

For the effects of this article, interested parties shall be understood to be any producer, manufacturer, or merchant engaged in the production, manufacture, or traffic of said product, or in the case of false representation of origin, one doing business in the locality falsely indicated as that of origin, or in the territory which said locality is situated.

ART. IX. Any person in any of the signatory States shall have the right to petition and obtain in any of the States, through its competent judicial authority, the annulment of the registration of a trade-mark, when he shall have made application for the registration of that mark, or of any other mark, calculated to be confused, in such State, with the mark in whose annulment he is interested, upon proving.

(*a*) That the mark the registration whereof he solicits has been employed or used within the country prior to the employment or use of the mark registered by the person registering it or by the persons from whom he has derived title;

(*b*) That the registrant had knowledge of the ownership, employment, or use in any of the signatory States of the mark of the applicant the annulment whereof is sought prior to the use of the registered mark by the registrant or by those from whom he has derived title;

(*c*) That the registrant had no right to the ownership, employment, or use of the registered mark on the date of its deposit;

(*d*) That the registered mark had not been used or employed by the registrant or by his assigns within the term fixed by the laws of the State in which the registration shall have been made.

ART. X. Commercial names shall be protected in all the States of the union, without deposit or registration, whether the same form part of a trade-mark or not.

ART. XI. For the purposes indicated in the present convention a union of American nations is hereby constituted, which shall act through two international bureaux established, one in the city of Habana, Cuba, and the other in the city of Rio de Janeiro, Brazil, acting in complete accord with each other.

ART. XII. The international bureaux shall have the following duties:

1. To keep a register of the certificates of ownership of trade-mark issued by any of the signatory States.

2. To collect such reports and data as relate to the protection of intellectual and industrial property and to publish and circulate them among the nations of the union, as well as to furnish them whatever special information they may need upon this subject.

3. To encourage the study and publicity of the questions relating to the protection of intellectual and industrial property; to publish for this purpose one or more official reviews, containing the full texts or digest of all documents forwarded to the bureaux by the authorities of the signatory States.

The governments of said States shall send to the International American Bureau their official publications which contain the announcements of the registrations of trade-marks, and commercial names, and the grants of patents and privileges as well as the judgments rendered by the respective courts concerning the invalidity of trade-marks and patents.

4. To communicate to the governments of the union any difficulties or obstacles that may oppose or delay the effective application of this convention.

5. To aid the governments of the signatory States in the preparations of international conferences for the study of legislation concerning industrial property, and to secure such alterations as it may be proper to propose in the regulations of the union, or in treaties in force to protect industrial property. In case such conferences take place, the directors of the bureaux shall have the right to attend the meetings and there to express their opinions, but not to vote.

6. To present to the Governments of Cuba and of the United States of Brazil, respectively, yearly reports of their labors, which shall be communicated at the same time to all the Governments of the other States of the Union.

7. To initiate and establish relations with similar bureaux and with the scientific and industrial associations and institutions for the exchange of publications, information and data conducive to the progress of the protection of industrial property.

8. To investigate cases where trade-marks, designs, and industrial models have failed to obtain the recognition of registration provided for by this convention, on the part of the authorities of any one of the States forming the Union, and to communicate the facts and reasons to the Government of the country of origin and to interested parties.

9. To co-operate as agents for each one of the Governments of the signatory States before the respective authorities for the better performance of any act tending to promote or accomplish the ends of this convention.

ART. XIII. The bureau established in the city of Habana,

Cuba, shall have charge of the registration of trade-marks coming from the United States of America, Mexico, Cuba, Haiti, the Dominican Republic, El Salvador, Honduras, Nicaragua, Costa Rica, Guatemala, and Panama.

The bureau established in the city of Rio de Janeiro shall have charge of the registration of trade-marks coming from Brazil, Uruguay, the Argentine Republic, Paraguay, Bolivia, Chili, Peru, Ecuador, Venezuela, and Colombia.

Art. XIV. The two international bureaus shall be considered as one, and for the purpose of the unification of the registrations it is provided:

(*a*) Both shall have the same books and the same accounts kept under an identical system.

(*b*) Copies shall be reciprocally transmitted weekly from one to the other of all applications, registrations, communications, and other documents affecting the recognition of the rights of owners of trade-marks.

Art. XV. The international bureaus shall be governed by identical regulations, formed with the concurrence of the Governments of the Republics of Cuba and of the United States of Brazil and approved by all the other signatory States.

Their budgets, after being sanctioned by the said Governments, shall be defrayed by all the signatory States in the same proportion as that established for the International Bureau of the American Republics at Washington, and in this particular they shall be placed under the control of those Governments within whose territories they are established.

The international bureaux may establish such rules of practice and procedure, not inconsistent with the terms of this convention, as they may deem necessary and proper to give effect to its provisions.

Art. XVI. The Governments of the Republics of Cuba and of the United States of Brazil shall proceed with the organization of the Bureaux of the International Union as herein provided, upon the ratification of this convention by at least two-thirds of the nations belonging to each group.

The simultaneous establishment of both bureaux shall not be necessary; one only may be established if there be the number of adherent Governments provided for above.

Art. XVII. The treaties on trade-marks previously concluded by and between the signatory States, shall be substituted by the present convention from the date of its ratification, as far as the relations between the signatory States are concerned.

Art. XVIII. The ratifications or adhesion of the American States to the present convention shall be communicated to the Government of the Argentine Republic, which shall lay them before the other States of the Union. These communications shall take the place of an exchange of ratifications.

Art. XIX. Any signatory State that may see fit to withdraw from the present convention shall so notify the Government of the Argentine Republic, which shall communicate this fact to the other States of the Union, and one year after the receipt of such communication this convention shall cease with regard to the State that shall have withdrawn.

In witness whereof the plenipotentiaries and delegates sign this convention and affix to it the seal of the Fourth International American Conference.

Made and signed in the city of Buenos Ayres, on the 20th day of August, in the year 1910, in Spanish, English, Portuguese, and French, and filed in the Ministry of Foreign Affairs of the Argentine Republic in order that certified copies may be made, to be forwarded through appropriate diplomatic channels to each one of the signatory nations.

The names of the signers of this convention constitute a guarantee of the wisdom and fairness of its provisions. Many of these men are members of the present Pan-American Congress. A perusal of the provisions of the convention shows that they comprehended the situation and provided for the remedies, and if the spirit of the convention is finally carried out, it will prevent the abuses enumerated.

The convention further provides that two bureaus shall be established, one in the city of Havana, Cuba, the other in Rio de Janeiro, Brazil, the bureau in Havana having charge of the registration of trade-marks coming from the United States of America, Mexico, Cuba, Haiti, the Dominican Republic, Salvador, Honduras, Nicaragua, Costa Rica, Guatemala, and Panama, and the bureau in Rio de Janeiro having charge of the registration of trade-marks coming from Brazil, Uruguay, Argentine Republic, Paraguay, Bolivia, Chili, Peru, Ecuador, Venezuela, and Colombia.

Article 16 provides that upon the ratification of this convention by at least two thirds of the nations belonging to each group, the governments of Cuba and Brazil shall proceed to organize these bureaux.

In compliance with this provision of the convention the following countries have ratified the convention:

| | |
|---|---|
| Brazil | November 9, 1914. |
| Cuba | June 13, 1912. |
| Dominican Republic | April 18, 1912. |
| Ecuador | April 8, 1914. |
| Guatemala | May 10, 1912. |
| Honduras | February 13, 1913. |
| Nicaragua | April 24, 1913. |
| Panama | June 12, 1913. |
| Paraguay | August 26, 1913. |
| United States | May 31, 1911. |

The first group lacks only one country of having enough to complete the two thirds necessary for the authorization of the establishment of the bureau in Havana, and it is the main object of this paper to urge the desirability of completing the requisite number of ratifications of this convention by the Republics.

Of course, after the ratification of this convention by a sufficient number of the Republics, legislation will be necessary to provide the machinery for carrying it into effect, and undoubtedly it will be found desirable from time to time to change some of the articles of the convention.

It is believed that the fees charged for registration will be sufficient to defray the expenses of the bureau, but in the case of the United States, at least, further legislation will probably be necessary to carry out some of the provisions of the convention.

In the case of Foster v. Neilson (2 Peters, 314), Chief Justice Marshall, delivering the opinion of the court, in discussing the effect of the United States Constitution on treaties, stated:

"A treaty is, in its nature, a contract between two nations, not a legislative act. It does not generally effect of itself the object to be accomplished, especially so far as its operation is infraterritorial, but is carried into execution by the sovereign power of the respective parties to the instrument.

"In the United States a different principle is established. Our Constitution declares a treaty to be the law of the land. It is consequently to be regarded in courts of justice as equivalent to an act of the legislature whenever it operates of itself without the aid of any legislative provision. But when the terms of the stipulation import a contract, when either of the parties engages to perform a particular act, the treaty addresses itself to the political, not the judicial, department; and the legislature must execute the contract before it can become a rule for the court."

To the same effect is the opinion of Attorney-General Miller in the case of Ferdinand Bourquin (1889 C. D., 253) and of the Court of Appeals of the District of Columbia in Rousseau v. Brown (104 O. G., 1120, 21 App. D. C., 73). The present United States trade-mark statutes already provide for carrying into effect many provisions of the convention. But these are details that can be taken care of as the necessities arise. The important step to be emphasized at this time is the ratification by a sufficient number of countries of this proposed convention.

## Cellulose for Explosives*

Confusion in the lay mind is common, and in the technical mind far from rare. That men skilled in one art should not be conversant with the argot of another art is pardonable, and we stand ourselves excused if for the benefit of the former we use terms obvious to the latter when we speak of cellulose and its products of nitration. At the present time the educated public is in process of acquiring a considerable amount of knowledge in military matters quite alien to its ordinary duties and interests, but now made a necessary part of its education by the compelling teaching of the greatest and most ghastly war in which human creatures have ever engaged. It has heard much lately about the use of wood pulp in Germany for the manufacture of explosives, in place of cotton, which it is hoped may become a rare commodity in enemy countries in a short time. The subject is outside the knowledge of the general engineer, and a few words about it may be acceptable.

Cellulose and cognate substances, such as ligno-cellulose of varying degrees of impurity, are the predominant constituents of all vegetable tissues. Fats, oils, waxes, mineral matter and carbo-hydrates which are not cellulosic are commonly associated with celluloses in such tissues. It is not necessary to consider these except as undesirables to be expelled, and we arrive at the fact that for the purpose of manufacturing propulsive explosives their elimination must be secured. Cotton and wood may be taken as types of cellulose and ligno-cellulose respectively. Both are impure, but apart from their respective impurities, such as fatty and resinous matters, ash and water, are unlike in that cellulose has a different chemical constitution from ligno-cellulose and is much more stable. It is from cotton that nitro-cellulose of the highest quality suitable for the manufacture of propulsive explosives for military use is prepared. It is from ligno-cellulose that some sporting powders are made, but even for these many makers prefer nitro-cotton. As the paper industry grew, the importance of obtaining cheap and abundant sources of cellulosic material became apparent, and such substances as "mechanical" wood pulp, merely disintegrated wood, were employed. Wood partly purified from non-cellulosic constituents by treatment with bisulphites or caustic soda also came into use. This "chemical" wood pulp naturally attracted the attention of manufacturers of nitro-cellulose for explosives, and is used for the comparatively unimportant pabulum of fowling-pieces—"birding pieces," as they used to be called. The best illustration of its inferiority is to be found in the fact cited above, that many makers of sporting powder prefer nitro-cotton in spite of the greater cost of the raw material, holding that with wood pulp the yield is lower and that there is a greater waste of nitric acid. Such differences of opinion among makers are common enough in all trades, and this need not now concern us. But when it comes to the manufacture of propulsive explosives for war, there is no difference of opinion. The propellants used for war by all nations are made from nitro-cotton and not from nitrated wood pulp. It was want of recognition of this fact which caused much difficulty in what is now known as the cotton campaign, when those who thought, as it now seems rightly, that cotton should be made absolute contraband were repeatedly met by the stale old story that nitro-cellulose for propulsive explosives could be made from "any old thing." No one with any reputation to lose would deny this for a moment; any chemist can make nitro-cellulose from cabbage, but that is scarcely a "business proposition," if one is allowed to go on talking "American." Those who wished to reconstruct a lost reputation, or having never been troubled with that precious possession, flung themselves at once into the breach, and with the very worst form of inveracity told an ignorant public that modern military propulsive explosives were made from ligno-cellulose purified to the extent that it aped celluose, may be happily consigned to the limbo which is their province. Now what are the facts? Cotton by long practice and consent of all makers is *par excellence* the material which from its physical and histological structure is fitted for nitration to the point when it becomes suited for gelatinization with nitro-glycerine, and can be made into cordite or one of its congeners. The stuff prepared from wood by the bi-sulphite or caustic soda treatment, though still far from being pure cellulose, can be nitrated, but the product is merely a "surrogate"—a word beloved by our sophisticated, or shall we say unsophisticated friends, whose habitat is in central Europe safe from maritime risks. This surrogate—or substitute—made from wood pulp, however prepared, is relatively unstable, and its disadvantages have been so fully recognized that the present situation is best summed up in the words which we quote from Mr. Marshall's exhaustive work published within the last few weeks: "Every nation now uses propellants consisting principally of gelatinized *nitro-cotton* (the italics are ours) either by itself or mixed with nitro-glycerine."

In the face of all these facts there can be no doubt whatever that cotton is far superior to wood pulp for the manufacture of explosives. But the question naturally arises, Can an enemy who finds himself deprived of the better material make use of the other? The reply must be in the affirmative, but—and it is a very big *but*—he will find himself involved in many troubles. In the use of ordinance it is important in the highest degree that the ballistic properties of the propellant employed should be constant. To secure this, even with explosives prepared from cotton, very careful blending has to be practised, and even then no two lots of cordite, for example, are precisely similar. The result is that varying weights have to be used in the gun charges.

The amounts must differ by ounces or even half-ounces, if an approximately constant muzzle velocity is to be assured. Now, it is probable that if wood pulp be employed the product will be far less regular than when cotton is used and the blending will be additionally difficult. But, furthermore, the explosive power, to put it in a way that will be readily understood, of a wood-pulp explosive is less than that of a cotton explosive, and hence either all the ballistic tables—the tables that give the range for different angles of elevation—for the guns must be altered or the powder chambers of the guns must be changed, unless by some happy and improbable chance the chamber is big enough to allow, and the explosive complacent enough to permit, a change in the density of the charge—that is, broadly, the relation between the volume of the charge and the volume of the chamber or cartridge case—which exactly counteracts the diminution in the power of the explosive. This, we may remark, without going into technical reasons, is in the highest degree improbable.

To make either modification in the middle of a war, which is already taxing her resources to the utmost, cannot be contemplated by Germany with anything less than grave anxiety. Hence, there can be no question at all that to stop the supplies of cotton to our enemy must embarrass him greatly. To say that he may have foreseen all this does not alter the fact. Even if he has already made preparation for the changes in manufacturing plant which will be necessary if wood pulp is used, even if he has got out new ballistic tables and re-designed his cartridge cases and powder chambers to meet the possible need, he must be inconvenienced by the change in a very high degree, and no excuse for the relaxation of the embargo on cotton can be found in this direction.

*From the Engineer.

## Present Condition of the Submarine*

By Max A. Laubeuf, Late Chief Constructor, French Navy, Paris, France

The difference between the submarine and the submersible are rather differences in mode of construction, reserve of buoyancy and form of body. With the submarine pure and simple, the water ballast tanks are placed inside the boat, which has circular cross sections. With the submersible type, these reservoirs, of much greater volume, are placed outside the hull proper. There results an entirely different mode of construction. The submersible has a double shell. The inner skin, which must resist heavy pressure, is made of thick plating. The shape of the sections is elliptical. The outer skin is made of very light plates. The double hull may be complete or partial.

The ratio of reserve buoyancy to the total volume of the ship immersed scarcely exceeds 13 per cent for the submarine type pure and simple. It is much greater for the boats of the submersible type. The boats built according to my designs have 27 per cent to 33 per cent and the "Narval" had 41 per cent.

It results from this difference that the submarine readily drives into the waves and that on the open sea it soon becomes necessary to withdraw the crew from the exterior and close all openings. The submersible, on the other hand, navigates under such conditions like an ordinary ship.

The submarine is distinguished by circular sections, and for many years it has been given a pointed form at both ends. When in 1897 the design of the "Narval" was presented, in which the external form was exactly similar to that of a torpedo boat, many persons expressed the opinion that a boat thus formed would never dive satisfactorily. It has proven, in effect, that the submersible type is as well suited to diving as the other. The most serious objection to the submersible at the beginning was that in order to pass from surface to underwater navigation, a change must be made to the electric motor; and then a considerable amount of water must be taken in to dive, and during the time thus required the boat was in a critical condition, permitting destruction by a ship of the enemy. On the "Narval," at the beginning of the trials, the time required for immersing reached 28 minutes, and the objection noted above was justified. But on this same boat the time was finally reduced to 12 minutes. On the "Sirene" type of 1900 this was reduced to 8 minutes; on the "Aigrette" type of 1902 to 6 minutes, and finally on the submersible of the "Pluviose" type of 1905, to less than five minutes.

The American firm which has built the greatest number of submarines, pure and simple, the Electric Boat Company, has long built boats of small reserve buoyancy. This company is now turning to the submersible type, type M now building having a surface displacement of 1,000 tons and a submerged displacement of 1,500 tons, a reserve buoyancy of 33 per cent. Finally, this firm, which until 1913 built submarines with a single shell and with water-ballast tanks inside, is now building the new type M with a partial double shell. This is a marked change toward the submersible type.

Submarines have not escaped the tendency toward increase in displacement. Ships which have the torpedo as the sole or preponderating offensive armament do not find much advantage in an increase in displacement. The same remark may be made with regard to submarines. Here it may be said that torpedoes form the sole armament, the two small guns which have been placed on certain of these vessels being of very little use, and it will be seen that the offensive power of submarines has increased very little, notwithstanding an enormous increase of displacement. Efforts were made especially to improve the speed and radius of action, both surface and submerged, for the first were quite insufficient in this respect.

To sum up, it will be seen that for submarines, increased displacement provides but a rather feeble increase in offensive power, and that to obtain higher speeds it is necessary to pass to large displacements. On the other hand, large displacements offer the following drawbacks: Greater difficulties of evolution while submerged; too great a draft both submerged and surface. The draft of water on the surface does not allow them to pass in small depths, and when submerged prevents them passing under the keel of an enemy's ship. Too large a turning circle on the surface or submerged is another serious drawback. Finally the cost of construction becomes too high. These considerations lead to the conclusion that it is preferable to have two distinct types of submarines.

Defensive or coast-guard submarines will have a moderate tonnage, good maneuvering powers, a small turning circle, moderate draft, and, on account of low cost, can be constructed in rather large numbers. These boats must be well armed, but they need not realize great speeds nor have a large radius of action when navigating on the surface.

This class of submarine must not only defend the coasts, but also take the offensive within a fairly large radius. They must have good armament, excellent nautical qualities and good quarters for the crew, all of which is difficult to obtain with a small tonnage. They must have a high reserve buoyancy. The good seagoing qualities of submersibles with a large reserve buoyancy have been proved by a great number of journeys of long duration made by ships constructed after my plans. In my last construction I augmented the buoyancy, with a view to further increasing the nautical qualities.

The second type of submarine, which it is now sought to realize, is the high seas or squadron submarine, intended to accompany the fighting ships in any weather, and to take part in naval battles. It is absolutely necessary for this boat to possess high speed on the surface and good speed when submerged; a large radius of action, great offensive power, good nautical qualities and excellent living quarters. These conditions can only be realized with considerable displacement. Ships of intermediate tonnage, ranging between the coast-guard and the squadron submarine, are useless; they are too large as coast-guard and too small as high-seas submarines. I include in the number of these ships, which should have never been put down, all of the submarines of 600 to 700 tons on the surface. All these ships represent but half-measures. They cannot accomplish much more than coast-guard submersibles of 400 to 500 tons on the surface, they possess too low speed and inadequate nautical qualities to accompany a squadron.

Three types of submarines only approach closely at the present time to the true conception of the squadron type. The French navy is in the lead; the "Gustave Zede" and the "Nereide" have 800 tons on the surface, 1,100 tons submerged, and two others a little larger were ordered in 1913 and five in 1914. They have 835 to 1,200 tons. In Great Britain the type "F" of 950 to 1,200 tons is still on the slip. It is said that a new English type, the "G," ordered in 1914, is 1,500 tons submerged. In the United States a new type, "M," is projected. The displacements are understood to be 1,000 to 1,500 tons. If my information is correct, the program of squadron submarines in France, Great Britain and the United States is similar: 19 to 20 knots on the surface, 11 to 12 knots submerged. Will these types of submarines adequately represent squadron submersibles? I answer without hesitation, no; their speeds on and under water are insufficient. To be able to accompany a squadron it is necessary to have a maximum surface speed at least equal to 22 or 23 knots. I say "at least," because small ships lose much more speed than large ones in heavy weather. It is necessary, also, to have a submerged speed at least equal to the current speed of evolution of the armored ships, and here a speed of 15 knots appears to me an absolute minimum.

What are the reasons which prevent these speeds at the present time? (1) It has not yet been possible to construct very powerful internal combustion motors, which would at the same time have a relatively small weight and size; (2) the double motive power.

To-day we should like to banish the electric battery from the submarine, and to place in these boats one motor only. Many attempts have been made in this direction, some with a single internal combustion motor, others with a single steam engine, but no boat with a single motor has solved the difficult problem. When they have given us the powerful, sure motor, with relatively small weight and size, the program of the squadron submarine set out above can be realized.

Present tendencies of submarine flotillas appear to be the following: (1) Coast-guard submarines of moderate displacement, 350 to 500 tons on the surface, 500 to 750 tons submerged; with 14 to 16 knots on the surface, 9 to 10 knots submerged; having a reasonable radius of action; having good living quarters, and, finally, with good nautical qualities—and this implies a high reserve buoyancy. (2) Squadron submarines having a great displacement, for example, 1,200 tons when submerged; having 23 knots surface and 15 knots submerged speed; with powerful armament; a very large radius of action on the surface; excellent quarters, and first-class nautical qualities, implying a high reserve buoyancy.

* *Pacific Marine Review.*

## Japanese Radium

According to *Engineering*, Dr. Ishidzu, of the Tokyo Hygienic Laboratory, has been investigating the hot and mineral springs of Japan with a view to ascertaining the quantity of radium in them. As the result of his researches, the doctor declares that Japan is the richest radium country in the world. The cold mineral spring which has been hitherto considered to contain the largest quantity of radium is Joachimsthal in Austria, which issues from a radium mine and contains 2,000 maches of radium emanation. Dr. Ishidzu's investigation has revealed the fact that a mineral spring in Yamanashi Prefecture is impregnated with 800 maches of radium-bearing water, while another spring at Chuggoka, Japan, has 300 maches.

## A Correction

In the article on Zeppelin Airships in the issue of January 29th, No. 2091, it appears there were several typographical errors. The last line of the second paragraph of the third column, page 77, should read ".107 kilogrammes to the square meter."

In the tenth paragraph the portion relating to the weights of the cells should read as follows: "On the contrary, the weight of the earlier gas cells had to be increased from 170 grammes per square meter to 230."

In the second paragraph of the third column on page 78 a decimal point should be inserted next to last line, making it read .24 kilogrammes per horse-power."


# SCIENTIFIC AMERICAN SUPPLEMENT

Founded 1876

NEW YORK, SATURDAY, FEBRUARY 12, 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 (established 1845) . . . . " 3.00
Scientific American Supplement (established 1876) per year $5.00
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**


*The purpose of the Supplement is to publish the more important announcements of distinguished technologists, to digest significant articles that appear in European publications, and altogether to reflect the most advanced thought in science and industry throughout the world.*

## Back Numbers of the Scientific American Supplement

Supplements bearing a date earlier than January 3rd, 1914, can be supplied by the H. W. Wilson Company, 39 Mamaroneck Avenue, White Plains, N. Y. Please order such back numbers from the Wilson Company. Supplements for January 3rd, 1914, and subsequent issues can be supplied at 10 cents each by Munn & Co., Inc., 233 Broadway, New York.



## Table of Contents