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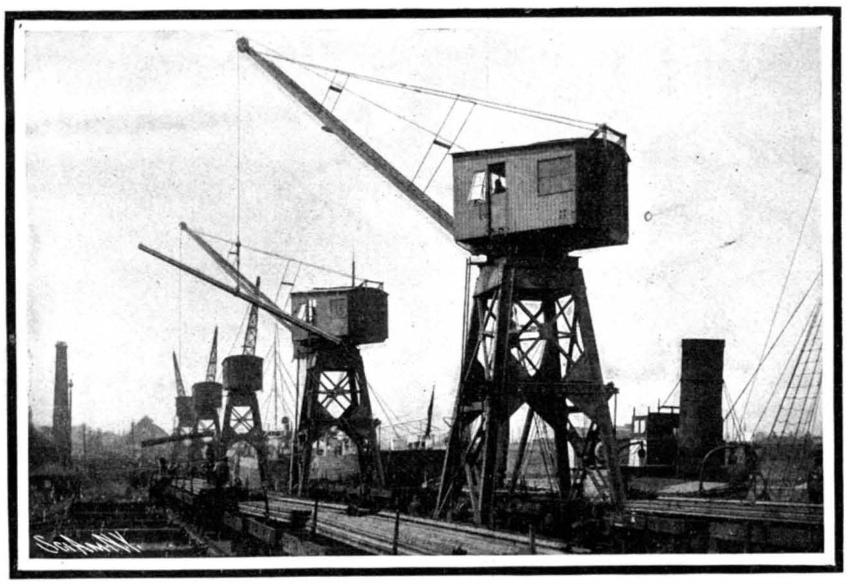
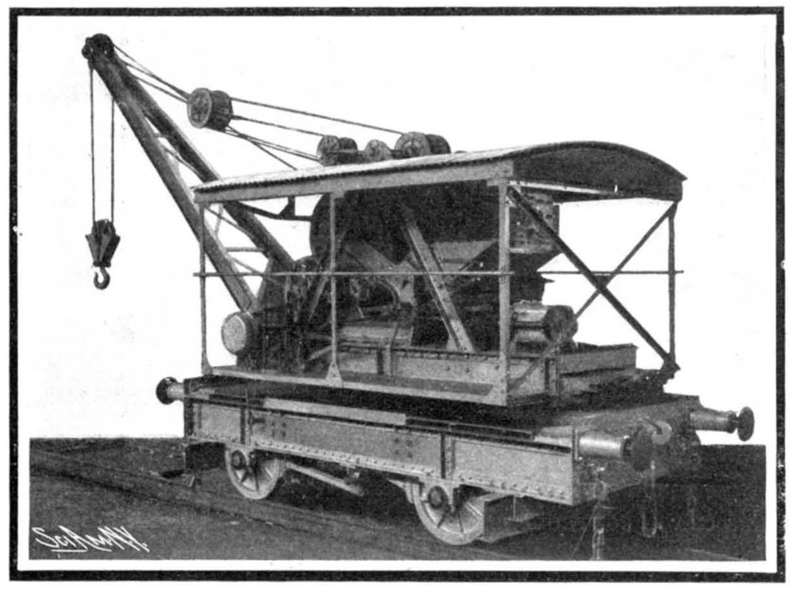
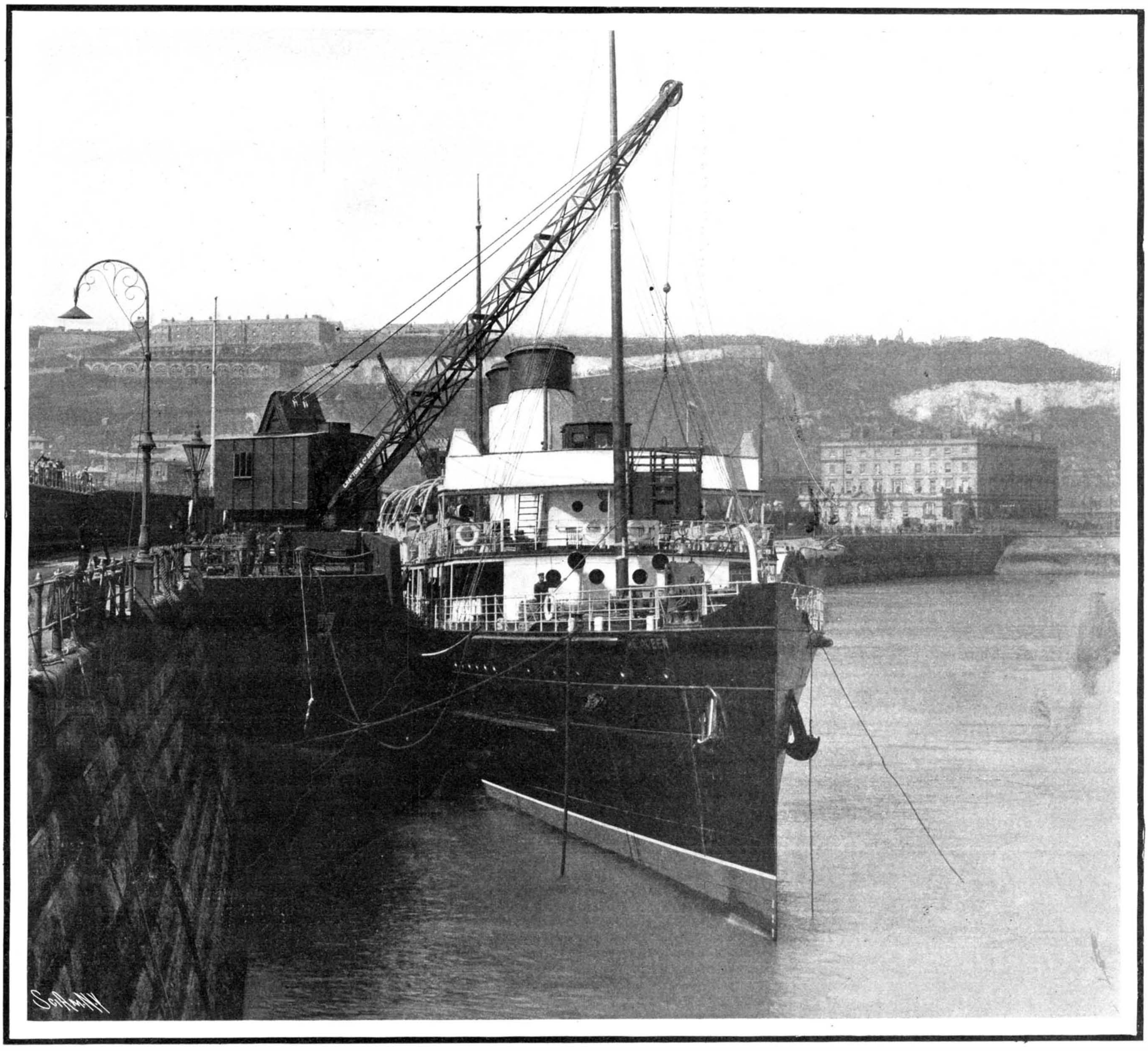


A GANG OF FIVE-TON CRANES USED ON THE WHARVES OF THE NORTH EASTERN RAILWAY CO. AT MIDDLEBOROUGH.



A TEN-TON PORTABLE CRANE.



A WHARF CRANE AT WORK LOADING THE TURBINE STEAMER "QUEEN."

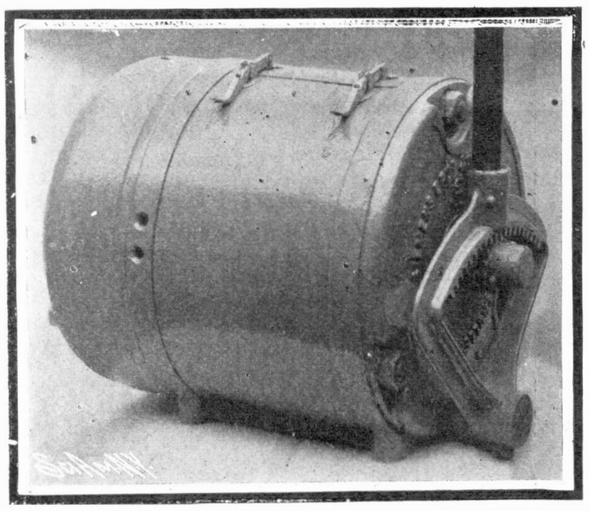
THE ADMIRALTY PIER CRANES AT DOVER.

THE ADMIRALTY PIER CRANES AT DOVER.*

By EMILE GUARINI.

THE advantages of electrical driving for all kinds of cranes, hoists, winches, and capstans have received the attention of engineers, who have come to acknowledge that the electrical system excels in mechanical simplicity, accuracy of control, speed, working economy, and in easy adaptability to the various requirements occurring in practice. But to obtain the best results, specialized manufactures are necessary, and the motors, controllers, brakes, etc., must be specially designed to meet the peculiar and exacting conditions of crane and capstan driving. In crane work ordinary standard motors and controllers would be as much out of place as on a steet car.

This principle is well exemplified in the two electrically-driven jib cranes recently erected on the



SIEMENS CRANE CONTROLLER, HORIZONTAL TYPE.

Admiralty Pier at Dover, with the object of facilitating and accelerating the transshipment of passengers, baggage, mails, and express parcels to and from trains and channel steamers. They are destined to lift the goods in boxes or crates of a gross weight not exceeding 3½ tons. The one crane has been erected on No. 3 east landing stage of the pier, and the other has been erected at the No. 1 west landing stage above the parapet of the pier. Each crane is constructed for lifting a maximum load not exceeding 4 tons at a maximum radius of 55 feet, and slewing or traveling with these loads suspended from the jib in any position without being blocked or clipped to the rails.

The cranes are arranged to operate with four motions, viz., hoisting, slewing, derricking, and traveling. The radius is variable up to a maximum of 55 feet, and the jib (which is constructed specially light, so as to offer little resistance to the wind pressure) measures 60 feet centers in length. The gage of the rails is 10 feet, and the total net weight of each crane in working order is 53 tons.

The cranes were constructed to the general specification drawn up by the engineer of the Dover Harbor Board, A. T. Walmisley, Esq., M.I.E.E., Messrs. Preece & Cardew, of Westminster, being the consulting electrical engineers. The cranes were constructed and the details of the mechanism set out by Messrs. Grafton & Co., of Vulcan Works, Bedford, the electrical

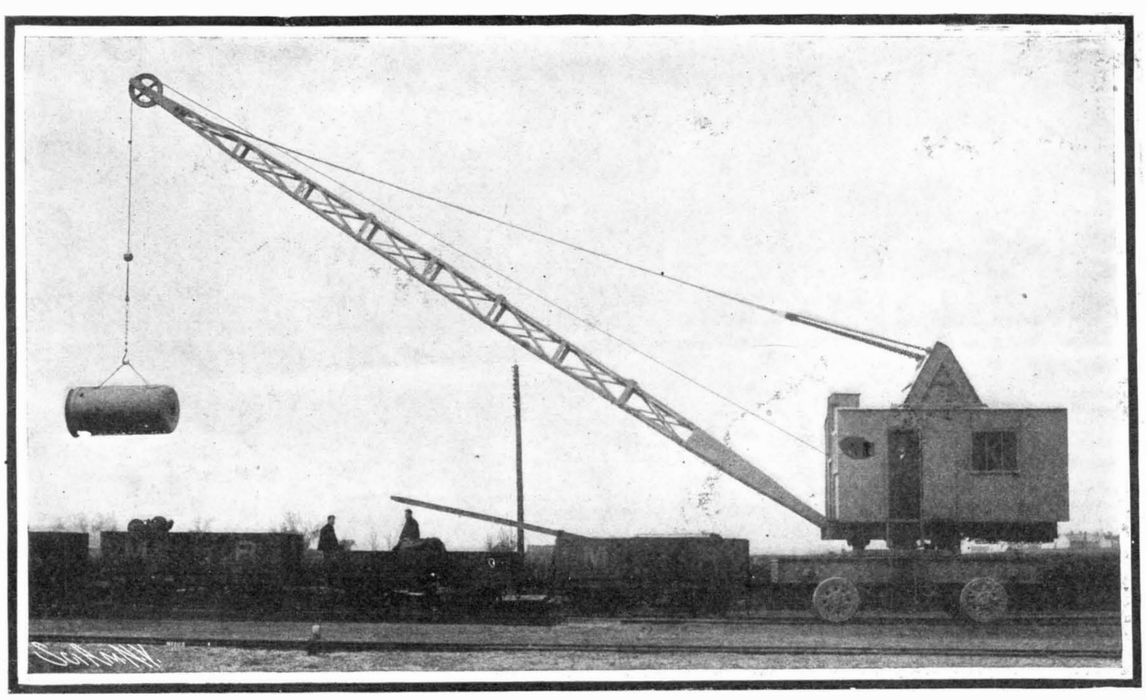
tramway generators. The motors are series wound, two in number on each crane—hoisting motor 37 brake horse-power at 420 revolutions per minute, slewing motor 18 brake horse-power at 310 revolutions per minute. This motor operates also the derricking and traveling motions.

The motors are of a very compact design to suit the confined spaces in which they are fixed. The frame is rectangular and of cast steel, with cast-iron bearings supported in large circular seats and bolted to the ends of the frame. The bearings are ring lubricated and are provided with suitable lips to catch any oil which may be thrown. The poles, which are rectangular in section, are cast solid with the frame and fitted with laminated pole shoes built up of thin sheets of steel riveted together. The pole shoes serve to retain the field coils in position. They are bolted to the frame with nuts on the outside, with the exception of the bottom shoe, which is held by screws tapped into the pole. Any field coil may thus be readily removed. The field coils are wound on formers, and afterward covered with several layers of tape, varnished and baked. Complete protection is insured by insulating pieces which prevent the coils from coming into contact with any of the metal parts of the motor. The armature is of the iron-clad construction, with formed coils embedded in slots open at the top, enabling the coils to be easily removed if necessary for repairs. The winding is of the barrel type, with ends well ventilated. The shaft is provided with large fillets. The commutator is built up of hard-drawn copper segments, retained in position by V-shaped grooves, commutator and armature being insulated throughout in the best manner. The brush holders are of the box type, in which the brushes are pressed against the surface of the commutator by a trigger which allows the brush to be removed when required.

As already stated, the motors are series-wound, and have the well-known advantages for crane-work that their starting torque is very considerable, and is gained without the absorption of excessive current; also that the speed of the motors adapts itself automatically to the load, being greater on light loads and less on heavy loads.

The controller is of the universal type, the direction of the hook and load following the direction of the driver's hand; e. g., if the lever is raised, the crane hoists, and so on. No part of the electrical equipment of cranes and capstans is of more importance than controllers, as upon their proper working depends the efficiency of the whole apparatus, and, to some degree, the safety of the attendants. It is essential for a controller to work continuously in the hands of unskilled men under the most exacting conditions without breakdown. To satisfy these requirements but little wear should occur at the contacts; sparking, due to the continual breaking of the current, should be prevented; the manipulation should be easy, so that the driver's attention should not be distracted from the load; and the design should be neat and compact, suitable for a confined crane cabin or capstan case.

In the Dover crane controllers these requirements have been met in the fullest manner. All parts are readily accessible and the construction throughout exceedingly simple. Heavy notching gear, so troublesome to the driver, has been discarded. The contacts are removable by the unscrewing of one screw, and the form of finger used on the reversing barrel is such that any finger may be easily and quickly removed. The replacing of any of the contacts or fingers, or the turning round of a contact to present a fresh edge to



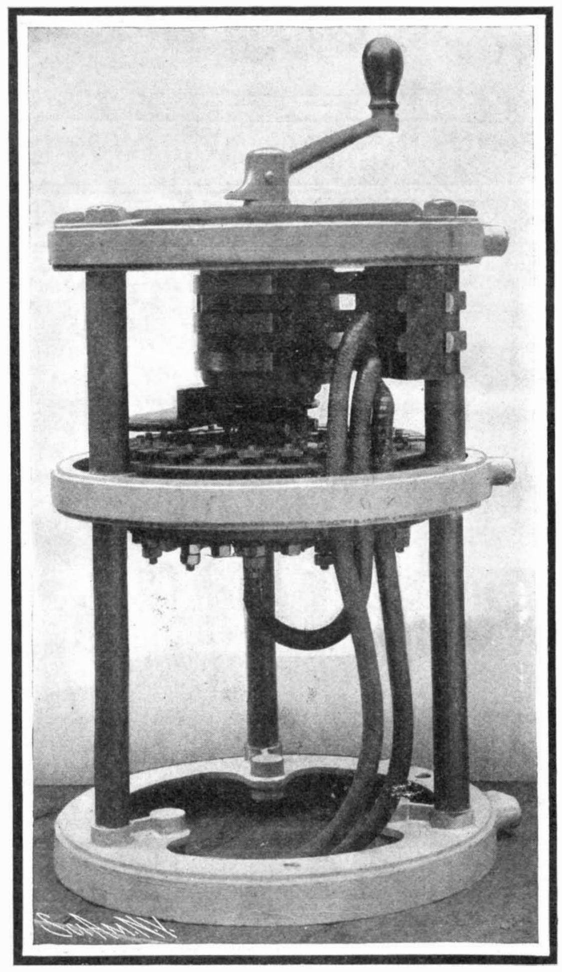
WHARF CRANE USED BY THE ADMIRALTY AT DOVER.

THE ADMIRALTY PIER CRANES AT DOVER.

equipment being supplied by Messrs. Siemens Brothers & Co., Limited, London.

The framework of the Dover cranes is of a simple kind, and of Siemens-Martins mild steel. The entire gearing is of steel, the quick-working gearing being machine cut. The current is supplied from 500-volt

the arc, is the work of only a few moments. In practice, however, little necessity has been found for removing any of the parts, a magnetic blow-out being employed, which effectually prevents arcking, the principal cause of deterioration. In the universal type, the hoisting and slewing mechanisms are operated by the same lever, the vertical movement of the lever hoisting, and the horizontal movement slewing. Thus both the hoisting and the slewing motors may be set in motion at the same time by the simple movement of one lever, an arrangement which gives the driver an easy and effective control. Moreover, the various movements of the lever are made to correspond with the movements of the load; thus upward movement hoists, downward movement lowers, movement to the



VERTICAL TYPE OF SIEMENS CRANE CONTROLLER.

right slews to the right, and movement to the left slews to the left. The horizontal universal type is especially useful with traveling cranes, the movement of the lever being made to correspond with the traveling and traversing movements of the load, and, if used in conjunction with a controller of the side lever type for lifting, a combination would be effected insuring that the load always moved in the same direction as the controller levers.

The connection board is less accessible, and, in order to facilitate the making of the connections, each controller is provided with short lengths of cable, the projecting ends of which are provided with unions for coupling to the leads.

As cranes are in an exposed position, special provision has been made for slewing against the wind, the motors provided being of greater power than would be necessary under ordinary conditions.

Two brakes are fitted to the hoisting gear, one being automatic and worked by an electric magnet and so arranged that the act of switching off current after the hoisting applies the brake, and *vice versa*. The second or emergency brake is operated by the driver's foot, and is capable of arresting the falling test load. The magnet of the automatic brake is connected in series with the driving motor, and the brake released when it is sufficiently energized. The magnet consists of a cast-iron shell and a cored plunger. Between the two is a brass bobbin, which serves as a guide for the plunger and holds the magnet winding. Attached to the plunger is a rod which passes through a hole in the end bracket, and has an eye, to which the brake gear can be linked. Connections to the winding are made through two holes bushed with rubber, an arrangement particularly suitable for damp or exposed positions. By packing the plunger sufficiently tightly a cushioning effect is obtained on the inward stroke, the air behind the plunger escaping through a small hole, which also serves as a channel for lubrication. The magnet is so designed that no magnetic leakage is caused by neighboring masses of iron. The switchboard consists of a slab of japanned slate, without framing but carried on hinged supports permitting it to be swung round for access to the back from right or left, as desired. It includes one double pole main isolating switch with quick break, one automatic cut-out, one quick break switch and fuse for motor circuit, one switch and fuse for each lighting circuit. The automatic cut-out can be set to act instantly at any desired overload within reasonable limits.

The connection boxes for readily making connection between the electrical network and the cranes in any position the latter may occupy consist of a specially flexible armored cable with two constructors, one end of which is provided with two eyes for connection to terminals inside a cast-iron box fixed near the bottom of the crane leg; on the other end is fitted a plug with two tongues, made to fit the clips of the socket of any one of the connection boxes on the quay. One of these flexible connections is carried by each crane.

The connection box itself is of cast iron, with a thick ribbed cover provided with fillets which fit into a

* Specially prepared for the SCIENTIFIC AMERICAN SUPPLEMENT

groove in the top of the box and are screwed down upon leather or rubber insertion so as to make a watertight joint. When not in use, the socket which receives the plug is protected by a strong cap gripping the cover by means of a bayonet joint, and making a watertight connection with it.

These boxes are let flush into the quay wherever required, and branches are taken to them underground from the quay mains, each branch being led inside the box to a terminal carried by a porcelain insulator and connected through a fuse to one of the contact clips which is carried by another porcelain insulator.

The speeds of the various motions are as follows: Hoisting full load at 120 feet per minute, lighter loads at proportionately greater speeds; slewing with full load, one complete turn of crane (380 feet travel of jib-head) in 40 seconds; slewing empty, two revolutions of crane per minute; derricking from maximum to minimum radius in one minute; traveling 100 feet per minute.

ALLOY STEELS.*

By William Metcalf.

The term "alloy steels" is used chiefly to distinguish steels containing influencing quantities of metals other than iron from the ordinary steel of commerce known as carbon steel, in which iron and carbon are the influencing elements for use, other elements being considered more as impurities than as useful ingredients. There are three kinds of carbon steel of universal use—namely, crucible, Bessemer, and open-hearth. Their discussion does not belong properly to our subject, but it may be observed that they contain small quantities of phosphorus, sulphur, silicon, and manganese, as well as oxygen, nitrogen, and hydrogen. Copper and arsenic are present sometimes, but not so generally or in such quantity as to require the careful analyses that are necessary for other ingredients. Certain small percentages of silicon and of manganese are often regarded as useful for special purposes, but not in such quantities as to justify their giving any specific name to the steel.

From time to time we have put upon the market silicon steel, phosphorus steel, chrome steel, aluminium steel, none of which have won any permanent place in commerce. Of permanent alloy steels, we have nickel steel, manganese steel, self-hardening or air-hardening steel, and the latest, the new variety called high-speed steel.

Nickel steel, containing comparatively small percentages of nickel, is used chiefly for structural purposes, giving increased strength and toughness. It has been applied mostly to armor plates and gun parts, and lately it is being tested largely in rails to determine whether the increase in durability in difficult places will justify the greater cost over ordinary Bessemer or open-hearth rails.

Hadfield's manganese steel is unique. Hard, tough, non-magnetic, non-hardening by quenching, non-annealable by any known method, practically unmachinable, it stands by itself; there is nothing to compare it to nor to test it by. It is finding large use for a number of special purposes.

Self-hardening or air-hardening steel derives its name from the fact that when it is heated to an orange color and allowed to cool slowly in the air it becomes exceedingly hard. Some years ago it was known generally as Mushet steel, from the fact that its first development was due to the distinguished metallurgist whose name it bore. The usual composition of this steel is about 2 to 3 per cent manganese, 4 to 6 per cent tungsten, and carbon high.

The distinctive, persistent hardness of manganese steel indicates that it is manganese that gives this steel its so-called self-hardening property. This was confirmed many years ago by Langley, who found that steel high in carbon, containing about 4 per cent tungsten and minute quantities of manganese, had no self-hardening property, and that the same steel remelted so as to contain 3 per cent manganese became an excellent self-hardening steel. Langley next showed by his beautiful emery-wheel test that tungsten is the element that acts as a mordant to hold the carbon in solution at a high temperature, giving this steel its most valuable property, that of remaining hard at a comparatively high temperature, so that a tool made of it could be used for cutting metals at a high speed, the tool continuing to do its work at a temperature, caused by the enormous friction of the high speed, that would soften completely and render useless the best carbon steel tool that could be made. This very useful variety of steel has a large place in the markets, being used for many purposes where its peculiar properties give it great value. It is being rapidly overshadowed, however, by the latest and most surprising steel of all, known as high-speed steel.

Air-hardening steel, as a rule, is not tough—that is to say, if it is made tough it will not be very hard. The edge of a tool will flow, and when it is so hard that it will not flow then it is so brittle that it will crumble easily, and this limits its usefulness. A few years ago, at the Bethlehem Steel Works, some person—whether he was a blunderer or a genius, history does not say—revolutionized the whole machine business. Either by design or accident he heated a tool made of air-hardening steel until it was nearly melted, and according to the traditions and teachings of the ages the tool was ruined utterly. Again, either by accident or design, this "ruined" tool was put into service, and to the amazement of everybody it did an unheard-of amount of work. This led to further experiments and tests, and the Taylor-White process was developed.

This process consisted in heating a tool excessively hot and cooling it by successive stages, producing a tool that would cut at enormous speed for metal work, and take off chips that developed enough heat to blue them. The process was patented, and therefore it is not necessary to go into a long explanation here, especially as it has been superseded. The process seems to have been uncertain—that is to say, when a tool was handled just right it produced results that were wonderful, and when the manipulations were not exactly right the results were *nil*.

The potentialities were so great that nearly all of the leading steel makers in the world attacked the problem, with the result that the present high-speed steels are in no sense of the word air-hardening. Manganese has been reduced from 3 to 4 per cent to 0.30 per cent to traces; tungsten has been increased to 10 to 20 per cent, instead of the usual 4 to 6 per cent, and the carbon is generally less than 1 per cent.

There are about fifty different brands on the market, and of course each one is the best. Perhaps the analyses of two of the leading brands will be interesting, as follows:

	Per cent.	Per cent.
Tungsten	9.99	18.48
Chrome	2.83	2.90
Carbon	0.69	0.78
Phosphorus	0.010	Not determined
Sulphur	0.010	Not determined
Silicon	Trace	Not determined
Manganese	Trace	0.33

Another contains the following:

	Per cent.
Molybdenum	9.65
Chromium	....
Carbon	0.66
Phosphorus	0.016
Silicon	0.046
Manganese	0.22

In one sense it is chaos. All traditions as to heating are completely reversed, and no one really knows what is the best. One brand is famous for its excellence in one kind of work, another in another kind, no one yet seeming to cover all of the ground.

One thing is certain, the machine business is revolutionized. These tools have crowded ordinary lathes, planers, drills, etc., away beyond their capacity; machine builders are remodeling their machines to meet the new conditions, and many of the users are throwing out their old machinery for the new, or else remodeling and strengthening what they have.

There are many records published of the work done by this steel, giving speed per minute, feed, depth of cut, etc., so that it is not necessary to repeat them here. A few illustrations of what can be done may be interesting.

In one case a couple of steel cast bed plates, about 4 feet wide and 9 feet long, were to be planed. There was nominally ½ inch to come off, but the unevenness of the casting made the cut about 1 inch in places. The surface was hard and gritty from the sand of the mold. Several tools were tried, each one going about ½ inch and then having to be reground. Next, one tool cut about 2 inches without grinding. Finally, a tool was tried that had turned up a large, rusty, gray iron pulley without grinding, and it cut clear across the bed plates and was still in good condition for further work. It is clear that the cost per pound of that tool cut no figure.

Another party had a great many castings to thread, with dies made of the very best carbon steel. He could at moderate speed thread from 2,000 to 3,000 pieces without grinding; with dies made of high-speed steel, and with his machine running as fast as he could drive it, he threads from 20,000 to 30,000 pieces without grinding. Another party turns many pieces of hard brasses. He found it difficult to get a tool that would cut them at all, until he tried the right high-speed steel, and made a tool that would cut all day without grinding, running his lathes at the highest speed he could get. The same party bores many cast-iron cylinders, and with tools made of steel that would not cut his brass he bores eight to ten cylinders without regrinding, and at a speed so great that the cylinders came out too hot to be handled with the naked hand. He tried in his cylinders the steel that cut his brass so well, and it would bore only two to four cylinders without grinding.

Another party drills 2⅜-inch holes 7 inches deep in soft steel forgings, drilling a hole in about three minutes; the same steel will not make a good threading die for the same forgings, and for this he uses another brand. Neither of these steels will make a good lathe tool for turning these forgings, and for this work he uses a third brand.

All of these brands, upon analysis, would come within the limits of the analyses given above. From all of this two things are clear: One is that there has been a marvelous, a revolutionary advance in the machining of metals; the other is that steel makers have met the demand remarkably.

It is also clear that we do not know yet where we are and there is much to be learned by everybody. The best methods of hardening may not have been found: it seems that for very high speed work it is necessary to fairly melt the point of a tool and quench it in a strong air blast, and then grind to shape. This would not do for threading dies, milling cutters, etc., for the heat would destroy the tools.

Such tools are finished from annealed bars; this high-speed steel can be annealed as nicely as carbon steel, differing in this respect from air-hardening steel.

The finished tools are heated in a lead bath of 1,800 to 2,000 degrees, and are quenched quickly in ordinary tempering oil, which must be kept cool by a coil containing circulating cold water; they are then tempered in a bath of heavy oil heated to about 450 degrees. The tools come out bright and clean and do their work wonderfully well.

The steel maker has the most to learn. He must find out why there is such a great difference in the work the steel will do, when there is so little difference in composition. He must find the composition or mixture that will come nearest to meeting all the requirements. He has at his command now ferro-manganese, ferrosilicon, ferrochromium, ferrotungsten, ferromolybdenum, ferrovanadium, and ferrotitanium. These alloys are all expensive, except the first two, costing from 60 cents to $12 a pound; therefore the present prices of high-speed steel, which to some people seem to be of the fancy order, are really not excessive.

As far as we know at present, the steel users have not succeeded in making tools that are satisfactory for finishing, and for this purpose they resort to tools of carbon steel, after having done the rougher, heavier work with high-speed steel. This difficulty may be overcome by proper methods of hardening and tempering, or the steel makers may find a composition that will make a tool that is as good for finishing as for roughing.

The successful production of the above-named alloys marks a great advance in metallurgy, and, now that a demand has sprung up, it is certain that the supply will follow, with certainty and uniformity of composition and reductions of cost.

The making and the utilizing of steel containing practically only carbon and iron, with some modifications made by the use of small quantities of manganese, silicon, tungsten, and nickel, have occupied the best minds in the manufacturing and engineering world for many years. The last half of the nineteenth century saw most wonderful developments produced by the inventions of Bessemer and Siemens, aided by the skill and energy of the brightest engineering minds. At the close of the century it was customary to "point with pride," and to assume that so much had been done and so much was known that there was no room for more revolutionary changes, and the coming generation had only to tag along, utilizing these great advances with ease and comfort to themselves and with blessings upon their predecessors.

Now, in the first five years of the twentieth century, we older men find ourselves standing on our heads once more. A revolution has come already, and we can look forward to a splendid opening for the exercise of the best energy and thought of the succeeding generation.

We enjoyed the struggle and the gains of our time, and we can rejoice with the younger men in the prospects of the great triumphs that are to come for them. Clearly, there is still plenty to do and plenty to learn, and in the doing of them there will be great pleasure.

* Presented at the meeting of the American Society for Testing Materials, Atlantic City, N. J., June, 1904.

THE CATATYPE PRINTING PROCESS.

Among the results of the numerous investigations on catalysis which have been carried out in Ostwald's institute at Leipzig, the "catatype" process has recently been attracting more general attention. The following quotation from a paper read by Demeler before the "Rheinischer Bezirksverein," and published in the Zeitschrift für Angewandte Chemie, gives a good idea of the nature of the process and its different modes of application. The lecturer says:

The catatype process, unlike most other copying processes, does not involve the action of light. It was developed by Ostwald and Gross, and is based on the fact that finely divided metals or metallic oxides catalytically decompose hydrogen peroxide into water and oxygen. If a negative is treated with ethereal solution of hydrogen peroxide (a platinum negative gives the best results), the peroxide is decomposed to a varying extent according to the density of the platinum deposit in different parts of the plate, the undecomposed portion remaining behind on the plate after the ether has evaporated. In this way an invisible image consisting of H_2O_2 is produced on the plate. This image can be mechanically transferred to paper by simply pressing a sheet against the negative. If the paper has been previously prepared, a visible image can thus be obtained. If for instance the paper has been treated with potassium iodide and starch, and is passed through water after having the image impressed upon it, the latter will appear in the familiar blue color of starch-iodide. Such an image is not, however, permanent, as it fades on drying.

But the image can also be rendered visible by other means; for instance, by placing the paper for a short time in a solution of a ferrous salt (e. g., ferrous sulphate or ferrous ammonium sulphate) ferric oxide is deposited wherever there is any hydrogen peroxide. In this way a very faint yellow image is produced, which can be rendered plainly visible by dipping it into a solution of gallic acid, when a black "ink" print is obtained, or into a solution of potassium ferrocyanide, when a blue image of "Berlin blue" is produced.

Other reagents also which are capable of being oxidized by the hydrogen peroxide can be used for

"developing" the latent hydrogen peroxide image; for instance, a brown image of manganese dioxide can be prepared by developing with a solution containing ammonia and a salt of manganese. Ammoniacal silver solution produces a dark silver image, etc. The hydrogen peroxide can also fulfill the function of light. If, for instance, a negative treated with hydrogen peroxide is laid against an unexposed photographic plate, the latter can then be developed with an ordinary developer, just as if it had been exposed behind the negative, and a positive image is obtained. On the other hand hydrogen peroxide destroys the latent photographic image. If a silver bromide plate is exposed to the light for a short time, so that developing would turn it black all over, and if then the (undeveloped) plate is pressed against a negative treated with hydrogen peroxide, the previous action of the light is canceled wherever the hydrogen peroxide acts upon the plate, so that a negative image is obtained, but one in which right and left are reversed. Similarly a reversed positive can be prepared from a positive. Manganese dioxide also, like silver or platinum, catalyzes hydrogen peroxide. This reaction can readily be made use of for copying drawings, plans, etc. The drawing is made on paper with a solution of potassium permanganate and is dried in a warm place, when manganese dioxide is formed from the permanganate. The drawing can then be copied by catatype. Or the drawing can be made by means of a reagent which dissolves manganese dioxide, upon a paper previously brushed all over with permanganate. In the first case the original drawing has dark lines upon white background, while the catatype copy is white upon a dark background. In the second case these conditions are exactly reversed.

The catatype process is particularly suitable for the preparation of "gelatine" prints.

The ordinary "gelatine" (pigment) process is rather tedious, but a print may be quickly prepared by the aid of catatype. The negative, after treatment with hydrogen peroxide, is applied to a gelatine paper, so as to transfer the invisible hydrogen peroxide image upon it, and the paper is then placed for a short time in a solution of a ferrous salt. An image of iron oxide is thus obtained, which "tans" the gelatine, rendering it insoluble in water. On developing with warm water and a little sawdust, a picture is obtained in just the same way as if the paper had first been sensitized with dichromate and had then been exposed.

Platinum negatives have been found most suitable for the catatype process; they are also less attacked by the hydrogen peroxide than are silver negatives. The latter, however, when reinforced by means of corrosive sublimate and ammonia, have also given very good results.

It is not yet possible to judge how far the catatype process may find general application in practice, as it is still in its infancy. Although the results obtained by it, especially in the case of iron oxide images, are still open to considerable improvement as regards detail and definition, the process serves very well even now for reproducing drawings, etc., and for preparing gelatine prints.

A Wood Polish.—Over a slow fire dissolve 80 parts of white wax, 20 parts of light pulverized rosin, and 12 parts of Venice turpentine. When it is thoroughly melted pour the warm compound into a roomy enameled dish and stir in 60 parts of oil of turpentine. The parts to be polished must first be well washed in soap and water or rubbed down with kerosene, when the polishing wax may be applied with a soft cloth and rubbed up to a high gloss.—Der Techniker.

PORPOISE AND BLACK-FISH OILS.*

By CHARLES H. STEVENSON.

AMONG the minor oils of technical importance are those of porpoise and black-fish, which are nearly equal in texture and are used for similar purposes. These oils are in two grades of widely different characteristics, viz., blubber oil and head or jaw oil; the former is worth about the same as right-whale oil, or 35 cents per gallon, while the latter sells as high as $10 per gallon. They are generally known as "porpoise oil" and "porpoise-jaw oil," respectively, although the black-fish yields many times as much oil of each grade as the porpoise.

Porpoise have at times been taken in considerable quantities in shore fisheries established primarily for securing the hides for tanning purposes; 6,450 porpoise secured on the North Carolina coast in 1887 yielded 10,460 gallons of body oil; 2,283 porpoise in 1889 yielded 3,897 gallons, and 1,747 in 1890 furnished 2,746 gallons.

This oil is pale yellow to brown in color, and has a slight fishy odor, which disappears on exposure to air. The specific gravity, according to Brannt, is 0.918 at 59 deg. F., and it congeals at about 3 deg. F. When fresh it is indifferent to litmus paper, but absorbs acid properties from the air. It is used for tanning purposes and in compounding with mineral lubricating oils.

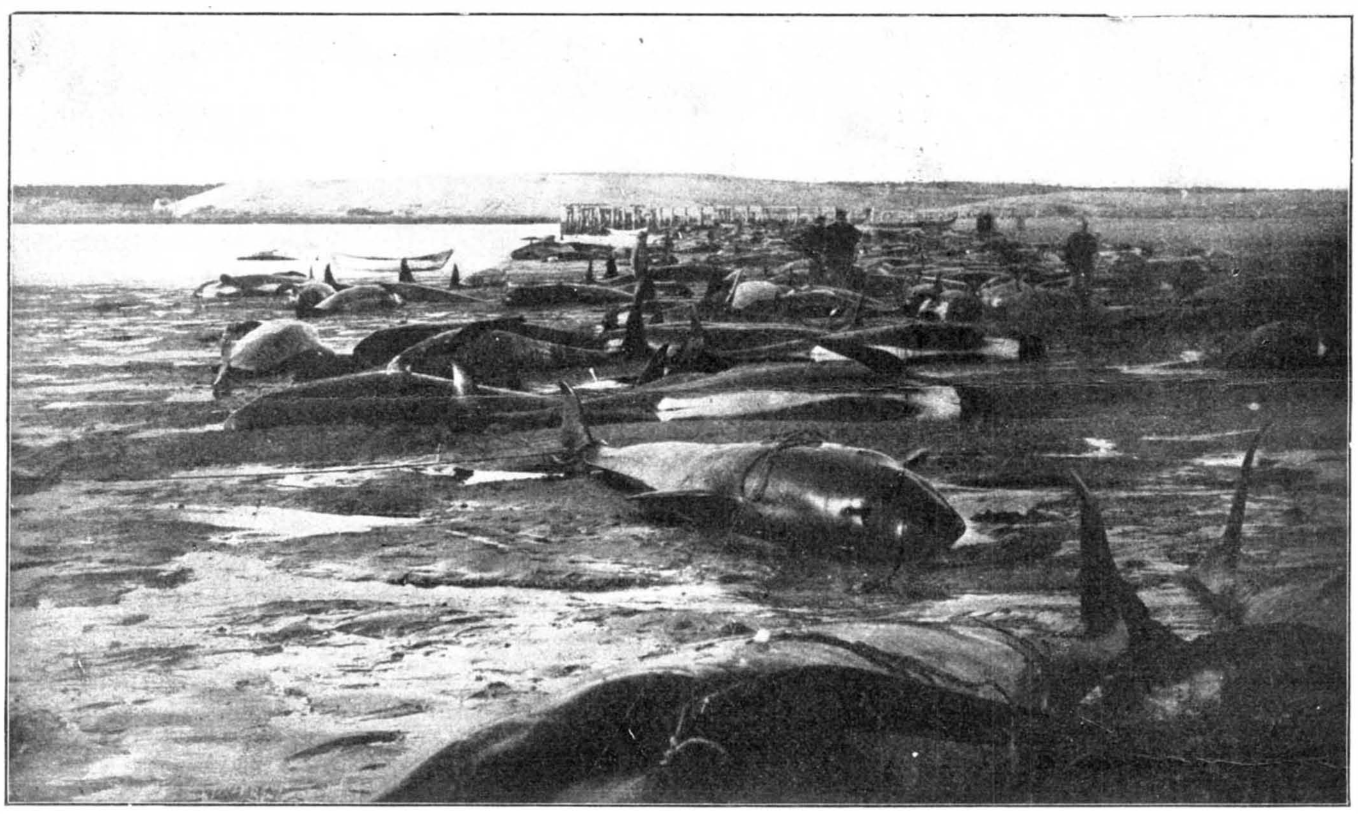
The sperm-whalers of the Atlantic occasionally harpoon Hatteras porpoise from the bow of the vessel and lift them aboard for food purposes. In many cases the blubber of these is removed and tried out for oil. This blubber is of a yellowish white or pearl color, varies in thickness from ½ to 1½ inches, and is of about the same texture as that of the beluga or white whale. It is cut in longitudinal strips 4 or 5 inches wide, minced, and placed in the try-pots with other blubber. The yield of oil is usually less than 2 gallons to each animal, and consequently the whalers do not often render it.

From the jaw-pans of porpoise taken more particularly for food, the whalers obtain the highly renowned "porpoise-jaw oil," which is used for fine lubricating purposes. The lower jaw is removed from the head, the pans extracted therefrom with a knife, minced, and placed in a small tin, such as a meat-can, and placed on the stove to simmer or boil gently. The quantity of oil obtained from each jaw is very small, probably about one-half pint, and the total quantity secured by the whaling fleet of New Bedford probably does not exceed 5 or 6 gallons annually, the market price of which is upward of $6 or $8 per gallon.

Some years ago the Passamaquoddy Indians on the Maine coast captured numbers of porpoise. Indeed, at one time that fishery furnished their principal means of support. As the animals were taken mostly during the winter and inshore, where food is abundant, they were very fat. The largest individuals measure about 7 feet in length and 5 feet in girth, weighing 300 pounds or more. The blubber of a large porpoise is from 1 to 2 inches thick and weighs 75 pounds and upward, yielding 5 or 6 gallons of oil, but the average for all taken was only 2 or 3 gallons. In the primitive method employed by the Indians, the blubber is stripped off and cut into small pieces, which are placed in a large pot. Inside a semicircle of large stones a fire is made, and when the stones are hot the fire is scattered and the pot containing the fat suspended over the stones and sufficient fire kept up to insure the melting of the blubber. The oil rising to the surface is skimmed off and placed in suitable receptacles. This oil, when pure, formerly sold for 60 to 80 cents per gallon, but was frequently adulterated with seal oil and sold at less price. It gives an excellent light, and also is good for lubricating machinery, as it is free from sticky characteristics and has quite a low weather-test. The superior oil in the jaw-pans is also extracted by hanging the jaws in the warm sunlight and permitting the oil to drip into cans placed underneath to receive it. About half a pint of this oil may be secured from each porpoise; it is sold at a very high price for lubricating watches, clocks, and the like. Very few of the Passamaquoddy Indians are now left, and these few have almost entirely abandoned "porpusin" for other occupations.

The "black-fish" (*Globiocephalus melas*) occurs in many parts of the Atlantic Ocean. Individuals vary in length from 8 to 22 feet. They are captured by the sperm-whalers, and also at irregular intervals they are secured when stranded on the shore, especially in Cape Cod Bay, where they have gone in pursuit of food, the fishermen getting to the seaward of them and driving them ashore. They are likewise secured on the rocky coast of Scotland and other parts of Northern Europe.

According to Capt. James Avery, of New Bedford, the sperm-whalers take them at all seasons of the year and throughout the Atlantic, but probably in greatest abundance on the west coast of Africa in 20 deg. W. longitude, and 6 deg. to 10 deg. N. latitude. The number caught annually has greatly decreased in the last 15 or 20 years. In 1881 the "Eleanor B. Conwell" caught 196, probably the greatest number taken in any one year by a single vessel. During the last three or four years the entire whaling fleet probably has not captured more than 20 or 25 annually, yielding about 800 gallons of body oil and 50 gallons of head oil, the former worth $280 and the latter $350 at fisherman's prices.



SCHOOL OF BLACK-FISH STRANDED ON THE SHORE OF CAPE COD, MASS.

The black-fish are captured in much the same manner as very small sperm whales, and for cutting-in they are hove up on deck by means of lifting tackle. The blubber is nearly white, from 1 to 5 inches thick, and is removed from the carcass in longitudinal strips 8 or 10 inches wide. These strips are cut in horse-pieces and minced in the same manner as in the case of whale blubber, the blood being washed off the fat by dashing buckets of water over it. The minced blubber is then placed in the try-pots and cooked, and subsequently treated precisely as that of the right whale. The product of oil ranges from 5 to 120 gallons from each individual, averaging probably about 35 or 40 gallons. This is sometimes mixed with whale oil, although it has a greater value, selling usually for several cents per gallon more than that of the right whale.

The head oil of the black-fish is taken from the melon or junk and the jaw-pans. The melon is a fatty mass on the top of the head, reaching from the spout-hole to the end of the nose, and weighs about 25 pounds. This is washed free from blood, minced, and placed in the try-pot. The lower jaw is cut off, the jaw-pans cut out with a knife, minced, washed, and placed with the cleaned jaws and the melon in the try-pot. Some whalers cook the melon and the jaw materials separately, but the above is the usual method.

It is customary to cook the head matter of black-fish in fresh water. About 15 gallons of fresh water is placed in the pot, the fat is then added, and the whole brought to a gentle boil by means of a slight fire. At this point a little overheating will effect great injury. When the cooking is completed the pot is allowed to cool and the following morning the oil is skimmed off. The product of head oil from individual black-fish ranges from ¾ gallon to 3 gallons, averaging probably about 2 gallons. At ordinary temperatures the

* From United States Fish Commission Report for 1902.

blubber oil and the head oil of black-fish are much alike in their appearance, thus furnishing great temptation to the fishermen to mix a little of the cheap product with that of greater value, resulting in much vexation and loss to the refiner, as it is only in in the process of refinement that the adulteration is revealed.

In addition to the black-fish secured by the sperm-whalers, large numbers have been captured on the shore of Cape Cod, where they are attracted by squid on which they feed. The animals are surrounded by boats and driven like cattle to the beaches, and are there stranded in endeavoring to escape. They are lanced to death and when the tide falls the blubber and the oil-producing head matter are stripped off and conveyed to try-works on the shore, where the oil is extracted in much the same manner as already described for the vessel fishery.

The greatest catch of black-fish on Cape Cod was made in 1884. On November 17 of that year 1,500 were killed at Blackfish Creek, South Wellfleet, where they had been driven ashore. About a month later 500 more were slain in a great round-up in the bay. Since that time very few have been secured in the bay, nor have they been seen at sea in any such numbers as previous to the slaughter above noted.

The oil from the blubber of porpoise and of black-fish is refined in precisely the same manner as whale oil, but the process of treatment applied to the head oils is far more complicated. These are very limpid, of an unusually low weather-test, and have little corrosive effect on metallic surfaces, making them when refined superior for lubricating such delicate mechanisms as watches, chronometers, typewriters, etc. Practically all of these oils secured in the American fisheries are refined at New Bedford and Provincetown, Mass., there being two refiners at the former place and one at the latter. We are indebted principally to Mr. William F. Nye and to Mr. Joseph K. Nye, of New Bedford, for the subjoined notes relative to the methods of refining.

In the preparation of watch and chronometer oils much depends upon the freshness of the fat at the time the oil is rendered and the freedom of the material from adulterants. Fresh substance produces much better oil than that which has partly decomposed, the product being sweeter and less rancid. No choice seems to exist between the porpoise-jaw oil and the black-fish-head oil, both producing refined articles of equal merit; but that of the black-fish seems to be the favorite by a slight margin among the refiners, owing to its having more body, and possibly also to its greater abundance. A peculiarity of these oils is that they improve with age, differing in this particular from blubber oils. This is accounted for by the alternate gathering and emission of moisture upon exposure to changes of temperature, and by this and other treatment they become clear and brilliant, in consequence of which they are seldom used within less than a year or two after they are obtained.

On receipt of the oil at the factory the first step in the process of refining is to gently heat it to complete the process of cooking begun by the fishermen. The oil is then placed in tanks or casks to await the process of grading, and often two years may elapse ere the trained and skillful eye of the refiner can determine to what class it belongs. It is almost impossible to describe the extremely delicate variations in color, texture, odor, and flavor which enter into this grading. The claim is made that there are not a half dozen men in the world who have had the training and experience necessary to separate these delicate oils into their proper classes, and yet a very large part of the reliability of watch and chronometer lubricants lies in the gradation under the almost instinctive skill of the refiner.

According to Mr. Joseph K. Nye:

"After two years or more of rest, the oil has got to a condition where its surplus oxygens have united with whatever animal or loose organic matter may have been floating in microscopic particles within it, and they are easily removed by the ordinary strainers of an oil factory. But something is still left in the oil which is very sensible to the high or low range of temperature, and to remove this requires its subjection, while spread out in thin layers, to a temperature far below zero. No further change in its construction can be made except at this very low temperature, nor must it be cooled too rapidly. When properly done, the process is one most interesting to watch. All through its liquid amber little flecks of translucent material appear, joining and rejoining like frost on a window pane into most beautiful forms, resembling a miniature forest whose foliage is white. By means of a certain fine and close-grained fabric these particles at this juncture are filtered out; and strange to say, this residuum, once a portion of a brilliant, almost colorless fluid, never even at normal temperature becomes anything but a slimy mass, resembling poor lard."

In order to get this low temperature, one of the New Bedford refiners has established a chilling plant at St. Albans, Vt., where long-continued cold can be depended upon.

To be thoroughly satisfactory the refined oil must be of uniform quality, entirely devoid of acidulous properties, absolutely gumless, withstand the rigors of the coldest climate without congealing, and maintain its body or stability in a high temperature. This is the most delicate and highly refined lubricant known, and some has been produced for which a temperature of —50 deg. F. has been claimed. While all watch-oil users do not prefer colorless fluid, the average customer demands an oil almost if not absolutely colorless and of crystal clearness. Much of the product is sold for repairers' use in wooden boxes containing one dozen half-ounce bottles, each bottle inclosed in a small pasteboard box. The remainder, in tin cans having capacity for one pint, one quart, or of larger capacity, goes to the manufacturers of watches, clocks, chronometers, typewriters, etc.

SUCTION GAS-PRODUCER FOR USE WITH EXPLOSIVE MOTORS EMPLOYING LOW-GRADE GAS PRODUCED DIRECT FROM COAL.

CONCURRENTLY with the development of gas motors proper, i. e., those that consume illuminating gas, strenuous efforts have been making to substitute for the latter a less costly fuel. As a consequence, some particularly good results have been obtained with producer gases—"poor" gaseous products that are somewhat different from each other and that are manufactured by various methods and apparatus which, however, are based upon the same principle. As pointed out by M. Witz, in his work on gas and petroleum motors, these gases, which may be logically termed "mixed," have been employed for obtaining water-gas and Siemens gas simultaneously, and they well merit the name of "poor" as compared in quality with illuminating gas. These gases are manufactured in producers into which air and steam are injected. Previous to the numerous improvements introduced by various inventors into the installation and operation of such generators, the calorific power of the gas obtained rarely exceeded 1,200 calories (4761.6 B. T. U.), although this was sufficient to allow of its being utilized for supplying explosive motors. But now, since the method of producing gases has been gradually improved in every respect, it may be said that producer-gas motors have sprung up in legions and are daily multiplying and taking the place of ordinary gas motors and steam engines of low power. It is particularly easy to run them, and the fuel used in them is exceedingly cheap. Let us note the fact, by the way, that producer gases always contain hydrogen and carbonic oxide (which constitute the essential elements), besides carbides, residual nitrogen, carbonic anhydride, and a little free oxygen. One might naturally think that anthracite is necessary for the production of these producer gases; but the fact is that coal of inferior quality will suffice and can be used to advantage. The Pierson apparatus, for example, works perfectly with poor quality French coal, the use of which is quite restricted. It is well to remark that the proper arranging of a gas producer is a difficult matter and requires much practical experience, because the duration of contact of the carbonic acid produced in the furnace with the incandescent column above is an essential factor of the amount of gas produced. On the other hand, the temperature of the furnace is an important matter to be looked after. It would be desirable that this should remain constant, and that the furnace should never be touched during its operation, save at the times of recharging, which must necessarily occur, when the plant is worked night and day. These conditions are evidently filled in well-designed gas generators, since in these the production is regular in the sense that the gas produced is sent to a gasometer where it accumulates under pressure, and that it is afterward supplied to the motor in proportion to the latter's needs. The gasometer, however, has some disadvantages, since it occupies space, is rather costly, and the use of it is attended with some danger. Furthermore, an annexed mechanical arrangement is necessary for blowing air and steam into the fuel. An arrangement that does away with this double complication is found in the gas generator operating by aspiration. Here, it is the motor itself that, at every suction stroke of the piston, draws in the mixture of air and steam that has to pass through the furnace in order to form the gas. Under such circumstances, the latter is produced only as fast as it is consumed, and the space required by the entire installation (which operates practically automatically after the charging with fuel has been effected) is considerably reduced.

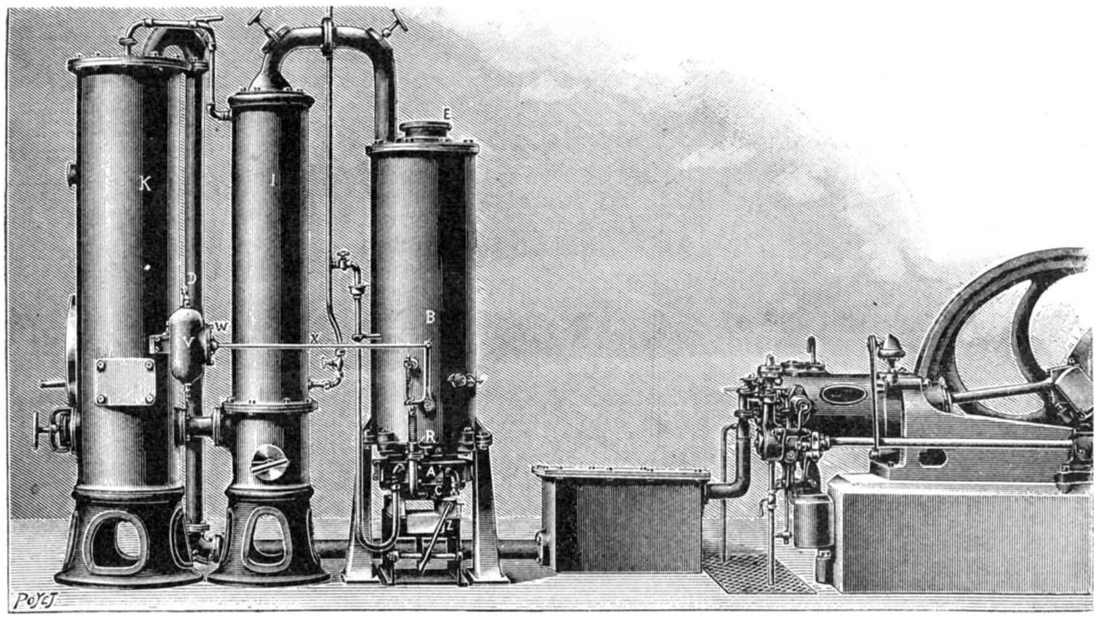


FIG. 1.—GENERAL VIEW OF A GAS-GENERATING INSTALLATION OF THE PIERSON SYSTEM.

Such is the principle; but it is further necessary that everything shall be well designed, so that the gas generator and its various accessory apparatus shall be combined in such a manner that the production of the gas shall proceed regularly, that it shall be of invariable composition, and, consequently, that the motor itself shall run with regularity. We have recently had an opportunity of closely examining a producer gas installation which perfectly fulfills the above conditions, and that, too, automatically. This installation is to be seen in a large Parisian printing house, where the motor designed for producing the motive power, as well as the light for the establishment, is supplied by a generator which, along with the various purifying apparatus, is placed in a small room a few yards in length, which is under the care of the engineer. This entire installation was furnished by the Pierson Company, which makes a specialty of the construction of gas generators and low-grade gas motors.

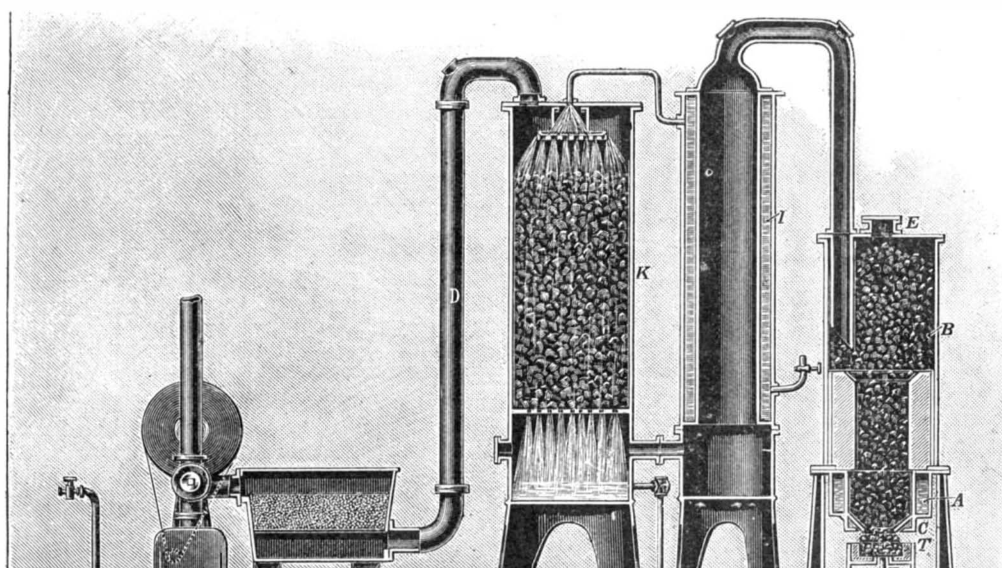


FIG. 2.—SECTIONAL VIEW OF THE GAS-GENERATING APPARATUS.

The motor, through a special conduit, sucks gas through the first of the suction devices of which we shall speak further along, and this suction corresponds to the introduction of a certain quantity of air and steam into the furnace. This brings about in the incandescent fuel the characteristic reactions $O + C = CO$, and $H_2O + C = 2H + CO$, which give the combustible gases that are to be ignited in the cylinder of the motor. Aside from the producer proper, the installation naturally comprises a condenser, a coke column with methodical washing, and a drying purifier. The producer consists of a boiler, *A*, and a cylinder, *B*, lined with refractory material and containing the fuel, which rests upon a piece, *C*. This latter is wide open at its lower part, it being one of the characteristics of this generator that it operates with an open furnace. In order to quicken the fire, poke it, and remove the clinkers, there is no longer any door to be opened and thus permit of the entrance of air to interfere with the equality of the temperature and arrest the suction of the steam. On the contrary, the fire is easily made by means of a vertical rod, *Z*, which is capable of piercing the crust of clinkers without deranging the fire. There is no grate, and the fuel rests upon a bank of cinders that forms upon the refractory hearth, *T*. Thus, not only are entrances of air prevented, but the cleaning can be done without haste and the passages be kept constantly unobstructed. When the plant is only run in the daytime, it is charged but once, before starting the motor. What is particularly interesting in this new Pierson generator is that there is a methodical and automatic regulation of the volume of the steam aspired, according to the fluctuations in the work of the motor, the aspiration always remaining the same. In a suction gas generator it is naturally necessary to give a greater or less proportion of steam with respect to the quantity of air aspired, and according to the number of suctions of the motor, since otherwise if, when running idle, for example, the entrance of the steam were not totally arrested, the fire might become extinguished. When running under a full load, on the contrary, the maximum amount of steam is allowed to enter, in order to prevent too great an elevation of the temperature of the furnace. Here the volume of water entering for vaporization is not acted upon, since it is too small to admit of a proper regulation, and therefore the admission of the steam is regulated, and that, too, in a most ingenious manner. In order to understand the operation of the apparatus that assures such a result, we must state in the first place that the gas coming from the generator enters the condenser, *I*, which consists of a cylinder surrounded with a double water-jacket. In this the cooled gas deposits a portion of its tar, and the coal dust falls into the base of the apparatus, whence it can be easily removed. The gas afterward passes into the coke column, *K*, and enters the purifier, *N*, previous to being aspired by the motor. The gas-supply pipe of the motor that runs from this coke column, *K*, has connected to it through a short branch a cylindrical chamber, *V*, and in the connecting branch is arranged a valve that opens under the effect of the motor's suction, and closes again by its own weight. Upon one side of *V* there is a diaphragm, *W*, which, through a rod *X*, and lever, *Y*, actuates the steam valve, *R*. A small cock, *D*, with graduated sector, and which can be set once for all at the time of regulating the apparatus, permits of counterbalancing the vacuum in *V* according to the speed of the external air that is aspired. At the moment at which a suction of the motor brings about a depression, this same depression is established at *V*, the diaphragm, *W*, is drawn toward the interior of the cylinder, and, opening the valve, *R*, permits the steam to pass from *A* into *C*, and to be aspirated at the same time as the air under the furnace. The valve, *R*, therefore permits of the passage of more or less steam according to the extent of the vacuum in the cylinder, *V*, this vacuum, moreover, being rapidly filled with air entering through the cock, *D*. We here have a mechanical solution of the problem, and one that has the advantage of giving an absolute stability to the quality of the gas produced, and a regular operation of the motor supplied.

This new and most important improvement introduced into producer gas motors will tend to make them much more widely used, to the great benefit of all industries that are not of sufficient importance to justify the heavy expenses accompanying the use of the smallest steam engines.—Translated from La Nature for the SCIENTIFIC AMERICAN SUPPLEMENT.

[Concluded from SUPPLEMENT No. 1495, page 23957.]

MOSELY EDUCATIONAL COMMISSION.*

What the Practical Man Thinks of the College Student.—Whenever we had the opportunity, the question was put: "What is your opinion of the college student? What is your experience of his value as compared with the untrained man?"

The replies to these questions became somewhat monotonous. "What do I think of the college-trained man? Well, I am a college-trained man myself. My chief assistants are college men. Educated men are undoubtedly essential to the success of our business." One manufacturer, who is at the head of one of the largest electrical firms in America, said: "Is it any good wasting time to answer this question?" We were frequently told that "the American manufacturer 20 years ago, like the English of to-day, thought little of the technically trained man. The difference between us now, is," he said, "that the American has changed his opinion, while England appears to be where she was."

These opinions, however, which we invariably met with personally, did not appear to represent entirely the opinion of the American practical man on this question a few years ago, as will be seen by the following extract from an address given in the summer of 1900 before the American Society for the Promotion of Engineering Education at New York by Vice-President Robert Fletcher. The speaker said: "In order to test the sentiment among representative practical men, request was made for an estimate of the professional value of the young graduates and for frank criticism of engineering colleges. About 17.5 per cent of the respondents have a high opinion of the graduate, finding him generally well adapted to his work. About 63 per cent have a low opinion, with modifying statements, such as: He is fitted to begin; has much to learn, especially about the simplest practical points; knows too little, and that not well; some picked graduates improve rapidly; granted that he has much useful knowledge and training, he needs to restrain his knowledge until it is wanted. The remaining 19.5 per cent were doubtful or non-committal. Again, in the criticism of the schools, out of a great variety of views, there was a general consensus of 70 per cent on the following points: The colleges should do more work on the fundamental subjects; teach thoroughly controlling principles which every engineer must fall back upon; develop practical sense and train the judgment and attend only to such details as are essential; avoid side issues. About 13 per cent declared that the engineering colleges generally are undertaking too much; that there is too much stuffing with facts and details and not enough thorough work on elementary and basal principles. Some further comments are to the effect that graduates should generally be much better draftsmen, with far more skill to meet immediate demands; that there is great lack of literary training shown in the inability of many graduates to write a proper business letter and to observe the most ordinary forms and procedure of business transactions; that there is lack of completeness and mastery, even of those things which the graduate professes to know, such as to make a neat and adequate set of notes, proper facility in some of the simplest field routine," etc.

The above remarks are severely critical, and have no doubt had their due effect upon the work of the colleges. But these institutions are undoubtedly steadily increasing in efficiency and in public estimation, and there is a growing appreciation of the better educated applicant for admission to manufacturing establishments.

Whatever the prejudice may be in some quarters there is no mistaking the fact that, great as is the annual output from the colleges, the demand for college-trained men is greater than the supply.

The Pennsylvania Railroad, which is the most advanced railroad company in America, has made it a *sine qua non* that the new appointments to all the executive positions shall be men with an engineering college training, and the majority of the officials on the general staff are men with college degrees. The example of this company is being followed by many other railroad companies who are in constant communication with the colleges for the supply of skilled assistants. In most of the colleges all their graduates at the end of the fourth year are secured by various companies before their college term is completed, and the usual remark on the part of the authorities was, "We could place twice as many men if we had them." Electrical firms especially keenly compete with each other for the best men, and representatives from the firms call at the colleges and select men by personal interview. The manufacturer comes to the college, the college does not go to the manufacturer.

All this is in very marked contrast to the condition of things a few years ago. Formerly letters of application for students specified that they must have had practical experience; now the employers write to say that the student must have had a sound scientific education; they will see that he receives the training.

In all cases young men engaged from the colleges are started at a living wage, so that they are at least able to maintain themselves at once.

Advantage of the Senior and Better-Trained Type of Student in Technical Colleges.—The students of the technical colleges in America being from 18 to 25 or 26 years of age, and having received a high-school and in some cases a college education, it is possible to do much superior work with them than with younger boys. The younger student has generally not received the necessary mathematical training to enable him to do advanced work, he has not a sufficient sense of responsibility in approaching his work, and he does not realize the importance of the issues with which he is dealing, nor the necessity for the strictest accuracy in his work. On the other hand, with a senior type of student there is more strenuous application and earnestness, the work is handled in a different spirit, and very much sounder and more thorough training may be given. In America at the present time the colleges are filled with students of a senior type, who are receiving an advanced and thoroughly sound training, and it is business concerns led by these men with which the British manufacturer will have to compete. The question for our country to ask itself is: Are we preparing the British youth of to-day to compete successfully with his commercial rival? It must be confessed that, so far as the study of science as applied to industry is concerned, our position at present is inferior to that of America.

Relations between Manufacturers and the Colleges.—The most excellent and cordial relationships appear to exist between the leading colleges and the works, and between the professors and the manufacturers. This mutual helpfulness is of the greatest value from the point of view of the college, whose usefulness and influence depend so much on the extent to which it is able to secure the confidence of the public in whose interest its work is carried on. The college keeps in close touch with the actual practice of the works. There are periodical visits of the students to the works, and similar periodical visits to the college of occasional lecturers who are distinguished engineers or commercial men, and who give an account to the students of some new development, or invention, or construction of practical importance, with which they themselves had been associated. Dr. Coleman Sellers, a well-known and successful manufacturing engineer, lectures on machine design, and is on the permanent staff of the Stevens Institute at Hoboken. The professors are, many of them, at the same time engaged in actual practice as consulting engineers, and they are given full power to carry on their professional practice as long as it is not allowed to interfere with the claims of the college. They say if the governing body cannot trust the professor on this point he is not the man for them.

It is not so much that the professor in America becomes the practising engineer as that the practising engineer is invited to become the professor, and that, as an inducement to him to accept the position, he is permitted to continue as much as he chooses of his professional practice. The effect of this is that the college is prevented from becoming a mere book-learning institution. It is considered vital that the professor should be "in the field of practice," otherwise he is liable to become stale and out of date, and to attach exaggerated importance to unnecessary things. Whatever may be thought of these views, there is no doubt that their effect on the constitution of the American college staff has been to the immense advantage of the college and of the character and quality of the work done by them.

Education of Apprentices.—The general practical training obtained by the apprentice in British workshops is unequaled in any other country, and in America the British-trained apprentice is a very much valued product, because his training is longer, he is taught more thoroughly, and he is a more patient and careful workman than the American. In the American workshop the British-trained workman is said to be an easy-going gentleman when he first starts, but he soon settles down to become the same aggressive and progressive person as the rest.

The question of the education of apprentices is now receiving much attention in the United States, though by no means more so than is the case in Britain. There is, however, this difference, that the British manufacturer undertakes this work from a sense of duty and patriotism, while the American manufacturer does so as a matter of necessity, to meet the demands of his own business, to equip himself with a better-trained class of employes; in other words, he takes up the question of the education of apprentices because it pays him to do so. For example, in talking with one of the directors of the Baldwin Locomotive Works at Philadelphia, we were told: "The result of our efforts to train apprentices is beneficial to the works, first, because we get a large application of youths for admission as apprentices in consequence of the training we give, and we have, therefore, a better pick of youths. We make a careful selection of the best by means of an oral entrance examination. Secondly, young men who have done well with us as apprentices are nominated by Baldwin's for good positions at home and abroad. These young men are loyal to Baldwin's and look upon it as their *alma mater*. Many of them reach responsible positions in connection with home and foreign railways, and whenever they can put work in the way of the firm they do so. They are a standing advertisement for the firm in all parts of the world."

A feature which should be mentioned in connection with apprentices in several large works in America is that an official called a "superintendent of apprentices" is set apart to look after their interests, to watch their work, and to see that they are promoted from step to step so that they may obtain the best possible training in the time. The duties of the superintendent extend also to observation of their health and general conduct, to visiting their boarding houses to see that these are respectable and suitable, to advise them as to attendance at evening classes, and to watch the regularity of their attendance. He also prepares weekly reports of their work and progress which are examined by the heads of the firm, who in some cases, arrange for personal interviews with the apprentices at the time of the examination of their reports. In this way the employers are able to keep in close touch with each apprentice. His history, character, and progress are well known to the firm, and a feeling of friendliness and co-operation is thereby secured, with beneficial effects both to the apprentices and to the firm.

Evening Classes.—There is less organized effort in America for the education of the artisan than we have at home, and evening schools are not a feature of American education. The great State colleges of America were founded by funds granted under the Morrell Land Act, with the object of supplying teaching in "agriculture and mechanic arts." These col-

* Report of Mr. W. Ripper, M.Inst.C.E., Professor of Engineering, University College, Sheffield.

leges have become, however, institutions of the highest grade, and provide advanced training for the leaders rather than elementary training for the rank and file. It was a very general subject of complaint that schools originally intended for the education of artisans, and endowed for that purpose, tended to run away from their task, to neglect their fundamental work, and to become second-rate colleges for advanced students. In some cities numerous evening classes are at work, but there is seldom anything in the nature of technical teaching given in them. There are, however, some important exceptions, as, for example, the Cooper Institute, New York, and the Williamson Trade School, Philadelphia. Several of the colleges also, as, for example, the Lewis Institute and the Armour Institute, Chicago, have important and elaborate evening class arrangements.

There is no organization of evening class construction comparable with that of the English Science and Art Department. The nearest approach to it was the evening class work of the Young Men's Christian Association, which is a remarkably strong organization throughout the United States. Their educational work, however, was chiefly confined to elementary instruction in commercial subjects.

The evening school education of Britain was spoken of with much disparagement in America. It was said that Britain is dependent for the technical training of her people on evening class instruction, and that the system had proved a failure. Although it is undoubtedly true that the evening school system of our country is quite inadequate to meet the modern needs of a first-rate industrial nation, yet it is a great mistake to undervalue the extremely important work that has been done, and is still being done, with so much success throughout the length and breadth of our country.

Wherever one went in America, English and Scotch foremen and managers and heads of departments were everywhere to be found. Those men were there because they deserved to be there. They are also to be found holding similar positions in every part of the world. They have as their assistants college-trained men. They are themselves, most of them, the product of the evening science class, and a testimony to the efficiency and effectiveness of British evening science class instruction.

Correspondence Schools.—The enormous proportions which the system of instruction by correspondence has reached in America calls for especial notice in this report, especially as the bulk of the work done through that system is concerned with the teaching of technical subjects to the artisan classes. There are, no doubt, instances of unsatisfactory and even fraudulent organizations professing to give instruction by correspondence, but these are evidently the exception and not the rule.

One of the most successful of the correspendence institutions, with its headquarters at Scranton, Pa., was carefully investigated. During the past ten years it has enrolled 600,000 students for the study by correspondence of technical subjects. It has offices in 28 different cities, and an organization of 1,500 agents and interviewers, together with a large staff of instructors and examiners, making up a total of 3,200 employes. The secret of the success of this organization is that it meets a real demand, and that it has a definite aim from which it does not allow itself to be diverted—to help the artisan class. It undertakes to teach one subject at a time, and for this purpose it provides special courses of instruction bound up in volumes. The volumes have been prepared with great care, and are written in language suitable for their purpose, with the addition of exceptionally well-prepared illustrations. "We take a man," they said, "engaged in a particular trade, and we teach him the theory of that trade, nothing else; we confine ourselves to that. We set the course to fit the man; we don't try to make the man fit the course. We get to the point; we don't wander all round it and never reach it." In this respect we have some lessons to learn from them.

Industrial Success of America.—American industrial success is due to the combination of a large number of contributing causes, of which education is undoubtedly one. In so far as American educational advantages are superior to our own, to that extent is American industry reaping an advantage. But there are other influences promoting American industrial success, among them the following:

The great natural resources of the country and the invigorating influence of climate; the qualities and characteristics developed through a race of pioneer forefathers who faced tremendous difficulties and won success in a new country; the phenomenal keenness for business enterprise shown by all classes; the impatience of slow and antiquated methods and devices and the intolerance of any method when a quicker or a better can be found; the development of improved systems of works' organization and management, including the policy of specialization and standardization; the assistance and encouragement given to trade by the government; the concentration of capital and ability in great concerns, and a world-wide commercial policy; the unrivaled railroad facilities and lowness of freight rates, and the high development of system and method in transportation; the versatility, readiness, and resource of industrial workers, and genius for building up business in new directions; the constant influx of skilled workers from Great Britain and the continent of Europe; the sobriety of the Americans as a people; the attention to small economies, and profits on utilization of waste products; the personal and friendly relationships between masters and men, and mutual co-operation for improving the plant, reducing costs, and increasing output; the attention paid to the comfort of the workers, not from philanthropic motives, but as a means of increasing the general efficiency and effectiveness of the workers.

Conclusions.—In this report a description is given of the present position of educational opinion and aim in the United States, as far as it could be discovered by the writer. On many of the points raised herein, and especially on the question as to the wisdom of adopting American methods in England, there would be great difference of opinion. Each country must work out its own educational problem for itself in its own way, and imitation of one country by another without regard to local conditions would be absurd.

Speaking from the point of view of the education of engineers, one would say that from the English standpoint too much importance may be attached to prolonged literary training, and not enough importance to the practical training of students during the earlier years of their career, nor to the culture value of a scientific and professional education. For the comparatively few who, by reason of their ability and opportunity, may hope to fill some high administrative position, a prolonged course of training, both literary and professional, such as that recommended in America would be undoubtedly of the greatest value, but English opinion would generally not approve such a training for the great mass of students who are youths of only average ability.

In some points, however, the British people might imitate America with advantage. It might do so, for example, in the direction of increased public interest in the subject of education; in the speedy provision of an improved system of secondary education; and particularly in the provision of an advanced type of teaching in secondary schools, so as to insure that the time spent in them by the older boys is spent to the best possible advantage. We should do well also to imitate America in the provision of institutions for carrying on the highest grade of research work in science as applied to industry, and in providing and maintaining them from Imperial funds, and not depend so much as we do at present upon local effort alone.

Some further points requiring earnest attention are: (1) The necessity for encouraging, strengthening, and developing the great work which is being carried on in the Science and Art Department evening classes of the Board of Education, and of our keeping this department very much alive, alert, and responsive to the industrial needs of the country; (2) the necessity for improving the curricula of the respective trade classes for artisans organized by the city and guilds of London Institute, so as to make these classes more suitable for their purpose, and more attractive and useful to the men for whom they are intended; (3) the necessity for a closer relationship between the technical schools and classes and the manufacturers, particularly for the purpose of the most efficient working of schemes for the education of apprentices.

WHY IS THE BOILING POINT MARKED 212 DEG.?

THIS is a question that no doubt everyone who has occasion to use the ordinary Fahrenheit thermometer to any serious extent has at one time or another asked himself, and at first sight it does seem a somewhat stupid number to use as compared with the round 100 deg. adopted on the scale of the Centigrade instrument used in France, and, in fact, now generally adopted in all chemical and scientific work. Like many other apparently stupid things, however, the 212 deg. had its origin in a desire for simplicity and permanence, and has become stranded on the rocks of inconvenience as a result of the world's wider knowledge, and aptly illustrates the danger of setting limits to its range. Fahrenheit, who first introduced the thermometer which bears his name, was familiar with a mixture of powdered ice and salt, which was then regarded as the very ultimate limit of cold obtainable, and made this his zero, in the expectation that it would serve for all time. Seeking for some fixed and equally convenient point which should serve as his upper datum, he fixed on the temperature of the human blood as a point which remains unvarying for all generations, and made this his 100 deg. mark (though it was subsequently found his measurement of this point was slightly inaccurate, blood temperature being about 98½ deg.). This scale of graduations it will be evident was, from Fahrenheit's point of view and limited knowledge, quite as rational—in fact identical in principle—with that adopted by Celsius in the Centigrade thermometer. Continuing the graduations upward beyond his 100 deg. or blood-temperature mark, it became purely a matter of registration that the temperature of boiling water was 212 deg. The primary range, viz., that between the temperature of an ice and salt mixture and human blood, was 100 deg., and Fahrenheit's mistake lay in assuming that his zero was the absolute one. In the light of present-day knowledge, when we can speak with certainty of absolute zero from physical principles being 461 deg. below Fahrenheit's zero—i. e., more below it than the melting point of tin is above it—and when we can solidify such gases as air and hydrogen, such an assumption seems an amusing one, though it appeared sound enough when first made. The Centigrade scale, with the freezing and boiling point of water as the upper and lower limits, certainly seems more rational for most ordinary temperature measurements, but the average person is apt to forget that it is only conventional, and that for purposes of exact measurement the physicist must refer his phenomena to the absolute zero, where temperature ceases to exist, where hot and cold have no meaning, and every form of matter is devoid of motion and is utterly dead. This is the only real zero of temperature.—Vulcan.

OLIVE OIL AND ITS SUBSTITUTES.

So widely distributed an article of commerce as olive oil, says the Times, could hardly be expected to escape the risk of adulteration, and there are at least a dozen well-known oils that are used in varying degrees as olive oil substitutes. Among the leading countries of production are Italy, France, and California. The processes of manufacture are simple. In the last-named country, for example, the fruit is picked when ripe, and dried either in the sun or by means of dryers. It is then crushed in a mill, and the oil extracted by a powerful press, the details of procedure varying in different mills. In some places the olives are mixed with hot water before making even the first pressing. The first oil that issues from the press is called the "virgin oil," and this constitutes the highest grade of salad oil. The pulp resulting from the first operation is put under much higher pressure to yield the second-pressing oil, which, as a rule, is mixed with the virgin oil. The pulp is now treated with hot water, and pressed again, when a third-grade oil is produced. This is used for the table, for lubricating fine machinery, and for burning. The pulp still contains oily matter, which is extracted with bisulphide of carbon, and used in making Castile soap and in dyeing. The oil from the several pressings is run into tanks with water, and is allowed to stand until the pulp and gummy matters settle. The oil is carefully drawn off, filtered, and stored in a cool, dark place until ready for bottling, as olive oil becomes rancid very quickly if exposed to light and heat. The subject of olive oils and their adulterations has been regarded as possessing sufficient importance to justify special investigation by the United States Department of Agriculture, and the results are embodied in an instructive bulletin. It was reported in 1897 that there were in California 2,500,000 olive trees, capable of producing, besides dried and pickled olives, 2,000,000 gallons of oil annually. This quantity is, however, greatly in excess of the present production, owing to the circumstance that both the French and Italian oils can be imported cheaper than the actual cost of production of the California article. Still, the figures quoted are of interest, as showing that California is capable of furnishing the entire quantity of olive oil consumed in the United States. In 1900 that country imported 649,423 gallons from Italy, 275,461 gallons from France, and 42,818 gallons from all other sources, the total being 867,702 gallons. These imports pay a duty of 50 cents per gallon. The Italian oil is much cheaper than the French product. The average difference in price is about 60 cents per gallon, and is partly due to the packages in which the oils are shipped. Another reason for the lower average price of the Italian oils is that a large proportion of low-grade oil is imported from Italy. The price of high-grade oils from both countries is about the same. Italian oils are valued at an average of about $1 per gallon and French oils at $1.60; adding 50 cents per gallon for duty, their values become $1.50 and $2.10 respectively. The cost of production of Californian oil is estimated at $1.88 per gallon, and the addition of 50 cents per gallon for bottling brings the actual cost of preparing these oils for market up to $2.38. The Californian oils retail at a slightly higher price than the French, and the latter at a somewhat higher figure than the Italian oils. As regards adulterated oils, it appears that price is not always, or even generally, an indication of purity. The Californian oils show very little variation in price, as all this oil is of highest quality. In the case of both French and Italian oils some very low grades are placed on the markets. The best grades of all three varieties of oil bring about the same retail price. Olive oil substitutes include the oil of cotton seed, peanut, sesame, maize, mustard seed, rape seed, and colza, sunflower, poppy seed, and lard. Cotton seed oil is the chief adulterant of, and substitute for, olive oil in America. It is used to a large extent under the name of salad oil, but is also frequently sold as olive oil, with which it is extensively mixed. The well-refined oil has a pleasant though characteristic taste and odor, and is much less liable to become rancid than are olive and other oils used in the preparation of salads. The cotton seed oil sold for salads is refined in part by the use of alkali, and this treatment removes all free fatty acids. Peanut oil is probably used as an adulterant of olive oil more extensively in Europe than in America, where cotton seed oil is so common. This oil has a pleasant nutty flavor, and makes a good salad oil, for which purpose it is largely used in Europe under its own name. Many of the ordinary chemical tests fail to distinguish this oil from olive oil, with which, therefore, considerable quantities of peanut oil might be mixed without being detected. Sesame oil, like peanut oil, has a pleasant flavor, and is well adapted to the adulteration of olive oil. Maize oil is produced in large quantities in the United States, and, owing to its cheapness, may find use as a substitute for olive oil. This product, which is a semi-drying oil, similar to cotton seed oil, has so far been but little used for salad purposes. It has the flavor and odor characteristic of maize, and these qualities aid in its detection. Mustard seed oil belongs to the rape seed oil group, and differs but slightly in character from rape seed oil. It is seldom if ever used as an adulterant of olive oils, although it is frequently added to rape oil, and this may find its way into olive oil. Means of detecting it in small quantities are as unsatisfactory as those for rape oil. The presence of

sulphur compounds in the oils of cruciferous seeds, such as mustard, rape, and colza, affords, however, a means for identification of these oils. If the latter are saponified with alcoholic potash and stirred with a silver spoon, the metal will become blackened by the formation of sulphide. Rape seed and colza oils are less well adapted than some that have been named as substitutes for olive oil, owing to their acrid taste, even when well refined. Sunflower oil is mild in taste and of pleasant odor, and the cold-drawn oil is stated to be used in some parts of Europe for culinary purposes. The characteristics of this oil are so widely different from those of olive oil that additions of even relatively small quantities to olive oil would easily be detected. The oil of poppy seed, though used in Europe as a salad oil and for culinary purposes, and sometimes as an adulterant for olive oil, is not used in America to any extent either as a salad or a cooking oil, and it is doubtful if it is ever employed as an olive oil adulterant. Lard oil is so manufactured that it remains liquid at ordinary temperatures, and when well refined is entirely free from the taste and odor of lard. When heated, however, it develops this odor, which may serve as a means of detecting lard oil. Generally speaking, it may be said that in the examination of olive oils for adulteration, a complete analysis is usually necessary to reveal the real nature of the oil. In cases of gross adulteration the qualitative tests, specific gravity, and index of refraction will often show the nature of the adulterant and the extent to which it is employed. The adulteration of foreign oils imported into the United States is practised on a much smaller scale than is popularly supposed. On the other hand, oils bought upon the market, bearing labels indicating a foreign origin, were found to be quite extensively adulterated with cotton seed oil. The inference is that these adulterated oils, bearing foreign labels, are labeled and modified after leaving the port of entry, neither the domestic nor the foreign producer being responsible for them. This practice is injurious to the interests alike of the manufacturer and the consumer of the Californian, French, and Italian pure olive oils.

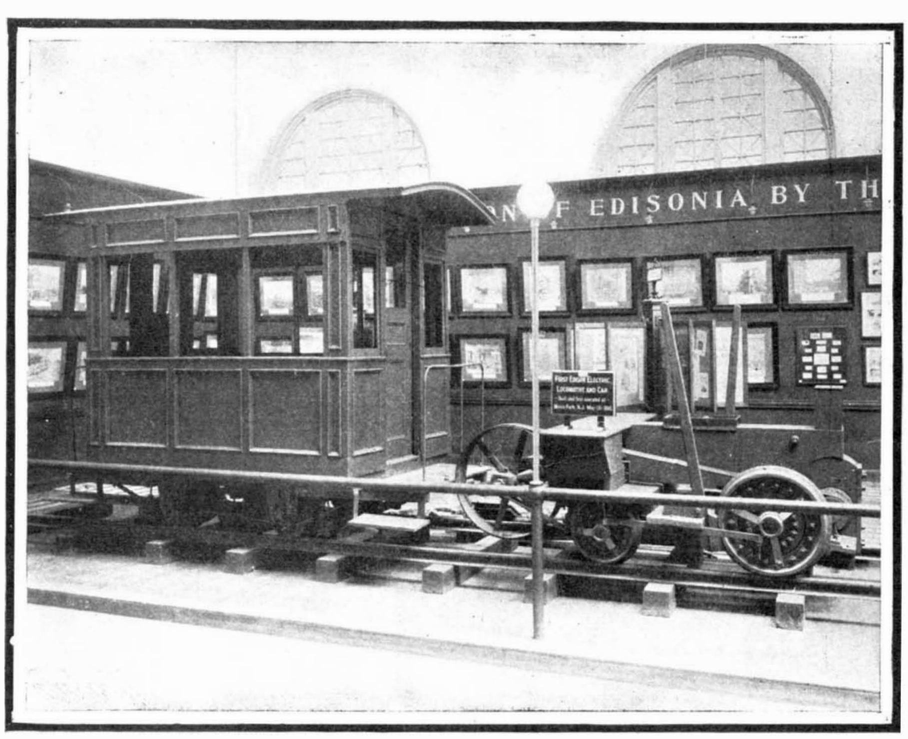
EDISON HISTORICAL EXHIBIT IN THE ELECTRICITY BUILDING.

By the St. Louis Correspondent of the SCIENTIFIC AMERICAN.

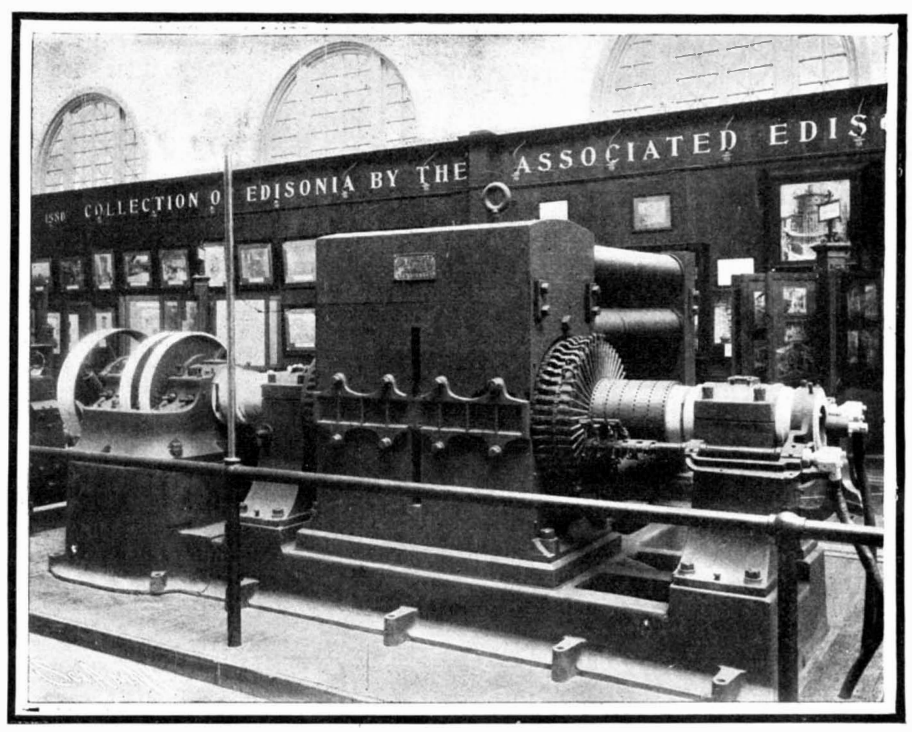
ONE of the most complete historical exhibits at the fair is shown in the exhibit of the Associated Edison Illuminating Company. It represents some painstaking work on the part of Mr. W. J. Hammer, an electrical engineer formerly an assistant of Edison's, when he was prosecuting some of his earlier investigations.

First we have the celebrated electric locomotive and trailer which was conceived, built and put in operation at Menlo Park, N. J., as far back as May 13, 1880. This was Edison's first electric locomotive and it was followed by others which were built and operated at the same place, one in 1881 and another in 1882. This exhibit is loaned by Mr. Edison himself.

Next to the electric locomotive stands the first Edison direct steam-electric generator "Jumbo." This was the first direct-connected steam-driven electric generator, and it possesses great interest as being the first of a type which has to-day attained such enormous dimensions. This machine was exhibited in Paris on October 11, 1881, and twenty-four similar machines were subsequently installed in London, New York, Milan, and Santiago. The total weight of the generator and engine is 30 tons.



FIRST EDISON LOCOMOTIVE AND CAR, BUILT AND OPERATED MAY 13, 1880.

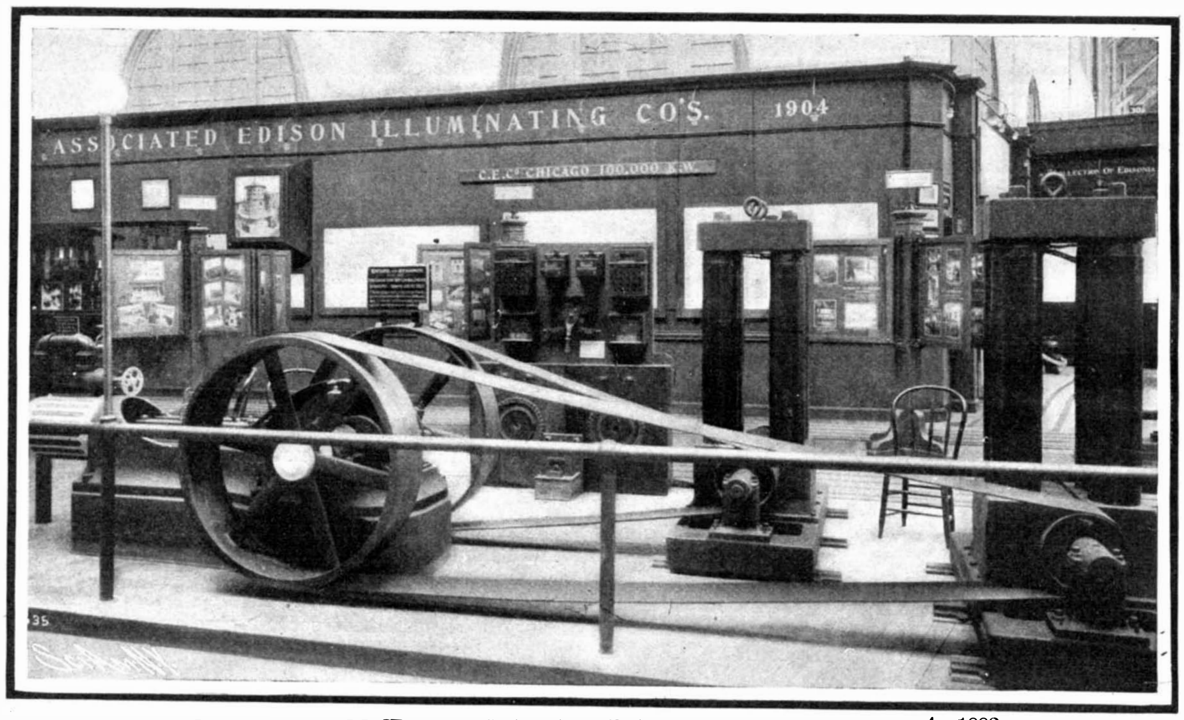


FIRST EDISON DIRECT STEAM-ELECTRIC GENERATOR "JUMBO," EXHIBITED AT PARIS, OCTOBER 11, 1881.

EDISON HISTORICAL EXHIBIT IN THE ELECTRICITY BUILDING.

Another of our photographs shows the first three-wire installation. It was used in the Edison electric-lighting station at Sunbury, Pa., where it was operated regularly. This machine was started for the public service of current on July 4, 1883. It consists of a high-speed Armington & Sims engine, belted to the two dynamos which stood in the relative position shown in our illustration. This machine was operated regularly from 1883 to 1898. It is still in good operative condition and forms a most interesting exhibit.

The collection includes also the first electrolier ever made; a model of the historical Pearl Street electric station, New York; a selection from Edison's private library; his first electric light plant; a glass-fronted case containing a collection of original brackets, lamp sockets, underground conductors, two-wire and three-wire, the first lamps made with wooden bases, original switches, wooden fuse plugs, early keyless sockets, etc., and the original chemical meter.



THE FIRST THREE-WIRE INSTALLATION AT SUNBURY, PA., JULY 4, 1883.

Another most interesting feature, entitled "The History of an Art," consists of a pair of large glass cases of incandescent lamps. The lower case of the two contains practically every type of lamp made by Edison and other inventors from the first to the present day. The upper case contains a collection of the work of contemporaneous inventors, and the whole constitutes a concrete history of the art that could not well be surpassed in value.

THE MANUFACTURE OF PEAT BRIQUETTES.

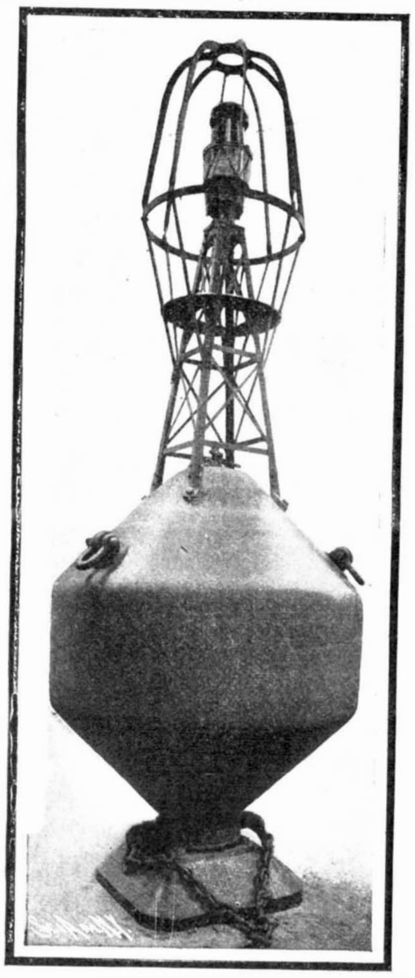
THE peat fuel industry has been left to a large extent to individual enterprise, mostly in rural districts of Germany, Netherlands, Scandinavia, Russia, and Ireland, and any statistics that have been issued on the subject are untrustworthy. The use of peat as fuel in Germany dates back to the earliest history of the Teutonic tribes. The peat bogs cover very extensive areas in the northern temperate regions of Europe and America. The German peat area is estimated to be about 11,000 square miles; and peat is utilized for hygienic purposes, for manufacture into paper stock, cardboard, felt, alcohol, etc., for burning in gas generator furnaces, and for manufacture into peat coke, peat slabs, and carbonized briquettes. The manufacture of peat slabs has been practised in a crude way by peasants in the north of Germany and in Holland for more than a century, for the purpose of obtaining a cheaper and more efficient fuel than wood or cut peat. During the past fifty years this industry has been placed on a more intelligent basis, due chiefly to the solution of the problem of a cheap production on a large scale. At the present day machine peat is made which stands transportation and the influences of weather, and in many localities even competes with coal. According to a report by the American Institute of Mining Engineers, the method of making machine peat is entirely automatic, the machinery for cutting the peat, elevating it to the press, and conveying the slabs to the drying ground being mounted on a truck which travels into the bog sometimes under its own steam. This arrangement is made for a capacity of from 50 to 80 tons in 24 hours, and costs from £800 to £1,200 at the factory. The truck travels on rails, and the bog is gradually exhausted by cutting each new trench next to the one just completed. An excavating elevator drops the raw peat into the machine where it is disintegrated, kneaded, and forced through a mouthpiece in the form of an endless plastic band, upon a truck on which it is cut, by a series of adjustable knives, into any desired lengths. The pressure required is very slight, and, as no water escapes, the chemical composition of the raw material is unchanged. The volume of the peat is reduced about one-half, and the slabs when thoroughly air-dried weigh from 40 to 60 pounds per cubic foot. One man is employed for every two or two and a half tons of peat briquettes produced. While the raw peat contains as a rule between 80 and 90 per cent of moisture, the air-dried slabs have seldom more than from 15 to 25 per cent. To effect a more thorough drying, large hot-air chambers are used. The cost of making machine-peat in Germany is from three to four shillings per ton at the outset, which allows a considerable depreciation for the machinery. This figure is taken from the Schilt Works, near Oldenburg, and from the Ranbow Works, near Langen, on the Elbe. There is a peat bog at Magdeburg which yields annually about £540 worth of machine peat per acre, while the cost of manufacture is but £180, thus leaving a profit of £360 per acre. The average depth of this bog is 40 feet. The experience gained with the use of press-peat as locomotive fuel in Bavaria, Austria, Sweden, Russia, and Ireland, is stated to be very satisfactory. The utilization of dried press-peat for gas-making and as a substitute for coal and charcoal is

also stated to be satisfactory. The problem to produce from a poor grade of fuel containing from 70 to 90 per cent of moisture, a briquette which can compete with coal, or can make up deficiencies in the fuel supply, is a very serious one. Huge masses of raw material have to be handled and cleansed from foreign matter, and tons of water have to be expelled in order to obtain a limited quantity of valuable fuel. Many processes have been tried and abandoned, as they proved to be too expensive. A few plants in Germany and Holland are working on similar lines with brown coal, but a large portion of the water is expelled mechanically before drying by heat. Much labor and money have been expended in Germany on the development of the peat industry, and nearly all modern methods have originated in that country. Great efforts are being made to establish the manufacture of solid peat briquettes as a permanent commercial industry. In Holland there are many acres of peat bog excavators under cultivation, and supporting from 300 to 350 people per square mile. In some water-filled bog trenches, fisheries are established on a large scale.—Journal of the Society of Arts.

A FINE EXHIBIT OF WELDED STEEL PLATE.

By the St. Louis Correspondent of the Scientific American.

A handsome exhibit of welded plate steel is made by the Continental Iron Works of Brooklyn at the center of the Machinery Building at St. Louis. The most conspicuous piece of work is a large plate-steel gas buoy seven feet in diameter and standing eight



A FINE EXAMPLE OF WELDED PLATE STEEL.

feet six inches in height, with a total height from the ground to the top of the frame of 17 feet 6 inches. The capacity of the buoy is 176 cubic feet, and when it is afloat the focal plane of the lantern is 10 feet 6 inches above the water line. Around the base of the buoy is a heavy ring, attached to which is a chain bridle for anchoring the buoy. For maintaining it in an upright position, a weight of 1,800 pounds is bolted to the base. The buoy is charged with Pintsch gas at a pressure of 12 atmospheres, and the variable light of six candle power is shown in continuous intermittant operation. The intermissions of the light are governed by a small pilot light, which burns all the time, the action being automatically controlled by a diaphragm.

To the right of the gas buoy are displayed some fine specimens of large-piece welding in the shape of a set of combustion chambers for Scotch marine boilers, provided with corrugated furnaces. A special advantage in these is that the flange of the furnace enters the combustion chamber, and its riveting is beyond the direct impact of the furnace gases. To the left of the buoy are seen some corrugated furnaces for internally fired Scotch stationary boilers. These are first welded and then corrugated.

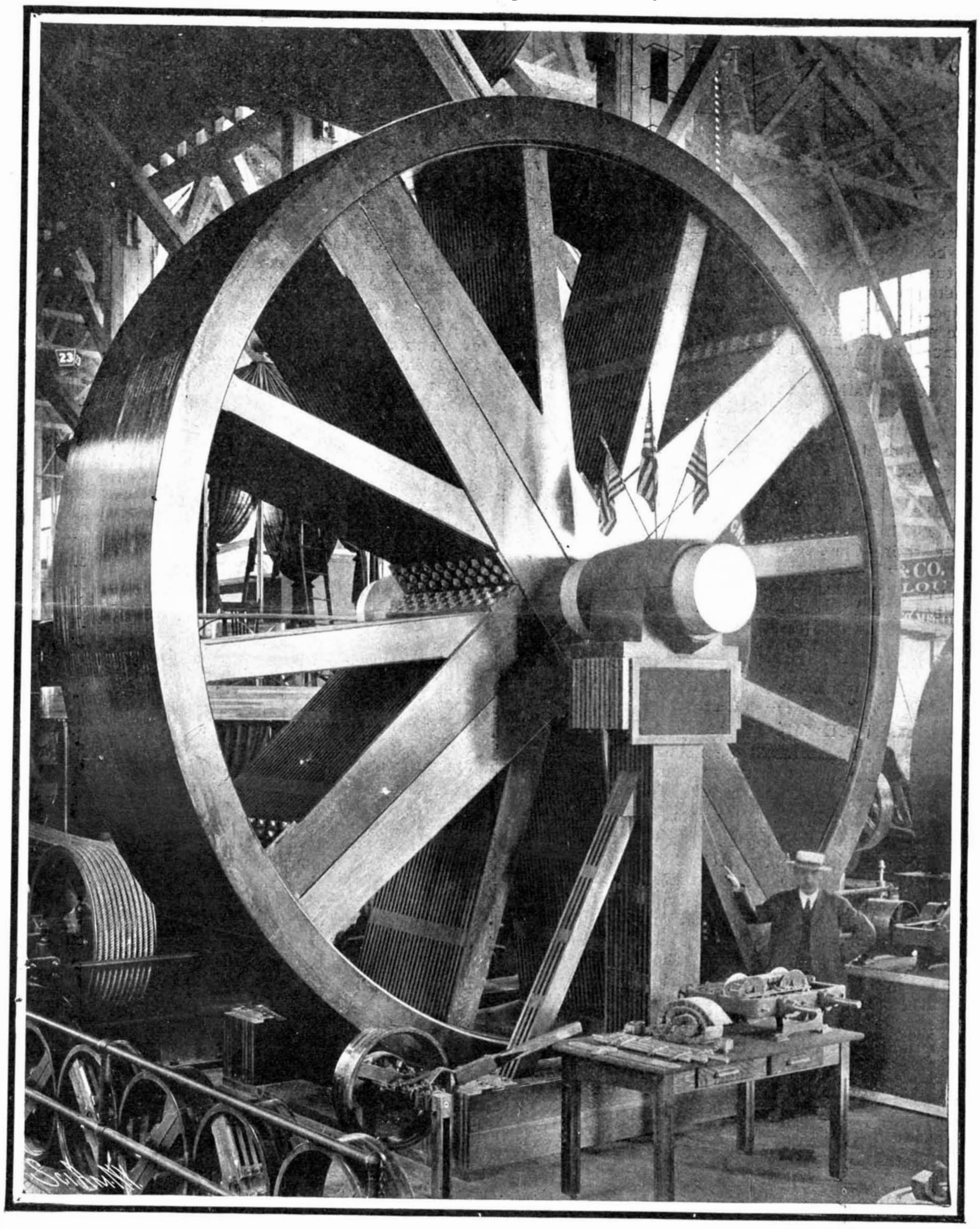
There is also shown a fine specimen of a Vanderbilt corrugated fire box. The largest piece exhibited is a splendid specimen of the welder's art—a soda-pulp digestor, which is 9 feet in diameter and measures 42 feet 9 inches in length on the axis. This massive piece of work is built of 11-16-inch steel plate and weighs 43,000 pounds. It is built up of four plates for the shell and two ends. The plates are rolled into shape and lap-welded and the sections thus formed are lap welded to each other and to the ends. The working pressure is 125 pounds to the square inch and the test pressure 190 pounds to the square inch. Another item in this exhibit that has special interest just now is a welded submarine mine. The absence of riveted joints in an object of this kind is of course an immense advantage in reducing the liability to decay and leakage.

THE BIG TWENTY-FOOT WOODEN PULLEY IN THE MACHINERY BUILDING.

By the St. Louis Correspondent of the Scientific American.

Not far from the massive 5,000-H. P. Allis-Chalmers engine in the Machinery Building, stands another exhibit, which, like the engine, attracts much attention because of its towering height. It is a mammoth, built-up, wooden pulley, exhibited by the Reeves Pulley Company, of Columbus, Ohio. Although there is not a piece of timber in it that is over one inch in thickness, the pulley has a diameter of twenty feet, measures 50 inches across its face, and weighs 11,500 pounds. Moreover, it is guaranteed to stand all the work that the largest three-ply belt can carry to it.

The rim of the pulley is built up of red gum planking dressed carefully to size. The plank segments are scant ⅞ of an inch in thickness, by 12 inches in depth, and 13 inches in length. The segments, of which it takes 61 to make the full width of the rim, are glued and nailed together, and are so arranged as to break joint. They are made in such short lengths to avoid presenting a roughened end grain at the periphery. In every alternate row of segments the arms of the pulley, which are made up of oak planking ⅞ of an inch thick by 12¼ inches in width, are carried right through to the periphery, and are glued and nailed in with the body of the rims. The "splits" occur at the main arms, of which there are four, and intermediate stiffening arms are run through from the periphery to the main arms near the hub, the stiffening arms being carried through to the face of the pulley and passing through between the planks of which the main arms are built up. They are thoroughly glued and nailed to the latter near the hub. At the intersection of the main arms at the hub, two heavy plates are carried across each arm, and twenty-six ⅝-inch bolts add to the strength and stiffness of the arms at this point. The whole pulley is carefully finished and varnished, and it is kept in motion by means of a small motor and a friction pulley which bears against the rim.



THE BIG 20-FOOT WOODEN PULLEY IN THE MACHINERY BUILDING.

THE CATTORI SYSTEM OF ELECTRIC RAILWAYS.

We cannot dwell upon the merits and defects of the series system, nor upon the reasons why almost all electric railway lines receive the current from a distribution in parallel, namely, with constant potential and variable intensity. The fact remains that the series system with variable potential and constant intensity conveying the energy by the rails is particularly adapted to work railway lines with large traffic.

The following description of an experimental line will illustrate and confirm this fact, an experimental line extending for about two miles, passing between the railway station of Castellammare di Stabia on the Gulf of Naples (Italy) and the Cattori's boiler, wagon, and bridge works at the mouth of the river Sarno, where the system has worked most satisfactorily.

It is well known that in the series system the current passes through each motor-car exactly in the same way as a current passes through each telegraph instrument on a line, or through each arc light on a circuit. The rails, suitably insulated, convey the current to the motor cars, and the current returns to the power station, by means of a conductor. On the experimental line there was used for this return a copper wire suspended parallel to the railway itself and some 30 feet distant therefrom.

The system operates in the following manner:

Possessing an electric energy of a very high tension in the form of polyphase currents, at a convenient distance from a railway line which is to be operated by electric traction, the energy is conveyed to a certain number of stations along the line, and there, by means of rotary transformers, reduced and transformed into continuous current of constant quantity and variable tension, utilized for the traction. By these means are obtained at every transforming station two circuits, one toward the right and another one toward the left, which circuits may have a greater or less extension according to the distance between the more important railway stations along the whole line.

Each circuit is so disposed that the rails themselves represent a part of the circuit, that is, either in the direction or the return of the electric energy, so that when an electric train, or separate electric motor-car, is running on the rails, the energy coming from the rails on one side of the track traverses the electro-motors of the train, and returns to the distributing station by means of the rails of the opposite side. This being

the case, and the distribution of the electric energy being at a constant quantity, it follows that there cannot be more than one electric train or one electric carriage running on the various sections of the circuit, because two electric units would stop completely, or would find their velocity much reduced and, at any rate, the amperemeters which are on the electric locomotive under the inspection of the guard, would indicate that the brakes must be applied. In this way the possibility of one train running into another would be avoided, rendering it possible to realize an effective and automatic block simply by the manner in which the energy is distributed, without any other apparatus.

If it be considered that by virtue of the great electric capacity of the rails it is possible to pass large quantities of current, which for light trains (which will occur for heavy traffic with trains leaving every half-hour or more frequently) do not require a very high tension. Let it be furthermore considered that with a distribution by means of the rails the current on the rails themselves will be shunted in proportion to the two resistances, i. e., that which constitutes the inner circuit of the electric motor and that which constitutes the earth to the dispersion from the rails. This dispersion can be much reduced (in fact it is not even important in the plant at Castellammare which was erected without any special isolation) and that, at any rate, such dispersion can be disregarded, because by this system it is possible to construct an electric railway in an easy and safe way. A special system of insulation has, however, been devised which is very simple and economical and highly efficient.

The essential features of the Cattori system are therefore: The difference of tension between the two sides of the track is, in fact, only the work done by the motor-car, while in the systems in derivation it is the whole tension of the line.

If the circuit is broken, at any point, the motor-car will stop at once without any inconvenience, while a car operated in derivation, if it happens to be running between the dynamo and the point of interruption, will continue to run toward said point without noticing it.

The Cattori system permits the transformation of any existing railway constructed for steam traction, rapidly, easily, and with little expense, into an electric railway.

The motor-cars running down a gradient diminish the tension, reducing both the loss of current and the expense of producing it, while with the systems in derivation these elements are constant along with the risks, which in the Cattori system do not exist at all.

By coupling the electric commutator of the crossings with the hydraulic apparatus of the Bianchi-Servettaz type the movement of a single lever will operate the crossing; while the amperemeter will indicate if the crossing is correctly disposed for the passage of the trains.

The system possesses the marked characteristic of an absolute block on the line and the crossings.

EARLY CHEMICAL MANUFACTURES.

A CONTRIBUTION TO THE HISTORY OF THE RISE AND DEVELOPMENT OF CHEMICAL INDUSTRIES IN AMERICA.*

By M. I. WILBERT.

CHEMICAL industries play such an important part in supplying the needs and wants of our every-day life that we, at times, can hardly realize that the time was, and not so long ago, when in the whole length and breadth of this great land there were practically no manufactures of this kind. It is now not much more than a century ago since the manufacture of chemicals, as such, was commenced in this city, and this, so far as known, was the first in the country. In a short sketch of this kind, it would, of course, be practically impossible to describe, or even enumerate, all of the concerns that have been interested in the manufacture of chemicals since the first introduction of the industry in America. We will content ourselves, therefore, by attempting to call your attention to some varied and interesting materials that are available for an extended sketch, or a history, of this subject.

Chemical processes enter so largely into manufactures of all kinds that it is at times difficult indeed to draw a distinctive line between what may or may not properly be classed as chemical products. For this reason we will confine ourselves, as much as possible, to the enumeration of substances of a distinctly chemical nature that are or may be used in other arts and manufactures or in the practice of medicine.

There is no distinct evidence that the aboriginal inhabitants of any portion of North America produced or used chemical substances as such. A number of these inhabitants did make use of chemical processes in the making or manufacture of pottery, paper, paint pigments, and fermented drinks; but even these were produced in limited quantities, and there was nothing like a general or widespread industry.

Chronologically, then, the earlier efforts at the manufacture of chemical substances may readily be divided into three distinct periods.

(1) The colonial period, from the first settlement of the country, to the time of the revolutionary war.

(2) The period from the revolutionary war to the war of 1812.

(3) The period from the war of 1812 to the rejuvenation of interest in scientific pursuits, about the middle of the nineteenth century.

The chemical manufactures of these several periods were quite distinctive. In the first period the manufactures, in the chemical line, were confined to the production of potashes and lime, with stray experiments and trials in the manufacture of salt, saltpeter, and gunpowder.

In the second period, largely, if not entirely, brought about by the exigencies of war, manufactures of salt and gunpowder were established as permanent industries, while the manufacture of paint pigments and a number of chemical substances was tentatively established in Philadelphia.

In the third period, due directly to the war of 1812 and the commercial restrictions which preceded it, we have the introduction of the manufacture of sundry chemicals for technical and medicinal purposes.

So far as is known, the first chemical substances made in America were produced in the Jamestown Colony, where as early as 1608 the manufacture of pot or soapashes was tried, and the resulting product, with samples of pitch, glass, and clapboards, was sent to England by these first colonists.

It would appear, therefore, that chemical substances were among the first exports of manufactured articles from what is now the United States.

While there is little or no evidence that the manufacture of potashes was entered into extensively for the next two or three decades, potash and pearl ash did, in later periods, constitute a very important article in the exports of nearly all of the English colonies in North America.

In this connection it might be of interest to mention that there are a number of records of premiums having been offered and awarded, by both home and colonial societies, for the encouragement of the industrial arts, for the largest and best production of potash or pearl ash.

Gabriel Thomas, in his account of Philadelphia and the province to the year 1696, mentions potashes among the list of exports, and in later years, even down to the opening decades of the nineteenth century, the making of potashes constituted one of the more important industries of Philadelphia, a number of manufacturers of this product being located along the Delaware front.

During the colonial period potash works were numerous throughout the American colonies. In Massachusetts alone, toward the end of the eighteenth century, it was estimated that they numbered fully 250. Many of these establishments were being conducted on a large scale and were quite successful. The average exports of potash and pearl ash from the United States at the beginning of the nineteenth century, according to the "Statistical Annals of the United States from 1789 to 1818," by Adam Seybert, was about 6,000 tons annually.

The manufacture of soap was probably one of the first uses for which the alkali was employed in the colonies. Soap boiling as a commercial venture was introduced at quite an early date. The father of Benjamin Franklin, Josiah Franklin, was probably one of the first to engage in it as a business. Josiah Franklin, a dyer by trade, came to Massachusetts about 1682 and engaged in business as a tallow-chandler and soapboiler.

The earliest mention of the manufacture of lime is probably that in the records of Providence, R. I., where, in 1662, a Mr. Hatchet applied for liberty to burn lime and to take stone and wood from the public commons for the purpose.

It is quite probable, however, that lime had been burned, even before this date, from shells that were found in great profusion along the coast. This shell lime was the principal dependence in several of the colonies until after the beginning of the eighteenth century.

In or near Philadelphia lime is said to have been made from limestone, about 1681, at Mountjoy, a manor that belonged to Letitia, the daughter of William Penn.

Common salt, one of the prime necessities of the European, was first made in the Virginia Colony some time previous to 1620. These earlier works were allowed to fall into decay, but were rebuilt, and in 1633 there is a record of salt having been made in appreciable quantity. In that year a considerable amount of salt was exported to Massachusetts for use in the fisheries.

About 1623 salt works were erected by a company on a site in or near the present city of Portsmouth, N. H. Several other attempts at the manufacture of salt from sea water are recorded, but as none of these proved successful or were continued for any length of time, it will not be necessary to enumerate them further.

It was not until the time of the Revolution that the manufacture of salt was established as a permanent industry.

The salt springs of central New York were first discovered about 1654 by Père Le Moyne, a French Jesuit. They were not readily accessible, however, and were not developed in a commercial way until some time after the American revolution, or nearly 150 years after their discovery.

The interruption of foreign trade by the revolutionary war led to the organization of a great number of small establishments for the manufacture of salt all along the Atlantic seaboard from Cape Cod to Georgia.

One of the more successful of these early salt manufactories was established on Quivet Neck, in the town of Dennis, Barnstable County, Mass., by John Sears, a mariner. This pioneer salt maker had probably become acquainted with the salt works along the Mediterranean or in the West India Islands and conceived the idea of making salt by the use of solar heat exclusively. This establishment, dubbed by the natives "John Sears' folly," was the first of a number of works in Barnstable County, where the salt industry subsequently developed into a large and flourishing business, in the early decades of the nineteenth century.

During the Revolution common salt was the most prized of all commodities. The ordinary product that before the war sold for 2 shillings a bushel rapidly increased in price, and in 1776 was not to be had for 25 shillings a bushel.

Philadelphia, with the surrounding country, was severely affected by this scarcity, and increase in the price, of salt, and several attempts were made to establish salt works along the New Jersey coast. One of these, at Tom's River, was conducted for a time by Thomas Savage, and was, with a number of others, burned or demolished by the British troops during the war.

For some time after the Revolution, salt in the country west of the Allegheny Mountains was worth "a cow and a calf" a bushel. This was the prevailing price until some time after 1790, when salt from the Onondaga salines was introduced and this, for a number of years, supplied a large portion of the western country. As late as 1815 salt in Cincinnati was quoted at from $3 to $5 a bushel, while the earlier settlers were obliged to pay as much as $7 and $8 for a very inferior quality. Salt was made on the Wabash, in the Indiana Territory, early in the nineteenth century.

The manufacture of salt was also commenced in Western Pennsylvania about 1812 and this led to the establishment of a number of similar works in Southern Ohio and also in what is now West Virginia.

Another substance of a chemical nature that was absolutely essential to the colonists was gunpowder. The manufacture of this product was attempted at an early date, the first available record being in 1639, when Edward Rawson was granted 500 acres of land at Pecoit, Mass., to aid him in developing the manufacture of this very essential article.

In 1642, to promote and perfect the making of gunpowder, it was directed that every plantation within the Colony of Massachusetts should erect a suitable house to make saltpeter. There are several additional records of early powder mills in Massachusetts, as well as in other colonies, but none of them appear to have been continued for any length of time.

The exportation of powder and its materials from England was prohibited by an order in council, of October 19, 1774, so that the American colonists were made dependent on other sources for their supply.

The Continental Congress, in various ways, encouraged the erection of powder mills, and also the production of nitrate of potash. Congress, in 1775, published a manual giving directions for making saltpeter, and about the same time the "Committee of the City and Liberties" erected a large saltpeter works on Market Street for the double purpose of making saltpeter and also to instruct such as were willing to engage in the making of this very necessary article for the powder mills.

Similar works were also erected in Boston by Dr. Whitaker and by others in different places.

As a further source of supply the ground about the tobacco warehouses in Virginia and Maryland was dug up and leached out and considerable quantities of potassium nitrate were obtained in this way.

In this same connection it may be interesting to note that, during the war of 1812, a very large amount of saltpeter was obtained by leaching out the deposits in the limestone caves of Kentucky.

The manufacture of gunpowder was very extensively carried on during the Revolution in nearly all of the American colonies. A very large proportion of this powder, however, was made in Pennsylvania. Philadelphia was among the first places in which powder mills were successfully operated.

Early in the Revolution a public powder mill was established in or near Philadelphia by the Assembly, while Congress opened, and for some time operated, what was known as "The Continental Powder Mill." Congress also offered advances to such persons as would be willing to establish powder mills within fifty miles of the city of Philadelphia, and this offer was taken advantage of by many who subsequently supplied a liberal proportion of the powder used in the Continental Army.

Probably the oldest of the still existing powder mills was established about 1802 by Eleuthere Irene Du Pont, who came to this country from France in 1799. Du Pont established his first mill on the Brandywine, about four miles above what was then the village of Wilmington. Having had some experience in the manufacture of gun powder in France and being able to produce a quality much superior to that in use in this country at that time, he soon established a business that developed into the most extensive of the kind in the country.

Philadelphia and Philadelphians have taken a very important part in the origin and development of chemical industries of all kinds. Probably the first to inaugurate the manufacture of chemicals, as such, in this country, was the firm of Christopher, Jr., and Charles Marshall, sons and successors of Christopher Marshall, an early druggist and one of the original "fighting Quakers" of Philadelphia. This firm had, as early as 1786, entered quite extensively into the business of making muriate of ammonia and Glauber's salt. The factory is described by Watson, in his "Annals of Philadelphia," as being a grim and forbidding looking building on Third Street near the stone bridge over the Cohocksink Creek. This firm is said to have

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developed an annual output of upward of 6,000 pounds of muriate of ammonia, quite an achievement for that time.

The manufacture of white lead was commenced by Samuel Wetherill, another Philadelphia druggist, about 1789. This business rapidly developed, despite the reputed opposition of English manufacturers. In 1809 extensive works were opened at or near the corner of Broad and Chestnut Streets. These being destroyed by fire a new plant was erected at the corner of Twelfth and Cherry Streets. This for a number of years was the site of the now very extensive manufacture of white lead and color pigments. After the enforcement of the Embargo Act, which preceded the war of 1812, a number of manufacturers engaged in the manufacture of white lead and paint. Among these was Dr. Joseph Strong, who undertook the manufacture of various lead pigments at his laboratory, 485 North Third Street, opposite the Globe Mills. Joseph Richards, about 1812, established a factory on Race Street near the Schuylkill River. This was later removed to Pine Street above Broad, where he was succeeded by the two brothers, Mordecai and Samuel N. Lewis, who developed a large and lucrative business. Harrison Brothers were also among the first to engage in the manufacture of white lead. The founder of this firm, John Harrison, was probably the first to manufacture sulphuric acid in the United States.

Sulphuric acid has been, quite properly, called the basis of all chemical industries. It it for this reason that the credit for establishing chemical industries in the United States is frequently accorded to John Harrison, a Philadelphia druggist, who, about 1793, was the first to produce sulphuric acid in a commercial way.

Mr. Harrison sold out his drug business in 1806 and devoted himself exclusively to the manufacture of acids and chemicals. It was not long before others followed in the manufacture of the heavy acids. In Philadelphia, Farr & Kunzi were probably the first to follow the example of Mr. Harrison. They engaged in the manufacture of sulphuric acid about 1812, and were soon followed by Wetherill & Brothers, who opened a manufactory of oil of vitriol on the east bank of the Schuylkill River. Mr. Harrison was also the first in this country to have and to use a platinum still. This still was constructed by a Dane, Erick Bollman, who appears to have been a man of more than ordinary attainments and who was particularly well versed in metallurgy.

Charles Lennig is said to have been the first to enter into the manufacture of sulphuric acid on a large scare, and he was also the first to use platinum stills so arranged that the operation was practically continuous and automatic.

Charles Lennig was the founder of the well-known firm of Nicholas, now Charles, Lennig & Co. He began operations about 1831, and in addition to the heavy acids made a number of chemicals for the use of textile manufacturers and dyers.

The development of the textile industry in different sections of the New England States created considerable demand for a number of chemical substances, particularly sulphuric and muriatic acids and the salts commonly used in bleaching and dyeing. This demand brought about the establishment of chemical manufactures in the same locality. The plants at Roxbury and Salem, Mass., were probably among the first to be established in New England.

The first to manufacture acids and heavy chemicals west of the Allegheny Mountains was Eugene Graselli, who built a large laboratory and established a successful business some time between 1820 and 1850. He was followed some years later by Harwood & Marsh, also in Cincinnati. Other manufacturers followed, and about the year 1850 sulphuric acid was being made in Pittsburg, Pa., Steubenville, O., St. Louis, Mo., New Orleans, La., and probably in other towns and cities west of the Allegheny Mountains.

The commercial restrictions that preceded the war of 1812 were the direct cause of firmly establishing a number of chemical manufactures as permanent industries.

Among the chemicals, the manufacture of which was introduced about this time, is copperas. This was first made at Strafford, Vt., about 1810, from native pyrites. Copperas was also made at a very early date at Pequannock, Morris County, N. J., and about the year 1811 works were opened on the Magothy River, Md., by Richard Colton and others. About three years later the manufacture of alum was added and the works were then put in charge of Gerard Troost, a Hollander by birth, who, though undoubtedly a poor business man, was a scientist of exceptional attainments and abilities. Gerard Troost was one of the founders of the Academy of Natural Sciences of this city. He was an able geologist, an excellent chemist, and an efficient teacher. He was, about 1823, professor of chemistry at the Philadelphia College of Pharmacy. Later, he was for some years one of the professors in the University of Nashville and also served as geologist to the State of Tennessee.

Epsom salt is said to have been made in this country as early as 1790 in the town of Bridport, Addison County, Vermont, from the waters of a mineral spring discovered by the Rev. Sylvanus Chapin. The same substance was also made at quite an early date in or near Baltimore, Md., from native magnesite, while in Barnstable County, Mass., Epsom and Glauber's salts were early obtained as by-products in the manufacture of salt.

In the first copy of the American Journal of Pharmacy, then called the Journal of the Philadelphia College of Pharmacy, published in 1825, Daniel B. Smith describes at some length the details of the manufacture of Epsom salt in Barnstable County, Mass. The credit for developing this particular portion of the industry is said to be due to the Rev. Mr. Briggs, who is described as being an industrious and ingenious chemist.

The Epsom salt of that early day was quite different in appearance, and also in price, from what we would expect at present. It was usually wet and soggy, always impure, and not infrequently mixed with or sometimes substituted by Glauber's salt. The difference in the price, in the early decades of the last century, made this quite a profitable form of adulteration, Epsom salt selling regularly for fifteen cents a pound, while Glauber's salt could be had for from two and a half to three cents a pound.

Chromates were probably first made in Baltimore, though as early as 1816 a Mr. Wesener, a German chemist, had established himself in Philadelphia, in the neighborhood of Broad and Cherry streets, where he made chrome salts and chrome pigments in considerable quantities. Being nearer the source of supply of the raw material, the Baltimore manufacturers had a decided advantage, so that before the middle of the last century the business had drifted back to that city.

Among the earlier manufacturers of chrome salts in Baltimore were Isaac Tyson & Son and William Davidson & Co. This latter firm also made ferrocyanide salts and probably other heavy chemicals.

The manufacture of ferrocyanides was also carried on quite extensively in Philadelphia, and it may be interesting to note, in this connection, that it was in the manufacture of ferrocyanide of potash that the first attempts were made to utilize atmospheric nitrogen by combining it with carbon at very high temperatures. The manufacture of ferrocyanides was, at a later period, gone into quite extensively at Cincinnati, Ohio, where the large pork-packing establishments insured an ample and cheap supply of organic materials necessary in its manufacture. About 1850, one firm alone in Cincinnati produced annually upward of 60,000 pounds of prussiate of potash.

The manufacture of bromine, as a by-product in the production of salt, was commenced at the salt springs near Pittsburg about 1845, and soon assumed enormous proportions.

Soda salts, particularly soda ash, sodium carbonate and also sodium bicarbonate (the latter first known as soda saleratus and later as baking soda), have developed into an enormous and highly specialized branch of chemical manufactures.

Among the first in this country to manufacture soda ash on a large scale was the Pennsylvania Salt Company, at Tarentum, near Pittsburg. This company, although it has probably developed along different lines from what was at first anticipated, has amply verified a prophecy, made more than fifty years ago, that it would become one of the largest chemical works in the Union.

John Dwight and Austin Church began the manufacture of soda saleratus about 1846. They were eminently successful and practically controlled the American market for sodium bicarbonate for a number of years. The rapid development in the manufacture of this particular product is well illustrated by a comparison of prices. In 1820, what was then called supercarbonate of soda was listed and sold regularly for $1.25 per pound, while in 1850 the same amount could be had, in regular trade, for 4 cents.

Previous to 1850, and for some time after that, Philadelphia was the acknowledged center for the manufacture of chemicals for medicinal use. One of the first to engage in this branch of chemical manufactures was Dr. Adam Seybert, a graduate of the Medical Department of the University of Pennsylvania, class of 1793. He was also one of the more prominent members of the Philadelphia Chemical Society. This society, as is well known, took an active part in the development of the mineral resources of the United States.

In 1801, Dr. Seybert established a chemical laboratory at No. 168 North Second Street, where he is said to have made the first mercurials made in this country.

The first to follow him in this line was John Shinn, Jr., who, about 1810, established a laboratory at No. 282 North Third Street for the manufacture of calomel, corrosive sublimate and a number of other chemicals for medicinal and technical uses.

About this same time (1810) Innes & Robertson established a laboratory in Elizabethtown, New Jersey, where they made aqua ammoniæ, sulphuric ether, benzoic acid, and, some time later, added a full line of mercurials and other medicinal chemicals.

About 1811, Dr. Gerard Troost, who has been mentioned before in this sketch, in company with his brother, Benoit Troost, began the manufacture of a variety of chemicals for medicinal use in a laboratory on Coates Street (now Fairmount Avenue), in this city.

The Wetherills were also manufacturers of a line of chemicals in their extensive laboratory at the corner of Twelfth and Cherry Streets.

Farr & Kunzi began the manufacture of chemicals about 1818. Abraham Kunzi, a Swiss by birth, retired in 1838, and the senior partner, John Farr, who had been born and brought up in England, associated with himself Thomas H. Powers and William Weightman, two young Philadelphians, who had been in the employ of the firm for some time. The new firm name was John Farr & Co. This was later changed to Farr, Powers & Weightman, and, on the death of the senior partner in 1841, the firm name was again changed, this time to the still existing title—Powers & Weightman. This firm, for a number of years, was considered to be one of the largest general chemical manufacturing concerns in the United States, and it still holds an enviable reputation for the quality and reliability of its manufactures.

George D. Rosengarten and Charles Zeitler, as Rosengarten & Zeitler, began the manufacture of chemicals in St. John Street, Philadelphia, about 1822. They were among the first to manufacture the alkaloids of cinchona and opium in this country. Zeitler, while admittedly a very able chemist, appears to have been rather eccentric in his ways. He withdrew from the firm about a year later and Mr. Rosengarten continued the business alone until 1834, when he associated with him N. F. Dennis, a French chemist of considerable ability. The firm continued as Rosengarten & Dennis until 1855, when the junior partner withdrew and the firm name was changed to its present style, Rosengarten & Sons, the laboratory, about the same time, being removed to its present location at Seventeenth and Fitzwater Streets. There were, of course, a number of other manufacturers of medicinal chemicals, but the majority of them have long since specialized into one or two particular lines or have discontinued business. One of the latter, Charles Ellis & Co., were at one time extensive manufacturers of chemicals. They were the successors of Christopher Marshall, who, in turn, was probably the first druggist, with any appreciable amount of chemical training, to settle in America.

Any historic account of the development of the chemical industries in America would be incomplete without at least some reference to the rise and development of the teaching of the technical side of chemistry.

The first systematic attempt to teach the principles of chemistry was made in 1765 in connection with the medical department of the then College of Philadelphia. The first teacher of this branch of science was John Morgan, the founder of the Medical School.

No separate chair of chemistry was instituted until 1769, when Benjamin Rush was appointed professor of chemistry in the same school.

The first school to institute a chair of chemistry as part of a collegiate education was the College of New Jersey, now Princeton, where John MacLean taught chemistry some years before the beginning of the nineteenth century.

Popular lectures on chemical subjects were given in Philadelphia as early as 1807, when Dr. Joseph Parrish, then quite a young man, commenced a series of public lectures on chemical subjects. To Dr. Parrish must be given the credit of establishing a system of instruction, by means of popular scientific lectures, that has done much to keep the citizens of Philadelphia in touch with modern progress.

Probably the first institution to take up and elaborate on this idea of popular instruction was the Franklin Institute. This institute, from its foundation, has always adhered to the practice of giving popular scientific lectures. The first course of these lectures was given in the old Academy Building, the original home of the College of Philadelphia, and later in Carpenters' Hall, where, also, was held the first exhibition ever given under the auspices of the Institute. On the completion of its own building the lectures were given in its own now venerable hall.

Altogether, the Franklin Institute has contributed no unimportant part to the progress of chemical industries in the United States. The popular lectures on chemistry no doubt tended to awaken a lively interest in the subject, while the at first annual and later periodical exhibitions, in connection with the reports and other papers published in the Journal of the Institute, have served to collect and give information of great value to the pioneer manufacturer.

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MEANS FOR PREVENTING THE DEFORMATION OF PAPER.

THE extension and expansion of paper plays a very unwelcome rôle in color printing technics and also in some photographic processes. As Mr. C. Fleck says in the Papierzeitung, there is as yet no paper that does not change its shape or size after being once wetted and again dried. The alterations depend upon the nature of the raw material, the method of manufacture and also upon its subsequent treatment or manipulation. Of all the varieties hand-made paper is the best because it expands equally in all directions, whereas machine-made paper, as a rule, stretches mostly in the direction perpendicular to the run of the paper—sidewise. To give the paper more size is of little value, because, especially in lithographic work, the paper gives up considerable quantities of the sizing in the acidulated or alkaline wash-water and the more the oftener it is printed. Now this difficulty may be easily overcome by treating the paper with thin lotions of

stearin, paraffine, wax caoutchouc, gutta-percha, or the like. The following expedient is cheap and simple: Pour over the surface of the paper a warm 5 per cent solution of gilder's size and plunge it in a bath of 10 per cent aluminium acetate solution, keeping it there until the waterproof coating is fully formed. Having received this dressing the dried paper may be washed with a damp sponge without suffering any injury.

PROBLEMS OF THE ATMOSPHERE.

By Prof. JAMES DEWAR.

IN the Proceedings of the Royal Institution of Great Britain, vol. 17, part 1, No. 96, November, 1903, p. 223, Prof. James Dewar, after describing his method for removing the more condensable constituents of the atmosphere and his process of analyzing the resulting mixture of rare gases, continues as follows:

These experiments prove that air* contains as a minimum 1-362,000 of its volume of helium, about 1-70,000 of neon, and not more than 1-100,000 of free hydrogen. . . .

The spectroscopic examination of these gases throws new light upon the question of the aurora and the nature of the upper air. On passing electric discharges through tubes containing the most volatile of the atmospheric gases, they glow with a bright orange light, which is especially marked at the negative pole. The spectroscope shows that this light consists, in the visible part of the spectrum, chiefly of a succession of strong rays in the red, orange, and yellow, attributed to hydrogen, helium, and neon. Besides these a vast number of rays, generally less brilliant, are distributed through the whole length of the visible spectrum. The greater part of these rays are as yet of unknown origin. The violet and ultra-violet part of the spectrum rivals in strength that of the red and yellow rays. As these gases probably include some of the gases that pervade interplanetary space, search was made for the prominent nebular, coronal, and auroral lines.

No definite lines agreeing with the nebular spectrum could be found, but many lines occurred closely coincident with the coronal and auroral spectrum. But before discussing the spectroscopic problem, it will be necessary to consider the nature and condition of the upper air.

According to the old law of Dalton, supported by the modern dynamical theory of gases, each constituent of the atmosphere while acted upon by the force of gravity forms a separate atmosphere, completely independent, except as to temperature, of the others, and the relations between the common temperature and the pressure and altitude for each specific atmosphere can be definitely expressed.

If we assume the altitude and temperature known, then the pressure can be ascertained for the same height in the case of each of the gaseous constituents, and in this way the percentage composition of the atmosphere at that place may be deduced.

Suppose we start with a surface atmosphere having the composition of our air, only containing 2-10,000 of hydrogen; then, at 37 miles, if a sample could be procured for analysis, we believe that it would be found to contain 12 per cent of hydrogen, and only 10 per cent of oxygen. The carbonic acid practically disappears; and by the time we reach 47 miles, where the temperature is minus 132 deg., assuming a gradient of 3.2 deg. per mile, the nitrogen and oxygen have so thinned out that the only constituent of the upper air which is left is hydrogen. If the gradient of temperature were doubled the elimination of the nitrogen and oxygen would take place by the time 37 miles was reached, with a temperature of minus 220 deg.

The theoretical distribution of the chief components of our atmosphere, on the assumption of steady equilibrium, is graphically represented in Figs. 1 and 2. In these diagrams nitrogen is represented by the horizontal hachure, oxygen by the diagonal hachure, hydrogen by the stippling, argon by the blank white space, and carbonic acid by black. A horizontal line drawn across the diagram at any height marked in kilometers (0.62 mile) shows the percentage by volume of the constituents at that elevation, by the respective lengths within the hachures of the individual constituents. The results of Hinrich's calculations, which involve no consideration of the effects of temperature, are represented in Fig. 1, and those of Ferrel, who assumes a temperature gradient of 4 deg. per kilometer throughout the upper air, in Fig. 2. The higher the assumed temperature gradient the lower the elevation at which the nitrogen and oxygen are eliminated and the true hydrogen atmosphere begins. The elevations marked *A, B, C, D,* in Fig. 2, refer to the respective gradients of 4 deg., 3 deg., 2 deg., and 1 deg., per kilometer, and mark the end of the nitrogen and the beginning of the true hydrogen atmosphere. The position *A* corresponds to 60 kilometers and a temperature of —220 deg.; *B,* to 67 kilometers and —181 deg C.; *C,* to 76 kilometers and —132 deg.; and *D,* to 87 kilometers and —67 deg.

On any of these temperature gradient hypotheses it appears that practically above 56 miles the atmosphere would be substantially composed of hydrogen. If helium and neon had been included in the calculations, they would have been found concentrated at high elevation between the regions occupied respectively by the hydrogen and the nitrogen in the diagrams. If the temperature is taken as constant, Fig. 2 shows that at an elevation of some 62 miles the composition of a sample of air, if it could be secured, would be 95.1 per cent of hydrogen, 4.6 per cent of nitrogen, and 0.3 per cent of oxygen.

The permanence of the composition of the air at the highest altitudes, as deduced from the basis of the dynamical theory of gases, has been discussed by Stoney, Bryan, and others.* It would appear that there is a consensus of opinion that the rate at which gases like hydrogen and helium could escape from the earth's atmosphere would be excessively slow. Considering that to compensate any such loss the same gases are being supplied by actions taking place in the crust of the earth, we may safely regard them as necessarily permanent constituents of the upper air.

The temperature at the elevations we have been discussing would not be sufficient to cause any liquefaction of the nitrogen and oxygen, on account of the pressure being so low. If we assume the mean temperature as about the boiling point of oxygen, then a considerable amount of the carbonic acid must solidify as a mist, if the air from a lower level be cooled to this temperature; and the same result might take place with other gases of relatively small volatility which occur in the air. The temperature of the upper air must be above that on the vapor-pressure curve corresponding to the barometric pressure at the locality, otherwise liquid condensation must take place. In other words, the temperature must be above the dew-point of air at that place. At very high elevations, on any reasonable assumption of temperature distribution, we inevitably reach a temperature where the air would condense, just as Fourier and Poisson supposed it would, unless the temperature is arrested in some way from approaching the zero.

Both ultra-violet absorption and the prevalence of electric storms may have something to do with the maintenance of a higher mean temperature than we should anticipate, following the deductions of our assumed formulas for temperature decrements. The whole mass of the air above 40 miles is not more than 1-700 part of the total mass of the atmosphere, so that any rain or snow of liquid or solid air, if it did occur, would necessarily be of a very tenuous description. In any case, the dense gases tend to accumulate in the lower strata, and the lighter ones to predominate at the higher altitudes, always assuming a steady state of equilibrium has been reached.

It must be observed, however, that a sample of air taken at an elevation of 9 miles has shown no difference in composition from that at the ground, whereas, according to our hypothesis, the oxygen ought to have been diminished to 17 per cent and the carbonic acid should also have become much less. This can only be explained by assuming that a large intermixture of the different layers of the atmosphere is still taking place at this elevation. This is confirmed by a study of the motions of clouds about 6 miles high, which reveals an average velocity of the air currents of some 70 miles per hour; such violent winds must be the means of causing the intermingling of different atmospheric strata. Some clouds, however, during hot and thundery weather, have been seen to reach an elevation of 17 miles, so that we have direct proof that on occasion the lower layers of atmosphere are carried to a great elevation.

The existence of an atmosphere at more than a hundred miles above the surface of the earth is revealed to us by the phenomenon of twilight and the luminosity of meteors and fireballs. When we can take photographs of meteoric spectra, a great deal may be learned about the composition of the upper air. In the meantime Pickering's solitary spectrum of a meteor reveals an atmosphere of hydrogen and helium, and so far this is a corroboration of the doctrine we have been discussing. It has long been recognized that the aurora is the result of electric discharges within the limits of the earth's atmosphere, but it was difficult to understand why its spectrum should be so entirely different from anything which could be produced artificially by electric discharges through rarefied air at the surface of the earth. Rand Capron, in 1879, after collecting all the recorded observations, was able to enumerate no more than nine auroral rays, of which but one could with any probability be identified with rays emitted by atmospheric air under electric discharge. Vogel attributed this want of agreement between nature and experiment, in a vague way, to difference of temperature and pressure; and Zöllner thought the auroral spectrum to be one of a different order, in the sense in which the line and band spectrum of nitrogen are said to be of different orders.

Such statements were merely confessions of ignorance. But since that time observations of the spectra of auroras have been greatly multiplied, chiefly through the Swedish and Danish polar expeditions. The spectrum recorded on the ultra-violet side has been greatly extended by the use of photography, so that, in a recent discussion of results, M. Henri Stassano is able to enumerate upward of 100 auroral rays, of which the wave length is more or less approximately known. Of this large number of rays he is able to identify, within the probable limits of errors of observation, about two-thirds as rays which Prof. Liveing and myself have observed to be emitted by the most volatile gases of atmospheric air unliquefiable at the temperature of liquid hydrogen. Most of the remainder he

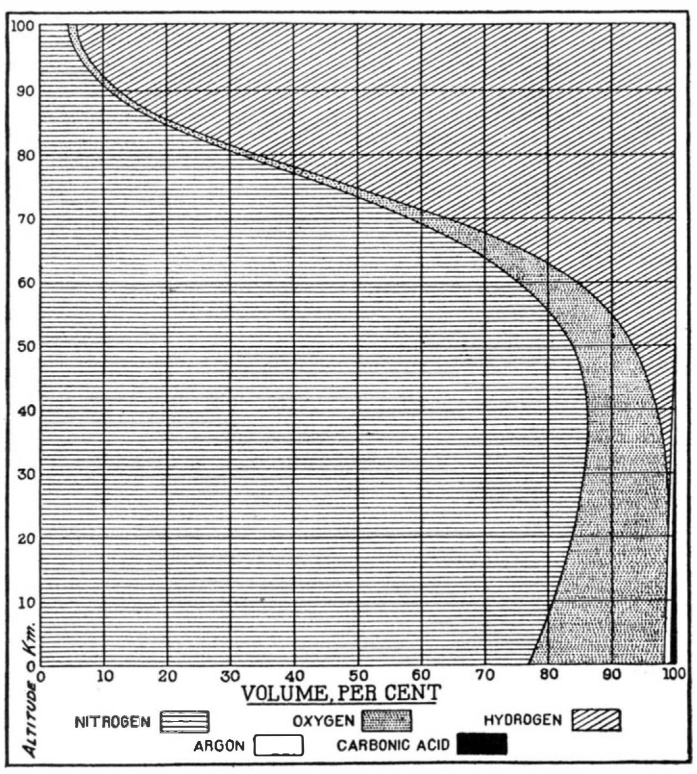

FIG. 1.—DISTRIBUTION OF THE ATMOSPHERIC GASES, HINRICH'S FORMULA.

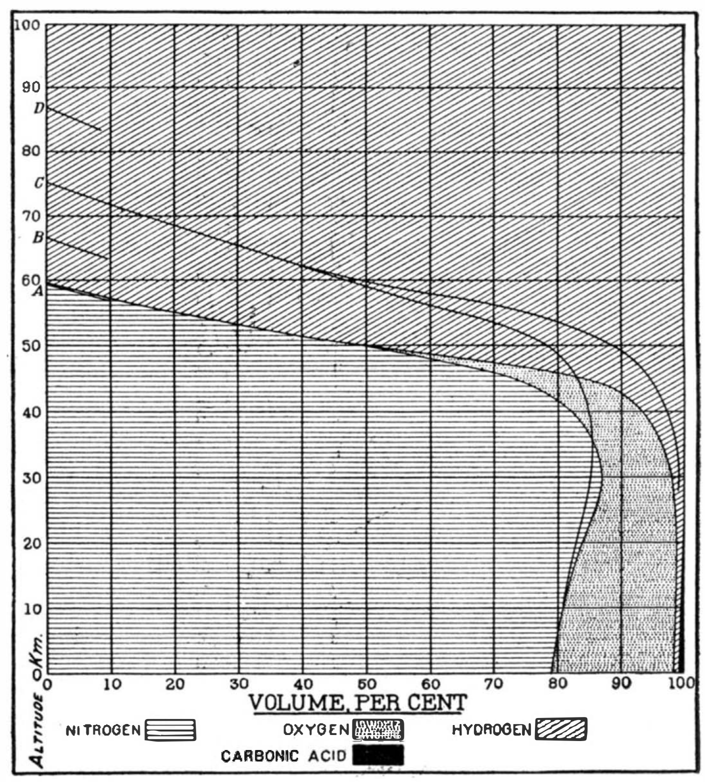

FIG. 2.—DISTRIBUTION OF THE ATMOSPHERIC GASES, FERREL'S FORMULA.

* We ought rather to say the air of London.

* See also S. R. COOK in Monthly Weather Review for August, 1902, pp. 401-407, and September, 1902, p. 405.

ascribes to argon, and some might, with more probability, have been identified with krypton or xenon.

The rosy tint often seen in auroras, particularly in the streamers, appears to be due mainly to neon, of which the spectrum is remarkably rich in red and orange rays. One or two neon rays are among those most frequently observed, while the red ray of hydrogen and one red ray of krypton have been noticed only once. The predominance of neon is not surprising, seeing that from its relatively greater proportion in air and its low density it must tend to concentrate at higher elevations.

So large a number of probable identifications warrants the belief that we may yet be able to reproduce in our laboratories the auroral spectrum in its entirety. It is true that we have still to account for the appearance of some and the absence of other rays of the newly-discovered gases, which, in the way we stimulate them, appear to be equally brilliant, and for the absence, with one doubtful exception, of all the rays of nitrogen. If we cannot give the reason of this it is because we do not know the mechanism of luminescence, nor even when the particles that carry the electricity are themselves luminous, or whether they only produce stresses causing other particles which encounter them to vibrate; yet we are certain that an electric discharge in a highly rarefied mixture of gases lights one element and not another in a way which, to our ignorance, seems capricious.

The Swedish North Polar Expedition concluded from a great number of trigonometrical measurements that the average above the ground of the base of the aurora was 50 kilometers (34 miles) at Cape Thorsden, Spitzbergen;* at this height the pressure of the nitrogen of the atmosphere would be only about one-tenth of a millimeter, and Moissan and Deslandres have found that in atmospheric air at pressures less than one millimeter the rays of nitrogen and oxygen fade and are replaced by those of argon and by five new rays which Stassano identifies with rays of the more volatile gases measured by us. Also, Collie and Ramsay's observations on the distance to which electrical discharges of equal potential traverse different gases throw much light on the question. They find that, while for helium and neon this distance is from 250 to 300 millimeters, for argon it is 45½ millimeters, for hydrogen it is 39 millimeters, and for air and oxygen still less.

This indicates that a good deal depends on the very constitution of the gases themselves, and certainly helps us to understand why neon and argon, which exist in the atmosphere in larger proportions than helium, krypton, or xenon, should make their appearance in the spectrum of auroras almost to the exclusion of nitrogen and oxygen.

How much depends not only on the constitution and it may be temperature of the gases, but also on the character of the electric discharge, is evident from the difference between the spectra at the cathode and anode in different gases, notably in nitrogen and argon, and not less remarkably in the more volatile compounds of the atmosphere.

Without stopping to discuss that question, it is certain that changes in the character of the electric discharge produce definite changes in the spectra excited by them. It has long been known that in many spectra the rays which are inconspicuous with an uncondensed electric discharge become very pronounced when a Leyden jar is in the circuit. This used to be ascribed to a higher temperature in this condensed spark, though measurements of that temperature have not borne out the explanation. Schuster and Hemsalech have shown that these changes of spectra are in part due to the oscillatory character of the condenser discharge, which may be enhanced by self-induction, and the corresponding change of spectrum thereby made more pronounced.

If we turn to the question what is the cause of the electric discharges which are generally believed to occasion auroras, but of which little more has hitherto been known than that they are connected with sun spots and solar eruptions, recent studies of electric discharges in high vacua, with which the names of Crookes, Röntgen, Lenard, and J. J. Thomson will always be associated, have opened the way for Arrhenius to suggest a definite and rational answer. He points out that the frequent disturbances which we know to occur in the sun must cause electrical discharges in the sun's atmosphere far exceeding any that occur in that of the earth. These will be attended with an ionization of the gases, and the negative ions will stream away through the outer atmosphere of the sun into interplanetary space, becoming, as Wilson has shown, nuclei of aggregation of condensable vapors and cosmic dust. The liquid and solid particles thus formed will be of various sizes; the larger will gravitate back to the sun, while those with diameters less than one and a half thousandths of a millimeter, but nevertheless greater than a wave length of light, will, in accordance with Clerk-Maxwell's electromagnetic theory, be driven away from the sun by the incidence of the solar rays upon them, with velocities that may become enormous, until they meet other celestial bodies, or increase their dimensions by picking up more cosmic dust, or diminish them by evaporation. The earth will catch its share of such particles on the side that is turned toward the sun, and its upper atmosphere will thereby become negatively electrified until the potential of the charge reaches such a point that a discharge occurs, which will be repeated as more charged particles reach the earth.

* This conclusion was afterward shown to have no logical basis. See Terrestrial Magnetism, 1898, Vol. III., pp. 152-154 and 164-169.

PLANTS AS BUILDERS.

In common with all the higher organisms the plant in its more fully developed condition stands also in need of a substantial framework upon which to construct and support its various organs. We shall be the better able to understand the purport of the mechanical demands made upon a plant by observing closely a high tree. Here the trunk must support the heavy load of the crown with its branches, leaves, and fruit—fulfill, in fact, the same function as the pillar which supports the arch of a refectory in a cloister.

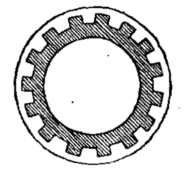

Fig. 1.—Schematic Cross-Section Through the Pedicle of Pipe or Moor Grass. *Molinia Cœrulea.*

Fig. 2.—Group of Bast Cells.

The branches which extend out horizontally from the body are bent downward by their own weight or the weight of external matter such as snow, and their pliability thus put to the test; again fruit hanging from long stems must be provided with an attachment strong enough to resist the strain. During storms the trunk as well as the branches must show its pliability, while the roots, which hold it securely to the ground, and are tugged at like a ship's cable, must also withstand the struggles of the structure above ground. As is the tree on a large scale so is the spear of grass and the herbaceous pedicle on a small scale. Each and every one must have its solid skeleton to resist the forces working upon it, and as was first shown by Schwendener through his most important and beautiful investigations, the associated members of the vegetable kingdom are in possession of an inexhaustible stock of building and construction plans according to which each individual structure is erected. If you would, at the very outset, obtain an adequate idea of such a building plan, you have but to consider minutely a blade of grass. A clear clean-cut through the stalk of the pipe grass or moor grass (*Molinia cœrulea*) viewed under the microscope furnishes us with a picture like the above. Even with a glass of low magnifying power we are enabled to discern a brightly gleaming ring with teeth projecting outward from its periphery. (See Fig. 1.)

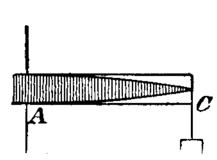

Fig. 6.—A Beam of Equal Resistance.

This is, in effect, the cross-section of a cylinder, strengthened by longitudinal ribs running along its exterior surface and between and on the outside of these ribs is lodged the green tissue so much in need of the light. It is this so-called mechanical ring that endows the stalk with its stability; it occurs in very many grasses, in the liliaceæ (though in their case without the projecting ribs) and also in the herbaceous dicotyledones. Let us now examine into the character of the stuff composing these rings and thus acquaint ourselves with the material used by the plant in its building up. While man, in the erection of his imposing architectural designs, employs iron most extensively, cellulose is the material which finds the greatest application in the constructions undertaken by the plant. This peculiar substance which is known to form the cell-walls of the plant can only demonstrate its superior adaptability as a fortifying medium when it is employed in sufficiently large quantities. For this reason the cells with very thick walls, the so-called mechanical cells, form the foundation of the mechanical system of the plant.

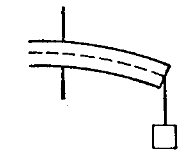

Fig. 3.—A Weighted Beam Supported at One End.

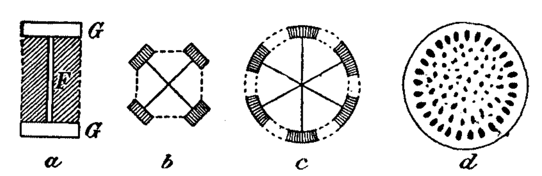

Fig. 4.—*a*, Cross-Section of I-Beam. *b*, *c*, *d*, Sketches of the Mechanical System of Various Plant Pedicles.

These cells are known in botany as bast cells, tracheïds, liber or libriform cells, collenchyme and sclerenchyme cells. (See Fig. 2.) With the single exception of the sclerenchymes they are all distinguished by their elongated form terminating in a point, as well as by their greatly thickened walls, upon which latter we find small and narrow pores running obliquely toward the left. Large pores would undoubtedly reduce the firmness. Moreover, the length of these cells is often very considerable; 2-4 millimeters—thus readily seen with the naked eye—is the ordinary length of the libriform and bast cell, and yet the bast cells of the flax plant (*Linum usitatissimum*) attain the length of from 20 to 40 millimeters, while those of the Chinese nettle, known also under the name of ramie,

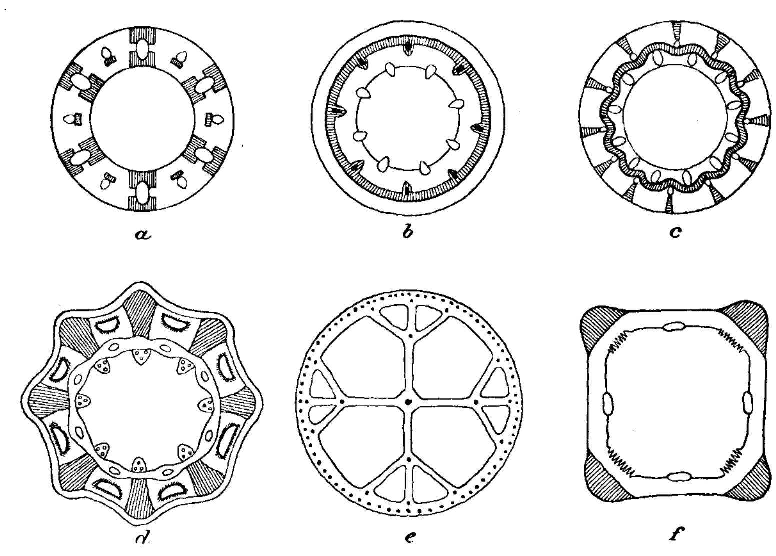

Fig. 5.—Ground Plans of the Mechanical Systems of Various Plant Pedicles. *a*, *Scirpus cæspitosus*. *b*, *Allium vineale*. *c*, *Alopecurus Pratensis*. *d*, *Eriocaulon decangulare*. *e*, *Scirpus Lacustris*. *f*, Cross-Section of the Pedicle of One of the Labiatæ. The Mechanical Cell Complexes are Cross Lined. (*a* to *e* according to Schwendener).

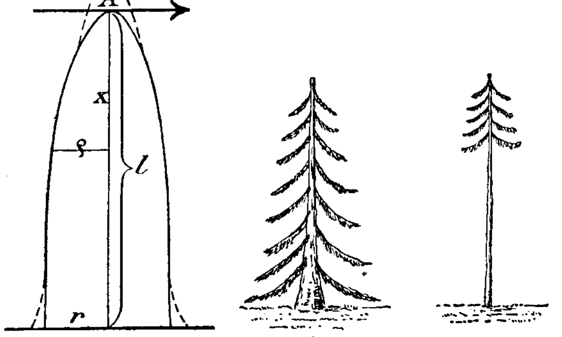

Fig 7.—*a*, A Schematic Drawing of a Pine Tree Trunk Representing a Beam of Equal Resistance. (The Elevation is upon a smaller Scale than the Radii.) *b*, A Pine Tree showing Deficiency of Timber *c*, A Pine Tree showing Sufficiency of Timber, of cylindrical Form.

extend themselves over a length of 200 millimeters. Bast and libriform cells differ only in their relative positions in the body of the plant. All tissues and strands composed of these cell-forms are distinguished for their extraordinary tenacity. In a fresh condition and saturated with water, according to results obtained from Schwendener's investigations, the tenacity is equal to 20 kilogrammes per square millimeter, which means that a strip having a cross-section of 1 square millimeter is capable of supporting a weight of 20 kilogrammes before it is ruptured. This is quite equal to the tenacity of wrought iron, brass wire being only capable of supporting 13 kilogrammes for the same cross-section.

When dried the tensile strength of the fiber increases materially, and it has been found that it reaches its highest value in the basts that are composed of pure cellulose, such as of flax, hemp, jute, and other similar growths, prized for ages as filament producers, where it attains a strength capable of supporting even 100 kilogrammes without rupture. This increase in the tenacity of the fibers results partly from the shrinkage of the membranes when drying, which shrinkage is the strongest in the so-called non-woody fibers. In this state the firmness of the best steel is attained, over which the cell wall enjoys the peculiar advantage of being of considerably less specific weight. All these figures give the firmness of the clear cellular walls, that is, without reckoning any of the cellular openings. The extensibility within the limits of elasticity is much greater in bast than in wrought iron; it is as a matter of fact about 12 to 14 per 1,000 against 1 per 1,000 in iron. The lignification, so-called, of the walls, which is commonly accepted as an incrustation of the pure cellulose with foreign substances, acts upon the quality of the material, at least in the sense of rendering it firmer, rather disadvantageously than otherwise.

Since we have already compared the matter employed by the plant for the purpose of obtaining the requisite firmness to the iron used in the construction of our modern buildings, so we may also find the shape of those iron beams duplicated; the identical form of the common I-beam is ever present as the basis of the natural constructions reared by the plant. In the I-beam we see exemplified the engineering principle of obtaining the greatest resistance with the least expenditure of material, which means that a firmness equal to all the possible demands to be made upon it shall be established with the smallest consumption of material.

The principle which we admire in the construction of our iron bridges by the clever engineer and the light but strong framework of a roof from the hands of the architect, has been employed by Nature's architect in the building up of her organisms from time immemorial, as early indeed as in the shave-grass of the coal formations. For the elucidation of the above-mentioned principle we are constrained to select from mechanics a very simple case, viz., one in which a horizontal beam or scantling is fixed at one end only. The weight of the outer or free end of the beam causes it to sag or bend down and thereby the uppermost fibers are unduly elongated while the undermost ones are correspondingly compressed. (See Fig. 3.)

Those on the upper surface experience a pull while the lower ones sustain a pressure. Those centrally located, the neutral fibers, so to say, are subjected to neither elongation nor contraction; they are bent only. The further therefore the fibrous layers are removed from the neutral axis, either above or below it, the more will they be called upon to withstand the pulling strain or resist the compression respectively.

The tensions of the individual fibers of a bent beam are relatively one to another as are their respective distances from the layer of the neutral fibers. Thus in the case of a rupture it results that the outermost, i. e., those subjected to the strongest pull or greatest pressure, are the first to break or to be crushed. It becomes of the greatest advantage, as a consequence, to supply these threatened positions with the largest possible number of resisting fibers and leave, on the contrary, as few as practicable on the interior. This may be found explained more in detail in any good text book on mechanics. Such then are the fundamental principles incorporated in the I-beam so extensively employed in the art of building.

It is, to a certain extent, a beam, the otherwise internal parts of which have been placed outside and appear in the flanges, *G G*, joined by the web *F*. (See Fig. 4.) It is not difficult to appreciate the saving in material by this practical removal of the internal and less efficient parts. I-beams of this sort are very often met with in the skeleton construction of the pedicle. The cross-section of the pedicle of the dead-nettle is shown at *b* in Fig. 4.

In the main it is two I-beams combined so as to be perpendicular to each other. The material here is, as with all strong-growing organs, collenchyme. This type is found in the whole family of the labiatæ with their four-cornered pedicles; it also occurs in other plants, in the nettles for example shown at *f* in Fig. 5. Quite similar construction is to be found in the method of putting together pillars for the supports of the elevated railroads and viaducts. If we combine similarly more than two I-beams we shall obtain, by the blending of the same, the ring cylinder, which is built to offer a resistance to bending in all directions. (See *C*, Fig. 4.) The webbing may be omitted here as in the other systems since their places are supplied by lateral webs. Such constructions are widely spread among the pedicles of the liliaceæ and also in the family of the gramineæ where we were already introduced to the delicate projecting and strengthening ribs. In the trunk of the palm the bast strands do not lose their separate identity but form a system of individual strands supported by or leaning up against the vascular bundle. (See *d* in Fig. 4.) Through the fuller development of the bast-cells and by placing them preferably at the periphery of the stalk quite a sufficient strength of flexure is obtained. In the center of the palm-stem, however, an extraordinarily small number of clusters are found. So much so is this the case that with the finger-nail alone it is very easy to make deep impressions in the pithy fiber, demonstrating clearly the softness of the interior tissues.

In Fig. 5 we exhibit a number of extremely delicate sketches of the mechanical systems of a variety of plant pedicles. In the building up of the lignified dicotyledons a somewhat different plan is followed from that used by the monocotyledones and the herbaceous dicotyledones. The regular annual deposit or formation of a new thickened ring from the cambium toward the inside, such as we find in the trunks of trees that last for many years, precludes constructions on the plan of a hollow column. On the contrary, in this case, another and singular fitness comes all the more prominently to the front, viz., a construction on the principle of the beam of equal resistance.

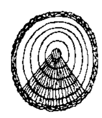

Fig. 8.—A Cross-Section of a Pine Tree Branch Showing the Position and Approximate Amount of White and Red Wood.

In his fundamental work, "The Mechanical Principle in the Anatomical Construction of the Monocotyledones," Schwendener has already remarked that large well-grown fir trunks are approximately beams of equal resistance, on the larger scale just as the grass and rush blades exemplify the principle on the smaller scale, the difference being only that they are built up solid. (See Fig. 7 *a*.) The external force, *A*, in this case is the wind which exerts its power against the crown. The center of gravity of the crown may be taken as the point of application of the resultant. As shall be shown later, the variation in the form of the crowns on trees either standing alone or in groups is of considerable importance.

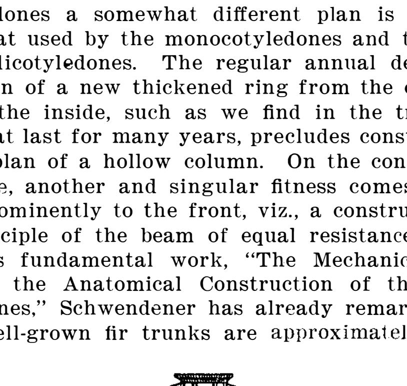

Fig. 9.—A Dock Yard Crane (Model of a Pine Tree Trunk).

Recent investigations by Metzger in the Hannover-Münden forests and by Schwartz in the Eber forest have treated this subject more in detail and the opinions of Schwendener have been confirmed beyond expectation.

To make it patent to the mind what we are to understand as a beam of equal resistance, it becomes necessary to return again to our horizontal beam fixed at one end. The weight *P* (see Fig. 6) exerts its pull on the point *A* with the longest lever; if we increase the load gradually until rupture takes place the break must occur at *A*. All other points in the beam are under less strain, and it is easy to see that as we advance toward *C* the strains become less and less. In prismatic beams then, the material situated at the danger point only can be fully utilized.

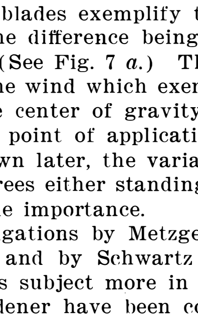

Fig. 10.—Schematic Representation of a Wharf Derrick Compared with the Branch of a Conifer. The Two Upper Tension Cables Represent the White Wood, while the Hollow Compression Column is Represented by the Red Wood.

In the case of a beam of symmetrical dimensions we should exhibit an extravagant use of the material at command. Such a beam may therefore preferably take on the form of a prism that tapers toward its free end after the manner of a truncated pyramid for instance, or if perchance the beam have a circular cross-section, it may be shaped up in the form of a truncated cone.

Now a beam which fulfils exactly all the conditions implied, which exerts an even resistance throughout its entire length to a flexing force applied at one end is termed a "beam of equal flexive resistance." In mechanics it is demonstrated that the true shape of beams of circular cross-section may be reliably determined from the formula $\frac{\rho^3}{r^3} = \frac{x}{l}$ (See Fig. 7 at *a*.)

By means of this formula ρ, the radius of a cross-section of the tree, may be determined for a previously fixed height, or on the other hand it may be found by direct measurement and then by comparison one may become convinced of its coincidence with the requisite size of the beams of like resistances.

Such computations and measurements were carried out by Metzger for pine and by Schwarz for fir trees. The values found showed a widely reaching conformity, the deviations being either nil or so small that they might be readily explained by the method of measurement. The base of the trunk alone shows any important deviations (see the dotted lines in Fig. 7 at *a*); there the trunk is, to a certain extent, anchored in the soil. As Metzger says "here we find the shell in which is situated the real shaft of the trunk." Again, within the crown itself, and for reasons that may be easily explained, deviations occur, such as the more rapid growing to a point. If we consider the shape of the tree trunk from this viewpoint then a whole series of phenomena, which one (Hartig) formerly sought to attribute to varying conditions or nourishment, are now explained without any trouble by the bending power of the wind. This will explain, for example, the so-called deficiency in timber, of trees growing in isolated positions, which consists in being of minor height and running more rapidly to a point. (See Fig. 7, *b*.) And on the other hand the sufficiency of timber in those tree trunks which stand in closely growing groups, whereby, under sufficiency of timber, is to be understood an approximation to the cylindrical form. (See Fig. 7, *c*.)

In isolated pine trees growing in a pyramidal form and covered with branches to the very earth, the surface subject to the wind pressure is practically an isosceles triangle, of which the base rests upon the soil. (See Fig. 7 *b*.) Here the demands are quite different from those made upon trees growing in clusters, of which the small projecting crowns only, high above the ground, come in contact with the violence of the wind. In the isolated trees the pressure of the wind is spread over the whole stem, increasing from the top downward as the width of the crown increases. If a tree that has grown up in a cluster be suddenly relieved of the protection afforded by its comrades, by the ordinary method of forest clearing, there may be observed in the lower parts of its trunk specially strengthening additional growths—the yearly rings become stronger and thicker. Formerly it was thought this resulted from the better nourishment obtained since the removal of its competitors in the life struggle; in that event the trunk should have shot up correspondingly, which is not the case. The true cause lies rather in the more rigid demands made by the winds to which the tree proceeds to make immediate answer. The thickening of the base of the trunk is, however, less when the undergrowth begins to make itself felt and the crowns of neighboring trees meet and intertwine overhead; then, too, the trunk becomes more cylindrical, particularly when its crown is made smaller by the removal of some of the lower branches.

The additional growth of the trunks is thus always of a sort that the mechanical demands may be met with the greatest saving of material. Now we must cast at least one glance at the construction of the tree's branches. They, too, are beams of equal resistance, but with them an entirely new factor appears; we find that they are not homogeneously built up, i. e., their upper sides are composed of a different material from that which forms their under parts. We must not fail to remark here that this is, as yet, only satisfactorily demonstrated for the branches of the cone-bearing family; however, judging from some observations lying before us there is a possibility of the statement applying equally to other trees. In the main, the branches are confined to the support of their own weight. As we observed above in the example of the horizontal beam supported from one end (Fig. 3) the upper side is stretched while the lower side is compressed. Now I have already shown that in accordance with this principle the wood of the upper side of the branches of the conifers can support twice as much weight without breaking as the wood found in the under side of the same branches. The under sides on the contrary offer greater resistance to compression. Here, too, the two sides are vastly different in color; above the wood is white while underneath it is red. (See Fig. 8.)

These circumstances bring about the effect that the branches, in their natural position, as experiment also proves, are more difficult to bend, either by their own weight or with the addition of snow and ice—in a word, possess greater strength of flexure—than in a reversed position. The sidewise flexure is also restrained by the crescent-shaped overlappings of the white wood. It is, moreover, well known that only in the rarest

cases are the branches built round or circular, for the most part the sides are pressed in forming an ovoid and thus adding to their resistance against up-and-down flexure. We have only to imagine a long ruler or a board, at one time fixed upon its edge and at another upon its flat side, extended into space, having one end firmly supported, and carrying a weight at its outer extremity, to appreciate the force of the above illustration. We beg to call attention here to the fact that in technical constructions we possess immense models for the building of a slender stem together with its branches. The enormous cranes used in dockyards on the quays and wrecking vessels are very instructive in this regard. (See Fig. 9.) The trunk of the crane is, as we see, a beam of equal resistance, it begins wide at the bottom and tapers off toward the top, and is built of course of iron or steel. From the upper part extend out into the air the two arms, like branches; their lower member being a solid or nearly solid bar to resist the compressing force while the pulling tension is overcome by the lighter steel cables fixed higher up on the trunk. The loading derrick which we show in Fig. 10 is similarly constructed though of smaller size and the same description of parts will apply here. The bars which let down at all surface railway crossings in Europe and in some places in America, are models exemplifying this same principle. We might cite still more examples of the way in which our mechanical engineers copy the lessons taught by Nature, but we feel that those already produced will suffice. The attainment of the greatest amount of rigidity with the expenditure of the least amount of material is the goal then toward which the student of technics as well as nature's system of plant life is striving. Both reach the same end by the application of the same mechanical laws.—Dr. P. Sonntag in Prometheus.

ELECTRICAL NOTES.

It is known that the introduction of chloroform into a flame which is colored by potassium or lithium salts greatly decreases the color intensity. Smithells, Dawson, and Wilson concluded from their experiments that it had no corresponding effect on the electrical conductivity produced by the salts. F. L. Tufts sees reasons for doubting this result. The chlorides of lithium, sodium, and calcium are used. The light intensity is measured by a Glans spectro-photometer; the red lithium line, the yellow sodium, and the red and green bands of calcium being used. Chloroform reduces the light intensity of the lithium by 64 per cent, and the current produced by 4 volts by 62 per cent. Corresponding figures for sodium are 78 and 73 per cent. The intensity of the red calcium line is reduced by 71 per cent, that of the green by 51 per cent, the current by 43 per cent.

A funny tale comes from the South, according to the Electrical Review, telling of the sad experience of a telephone subscriber who attempted to repair his transmitter. Finding some difficulty with his telephone, this self-appointed repair man undertook to put it in order, but not with entire success, for upon taking apart the transmitter, the granulated carbon was spilled upon the floor and some lost. An examination of what was left convinced the would-be expert that the grains were nothing more than gunpowder. Consequently, when putting the instrument together again, he used gunpowder to replace the lost material. After finishing the job to his satisfaction, he attempted to call up the exchange, so that he might ascertain how successful his work had been, not thinking that now his transmitter was loaded; but, upon ringing the magneto, the gunpowder in the transmitter exploded, with some damage to the subscriber's face, and disastrous effects upon the telephone.

It is a peculiarity of vision that impressions on the retina do not fade instantly but persist for a fraction of a second after a change has taken place in the aspect of the object viewed. This persistence of vision is what enables a fairly good view of a fair ground or baseball field alongside of a railroad track, to be seen from the window of a rapidly-moving train, when, if the train were standing still, all that could be seen would be a high fence with narrow cracks between the vertical boards. When the car carries one by the fence rapidly the eye receives a series of views of the field through the cracks, which blend together and give the panorama effect. This peculiarity is taken advantage of in investigating the action of certain vibrating or revolving mechanisms like engine flywheel governors, etc. If a rapidly-running flywheel governor is seen for a fraction of a second at one spot at every rotation, it appears to the eye to stand in space and under that condition the in-and-out movements caused by the changing load, may be readily seen. One method of obtaining this effect is to mount a radially-slotted disk on the flywheel shaft so that the slot covers the portion of the governor to be watched. In front of this disk is another slotted disk which stands stationary. Now if a strong light illuminates the object a flash of reflected light will reach the eye at every revolution. The same stroboscopic effect was obtained in another way in the elaborate investigations of the Pelton water wheel which were carried on some months ago. To perfect the shape of these buckets so that they should have the maximum of efficiency and durability it seemed necessary to observe the action of the jet as it impinged on the buckets, but to get a perfect visual impression the buckets should stand still, which, of course, was impossible in running tests. An arc lamp was arranged with a shutter, which was worked in synchronism with the revolving water wheel. At every revolution a flash of light was directed upon the jet and buckets, giving them the impression of standing still while the water entered the buckets and flowed out at the sides. With the same apparatus instantaneous photographs of the jet and buckets were taken.—Machinery.

ENGINEERING NOTES.

The calculation of the cross-section of the steam passages from valve to cylinder is generally done by means of empirical formulæ. M. F. Gutermuth (Zeit. Ver. Deutsch. Ing.), in examining these, comes to the conclusion that the steam velocity in these valves is generally taken needlessly low, and he gives results of tests showing how small the drop of pressure is when steam velocities as high as 100 meters per second are taken. He further describes in detail his method of calculating the cross-section of the inlet and outlet passages.

Japanese imitation of European methods of doing things has not yet extended to their manipulation of tools in the handicrafts. The Japanese plane has the cutting blade set near the end of the wooden stock. The workman grasps the long end of the stock with the right hand, puts his left around the back of the cutter and the end of the wooden block, and makes the cutting stroke by drawing the tool toward him. The blade is wedged in the stock in the manner with which mechanics are familiar, and is removed by tapping the end of the stock lightly with a hammer in the usual way. The teeth of the Japanese wood saw are arranged to cut in the opposite direction to ours. They plane and saw with a pulling stroke, whereas ours is essentially a thrust when cutting. The saws are notched with teeth on both edges, and the end of the blade is extended for insertion in a handle about 15 inches long. The workman grips the handle at points about 10 inches apart, the left hand nearest the saw blade, and soon pulls his way through the wood.

An interesting test of copper locomotive-boiler tubes is described by F. W. Webb in Inst. Civil Engin. Proc. A set of 198 tubes by ten makers was put into the boiler of an engine, groups of ten tubes of different kinds being arranged at different parts of the boiler so that each make of tube received similar treatment. The experiments lasted 38 months, during which the engine ran 142,348 miles. The first tube failed at 34,067 miles and the second tube of the same make at 40,612 miles; when two tubes had failed, all the tubes of the same type were removed. The best type did not give a failure till after 123,896 miles, and the second best after 107,507 miles, the remaining tubes of these two types being in fairly good condition at the end of the test. With one exception the tubes failed through wearing thin from the inside, invariably at the bottom and within 6 inches of the firebox end of the tube. It is suggested that this might be due to condensation of sulphurous acid during the lighting up of the boiler, or that the cinders striking against the top of the steel ferrule that protects the end of the tube are deflected on to the lower surface of the copper tube. Analyses were made of the burst and unburst tubes, and the conclusion is drawn that the best tubes are those containing either 3 per cent of nickel, or at least 0.5 per cent of arsenic. Copper tubes hardened with nickel are now being put into locomotives on the L. N. W. R., and good results are anticipated from them.

The loss of the destroyer "Cobra," which occurred some little time ago, resulted in the British Admiralty's coming to a decision to build this type of vessel of heavier scantling, and to run at a reduced speed. This decision has now been questioned by a committee of experts who were subsequently appointed to make a thorough and scientific investigation of the subject, and who have arrived at the conclusion that the alarmist attitude taken at the time of the "Cobra" accident was quite unnecessary. The new 25½-knot boats are on an average 230 tons heavier than the earlier 30-knot boats. This reduction in speed is a serious matter, as events in the Far East have shown that fastness is everything in destroyer tactics, while in addition the larger boats cost something like 25 per cent more, and reduce materially the radius of action at any given speed. That the Admiralty are anxious to increase the speed of the destroyers is evident from the fact that they have recently approached the builders of this type of craft with the question as to whether the guaranteed speed can be increased without forfeiting any of the other qualities. A number of these new destroyers, says the Mechanical Engineer, have now completed their trials, and the results are contained in a parliamentary return just issued. Two of the boats are turbine driven, and one, the "Velox," steamed 27.1 knots for 7.35 tons of coal per hour; the other the "Eden," 26.2 knots for 7.45 tons per hour. The best result with reciprocating engines was 26.2 knots with a coal consumption of about 5½ tons per hour, this vessel having the remarkably low rate of 1.65 pounds per indicated horse-power per hour. Another reciprocating-engined vessel returned 1.56 pounds for 25.8 knots, which also gives a better result than the turbine vessels. A third, which steamed 26.1 knots, only consumed 1.9 pounds. All these three vessels were Yarrow boats. In the case of the other vessels the consumption ranged up to 2.79 pounds, so that the average result is not more than the 7 1-3 tons recorded for the turbine vessels. Where the consumption was over 2½ pounds, the vessel had to carry an increase in load at the rate of four tons for each tenth of a pound in excess of 2.5 pounds per indicated horse-power per hour. While for less consumption a deduction was made for the saving on the same basis.

SCIENCE NOTES.

Examination of the Harvard photographs of the region of the nebula of Orion has resulted in the confirmation of 16 of Wolf's variables, and the discovery of many new ones. A list of these is given, their distribution emphasizing their close connection with the nebula. They are found principally in a narrow region on each side of a line extending southward from *C Orionis* through θ and ι, and beyond. North of declination—4 deg. 44 min. only one variable was found out of about 900 stars examined.

It is said that when sound of any pitch is shut off, say, 64 times per second, a sound is also heard whose frequency is 64. Is this a physical or a physiological effect? But experiment by means of a telephone shows that this is not a fact; the primary sound disappears and the intermittence tone is not heard, and instead we have a more or less complicated noise, apparently made up of difference-tones and overtones, audible in a resonator, and shown by oscillating flames. The cause appears to be that the telephone disk, subjected to interrupted vibration, takes up a new form of vibration involving these difference-tones and harmonics. No other method of producing the alleged subjective intermittence tones is beyond some analogous physical examination, independent of the internal ear.

J. Stark has discussed (Phys. Zeitschr.) the various explanations of the experiments by W. Wien, which showed that positive rays exhibit a variable deflection. After reviewing previous explanations, a new hypothesis is advanced as follows: Suppose first, that the charge of the negative electron is constant and of value 3.1×10^{-10} electrostatic units. Let the charge of the positive ions be the same or vary discontinuously as the natural whole numbers, so as to be a multiple of the above elementary quantity. Secondly, suppose that the positive rays on entering the deflecting electromagnetic field and the gas there existing are all of identical character, i. e., possess equal masses, charges, and velocities. Thirdly, make the new assumption that just as positive and negatively charged particles, if they possess speed enough, so also neutral molecules or atoms under like circumstances may assume the ray-like character. Consequently a gas throughout a certain region may move rectillinearly and by bombarding a certain body make it luminous. The condition of a sufficiently high velocity is easily obtained in the case of the ions by means of a potential gradient, but this does not avail for the neutral particles. But these may attain the necessary high velocity in either of the two following ways: First, a positive ray particle may give its velocity to a neutral one by collision, being itself brought to rest. Secondly, a positive ray particle may, by receiving a negative electron, be changed into a neutral particle and thenceforward be a neutral ray tangential to the curved path the particle was previously describing. In this case the velocity of the positive ray particle would hardly be changed as the mass of the acquired negative particle is so much smaller. Thus, however, the transformation of the positive rays into neutral rays occurs, whether by impact or neutralization, the further angular deflection of the rays at that instant ceases. But, since the neutralization may be effected at various places, the rays are spread out into a bundle, exhibiting a variable deflection, or form a spectrum as observed by W. Wien.

In a paper read to the Dutch Physical Society last June, Dr. F. Heusler described how he discovered, owing to one of his tools having been accidentally magnetized, that a particular alloy of manganese and tin was strongly magnetic. He has since made a careful research on the magnetic properties of alloys of manganese, and has made one or two further discoveries which may have several commercial applications. He has noted that given alloys become non-magnetic at definite temperatures, and that this temperature, when the manganese is alloyed with lead, is only 140 deg. F. This can obviously be utilized for temperature-indicating devices, and, if it is found that the alloys do not lose their magnetic properties with time, it can also be used in connection with fire alarm devices. A manganese lead magnet, for example, would lose its magnetic properties at 140 deg. F.; its keeper would therefore drop at this temperature, and it could easily be arranged that it should complete an electric-bell circuit, and so give the alarm. Theoretically, also, it seems to us that this discovery of Dr. Huesler's solves the problem of converting heat directly into work. By alternately heating and cooling a magnet made of one of these alloys, the keeper may be kept oscillating by the magnetic attraction continually overcoming its weight, and thus work could be obtained. A generator for electric currents could also be made on this principle. It was found that an alloy of manganese, aluminium and copper rivaled cast iron in its magnetic properties, and although the cost of this alloy makes its commercial application at present out of the question, yet it is highly probable, seeing the important results obtained in this brief research, that further discoveries in the immediate future will make these alloys useful in dynamo construction. From a theoretical point of view many interesting problems have arisen. A new magnetic theory seems to be required to explain why, for example, the addition of aluminium to a practically non-magnetic alloy should convert it into a powerful magnet.

TRADE NOTES AND RECIPES.

Treatment of Newly Laid Linoleum.—Upon a floor newly covered with linoleum the furniture should never be rolled or skidded about, but lifted and carried from place to place; moreover, under the feet of heavy pieces on castors, small bits of linoleum should be placed. The proper way to cleanse a linoleum flooring is first to sweep off the dust and then wipe up with a damp cloth. Several times a year the surface should be well rubbed with floor-wax. Care must be had that the mass is well pulverized and free from grit. Granite linoleum and figured coverings are cleansed without the application of water. A floor covering which has been treated from the beginning with floor-wax need only be wiped off daily with a dry cloth, either woolen or felt, and afterward rubbed well with a cloth well filled with the mass. It will improve its appearance, too, if it be washed several times a year with warm water and a neutral soap.—Neueste Erfindungen und Erfahrungen.

To Remove Odors from Chests.—To free chests and trunks from evil-smelling and other odors it is sufficient to paint them several times with a solution of shellac according to the following directions. To assure a pleasing color to the inside of the box, similar to gold varnish, in fact, we should recommend that the shellac solution be thinned down with one or two parts of alcohol for the first coat; after that the coats may be laid on with the original varnish. We consider at least one coat advisable for all chests except such as contain pulverized spices, since the varnish often becomes tacky in these. The varnish is made up of 1 kilogramme of shellac, 1 kilogramme alcohol from 90 to 95 per cent pure, 50 grammes of boracic acid, and 50 grammes of castor oil. Pour the alcohol over the shellac and dissolve it by frequent turning of the vessel. The boracic acid and castor oil may now be added. This varnish is well adapted for the covering of stationary boxes. For this purpose it is well to give the articles one or two coats of linseed oil, after which three coats of the varnish will complete the job.—Pharmazeutische Zeitung.

A Durable Label Varnish.—The varnished labels of stock vessels often suffer damage in a very short time from the spilling of the contents over them or the dripping after much pouring. This inconvenience, says the Pharmaceutische Zeitung, brought the author of the following recipe upon the idea of testing the property possessed by formaldehyde of hardening like gelatine, for the making of durable labels. His success is apparently assured, for he maintains that the formaline gelatine is indeed capable of withstanding the baneful influence of ether, benzine, water, spirit of wine, oil, etc., etc. The following method of applying the preservative is recommended. Having thoroughly cleansed the surface of the vessel paste the label on and allow it to dry well. Give it a coat of thin collodium to protect the letters from being dissolved out or caused to run, then after a few minutes paint over it a coat of gelatine warmed to fluidity—5 : 25—being careful to cover in all the edges. Just before it solidifies go over it with a tuft of cotton dipped into a 40 per cent formaline solution. It soon dries and becomes as glossy as varnish and may be coated again and again without danger of impairing the clear white color of the label or decreasing its transparency.—Neueste Erfindungen Erfahrungen.

Phosphate of Casein and Its Production.—The process is designed to produce a strongly acid compound of phosphoric acid and casein, practically stable and not hydroscopic, which may be employed as an acid ingredient in bakers' yeast and for other purposes.

The phosphoric acid may be obtained by any convenient method; for example, by decomposing dicalcic or monocalcic phosphate with sulphuric acid. The commercial phosphoric acid may also be employed.

The casein may be precipitated from the skimmed milk by means of a suitable acid, and should be washed with cold water to remove impurities. A caseinate may also be employed, such as a compound of casein and an alkali or an alkaline earth.

The new compound is produced in the following way: A sufficient quantity of phosphoric acid is incorporated with the casein or a caseinate in such a way as to insure sufficient acidity in the resulting compound. The employment of 23 to 25 parts by weight of phosphoric acid with 75 to 77 parts of casein constitutes a good proportion.

An aqueous solution of phosphoric acid is made, and the casein introduced in the proportion of 25 to 50 per cent of the weight of the phosphoric acid present. The mixture is then heated till the curdled form of the casein disappears, and it assumes a uniform fluid form. Then the mixture is concentrated to a syrupy consistency. The remainder of the casein or of the caseinate is added and mixed with the solution until it is intimately incorporated and the mass becomes uniform. The compound is dried in a current of hot air, or in any other way that will not discolor it, and it is ground to a fine powder.

The intimate union of the phosphoric acid and casein during the gradual concentration of the mixture and during the grinding and drying, removes the hydroscopic property of the phosphoric acid, and produces a dry and stable product, which may be regarded as a hyper-phosphate of casein. When it is mixed with water, it swells and dissolves slowly.

When this compound is mingled with its equivalent of sodium bicarbonate it yields about 17 per cent of gas.—Translated from La Revue des Produits Chimiques.

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