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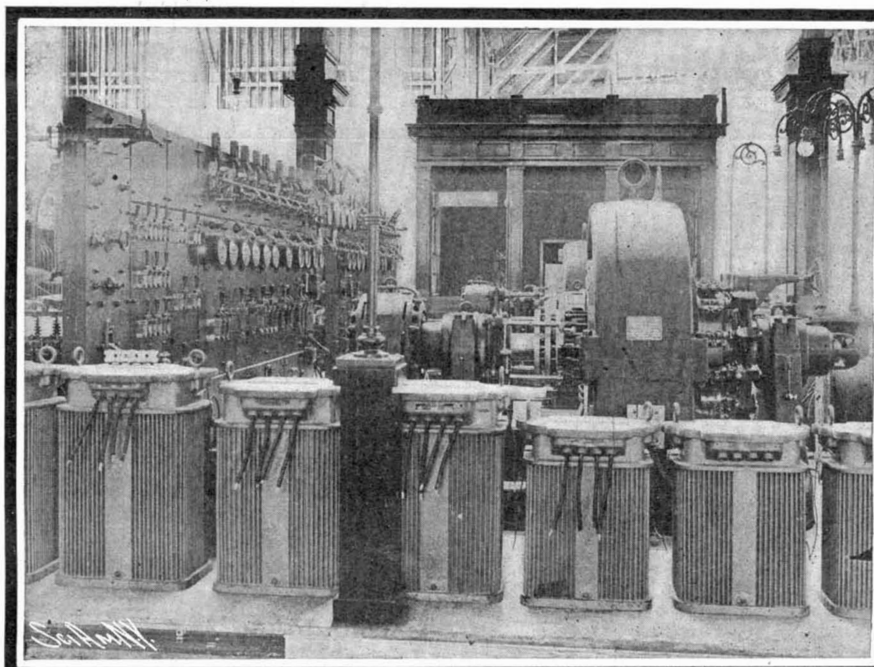
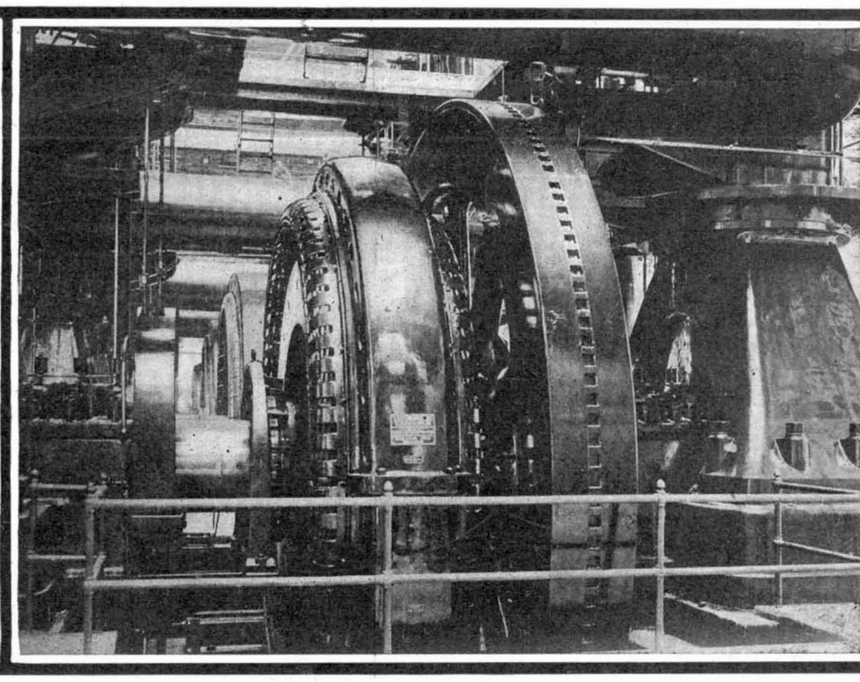
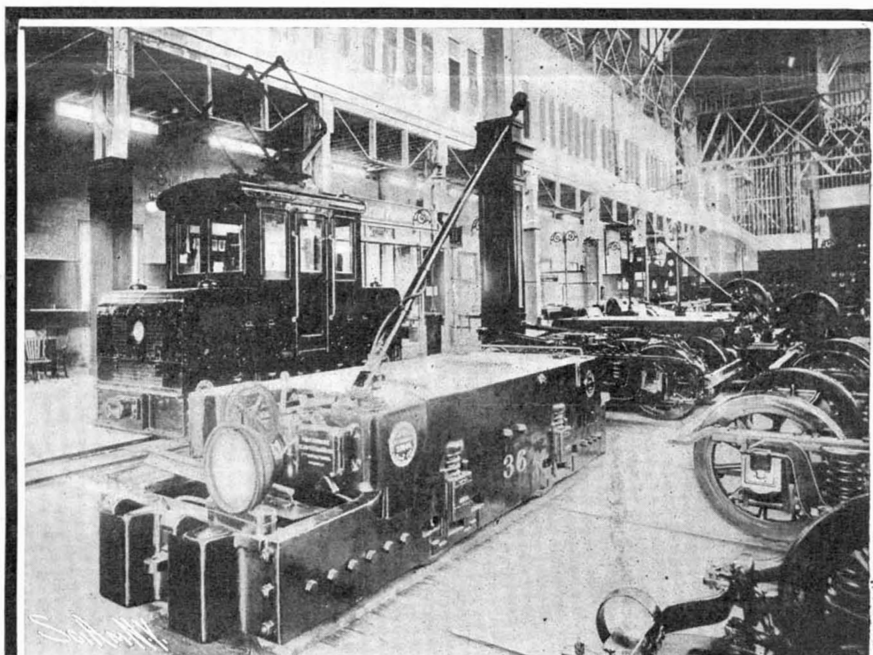


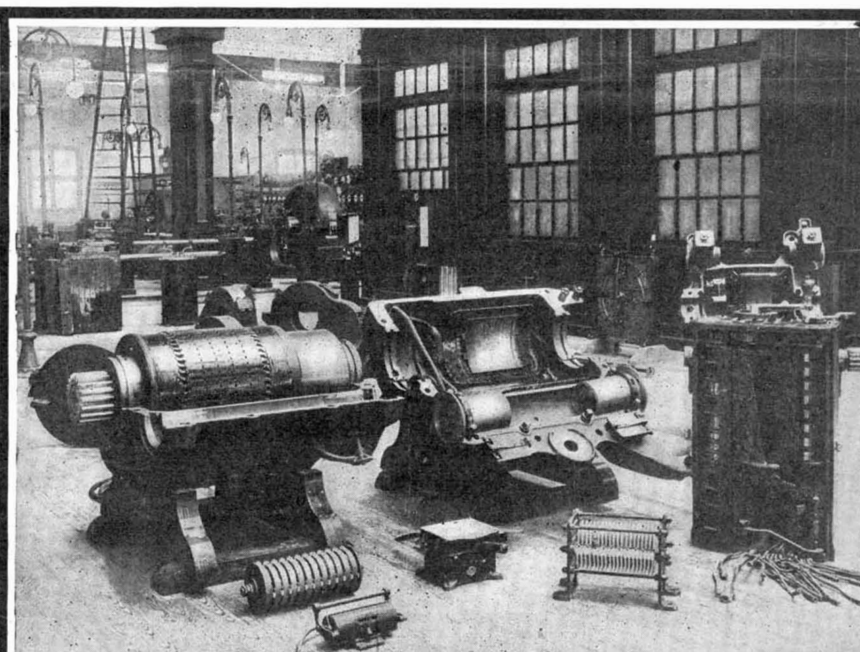
TRANSFORMERS IN FOREGROUND; ROTARY CONVERTERS IN CENTER; TRANSFORMER SWITCHBOARD AT THE LEFT.



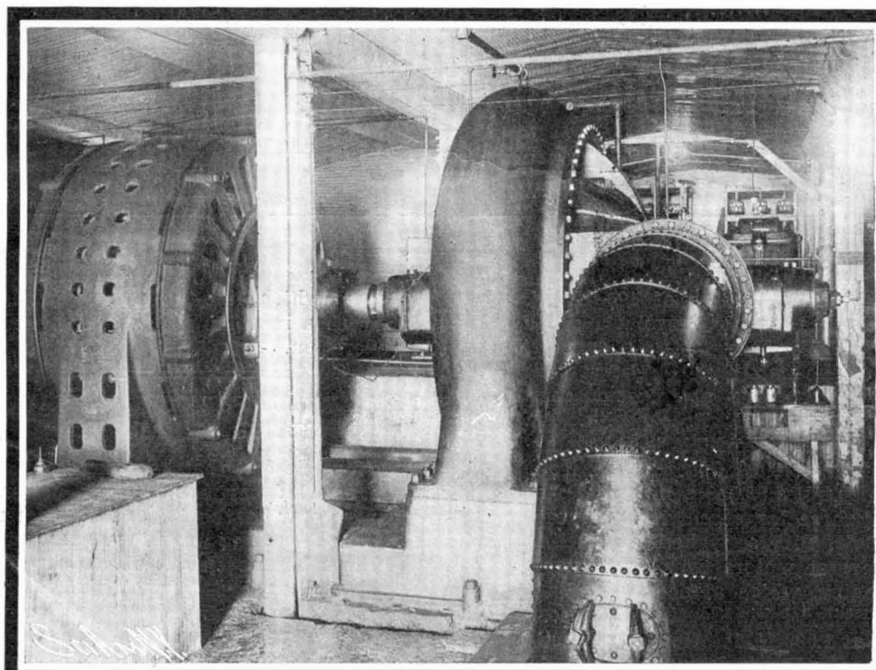
A BATTERY OF WESTINGHOUSE-CORLISS ENGINES.



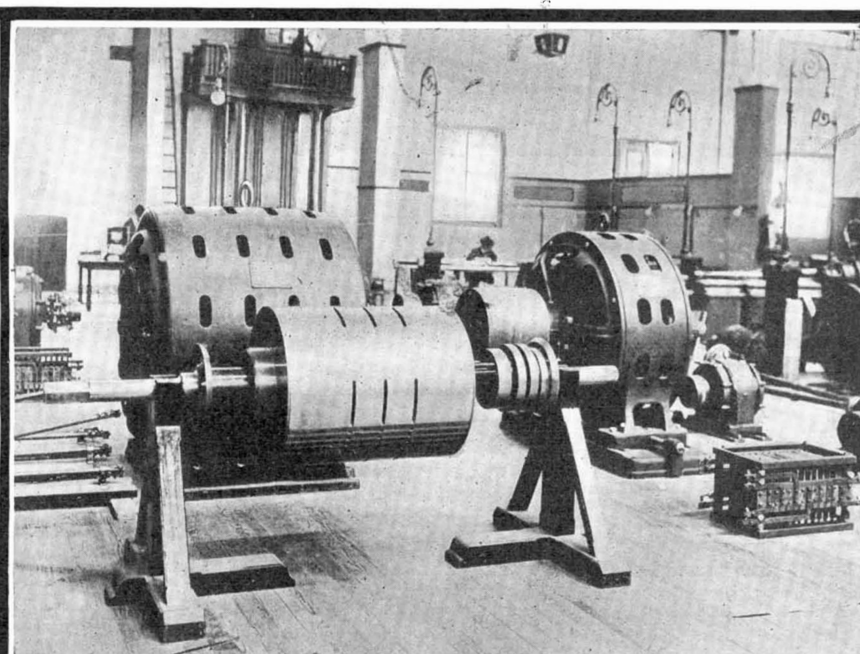
ELECTRIC LOCOMOTIVES IN PALACE OF ELECTRICITY.



MOTORS FOR THE SUBWAY CARS OF NEW YORK CITY.



ONE OF THE THREE CENTRIFUGAL PUMPS WHICH SUPPLY THE CASCADES WITH 90,000 GALLONS OF WATER PER MINUTE.



REVOLVING-FIELD AND STATIONARY ARMATURE OF A TURBO-GENERATOR.

WESTINGHOUSE EXHIBITS AT THE ST. LOUIS WORLD'S FAIR.

WESTINGHOUSE EXHIBITS AT THE ST. LOUIS WORLD'S FAIR.

By the St. Louis Correspondent of the Scientific American.

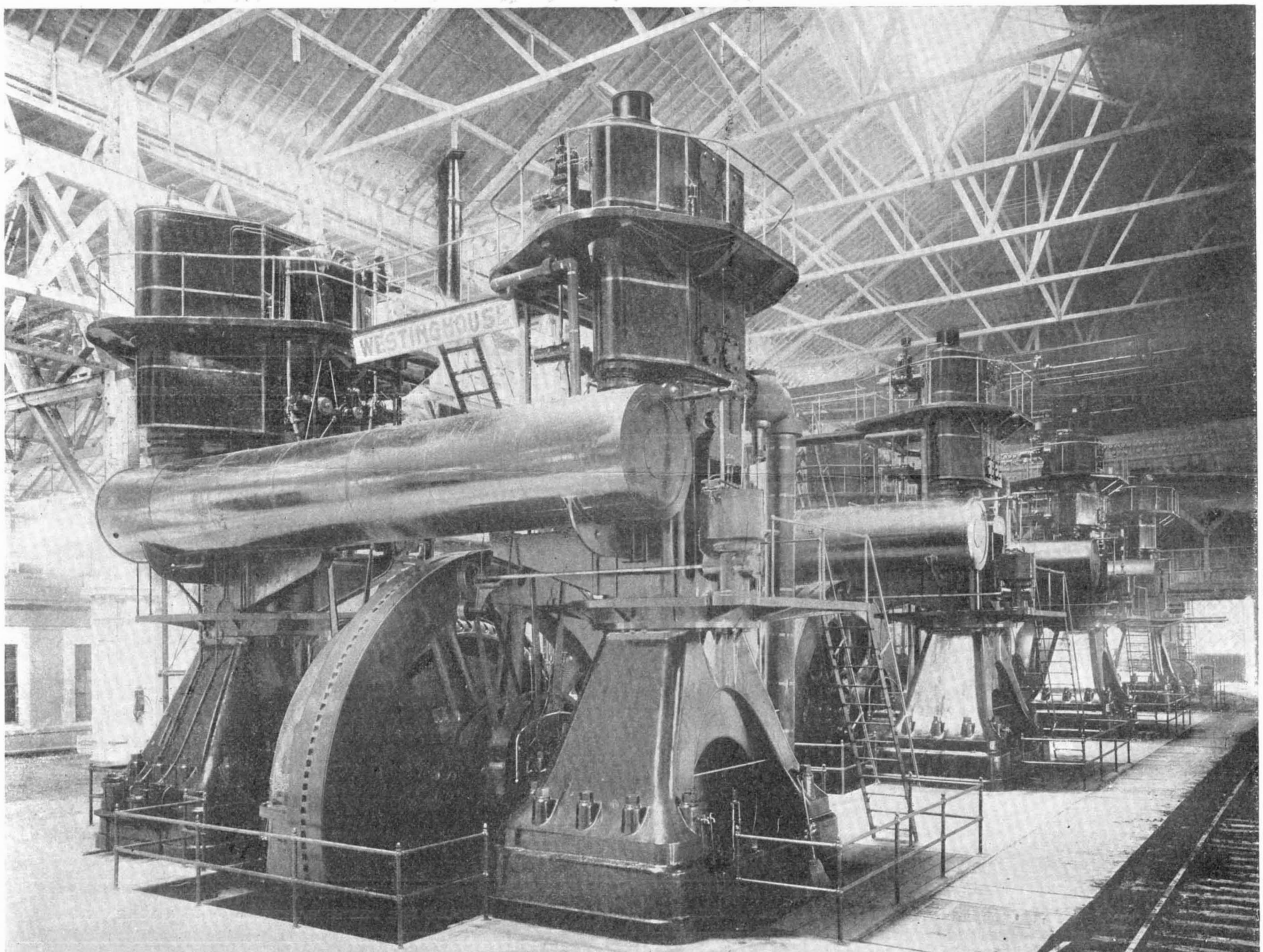
The main service plant at the Louisiana Purchase Exposition for which the Westinghouse Co. received the general contract, was brought conspicuously into public notice by the presence, near the main entrance to Machinery Hall, of four large electric generating units, each of 2,000 K. W. capacity. Naturally popular interest centered in the great engines and generators, from which radiated the power that filled the lagoons and court basins with constantly changing water, created the Cascades by day, and by night assisted in outlining the architectural beauty of the fair in glowing lines of fire. At the Chicago Fair in 1893, the central station plant, which was installed by the same company, was a complete exhibit of the most modern type of electrical machinery at that time and the twelve 750 K. W. generators were at that date the largest alternating-current polyphase machines ever constructed. The 2,000 K. W. generators of the present fair plant, although of almost three times the individual capacity of those seen at Chicago, are not to-day remarkable on account of their size. Indeed the entrance to the exhibit of this company is through a large 35-foot plaster ring, which is an exact duplicate, in size and form, of the stationary armature of the 5,000 K. W. generators constructed for the elevated and subway train service in New York city. Moreover, a set of 10,000 K. W. generators are now being constructed by the Westinghouse Company for the turbine-driven generators of the Ontario Power Company on the Canadian side of the Niagara Falls. As showing the growth of the electrical industry in this country, it may be mentioned that the various organizations associated with the Westinghouse name, which have a united representation at the St. Louis fair, have in addition to the 26,000 square feet of space in Machinery Hall other space concessions in the various industrial palaces which bring up the total to over 65,000 square feet, or nearly ten times the space occupied by the same interests at the Pan-American Exposition at Buffalo in 1901. The organizations associated with these joint exhibits represent an army of 30,000 employes and occupy a total workshop floor space of over 140 acres, or more than is found in all the twelve great exhibition palaces of the St. Louis Exposition.

In addition to the installations in Machinery Hall there is an auditorium seating 350 persons, in which are shown biograph pictures of scenes at the various works of the company in the Pittsburg district, including the first interior photography of the kind ever taken by means of the Cooper Hewitt mercury vapor lamp. These lamps and the Nernst glowers, of which there are 10,000 in use in the exhibition buildings, are being used successfully for various indoor and outdoor illuminations. Steam for the electric service plant is piped from the boiler house, known as the Steam and Fuels Building, near by, in which there has been installed a large battery of Babcock & Wilcox water-tube boilers in a single setting, of a total capacity of 6,400 H. P. The equipment includes mechanical stokers at the furnaces, a complete coal-conveying system, feed-water heaters, etc.

The exhibit service plant of Machinery Hall includes a Westinghouse-Parsons steam turbine of 400 K. W. capacity, running at a speed of 3,600 revolutions per minute and delivering three-phase, 440-volt current. This is the smallest turbine unit built at the present time by the company, who are at present completing several units of 7,500 H. P. capacity. An important part of the company's exhibit is the pumping apparatus under the beautiful Cascades, in front of Festival Hall, which supplies 90,000 gallons of water a minute by means of three large centrifugal pumps each driven by a 2,000-H. P. Westinghouse induction motor, probably the largest motors ever constructed. The famous Jumbo engine, which alone operated all the machinery of the Philadelphia Centennial Exposition in 1876, was rated at 1,000 H. P. Here, in a single plant operating but one solitary feature of the St. Louis fair, is machinery of six times that capacity.

In the Palace of Electricity the company occupies a space of over 10,000 square feet in which is placed a display of electric trucks and locomotives constructed in conjunction with the Baldwin Locomotive Works. This includes two locomotives for mine service and another for switching purposes, while in the same exhibit are a 400 K. W. turbine type generator, oil-insulated and air-blast transformers and a multitude of other pieces of apparatus, representing the latest development of electrical art. The exhibit of the Westinghouse brake extends for 150 feet down one of the aisles of the Transportation Building; and included in this exhibit is a display of the company's alternating-current, single-phase railway motors, whose introduction may be said to be almost epoch-making in the art of electrical traction. The successful production of the alternating-current railway motor constitutes the most important development in electric traction of the past two years, and it may be said without exaggeration, that this is one of the most interesting exhibits to the electrical engineer, at least, in the whole of the company's exhibits.

The Air Brake Company also shows a rack made up of apparatus constituting the equipment for a six-coach passenger train, with engine and tender all fitted throughout with the high-speed brake and signal equipment. Another item of interest is the company's friction-draft gear, which, like the brake exhibit, is shown in section, with a machine specially designed for testing it in operation.



THE FOUR 2,000-KILOWATT GENERATING UNITS IN MACHINERY HALL, WHICH FURNISH MOST OF THE POWER AND LIGHT OF THE EXPOSITION.

WESTINGHOUSE EXHIBITS AT THE ST. LOUIS WORLD'S FAIR.

A NEW APPARATUS FOR COALING WARSHIPS AT SEA OR IN HARBOR.

One very forcible fact that has been impressed upon the various naval departments of the powers by the Russo-Japanese war is the imperative necessity of a reliable system of coaling warships at sea, when either their coal bases have been cut off, or are too distant from the scent of action. Several systems have been devised for the accomplishment of this purpose, such as the Miller apparatus, which has been fully described in the Scientific American. A new system has now been devised and subjected to severe experiments, by the Thames Ironworks, of London. One feature of this system is that it can be utilized for coaling vessels either at sea or in harbor with equal facility. Through the courtesy of the naval architect

to the Thames Ironworks and Shipbuilding Company, Mr. G. E. Mackrow, M.I.N.A., who in conjunction with Mr. Cameron devised the apparatus, we are able to publish a few facts concerning the device, which has been fully described in the Works' Gazette.

The vital points of this system are the hoisting and transferring of the bags of coal from the hoist on to a continuously running conveying line, traveling at any speed up to 1,000 feet per minute, and again upon reaching the battleship the transferring of the bags of coal from the said running line to the deck without in any way reducing speed. The three requirements which are essential in any such apparatus are rapidity, safety, and ability for the ships engaged in the operation to proceed with the minimum diminution of speed.

The gear comprises: First, a vertical cylinder called a slewing jib or transporter, which contains a tension weight in which is a set of sheaves suspended by means of the conveyer line from another set of sheaves attached to the crown of the cylinder, or transporter. Second, an endless steel-wire traveling rope passing round the two sets of sheaves in the transporter, the bight being carried to sheer legs on the after part of the deck of the warship, or to the military top, as preferred, where it passes round a free wheel or pulley. The tension weight maintains a practically uniform tension on the said rope and allows for the distance between the ships varying to the extent of ten to twelve fathoms. Third, a novel form of hoist secured to the front of the vertical cylinder with a series of projecting hooks that catch other duplex hooks attached to the coal bags. The bags are carried on a circular continuously traveling feeding ring, which is fitted around the transporter at a height of about five feet above the deck, and is provided with scores in its upper edge about two feet apart. The duplex hooks drop into these scores, and are carried by the revolving ring into position ready to be automatically picked up by the projecting hooks of the hoisting gear. Fourth, at the head of the above-mentioned hoist is secured a shunt-bar which receives the duplex hook of the coal bag when it is cast off the hoist. The bag then travels by gravity down the shunt-bar, and so passes on to the transporting line. Fifth, there is a small engine fixed at the head of the slewing jib, and this gives movement to the following gear, viz.: the transporting line, the hoisting gear, feeding ring, the tension-relieving gear, and also the slewing gear, so that the sheaves at the head of the transporter may always reach direct to the sheaves on the warship, in order that the coaling operation may proceed independently of the relative positions of the ships. By this means the collier may be towed direct astern, or on the quarter, or even on the broadside should occasion require it.

It will be seen from this that a continuous train of coal bags may be hoisted from the deck of the collier, transferred to the transporting line, and when arriving at the warship be again transferred by means of another shunt-bar from the transporting line on to a carrier rail, and so arranged to travel to any point on the deck that may be desired near the coal shoots. The movement is not reciprocating, but continuous, and so no time is lost while the empty bags are being returned, as they are sent back on the inward-running line, while the coal is being sent out to the warship by the outward-running line.

For use with this type of transporter a special class of high-speed collier has been devised with a coal capacity of 5,000 tons, and a steaming speed of 15 knots per hour, designed upon such lines that the coal may be brought to the head of the transporter at the same rate at which it is dispatched to the warship. It is maintained by many naval officers that such colliers are absolutely imperative to render coaling in this wise successful and satisfactory. The dimensions of this special type of collier are as follows: Length 450 feet; breadth 50 feet; draft of water 26 feet; twin screw engines of 5,600 I. H. P.; displacement, 11,000 tons.

The propelling machinery is placed aft with the fore part divided into six holds, and at the lower part in each hold there is a filling room entered by means of a trunk from the upper deck. A sloped or arched floor is erected about seven feet from the bottom of the hold, so as to allow the coal to pay down on to a table in the filling room, and from thence be raked into bags suspended with their open mouths close to the table. The bags when filled are hoisted up the trunk to a traveler fitted overhead along the upper deck, which, being made to travel continuously, conveys the coals from the holds to the heel of the transporter, as above described. The bags, as they arrive at the revolving ring at the heel of the transporter, are each in its turn caught by the hook of the elevator, and so hoisted to the head and transferred to the conveyor line as above described. With twenty to thirty men in each of the compartments from 600 to 1,000 bags per hour, equal to from 60 to 100 tons, making a total of from 360 to 600 tons per hour, can be filled with ease.

The system for coaling vessels in harbor devised by these inventors is simple and rapid, and the British Admiralty proposes to carry out several trials with the scheme. This harbor-coaling system comprises the construction of a 1,000-ton lighter with a filling room provided in the lower part of the hold, on the sloping crown of which coals are deposited as in an ordinary open lighter. The sloping crown or floor does not run home to the sides of the lighter, but stops some three or four feet short of each side, thus allowing the coal to pay down through this opening on to a receiving table placed underneath the opening, on the edge of which table the bags are suspended with open mouth and the coal is raked off the table into them. As the table is cleared more coals pay down by gravity, which entirely obviates the necessity and consequent labor of digging and shoveling, as in an ordinary open hold. The bag filling being carried on under cover, the men are protected from all weathers and can carry on the work with much more comfort and with less labor.

The lighter is divided into two parts, one hold forward and one aft, and in each lower hold or filling room there is ample room for twenty men to work filling, each man handling three tons per hour, equal to 60 tons, or, by increasing the number of men to thirty in each hold, 90 to 100 tons of coal per hour can be dealt with, making a total output of 200 tons per hour. At the end of each hold is fitted one of the Thames Ironworks' express transporters, which will lift the coal after being bagged to any required height, either of a gunboat alongside or a battleship, the bag of coal upon reaching any required height being detached and allowed to slide down the shunt-bar on to the deck of the gunboat or battleship, as the case may be. By this means, from the time the bag is filled in the hold of the lighter and hooked on to the overhead traveling rail until it reaches the deck of the battleship it has not to be handled by anyone.

The dust arising from this operation is surprisingly small, as the coal pays down quietly, and what dust there is floating in the air is removed by a Sturtevant or other fan working in the end of each hold, and depositing the fine dust in a receptacle provided at the end of the hold, so that a constant supply of fresh air is maintained.

The whole of the mechanism for hoisting the bags from the receiving table to the traveler, and again to the hoist is in charge of one man to each hold, stationed on deck amidships, who can see what is passing, and can stop and start the gear as desired.

These lighters, being for harbor use, are not self-propelling, but are towed from the coal depot to a berth alongside the battleship.

The general particulars of the coaling apparatus are as follows:

Extreme length of transporting trunk, 56 feet.

Diameter of transporting trunk, 5 feet, 3 inches.

Total weight of transporter complete, 28 to 30 tons.

Height of transporting line above sea at collier about 35 feet.

Height of transporting line above sea at battleship about 30 feet.

Dip of line when loaded, from 13 feet to 19 feet.

Weight of tensioning apparatus, complete, 8 tons.

Normal tension of transporting line, 2 tons.

Diameter of sheaves on tread, 3 feet, 6 inches.

Working speed of transporting line, 600 feet per minute.

Spacing of coals on transporting line, 60 feet apart.

Weight of coal in each bag, 224 pounds.

Speed of hoisting gear for bags, 60 feet per minute.

Working distance between transporter on collier and sheer legs on battleship, 350 feet.

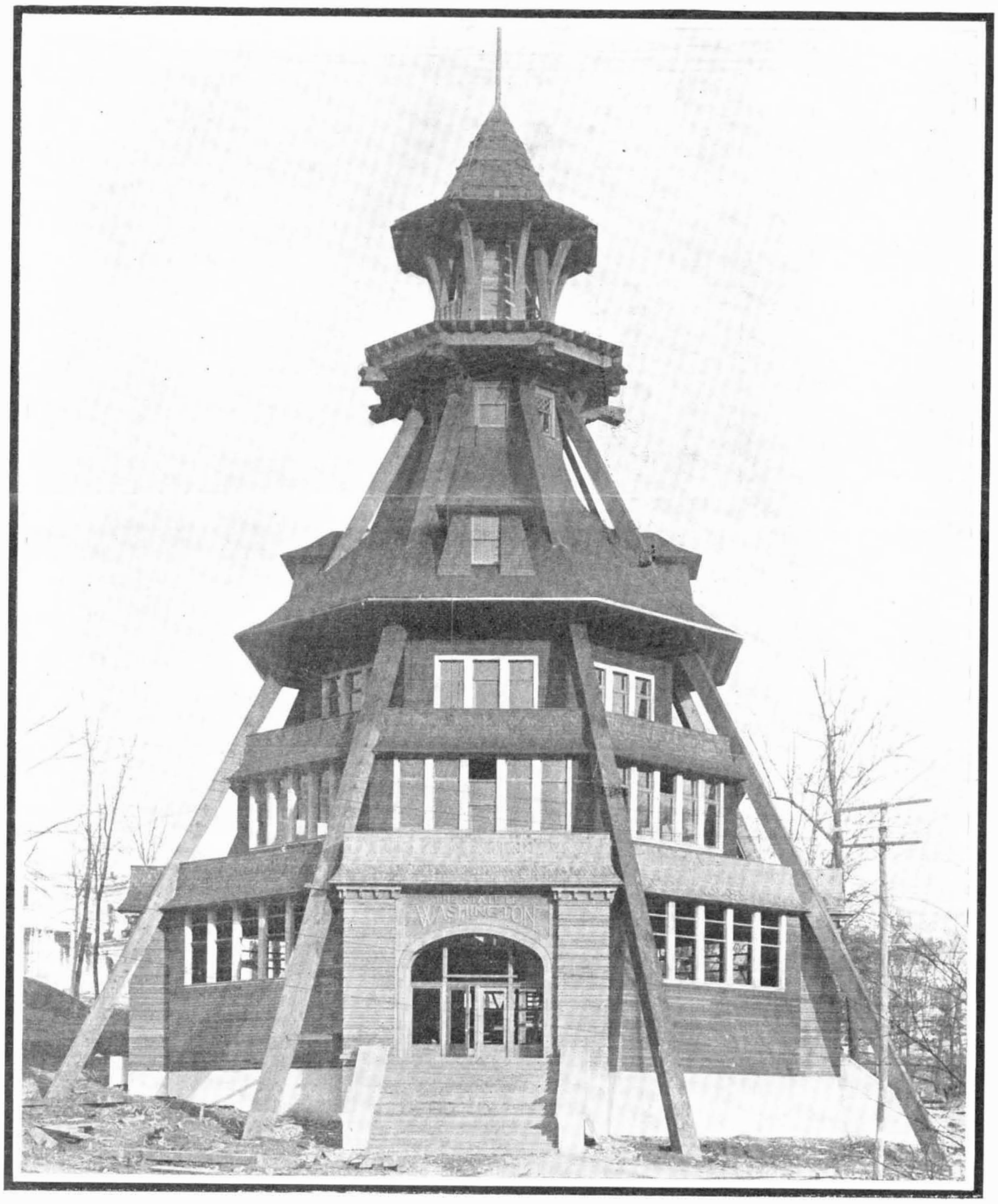
Amount of veer and haul, 66 feet.

The trials with this coaling apparatus that have been carried out in connection with coaling a vessel in port have been attended with complete success, and it has proved highly efficient, reliable, and rapid in operation. The British navy department are keenly interested in the scheme and it is probable that they will institute a series of exacting experiments with the invention.

THE STATE OF WASHINGTON AT THE FAIR.

By the St. Louis Correspondent of the Scientific American.

The State of Washington is represented by what is certainly the most unique and in some respects the most illustrative of all the State buildings. The ground plan is that of an octagon, and the whole structure, which rises to a height of about 125 feet, is intended broadly to represent an Indian tepee. It is built in five stories, and the material of construction consists entirely of native woods. Perhaps the most striking feature is the eight huge timbers of Washington fir, intended to represent the poles of an Indian tepee, which extend from the ground almost to the apex of the building. These timbers, which have not a single splice in them, are 110 feet in length, and measure 2 feet by 2 feet in section throughout, forming a noble testimony to the magnificence of the Washington fir. Outside the building are shown some large spruce planks, 10½ feet in width by 7 feet long. This building is an exhibit building, and is crowded on its various floors with representative products and manufactures of the State.



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THE STATE OF WASHINGTON'S BUILDING, DESIGNED LIKE AN INDIAN TEPEE.

The eight "poles" are sticks of timber 2 feet square and 110 feet long.

THE SCIENCE OF BURNING LIQUID FUEL.

By W. N. BEST.

THE application of liquid fuel in the various services where it has superseded coke, coal, and wood, has now reached that degree of perfection where no reasonable mind can deprecate its value. If there are any failures in the use of this fuel, they are by no means the fault of the fuel, but are caused either by improper equipment or by its being handled by incompetent men whose ideas of modern equipment are as crude as the oil they are attempting to burn. With proper modern equipment, all smoke is entirely eliminated in marine, locomotive, and stationary services, and hence the greatest possible economy in fuel is effected. Let us briefly consider some of its advantages in the various branches of service over other fuels.

In foundry practice it is well known that although you may carefully weigh the coke and the charge of iron, yet the iron of the last of the pour is always much harder than that of the first, because the iron absorbs the carbon of the coke; while with oil as fuel, the metal can be made molten and maintained at any desired temperature without increasing the amount of carbon in the charge, and the last of the iron is as soft as the first.

One pound of coke contains 13,500 B. T. U., while a pound of Beaumont (Texas) oil contains 19,060 B. T. U. and California oil contains 20,680 B. T. U. Some Russian oils contain as many as 22,207 B. T. U. per pound. One ton of coke contains 27,000,000 B. T. U. while 4½ barrels (42 gallons each) of Beaumont oil contain 27,017,550 B. T. U. and 4 1-5 barrels of California oil contain 27,359,640 B. T. U. From these figures can be seen the relative amount of heat contained in the two fuels. Oil furnaces can be so constructed and equipped that there is perfect combustion and every heat unit in the oil is used. A small oil furnace of proper modern construction and equipment will produce a daily output equal to that of five forges and of far superior quality. Instead of the men having to wait on the iron, as is the case with other fuels, with oil the iron waits upon the men.

To obtain the best results from liquid fuel, a furnace should be so equipped that when the doors are opened, for charging or drawing the charge, the interior is as free from all appearances of flame as an arc light, and of about the same brilliancy. There is as much difference between a furnace filled with an incandescent heat and one filled with a red flame, from the standpoint of efficiency and economy, as between satisfaction and disappointment.

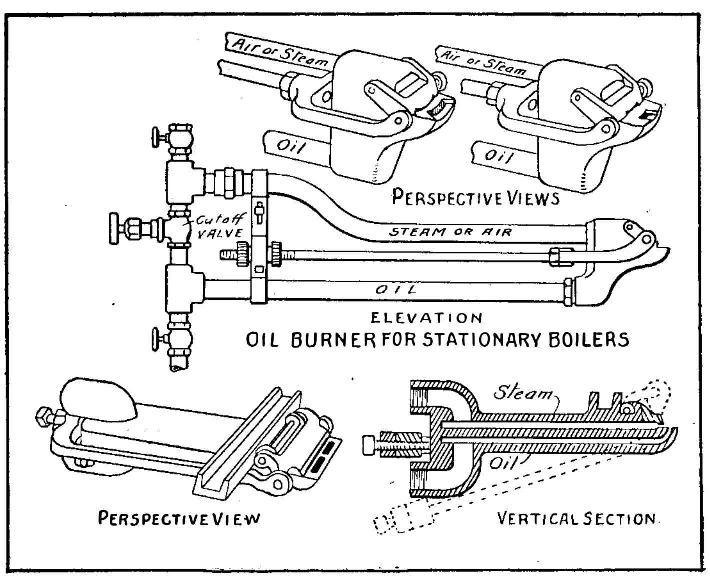
The main points in any equipment of liquid fuel are the admission of just sufficient air at the proper time and place to effect perfect combustion and the thorough atomization of the oil. The latter cannot be accomplished by two pieces of pipe or any other type of burner of such construction that every drop of the oil is not dashed into ten thousand molecules. The oil must be thoroughly broken up in order to allow the oxygen of the air to mingle freely with the volatile gases. A burner that simply pours the oil out upon a sheet of steam or compressed air cannot give the desired results. Furthermore if the oil is above the atomizer slot, when the fire is cut low, the oil will slobber and soon solidify, or carbonize, over the atomizer slot. As all crude oil is of either asphaltum or paraffin base, internal combustion burners always carbonize and are a source of constant annoyance. A hydro-carbon burner should exteriorly atomize the oil and have the atomizer slot above the oil cavity, which prevents the oil carbonizing over the atomizer slot. Such a construction is shown in the accompanying cut. In this burner, as the oil channel turns upwardly, the flow of oil must cross the stream of steam or compressed air used as atomizer, and in so doing it is dashed into molecules, thoroughly atomized, and forced over the nose of the burner. The atomizer lip can be raised by means of a bridle, so that any foreign substance, such as red lead, pipe scale, etc., which may get into the pipe while the burner is being installed, can be easily blown out without removing the burner. The atomizer slot being above the oil channel, this burner cannot carbonize. The atomizer lip can be so filed as to produce any width of flame desired. A burner may either have a very long, narrow flame, or can be so filed as to make a fan-shaped blaze eight and one-half feet in width, according as the various requirements may demand.

The most severe test to which any burner can be put is furnace practice, for this demands perfect combustion and the even distribution of a high degree of heat. If we visit a plant having a blacksmith furnace, of either large or small proportions, equipped with a modern scientific burner, the furnace having no smokestack, we find combustion so perfect that when the furnace doors are opened no flame is visible, only a white heat of about 3,000 deg. F. As the heat is evenly distributed there is very little furnace loss. The metal is perfectly welded and free from seams, as there is no corrosion. On the other hand, if we remove this burner from the furnace, and in its stead use a pipe burner, or some other back-number type, we will note imperfect atomization of the oil and its results: First, smoke or a red flame fills the furnace; this ruins the efficiency of the furnace because its output is decreased. Second, the welds are imperfect, as can be seen by the numerous seams, and are similar to those made with a green coal fire. Third, the furnace loss is excessive and the increased consumption of oil is marked. I merely quote this instance to illustrate the difference between perfect and imperfect atomization of the oil. It is a simple method of test and any doubter can easily make the test himself or visit shops where the outputs can be contrasted.

It is amusing to note some of the so-called tests being made in stationary practice by various engineers and inventors of burners. Their reports (?) often show an evaporation of from 15 to 20 pounds of water per pound of oil, but it is noticed that there is a vast difference as to who makes the tests. The Liquid Fuel Board of our navy, over which Lieut.-Commander John R. Edwards so ably presides, are compiling a report founded on actual, thorough, and impartial tests of the various inventions, which will stand as authority for years to come. From the report of Rear Admiral Melville, already published, it is noticed when the inventions are tested by the United States government (the impartiality of which cannot be questioned) that the previous statements made by some inventors in regard to high evaporations are greatly exaggerated.

In some plants it is considered economy to make a burner from two pieces of pipe in exactly the same old crude way as those used in crude plants throughout Russia and the United States for the past forty years. If you were to ask the owners of such plants for a thousand-dollar contribution for an orphans' home or some other worthy cause, it would not be granted or even considered for a moment; but they are annually allowing thousands of dollars to pass away through their chimneys. Often the engineer or fireman, using such a burner, says he knows his pipe burner (which only costs fifteen cents to make) saves twenty-five per cent in fuel over every other burner made. This he knows to be true, for he measures the oil by water meter and keeps a record of the daily oil consumption and indicated horse-power, etc. (He probably would also use nothing but a McCormack reaper made some forty years ago). If this type of burner does not smoke, investigation will reveal the fact that fully twice the amount of air necessary if a modern scientific burner were used is being admitted to his firebox. Can the admission of superfluous air cause economy in fuel? There is a vast difference between burning at oil and burning oil. The first cost of a burner does not indicate economy; only actual test can reveal its true merits, especially when using low-gravity oil (12 to 16 gravity). The stockholders of the various railroad and other companies using liquid fuel should look into the merits of the various systems of modern oil burning and keep pace with the progress being made along this line the same as they investigate and keep up with all the late improvements in electricity and compressed-air apparatus. Their lines or plants will never attain success until they do.

The adoption of crude oil as fuel is revolutionizing the entire marine, railway, metallurgical, and manufacturing world, for the benefits derived from its use are so marked, especially in the production and reduction of copper, iron, steel, brass, and other metals. Within the next three years thousands of cupolas will be changed from coke to oil. Crucibles for melting brass are now giving place to a more modern idea, that of a rotary melting oil furnace, which both improves the quality of the metal and increases the output at considerably less expense and with greater ease. Soon every up-to-date blacksmith shop throughout the country will be using liquid fuel, regardless of the price of oil, because of the superior quality and quantity of output produced by its use. Let us each during the coming years aid all we can in the scientific introduction of this fuel.



OIL BURNER FOR LOCOMOTIVES.

CONTEMPORARY ELECTRICAL SCIENCE.*

EFFECT OF CONCENTRATION UPON RADIO-ACTIVITY.—Some experiments have recently been made to test whether the radio-activity of radium is influenced by the continuous bombardment to which it is subjected by its own radiations. In order to test this point E. Rutherford has made measurements of the radio-activity of radium bromide when in the solid state and when diffused throughout the mass of a solution more than a thousand times the volume occupied by the radium compound. The results show that such a dilution has no appreciable influence on the radio-activity. This experiment shows that, over the range investigated, the radio-activity of radium is not influenced by its own intense radiations. The result is in agreement with previous observations, for neither the radio-activity of any active product nor the rate of loss of its activity has been found to be affected by its degree of concentration. It is thus improbable that the energy given out by radium is due to an absorption of an unknown external radiation which is similar in character to the radiations which are emitted. Experiments are in progress to test whether still further dilution of the radium solution produces any alteration in its radio-activity.—E. Rutherford, Nature, January 7, 1904.

ELECTRO-MECHANICAL GEARING.—No mechanical system has been hitherto devised which allows of a continuous variation of speed with any considerable power. The electric motor is the most elastic machine in use, but where the motive power is supplied in a mechanical form it requires its complete transformation into electric power. Paul Gasnier has devised a new system of transmission which he calls the "electro-mechanical" system, which, with very simple constructions, enables one to produce a continuous variation of the velocity of the working part from complete stoppage to the maximum, and only requires secondary dynamos of about one-third or one-fourth of the original motive power. A varying fraction of the motive power is always transmitted direct to the shaft. The rest, which varies with the velocity, is absorbed by one of the dynamos working as a generator and given out by the other dynamo working as a motor. This transmission is particularly convenient where the distances to be traversed are small, as in automobiles. It is superior to pure electric transmission in weight and efficiency. The principle is the following: A train of epicyclic gearing is employed in such a manner that the final shaft is always driven both by the motive power and by the motor dynamo. These two machines are, however, separate, and can have different velocities. In one arrangement there is an epicyclic train of straight-cut wheels, composed of a central pinion concentric with an outer and larger pinion having internal teeth. The two pinions are joined by a number of idle wheels. It suffices to combine the three things—outer pinion, inner pinion and supports of the idle wheels—each with one of the three organs—motive power, dynamo and final shaft—to obtain the desired result.—P. Gasnier, Comptes Rendus, December 28, 1903.

SYNCHRONOUS ROTATIONS.—In the telegraphic transmission of photographs, half-tone blocks, handwriting and drawings, the main requisite is the accurate synchronism of two cylinders, one at the transmitting station and the other at the receiving station. The adoption of the telautograph principle renders this synchronism unnecessary in the case of drawings, but when the picture has to be split up into a number of elements of various intensities the synchronous cylinders becoming dispensable. A. Korn gives some hints as to how this synchronism can be best secured. A shunt-wound continuous-current motor is the best for securing a uniform speed, and it can be maintained in uniform rotation at a given speed with the aid of a Hartmann-Kempf speed indicator, in which the frequency is indicated by a set of springs tuned to different natural pitches, one of which, having a pitch corresponding to the revolutions of the cylinder, responds, while the others remain at rest. The record is traced on the cylinder in a close spiral. The uniformity of the revolutions is not, however, sufficient to insure a good record, since a lag too slight to be discovered might be fatal to a proper transmission. It is, therefore, necessary to have an automatic controlling and correcting device. The author describes such a device.

* Compiled by E. E. Fournier d'Albe in the Electrician.

The principle is that the faster cylinder is arrested at each revolution for the small fraction of a second by which it is in advance of the slower cylinder. To avoid the necessity of stopping both cylinders alternately, the receiving cylinder is made to rotate 1 per cent quicker than the transmitting cylinder, so that the corrections are always in the same direction. The stoppage is made by a catch which is released by a current from the transmitting station as soon as the transmitting cylinder has completed its own revolution. During the stoppage, the driving shaft revolves in the receiving cylinder with slight friction, sufficient to make the latter revolve at full speed on release.—A. Korn, Phys. Zeitschr., January 1, 1904.

Selenium Cells.—Bidwell's theory attributes the sensibility of a selenium cell to the presence of selenides from which selenium apparently never is free. This view is supported by the facts that the conduction of the cell is electrolytic in character and that selenium is a poor conductor, while the selenides are not. Besides, sunlight actually brings about a combination of metal and selenium, forming a stable conducting selenide. A. H. Pfund has tested this theory by a number of experiments, and concludes rather that the sensitiveness is due to some direct action of light upon the selenium itself. He purified selenium by a method devised by Lehner, in which the selenium is dissolved in hot nitric acid and evaporated to form the dioxide, which is then sublimated until it has lost all color. He used carbon electrodes instead of metallic electrodes. Granting that in a selenium cell most, if not all, of the conduction is electrolytic in character and due to the presence of a selenide, it follows that there is an actual motion of the components of the selenide toward the electrodes of the cell. It is not unreasonable to suppose that light, in falling upon selenium, might also change its crystalline character, and that this new modification might offer less resistance to the ions of the selenide as they wander toward the electrodes, thereby producing indirectly an increase in their velocities, which is equivalent to a decrease in the resistance of the cell. If the new modification of selenium is stable only in light, it would revert to its original condition when light is cut off, the change taking place more rapidly at first. This would account for the fact that light produces changes in the resistance of a cell whether a current be flowing or not, and affords a possible explanation of the fact, discovered by the author, that the position of maximum sensibility is independent of the metal in the selenide.—A. H. Pfund, Phil. Mag., January, 1904.

PRIMITIVE RUBY MINING IN BURMAH.

The system practised for obtaining rubies in the mining district in Burmah is of the most primitive description. The mining shafts are simply holes about two feet square, sunk to a depth varying up to 50 or 60 feet. The shoring up of the walls of the shaft is most crude, the sides being supported by posts at the corners and branches of small trees secured against the sides by stout sticks. The miner carries a tin pot similar in shape to a blunt-ended cone on his head. He squats down in one corner and digs between his knees in the opposite corner. The earth or byon, as the ruby-bearing earth is called, is conveyed to the top as fast as it is excavated, in small buckets let down from above. The apparatus for raising and lowering the buckets and baskets is simple in the extreme. A stout bamboo post about 20 feet high called a maungdine, is fixed upright in the ground at a convenient distance from the pit or dwin, and a long thinner bamboo, pivoted horizontally into the upper end of it so as to project an eighth from the mine, and the long arm toward the mine. From the end of the long arm hangs a long cane fastened to a longer thin bamboo, the latter ending in a double hook, and from the short end hangs a basket of stones. The buckets are raised by the inner arm with its hook, while the stones counterbalance the weight. Usually three men work in a dwin, one down below, one hauling up the baskets, and the third operator piles up the byon as it is received. The byon is excavated by means of a straight strong tool about 2 feet 3 inches long with a broad blade. The baskets are shallow and circular, with loop cane handles. When enough byon has been piled up it is taken off and put into a stone-paved circular inclosure resembling a bath, under a fall of water, and shoveled about with a mattock till the mud and clay is washed away, and the stones are all collected in a deep hole at the end of a narrow channel. These are then strained, sieved and finally sorted, and all rubies and sapphires placed in a little bamboo cup full of clean water, till the wash is over. They are then transferred to a little calico bag, which every mine-owner carries, and are finally transferred to the unclean hands of the money-lending fraternity, who flock round in crowds on the bazaar days to buy any stones found during the week.

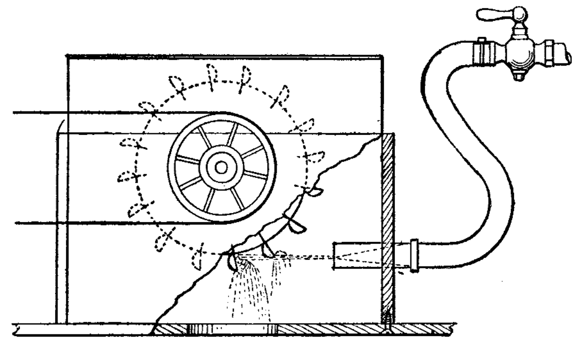
A HOMEMADE WATER MOTOR OF ONE-QUARTER HORSE-POWER.*

By H. F. Swartz.

A source of power lies in the city water service which can furnish motion for a multitude of experimental purposes. The impulse wheel here described developed 0.28 brake horse-power, and 1,000 revolutions, on a pressure of fifty pounds. But little water is consumed, since the jet is of only 3-16-inch diameter. The cost of materials is $1.05.

* Specially prepared for the Scientific American Supplement.

Cut a flat sheet of 1-16-inch brass into a circle 10 inches diameter, and in the center bore a ½-inch hole for the shaft. With a hack-saw cut in the circumference 16 radial slits ¾ inch deep. Take sixteen pieces of brass 1½ inches by 2½ inches, and of the thickness of the hack-saw, each making one cup. Shaping the cups is easy. A piece of broom-stick, with the tip rounded, serves for half the die, while a piece of iron pipe of 1 inch inside diameter serves as the other half. Lay one end of a brass strip on the pipe and hammer

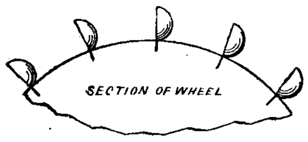


HOME-MADE WATER MOTOR.

the rounded end of the stick into it (see drawing), whereupon the cup is formed. Trim to shape indicated in the drawings, and hammer out any irregularities by fitting again upon the broom-stick. Solder the cups in the radial slits, best done over a Bunsen burner. The bowls of the cups must come tight against the wheel, and also run in good alignment.

The wheel is attached to the shaft by clamping between pulley collars. Get the size for a ½-inch shaft, by special order if necessary. Let the shaft be ½ inch in diameter and 10 inches long. Polish with emery cloth. Slip it through the wheel and mount a collar on each side, pressing them tight together, and fastening with the set-screws in the collars. A pulley can be mounted on either end of the shaft.

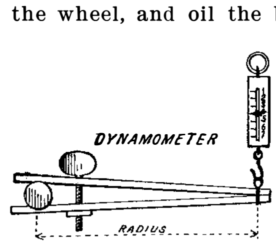
In making the jet, fill a piece of ½-inch galvanized pipe, 3½ inches long, with Babbitt metal. When cold bore a 3-16-inch hole through the center lengthwise. Make this hole conical, tapering from 3-16 inch to the full ½ inch. A square section wood reamer will do the job. Make the bore very smooth. The jet is attached to the water supply by a section of garden hose, held in place by the clamps furnished by any dealer for five cents.



SECTION OF THE WATER WHEEL.

The box is made in two parts. The lower carries the wheel, the bearings, and the jet, the upper serves to protect against spray. Use seasoned ⅞-inch stuff. The outside dimensions are 17 inches long, 11 inches high, 5 inches wide. Screw securely and brace with cast-iron angles. The box has no top nor bottom. Varnish to make waterproof.

Midway on each side, with its center 3 inches from the top, bore a 1½-inch hole for the Babbitt box, and from the upper edge of the box bore with a ¼-inch bit down through the larger holes well into the wood below. To prepare for casting the bearings, first wrap the shaft with two thicknesses of tissue paper, serving ultimately to give a little play between the bearing surfaces, then run it through the holes, centering it carefully. The shaft is held in place and the holes are covered to permit casting, by mounting the pulley collars and shoving them tight against the wood on the inside, and by snugly fitting cardboard to the shaft and tacking it on the outside. The metal is poured through the ¼-inch hole in one steady stream until it overflows. When the shaft is withdrawn and the cards and tissue paper removed, an excellent bearing will be found. From the top bore out ⅛-inch oil holes. Mount the wheel, and oil the bearings, when



ASCERTAINING THE POWER DEVELOPED.

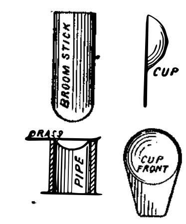
if the shaft is true, it will run easily and smoothly.

In the end of the box bore a hole with its center 2¾ inches from the lower edge, and 2½ inches from each side. The diameter of this hole should be such as just to permit the jet to be hammered in. The stream of water will thus hit the upper quarter of the lowest cup, when directly beneath the shaft, and the center of the cup next following. As the jet is apt not to be absolutely true, slight adjustment can be made by turning it upon its long axis.

Screw the box to a stout plank having a 3-inch hole directly under the center of the wheel. This board should be long enough to reach the length of the sink and be attached to the woodwork at each end. This is simple and firm. The joint can be made watertight by a washer of thin sheet rubber. If the wheel is used to drive a dynamo, both may be attached to the same base-board.

The spray guard is separate for convenience in casting the Babbitt boxes and subsequently for oiling. It is constructed of zinc, 6 inches high, and long and wide enough to slip snugly into the lower section for about 1 inch. Four screws will keep it in place. The machine is now complete.

To ascertain the power developed, there is needed a speed indicator, a spring balance graduated to fractions of an ounce, such as a postal scale, and a brake easily improvised of two small sticks and a screw, as shown in the drawings. Slip the brake on the shaft, attaching



MAKING THE CUPS.

the other end to the scales. Start at full speed, tighten the brake until the speed is reduced about one-third, count the revolutions and note how much the pressure on the scales exceeds that shown when the machine is at rest. Note also the exact distance from the center of the shaft to the point where the brake touches the scales; this is the "radius." The formula is as follows:

2 x radius x 3.1416 x revolutions per minute x weight on scale ÷ 33,000 = H. P.

For example, let radius be 8 inches, revolutions be 800, weight be 4 ounces;

$$\frac{2 \times 8 \times 3.1416 \times 800 \times 4\text{-}16}{33{,}000} = .3046 \text{ H. P.}$$

HISTORY OF TIMBER TREATMENT.*

Active progress in timber preservation dates from the year 1832. During this and the ten following years, the processes of Kyan, Bethell, Burnett and Boucherie, each giving his name to a process still known thereby, as well as the treatment patented by Margery, were introduced in England and France, and shortly put into very general use. Bethell, Burnett, and Margery differed principally and as applied later, entirely, in the chemicals used. Kyan advocated the bichloride of mercury or corrosive sublimate; Bethell, various substances, including the dead oil of coal tar; Burnett, chloride of zinc; Margery, sulphate of copper. Kyanizing was performed in open masonry pits without pressure, because of the corrosive effect of the mercury on metal. Burnett's and Margery's patents show that the chemical was intended to be introduced into the wood by soaking; but this in practice was soon abandoned by them and injection by pressure substituted.

The Bethell patent related more particularly to the *method* of treatment. This consisted of the use of closed vessels to contain the timber, in which first a vacuum was produced, the timber being partially surrounded by the chemicals, and being preferably placed in an upright position; then fully surrounded by the chemicals and pressure applied to force it into the wood. Bethell mentions the dead oil of coal tar as one of the preservatives which can be used. Two years prior to this, a patent was issued to Franz Mill for a treatment consisting of a preliminary heating in a closed vessel, then the admission of the vapor of the first distillate from coal tar, followed by soaking in this same distillate, which he called eupion—the object of all of which was to season the wood and prepare it for the next treatment, which was the soaking in the second distillate of coal tar, or what he called kreosot. This treatment has never been followed in practice, as it only wastes the first distillate; and Bethell's method of treatment using the dead oil, which is the second distillate of coal tar, called by Moll kreosot, supplanted it. Presumably the name of creosoting came from Moll's suggestion, although it is a misnomer. Creosote properly is the name given to one of the products of the destructive distillation of wood; and none of this material is secured in the distillation of coal tar. Several of the constituents of both are identical, however, and the name was early given to the dead oil of coal tar.

The name at any rate has stuck, and while the disposition to-day is to discourage the use of the term creosote for the material, using in preference the term "dead oil of coal tar," there is no objection to its use as a name for the treatment.

The Boucherie method differed radically from the others in the method of injecting the chemical, which was generally sulphate of copper. At first, Boucherie applied his chemical by means of vital suction. A tree was stripped of its branches, excepting those at the extreme top, a cut made around the tree near the bottom, through the sap wood, the cut covered by a cloth or other means, and the solution of the salt fed to the

* Extract from a paper by Walter W. Curtis, read before the New York Railroad Club.

open cut. The tree by its own suction would draw the preservative up through its entire length in a surprisingly short time. It is reported that in poplar it would rise 95 feet in seven days, and that a good-sized tree would absorb from 200 to 300 liters.

To follow this method on a commercial scale evidently was difficult, so it was modified by substituting for vital suction hydraulic pressure. The trees were cut into logs, a cap applied to one end and connected to a supply of the preservative under pressure, resulting in its being forced through the log, driving out sap and water ahead of it. This process was at one time extensively used in France with good results, and is still used there for the treatment of telegraph poles.

The processes of Kyan and Burnett, especially the latter, were used largely in Europe for many years. Burnettizing is still used to a considerable extent there, especially in Russia. Perhaps the proportion is best expressed in the statement in the 1901 Bulletin of the International Railway Congress, where of eighty-seven railroad managements reporting on ties, twenty-eight used no preservative methods, thirty-eight used creosote, eighteen used zinc chloride (Burnettizing), four used emulsions of creosote and zinc chloride, three used copper sulphate, one used brine. This plainly exhibits the recognition of the superiority of creosoting.

The history of treatment in the United States extends about as far back, but the adoption of treatment has not been as general. For this there has been good reason. Our supply of timber being much greater, and the quantities required greater while the cost has been much less, the necessity for the conservation of the supply and the economy of an expenditure for treatment has not been sufficiently evident.

The use of zinc chloride or Burnettizing dates from 1850, but prior to 1885 the amount of timber so treated was not large. The times were not ripe for it—timber was too cheap and plentiful. There are three men in this country who have done yeoman work for the subject of timber preservation; Mr. O. Chanute, who designed and built several of the early plants and who has been interested in the operation of works for nearly twenty years; Mr. A. A. Robinson, who as chief engineer of the Atchison in 1885, after four years of experimental work, had works built in New Mexico; and Mr. Kruttschnitt of the Southern Pacific, who built works at Houston, Texas, in 1887, and who supplemented this good work by having such records kept of the life of the timber so treated as to give us now something like reliable data as to what may be expected under like conditions.

The progress of Burnettizing was comparatively slow. I prepared a paper on this subject in 1899, in which I estimated that during the previous twelve years about 10,000,000 ties (and Burnettizing is used for nothing else) had been treated; and that during 1899 probably 1,500,000 more would be treated. Returns from all the works in the country, now numbering thirty-three, show that in 1903 over 11,000,000 ties were so treated, amounting to about 10 per cent of the entire tie supply of the country. This figure will be largely exceeded this year, probably reaching 14,000,000.

Creosoting in this country dates from 1865 and has been principally used for the treatment of piles and timber for marine work, to prevent destruction by worms. While a considerable number of ties have been so treated, the expense has been and still is too great to permit general use for this purpose. Creosoting is by all means the best method of preserving timber known, and wherever the financial conditions are such as to permit the first cost, and where the timber will not be destroyed mechanically regardless of its freedom from decay, there can be no question as to the best treatment to adopt.

When creosoting was introduced into the United States, the Bethell process was followed, consisting of a vacuum followed by the application of the preservative under pressure. This required thoroughly seasoned timber, which was an impossible condition here at that time.

I have not yet been able to satisfy myself as to who first proposed seasoning wood by steaming it. Various methods of seasoning were patented. Seely in 1867 was granted a patent on a method of impregnating, consisting of immersing the timber in an iron tank filled with oil, heating it to drive out moisture, replacing the hot oil suddenly with cold oil, whereby it is forced into the wood by condensation. A patent to Hayford in 1872 added to the use of steam for seasoning the pressure of hot air, to prevent the checking of the timber by the more rapid seasoning of the exterior portions of the wood. This method was advocated and followed by E. R. Andrews in his works at Boston.

S. B. Boulton in 1881 patented a method of seasoning by boiling the wood in the dead oil of coal tar, keeping the pressure in the cylinder below atmosphere, to permit the water to be removed at a lower temperature than 212 degrees. A patent to Messrs. W. G. Curtis and J. D. Isaacs, of the Southern Pacific Railroad, was granted in 1895, covering a process identical with Boulton's, except that they do not use the vacuum during boiling.

The philosophy of both is that as water is vaporized at 212 deg., while the oil does not vaporize under 300 deg., a temperature maintained between these will drive off all the water, which can then be replaced with oil by pressure. Both of these methods have been used in this country with success.

Preservatives for timber are needed to prevent decay and to prevent destruction by marine worms. As under ordinary conditions, untreated timber will resist decay for a considerably longer period than it will a hungry teredo family; and as the amount of timber used on land and in water differed very materially, the use of treated material for marine work made more rapid and general progress. It was soon recognized that no treatment would avail against the teredo and limnoria, except a large injection of dead oil of coal tar. Treating works naturally sprang up to supply the demand, located along the sea coast and gulf line.

These works doing commercial work principally, orders being placed only at the time the material was needed, necessitated the use of green timber and, I believe, few if any of these plants have yard room sufficient to store any considerable supply of material. The use of such green stock results in a much longer treatment being required and, in the opinion of some, in inferior work.

From eighteen to twenty hours are required to secure the same penetration as is possible with ten to twelve hours if air-seasoned material is used, the difference being principally in the length of time spent in steaming the timber.

If the English and Continental practice of long-time seasoning is followed, requiring storage for from eight to twelve months, the steaming is eliminated entirely and the time of treatment is cut down to about three hours.

The disposition in the West is to adopt air seasoning, as being more economical and better, for treatment by either the creosoting or Burnettizing processes. The plants at Somerville, Carbondale, and Grenada and those of the Chicago Tie Preserving Company operate on seasoned material entirely. At the Somerville plant there was on the ground seasoning on March 19, 1904:

Ties	859,207
Lumber	5,533,933 ft. B. M.
Piling	64,560 lineal ft.

The other plants being located farther north and being unable to secure their supplies at all seasons of the year, have so far been unable to secure such large stocks.

The use of creosoted material is now becoming more general for another purpose, which promises a large market. This is for decked trestle bridges, where the ballasted track is carried directly over the structure. Two types of such structures are in use; one where the deck is of solid timber, constituting the stringers and floor of the structure; the other, where separate stringers are used, covered with a 3-inch plank floor.

Mr. E. B. Cushing, engineer of M. of W. of the Atlantic system of the Southern Pacific, states that road began using solid deck creosoted bridges in 1885. "The first one built was examined recently and found to be in perfect condition. It has never had a dollar's worth of bridge work on it since it was driven, the surfacing, aligning, etc., being done by section men in ordinary process of track work."

The other type of bridge, using stringers and a plank floor, has been in use on the Louisville & Nashville for many years. Mr. R. Montfort, chief engineer, recently wrote me:

"I cannot state the length of life of creosoted timber where properly treated. I can, however, say that during the year 1876 the New Orleans, Mobile & Texas used a large quantity of creosoted timber as piling for piers of iron bridges over Chef Menteur, Rigolets, Pearl River, West Pascagoula and East Pascagoula rivers. We are now renewing the superstructures of these bridges; replacing bridges erected by the Phoenix Bridge Company in 1876 with plate girders. At the Great Rigolets we have placed the new superstructure on the piles driven in 1876. Some of these piles are as much as ninety feet long. At Chef Menteur we used seven piers, each consisting of sixteen piles, or a total of 112 piles, not one of which was found defective, although driven twenty-eight years ago. In this climate an untreated pile could not be counted on to last but about seven years, or at the most eight years. The piles at Chef Menteur vary from 75 feet to 90 feet in length.

"We have on the L. & N. miles and miles of trestle with creosoted stringers that were placed in 1876 and 1878, and are apparently as sound now as they were then. These trestles have, of course, been strengthened by the addition of other stringers so as to carry modern loads."

Mr. Montfort well says, in the face of such results, he cannot tell what is the length of life of properly creosoted material.

The development of the two types of timber deck described above has been due probably to two causes. The solid timber floor costs more and the open stringer form permits the use of both creosoted and uncreosoted material in the same structure. The Chief Engineer of the Southern Pacific, Mr. Hood, has made some tests of creosoted timber, which satisfied him the treatment seriously decreased its transverse strength. He has consequently changed his designs, using creosoted piles and timber below the stringers. These are spaced open and covered with 3-inch plank protected by ¼-inch thickness of prepared roofing and asphalt or with 3-inch plank creosoted.

He expects in this way to secure a long-lived structure with the maximum strength. Before generally accepting Mr. Hood's conclusions as to the effect of creosoting on the strength of timber, opposed as they are to the general understanding on the matter, confirmatory tests will be necessary to show that it is the creosote and not the manner of injecting it or the particular timber tested, which is responsible for his results. Such tests are in process and in contemplation, and I will be much surprised and disappointed if the same timber treated when air seasoned and with moderate temperatures, does not give better results. It is very unfortunate that more tests to prove the theories and methods in timber treatment have not been made; and disappointing as Mr. Hood's results are, the facts are needed and his work may result in showing a decided difference in the value of the various ways of applying the preservative.

The greatest demand, of course, of the railroads on our forests is for ties. A perfect preservative must be a germicide, which is insoluble in water, non-volatile under usual temperatures, preferably an excluder of air and water—and cheap. In the dead oil of coal tar, we have the first three elements and the fourth to a considerable degree. By the usual methods of injection, it cannot be called cheap, except in consideration of its ultimate economy through long life. Creosote in America is worth about one cent per pound, delivered at the works. The cost of the ties treated depends upon the amount injected. In Great Britain they use from eight to ten pounds of oil per cubic foot of timber for Baltic red-wood; in France and Germany for beech and pine, from ten to twenty pounds.

The life secured from the ties varies pretty closely according to the amount of preservative used.

On the basis of ten pounds per cubic foot, a tie containing three cubic feet would cost here, for oil alone, thirty cents.

The usual charge made by treating works for labor, fuel, profit, etc., is from $5 to $7 per 1,000 feet B. M. This adds to the cost of oil twenty to twenty-five cents. The cost of a 12-pound treatment would be about fifteen cents per cubic foot.

The cost of Burnettizing is about 3¼ cents per cubic foot.

The cost of zinc tannin is about 5 cents per cubic foot.

The cost of zinc creosote is about 7.5 cents per cubic foot.

This high cost of creosote accounts for the many efforts to secure the same results with other materials, or with combinations with other materials which will reduce the amount of tar oil required.

One way of doing this is to put in less oil alone, but the trouble is that the injection is then superficial and any checking of the timber or wearing under the rail destroys the protection, permitting access of air to the unprotected center and early decay. The Southern Pacific made a test in 1895 in West Texas, where 1,694 sap pine ties were impregnated with 6 pounds of tar oil per cubic foot, and laid in track with the same number of untreated ties of the same character. After 5 1-3 years' service, not one of the creosoted ties had been removed, while 16 per cent of the untreated ones had been taken out on account of decay. Unfortunately no later reports have been made on this experiment.

The principal objection to the processes using zinc chloride, sulphate of copper and other mineral salts is that such salts are all more or less soluble in water—some of them indeed hygroscopic. They are effective germicides, and as long as they remain in the wood in sufficient quantity, will prevent decay. It will probably be admitted that the injection of any antiseptic, which at the same time has no directly injurious effect on timber, is beneficial, and in proportion to its antiseptic power and its difficulty of removal. The solutions containing metallic salts are more readily injected than oils and it has consequently been attempted to use them in conjunction, and various methods have been patented for this purpose. Mr. J. B. Card, who introduced the Wellhouse treatment, proposed a method of first injecting a small amount of tar oil, then, immediately thereafter, injecting a solution of zinc chloride. He stated that by this means he secured a much better distribution of the oil throughout the wood than was possible with the ordinary injection of the same amount of oil, and at the same time thoroughly protected the interior of the stick with the zinc chloride.

In Germany a method has been used for a number of years in which the solution of zinc chloride is mixed with tar oil and the two injected at one time into the timber. This method requires for its success a very light grade of oil difficult to obtain and of high cost, and there is some discrepancy in the reports of observers as to the uniformity of injection in ties occupying varying positions in the cylinder, the tendency being, of course, in any such mixture for the oil and water to separate on account of their varying specific gravities. This method, however, has given satisfactory results in practice, and is undoubtedly an improvement over straight Burnettizing.

In April, 1894, the Southern Pacific laid in western Texas 1,824 sap pine ties, which were given an injection of 12 pounds of 2 per cent solution of zinc chloride. The ties were then removed, allowed to dry in the air for ten days, replaced in the cylinder and given a second injection of 3 pounds of creosote, both quantities being in pounds per cubic foot.

At the same time, 1,694 untreated heart pine ties were placed in the same piece of track. In December, 1900, after nine years and eight months of service, 8 per cent of the treated ties had been removed, and 94 per cent of the untreated heart pine ties had been removed.

Another method of doing the same thing has been that of injecting the solution of zinc chloride and immediately following this with a second injection of tar oil, the first injection being stopped at the proper point

to permit the injection of about 3 pounds of tar oil per cubic foot. A number of these ties have been in service for six or eight years with very satisfactory results.

I have given above a statement of the comparative costs of the zinc creosote treatments as compared with others.

There is one other treatment which has been before the public for some years, and which has some very desirable theoretical features about it—namely, the Hasselmann process. This consists in boiling the timber in a solution of several substances, the principal one being sulphate of iron. There have been a number of treatments proposed whose value was based upon the securing of a chemical reaction in the wood itself, but there has been a good deal of skepticism about the securing of such reactions and the Hasselmann process seems to be the only one in which clear evidence has been given of success in that regard. This process is very cheap, the penetration of the wood thorough, and it is to be hoped that the claims of the promoters thereof may be justified by the test of time. The actual value of this process, however, for ties is still to be demonstrated, as compared with other treatments.

I have so far failed to mention a modification of the zinc chloride process known as the Wellhouse treatment. This consists of the injection of zinc chloride, followed by injections of solutions of glue and of tannin, the object of the two latter being to plug up the ducts of the timber by the artificial leather formed by the glue and tannin. This treatment has been in use in this country for a number of years with very satisfactory results, although it is now disputed as to the increased cost over the ordinary Burnettizing being justified by the increased life secured.

I do not propose to cumber your records with long statements as to the detailed results of treatment in this country, and I will only say that the Atchison, with an experience extending over 17 years, shows an average life for inferior pines and spruces treated with zinc chloride of 11 years. The Atlantic system of the Southern Pacific, with the same number of years' experience, shows a life of sap pine ties treated with the same material of nine and one-half years, while the Pacific system of the same road where treated ties have been used for 10 years report 57 per cent of the ties laid in track in 1895 as being in service after 8 years. The Pennsylvania Railroad in a test instituted in Indiana in 1892, where Burnettized hemlock, and untreated white oak laid in rock ballast, show an average life to date of 10.58 years for the first and 10.17 for the second, with 41½ per cent of the hemlock and 33 per cent of the oak still in service. With Burnettized tamarack, an average life of 8.84 years and of untreated white oak 9.47 years, both laid in gravel ballast and with now all of the ties removed, has been secured.

In a paper read last year before one of our societies, I summarized the situation as follows: "It is safe to say that whenever an inferior tie can be purchased and treated by Burnettizing, and then cost no more than a white oak or other first-class tie, the adoption of treatment by that or a better process is justified. It may not be possible to determine which particular treatment is the most profitable, but this should not be considered as justifying the failure to begin treatment. A plant should be designed to treat by either, and if the future necessitates a change, this can be readily made; and in the meanwhile, whichever has been adopted, it is reasonably certain results will be worth the cost."—Railroad Gazette.

STEEL AXLES.

An interesting paper on this subject was read at a meeting of the Western Railway Club, Chicago, by J. L. Replogle, superintendent of the forge and axle department of the Cambria Steel Company, of which the following is an abstract:

The comparative merit of steel and iron for car axles is a question which has engrossed the attention of railroad officials and axle makers for many years. We feel justified in saying that the experience of these years has demonstrated that steel is superior to iron for this purpose, not only on account of its greater power of resistance against the shocks and vibrations to which it is subjected in service, but also on account of its greater wearing properties, the friction being less than in the iron axle, where lack of sufficient heat, presence of scale, or other conditions often prevent perfect adhesion of the various constituent parts. Even a perfectly-welded iron axle will not allow the high polish and minimum amount of friction obtainable in the steel axle of the proper composition.

Method of Manufacture.—In the early days of steel axles, the steel maker had difficulty in proving the superiority of his product, as there were numerous breakages in service for which he could not account, his chemical analysis indicating that the elements were of the proper proportion to the evident requirements of the purpose. In looking for the cause, he found that while his light hammers of probably 2,000 pounds falling weight were sufficiently powerful for building up iron bars probably 1 inch to 2 inches thick into an axle of approximately 5½ inches diameter, they were entirely inadequate for forging steel axles, as steel, not possessing the welding properties of iron, could not be forged in the same manner. Instead of building up from bars 1 inch to 2 inches thick, he was compelled to reverse the method, and hammer down from a billet about twice the size his finished forging should be.

His hammer, not being sufficiently powerful to penetrate throughout the mass, did not give the axle that homogeneous structure so essential in a forging subjected to the heavy alternating stresses which a car axle undergoes in service. The internal condition of his axle was revealed to him by the end of his rough forging, which was a deep concave, showing that the service metal only had expanded and that the inner portion had not received the proper working and consequent homogenity of structure which he desired. It also showed inclination to "pipe."

He appreciated his position and promptly strengthened it by the installation of heavier hammers—of about three times the weight formerly used. While he immediately saw a distinct improvement in his forging (the end now being convex, indicating that the inner portion had received proper attention), the steel axle did not give the absolute satisfaction of which he thought it capable, and an investigation proved to him that heat treatment in the forge was largely responsible. He reasoned that as no two parts of the axle were forged at the same temperaure, internal strains had set in which were very detrimental to the forging, and which would have to be relieved. This was particularly evident in locomotive driving axles, which, after cutting key-way, thereby relieving strains in the fibers, would often become distorted.

To relieve the injurious strains above stated, he resorted to annealing. By heating the forging to a temperature slightly above the recalescent point (which, in steel of the carbon usually found in axles, would be approximately 1,200 deg. Fah.), he eliminated all crystallization resultant from the cooling from the forging temperature of about 1,800 deg. Fah., and a fine amorphous structure was obtained. Crystallization would of course set in again when forging was being cooled, but as in the annealing he did not approach within 400 deg. or 500 deg. the temperature at which his axle was forged, the resultant crystallization was comparatively small. While the ductility of the annealed forging was greatly increased, it suffered a slight loss in elasticity.

Realizing the importance of having a high degree of elasticity in his material, which was continually subjected to severe alternating tension and compression, and often torsional strains, the axle maker started to experiment with a view of not only maintaining the elasticity found in the original forging before annealing, but also to increase it.

Various methods have been used to gain this result, among the more prominent being the Coffin toughening process and "oil tempering and annealing," either of which gives the following results: (1) The elastic limit is increased to a marked degree; (2) the percentage of elongation and reduction of area are greatly increased; (3) a remarkable degree of toughness is obtained; (4) steel changes from a crystalline to an amorphous state; (5) internal stresses are eliminated; (6) uniformity of structure and strength are obtained. The increase of elasticity is of the greatest possible benefit, as it is a recognized fact that once the elastic limit of metal has been passed and forging therefore distorted, it cannot be depended upon to sustain even minor loads.

In wrought iron forgings the elastic limit probably does not exceed 20,000 pounds per square inch. Steel of, say, .45 carbon, properly treated, will show almost three times as much elasticity, and is, therefore, much better fitted for the service described.

Specifications.—Our opinion as to the best specification would be an indorsement of the present master car builders' specification, with a few exceptions, viz.:

(1) We would recommend an increase in carbon, making the limit .40 to .55 per cent, instead of .35 to .50 per cent, as at present. This would insure greater wear, permitting a higher polish with a consequent reduction of friction, and if properly treated, greater strength, but would necessitate a slight modification of the present drop test.

(2) We would insist upon all axles being thoroughly annealed, as by this method only is the true strength of the steel represented.

(3) We would adopt a "maximum weight" clause compelling manufacturers to rough turn forgings on journals and wheel seats to within ⅛ inch of your finished dimensions, thereby eliminating the necessity of your paying for 50 pounds to 75 pounds of excess material per axle, which also necessitates a vast amount of extra work and expense at the railroad shops, subjecting your lathes to both roughing and finishing duties, which are detrimental to the best results in fitting.

(4) We would recommend a maximum limit on phosphorus of .05 per cent instead of .07 per cent, as at present, to compensate for the recommended raise of the carbon by five points, both elements being hardeners, but carbon affecting the ductility less than the phosphorus, and being conducive to greater wearing qualities.

(5) We would modify that portion of clause 1 in the specification relating to the rough turning of axles, to read: "Axles must be rough turned on journals and wheel seats to within ⅛ inch of finished dimensions, and must be smooth forged between wheel fits." Rough turning on an axle between wheel fits robs the axle of the tough surface skin, which is a very valuable asset.

In this connection I would cite results of a test made at our works to demonstrate our claim: During a controversy with an inspector of a prominent road which specifies rough turning all over, we suggested to him that he take two axles of the same heat, one being rough turned to 5⅞ inches in center, the other being smooth forged to same dimension. These axles were subjected to same treatment throughout, and were then tested to breakage. The rough turned axle stood 21 blows of a 1,640-pound drop from 43 feet height, and the smooth-forged one stood 78 blows, or almost four times as severe a test. Tensile tests cut from the broken axles showed the same chemical and physical structure. Extensive tests made at another works by one of the leading railroads specifying this, show that in axles of the average carbon, the smooth-forged axle will stand approximately 43 per cent harder test than the rough-turned one. Rough turning an axle also makes it more susceptible to rust. These are but a few tests of the many made along this line, the aggregate of which leads us to believe that the railroads of this country are annually expending hundreds of thousands of dollars on this feature, and are thereby getting an inferior axle.

Broken Axles and Their Lessons.—We have seen broken axles around in various railroad shops, the examination of which leads us to the conclusion that failures were due to the fact that steel was too low in elasticity and tensile strength, steel of probably 30 or 35 per cent carbon being used. The failures were due largely to what has been termed "fatigue of metal," and show a detail fracture, a gradual parting of the steel, extending toward the center all around the piece, unquestionably caused by the imposed strains repeatedly approaching the low elastic strength of the soft steel. The substitution of a steel of higher carbon and elasticity would prevent failure of this kind. The observations of Dr. Charles B. Dudley, the eminent chemist of the Pennsylvania Railroad Company, are interesting and pertinent to this subject, and we quote him: "It is obvious that the journal of a car axle gets alternating bending stresses, that is, the metal is subject to alternate tension and compression with each revolution, and that during the life of an axle these stresses are many thousand, and perhaps million, times repeated."

The metal between the wheels is in like manner subjected at each revolution to the same alternating stresses. The effects of these repeated alternate bending stresses are almost too well known to need comment. Sooner or later, if the stress is high enough, all metal will rupture under these alternate strains. A marked characteristic of the fractured surface of a piece of metal which has broken from this cause is that it never presents fibrous appearance in the fracture, but is more or less smooth, possibly due to the fractured parts rubbing against each other and having the appearance of an old break. It commences where the maximum stress occurs on the surface of the section, and gradually works in from the surface until so small a part of the original area is left unbroken that a sudden shock or stress finishes the rupture. This breaking slowly, a little at a time, led to the description of this fracture as "detail fracture," which will never be confounded with a rupture produced in any other way.

The experience of the Pennsylvania Railroad Company on car axles on this point may be interesting. Steel axles were first used on the Pennsylvania Railroad in 1875. The maximum calculated fiber stress between wheels was about 15,000 pounds per square inch, and the maximum fiber stress in the journal was about 6,700 pounds per square inch. The steel of these axles was an acid, open-hearth steel, containing from .22 to .28 per cent carbon, and not over .04 per cent phosphorus, and with a tensile strength of about 65,000 pounds per square inch, and an elongation in 2 inches of over 25 per cent. So tough was this steel that one passenger car axle was tested under the drop test with 67 blows without rupture. Some 300 of these axles were put in service, and in the course of two years the journals began to fail from detail fracture. The matter became serious, and a consultation was held as to how to meet the difficulty. There seemed but two ways of procedure—either to increase the size or to change the nature of the metal. Since an increase in size meant a re-design of all the parts, the latter alternative was chosen, and a metal of 80,000 pounds tensile strength was substituted for the softer steel, no other changes being made. This completely cured the difficulty, and no case of breaking in detail in car axles is known to have occurred since that time, unless the metal was of lower tensile strength than the figure given, or the axle was worn to limit, so that the maximum fiber stress was too high.

Endurance tests made at the Watertown Arsenal by the United States government on wrought iron and .45 per cent carbon steel bars 1 inch diameter, 36 inches long, loaded in the middle, so that the fiber stress was 40,000 pounds per square inch, show a great superiority in favor of the latter. These bars were rotated 1,500 times per minute, the number of revolutions being recorded. The average number of revolutions of the wrought iron was 59,000, while the .45 per cent carbon steel bars broke after 976,000 revolutions, or 16½ times as severe a test.

To test the value of iron or steel for car axles, and the effect of strains similar to those imposed in service, Mr. Wohler, chief engineer of the Prussian State Railways, constructed machines for the purpose, by which the bars were exposed to vibrating actions and repeated strains within adjustable limits. For straining a cylindrical bar in a manner similar to that in which an axle is acted upon by the load it carries, a bar, placed in bearings, was caused to revolve; to one end (corresponding to the journal of axle) was attached a spring, giving a constant downward pull, by which action the bars were bent down at the end to a fixed distance, and, in its rotation, the action of the spring

caused it to bend in all directions successively, all around the circumference of the bar, by which means the alternate strains of compression and tension were produced. The breaking strain of fibrous iron, under these conditions, was from 20,160 pounds to 22,400 pounds per square inch; soft steel, 26,880 pounds to 33,600 pounds per square inch. Testing further, the effect of repeated strains applied to the center of a revolving axle, in which the fibers in each section are strained in the same direction each time, the tension on each fiber varying between zero and the strain imposed. Fibrous iron broke at a tensile strain of 33,600 pounds to 40,320 pounds per square inch; soft steel at 50,400 pounds to 56,000 pounds per square inch.

Walter E. Koch, formerly of the works at Landore (the original Siemens works and later of Pittsburg), in his paper on "Fifteen Years' Experience with Open Hearth Steel," says: "Statistics show in Great Britain that eight iron axles break to every one of steel, and it is astonishing to me that so many iron axles are still in use in this progressive country." Mr. Koch, when written to concerning this statement, said: "I referred to straight and not to crank axles, and at that time there were about half iron and half steel in use."—Mechanical Engineer.

MOVABLE CYLINDRICAL DAMS.

Dams have assumed considerable importance during the last twenty-five or thirty years, both from the viewpoint of interior navigation for assuring or raising of the plane of water in the successive reaches of canals, and from that of installations of hydraulic motive power, which electricity permits of complying under the best of conditions. In most cases it is of importance to have a means, of causing the almost complete disappearance of the parts of a dam during a high flood, so that they shall not interfere with the flow of the water and thus involve inundations or the destruction of the dam by the violence of the water. Of course, if it is a question of a water course having a large discharge, it must be rendered possible to effect the manipulations quite rapidly, despite the width of the entire channel, and consequently that of the dam, divided into a certain number of secondary channels; and it is desirable that all the parts of the work, aside from the sustaining piers, shall be removed from the water, since the stream is constantly carrying along sand and gravel that would soon wear away and quickly bury such parts.

Wooden dams such as the one that may be seen, for example, at the Sluice of La Monuaie, at Paris, are far from answering this desideratum, since the removal of the narrow pieces that compose them is a long and troublesome operation. M. Cameré, a French government engineer, has devised a very practical system, which is very highly appreciated in foreign countries, and which is called a curtain dam. The retaining arrangement is a curtain formed of strips of wood and which may be rolled up or unrolled vertically upon supports which are themselves vertical. These latter are jointed at their upper part by a swivel fixed upon the lower beam of a foot-bridge crossing the entire width of the dam, and they rest beneath upon a projecting masonry sill arranged in the bed of the watercourse. A windlass, rolling over the bridge, permits of winding up and unwinding the curtains, or of removing them entirely during freshets, after which the vertical supports are lifted and then laid in a horizontal position. Unfortunately, although this system renders great services, it necessitates a projecting sill which collects sand very rapidly and often requires cleaning; and all this complication involves a considerable cost of establishment. So, upon works as important as the Rhone dam at Chivres, or that in the Rhine at Rheinfelden, recourse is had to flood gates

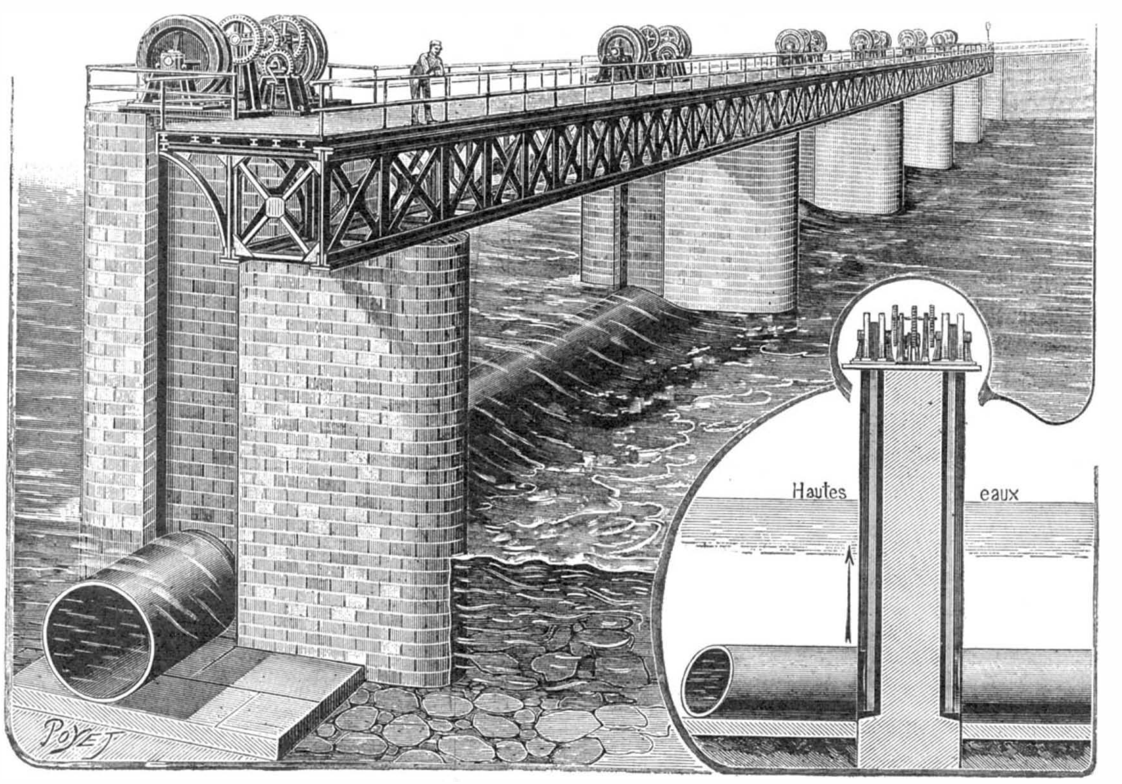


Fig. 1.—A DAM OF THE KŒCHLIN TYPE.

that slide in grooves through the intermedium of rollers, in order to diminish the weight of parts of very large dimensions. But, in place of flat and vertical flood gates, there has just been devised, in two places at the same time, a very original cylindrical arrangement. We shall mention in the first place the system devised by M. René Kœchlin, who, in planning a powerful installation of motive power at Mulhouse upon the Rhine, with a dam of 10 feet for a width of 690, has endeavored to establish flood gates of more than 85 feet in width, under the simplest conditions of operation and maintenance. The flat gate is here replaced by a hollow cylinder of iron or steel plate, of a diameter equal to the height of the water that it is desired to hold back. Here there is no need of a sill in relief, since the rolling gate rests through its own weight upon a horizontal smooth sill established upon masonry in the bed of the watercourse. The extremities of the roller engage with two vertical grooves formed in the masonry of the piers situated on each side of the channel of the dam. Vertical rails arranged in these grooves form rolling-paths that diminish by so much the resistance of the cylinder when it is desired to cause it to roll in order to raise or lower it. This motion is assured by two cables that pass under each end of the cylinder. One of the extremities of each of these cables is anchored at the summit of the lateral pier, while the other passes over the drum of a hoisting apparatus. When, for example, it is a question of raising the cylinder, the two hoisting apparatus which are rendered interdependent by one shaft in common, are set in operation, and the two cables are consequently wound up by a synchronous motion, and the cylinder is raised by revolving upon itself. For a depth of 10 feet, the cylinder, with its diameter of 10 feet and its thickness of 6 inches, has a weight of 45 tons with the re-inforcements necessary, and each hoisting apparatus has a load of scarcely 11 tons. With electric motors, the hoisting, which would

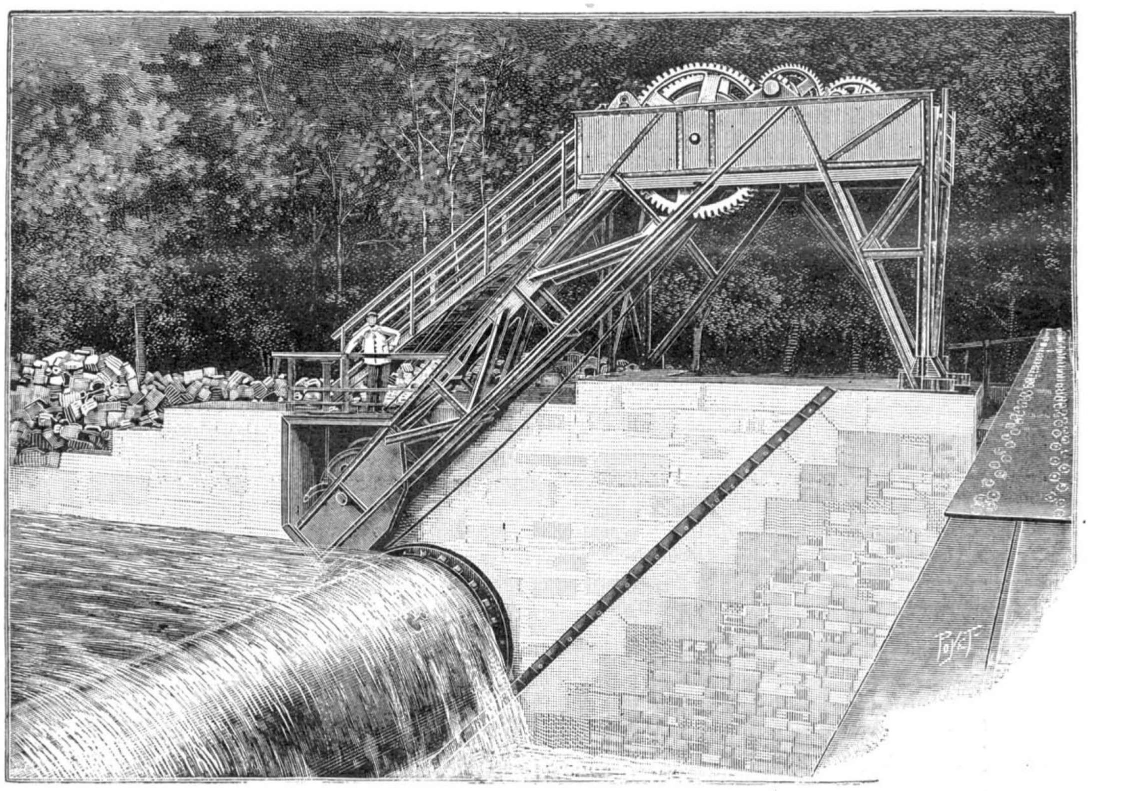


Fig. 2.—A GERMAN CYLINDRICAL DAM.

take an hour by hand, can be performed in ten minutes. As the cylinders hollow and naturally open up its two ends, an accidental overload in cases of frost must be anticipated.

It is unnecessary to say that, instead of employing cylinders of large diameter, it is possible to superpose two or more cylinders in the same channel. At all events, such a kind of gate permits of damming very long spans without any fear of distortions. The cylindrical form assures a great saving with a very high resistance, and is well adapted to the passage of water. There are no pieces that are apt to become clogged up with sand, and the resistances, owing to the constant rolling, are reduced to a minimum.

This idea is so practical that it has attracted the attention of a German house, the Vereinigte Maschinenfabrik, of Augsburg and Nurnburg. This establishment also has given a cylindrical form to the movable part of a dam; but, as may be seen from the accompanying figure, the cylinder, instead of being raised vertically, rolls over two planes inclined at an angle of about forty-five degrees, and provided with racks. It can be easily seen that the rotary motion of the cylinder is here likewise obtained by means of a double cable which passes over each of its extremities, and, on the other hand, over a drum actuated by gears. A dam of this kind is already established at Schuimfurth, of which the span is 60 feet and the height of the retained water 13. The same establishment is now constructing another dam of its system that will have a span of 115 feet, but a height of only 6½. It seems to us, however, that the vertical arrangement is superior, since the use of the rack, although having the advantage of furnishing a point of fulcrumage for the raising of the cylinder, will perhaps give rise to miscalculations, as deposits of sand may form in its submerged part. But, in both cases, the general idea is excellent, and will doubtless be put in practice under many circumstances.—Translated for the Scientific American Supplement from La Nature.

Annealing Tools.—This work requires the use of substances which yield their carbon readily and quickly to the tools on contact at a high temperature. Experience has shown that the best results are obtained by the use of yellow blood-lye salt (yellow prussiate of potash), which, when brought in contact with the tool at a cherry-red heat, becomes fluid, and in this condition has a strong cementing effect. The annealing process is as follows: The tool is heated to a cherry red and the blood-lye salt sprinkled over the surface which is to be annealed. A fine sieve should be used, to secure an even distribution of the substance. The tool is then put back into the fire, heated to the proper temperature for tempering, and tempered. If it is desired to give a higher or more thorough tempering to iron or soft steel, the annealing process is repeated two or three times. The surface of the tool must, of course, be entirely free from scale. Small tools to which it is desired to impart a considerable degree of hardness by annealing with blood-lye salt are tempered as follows: Blood-lye salt is melted in an iron vessel over a moderate fire, and the tool, heated to a brown-red heat, placed in the melted salt, where it is allowed to remain for about 15 minutes. It is then heated to the hardening temperature and hardened. A similar but milder effect is produced in small, thin tools by making them repeatedly red-hot, immersing them slowly in oil or grease, reheating them, and finally tempering them in water. To increase the effect, soot or powdered charcoal is added to the oil or grease (train oil) till a thick paste is formed, into which the red-hot tool is plunged. By this means the tool is covered with a thick, not very combustible coating, which produces a powerful cementation at the

next heating. By mixing flour, yellow blood-lye salt, saltpeter, horn shavings, or ground hoofs, grease, and wax, a paste is formed which serves the same purpose. A choice may be made of any of the preparations sold as a "hardening paste"; they are all more or less of the same composition. We give one recipe: Melt 500 grains of wax, 500 grains tallow, 100 grains resin, add a mixture of leather-coal, horn shavings, and ground hoofs in equal parts till a paste is formed, then add 10 grains saltpeter and 50 to 100 grains powdered yellow blood-lye salt, and stir well. The tools are put into this paste while red hot, allowed to cool in it, then reheated and tempered.—Der Metallarbeiter.

BETHLEHEM STEEL COMPANY EXHIBIT IN THE MINES AND METALLURGY BUILDING.

By the St. Louis Correspondent of the Scientific American.

Too much cannot be said in praise of the very thorough manner in which several of the largest industrial concerns in the United States have exhibited the products and processes of their plants at the St. Louis Exposition. The Bethlehem Steel Company is a notable instance of this, and their remarkable collection of material in the Mines Building is one of the best exhibits in the whole exposition. It stands partly upon the level of the main floor and partly in a large depressed area. Upon the upper portion stands a full-sized model of a 12-inch gun turret, with the two 12-inch guns projecting far over the exhibits in the tower area. Flanking this gun on either side are several fine specimens of the smaller types of army and navy guns.

Below the 12-inch guns are several pieces of armor plate which have undergone test at the proving ground. To the left of the 12-inch gun turret, as viewed in the picture, is a section of the cast-iron lining for the tunnel beneath the Hudson River, one tube of which was recently completed, and has been fully described in this journal. In front of this section is a 4-inch 50-caliber rapid-fire gun on a pedestal mount, and, from left to right, are a limber for a 3-inch field gun, a three-pounder semi-automatic gun, a 3-inch long recoil horse artillery gun and carriage and a limber for the same, while in the right-hand corner at the foot of the stairway is a 5-inch 45-caliber gun on a pedestal mount. Returning to the left side of the picture we see a full-sized model of a side armor plate for the United States battleship "Louisiana," and back of it is a model of the big steel ingot from which this armor plate was forged. In the foreground to the right of the picture is a hollow forged-steel jacket for a 13-inch gun, ready machined for assembling; its weight is 43,000 pounds. The large piece shown adjoining this in the foreground is a cast-steel top-carriage for a 12-inch disappearing gun carriage, and to the left of that is half of a four-throw crankshaft for a marine engine.

In view of the popular belief that the price paid for modern armor plate is such as to secure for the company unprecedented profits, there has been laid out on shelving that runs entirely around the depressed portion of this exhibit, a display of the materials that are necessary to produce an armor plate. First on this shelf is seen a small model of the big "Louisiana" armor plate shown at the left of the exhibit, the model being one-twenty-fifth the size of the actual plate. Then follow little (and not so very little) piles of ore, coal, and limestone, representing the actual amount necessary to produce the pig iron from which the plate is cast and forged. Then follow other piles of coal, representing the fuel used in the various heat treatments; piles of fuel representing consumption of power in the machine shops, one pile for each machining process through which the plate has to pass—the whole proving clearly that the mere bulk of the plate is no criterion whatever of the enormous cost in fuel and labor necessary to bring it to the proper condition for resisting modern projectiles. We venture to say that if any citizen will take the trouble to enter this exhibit, pass around this succession of coal piles, and learn from the engineer in charge just what each represents, he will come away with a new idea of the marvelous complexity and difficulty of armor-plate manufacture, and with a clear understanding of why it is that the government pays from $400 to $500 for every ton of armor plate that it places upon its warships.

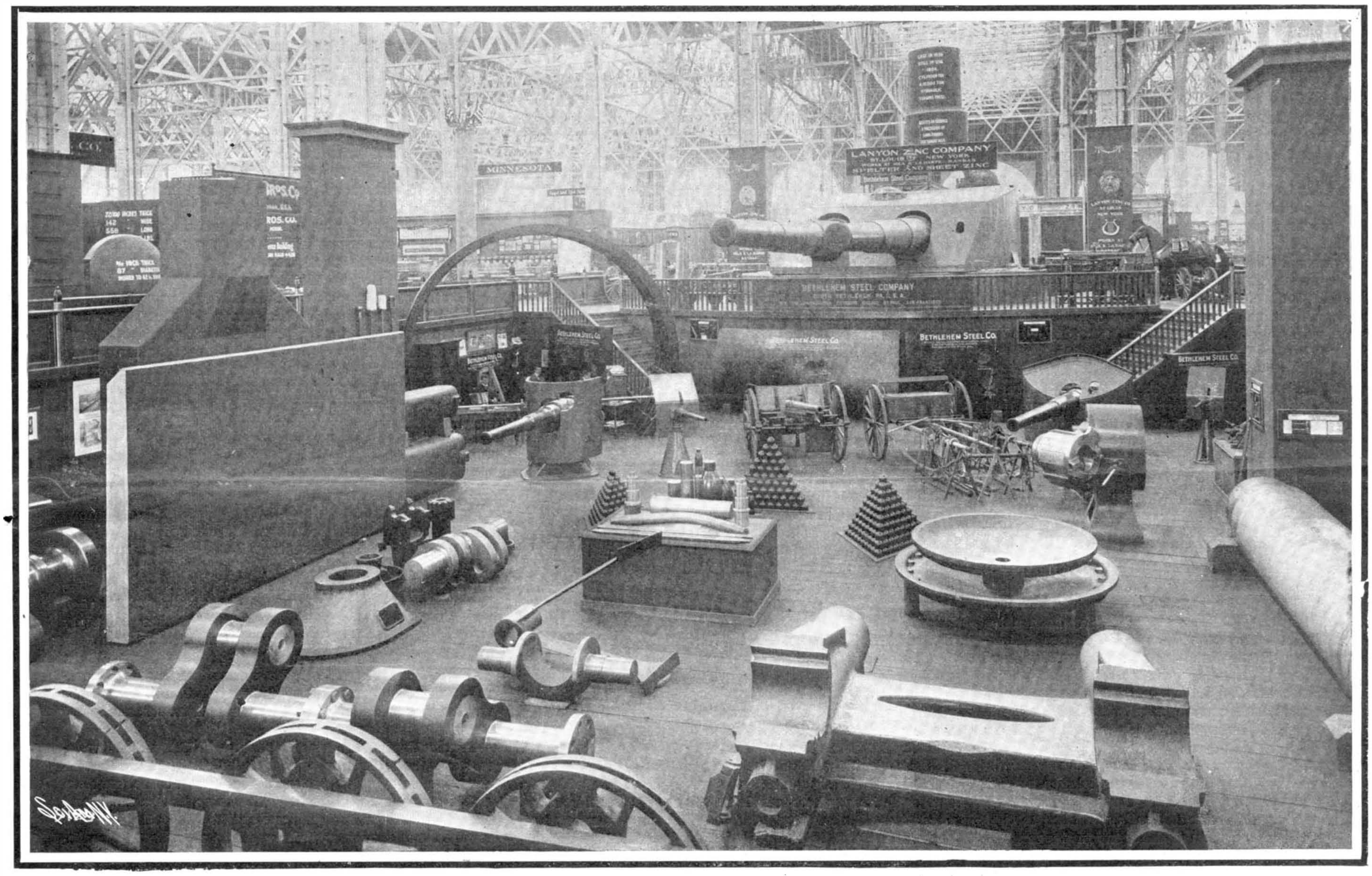


EXHIBIT OF WAR MATERIAL IN THE MINES AND METALLURGY BUILDING.

SIR ARCHIBALD GEIKIE ON EMERGENCE AND SUBMERGENCE OF LAND.

At the recent anniversary of the Geological Society, when the president was unable from illness to be present, his place was taken by Sir Archibald Geikie, who prepared an address for the occasion on the evidence supplied by the British Isles as to the problem of the causes of changes in the relative levels of sea and land. This address appears in full in the Quarterly Journal of the society, and we here reproduce it in abstract.

(i.) *Emergence.*—Geologists in the British Isles have long indulged the confident belief that raised beaches afford demonstrative proof of changes in the relative levels of sea and land. The abundant and striking examples of them around our coasts have been universally accepted among us as marking former sea-margins, whether the sea be supposed to have risen upon the land or the land to have been upheaved above the sea. The recurrence of precisely similar terraces along the western coast of Norway, but on a still more impressive scale, has been regarded as furnishing evidence of an extensive emergence of land, from the south of Britain to the northern end of the Scandinavian peninsula. Prof. Suess, however, seeks to show that, at least as regards the northwestern coast of Norway, these opinions are based upon a misreading of the evidence. After his visit to that region, and his study of the literature of the strand-lines, there so wonderfully developed, he has come to the conclusion that the Norwegian fjords furnish no argument against his doctrine that there has been no recent upheaval of the land. He asserts that "we must interpret all the *seter* (rock-shelves) and the great majority of the terraces in the fjords of western Norway as proofs of the retreat of the ice that once covered so much of the peninsula, and not as proofs of any oscillations of the surface of the sea, still less of any movement of the solid land." It would widen the inquiry too much to enter upon an examination of the evidence as it is presented in Scandinavia. But the author of the address, having been all his life familiar with the strand-lines of this country, and having traced those of the Norwegian coast from Bergen to Hammerfest, directed attention to one or two of the insuperable difficulties with which Prof. Suess's theoretical explanation seemed to him to be beset. The great Austrian geologist appears to have unwittingly confounded two sets of beach-lines, which differ a good deal from each other in general character, and are entirely distinct in origin. Availing himself of the remarkably full and interesting researches of Scandinavian geologists regarding the glaciation of their country, he dwells upon the importance of the terraces left by the fresh-water lakes that were dammed back by the great ice-sheet as it retired. He believes that these phenomena extended even to the Norwegian coast, and that the strand-lines of the fjords, whether in the form of platforms eroded out of the solid rock (seter) or terraces of sediment, mark former levels of lakes that filled these valleys when their mouths were blocked up with the ice-sheet. As the lowest of these strand-lines includes sands and gravels crowded with marine shells, he is compelled to admit that it marks a former sea-beach. But he endeavors to discriminate between it and the other horizontal shelves, which follow it in parallel lines at higher levels. He affirms that the latter present a series of "characters absolutely irreconcilable with what we know of the action of the sea along a shore"—such as the series of fragmentary terraces found at increasing heights inland, their absence from the parts near the general coast-line, and the breadth of the seter. He passes lightly over the fact that some of these higher terraces have yielded marine organisms which are progressively of more Arctic character, according to their altitude, and according, consequently, to the antiquity of the sediments in which they lie.

Now, according to the experience of those northern geologists who have specially studied Scandinavian glaciation, the lakes that were formed by the ponding-back of the drainage against the flanks of the ice-sheet lie to the east of the watershed of the peninsula. These observers have ascertained that when the ice-sheet was waning, it retreated eastward from the backbone of the country and lay on the eastern or Swedish slope, leaving a gradually increasing breadth of ground clear of ice. The streams flowing eastward over this liberated area had their drainage arrested against the margin of the ice; and hence arose a vast series of

lakes which lasted for longer or shorter periods, until, by the continued creeping backward of the ice, their contents were drained off to lower levels. A multitude of records of old water-levels, or "strand-lines," was thus left over the surface of the country. It is the opinion of Scandinavian geologists that all the terraces not of marine origin lie within that area.

As one of the distinctive characters of the shore-lines left by the glacier-lakes, the author of the "Antlitz der Erde" cites the occurrence of the rock-shelves or platforms (seter) eroded out of the solid rock, and he refers the origin of these common features of the fjords to the daily oscillations of temperature at the surface of the lakes. A reference to the abundant examples of such rock-shelves in our own islands showed that this explanation is at least inadequate. If, however, for a moment, we grant that the strand-lines, including the seter of the Norwegian fjords, do mark levels of former fresh-water lakes, it is obvious that, in order to pond the drainage back and produce these lakes, the mouths of the fjords must have been in some way blocked up by a barrier which has disappeared. If this barrier were land-ice, as Prof. Suess appears to assume, the water would rise behind it, until, if the overflow found no escape into the Atlantic, it would pass over the watershed, and joining the various bodies of water that were there intercepted by the great Swedish ice-sheet, would eventually find its way into the Gulf of Bothnia. There would thus be two huge bodies of ice, between which the drainage was accumulated. We must remember, however, that the strand-lines are not confined to the fjords, but sweep round the coast on either side, and even appear on the islands that flank the mainland of Norway, some of them actually looking out to the open sea. The supposed ice-sheet must therefore have lain mainly outside these islands. But there is absolutely no evidence of any such detached western ice-body, and every reason to believe that it never existed.

At the period of maximum glaciation the ice-sheet probably advanced westward beyond the present limits of the land. But, when it began to retreat, it would naturally creep backward up the fjords, which would be still the main lines of ice-drainage. We can conceive, indeed, that at an early stage of this retreat, a glacier or ice-lobe may here and there have blocked up a large valley and produced a lake, as in the instances cited by Prof. Suess from Greenland. But the strand-lines of western Norway are not exceptional phenomena. They continue as characteristic features of the coast-line and of the fjords for several hundred miles, and must owe their origin to some general and widely extending cause. That they are true sea-beaches, as has been generally believed, Sir Archibald Geikie had not the smallest doubt.

Fortunately, we possess in our own islands a body of evidence bearing on this question, not certainly as voluminous and impressive as that of Scandinavia, but having the compensating advantage of great simplicity and clearness. On the one hand, the famous Parallel Roads of Glen Spean and Glen Roy, and those of other less known valleys, stand out as acknowledged relics of glacier-lakes; while round our coasts, on both sides of the country, raised beaches, which have been hitherto regarded as old sea-margins, run for hundreds of miles. These two series of terraces are found close together, yet there is no difficulty in drawing a satisfactory distinction between them. Indeed, their proximity enables us all the more clearly to perceive their contrasts.

There must, of course, be certain general resemblances between the littoral formations of lakes and of the sea. The erosion produced by the waves or wavelets of a body of fresh water is similar in kind to that performed by the sea, although different in degree. In like manner, the beaches of deposit formed in lakes possess, on a minor scale, many of the characters of those accumulated along the seashore. And it may readily be granted that, in isolated exposures of some old beach, it may be difficult or impossible to decide, in default of evidence from elsewhere, whether the phenomena observable are to be assigned to the work of the sea or of a lake. Nevertheless, on a review of the whole evidence, at least as it is presented in this country, Sir Archibald felt very confident that there is no risk of confusion in this matter. The marine terraces maintain their distinctive features up to the very foot of the slopes where the lake terraces begin, while those in turn are marked by other special peculiarities.

Let any observer who has followed the great 50-foot raised beach along the western coast of Scotland and up the Linnhe Lock to the mouth of the Great Glen, look away to the right hand where the wide Strath of Spean leads into the interior. While yet standing on the platform of the raised beach, if the air be clear, his eye may detect the beginning of a line, drawn as with a ruler, at the same height along the slopes on either side of the valley. This is the lowest of the three great Parallel Roads of Glen Roy, and runs at a height of 850 feet above the level of the sea. If he will now ascend into Glen Roy, where the three terraces are best seen, he will soon be struck by the distinctive differences between these old lake-margins and the raised beaches with which he has already made himself familiar. In the first place, he will remark their faintness as compared with the marine platforms of the coast. Though readily traceable from a distance in their horizontal continuity, they are in many places hardly discernible when one is actually standing upon them. A little examination soon reveals that each of them has been produced mainly by the arrest of sediment washed from the slopes above into the water of the vanished lake. Instructive illustrations of this process may often be observed along the sides of reservoirs which have been constructed in steep-sided valleys; there each prolonged halt of the water at a particular level is marked by a shelf of detritus which, blown in by wind and washed down the declivities by rain, is stopped when it enters the water, where it accumulates as a miniature beach.

Here and there, especially on more exposed projections of the hillsides, there has been a little-cutting-back by the shore-waves or drifting ice-floes of the old lake in Glen Roy. Occasionally also, where a streamlet has entered the water, its arrested detritus has accumulated as a broad, flat delta or terrace. But it is manifest that, in such limited expanses of water, wind-waves could have been comparatively little erosive power. Nor can we imagine that, even if the water froze, its floe-ice could have had any potent influence in sawing into the rocks of the declivities, and producing seter or rock-shelves. Certainly throughout this wonderful assemblage of lake-shores, there is nothing for a moment to be compared to the incised platforms of rock so abundant as part of the raised beaches of the western coast of Scotland. We must remember also that the production of such ice-dammed lakes took place as a mere episode in the retreat of the ice. No means are available to determine what may have been the length of time during which the water stood at the level of any one of these Parallel Roads. We may probably infer, from the absence of well marked and continuous intervening shore-lines, that the shrinkage of the ice and the consequent lowering of the level of the water were somewhat rapid.

The Parallel Roads of Lochaber, although the most imposing, are not the only examples of the shore-lines of ancient glacier-lakes in this country. Another striking case is that of the Strath Bran in Ross-shire, where the glaciers descending from the mountains on each side ponded back the drainage of the valley, and sent it across the present watershed of the country at a height of about 600 feet above the sea. The conspicuous gravel-terraces at Achnashean are a memorial of this vanished sheet of water.

Now, with these undoubted records of ancient lakes, let us compare the structure and distribution of our Raised Beaches. These shore-lines are found, on both sides of Scotland at approximately the same heights above the level of the sea. They are partly terraces of deposit, and partly true seter or platforms cut out of the solid rock, the same beach presenting frequent alternations of both structures. In general, it may be said that the detrital terraces are found chiefly in bays, sea-lochs, or other sheltered places, while the rock-terraces are conspicuous in more open sounds and exposed parts of the coast, where the tidal currents and wind-waves are most powerful.

As the highest terraces are the oldest, they have been longest exposed to the influences of denudation, and are thus the faintest and most fragmentary. But the dimensions and perfection of a raised beach do not depend merely on age, but in large measure on the length of time that the water stood at that level, and the varying local conditions that favored or retarded the planing-down of solid rock or the deposition of littoral sediment.

That these beaches unquestionably mark shore-lines of the sea may be inferred on three grounds: (1) Their position on both sides of the island at corresponding heights. No possible arrangement of ice-dams in the Atlantic and in the basin of the North Sea can be conceived that would have everywhere ponded back the land-drainage to similar levels. (2) Their independence of local conditions. The same terrace may be traced down both sides of a sea-loch and round the coast into the next loch, retaining all the while its horizontal continuity. Not only on the mainland, but on the chain of islands outside, the same parallel bar has been incised, both on the inner or sheltered side and also on the outer flank looking to the open Atlantic. (3) Their organic remains. From the youngest of the beaches up to the highest, the terraces of deposit contain marine organisms which have not been scooped out of some earlier formation, but lie in the positions in which the animals died, or into which they were washed by shore-waves and currents. The fossils of the latest beaches are entirely identical, or almost so, with forms still living in the adjacent seas, while those of the higher beaches are boreal or Arctic.

In some sheltered places, such as the Dornoch Firth, especially near Tain, and some inlets on the west side of the Island of Jura, a number of successive bars or terraces of deposits may be observed up to heights of 100 feet or more above the sea. But there are in Scotland three strand-lines so conspicuous and so persistent that attention may be confined to them. From what has been taken to be their average height above mean sea-level or Ordnance-datum, they are known respectively as the 100-foot, the 50-foot, and the 25-foot beaches.

The author here adverted to what he has long regarded as a reproach to the geologists of this country. No systematic effort has ever yet been made to determine accurately, by a series of careful levelings, the precise heights of these old shore-lines. We only know that, roughly speaking, a raised beach retains its level for long distances, and appears to lie at the same height on both sides of the country. But we are still ignorant whether or not an appreciable difference of level might not be detected between the western and the eastern development of the same beach, nor do we know whether it would not betray some variation in its height between its northern and southern limits. There seems to be a tendency for the levels of the beaches to rise slightly toward the head of an estuary or sea-loch. But whether this difference is more than can be accounted for by the ordinary elevation of the tidal wave as it ascends a narrowing inlet remains to be determined.

Obviously, until accurate information is obtained on all ascertainable differences of level in the system of our raised beaches, we must remain unprovided with some of the most important material for a discussion of the history of these beaches. It is surely not too much to hope that one or more observers, endowed with the requisite geological knowledge and geodetic skill, may before long be found who will undertake the investigation of this interesting subject, and thus aid in the solution of a problem which does not merely concern the evolution of our own islands, but is of high importance as a question of geological history.

The 100-foot, 50-foot, and 25-foot beaches of Scotland were briefly described, and it was pointed out that in the structure of these old sea-margins a feature of special interest is presented by the platforms which have been eroded out of the solid rock, and which afford not a little light as to the origin of the Norwegian seter. The surface of these rock-terraces is flat, and usually covered with a thin coating of grass-grown soil through which harder knobs and stacks of the underlying rock here and there protrude. At the inner margin of the terrace, the rocks rise into a cliff or steep bank, the base of which is frequently pierced with caves. That these caves were mainly due to erosion by moving water is abundantly evident in the rounded and smoothed surfaces of their sides. Their floors are often rough with round shingle, which has undoubtedly been the material employed by nature in their excavation. No one who has made himself familiar with the rock-platforms which at the present day are in course of erosion by the sea along these same coasts can for a moment doubt that the rock-platforms of the raised beaches which, down to the minutest point, resemble them, have likewise been eroded by the waves of the sea.

That the daily oscillations of temperature invoked by Prof. Suess in explanation of the Norwegian seter have had their share in the erosion of these Scottish examples cannot be doubted. But this share is evidently feeble in amount now, although it may have been more considerable during the Glacial period. More potent as a contributory influence in the erosion of the older terraces was probably the action of floating ice, driven along the shores by winds and tidal currents. Down to the time of the 50-foot beach, when glaciers in the north of Scotland descended to the edge of the sea, there may have been a good deal of such ice in the more enclosed sea-lochs, where the water, freshened by the discharge of melting snow-fields and glaciers, might itself be covered with a cake of ice. And there was not improbably a good deal more ice in the fjords of Norway. The grinding and rasping action of such ice, driven by gales ashore, has long been remarked. But in any case we are justified in regarding the Scottish seter as examples of truly marine erosion, and there appears to be no reason why those of Norway should not have had the same origin. It is at least clear that the statement that the characters of seter "are absolutely irreconcilable with what we know of the action of the sea near its surface," cannot be sustained.

Certain features of the extension of the raised beaches throughout Britain appear to be of fundamental importance in relation to the discussion of the problem of the emergence of land. Though so persistent along both the western and eastern coasts of Scotland, these beaches, as is now well known, do not stretch northward into the Orkney and Shetland Isles. Along precipitous sea-fronts we could not expect to meet with them, but among these islands there are endless sheltered inlets and bays which, had they indented the shores of the mainland of Scotland, would undoubtedly have had their fringe of terraces. The conditions for the development and preservation of the beaches were so entirely favorable, that their absence can only be legitimately accounted for on the supposition that they can never have existed here. Still farther north, among the Færöe Isles, no trace of any raised beaches has been found among the numerous natural harbors and creeks that break the monotony of the vast ranges of basalt-precipice. Here, again, we cannot suppose that any such beaches were ever formed.

In the southward extension of the Scottish raised beaches these features begin to lose their distinctness as they are traced into England. The 100-foot beach, which has not been recognized along the northern coast of Sutherland or in Caithness, appears also to fail before it reaches the English coast. It is well marked in the estuaries of the Clyde and Forth, whence in a fragmentary condition it has been traced into Wigtonshire on the one side and to the north of Berwickshire on the other. But no remnants of it appear to have been detected in the north of England.

The raised beaches of the north and east of England were briefly referred to, and it was then shown that in England and Wales the most continuous and best preserved examples are to be seen on the coasts of the southern counties. The lower raised beaches along the coasts of Dorset, Devon, and Cornwall have long been known, although their geological age, their history, and their relation to the later phases of Pleistocene time, have not yet been satisfactorily cleared up. William Pengelly, who devoted so much time to this subject, clearly proved that these beaches do not stand

now at their original level, but that after their formation the region was upraised to the amount, as estimated by him, of not less than 70 feet, when the lowest sunk forests flourished at land-surfaces, and that thereafter came a submergence of certainly 40 and perhaps many more feet.

Mr. Tiddeman has shown that, in Gower, on the coast of Glamorgan, a raised beach which lies from 10 to 30 feet above the level of the modern beach, and contains littoral shells of common species, is yet older than at least some part of the Glacial period, for it is overlain by Glacial drift. In this case, also, its present is probably not its original level. There is evidence of considerable submergence, at a comparatively late period, farther east in the same county and along the southern coast of England, and the inter-Glacial or pre-Glacial raised beaches of the whole of this region doubtless stood at one time higher above the sea-level than they do now.

The raised beaches of Ireland were alluded to, special attention being directed to an ancient shore-line at Cork Harbor, which has recently been traced by Messrs. Muff and Wright, of the Geological Survey, not only within the harbor, but for a long distance on the shore to the east and west of that inlet. Though only a few feet above the present high-water mark, this beach has been ascertained to be older than the oldest Irish Boulder-clay, for it is overlain by the so-called "shelly marl" which was brought in upon the land from the sea-basin. The similarity of position and antiquity between this beach and that underlying the drift in Gower is obviously as important as it is interesting. A shore-line, which must be of pre-Glacial or inter-Glacial age, is traceable in the south of Ireland and in South Wales. It has not only survived the erosive processes of the Glacial period, but it appears to have outlived some serious alterations in the relative levels of sea and land, which have taken place since its formation. Moreover, we have to note the fact that neither at Cork nor in Gower does any younger post-Glacial terrace appear to be recognizable. If we might judge from the analogy of other parts of these islands where the succession of raised beaches is tolerably complete, we should infer that if ever any later terrace existed here it must now be submerged—an inference which, it will be observed, is supported by the evidence of considerable submergence in South Wales and on the southern coast of Hampshire.

(ii.) *Submergence.*—Of the various kinds of proof of the submersion of terrestrial surfaces furnished in these islands only two were dealt with; first, the extension of land-valleys beneath the sea, and, secondly, the existence of what are known as sunk forests.

(1) That the fjords of Norway, the sea-lochs of the west of Scotland, and the harbors or inlets of the west of Ireland were originally valleys on the dry land, although now deeply submerged, has long been an accepted belief among those geologists who have specially considered the subject. The interval of time which has elapsed since this submergence has not sufficed to fill up with sediment these submarine depressions. By a study of the sea-charts, we can still trace the winding curves of the ancient valleys, and can even here and there detect among them the basins which, when the present sea-bottom was a land-surface, were filled with fresh-water lakes. On the sea-floor to the east of our own country and of Scandinavia, such relics of subaerial denudation are less imposingly preserved, yet evidence of the submergence of land-valleys has been noted there also. It must of course be remembered that the land on that side is of much lower altitude than on the western coasts, that the ground slopes gently under the sea, and that the valleys are comparatively insignificant depressions on its general surface. Moreover, the more abundant drainage on the longer slope east of the watershed, and the much greater development of drift on that side, leads to a far more copious discharge of sediment into the shallow North Sea and the Gulf of Bothnia, and the submarine prolongations of the old land-valleys are thus apt to be buried under recent accumulations of detritus. There may, however, perhaps be another cause for the contrast between the profoundly indented and precipitous western coast and the comparatively low and monotonous trend of the eastern coast. The author had long been disposed to believe that the submergence has been greater toward the west than toward the east. In the prolongation of the West Highland sea-lochs on the floor of the Atlantic outside, the original land-surface sometimes lies 600 feet or more below the present sea-level. If the submerged land-surface of northwestern Europe could be upraised some 600 feet the submarine prolongations of the sea-lochs would once more become glens and straths, and their rock-basins would again be turned into fresh-water lakes.

There is no similar series of well marked submerged valleys on the floor of the North Sea from which to estimate the amount of submergence of that tract, at least half of which, at no very distant date, formed a land-surface that connected Britain with the rest of the Continent. The charts show this sea-floor to consist of two distinct portions. The northern half forms a plain, which appears to slope gradually toward the north. The southern half, however, rises somewhat rapidly from the edge of that plain into an escarpment that runs in a northeasterly direction for a distance of 500 miles, from off Flamborough Head to the Skagerrak. From the top of this escarpment the surface undulates southward as a higher submarine plain, traversed by the still feebly traceable submerged valleys of the Elbe, the Rhine, and the Thames, and covering an area of more than 50,000 square miles. An uprise of not more than 300 feet would turn this tract into a rolling plateau of dry land, like the downs and wolds of Yorkshire, which are its emerged continuation. Such an amount of uplift would probably be amply sufficient for the transaction of all the later geological history of the region. The conversion of the area into a sea-bottom may not have been a continuous process. It was probably in operation during the early stages of the Glacial period, and its latest phases come down at least into Neolithic time.

(2) The sheets of peat with stools and trunks of trees, known as sunk or submerged forests, and of such frequent occurrence around the coasts of the British Isles, have long been confidently regarded as proofs of recent subsidence of the land. That they generally mark former land-surfaces cannot be doubted, for the tree stumps are seen to send their roots down into the soil underneath, and manifestly stand in the places where they originally grew. The presence of hazel-nuts, elytra of beetles, land-snails, and other terrestrial organisms, affords further confirmation of this conclusion. The great majority of these vegetable accumulations are found between tide-marks in bays and estuaries, and in many cases they can be seen to pass below the limits of the lowest tides, and thus be constantly in part submerged. The trees and the fresh-water plants, must have lived above the reach of the sea, so that they now lie 20 feet or more below the level at which they originally grew, and the conclusion has been drawn that they mark a general subsidence of these islands, to the amount of at least 20 feet, at a comparatively recent date.

Sir Archibald Geikie was inclined to believe that this conclusion has been rather too sweepingly drawn. That some of the submerged forests may be satisfactorily accounted for without any change in the level of the land or of the sea was urgently enforced more than eighty years ago by John Fleming, in reference to the examples first brought to notice by him in the estuaries of the Tay and the Forth. It will be readily understood that, in the later stages of the Glacial period, when much detritus was swept off the land into the sea, the conditions would probably be especially favorable for the formation of alluvial bars along our coasts, such as are now in course of accumulation for hundreds of miles on the southern coast of Iceland, where some of the features of that period may still be said to linger. Behind these barriers lagoons would arise, which in course of time might become marshes, and eventually peaty flats, supporting a growth of trees. But when the supply of sediment failed, and the sea, instead of heaping up the bars, began to breach them, the level of the bogs would sink by the escape of their water to the beach, and the tide at high-water would overflow and kill off the forests. Occasionally, owing to the action of the underground drainage, the seaward margins of forest-covered peaty flats may have been detached from the main body and launched downward on the beach, even beneath low-water mark.

Had our littoral sunk forests been confined to a few places where the topographical conditions were specially favorable for their production, we may concede that they would not in themselves furnish sufficient proof of a shift of level, either on the part of the land or of the sea. But when we consider their widespread distribution all round the margin of these islands, even on those shores where it is difficult to believe that there has been any subsidence or slipping downward of a land-surface owing to the drainage off of underground water, we may well doubt whether the old belief should be disturbed, that the facts, taken as a whole, prove a general submergence.

Fortunately, the evidence available on this subject allows us to go a step farther. We need not be content with such debatable proofs as are furnished by the sunk forests between tide-marks, for land-surfaces can be adduced which are buried beneath marine accumulations in circumstances that leave no doubt as to the facts of submergence.

The author, after presenting some details proving submergence at Belfast, at Hull, and at Grimsby, to the extent of sometimes as much as 52 feet, stated that on the coast of South Wales interesting sections had been laid open in the excavation for the Barry Docks, in Glamorgan, furnishing conclusive proof of a succession of at least four layers of peat overlain by estuarine deposits, and in a situation which precludes any recourse to local settlement by drainage of underground water or downward slipping. The strata are manifestly undisturbed, and the lowest is an unmistakable land-surface. It consists of peat full of remains of oak, hazel, cornel, hawthorn, and willow, together with crushed shells of Hyalinia and, apparently, Pisidium and Planorbis. The soil underneath this forest-growth has yielded specimens of Helix, Hyalinia, Succinea, Limnæa, Pupa, and Valvata. This buried forest-growth lies at a depth of 35 feet beneath Ordnance-datum, or 55 feet beneath the line of high-water of ordinary spring tides. It proves a submergence of at least 55 feet, and the peat-bands at higher levels mark successive pauses in this submergence. That the movement was in progress in Neolithic time may be concluded from the occurrence of a portion of a polished celt in the uppermost layer of peat, from which also two bone needles are reported to have been obtained. Mr. Strahan informed the author that, wherever excavations have been made at the mouths of the valleys on the coast of South Wales, similar layers of peat have been cut through at depths below low-water mark. It would thus appear that the submergence has been general all along the coast-line. On the southern English coast similar evidence of a considerable change of level has long been known. During the extensive excavations for new dock accommodation at Southampton, a bed of peat, 10 feet thick, has been found, descending to a depth of 43 feet below Ordnance-datum. This vegetable accumulation has yielded many land and fresh-water shells; abundant trunks of oak with roots, sometimes 2 feet long, passing down into the loam beneath; plentiful remains of beech and hazel, together with some birch and pine. The plants also include bulrush, sedge, bog-myrtle, heaths, and bracken. From this bed, bones, horn-cores, and part of the skull of *Bos primigenius* were obtained; likewise horns and bones of red deer, tusk of boar, bones of hare, and horn of reindeer. Traces of man were found in the same deposit, as shown by the occurrence of dark flint-flakes, a round perforated hammer-stone, and a fine bone needle polished by use.

There is thus evidence of a comparatively recent submergence of the southwest of England to the extent of at least 50 or 60 feet. We are probably justified in considering the present position of the Glacial raised beach in Gower as a further indication of the same movement, and there seems no reason why we should not connect the evidence of this beach with that of the terrace lately detected in Cork. If these tracts are included in our survey, we see that the submergence probably stretched across South Wales and St. George's Channel to the South of Ireland. The evidence from Hull and Grimsby, which shows that a similar marked submergence has taken place along part of the east coast, not improbably indicates that the change of level extended across Wales, and the center of England. This submergence appears to be the latest in the long series of oscillations which have affected the southern portions of our islands. No proof has yet been obtained that so serious an amount of recent submergence has extended farther north. In the northern tracts the latest recorded change of level has been an emergence of the land in Neolithic time.

(iii.) *Bearing of the Evidence on the Causes of Emergence and Submergence.*—In conclusion, the author pointed out the inferences that appeared to him to be deducible from the evidence obtainable in the British Isles, in regard to the causes which, in this region, have determined the emergence and submergence of land. The vertical range of the changes of level to which the discussion in this address was limited amounts at least to as much as 700 feet, that is, some 600 feet below and 100 feet above the surface of the sea. But it will be remembered that, if we include all the deposits that contain recent marine shells *in situ*, the range of movement will be found considerably to exceed 1,000 feet. The problem to be solved is whether this wide amplitude of shift in the relative levels of sea and land should be attributed to variations in the height of the surface of the oceanic envelope, or to secular movements of the terrestrial crust.

Any change of sea-level might be expected to be general and fairly uniform over long distances. The area of the British Isles is too restricted to permit us to believe that there could ever have been any serious difference in sea-level between the eastern and western coasts, or between the northern and southern limits of the country. Whether, therefore, the surface of the sea rose upon the land or sank away from it, we should find the records of these changes to extend over the entire region, and to be marked on the whole by a persistent uniformity of level. But an examination of the evidence fails to furnish proofs of any such extension and uniformity.

In the first place, the raised beaches although so perfectly developed over nearly the whole of Scotland, disappear toward the north among the Orkney and Shetland Islands where, had they ever existed, they had every chance of being as well preserved as anywhere on the mainland. These islands obviously lay outside of the area affected by the movement that led to the formation of the beaches. But they could not have escaped from the effects of any rise in the level of the sea. Again, it is incredible that if the great 100-foot terrace, so prominent a feature in Scotland, had been formed by an uprise of the surface of the sea, the same terrace should not have been visible in thousands of favorable positions in England, Wales, and Ireland. Its entire absence cannot be accounted for by the presence of former ice-sheets in these regions, or by subsequent denudation. This absence may surely be taken as proof that the terrace never extended over these parts of our islands.

In the second place, had the position of the buried forests in the southern half of England and Wales been due to a rise in the sea-level, similar evidence of submerged land-surfaces at corresponding depths should have been met with generally round our coast line. Neolithic man was an inhabitant of the country before this submergence was complete, and has dropped his handiwork in the beds of peat. In the north of Ireland and in central Scotland, however, during Neolithic time the land was emerging from the sea, and man has left his flint-flakes and weapons in the youngest raised beaches. Thus in the same period of geological time the sea-level must be supposed to have risen 50 or 60 feet in the south, and to have sunk 25 or 30 feet in the north. But we cannot suppose that within a distance of 300 or 400 miles there could have been a difference of 75 feet or more in the level of the water.

In the third place, there can be little doubt that when accurate levelings are taken of the raised beaches, it will be found that their apparent horizontality is

not absolute, but that they rise slowly in certain directions, more particularly toward the axis of the country. It is not improbable also that a difference of level will be detected between the same beach on the eastern and on the western coast, and between its most northerly and most southerly parts. Such evidence of a deformation of the land can only be determined by careful geodetic measurements still to be undertaken.

In the meantime, on a review of the whole evidence, the author felt confident that the balance of proof is largely in favor of the old belief that the changes of level, of which our islands furnish such signal illustrations, have been primarily due, not to any oscillations of the surface of the ocean, but to movements of the terrestrial crust connected with the slow cooling and contraction of our globe. If this belief is to be overthrown, better evidence must be brought against it than has been hitherto adduced.

SHADOWS.*

By the Right Hon. LORD RAYLEIGH, O.M., M.A., D.C.L., LL.D., Sc.D., F.R.S. (Revised by the Author.)

MY subject is shadows, in the literal sense of the word—shadows thrown by light, and shadows thrown by sound. The ordinary shadow thrown by light is

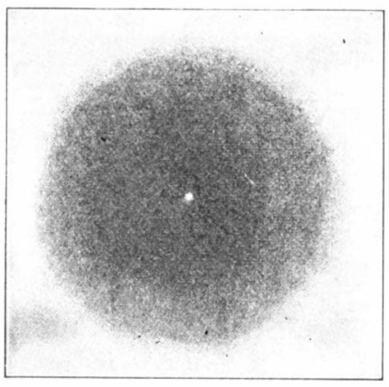


FIG. 1.—REPRODUCTION OF A PHOTOGRAPH OF THE SHADOW OF A SILVER PENNY PIECE.

familiar to all. When a fairly large obstacle is placed between a small source of light and a white screen, a well-defined shadow of the obstacle is thrown on the screen. This is a simple consequence of the approximately rectilinear path of light. Optical shadows may be thrown over great distances, if the light is of sufficient intensity; in a lunar eclipse the shadow of the earth is thrown on the moon; in a solar eclipse the shadow of the moon is thrown on the earth. Acoustic shadows, or shadows thrown by sound, are not so familiar to most people; they are less perfect than optical shadows, although their imperfections are usually over-estimated in ordinary observations. The ear is able to adjust its sensitiveness over a very wide range, so that, unless an acoustic shadow is very complete, it often escapes detection by the unaided ear, the sound being sufficiently well heard in all positions. In certain circumstances, however, acoustic shadows may be very pronounced, and capable of easy observation.

The difference between acoustic and optical shadows was considered of so much importance by Newton, that it prevented him from accepting the wave theory of light. How, he argued, can light and sound be essentially similar in their physical characteristics, when light casts definite shadows, while sound shadows are imperfect or non-existent? This difficulty disappears when due weight is given to the consideration that the lengths of light waves and sound waves are or different orders of magnitude. Visible light consists of waves of which the average length is about one forty-thousandth of an inch. Audible sound consists of waves ranging in length from about an inch to nearly forty feet; the wave length corresponding to the middle C of the musical scale is roughly equal to four feet. It is, therefore, no matter for wonder that the effects produced by sound waves and by light waves differ in important particulars.

Moreover, the wave length is not the only magni-

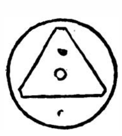


FIG. 2.—PLAN OF BIRD CALL.

tude on which the perfection of the shadow depends; the size of the obstacle, and the distance across which the shadow is thrown, must also be taken into consideration. The optical shadow of a small object, thrown across a considerable distance, partakes of the imperfections generally observed in connection with sound shadows.

It was calculated by the French mathematician, Poisson, that, according to the wave theory of light, there should be a bright spot in the middle of the shadow of a small circular disk—a result that was thought to disprove the wave theory by a *reductio ad absurdum.* Although unknown to Poisson, this very phenomenon had actually been observed some years earlier, and was easily verified when a suitably arranged experiment was made.

Under suitable conditions a bright spot can be observed at the center of the shadow of a threepenny bit. The coin may be supported by three or four very fine wires, and its shadow thrown by sunlight admitted at a pin-hole aperture placed in the shutter of a darkened room. The coin may be at a distance of about fifteen feet from the aperture, and the screen at about fifteen feet beyond the coin. To obtain a more convenient illumination, a larger aperture in the shutter may be filled by a short-focus lens, which forms a diminutive image of the sun; this image serves as a point source of light. A smaller disk has some advantages. Fig. 1 is reproduced from a photograph of the shadow of a silver penny piece, struck at the time of the coronation. The shadow, formed in the manner just described, was allowed to fall directly on a photographic plate; after development a negative was obtained, in which the dark parts of the shadow were represented by transparent gelatine, while the bright parts were represented by opaque deposits of silver. To obtain a correct representation, a contact print was formed from the negative in the usual way, upon a lantern plate; and from this Fig. 1 has been reproduced.

It is at once evident that at the center of the shadow, where one would expect the darkness to be most complete, there is a distinct bright spot. This result has always been considered a valuable confirmation of the wave theory of light.

I now propose to speak of acoustic shadows—shadows thrown by sound. The most suitable source of sound for the following experiments is the bird call*

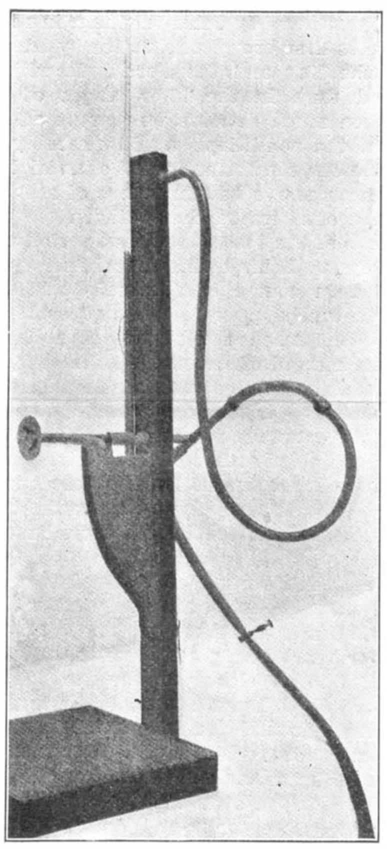


FIG. 3.—THE BIRD CALL

(Figs. 2 and 3), which emits a note of high pitch—so high, indeed, that it is inaudible to most elderly people. The sound emitted has two characteristics, valuable for our purpose—the wave length is very short, and the sound is thrown forward, without too much tendency to spread, thus differing from sounds produced by most other means.

Since the sound emitted is nearly inaudible, some objective method of observing it is required. For this purpose we may utilize the discovery of Barrett and Tyndall, that a gas flame issuing under somewhat high pressure from a pinhole burner flares when sound waves impinge on it, but recovers and burns steadily when the sound ceases. The sensitiveness of the flame depends on the pressure of the gas, which should be adjusted so that flaring just does not occur in the absence of sound. If the bird call is directed toward the sensitive flame, the latter flares so long as the call is sounded, and no obstacle intervenes. On interposing the hand about midway between the two, the flame recovers and burns steadily. Thus the sound emitted by the bird call casts a shadow, and to this extent resembles light.

It will now be shown that the sensitive flame flares when it is placed at the center of the acoustic shadow thrown from a circular disk, but recovers in any other position within the shadow, thus proving that there is sound at the center of the shadow, although at a small distance from this point there is silence. The part of the flame which is sensitive to sound is that just above the pinhole orifice, so that it is necessary to arrange the bird call, the center of the disk, and the pinhole orifice in a straight line (Fig. 4). For the disk, it is convenient to use a circular plate of glass about 18 inches in diameter with a piece of black paper pasted over its middle portion, a small hole being cut in the paper exactly at the center of the disk. The glass disk is hung by two wires, and the positions of the bird call and sensitive flame can be adjusted by sighting through the hole in the paper. If the disk is caused to oscillate in its own plane, the flame flares every time that the disk passes through its position of equilibrium and recovers whenever the disk is not in that position. The analogy between this experiment and that in which a bright spot is formed at the center of the optical shadow of a small disk is sufficiently obvious.

Before leaving these interesting phenomena, I should like to give some indication of their theoretical explanation. Let spherical waves be supposed to spread out

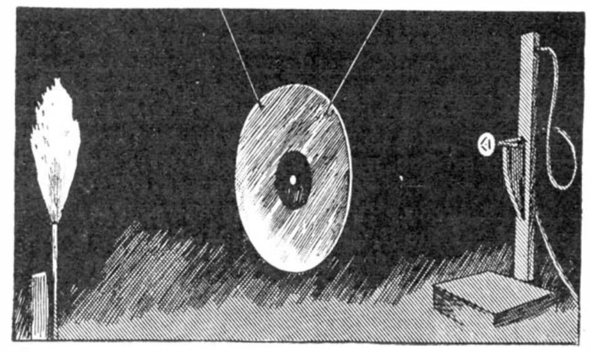


FIG. 4.—APPARATUS FOR DEMONSTRATING THE PRESENCE OF SOUND AT THE CENTER OF THE ACOUSTIC SHADOW OF A DISK.

from the source; then at a considerable distance from the source the radius of curvature of a wave will be so large that a limited portion of a wave may be treated as if it were plane. We may thus assume that plane waves travel up to the imaginary plane in which the circular disk is situated. At a given instant, all points in the plane of the disk are subjected to the same kind of wave disturbance. This disturbance is oscillatory in character, consisting of a to-and-fro motion which is completed in a certain small interval of time, termed the period of the waves. The disturbance at each point may be considered to give rise to a secondary wave or wavelet, which spreads out with a uniform velocity; and the disturbance at any point beyond the plane may be considered as due to the combined action of all the wavelets arriving there from the various points of origin.

Let us now consider the nature of the resultant disturbance at a point on the axis of the disk. At any instant wavelets arrive there from all points of the disk itself. If we divide the plane of the disk into narrow rings or zones concentric with the disk, then wavelets which started simultaneously from different points of a given zone will arrive simultaneously at the point on the axis of the disk, since all have traveled through equal distances. But the zones farthest from the edge of the disk are farthest from the point on

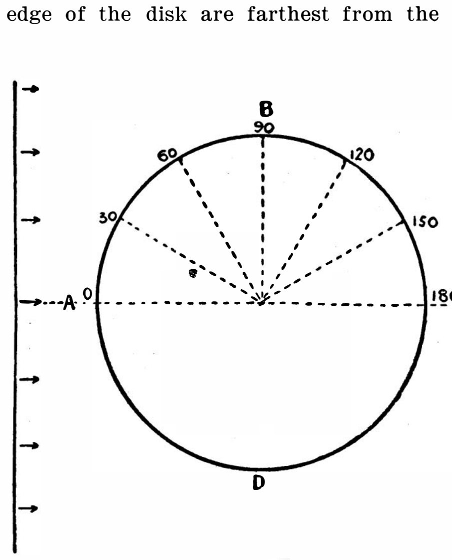


FIG. 5.—TO EXPLAIN THE MEANING OF THE CURVES IN FIG. 6.

the axis; thus we may choose the breadths of the zones in such a manner that the time required for a disturbance to travel from the middle of one zone to the given point on the axis is shorter than the time required for the disturbance from the next exterior zone to reach the same destination, by an interval equal to half the period of the waves.

Let the disturbance derived from the zone nearest to the edge of the disk be denoted by $(+a)$; then the disturbance simultaneously arriving from the next zone may be denoted by $(-b)$, since it must have started half a period earlier, when the disturbance in

* Report of a lecture delivered at the Royal Institution of Great Britain, on January 15, 1904.

* The sound emitted by a bird call is due to a stream of air from a circular aperture in a thin plate, which impinges centrally upon a similar hole in a parallel plate held at a little distance. Bird calls are easily made. The first plate, 1 or 2 centimeters in diameter, is soldered to the end of a short supply tube. The second plate may conveniently be made triangular, the turned-down corners being soldered to the first plate (Fig. 2). In constructing calls of medium pitch, ordinary tin-plate may be used. The holes may be 1 millimeter or ½ millimeter in diameter, and the distance between them as small as 1 millimeter. In any case the edges of the holes should be sharp and clean. There is no difficulty in obtaining sound waves as short as 1 centimeter.

the plane of the disk was in an opposite direction. The disturbance simultaneously arriving from the third zone may be denoted by $(+c)$, since it started a whole period earlier than the disturbance from the first zone, and in a complete period the disturbance in the plane of the disk changes back to its original character. Thus the disturbance D, due to all of the zones, may be written:

$$D = a - b + c - d + e - f + g - \ldots\ldots\ldots (1)$$

It can be proved that the zones, drawn in the above manner, are equal in area; and hence it may be concluded that the numerical values, a, b, c, etc., are nearly equal, decreasing slightly as we proceed along the series, if only on account of the increasing distances traveled by the corresponding wavelets.

We might sum up the series (1) in various ways. Since a is slightly greater than b, $(a-b)$ must be equal to a small positive quantity. Similarly $(c-d)$ is equal to a small positive quantity, and so on. Finally, the value of the whole series must be equal to the

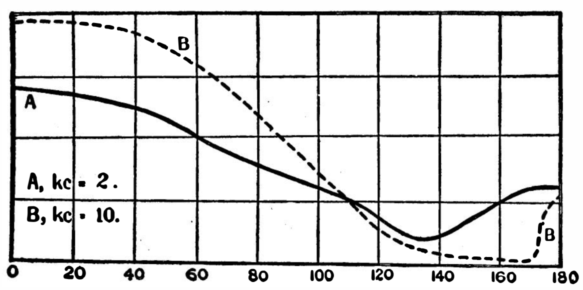


FIG. 6.—CURVES SHOWING THE INTENSITY OF SOUND AT VARIOUS POINTS ON A SPHERE, THE INCIDENT SOUND WAVES BEING PLANE, AND CONFINED TO ONE DIRECTION.

sum of a great number of small positive values, which at least shows that there will be some resultant disturbance at a point on the axis of the disk, and therefore in the center of the geometrical shadow.

A more satisfactory way of dealing with (1) is suggested by the consideration, that the numerical value of any term is about midway between the preceding and succeeding terms; thus, the value of b is equal to the mean value of a and c, the value of d is equal to the mean value of c and e, and so on.

If we now throw (1) into the form,

$$D = \frac{a}{2} + \left(\frac{a+c}{2} - b\right) + \left(\frac{c+e}{2} - d\right) + \ldots\ldots\ldots (2),$$

each term within brackets is approximately equal to zero, and

$$D = + \frac{a}{2};$$

or the resultant disturbance at a point on the axis of the disk is equal to half the disturbance arriving there from the half-period zone nearest to the disk.

Another point of importance may be noted. If we imagine the diameter of the disk to progressively diminish, the resultant disturbance is still equal to half that due to the first half-period zone. When the disk shrinks to a mathematical point, the first zone will be a circular space of approximately the same area as the zones previously dealt with. Thus if a^1 is equal to the disturbance from the central zone, the disturbance produced at the point on the axis of the disk would become equal to $\frac{a^1}{2}$ if the disk were removed; and since a^1 is nearly equal to a, it follows that the

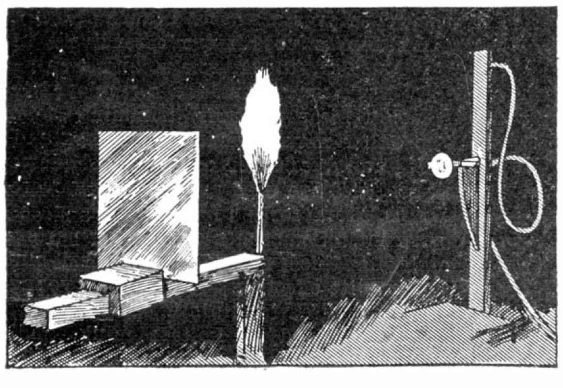


FIG. 7.—APPARATUS FOR DETERMINING THE WAVE-LENGTH OF A NOTE OF HIGH PITCH.

disturbance at the center of the shadow of the disk is as great as if the disk were removed.

The above reasoning explains the cause of the disturbance at the center of the shadow of a disk; and it is only in the immediate neighborhood of this point that there is any appreciable disturbance. I cannot pretend that the above investigation is very rigorous, or even that a rigorous investigation could be carried out on the lines indicated. Up to the present it has been found impossible to determine, with mathematical precision, the nature of the disturbance at the various points within the shadow of a flat obstacle, even when, for simplicity, we suppose the obstacle to be an accurately circular disk, and the source of light or sound to be so distant that the waves near the disk are plane. But the simple result indicated is doubtless sufficient for practical purposes.

To obtain the simplest mathematical conditions we may investigate the shadow of a spherical obstacle. If the sphere is small—comparable in magnitude with the length of the waves which throw the shadow—then we obtain a problem which admits of a complete solution.

It can be shown experimentally that there is sound at the center of the acoustic shadow thrown from a small sphere, while at points removed from the center of the shadow there is silence. To do this, a sphere is suspended so that its center lies in the straight line joining the bird-call to the orifice of the pinhole burner; the only modification required in the arrangement illustrated in Fig. 4, is the replacement of the disk by a sphere. For the sphere, an ordinary ten-inch celestial globe, or on a smaller scale, a croquet ball, may be used. The sensitive flame flares when its orifice is situated at the center of the shadow; the smallest displacement of the sphere causes the flame to recover, thus showing that it is only within a very small distance from the center of the shadow that there is any appreciable sound.

I first observed this phenomenon when exploring the acoustic shadow of a sphere with the aid of a Helmholtz resonator and flexible tube applied to the ear. Such experiments are rather difficult to perform; they require some practice on the part of the observer, and they cannot be carried out in a room, owing to the multiple images of the source of sound formed by reflection at the walls. I therefore placed the source of sound in the open air, near the ground; and proceeding thus, I was able to detect sound at the center of the shadow.

The difficulties to be overcome in the practical solution of the mathematical problem are very great; in the case of a large sphere (e. g., a sphere of which the diameter is one hundred times as large as the wavelength of the sound), the problem is practically insoluble, owing to the difficulty of computing the numerical values of the expressions obtained. Let the ratio of the circumference of the sphere to the wave-length of the sound be denoted by kc; when kc is equal to 10, the circumference of the sphere is equal to 10 wavelengths, and so on. The solution of the problem depends only on the value of kc, so that when obtained for a given sphere and a given wave-length, the results will apply to any other sphere of which the circumference is in the same proportion to the wave-length employed.

Let it be assumed that plane-waves travel up to a sphere in the direction indicated by the arrows in Fig. 5; the section of the sphere is represented by the circle $A\ B\ C\ D$. The waves first reach the point A, which may be termed the pole A. The position of any point on the sphere may be denoted by its angular distance from the point A; thus the point B is denoted by 90 deg., and lies on what may be termed the equator of the sphere. The anti-pole, opposite to A, is 180 deg. The intensity of the sound at various points on the surface of the sphere is shown graphically in Fig. 6, in which curves for $kc = 10$ and $kc = 2$ are drawn. It will be noticed that the intensity of the sound falls off regularly as we proceed from pole A toward the equator (90 deg.). Beyond this position the intensity continues to fall off, until a minimum is reached at about 135 deg. for $kc = 2$, or 170 deg. for $kc = 10$. In both cases, however, the intensity of the sound ultimately increases as we approach the anti-pole (180 deg.)—the point where we might naturally expect the intensity of the sound to be least.

I should have been unable to carry out, with any completeness, the calculations on which the curves in Fig. 6 are based, but that I was able to interest Prof. Alfred Lodge in the subject. He has computed the tables of Legendre's functions necessary for the practical evaluation of the mathematical expressions.

In testing the results indicated graphically in Fig. 6, it is necessary to know the circumference of the sphere and the wave-length of the sound employed. The first of these magnitudes is easily measured directly, or calculated from the measured diameter of the sphere. The wave-length of the note emitted by the bird call is determined experimentally by the arrangement represented in Fig. 7.

The sound waves from the bird call are reflected normally from a plane surface, such as a sheet of glass. As a result, two trains of similar waves travel with equal velocities in opposite directions in front of the reflecting surface, thus forming stationary waves. At the reflecting surface, and at distances equal to 1, 2, 3, 4, etc., half-wave-lengths from it, there will be nodes, or points where the air is stationary. In the space between any two consecutive nodes the air is in vibratory motion. The sensitive flame burns steadily when its orifice is situated at a node, but flares at points where the air is in motion. Thus we might measure the wave-length of the note by moving the sensitive flame away from the reflecting surface, counting the number of nodes passed through in a measured distance. It is preferable, however, to keep the flame stationary, and to move the reflecting surface. If we start with the surface at a point such that the flame burns steadily, we find that we must move the surface through 15 centimeters to reach the point where the flame recovers for the tenth time, so that 15 centimeters comprise 10 half-wave-lengths, or the wave-length of the sound is equal to 3 centimeters.

Using the croquet ball, of which the circumference is equal to 30 centimeters, we have $kc = 10$; and the results represented by curve B (Fig. 6) may be tested. To satisfy the conditions assumed in the calculations, the point of observation should be taken upon the surface of the sphere. For various reasons this cannot be done; but we may take it fairly close, when we obtain a sufficient verification of the results represented graphically in Fig. 6.

My attention was recalled to this subject some time ago, in connection with the remarkable results obtained by Marconi in signaling across the Atlantic. Some hitch appears to have occurred in the transmission of messages, but without doubt signals have been transmitted across the Atlantic, and considering the difficulties standing in the way of such an achievement, the success obtained is truly remarkable. Moreover, this success is somewhat difficult to explain. Owing to the curvature of the earth, the sea rises nearly 150 miles above the straight line joining the transmitting

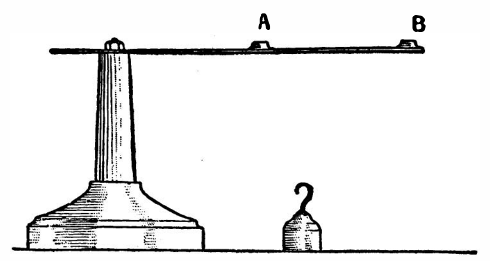


FIG. 8.—TO ILLUSTRATE A SIMPLE MECHANICAL APPLICATION OF THE PRINCIPLE OF RECIPROCITY.

station in Cornwall and the receiving station in Newfoundland; that this huge mass of matter does not cast a more perfect shadow than it appears to do is very surprising. The explanation is as yet unobtained; certain calculations which I have made tend to show that the success achieved may be mostly due to the extreme delicacy of the receiving apparatus.

In connection with the mathematical investigation which led to the results represented graphically in Fig. 6, there is a point of interest which I should like to mention. The investigation was carried out upon the supposition that the source of sound is at a considerable distance, so that the waves reaching the sphere are plane; and that the receiver, by which the sound is detected, is situated on the surface of the sphere. At any given position on the surface of the sphere, the receiver will indicate the reception of sound of a certain intensity, which may be read off from Fig. 6. Now the final results assume a form which shows that, if the positions of the source and the receiver are interchanged, the latter will indicate the reception of sound of the same intensity as in the original arrangement. Thus each of the curves in Fig. 6 represents the solution of two distinct problems—the intensity of the sound derived from a distant source and detected at any point on the surface of the sphere; and the intensity of the sound derived from a source on the surface of the sphere, and observed at a distant point. This result forms an interesting example of a principle of very wide application, which I have termed the "Principle of Reciprocity." Some special cases were given many years ago by Helmholtz.

It is a matter of common observation that if one person can see another, either directly or by means of any number of reflections in mirrors, then the second person can equally well see the first. The same law applies to hearing, apparent exceptions being easily explained. Consider, for instance, the case of a lady sitting in a closed carriage, listening to a gentleman talking to her through the open window. If the street is noisy, the lady can hear what the gentleman says

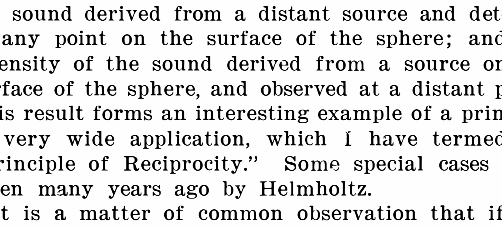


FIG. 9.—MODEL ILLUSTRATING THE PECULIARITIES OF A WHISPERING GALLERY.

very much more distinctly than he can hear what she says. This is due to the fact that the gentleman's ears are assailed by noises of the street from which the lady's ears are shielded by the walls of the carriage.

Another instance may be mentioned, which will appeal to electricians. In the arrangement known as Wheatstone's bridge, resistances are joined in the form of a lozenge, a galvanometer being connected between two opposite angles of the lozenge, while a battery is connected between the other two angles. When the resistances are suitably adjusted, no current flows through the galvanometer; but a slight want of ad-

justment produces a deflection of the galvanometer, thus indicating the passage of a small current. Now if the positions of the battery and the galvanometer are interchanged the same current as before will flow through the galvanometer, and therefore, the deflection will be the same as before. Thus with a given cell, galvanometer, and set of resistances, the sensitiveness of the Wheatstone's bridge arrangement is the same whichever pair of opposite angles of the lozenge are joined by the galvanometer. If a source of alternating E. M. F. is used instead of the battery, and a telephone is substituted for the galvanometer, then the principle of reciprocity still applies, whether the resistances are inductive or non-inductive.

A simple illustration, of a mechanical nature, is now shown. Fig. 8 represents a straightened piece of watch-spring clamped at one end to a firm support. A weight can be hung at either of the points *A* or *B* of the spring, when it may be observed that the deflection at *B* due to the suspension of the weight at *A* is exactly equal to the deflection at *A* due to the suspension of the weight at *B*. This result is equally true wherever the points *A* and *B* may be situated; it applies not only to a loaded spring, which has been chosen as suitable for a simple lantern demonstration, but also to any sort of beam or girder.

It will have become clear, from what has been said, that waves encounter considerable difficulty in passing round the outside of a curved surface. I wish now to refer to a complementary phenomenon—the ease with which waves travel round the inside of a curved surface. This is the case of the whispering gallery, of which there is a good example in St. Paul's Cathedral. The late Sir George Airy considered that the effect could be explained as an instance of concentrated echo, the sound being concentrated by the curved walls, just as light may be brought to a focus by a concave mirror. From my own observations, made in St. Paul's Cathedral, I think that Airy's explanation is not the true one; for it is not necessary, in order to observe the effect, that the whisperer and the listener should occupy particular positions in the gallery. Any positions will do equally well. Again, whispering is heard more distinctly than ordinary conversation, especially if the whisperer's face is directed along the gallery in the direction of the listener. It is known that a whisper has less tendency to spread than the full spoken voice; thus a whisper, heard easily in front of the whisperer, is inaudible behind that person's head. These considerations led me to form a fairly satisfactory theory of the whispering gallery, nearly twenty-five years ago.* The phenomenon may be illustrated experimentally by the small scale arrangement represented diagrammatically in Fig. 9. A strip of zinc about 2 feet wide, and 12 feet long, is bent into the form of a semi-circle; this forms the model of the whispering gallery. The bird call *B* is adjusted so that it throws the sound tangentially against the inner surface of the zinc; it thus takes the place of the whisperer. The sensitive flame *F* takes the place of the listener. A flame is always more sensitive to sound reaching it in one direction than in others; the flame *F* is therefore adjusted so that it is sensitive to sounds leaving the gallery tangentially. The flaring of the flame shows that sound is reaching it; if an obstacle is interposed in the straight line *F B* the flame flares as before; but if a lath of wood *W*, which need not be more than 2 inches wide, is placed against the inner surface of the zinc, the flame recovers, showing that the sound has been intercepted. Thus the sound creeps round the inside surface of the zinc, and there is no disturbance except at points within a limited distance from that surface.

Before concluding, I should like to say a word or two on a subject which, many years ago, led me to devise some experiments which I have already described; I mean binaural hearing.

Experiments on this subject may be easily carried out, but unless the conditions are carefully chosen, trustworthy results cannot be obtained. It would be as futile to experiment in a room, where the walls act as nearly perfect acoustic reflectors, as it would be to conduct optical experiments in an apartment with walls, floor, and ceiling covered with mirrors. Even in the open air we have the ground to reckon with. Experiments on binaural hearing may best be conducted on a lawn, one person being blindfolded, while others, occupying different positions, make various sounds; the blindfolded person attempts to point out the position from which each sound proceeds. When the human voice is used in its natural manner, there is no difficulty in locating the position of the speaker. When other sources of sound are used, difficulties arise. For instance, it is impossible to determine whether a tuning fork is sounded directly in front of, or directly behind the head. But when the fork is placed on one side of the head it is easy to decide its location with absolute certainty. It might reasonably be supposed that this decision is arrived at by noting which ear perceives the strongest sound; but evidence in support of this explanation is hard to come by. If one ear is closed, while the other is in turn directed toward, and away from the sound, very little difference can be noted. At present, however, there is no other explanation, and further discussion can scarcely prove profitable until more trustworthy experimental data have been obtained. Observations by experimenters deaf in one ear are especially valuable.—Technics.

* Theory of Sound.

MUSKRAT FURS.*

By CHARLES H. STEVENSON.

THE fur of the muskrat is dense and soft, somewhat like that of the beaver, but is shorter and inferior in denseness, fineness, and durability. The color is generally drab blue, in some cases with a whitish appearance, and tipped with reddish brown. The fur of the small muskrat found in Alaska is of a lighter silvery color, almost white on the abdomen, and very fine, the pelts from that locality being highly prized when beaver hats were in fashion. The fur is concealed by long, stiff, brown overhairs on the upper surface and sides of the body. The general color of the animal is dark umber brown, almost blackish brown on the back and gray below, but specimens are found ranging through the various shades of brown, blue, and yellow to pure white.

In the Chesapeake and Delaware regions and, to a less extent, in other parts of America, in addition to those of the usual coloring, some individuals are very dark, so nearly black, in fact, that they are designated "black muskrats" in the trade. These are of superior quality and value. In some specimens, especially among those found in certain regions of Canada, the chest and abdomen is of a chestnut brown, and in others almost white, but the latter are by no means common. Pure white muskrats are occasionally found, but they are of no more value in the trade than those of the ordinary coloring, although highly prized by collectors of natural history specimens. As is the case with most aquatic mammals, the skins of those occurring in southern localities are thicker and more spongy than those in the colder latitudes. Muskrat fur is inexpensive, the skins selling usually for 10 to 20 cents each; however, under the skill of the fur dresser and the dyer, it assumes a high rôle in the form of imitations of more costly furs; in retail stores it is found prepared in so many different ways and with such a variety of finish as to be scarcely recognizable to the most expert trappers who are familiar with the raw skins only.

PRODUCT OF MUSKRATS AND THE MARKETS THEREFOR.

While the annual product of muskrats is at present very large, this extent is of comparatively recent development. During the eighteenth century the annual yield was relatively small and the fur was little prized. Many farmer boys found it convenient to set a few traps, using some of the skins for making caps, gloves, etc., and sending the rest to the market. The average quantity received on the market throughout that century probably did not exceed 100,000 skins annually, although on three or four occasions the annual receipts at London exceeded 200,000, but in other years they amounted to only 25,000 or 30,000. During the second and third decades of the nineteenth century the output increased considerably, principally on account of the greatly increased market value and the opening up of new trapping territory. In 1829, for the first time, the London receipts exceeded 1,000,000 skins, the total being 1,165,663. The annual receipts thereafter fluctuated greatly, but on the whole continued to increase, exceeding 2,000,000 in 1862, 3,000,000 in 1867, and 4,000,000 in 1871. Since the year last named, the price of the skins has greatly decreased, but the receipts at London have been fairly constant, averaging about 3,500,000 annually.

In addition to those handled at the London sales, about 2,000,000 muskrat skins are placed on the markets each year. Of these, 1,500,000 pass through Leipsic, and 500,000 are sold to the furriers of the United States and Canada without passing through the two large market centers. This makes an aggregate of over 5,000,000 skins annually, of which nearly one-fourth are obtained from the Dominion of Canada and the remainder are caught in the United States. The total product of muskrat skins in the United States and Canada during the nineteenth century reaches the enormous amount of 250,000,000 in number, sufficient to make a blanket which would cover nearly 4,000 acres.

Formerly the fur of the muskrat was used largely as a substitute for that of beaver in hat making, forming a cheap and fairly satisfactory imitation. Owing to its scarcity it was then of much greater value than at present, selling for 40 or 50 cents per skin, even equaling the value of the mink at times. The general adoption of the silk hat resulted in a great decrease in the demand, and the price fell as low as 6 or 7 cents per skin, and trapping them was of little profit. During the last sixty years muskrat has been used principally as dressed fur, prepared in imitation of the more highly-prized beaver, otter, and fur-seal. It is about the best of all the cheap furs.

In the market muskrat skins are classed as "firsts," "seconds," "thirds," "fourths," and "kittens." The firsts are those caught during the spring or very late winter; seconds are caught in mid-winter; thirds, those taken in very early winter or fall; fourths, in early winter or fall, and are poor and small; and kittens are those less than 3 or 4 months old. The value of the skins varies from 5 to 40 cents each, according to color and condition. Those from the Chesapeake average about 14 cents each for brown and 25 cents for black. The black pelts are marketed principally in Russia, where they are used for coat linings, but many are used in England, France, and America for cloaks, trimmings, and gloves. The price of the No. 1 black skins at the last London sales averaged 1s. 3d.; in 1891 it was about 1s. 7d., while in 1875 it was over 3s. The lighter skins fetch about 7d. each.

* Extracted from U. S. Fish Commission Report for 1902.

DRESSING MUSKRAT SKINS.

At the fur dresser's, muskrat skins are first dampened on the pelt or flesh side with salt water and permitted to so remain over night, for the purpose of softening. The following morning the skins are placed in a tramping machine, where they are fulled or tramped for eight or ten hours. Formerly the tubbing process was used, but the tramping machine is much more economical and is now employed for these skins by nearly all dressers. In tubbing, a good operator can work 100 muskrat pelts in a day, whereas a tramping machine can work 2,000 in the same time.

The pelts are next covered with a mixture or paste of sawdust and salt water and so remain over night. The water is used to keep the pelt soft, the salt to prevent the hair from falling out in the heating, and the sawdust to hold the moisture. The following morning the skins are cut open down the front, provided they are cased, and are then fleshed, one man being able to flesh 200 to 300 per day. They are now stretched lengthways and crossways and hung up to dry. When thoroughly dry, in the leather as well as in the hair, they are again moistened with salt water on the leather side, remaining thus over night. They are next brushed on the leather side with animal fat, such as butter or fish oil and tallow, most of the grease being placed in the center, and the skins laid in pairs with the hair side out. After remaining thus over night, they are placed in tramping machines and worked constantly for 6 or 8 hours or until thoroughly soft and pliable. On removal from the tramping machines the skins are stretched in every direction.

At this stage the fur has a dirty, greasy, and uninviting appearance, the grease and sawdust having worked into it during the preceding operations. The skins are placed in quantities of 300 or 400 with sawdust in revolving drums, where, exposed to steam heat or charcoal fire, they are revolved for about three hours, the sawdust by that time having completely absorbed the grease, leaving the fur clean and soft. They are next put in a beating drum and revolved for two or three hours. On removal they are beaten with rattans and the fur cleaned with a comb. The pelt of many muskrats is quite thick, and these are selected out at this stage of the process and fleshed down, thus completing the operation of dressing with the exception of plucking.

Plucking is performed the same as in the case of beaver pelts, except that it is done after the pelt has been dressed rather than before; after plucking, the fur is again cleaned and the process is ended. Twenty years ago 85 per cent of the muskrats were plucked, but at present the conditions are reversed and only a very small percentage are so treated. Indeed, on one occasion the writer spent nearly two hours among the furriers of New York in fruitless quest of a plucked muskrat skin, visiting eight or ten of the principal establishments, and finally was obliged to have one specially plucked for his use.

For the home dressing of a small quantity of muskrat skins the following has been recommended: After washing them in warm water, all fatty and fleshy matter is carefully removed. In a liquor composed of 10 gallons of cold soft water, 8 quarts of wheat bran, ½ pint of old soft soap, 1 ounce of borax, and 1 pound of salt, the skins are soaked eight or ten hours if they are fresh, or until very soft in case they have been previously dried. The salt should be omitted from the solution if the skins have already been salted, and the addition of 2 ounces of sulphuric acid to the solution will prepare them in about one-half the time. The skins should then be soaked in a liquor made of 10 gallons of warm soft water, ½ bushel bran, and 2½ pounds sulphuric acid. The bran should be stirred in the water until thoroughly mixed, and then left to stand in a warm room until it ferments, when the sulphuric acid is added by degrees and with constant stirring. After soaking in this liquor for about four hours, the skins are removed and rubbed with a fleshing knife and then over a smooth beam until dry.

Muskrat fur is used more extensively in Europe than in America, the Russians and Germans being especially large consumers. It is employed in making gloves, collars, capes, muffs, trimmings, etc., and is made up either natural, plucked, plucked and pointed, or plucked and dyed black or various shades of brown. Large quantities are used as linings for overcoats and long wraps, from forty to sixty being necessary for each garment. Sometimes the under parts are used separately for this purpose, the natural bluish-white color being quite effective. The skins of young animals are especially suited for linings. The unplucked skins are frequently dyed to imitate mink, and sold as Alaska mink, water mink, or black mink.

Two or three decades ago quantities of muskrat skins were plucked and dyed to imitate fur seal, the resulting article readily deceiving the uninitiated. While the fur is soft and short, it is not as thick as that of the fur seal, and the leather is much heavier and not sufficiently strong to permit its being scraped to a suitable thinness. After a few weeks' wear the fur becomes matted down, being less elastic than seal fur. During the eighties the use of muskrat for this purpose was extensive, especially in Europe, thus providing a large market for this abundant and easily procured fur. It injured the popularity of fur seal, persons hesitating about paying $200 for a garment when a fairly good imitation was obtainable for one-fifth of that amount. The imitation, however, was generally unsatisfactory to the trade, and on the introduction of "electric seal," made from the cony, the use of muskrat pelts for this purpose was generally abandoned, except for small articles, as gloves, caps, etc.

SELECTED FORMULÆ.

Glue or Paste for Making Paper Boxes.—The following comes highly recommended:

Chloral hydrate	5 parts
Gelatin, white	8 parts
Gum arabic.	2 parts
Boiling water	30 parts

Mix the chloral, gelatin, and gum arabic in a porcelain container, pour the boiling water over the mixture and let stand for one day, giving it a vigorous stirring several times during the day. In cold weather this is apt to get hard and stiff, but this may be obviated by standing the container in warm water for a few minutes. This paste adheres to any surface whatever.—Nat. Drug.

Starch Recipes for High Luster.—

I.	Parts by weight.
Starch	1,044
Borax	9
Common salt	1
Gum arabic	8
Stearine	20
II.	
Starch	1,000
Gum arabic	10
Spermaceti	10
Alum	10
Glycerine	24
Water	100
III.	
Starch	1,000
Borax	18
Gum arabic	20
Spermaceti	22
Glycerine	45
Water	45

—Seifensieder Zeitung.

Universal Cleaner.—

Green soap	20 to 25 parts.
Boiling water	750 parts
Liquid ammonia, caustic	30 to 40 parts
Acetic ether	20 to 30 parts

Mix. —Journal de Pharmacie.

India Rubber Varnishes.—1. Dissolve 10 pounds of India rubber in a mixture of 10 pounds of turpentine and 20 pounds of petroleum by treating same on a water bath. When the solution is completed add 45 pounds of drying oil and 5 pounds of lampblack and mix thoroughly.

2. Dissolve 7 pounds of India rubber in 25 pounds of oil of turpentine. By continued heating dissolve 14 pounds of rosin in the mixture. Color while hot with 3 pounds of lampblack.

3. Fuse together 10 pounds of rosin and 6 pounds of oil of turpentine. Then add 5 pounds of India rubber and 11 pounds of linseed oil and heat and stir to complete mixture. Then add 3 pounds of lampblack.

4. Dissolve India rubber in 7 times its weight of benzol by keeping them together in a warm place in a stoppered bottle and frequent shaking. This varnish serves also as a cement for India rubber.

5. Heat together 100 pounds of raw linseed oil, 10 pounds of India rubber, 10 pounds of boiled oil and 8 pounds of Prussian blue.—Gummi Zeitung.

Shampooing Paste.—

White Castile soap	14	oz.
Carbonate of potash	3½	oz.
Glycerine	7	oz.
Water	28	oz.
Oil of lavender	30	drops
Oil of bergamot	30	drops

Heat the soap, carbonate of potash, and water on a water-bath till a homogeneous mass results, then add the glycerine and perfume.—Seifensieder Zeitung.

Piano Polish.—

Alcohol, 95 per cent	300 parts
Benzol	700 parts
Gum benzoin	8 parts
Sandarac	16 parts

Mix and dissolve. Use as French polish.

Another excellent polish for freshening up polished or varnished surfaces is as follows:

Beeswax	2,500 parts
Potassium carbonate	25 parts
Oil of turpentine	4,000 parts
Water, rain or distilled	4,500 parts

Dissolve the potassium carbonate in 1,500 parts of the water and in the solution boil the wax, shaved up, until the latter is partially saponified, replacing the water as it is driven off by evaporation. When this occurs remove from the fire and stir until cold. Now, add little by little and under constant agitation, the turpentine, stirring until a smooth homogeneous emulsion is formed. When this occurs add the remainder of the water under constant stirring. If a color is wanted use alkanet root, letting it macerate in the oil of turpentine before using the latter (about an ounce to the quart is sufficient). This preparation is said by the Journal of the Austrian Pharmaceutical Association to be one of the best polishes known. The directions are very simple: First, wash the surface to be polished, rinse and dry. Apply the paste as evenly and thinly as possible over a portion of the surface, then rub off with a soft woolen cloth, using plenty of elbow grease.—Nat. Druggist.

TRADE NOTES AND RECIPES.

Anti-Rust Paper for Needles, etc.—This is paper covered with logwood, and prepared from a material to which fine graphite powder has been added, and which has been sized with glue and alum. It is used for wrapping round steel goods, such as sewing needles, etc., and protecting them against rust. According to Lake, the paper is treated with sulphuric acid, like vegetable parchment, the graphite being sprinkled on before the paper is put into the water.—Metallarbeiter.

New Meat Preservatives.—From time to time during the last year or two we have given the newest formulæ for the preservation of meats and give herewith the latest, for which we are indebted to the Pharmazeutische Zentralhalle:

Barmenite Corning Agent: In every 100 grammes take 25.2 g. of saltpeter, 46.8 g. sodium chloride, 25.7 g. cane sugar, 0.8 g. plaster of Paris or gypsum, 0.1 g. of some moistening material, and a trace of magnesia.

Carniform, A: In every 100 g.: take 3.5 g. sodium diphosphate, 3.1 g. water of crystallization, 68.4 g. sodium chloride, 24.9 g. saltpeter, together with traces of calcium phosphate, magnesia and sulphuric acid.

Carniform, B: In every 100 g.: take 22.6 g. sodium diphosphate, 17.3 g. water of crystallization, 59.7 g. saltpeter, 0.6 g. calcium phosphate, with traces of sulphuric acid and magnesia.

"Cervalatwurst" (spice powder): In 100 g. take 0.7 g. of moistening, 3.5 g. spices—mostly pepper—89 g. sodium chloride, 5 g. saltpeter, 0.7 g. gypsum and traces of magnesia.

Cervelatwurst Salt (spice powder): In 100 g. take 7.5 spices—mostly pepper—1.6 g. moistener, 81.6 g. sodium chloride, 2.5 g. saltpeter, 6.2 g. cane sugar and traces of magnesia.

Rubrolin Sausage (spice powder): In 100 g. take 53.5 g. sal ammoniac and 45.2 g. of saltpeter.

Servator Special Milk and Butter Preserving Salt: 80.3 per cent of crystallized boracic acid, 10.7 per cent sodium chloride and 9.5 per cent of benzoic acid. (Its use is, however, prohibited in Germany.)

Wittenberg Pickling Salt: In 100 g. take 58.6 g. sodium chloride, 40.5 saltpeter, 0.5 g. gypsum, traces of moisture and magnesia.

Securo: In a liter, take 3.8 g. aluminium oxide and 8 g. acetic acid as acetate and basic acetate of alumina, 62 g. sulphuric acid, 0.8 g. sodium oxide, with traces of lime and magnesia.

Michels Cassala Salt: This is partially disintegrated. 30.74 per cent sodium chloride, 15.4 per cent sodium phosphate, 23.3 per cent potassio-sodic tartrate, 16.9 per cent water of crystallization, 1.2 per cent aluminium oxide, and 2.1 per cent acetic acid as basic acetate of alumina, 8.4 per cent sugar, 0.98 per cent benzoic acid, 0.5 per cent sulphuric acid, and traces of lime.

Ink for Writing on Glass.—The following is the best preparation that we have ever tried: In 500 parts of water dissolve 36 parts of sodium fluoride and 7 parts of sodium sulphate. In another vessel dissolve in the same amount of water 14 parts of zinc chloride and to the solution add 56 parts of concentrated hydrochloric acid. To use, mix equal volumes of the two solutions and add a little India ink; or, in the absence of this, rub up a little lampblack with it. It is scarcely necessary to say that the mixture should not be put in glass containers, unless they are well coated internally with paraffin, wax, gutta-percha or some similar material. If you desire to avoid the inconvenience of keeping the solutions in separate bottles, you can mix them and preserve in a rubber bottle. A quill pen is best to use in writing with this preparation, but metallic pens may be used, if quite clean and new.—Nat. Drug.

The Pickling of Iron with the Assistance of the Electric Current.—To pickle cast or wrought iron articles mix one part of sulphuric acid or muriatic acid with 10 parts of water, adding a little wood or coal tar and dip into the articles until the so-called iron scale is dissolved away, whereupon they are to be rinsed in clear water and dried. When objects of iron are pickled in this manner, receiving a bright exterior, the acid usually dissolves away not only the scaly oxide but also a part of the metal itself, where the surface loses some of its smoothness and often becomes pocked. The electric current renders good service here inasmuch as it prevents this evil. Connect the dipped articles with the negative pole of the battery during the immersion in the acid and the metal will be almost perfectly protected.

Use for the purpose a quadrilateral tank in the middle of which two four-sided cells are placed. In each of these cells place a number of zinc plates which are connected with an iron bar across the top of the cells. Beside each cell in the tank is placed a movable wooden shelf provided with holes; upon its upper surface is adjusted an iron bar bent backward and forward across the top. This bar is metallically connected with the bar from which the zinc plates are suspended in the cells. When in use, fill the tank and the cells as far as necessary with a liquid composed of 1 kilo sodium chloride, 20 kilos of water and 1½ kilos of sulphuric acid. The objects to be cleansed are now placed upon the wooden shelves in contact with the bar thereon and form the negative pole of a simple galvanic chain. By warming the liquid by means of a steam coil passed through it the action will be expedited.—Neueste Erfindungen und Erfahrungen.

ELECTRICAL NOTES.

The Aging of Dynamo Iron Sheets.—The Elektrotechnische Zeitschrift contains a preliminary report by Prof. Epstein on the results of experiments made by members of the hysteresis commission of the Elektrotechnische Verein. The members of the commission worked independently, but on the same plan, the losses being determined both by the wattmeter and statical methods with apparatus of Ewing, Epstein, and Siemens & Halske. The experiments were conducted by Dr. G. Stern, in the laboratory of the Union Elektricitäts Gesellschaft, of Berlin; Prof. Epstein, in the laboratory of the Elektricitäs-Actien-Gesellschaft, vorm. Lahmeyer & Co.; and by Mr. Soschinski, in the laboratory of the Siemens-Schuckertwerke. Prof. Epstein observed that heated iron sheets aged at the same rate, whether or not they were simultaneously traversed by induced currents, and his further experiments were therefore confined to heating the iron up to temperatures of 140 deg. Cent. (284 deg. Fahr.). Mr. Soschinski gives particulars about parallel transformer and heating tests which, on the whole, agree well with one another. It results that transformer iron deteriorates electro-magnetically in the laboratory where it is exposed to atmospheric temperature changes, even when not experimented upon or used in any way. These increased hysteresis losses are not considerable, however, and a stable condition seems to be reached in two or three months. This conclusion does not quite agree with the statement which Dr. Stern made a year ago, when he published a summary of tests he had been conducting in the years of 1897 to 1902. It had then appeared to him that there was a steady increase in loss for seventeen months; but he had also observed that iron supplied by firms which made a specialty of dynamo and transformer iron was less liable to aging in this respect, and the results of the recent trials demonstrate that manufacturers have learned mechanically to prepare the iron in such a way that the hysteresis does not much increase afterward. Prof. Epstein's figures show the superiority of the iron from well-known firms over the iron that he had for these tests obtained from works comparatively inexperienced in this branch. One specimen of iron, at once recognized as not homogeneous, showed a current waste—comprising losses from hysteresis and Foucault currents—of 25 per cent; but, as a rule, the hysteresis losses amounted to from 3 per cent to 8 per cent at the end of two and a half months. The thinner sheets, 0.35 millimeter in thickness, aged more than the 0.5 millimeter sheets (0.014 inch and 0.02 inch respectively). Iron containing 2 per cent of aluminium gave a loss figure of 33 per cent; an alloy containing 1 per cent of aluminium and 0.25 per cent of silicon a loss of 15 per cent. These alloys, therefore, which Mr. Soschinski tested, age very much. The Foucault current losses, as distinct from the hysteresis losses, were in all cases small, and remained fairly constant throughout the experiments. The just-mentioned aluminium alloys, indeed, appeared to improve a little with time in this respect.

The British government proposes to control absolutely the operation of wireless telegraphy in the United Kingdom. According to existing legislation the government has full powers to acquire any system of ether telegraphy, but the object of the present law is to specify particularly upon this method of communication. This proceeding is to prevent the possibility of any private installations being set up for ulterior motives in time of war. The threats of the Russian forces during the present campaign with Japan concerning the utilization of ether telegraphy by private and newspaper correspondents, has demonstrated the fact that the government should exercise some control over such action. Under the existing laws, in any such contingency the government would be powerless, but by converting it into a part of the country's monopoly such use would be possible of restriction. Then again, owing to the numerous systems that have been invented, and the setting up of experimental stations indiscriminately, the utility of the discovery has been considerably nullified by the wanton transmission of interfering currents. The government contends that the various systems should have full facilities extended for their respective development, so that in the long run the best system may triumph. Unfriendly rivalry will thereby be rendered impossible. Furthermore, it is recognized that coast communication between land stations and passing vessels, regardless which systems are used in such cases, should be compulsory. At present, in some instances, it has been found that such communication has been refused owing to the fact that the land station is equipped with a different system from the vessel. By nationalizing the scheme such refusals will become unlawful. The government purposes to extend licenses to any *bona fide* inventors and systems, but if such experimental stations are installed without their consent the persons operating such unrecognized systems will be liable to a fine of $500 and the confiscation of their apparatus. Certain conditions will be imposed upon all those who apply for such licenses, but it is recognized that this procedure will tend not only for the public benefit, but will also encourage the development of all serviceable and efficient systems.

ENGINEERING NOTES.

Brakes as used in connection with hoisting engines and drums are for the purpose, first, of slowing or stopping the motion; second, holding the drum and load stationary; third, regulating the rate of lower-

ing. There are many forms and styles of brakes, the leading characteristics of which will be briefly mentioned. Brakes may be applied by a hand lever, a hand wheel, and a lever operated by the foot. They may also be operated by air, steam, hydraulic power, and electricity. Two methods of operating the same brake are sometimes made use of, hand and power, for instance. A brake being ordinarily operated by power may have a hand-power attachment for use in case the power attachment for any reason fails. The hand power, if provided with a locking device, may be used to make the skip safe from accidental lowering on leaving the hoisting plant at noon or night. A singular and unexpected runaway of an empty skip and rope occurred at an iron mine. At the end of the day's work the skip had been left at the top; the drum being independent of the engine, was held by a power brake operated by compressed air. In the night it was desired to attach a new branch, and the air was shut off, the pipe line supplying that engine house; this released the brake and allowed the skip to run down the shaft; the drum ran until the end of the rope was reached, cutting the rope, which also went down the shaft. Had the brake been provided with a hand motion, in addition to the power brake, such an accident could not have occurred if only the precaution had been used to apply the hand brake before leaving the plant.—J. S. Lane, in Mines and Minerals.

The recent record run of the North German Lloyd steamer "Kaiser Wilhelm II.," which covered the trip across the Atlantic at an average speed of 23.58 knots, is credited to the alterations which have been made in her propellers. Up to the time of this record the vessel had not succeeded in maintaining 23 knots for any length of time, but, impressed with the gain in speed in the case of the cruisers of the "Drake" and of the "County" class, as a result of a change in propellers, the builders and owners decided to fit the vessel with new propellers, increasing the blade area very considerably, as was the case with the cruisers, and thus a marked addition to speed has been attained. The engines ran at about 79 revolutions throughout the trip, which is about the same speed as with the smaller propellers. On the last two days of the trip, when the displacement had been considerably reduced owing to the depletion of the coal in the bunkers, a rate of 24.35 knots was maintained.

Mr. J. W. Endean, electrical engineer to the Devonport and District Tramways Company, England, in a communication to the Electrical Review, gives some interesting information relating to the life of the wheels and brakes used on the tramways of his company. Regarding the wheels, which are of chilled cast iron, these when new weigh 315 pounds, and when they retire to the scrap heap their weight is reduced to 266 pounds, thus showing a net loss per wheel of 49 pounds, or 196 pounds per car. This result is attained after an average mileage of 35,000 miles, which gives an average of 5.6 pounds of wheels per 1,000 miles. In the same time (which is about 12 months) the brake blocks are renewed 18 times. When new they weigh 112 pounds per set, and their scrap weight is 68 pounds. The total weight of brake blocks ground down is, therefore, 792 pounds, or wheels and brake blocks together equal 28.2 pounds of metal per 1,000 miles. The track brakes are made of wood, and are renewed every day; their morning weight is 10 pounds, and their evening weight is 6 pounds. Therefore, in 12 months 2,920 pounds of wood is ground up per car. The author gives the cost of wheels and brakes as equal to 0.279 d. per car mile.

The length of rails for old-time tramways was determined by the following interesting rule, taught to the cadets at West Point eighty years ago and recently resurrected by Mr. Edwin F. Smith: "The price of a ton of iron delivered on the railroad must be known, and also the price of the chair, stones and setting one support. Then divide the price of a ton by the price of one support, both being in dollars; square the quotient and multiply it into the breadth of the rail in inches, and this product by one-twentieth part of the weight of the loaded wagon in pounds, and extract the cube root of the product; divide 700 by the cube root found and the result will be the distance in feet." This rule was for tram rails of cast iron, which, the author states, must be guarded by every possible precaution from becoming wet.

The value of water meters in checking water waste in a city where the capacity of the works is reached and any unusual draft produces unpleasant consequences, was well indicated at the recent convention of the American Water Works Association by Mr. Jerry O'Shaughnessy, superintendent of the Columbus, Ohio, water department. The same facts are mentioned as follows in the last annual report of Mr. Charles E. Bolling, superintendent of the Richmond, Va., water department: "Had we not adopted the meter system, Richmond would undoubtedly have experienced a water famine this winter, due to the constant stoppage of the water pumps from ice and the excessive waste in fixtures to prevent bursting of pipes. For comparison, in 1893, during a long cold spell, the average pumpage per day was 17,000,000 gallons. Our reservoirs were nearly empty, and there was little or no pressure along some of our principal streets. During this long cold season the daily pumpage has been 14,000,000 gallons, at no time a scarcity of water in the reservoirs, and the pressure of the mains has been ten times greater than in 1893."—Engineering Record.

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