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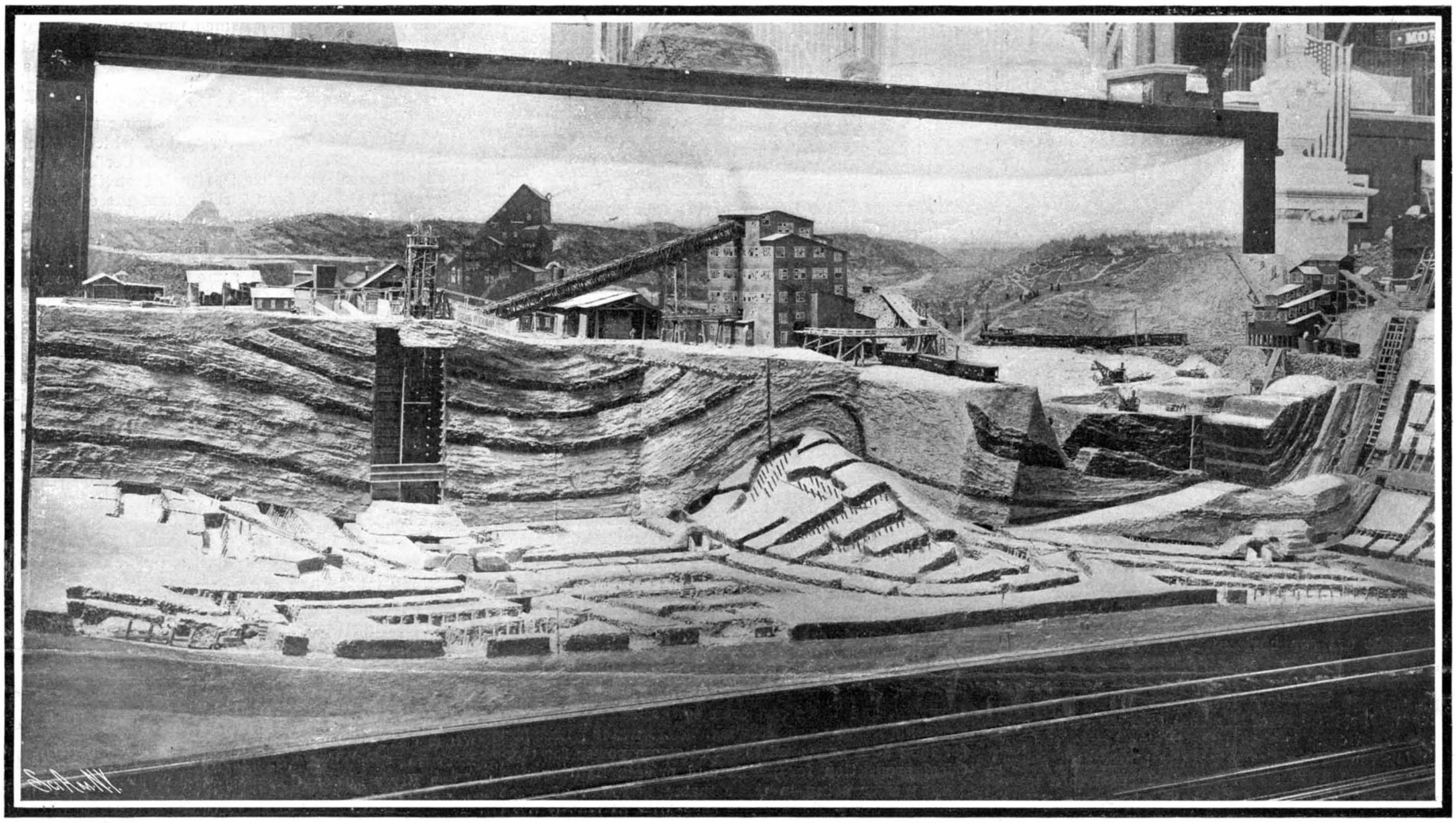
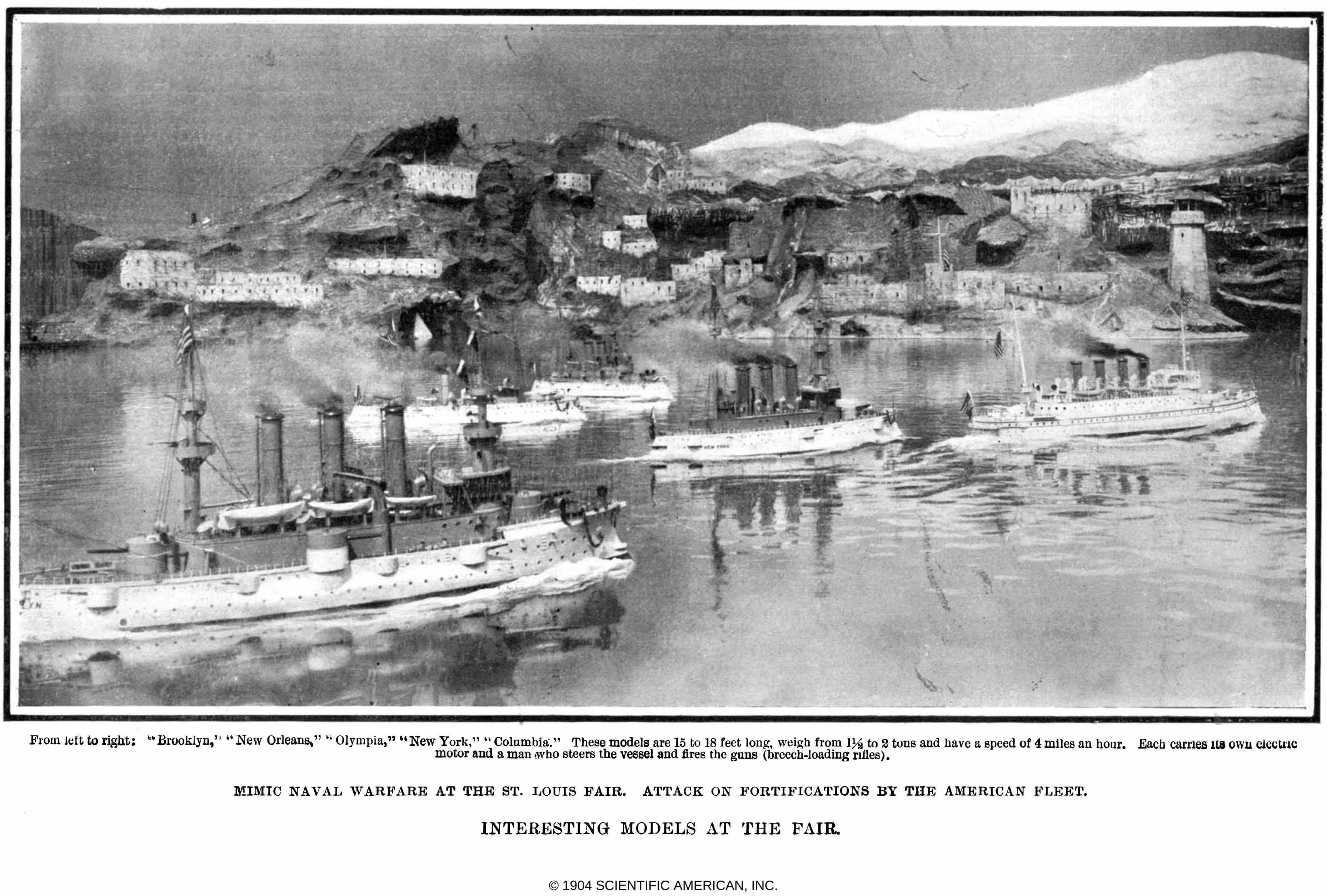


PENNSYLVANIA STATE MINING EXHIBIT. MODEL SHOWING METHODS OF MINING ANTHRACITE COAL.



From left to right: "Brooklyn," "New Orleans," "Olympia," "New York," "Columbia." These models are 15 to 18 feet long, weigh from 1½ to 2 tons and have a speed of 4 miles an hour. Each carries its own electric motor and a man who steers the vessel and fires the guns (breech-loading rifles).

MIMIC NAVAL WARFARE AT THE ST. LOUIS FAIR. ATTACK ON FORTIFICATIONS BY THE AMERICAN FLEET.

INTERESTING MODELS AT THE FAIR.

INTERESTING MODELS AT THE FAIR.

By the St. Louis Correspondent of the SCIENTIFIC AMERICAN.

A NOTABLE feature of the World's Fair of 1904 is the great excellence of the work done by the model makers, and nowhere is this shown to better advantage than in the Mines Building. We present an illustration of one of the finest of these models, which is to be found in the Pennsylvania State mining exhibit. The model, which is 16 feet in length by 10 feet in height, does not represent any particular mine, but is rather a composite, made to include as much information as possible as to the overhead structures and underground workings of anthracite mining, as carried out in the State of Pennsylvania. The rear part of the model shows the natural surface of the ground with the coal breaker in the center and the conveyor leading from the shaft to the top of the breaker. The ground is supposed to be cut away, showing the various strata of coal and slate until the fifth stratum is reached, where the workings at this particular level are exposed over a wide area covering the entire width from the shaft to the front of the model. The stratum of coal that is thus shown in plan is about 8⅓ feet in depth, and it gives an excellent idea of the general plan on which the various excavations are run, and the way in which the roof is carried by timber props. The slope that is seen slightly to the right of the center of the model shows the method by which the washings of slate and refuse from the breaker are used for filling up the workings in order to support the roof. When this filling is completed, the coal that remains is excavated, the spaces thus formed being in turn filled up, thus providing a continuous solid support for the overlying ground. In other parts of the model there are shown such things as the underground mule stable, the pumps, and the underground hospital with its staff of trained nurses. To the left are shown the various methods of loading coal where the workings are on an incline, the full car generally serving to pull the empty one up, ready to be filled in its turn. To the right of the breaker, the dark section shows an outcropping of the "mammoth" vein which runs throughout the whole anthracite district. This huge vein varies from 50 to 100 feet in thickness, and this section of the model serves to show the process of stripping this outcrop and working it as an open quarry. At the extreme right is illustrated the method of "overhead" mining, which is used on a steeply inclined outcrop of the coal. An inclined shaft, as shown, is run down into the strata; then the coal is taken out by a process of cross-drifting. Drifts are run horizontally into the coal strata at stated intervals, and after the drifts are completed, the cars are hauled in, and the miners proceed to break down the coal from the ceiling overhead into the cars. To the left of the coal breaker at the surface of the ground is shown the engine house, the fan room for ventilating the mine, the blacksmith shops, storehouses, and other buildings incidental to a large anthracite coal mine. At the back of the model is a realistic picture showing typical scenes in the anthracite mining districts.

The great popular interest in naval matters is evidenced by the success which invariably attends any effort to reproduce the conditions of naval tactics and warfare by means of large working models. The latest, and by long odds the most meritorious, of these model fleets, is the one now on exhibition at the St. Louis fair. In previous attempts of this kind, an effort has been made to give the appearance of independent automobile movement to the different war vessels, by constructing them so that they could be moved by operators who walk on the bottom of the tank, with their heads and shoulders projecting into the vessel from below. This was at best a clumsy and easily-detected fraud. In the present case, vessels have the advantage that each carries its own motor, and has within it an operator who controls both the speed and direction of the vessel. The fleet is made up of 28 models of existing warships, each built to an exact scale of 1-25 full size. The models are built of steel plate, and vary in length from 15 to 18 feet. They are provided with electric motors and storage batteries, the motors varying from one-half to three-quarters of a horse-power. They draw from two to two and one-half feet of water and weigh from one and one-half to two tons apiece. The maximum speed is about four miles per hour. In most of the warships the foremast, conning tower, and fore bridge are removable, disclosing a hole large enough for the operator to step down into, and seat himself with his head at the level of the conning tower, which is fitted with a wire screen, rendering him invisible to the audience, but enabling him to see clearly the other vessels and the fortifications. Each ship carries four guns, two in the forward and two in the after turret, that can be fired with blank cartridges, the other guns in the turrets and throughout the ship being dummies. The guns that are fired are actually revolvers, containing 20 cartridges in a charge. This enables the operator to fire 100 rounds per minute, and in a general engagement of the whole fleet there are some 200 guns in action and some 10,000 shots are fired during each performance.

At the back of the fortifications which form the background of the basin in which the operations take place is a large naval dock, containing fourteen harbor docks and one drydock. It is a truly remarkable sight to see these miniature battleships, cruisers, torpedo boats and submarines moored at their respective docks, get under way at the word of command, and pass out in line of battle between the harbor piers and into the open. The whole plant was designed and is in charge of a naval officer, who was for twenty years in the German navy, and the crew have been so well trained that the miniature fleets go through the series of operations with the precision and accuracy as to line and distance that mark the maneuvers of a fleet of full-sized warships. When a similar exhibition was made at Dusseldorf, Germany, Emperor William evinced the keenest interest in the venture, and was a frequent visitor, especially to the dock where the little warships are moored and which they enter and leave with such remarkable precision. The events that are reproduced are the battle of Santiago, the capture of merchant ships, target practice by the battleship "Texas" while she is under way, and torpedo attack upon a target by a fleet of four or five torpedo boats.

ELECTRICITY FROM WATER POWER.*

By A. A. CAMPBELL SWINTON.

IT should be gratifying to our national pride to know that probably the very earliest example of the production of electricity by means of water power on a practical scale and its transmission to a distance was the installation put up—for the purpose of lighting—at Cragside, Northumberland, by the late Lord Armstrong in the year 1882. This plant, which was still in daily use in the year 1884 when the author saw it in operation, consisted of a Siemens continuous-current dynamo which was driven by means of a belt off an 8 horse-power water turbine operating with a fall of 30 feet, the electricity—which was delivered at 90 volts pressure—being carried by bare overhead wires attached to porcelain insulators on poles to the house about a mile distant. It is an interesting fact that when the installation was first put to work it was designed to operate with only a single wire, connection being made to the hydraulic power pipes at the one end and to the ordinary household water pipes at the other, the earth being expected to form a sufficient return in the manner employed in telegraphy. This plan, which was adopted on the advice of the late Sir William Siemens, was found to be quite ineffective, as, owing to the low voltage employed and the exceedingly rocky nature of the ground, no useful amount of electricity could be transmitted, until the earth return was done away with and a second metallic conductor substituted.

Though this 22-year-old English example of electricity developed by water power and transmitted to a distance was, as already mentioned, probably the first such installation in existence in the world, the great development of such installations has, up to recently, taken place almost exclusively abroad. No doubt up and down this country a very considerable number of small electric plants operated by water power have been put up for private house lighting and such like purposes, and there are even towns, such as, for instance, Salisbury and Keswick, where water power has for long been employed to assist steam power for electrical production for public and private lighting, the water power being in these instances found of great value for the purpose, more especially of maintaining the supply during the periods of minimum load. A few hundred horse-power will, however, probably cover the whole of the plants of this character at present running in Great Britain, which is an altogether insignificant amount compared with the much larger corresponding figures for the continent of Europe, America and other countries.

To obtain accurate statistics as to the amount of water horse-power at present employed for electrical production throughout the whole world is a very difficult matter, as in many countries no figures are available, while in others, such as are obtainable are not up to date. The following summary, giving an aggregate horse-power of nearly one and a half millions, comprises all the hydraulic electricity works of which the author has been able to obtain particulars. He has, however, no doubt that there must be many others in existence to which he has not been able to find any reference, while again, in the case of a number of the installations which have been included, the horse-power now employed is greater than that in use at the time that the statistics were made out.

Water-power Electricity Installations.—United States of America, 527,467 horse-power; Canada, 228,225 horse-power; Mexico, 18,470 horse-power; Venezuela, 1,200 horse-power; Brazil, 800 horse-power; Japan, 3,450 horse-power; Switzerland, 133,302 horse-power; France, 161,343 horse-power; Germany, 81,077 horse-power; Austria, 16,000 horse-power; Sweden, 71,000 horse-power; Russia, 10,000 horse-power; Italy, 210,000 horse-power; India, 7,050 horse-power; South Africa, 2,100 horse-power; Great Britain, 11,906 horse-power; total, 1,483,390 horse-power.

It therefore seems reasonable to suppose that the total amount of water power actually used for electrical production throughout the world at the present time must exceed 2,000,000 horse-power, which is about double the total steam power at present devoted in Great Britain and Ireland to the same purpose.

It is interesting to calculate what would be the amount of coal required to produce this large amount of horse-power were it generated by steam engines in the ordinary way; in other words, what is the saving of coal that the adoption of this amount of hydraulic power entailed. Many of the hydraulic plants, particularly those which are used for chemical processes, operate at full power continuously night and day, but others work for shorter hours. Assuming, however, that the whole 2,000,000 horse-power is in use for 12 hours per diem, in other words, is employed on the average with what engineers call a 50 per cent load-factor, and assuming, as is reasonable, that were the energy produced by means of coal, at least 3 pounds of this fuel would be required on the average per horse-power hour, we get 5.86 tons of coal per horse-power year, or 11,720,000 tons of coal saved annually on account of the 2,000,000 water horse-power utilized. Though this may appear a large figure, it amounts to less than 2 per cent on the total output of coal in the world, which, on the average of the last five years, was 632,000,000 tons per annum. Assuming, however, an average cost of coal of 10s. per ton, this 11,720,000 tons represents £5,860,000 yearly, an amount which it would take over £100,000,000 of capital earning 5 per cent per annum to provide.

Apart from mere magnitude, many of the more recent examples of hydro-electric engineering abroad, especially in America, are interesting by reason of the enormous distances over which the electric energy is being economically transmitted and the very high electric pressures that in numerous cases are being successfully employed. The longest distance over which transmission has so far been commercially effected is probably the 232 miles of line belonging to the California Gas and Electric Corporation, which stretches from the De Sabla power house *via* Cordelia to the town of Sausalito, which is situated on the opposite side of the Golden Gate Straits from the city of San Francisco. What this transmission means will be realized when it is stated that the distance covered is about equal to that which separates Cambridge from Newcastle-on-Tyne. The same Californian company also owns the Colgate and Oakland transmission line, which runs 142 miles from the Colgate power house, where 14,000 horse-power is developed from a head of water of 702 feet.

Another very long line is that which reaches from the Electra power house *via* Stockton and Mission San José to San Francisco, a distance of 147 miles, over which 10,000 horse-power is being delivered regularly. This line belongs to the Standard Electric Company, who have 217 miles of power line with a capacity of 27,000 horse-power in operation. The voltages employed, as is to be expected having regard to the distance covered, are very high, ranging from 55,000 to 67,000 volts, 60,000 volts being apparently the standard figure for many recent installations, of which the following table gives some examples.

Plants recently installed by the Stanley Electric Manufacturing Company, Pittsfield, Massachusetts.*

Name.	H.P. Capacity.	Voltage.	Transmission distance. Miles.	Head of Water.
Guanajuato Power and Electric Co., Mexico.	8,000	60,000	101	300 ft.
Washington Water Power Co., Spokane	12,000	60,000	110	68 ft.
Kern River Power Co., Los Angeles, Cal	16,000	67,500	110	..
Pierce Co.	26,000	55,000	40	..
Mexican Light and Power Co., Mexico	....	60,000	110	1,500 ft.
Winnipeg General Power Co.	10,000	60,000	60	40 ft.
Canadian Niagara Power Co.	......	60,000	93	..
Electrical Development Co. of Ontario	......	60,000	93	..

Mention should also be made of the 50,000-horse-power and the 125,000-horse-power plants for the Canadian Niagara Power Company and the Electrical Power Company, of Ontario, contracted for by the Canadian General Electric Company, both of which will employ pressures ranging up to 60,000 volts, while, to pass to another quarter of the globe, the Cauvery Falls electric power scheme in India has now been at work for over two years, and transmits 5,000 horse-power to the Mysore gold mines, a distance of 92 miles, using a pressure of 35,000 volts.

Turning now to the British Isles, the only large scale plant for the production of electricity by water power at present in operation in this country is the well-known installation of the British Aluminium Company at Foyers. This installation, which was originally designed by the late Mr. Birch and carried out by Mr. W. Vaux-Graham, has been at work ever since the year 1896, and the whole of the power has been employed for electro-chemical purposes on the spot. A small percentage of the power is utilized for the production of calcium carbide, but the bulk is, and in the near future the whole of the power will be, used for making aluminium. At present the gross horse-power of the plant is 7,000 horse-power, but plant for a further 2,000 horse-power is at the present moment being installed, and will shortly be working.

The water is derived from the River Foyers, which has a catchment area of upward of 100 square miles. Storage is effected by means of two lakes which have been joined together by the raising of dams and embankments, the result being a continuous lake of about 5½ miles long by about half a mile in width. The storage thus obtained is sufficient to run the entire plant continuously day and night for about 50 days. From the River Foyers the water is first passed through a tunnel 8½ feet diameter, cut through the solid rock, to the penstock chamber, from which the water is delivered by separate cast-iron pipes to the

* Paper read before Section G of the British Association, Cambridge meeting.

* For these particulars the author is indebted to Mr. C. C. Chesney, the chief engineer of the Stanley Electric Manufacturing Company, who have recently installed these and numerous other similar plants.

turbines, which are installed on the shore of Loch Ness, and into which the water is finally discharged, the available head of water being 350 feet.

The British Aluminium Company have obtained parliamentary powers for a further large water-power installation on Loch Leven. It is their intention to commence immediately the development of this scheme, which is capable of giving 17,000 gross horse-power. The reservoir is artificial, and will contain about 150 days' storage of the full power, the head of water at the turbine being 964 feet. It is anticipated that the whole of this power will also be taken up in the manufacture of aluminium on the spot, no distant transmission being, at present, at any rate, contemplated.

Another interesting water-power scheme of considerable dimensions is at the present moment being developed in Wales by the North Wales Electric Power Company, who have obtained parliamentary powers for this purpose. Their first installation is at present being erected under the superintendence of Messrs. Harper Bros., the company's engineers, and derives its power from Lake Llydaw, on Snowdon. This lake, into which runs the water from Lake Glaslyn, is about 1 1-5 miles in length and about a quarter to half a mile in width. Its area is 5½ million square feet, and it derives its water from a catchment area of about 1¾ square miles, including the summit of Snowdon. Being in the track of the Atlantic depressions, this area has one of the heaviest rainfalls in Europe, amounting on the average to 180 inches per annum. In 1903 it reached the phenomenal figure of 250 inches. The prevailing winds are from the sea, and the atmospheric moisture is driven up the sloping side of the mountain, and on being condensed at the summit is discharged in the form of rain or snow on the eastern side over Lakes Glaslyn and Llydaw. The fall of the year gives the wettest months, and it happens that the quantity running from the lakes in spring is averaged up by the snow melting on the sheltered eastern side.

By means of a dam about 100 feet in length, the level of the lake is to be raised 20 feet. The water will be drawn from the lake by means of a tunnel 600 feet in length at a point 30 feet below the present level, or 50 feet below the level when the dams are completed, with the result that there will be sufficient storage for meeting a 90 days' drought. The total fall utilized will be about 1,150 feet, and the total horse-power available, on the basis of a nine hours' working day, is calculated at 8,200. The first installation consists of two steel pipe lines and four 1,000 kilowatt sets, each consisting of a double tangential water wheel coupled to a 3-phase alternator giving 11,000 volts at 40 periods per second. The company will develop the full horse-power of Lake Llydaw before proceeding further, but they have also acquired a further water power at Llyn Eigiau, in the Conway Valley, where a fall of 800 feet is obtainable, and where it is calculated there will be nearly twice as much horse-power available as there is at Llydaw.

One of the first objects of the North Wales Electric Power Company, as soon as their installation is completed, will be to supply energy for the working of certain light railways which they control in the district. It is, however, in addition, intended to supply electric energy throughout a large area, comprising the whole of the counties of Carnarvon, Merioneth, and Anglesea, and also a portion of the county of Denbigh. Three-phase currents are to be used, and the transmission lines will be of bare copper wires, 0.324 inch diameter, carried on insulators triangularly placed on wooden poles. A large proportion of the transmission lines will be carried along the track of the above-mentioned light railways. Lines are to be laid to the principal slate quarry districts of Nantlle, Llanberis, Penrhyn, and Festiniog, where a considerable demand for power exists. The distances from the power station to these places ranges from 6 to 12 miles.

The latest water power electric scheme in the United Kingdom is that of the Scotch Water Power Syndicate, who have, by agreement, obtained from Lord Breadalbane and the trustees of the Colquhoun Estate of Luss important water power concessions. These agreements have been negotiated by Mr. E. Ristori, who, it may be mentioned, was one of the original founders of the Falls of Foyers installation, while the engineering and electrical details have been worked out by Mr. William Vaux-Graham and the author.

The first power that it is proposed to develop is one connected with Loch Sloy, which is situated some five miles north of Tarbet on the side of Ben Vorlich, between Loch Long and Loch Lomond. Loch Sloy, which is situated some 757 feet above Loch Lomond—which, in turn, is some 26 feet above the sea level—is fed from a catchment area of about 3,801 acres, which includes one side of Ben Vorlich, which, with its 3,092 feet, is one of the highest mountains in Scotland. The district has the very heavy rainfall of some 74 inches per annum, of which it is calculated that 60 inches will be collectible.

A dam will be constructed at the eastern end of the loch, which will raise the height of the latter by some 60 feet. This will impound some 240 million cubic feet of water, capable, with a calculated net fall of 700 feet to Loch Lomond, of maintaining 6,000 effective horse-power on a 25 per cent load factor for the maximum possible periods of drought, which are calculated at 100 days. From the loch the water will be taken in the first instance along an open conduit 3,650 yards in length, which will follow the contour line round Ben Vorlich till a point is reached almost immediately above the position where the power house will be constructed, on the shore of Loch Lomond, at a spot called Inveruglas. From the end of this conduit to the power house the water will be conveyed in steel pipes, the length of the pipe line being about 600 yards and the height of fall 700 feet.

From the power house an overhead transmission line is to be constructed in duplicate for the purpose of conveying the electric energy to the industrial areas of the Vale of Leven and the Clyde, which comprise the towns of Dumbarton, Helensburgh, Renton, and Alexandria, and includes shipbuilding yards, engineering and dye works, calico printing works, and factories of various descriptions, many of which have already intimated their desire to be supplied. The transmission line, for which private wayleaves have been obtained throughout, will be overhead on poles, starting from the generating station of Inveruglas, and continuing across country for a distance of 22 miles to a substation which will be situated at Renton, about midway between Dumbarton and the foot of Loch Lomond, in the center of the Vale of Leven industrial area. At this sub-station the voltage will be reduced from 40,000 volts, which it is proposed to employ for the long overhead transmission, to some 6,000 to 10,000 volts, it being the intention that the distribution from the sub-station to the various works shall be underground.

The following are the efficiencies which it is calculated will be obtained:

	Full Load Efficiency. Per cent.
Open conduit	75
Pipe line	75
Turbines	75
Three-phase generators	94
Step-up transformers	97
High-tension transmission line	93
Step-down transformers	97
Underground distribution (say 6,000 volts average	95
Total efficiency	58.6

This is on the assumption of the energy being delivered to customers at 6,000 volts. If, as is probable in most instances, it will be delivered at lower voltages, there will be a further transformation, the efficiency of which will be 95 per cent in the case of transformation in pressure only, and 86 per cent in the transformation to continuous current, making total overall efficiencies of 55.6 per cent for 3-phase current delivered, and 50.3 per cent for continuous current delivered.

So soon as a market has been found for the total power procurable from Loch Sloy it is intended to utilize a further water power, for which the rights have also been obtained, at Ardlui, about two miles further up Loch Lomond. This power is also fed by a small loch with an available fall of 800 feet, the horse-power obtainable being about half that available at Loch Sloy. The Scotch Water Power Syndicate have, in addition, obtained the rights to still further water powers on the Breadalbane Estate that exist further north, and these will be utilized as soon as the demand for power justifies the capital expense. It is because of these additional powers (which will considerably extend the length of the transmission) that it is proposed from the start to employ so high a pressure as 40,000 volts.

It is estimated that the total cost of the Loch Sloy scheme, including the transmission line and the distribution to the various factories, will not exceed £200,000 which, on a basis of 5,000 horse-power delivered, works out at about £40 per horse-power—everything included. Seeing that many of the existing electric generating stations worked by steam have cost almost this amount for land, buildings, and generating plant, this does not appear to be an excessive figure, and it may be pointed out as an interesting fact that the 20 miles of overhead transmission line only accounts for some £24,000, or about 12 per cent of the total expenditure. This, coupled with the fact that the calculated loss on the transmission line at full load will only amount to about 7 per cent, and the step-up and step-down losses to another 6 per cent, making 13 per cent in all, will give some idea of the extent to which the length of the transmission line is but a comparatively unimportant factor in schemes of this description. It may be pointed out further that the above-mentioned line loss of 7 per cent is upon the basis of only one of the two duplicate transmission lines being in use. When both are employed the line loss will be reduced to 3½ per cent, and the total transmission loss at full load will be only a little over 10 per cent.

The main transmission will be on the 3-phase system over two sets of three copper conductors each about 3-10 inch diameter, the possibility of conveying as much as 5,000 horse-power over a distance as great as 22 miles with only 3½ per cent loss by means of such comparatively small wires being, of course, due to the high pressure employed. Indeed, using pressure as high as 40,000 volts when it is a matter of transmitting comparatively small amounts of power, as for instance, the 600 horse-power or thereabouts that under the present scheme it is expected will be required for the supply of the town of Helensburgh, the interesting point arises that the minimum size of conductor allowable is limited, not by electrical conditions, but by considerations of mechanical strength. On the main transmission line the conductors will be carried at a minimum height of 40 feet from the ground, while at all crossings over roads they will be inclosed in a wire cage to meet the Board of Trade requirements for insuring public safety.

The application of water power in the United Kingdom can, of course, never attain the dimensions that it has already reached in America and elsewhere; still, the above brief account of what is at present being done in Scotland and in Wales shows that there are possibilities even in this old country of which till recently but few were aware. As regards the economies of electrical generation by water power, no general rule can, of course, be enunciated, and every case must be dealt with on its merits according to local circumstances. This notwithstanding, it is possible to give an indication of what is generally involved, having regard more especially to the fact that, with water power, as a rule, interest on capital plays a much greater part in determining the cost than does labor or upkeep.

Avoiding, on the one hand, small powers, where the costs are likely to be abnormally high, and, on the other, very large powers, such as we do not possess in this country, it may be taken generally that interest on capital, depreciation, upkeep, and working expenses in this country will amount to about 12 per cent on the capital expenditure.

On this basis it is easy to see that to be economically sound, the capital involved must not exceed 8½ times the annual price which can be got for the whole of the energy. For instance, if 5,000 horse-power is available for sale and £6 can be got for each horse-power on the average per annum, the capital involved must not exceed £52 per horse-power, or £260,000 in all.

To conclude, it has been said that the greatest benefactor to the human race is he who makes two blades of grass to sprout where only one grew before. On this principle the utilization of natural water power is obviously to the public advantage. When mechanical or electrical energy is generated by the burning of coal, it is a matter of the consumption not of interest but of capital. On the other hand, every water horse-power that is put to use is something added, mundanely speaking, for all time, to the permanent resources of mankind.

A NEW PROCESS OF COLOR PHOTOGRAPHY.

Scientists, dabblers in science and earnest amateur photographers have been trying for years to discover the secret of producing photographic prints in the colors of nature as seen upon the ground glass of the camera and as projected by the lens upon the sensitized plate. The lens views and the plate receives the picture in colors, but the negative plate is incapable of fixing anything else than form and producing that in fine gradations of light and opacity. Color negatives have been made, but have not been capable of transmitting color qualities to positives, nor have color positives been successfully made by any purely photographic principles. Good color effects are produced by superimposing photographic plates in mechanical printing processes, but hitherto there has been little success in chemical reaction upon ordinary printing paper to produce color effects.

Recently Rudolph Isenmann, of 385 Bergen Street, Newark, N. J., has produced some most promising effects in making color photographs by purely chemical manipulation in the simplest possible manner. With ordinary printing-out paper, either gelatin, albumen, or collodion surfaced, such as is sold by photographic stock houses, he claims to make prints containing blue, yellow, green and brown by merely soaking the prints as taken from the printing frames in two successive baths with a washing between the chemical immersions. The colors find their places with wonderful accuracy. The rich cerulean blue arranges itself in the sky with white cloud effect, and in the sunlit parts of the water in the foreground, while the water in the shade of the green trees takes up a greenish cast and the browns and autumnal yellows appear on the leaves and are reflected in the water in some of the pictures. The arrangement of the colors seems to be natural selection influenced entirely by the density of parts in the negatives from which the prints are made. Mr. Isenmann says that he allows the colors to work out their own progress, and never uses any effort to direct them by hand manipulation. He says further that the process is extremely simple and cheap. He uses no gold in toning the pictures, nor does he use hyposulphite of soda to fix them. What becomes of the free silver he does not say, but he has examples of his color work which have been made and exposed for six months, and he can see no change in the colors.

While Mr. Isenmann's results are by no means perfect, they show great advance in color photography, and give promise of still greater success. He despairs of ever reaching the reds by this process, but feels that he has secured a satisfactory end by extremely simple means.

The Manchester Corporation intend spending between four and five millions in bringing three more lines of pipes from Thirlmere Lake to Manchester, which will then have a supply of about 60,000,000 gallons per day. By the construction of the massive embankment, the level of Thirlmere will be raised 50 feet, and the lake will be increased in length from 2¾ miles to over 3½ miles, with a capacity of 8,135,000,000 gallons, equal to 150 days' supply if no rain was to fall during the time.

EXPERIMENTAL ELECTROCHEMISTRY.*

By N. Monroe Hopkins, M.Sc., Ph.D.
Assistant Professor of Chemistry in the George Washington University, Washington, D. C.

FIRST PAPER.

Historical Notes, and Important Classic Researches, with Simple Diagrams of the Use of the Electric Current to Electrolysis.

Believing that the proper introduction to this series of electrochemical papers should give a review of the historical work, together with a notice of the more basic experimental evidence obtained in support of the theories and laws advanced, the opening columns are devoted to recording the more important researches and discoveries.

As these papers deal jointly with electricity and chemistry, the best place to commence the recording of events is the time where we have introduced, or grafted into chemistry, the galvanic or voltaic current. The history of electrochemistry before the discovery of the galvanic current requires but a brief description. Ages before the discovery of voltaic electricity it had been observed that various metals, by being simply immersed in metallic solutions, became coated with the metal previously dissolved in the liquid.

Thousands of years ago Zosimus mentioned the deposition of bright metallic copper upon iron immersed in a solution of a copper salt. In the year 1752 Sulzer remarked: "If you join two pieces of lead and silver, so that they will be in the same plane, and then lay them upon the tongue, you will notice a certain taste resembling that of green vitriol, while each piece apart produces no such sensation." Becaria demonstrated in 1772 that metallic zinc could be obtained from its oxide by means of a powerful electric spark, as from a battery of Leyden jars. Paetz and Van Troostvik in 1790 decomposed water by passing electric sparks through it by means of very fine gold wires.

Up to the close of the eighteenth century, however, a possible affiliation of electricity with chemistry was not thought of, the second celebrated experiment of Galvani upon the nerves and limbs of recently-killed frogs, in 1786, marking the dawn of what is now known as dynamic electricity. As early as 1780 it was observed by Galvani that the limbs of dead frogs contracted violently when hung upon a copper hook in the neighborhood of a frictional electrical machine, at each disruptive discharge of the then known and so-called static electricity. Six years later, Galvani obtained the same results with the limbs and nerves of frogs without the agency of an electrical machine, simply by bringing a copper wire joined to a nerve and one of the limbs in contact with a piece of iron. The analogy of these results, although six years separated, caused Galvani to refer the phenomenon to a common agency, namely, electricity. Galvani describes his discovery of what he called "animal electricity" in his famous "De Viribus Electricitatis" of 1791 in the following words: "It is principally found in the nerves and muscles, and its path seems to be from the muscles to the nerves, or rather from the nerves to the muscles by the shortest route, as in the Leyden jar. There is in every part a double electricity, positive and negative, and disjunctive. One exists internally in the muscles, the other externally; so that the muscular fiber acts like a little Leyden jar, and the nerves simply serve the office of conductors." In the year 1792 Alexander Volta discarded the theory given by Galvani; and from the fact that convulsions took place more energetically when there were dissimilar metals in the connecting circuit, instead of only one variety, attributed the electricity to their being unlike, and laid the basis for the contact theory of electricity. In 1792 Prof. Fabroni, of Florence, first suggested chemical action. The following words are from Prof. Fabroni's report to the Scientific Academy of Florence, concerning experiments which he had made with metals which he had immersed in water. He said that he was convinced that "a chemical action had taken place, and that it was unnecessary to seek elsewhere the nature of the new stimulus, that it was manifestly owing to the slow combustion and oxidation of the metal; which combustion must have been accompanied by an attraction of oxygen and by a disengagement of light and caloric." In 1793 Alexander Volta of Pavia advanced his contact theory of electricity in the Philosophical and Medical Journal of Leipsic, and later in his famous memoir to the French National Institute, he gives an exposition of his "electro-motive apparatus." It is made, he says, writing in 1801 in the above celebrated communication to the National Institute, "in the form of a pile or of a range of cups, and consists in the simple metallic pairs of plates, so arranged as to impel the electric fluid in one particular direction. The zinc is laid upon the silver, the moist pasteboard over the zinc, and so on consecutively." He called the different conducting substances the "motors," and their arrangement a "circle," "in which an electric stream is occasioned, which ceases only when the circle is broken, and which is renewed when the circle is again rendered complete." The power of chemical decomposition of the voltaic "stream" or current was immediately noticed by numerous workers, Nicholson and Carlisle being the first to decompose water by means of such a current of electricity on May 2, 1800, and soon afterward Dr. Henry, of Manchester, decomposed nitric and sulphuric acid, and also ammonia by similar means. With the discovery of the voltaic current scientists became occupied with two great questions: First, what is the true principle of the voltaic cell and the source of the electricity? And second, what is the mechanism of electrolysis, or in other words, how does the electric current decompose chemical compounds? Let us take up the question of electro-decomposition first in our series of papers, and discuss the origin of the electric current when we are in a better position to appreciate the various factors.

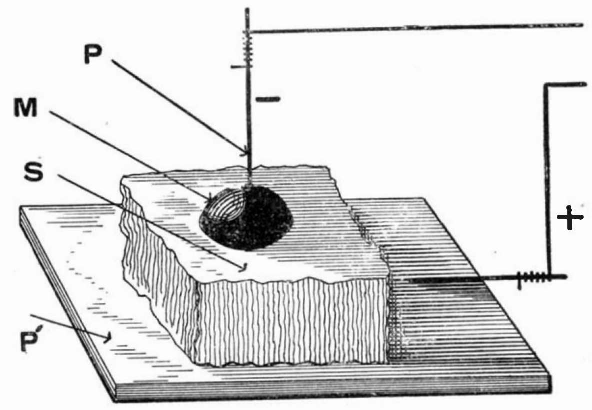


Fig. 2.—S. Block of Moistened Caustic Soda or Potash M. Mercury in Cavity of Caustic Soda or Potash. P. Platinum Wire Dipping into Mercury. P'. Platinum Sheet for Positive Wire Connection.

In 1801 Dr. Wallaston discovered that if a piece of silver in connection with a more positive metal be put into a solution of copper, the silver becomes coated with copper, which coating will stand the operation of burnishing. During the same year Gerboin first noticed the movement produced in mercury during the act of electrolysis.

In 1803 Hissinger and Berzelius discovered that by means of a voltaic current the elements of water and of neutral salts were transformed to the respective polar wires immersed in the liquid; and Cruickshank, about the same time, observed the electro-deposition of lead, copper, and silver upon one of the polar wires (the one connected with the zinc end of the battery) immersed in solutions of salts of those metals, and was thus led to suggest the analysis of minerals by means of the voltaic current.

In 1805 Brugnatelli observed the electro-deposition of gold upon silver when the former was made the negative pole in a solution of "ammoniuet of gold"; he also discovered the electro-deposition of zinc.

The most brilliant and striking proof, however, of the great breaking-down power of the electric current, when applied to chemical substances, was discovered on October 6, 1807, by Sir Humphry Davy, in the electrolytic decomposition of potash and soda, and the liberation of their respective metals, by a current from a voltaic battery of 274 cells.

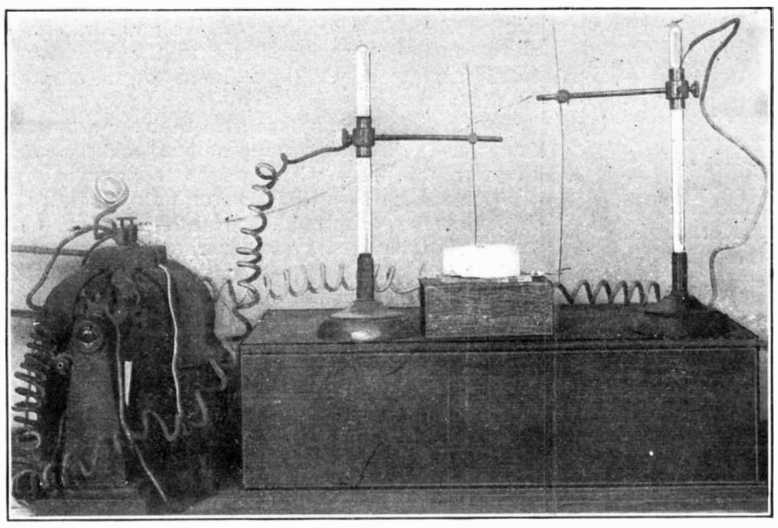


Fig. 1.—Reproduction of Sir Humphry Davy's Classic Experiment in Isolating the Metals Sodium and Potassium.

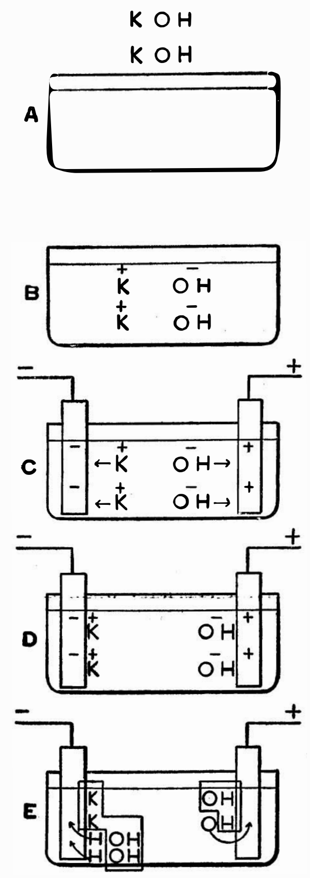


Fig. 3.—A. Two Molecules of Potassium Hydroxide before Immersion in Water. B. The Same Molecules Broken Down into "Ions" on Being Dissolved. C. The "Ions" being Attracted to Electrodes of Opposite Polarity. D. "Ions" Arrived at the Electrodes Ready to give up their Charges. E. The Electrical Charges Neutralized, the "Ions" Become Atoms and React to form Potassium Hydroxide again, and Water, and Setting Free Oxygen and Hydrogen Gas.

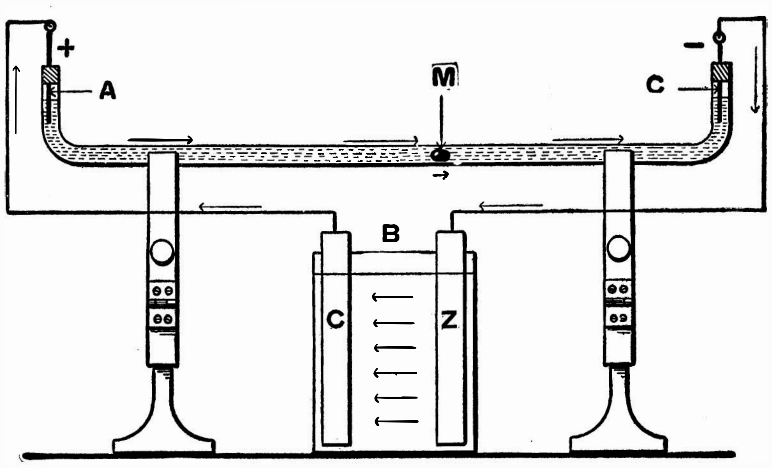


Fig. 5.—A and C. Anode and Cathode Respectively in Glass Tube. M. Globule of Mercury which Travels with the Current. B. Cell of Battery Supplying Current. C and Z. Copper and Zinc Electrodes of Battery. The Arrows Indicate the Direction of Flow of the Electric Current as Well as the Movement of the Mass of Mercury.

Let us study this classic experiment, and begin our practical laboratory work by reproducing it, and under the stimulus of the famous experiment, undertake to explain the mechanism of electrolysis, or in other words, to learn if possible what takes place when an electric current is made to pass through the substances Davy used. First let us look into the actual arrangement of the details of the experiment. For this purpose we will turn to our illustration. In our electrochemical studies, a fair knowledge of chemistry is presupposed, although the author will deal with the subject throughout as simply and as clearly as possible. A small cavity was made in a piece of caustic soda, or sodium hydroxide (NaOH), and then moistened with water. This was placed upon a piece of sheet platinum connected with the positive wire of a voltaic battery. Mercury was poured into the cavity and connected with the negative wire of the battery,

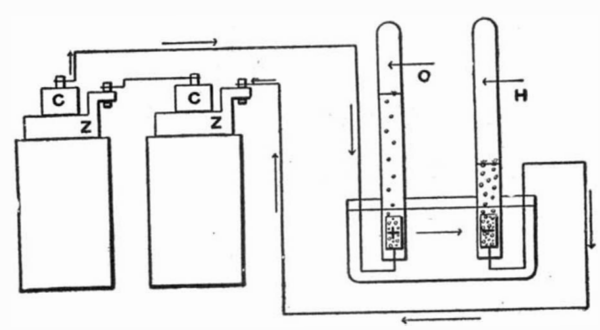


Fig. 4.—Experimental Electrolysis of Sodium or Potassium Hydroxide Solution. O. Oxygen Collected in Positive Tube. H. Hydrogen Collected in Negative Tube. C C. Carbons of Battery. Z Z. Zincs of Battery. Arrows Indicate the Direction of Current.

thus closing the circuit through the system. Electrolysis began immediately, the metal sodium, from the sodium hydroxide, being liberated from the hydroxide, and propelled to the mercury, with which it amalgamated. After about an hour, having kept the caustic soda moistened by the addition of water from time to time, the mobile mercury became quite stiff, due to the presence of the sodium amalgamated with it. This experiment can be most easily reproduced, and the sodium be freed from the mercury by distillation of the mercury, leaving the sodium behind, or the

* Specially prepared for the Scientific American Supplement.
This is the first of a series of practical articles by Prof. N. Monroe Hopkins, in which the subject of electrochemistry will be discussed in an intelligible way from the experimental standpoint. The apparatus described has been used by the author in making the experiments that he explains, so that their operativeness is assured. These articles are to appear in alternate numbers of the Scientific American Supplement for a number of weeks, and should prove of great interest to the experimenter and student.

little mass of amalgam may be put into water, when the sodium will react with the water ($Na + H_2O = NaOH + H$), setting hydrogen free, which may be ignited, and forming a solution of sodium hydroxide, which may be obtained in the solid form by evaporating to dryness on a watch glass. In distilling the mercury from the sodium, the reader is referred to any general work on chemistry, where the proper precautions are given for this operation. This is a beautiful little experiment, and it is strongly urged that every student in electrochemistry repeat it for himself. In the place of the historic battery of 274 cells, six or eight modern cells of battery will suffice, although the direct current from a lighting system, properly modified by lamps, is to be desired. The use of lighting circuits and lamps for electrochemical processes will be fully dealt with later. Let us now look into the theory of the breaking up of the sodium hydroxide by the electric current. Davy might have used a strong solution of sodium hydroxide in water placed in a dish, with a layer of mercury at the bottom to act as the negative electrode, and to receive the sodium, and the principle would have been just the same. Let us represent graphically such a solution, and illustrate by diagram the various steps in the electrolysis. As an exposition of all the ancient theories would lead to confusion in our practical work, the latest views only

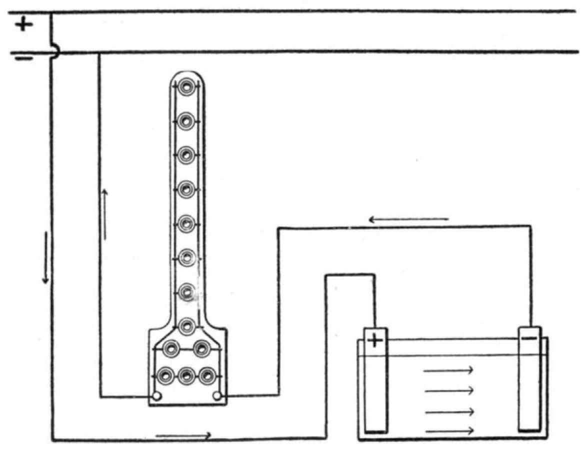


Fig. 6.—Diagram of Lamp Bank and Electrolytic Cell in Connection with a 110 or a 220 Volt Direct-Current Electric Lighting Circuit.

upon this subject are given, and we will begin our work based upon the famous theory of "electrolytic dissociation." This theory explains in a most satisfactory manner many chemical and electrochemical phenomena, which without its aid would be hopeless. This celebrated doctrine was advanced by Svante Arrhenius in 1887, and although there are many chemists, physicists, and physical chemists who do not accept it, they have not advanced anything better to account for the numerous things it explains. There is the most excellent experimental evidence in support of this doctrine, which will be taken up in detail later on. For the present we will assume it to be true, for besides being a theory of exceptional beauty, it will be of great assistance to us in all our work in electrochemistry. The theory simply states that the molecules of certain chemical substances, when dissolved in water, break up into ultimate parts, and that these ultimate parts carry upon them little charges of electricity. Let us look at the matter from a digrammatic point of view. The accompanying illustration (Fig. 3) shows a series of vessels in which we will electrolyze a solution of potassium hydroxide. *A* represents two molecules of potassium hydroxide about to be plunged into the vessel of water. Here the familiar molecular chemical formula of the base is given. *B* shows what is supposed to take place according to the theory of electrolytic dissociation. The potassium atom breaks away from the hydroxile group, and takes upon itself a charge of positive electricity, and the hydroxile group takes upon itself a charge of negative electricity. All this is believed to happen simply upon dissolving in the water, with no electrical

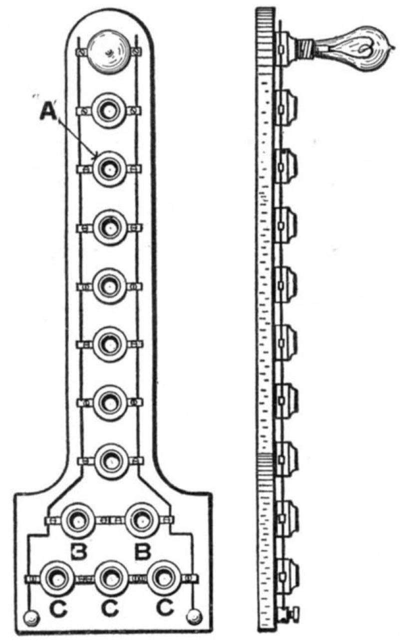


Fig. 7.—Laboratory Lamp Bank for Electrolytic Work. Range from $\frac{8}{100}$ Ampere to 8 Amperes.

influence whatever being brought to bear. Here we have, according to our theory, free potassium detached, and isolated from the hydroxile radical, floating around independently in the water, but covered with a charge of electricity. At first sight of such a diagram the majority of chemical readers would say that they did not believe a word of it, for in the first place we could not have free potassium floating about in water without a violent reaction taking place between it and the water; and in the second place, where did the charge of electricity come from? Let us not attempt to answer these questions for the present, but accept the truth of the theory for the time being, and take up the next step in the electrolysis. In *C* we have introduced into the vessel two electrodes, one positive and the other negative, as they are connected to the positive and negative ends of a voltaic battery respectively. We know from our elementary physics and electricity, that like signs repel, and that unlike signs attract. In this case, if the ultimate parts of the molecule of potassium hydroxide carry positive and negative electrical charges respectively, there should be an attraction between the negative charge of one electrode and the positive charge of the potassium on the one hand, and an attraction between the positive charge of the other electrode and the negative charge on the hydroxile group on the other hand. If all this is true, there will be a movement of the potassium toward the negative electrode, and a movement in the other direction of the hydroxile group toward the positive electrode, as indicated by the small arrows in the diagram. These ultimate parts of molecules are called "ions," whether they consist of a single atom, like our potassium with its electrical charge, or whether they consist of a group of atoms, like our hydroxile, with its electrical charge. Let us then adopt the technical term, and speak of the potassium hydroxide molecule as breaking down, in the presence of water, into a positive potassium ion, and a negative hydroxile ion. The next little diagram, *D*, shows the potassium ions arrived at the negative electrode, and the hydroxile ions arrived at the positive electrode. We may think of the electrical charges upon these ultimate parts of the molecule as having a protective action, that is to say, rendering them inert so far as the water is concerned. We know that we could not put ordinary metallic potassium into water without a violent reaction taking place, with the liberation of hydrogen and the formation of potassium hydroxide. Now let us account for the passive state of the ion potassium in the water to be due to the protective action of the electrical charge. What happens when this ion reaches the electrode? We have plenty of negative electricity there, with which to neutralize the positive electricity upon the potassium, and neutralization quickly takes place. The little diagram, *E*, shows the next step; there the electrical charges have been neutralized and removed, and instead of ions, we now have ordinary chemical atoms and groups of atoms. In the lower left-hand corner of this last diagram, two molecules of water have been graphically inserted; for as soon as the potassium ions become atoms, we know as general chemists that there will be a reaction to form potassium hydroxide, with the liberation of hydrogen. The water was not represented in the previous diagrams simply because it played the part of solvent only, and did not combine chemically with our ions. The small arrows here indicate the setting free of two atoms of hydrogen at the negative electrode, and the formation of a molecule of water at the positive electrode, and the setting free of one atom of oxygen. Now, what are the facts in an actual experiment? If we electrolyze a solution of potassium or sodium hydroxide in water, we will have two volumes of hydrogen set free at the negative electrode, and one volume of oxygen at the positive electrode. If our negative electrode consists of mercury, as in Davy's experiment, the sodium or potassium will amalgamate with the mercury, which prevents it from acting upon the water so long as the current of electricity continues to pass. In the experiment with the little block of caustic soda or potash, there would be only sodium or potassium set free in the mercury, and oxygen at the moist surface of contact of the caustic block and the platinum sheet base.

To electrolyze such a solution experimentally, set up an apparatus like that shown in the next illustration. Two large test tubes may be used, and it will be observed that just twice the volume of hydrogen will be set free, in other words, two volumes of hydrogen to one volume of oxygen will be liberated. Where the wires dip under the caustic solution, it will be necessary to insulate them with a solution of rubber, or else several coats of gum shellac, to prevent the liberation of gases from the wires themselves. With the ends properly insulated, the setting free of the oxygen and hydrogen will be confined to the little platinum plates within the tubes. Now, these little platinum plates or electrodes have technical names, and we must become familiar with them. The positive electrode is called the "anode," and the negative electrode is called the "cathode." The current in an electrolytic bath always flows from the anode to the cathode, all electropositive ions going to the cathode, and all electronegative ions going to the anode. As a general rule, all the metals and hydrogen go to the cathode in an electrolytic cell, and all other chemical elements go to the anode. The following table shows the chemical elements arranged in their electrochemical order, some of the extremely rare ones not being included. In this table each chemical element is positive to any element placed above it, and negative to any one given below it. These distinctions although of a relative character, are very important, since it seems probable that the very nature of chemical attraction itself rests upon these electrochemical relations. The following columns are arranged seriatim as if placed in an electrolytic cell:

+ Anode or Positive Electrode.

	NEGATIVE ATOMS.	
Oxygen	Fluorine	Bromine
Sulphur	Chlorine	Iodine
Nitrogen		
	POSITIVE ATOMS.	
Selenium	Platinum	Lanthanum
Phosphorus	Rhodium	Didymium
Arsenic	Ruthenium	Cerium
Chromium	Palladium	Thorium
Vanadium	Mercury	Zirconium
Molybdenum	Silver	Aluminium
Tungsten	Copper	Scandium
Boron	Uranium	Erbium
Carbon	Bismuth	Ytterbium
Antimony	Gallium	Beryllium
Tellurium	Indium	Magnesium
Tantalum	Germanium	Calcium
Columbium	Lead	Strontium
Titanium	Cadmium	Barium
Silicon	Thallium	Lithium
Tin	Cobalt	Sodium
Hydrogen	Nickel	Potassium
Gold	Iron	Rubidium
Osmium	Zinc	Caesium
Iridium	Manganese	

— Cathode or Negative Electrode.

From this table is very forcibly illustrated the preponderance of positive elements over negative ele-

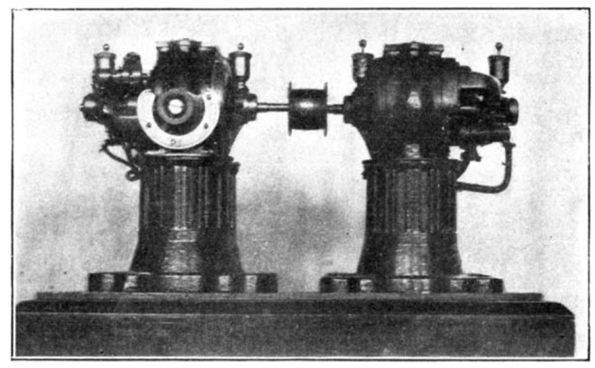


Fig. 8.—Photograph of a Motor-Generator Used to Convert the 110-Volt Lighting Current into a 15-Ampere Current at 4 Volts Pressure, which are the Ideal Conditions for Many Electrochemical Processes for Experimental Purposes.

ments, and also the fact that we can only have about seven simple negative ions. By simple ion, a single charged atom like our $\overset{+}{K}$ is meant; a complex ion being like our $\overset{-}{OH}$, which is negative. Here we have a negative atom and a positive atom, composing a negative ion. In this negatively-charged hydroxile group, or hydroxile ion, we can think of the hydrogen striving to go to the cathode, and the oxygen striving to go to the anode, and the oxygen having the greatest pull, and winning, as it is more strongly electronegative than the hydrogen is electropositive, as a glance at the table will show. By means of this table we should be able to predetermine the polarity of a complex ion with facility.

For example, let us take the three acids, hydrochloric, sulphuric, and nitric, and dissolve them in water. How do they ionize? With the help of the above table and carefully conducted experiment it is an easy matter to determine. The HCl gives $\overset{+}{H}\ \overset{-}{Cl}$, the H_2SO_4 gives $\overset{++}{H_2}\ \overset{--}{SO_4}$, and the HNO_3 gives $\overset{+}{H}\ \overset{-}{NO_3}$. Sulphuric acid has been shown to ionize by the present writer into the ions $\overset{+}{H}\ \overset{-}{HSO_4}$. Here we have a case where hydrogen goes to the positive electrode, or anode, but it is drawn there by being linked to two more powerfully electronegative atoms. There are a few cases where metals go to the anode in electrolysis, but only under such circumstances as the hydrogen. No metal goes to the anode in an electrolytic cell, unless it is part of a powerful group of electronegative atoms. Now, if we accept the theory of electrolytic dissociation, we

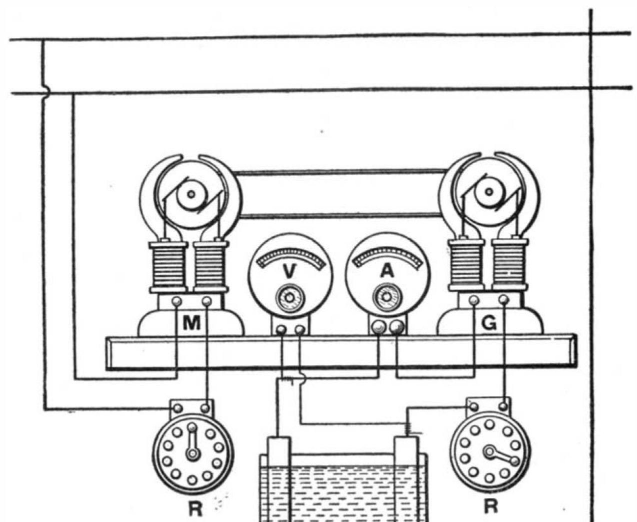


Fig. 9.—Diagram of Motor-Generator and Electrolytic Cell in Connection with Electrical Measuring Instruments for Observing Electrical Conditions Within the Electrolyte. Here the Comparatively High Voltage Electric Lighting Current is Stepped Down to the Ideal Voltage for Electrolysis of Chemical Compounds.

are led to believe in a number of things. Perhaps the most important consequence of such a theory is the fact that we have actually moving masses of matter in a solution when an electric current is made to flow through it. Such a solution of a chemical substance, capable of conducting the electric current, is technically known as an electrolyte. In all electrolytes, therefore, the passage of an electric current through it is accompanied by the movement of ponderable particles of matter ; in other words, the atoms themselves act as carriers of electricity. There will be an abundance of "experimental evidence" later to show this, but for the present we must accept the theory upon faith. As we shall deal a great deal with anodes and cathodes, and the direction of the electric current, together with its management and application, the latter part of the present paper will be devoted to the more practical side of the question.

Simple Diagrams of the Use of the Electric Current to Electrolysis.

Direction of the Electric Current.

As we must always know the direction of the electric current in all our electrolytic investigations, it does not seem out of place to introduce at this time a purely electrolytic pole finder, or current indicator. This merely consists of a glass tube with the ends bent up as shown in Fig. 5, and supported horizontally by a couple of laboratory stands. Two loose-fitting stoppers carry the platinum wire electrodes connected to a battery, or modified electric light current, or small dynamo. A globule of mercury is placed in the tube as indicated at *M*, and the tube filled to near the level of the stoppers with a dilute solution of sulphuric acid in water. Upon closing the circuit, the little mass of mercury will immediately travel to the negative pole or cathode. On reversing the direction of the current, the globule of mercury will be propelled in the reverse direction, serving as a very pretty illustration of the behavior of positive ions, and answering all the requirements of a pole finder or indicator of current direction, if the current is sufficiently strong. If the mass of mercury is large it will require a stronger current to move it, and if quite small it will be propelled by about one-tenth of an ampere. For very feeble currents, the direction of flow must be learned by means of a compass needle. Perhaps for all ordinary work there is no source of electrical current so handy and satisfactory as the modified electric lighting current when of the direct type, and from 110 to 220 volts pressure. The accompanying diagram, Fig. 6, indicates the use of such a current in connection with an electrolytic cell and a lamp bank, which may be placed in any convenient part of the laboratory or workroom. This lamp bank, which is the special design of the author, has proven so useful in many electrochemical processes, that an enlarged diagram of it is given in Fig. 7. When connected with the 110-volt circuit a 16 candle-power lamp inserted in any of the single sockets *A* allows about ½ ampere to pass. With all eight of the single sockets filled, it allows about 4 amperes to flow; and if these same sockets are filled with 32 candle-power lamps, a current of about 8 amperes will be obtained. Now, for a more feeble current, less than ½ ampere, two 16 candle-power lamps are placed in the sockets *B B*. and a current flow of about 25-100 will be obtained. With three of these lamps in the sockets *C C C*, a current of about 18-100 will be allowed to pass; 220-volt lamps may be used here in series, when the current will be less than 9-100 ampere. This is only in accordance with the well-known law of Ohm: $C = R \div V$, where *C* is the current, *R* the resistance, and *V* the voltage. A 16 candle-power 110-volt lamp has a resistance of about 220 ohms, a 32 candle-power lamp about 110 ohms, and a 220-volt lamp, about 440 ohms. So it will be seen that with the three kinds of lamps at hand a very flexible lamp bank results from the design given.

Now, for certain work the high potential of the electric lighting circuit is not desired, and the lamp bank, no matter how designed, will not meet requirements. Again, should we require 20 amperes of current for certain work, the lamp bank would have to hold twenty 32 candle-power lamps, or forty 16 candle-power lamps, and would be very wasteful of energy, when we consider that we are working under a difference of potential of at least 110 volts: 110 volts x 20 amperes would represent 2,200 watts, which would be nearly 3 horse-power; 2,200 watts divided by 746 (number of watts to the horse-power) equal 2.94 horse-power. Whereas we would require the 20 amperes for our electrolysis, we could not only get along with 4 volts pressure, but would actually prefer it, so we use a motor-generator, and consume something like 80 watts, instead of the 2,200. 20 amperes × 4 volts = 80 watts. The little photograph, Fig. 8, shows a simple form of motor-generator used by the author for the past six or seven years, which gives about 20 amperes at a pressure of only 4 volts, the driving motor taking a trifle more than the corresponding number of watts.

The last illustration in our present paper is a diagram of a similar motor-generator, but of the belted type, and represents electrical measuring instruments properly connected for observing the watts used in the electrolyte for any kind of electrolytic work. Here *M* is the driving motor, *G* the generator, *V* and *A* the voltmeter and ammeter respectively, and *R R* rheostats for controlling the speed of the motor on the one hand, and the current supplied to the electrolytic cell on the other. The generator is of the shunt-wound type, and it is very necessary to have a good variable resistance in the outside circuit. The ammeter shows the current taken, and the voltmeter the drop of potential across the electrodes. Such a small rotary converter can be ordered from almost any of the manufacturers of small dynamos and motors. Having outlined the simple apparatus necessary for practical work on a small scale, we will close the present paper with definitions of the technical terms introduced, and continue the development of the subject in the next paper.

Electrolysis.—The breaking up of chemical compounds by the electric current, and the setting free at the electrodes of the constituents.

Electrode.—The terminal of the source of electricity which dips into the electrolyte.

Electrolyte.—A chemical compound, capable of conducting the electric current, when in solution, or in the fused state.

Anode.—The positive electrode in an electrolyte. The electrode from which the electric current flows.

Cathode.—The negative electrode in an electrolyte. The electrode to which the electric current flows.

Ion.—A chemical atom, or group of atoms possessed of an electrical charge.

Electrolytic conductivity.—The passage of the electric current through an electrolyte accompanied by the movement of ponderable material. Ion transfer. The carrying of the electric current by moving ions.

Electrolytic dissociation.—The breaking up of certain chemical molecules when dissolved in water or other suitable solvents, into ultimate parts charged with electricity.

(To be continued.)

SCIENCE NOTES.

The International Geographical Congress at its recent meeting in New York asked the government to make a general map of America on a scale of 1:1,000,000. At the present time three governments are producing maps on this scale which will cover about one-fourth of the land surface of the globe. If the United States should make a similar map of the whole of America it would include nearly one-third of the area of the entire land surface. No uniform map of the entire land surface exists on a scale large enough to serve many practical and scientific purposes. There are many maps of parts of the lands on a far larger scale, as for example nearly all of Europe, large tracts of North America, and parts of Africa; but a map of all the lands on a uniform scale is also highly desirable for many purposes.

The possible analogy between the structure of the atom and the planetary system, as demonstrated more especially by its characteristic spectrum, has been repeatedly discussed. The disintegration theory of radioactivity accounts for the liberation of energy by radioactive bodies by assuming that after a certain average interval of time this sub-atomic system comes into an unstable configuration, and tumbles to pieces with great liberation of energy. In considering the large number of atoms contained even in a single milligramme of salt, this liberation of energy would appear to be continuous. An alternative theory has been suggested by Mons. Filippoke, who has suggested that the energy of the radio-active elements is not due to the destruction of the atom, but rather represents a part of its heat of formation. The suggestion is made that whereas the smaller atoms, like the minor celestial systems, have reached a final condition, in which all available energy has been liberated, the larger atoms are still, for the most part, in a condition similar to that of the solar system, and will remain sources of energy until the whole of the supply represented by the "heat of formation" of the atom has been exhausted.

Clemens Winkler has called attention, in an article which recently appeared in the Chemical News, to the danger that arises from attempting to deduce the existence of an element from physical properties alone. Thus he points out that in the early days of spectrum analysis, when the discovery of this new method of observation had produced a state of agitation similar to that now excited by the discovery of radio-activity, it was believed in all seriousness that calcium had been decomposed, because it had been found possible to cause the disappearance of the green line of its spectrum in one of the parts obtained by the fractional precipitation of a solution of calcium chloride. The question is raised as to whether, in the majority of cases, radio-activity is not a purely physical process, or a property which may be induced in matter without influencing its chemical composition, in much the same way that a piece of iron ore may become magnetized. In this connection it is noteworthy that radium is never found associated with the element barium in any of its common ores, but invariably with uranium, which was not only the first of the radio-active elements to be discovered, but is now regarded by many writers as the source of all radio-activity.

A CHEMIST IN THE DAYS OF THE STUARTS.

At the time of the Great Plague and the Great Fire and the Great Frost, there lived "at the sign of Hermes Trismegistus," in Watling Street, London, a chemist named George Wilson. He carried on his business for upward of fifty years, and in the course of it made many of the remedies that were used for the cure and prevention of the plague; and in later days he made among other things honey-water for King James II. He was a sufferer by the fire, inasmuch as it forced him to remove into other premises. He practised alchemy also, and made many experiments to transmute silver and baser metals into gold. We have his word that during one of his chemical investigations a mob besieged his laboratory and broke everything in it to pieces, under the impression that he was dealing with occult powers and was about to destroy the city and Whitehall. He varied his chemical and alchemical pursuits by writing a book entitled "A Compleat Course of Chymistry," which bears the honored impress and portrait of Elzevir in the tail-pieces with which it is ornamented, and is illustrated with sheets of "chymical characters," as well as with diagrams of furnaces, crucibles, retorts, stills, and every other contrivance used in the chemical processes of his day. This work reached a fourth edition in 1704, when, as he tells us complacently, he stood upon the brink of fourscore. As we turn over its rough and deeply ribbed pages we get glimpses of London in the days of the Stuarts, the London of Milton and Mary Powell, of Pepys and Evelyn, as well as of the London that owed so much to Sir Christopher Wren and Inigo Jones.

The topographical allusions in this complete course of chemistry, however, are not numerous. There is mention, in connection with various preparations of vitriol, that most of the old iron that was gathered by poor people was sold by them to the copperas-houses at Rotherhithe and Deptford, where it was boiled up with a dissolution of fire-stone; and there is word of a brimstone-refining house in Petticoat Lane, and of color-shops; and reference to a garden in Lambeth where aloe-trees grew to a surprising size. It is the frequent mention of the physicians who attended the royal families, Cromwell, and the fashionable folk of the Court that brings the times so distinctly before us.

There were particular preparations that enjoyed similar or superior repute to that of some of our own patent medicines, and were associated with the names of the leading physicians as being either invented or prescribed by them. Among these were Dr. Sydenham's liquid laudanum, Dr. Goddard's extract of opium (Dr. Goddard was Cromwell's physician), Dr. Willis's steel wine, Mathews's pills, Dr. Starkey's pills (Dr. Starkey was the author of a work on pyrotechny), Dr. Browne's panacea of antimony (Dr. Brown was physician to Charles II.), Mr. Lockyer's pills, whereby "he made a large estate," and Russel's powders. There were others associated with still more august personages, such as the princes' powder, the Queen of Hungary's water, and the cordial of Poterius, which last was good against the plague. A preparation of gold is given by the chemist "as I prepared it for the chief physician of a great prince, 1692;" and after detailing the intricate process very minutely, he adds: "I gave a part to the gentleman that employ'd me, who seemed to receive them with great satisfaction, and gratify'd me generously." After giving the details of the manufacture of sweet honey-water, which was composed of brandy, honey, many spices, lemons, rose and orange-flower water, musk, ambergris, and other good things, he adds: "This water I often made for King James II. It is an anti-paralytick, smooths the skin, and gives one of the most agreeable scents that can be smelt. Forty or fifty drops put into a pint of clean water are enough to wash the hands or face with; and the same proportion to punch or any cordial water gives a most pleasant flavor."

Many remedies mentioned as held in esteem at that time are still in use at the present day; the reputation of some more, however, that we have discarded in a general way, still lingers in remote parts of the country, as in the case of decoctions of vipers, than which Cheviot shepherds aver there is yet no better cure for snake-bites. Others, such as elixirs of human skulls, then esteemed "a noble medicine against madness, convulsions, and hysterick fits," have disappeared altogether from the modern pharmacopœia. Amulets have gone out of fashion with us, too; but in the days of the plague they were much used. Our chemist mentions a preparation of crystalline arsenic, yellow sulphur, and crude antimony, called an arsenical magnet, that he sold for this purpose. "In the time of the plague, 1665, I made this magnet, and it was much used both in plasters and amulets." A compound tincture of vipers was another remedy that he prepared for sufferers from the plague; and he gives a recipe for an anti-pestilential elixir, made of myrrh, aloes, saffron and camphor, snake-root and cochineal, that, he tells us, was said to be the most powerful medicine yet known against the plague. Some insects were used as remedies when dissolved in the course of various processes, such as hog-lice or millepedes, ants, and Spanish flies, of which we retain the last only. The first, made into tinctures and essences, were accounted good for jaundice, colic, and stone; the spirit, oil, and voltatile salts of ants were prescribed as tonics and to restore hearing; and Spanish flies, though seldom used inwardly "without good correction," were nevertheless occasionally partaken of as a tincture diluted with canary wine. A distillation of hartshorn was used in fevers. "Take that which we call the velvet-head, in the spring time, while it is soft, cut it into little pieces, and put them into a cucurbit; lute on its head and receiver; place it in Bal. Mar., and distil a water from it." When we think of the beauties of King Charles's Court, with their bewitching personalities that Lely has handed down to us so clearly, and realize that they were probably dosed with these remedies on occasion, we feel that they were sufficiently punished for any indiscretions of which they may have been guilty. Opium was used in various forms. Mathews's pill and Dr. Starkey's pill were both based upon it, with differences as to the other ingredients. Concerning the latter our chemist avers: "This I had from the ingenious Dr. Starkey's own mouth, in the year

1665, a little before his death; who then told me he gave Mathews the former for a little money; but this is that which he successfully made use of himself. It is both more diaphoretick and a greater anodyne than the former; and I have heard it affirmed by several gentlemen who have made use of it in their practice to be the best laudanum they ever met with." There were other preparations of opium, one of which was called the "drops of life," and another the "universal anodyne." Dr. Goddard's compound extract was prepared with saffron and nutmegs, tincture of tartar, and rectified spirits of wine. This was allowed to alleviate all pains "in what part of the body soever." Pepys mentions that he met Dr. Goddard at a club supper given at the Crown Tavern, behind the 'Change, in February, 1664; and on January 22, 1665, he records the first meeting in Gresham College since the plague: "Dr. Goddard did fill us with talk." The preparations of these eminent authorities were all taken seriously and scientifically; but the term quack was not unknown to King Charles's lieges, although it was applied to a different class of persons from that with which we associate it. There is mention of one in the description of the process to make red precipitate of mercury. The prince's powder contained this precipitate among other ingredients. George Wilson observes that the red precipitate must be ground very fine, and adds: "Mr. Barton, an eminent surgeon of London, kept this as a secret."

Another individual out of the forgotten population of those days is mentioned in the preface, where our author asserts he has studied brevity and avoided Mr. Lemery's pompous way of philosophizing upon the processes, though he feels he is to blame for such directions as "fill half full," and apologizes for the expression. A Dr. Friend is also mentioned as well skilled in speculative and practical "chymistry." In his accounts of his alchemical experiments reference is made to a few other persons who likewise inhabited London when it was visited by the terrible plague and fire and great frost. On the 10th of October, 1677, for instance, he says he bought of Mr. Willmore, the refiner, five pounds of mercury (which he had distilled from various metals); and it was a Mr. T. T. who came to him and urged him to try once more when he had abandoned his endeavors to obtain gold by chemical processes. "The eleventh of June, A. D. 1694, I met with my old friend (Mr. T. T.), who assured me that at the last, after forty years' search, he had met with an ample recompense for all his troubles and expenses. This he confirmed with some oaths and imprecations; but, considering his great weakness and age, he looked upon himself incapable to undergo the fatigue of the process. 'I have here,' says he, 'a piece of sol that I made from silver about four years past; and I cannot trust any man but you with so rare a secret. We will share equally the charges and profit, which will render us wealthy enough to command the world.' "

Each alchemical experiment extended over a long period of time. For instance, on the 10th of March, 1687, he commenced a fresh endeavor by dissolving four ounces of gold in aqua regia. Next day he distilled in a retort the aqua regia from it; and he repeated these dissolutions, distillations, and cohobations seven times, by which time his gold looked like red gum. He then added two pounds of spirit of salt and twelve ounces of mercury that he had kept for ten years, and again began processes which he continued till the gold and mercury had become a clear red syrup. On the 5th of April of the following year he divided this syrup into two portions, which he put into two retorts with half a pound of spirit of niter in each, and then went on with various processes too technical to describe, till the 11th of December, when, in his own words, "I was treated as the Spanish Ambassador was: for the mad mob taking me for a conjurer, or something worse, broke my glasses and athanor, saying I was preparing the devil's fireworks purposely to burn the city and Whitehall. And thus ended this operation." One experiment obtained a gain of two scruples and thirteen grains of gold, but suffered a loss of rather a larger amount of silver. In the end he came to the conclusion, after experiences extending over forty-three years, that any accretion of gold could only result from the fact that all metals are likely to contain within themselves minute particles of the noblest, and when analyzed these particles are set at liberty and join one another by attraction.

Rheumatism appears to have troubled King Charles's lieges as much as it afflicts the present generation. Our chemist made a particular remedy for it from which he derived considerable profit, called "tinctura antirheumatica." He remarks that it may appear odd that he does not give the ingredients of this tincture in his work, and adds this practical reason: "This medicine having obtained an uncommon reputation, it may be a comfortable support for me and my family should I fall once more under the frowns of fortune. But, after all, in due time, it shall be published." The genius of advertising, we may see, was not altogether unknown in Stuart times. The lieges of the Merry Monarch also suffered from many other of our ailments, as well as from those we have almost vanquished, like the plague and rickets.

As we close this Elzevir, the Stuarts and their Court beauties, the courtiers, train-bands, 'prentices, watermen, fanatics, the streams of people that passed and repassed, seem to fade out of sight again into the faint and distant past.

There are two copies of George Wilson's "Compleat Course of Chymistry" in the British Museum. In the same treasure house is preserved one of his shop handbills, a broadsheet printed on one side only. It is headed: "Gaza: A Magazine or Storehouse of Choice Chymical Medicines Faithfully Prepared in my Laboratory, at the sign of Hermes Trismegistus in Watling Street in London, by me, George Wilson, Philochym, 1686." It is thus addressed: "To all Doctors of Physick, Apothecaries, Chirurgeons, and others studious of physick, or curious in chymical operations. Though I here present you with a catalogue of such Medicines as I have always ready prepared for your Occasions, and faithfully elaborated, according to the best Processes I could ever meet with, yet further to satisfy you I here offer to your service the conveniency and use of my Laboratory, if any of you shall at any time desire it, there to have any particular Process of your own experimented, paying for the coals and glasses and a Reasonable Recompence for the Use of my Furnaces. And at all times Free and Welcome access to see any of those Medicines you shall have of me prepared from the beginning to the compleating of the same; by which means you may the better be satisfied of their true and faithful Preparation and consequently of the goodness and purity of the Medicines I sell."

This was more than two hundred years ago. Two hundred years hence will our representatives find the handbills of to-day equally quaint?—Chambers's Journal.

RUSSIA'S NEW GREAT RAILROAD IN ASIA.

A correspondent of the London Times says:

"Only a few days ago a railway was completed which is destined to play a part in Asia second only to the Trans-Siberian, or the great lines that have transformed India. Although the line is finished so far as the rail laying is concerned, it will not be open for passenger traffic until July, 1905. Still it exists as an available means of communication. It is known as the Orenburg-Tashkent Railway.

"Orenburg, a town of some 60,000 inhabitants and chief town of the Government of Orenburg, is situated on the River Ural, at this point the boundary line between Europe and Asia. Its commerce is trifling; the town owes its importance to its strategical situation. It has been for 200 years the spot whence expeditions have been organized for 'research' in Asia. It is the terminus alike of the old post road to Tashkent and of the European railway system in this direction. Although it produces nothing, it has for two centuries been the mart at which Asiatic goods were received and sorted for distribution in Europe.

"Every year caravans of Bactrian camels brought thither the silks of Samarkand and Khiva, the beautiful lambswool skins and carpets of Bokhara, which were exchanged in the Gostini Dvor, or bazar, outside the town, for hardware, grain, and sugar. If Peter the Great built St. Petersburg as a peephole into Europe, he used Orenburg as a window to look into Asia.

"When it was decided by passing north of the Caspian to extend the Russian railway system into Turkestan, three different projects were submitted to the commission charged with the selection of the route. Of these the first was the line now completed—of which presently. The second idea was to take advantage of the Saratof-Uralsk Railway, to extend it across the desert to Kungrad, a little fisher village near where the Amu-Daria River falls into the Aral Sea. From Kungrad the track, passing east of Khiva town and over the Karakum, or Black Sand, would have joined the Central Asian Railway at Chardjui (Four Springs), where a magnificent iron girder bridge resting on nineteen granite piers spans the Amu-Daria. A third project was to connect Tashkent by rail with Semipalatinsk, *via* Aoulie-à-ta, Vierni, and Kopal. This line was to pass between the two great, though little known, lakes, Issk-kul and Balkash.

"From Semipalatinsk, the head of the steamboat service on the great Irtish, two alternative routes were proposed. One, following the river valley more or less, would have joined the Trans-Siberian at the station of Omsk; the other was designed to pass along the post road to Barnaöul, and thence to Obi station, where the Trans-Siberian bridges the Old River. The partisans of this scheme desired to join the Central Asian and Siberian railway systems. Those who favored the Khivan route did so on the grounds that it would run almost in a straight line from Uralsk to Chardjui.

"But both schemes were destined to give way to the advocates of the old post road route from Orenburg. The whole of Tashkent desired to take advantage of this well-known roadway, which was called the 'natural' connecting link between Europe and Asia. Of late years but few passengers or goods followed this way, which had been quite supplanted by the Tashkent-Samarkand-Merv-Askhabad Railway line, the creation of Annenkoff.

"The direct Orenburg-Tashkent Railway, of which the two sections were joined in October (September, O. S.), 1904, runs as follows: From Orenburg, the terminus of the railway from Samara over the Ural River to Ilensk, on the Ilek, a left affluent of the Ural. From Ilensk to Aktiubinsk, Kazalinsk, up the Sir-Daria Valley to Petrovsk, Turkestan, and across the steppe direct to Tashkent.

"The new line does not exactly follow the old post road which led from Aktiubinsk to Irgiz in the steppes of the nomadic Khirgiz, and from Turkestan town, *via* Chimkent to Tashkent. But it so nearly adhered to it as to render new surveys necessary only here and there; it passed over a country offering no natural difficulties, and, further, it certainly was the route desired by the Russians established in Central Asia.

"Consecrated by almost two centuries' use, it appealed more to their sentiments than the desert route to the west of Aral, or the distant journey through Semirechia, the land of seven rivers. And this consideration is no mean one in Russia, for the Slav is essentially a creature of sentiment—dreamy, sedentary, averse to change, preferring to tread in the footsteps of his ancestors.

"In September, 1900, as the writer can state from observation on the spot, the embankment near Orenburg had only been laid for about ten miles. The bridge to span the Ural River had not yet left the work shop in Tula. It had been necessary to wait until the snows melted and the river had re-entered its bed before building the earth approaches. The work had been carried through many miles at the European end before that on the other section, 1,300 miles away at Tashkent, was even commenced. For at the Asiatic end the work was even easier than at the other extremity. Rumors of great difficulties to be encountered at Kazalinsk and thence to Karmakchi (Fort No. 2), along the bed of the Sir-Daria, turned out groundless.

"After having seen Orenburg I determined to visit Tashkent. Only four years ago there were still difficulties placed in the way of strangers passing over the Central Asian Railroad, and British subjects were not allowed to visit Bokhara or Khiva. In the spring of 1901, these difficulties were removed. A journey from Moscow *via* Rostov on the Don and Baku, across the Caspian to Krasnovodsk, and thence by train again some 1,500 miles on the Tashkent, became quite an easy matter. Full of interest as was every mile of the way, through desert and oasis, over the great rivers Oxus and Jaxartes, I will not dilate on it here, but will at once describe the Asiatic terminus of the new line.

"Tashkent lies as if destined by nature for a capital. The Shirt-schak, carrying the melted snows from the Ala-tau, a branch of the Tian Shan or Heavenly Mountain chain, rushes foaming a mile or two south of the town to mingle with the Sir-Daria. Local tradition attributes to Iskander the curious Persian bridge that spans its dry bed, or stands in flood-time useless amid its waters.

"Quite near Tashkent, sheltering it from the icy east winds, are the Chatkall hills, where Chadshikent's peaks rise some 9,000 feet above the dust haze. From the railway station on a clear day can be seen Hasret-i-Sultan, rising white above the Zarafshan River bed eighty miles away to the south. The longitude of Tashkent is the same as that of Haidarabad in Sind. Its altitude of 1,200 feet tempers the excessive heat in summer, while its winter is cold and bracing. The Russian town is nearest the station. Embowered in poplar and other trees, lately planted but high in growth, it is laid out in the form of a sector of a circle.

"Three great boulevards radiate from the cathedral which shelters the remains of Kauffman. Each house stands separate in its own compound or garden, sometimes of great extent. Beyond the park which surrounds the cathedral is the residence of the governor-general, the great gardens of which bound the Russian town on the north.

"Two miles further, on the road to Akdjar, begins the native city. It is a vast assemblage of narrow streets, mud houses, mosques, madrassés, and bazars. The latter are all covered in with reed mats hung over frameworks of wood, to keep out the fierce rays of the sun. Although the native city contains some 150,000 inhabitants and the Russian town perhaps 10,000, yet the latter occupies as much space as the former. From the governor's palace to the station is quite three miles. On the way one passes an elegant iron railing decorated with an imperial cipher. It incloses the residence of the Grand Duke Michael Constantinovitch (not to be confounded with other Michaels of the same family) who was exiled many years ago.

"I arrived at Tashkent on October 15, 1902, in time to see the first train steam north from the station. It did not go far, in truth, for the railhead ended eight miles off; but the embankment was finished much further. Gen. Ivanoff, the governor general, made the journey to the railhead. The boys of the cadet college near the station had erected a triumphal arch, and their treble cheers saluted the decorated train on its passage.

"Every one in Tashkent was full of joy at the prospect of being able to get to St. Petersburg in a week. For the distance of 1,300 miles to Orenburg, which took a tarantass nineteen days, would be traversed by the train in four days, and the capital was only seventy-two hours' journey from Orenburg. A great future is open to the cotton-growing industry of Merv, where the imperial cotton farm at Bairam-Ali, fertilized by the waters of the Murghab, serves as a model to the cultivators of Bokhara and Fergana. The Central Asian cotton hitherto has not been able to compete at Moscow with that grown in Egypt or America.

"But under the supervision of M. Tolstoy, with machinery purchased in the United States, the methods of cleaning have been much improved. New and better plants have been grown from imported seed. The Orenburg-Tashkent Railway will carry this cotton straight to the Moscow mills, and the bales will escape the rough usage entailed by shipment at Krasnovodsk and transfer from steamer to rail again at Baku.

"It is thought, also, that the wines of Samarkand and the fruit of this region may now be sold at a profit in Russia. The experience of the poor success of the

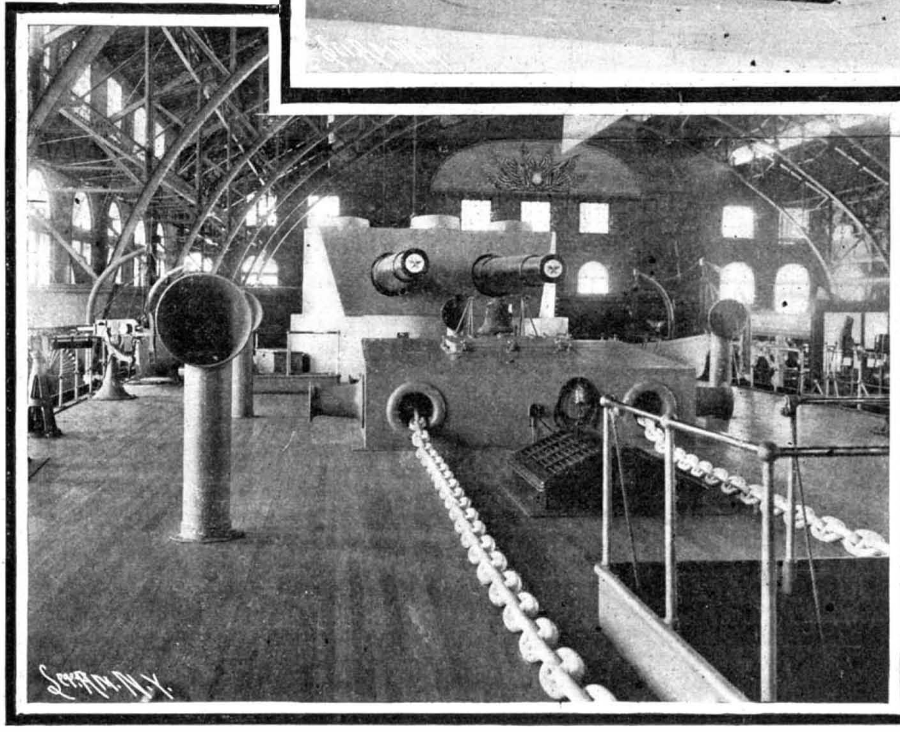
Crimean and Caucasus wines in the metropolis leads me to doubt that this will be the case. In a St. Petersburg restaurant a bottle of indifferent French wine, sold at three times its value in Paris, will always be a more fashionable drink than the home-grown article.

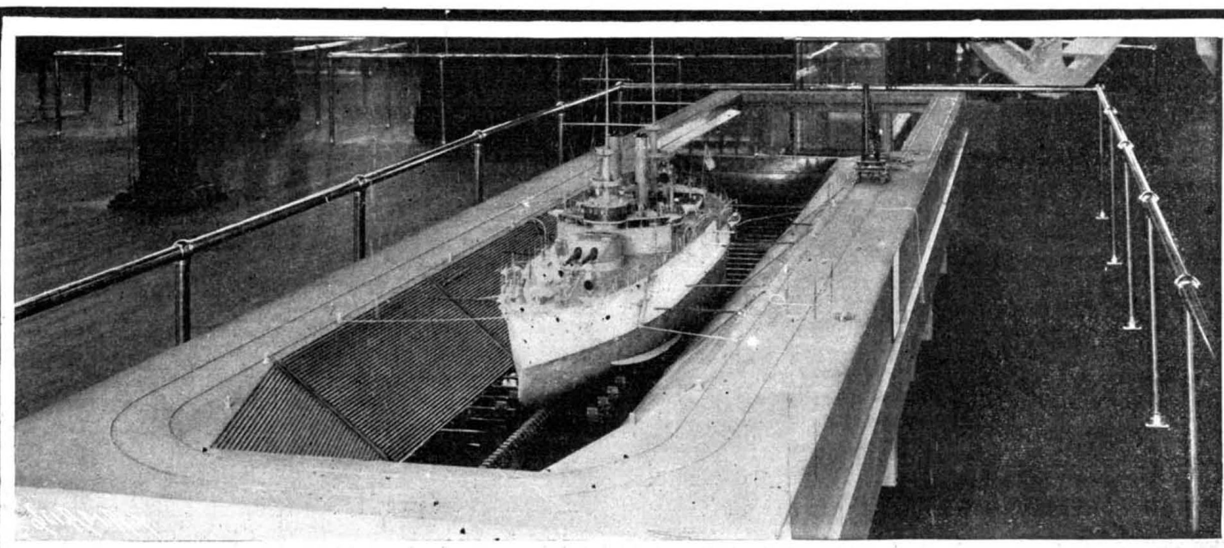
"But if the new railway is destined to achieve but small economical results, its value as a strategical factor must not be underrated. Hitherto Tashkent has been a comfortable garrison for 10,000 men. Henceforth it will become the storehouse and advance base of the Russians in Asia.

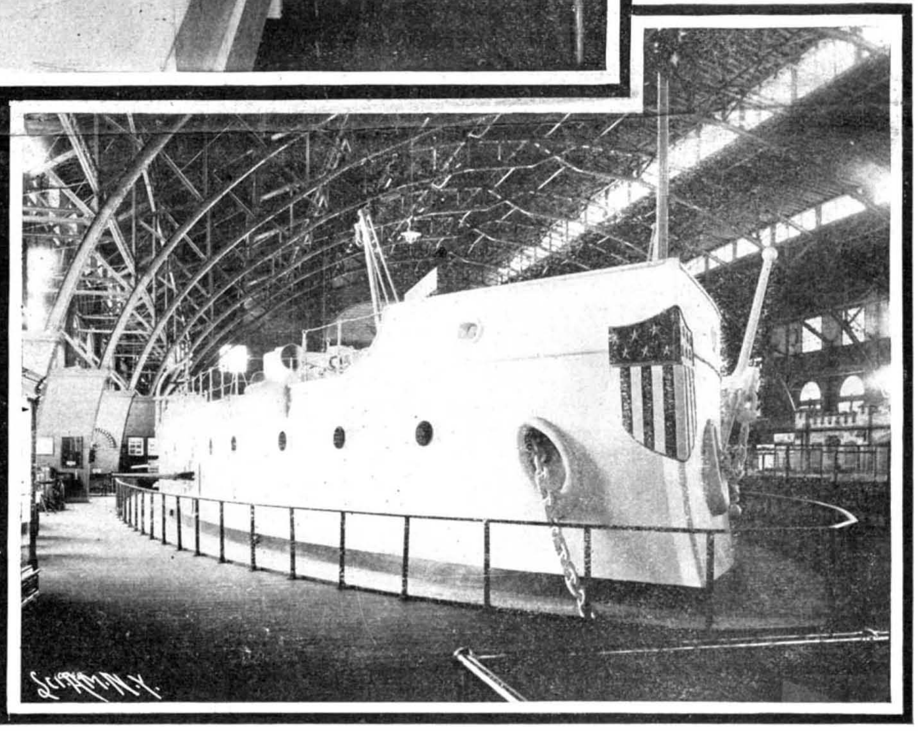
"I am not one of those who look with fear on the prospect of an advance of Russia upon India. I have always been of opinion that two British army corps in the front line in Afghanistan could receive reinforcements more quickly than those sent to the Russians in central Asia. But the position will be very much changed by the opening of this new railway.

"The First and Second Turkestan Army Corps, quartered at Askhabad and Tashkent, were very much *en l'air* as regarded position and supply. Reinforcements could only be brought to them from the Caucasus across the rough Caspian Sea in twelve or fourteen steamers which took twenty hours to get from Baku to Krasnovodsk. The Central Asian line being without water was by no means an ideal method of transport across the desert. But this line of communication will now become merely an auxiliary one. Troops from the Caucasus even would be sent by rail, *via* Tzaritzin and the Volga, to entrain direct for Tashkent at Samara.

"Moreover, the great military centers of Odessa, Simpheropol, Kieff, Kharkoff, and Moscow, now being drawn upon to reinforce Kuropatkin, who is two months' journey away in Manchuria, will be brought within fourteen days of Tashkent. Room exists there for enormous additions in the way of barrack and storehouse accommodations. Close to the railway station (which now scarcely yields to that of Bombay in comfort and convenience) is a huge Maidan some fifty acres in extent. This can be utilized for buildings connected with the railway, the more easily as its *raison d'être* as a resting place for camel caravans has passed away. For where the shriek of the whistle is heard the 'ship of the desert' is no longer seen."







DECK VIEW OF FULL-SIZE MODEL OF A BATTLESHIP.

MODEL OF DRYDOCK SHOWING METHOD OF DOCKING.

BOW VIEW OF FULL-SIZE MODEL OF A BATTLESHIP.

NAVAL EXHIBIT IN THE GOVERNMENT BUILDING, ST. LOUIS.

NAVY DEPARTMENT EXHIBIT IN GOVERNMENT BUILDING, ST. LOUIS EXPOSITION.

By the St. Louis Correspondent of the SCIENTIFIC AMERICAN.

THE exhibit of the Navy Department in the Government Building at the St. Louis Exposition, though not so imposing as that at Chicago, where a full-sized reproduction was made of the battleship "Indiana," is nevertheless very complete, and serves well the purpose for which it was planned. This was to present to the visitors an easily-understood reproduction of the internal and external features of a United States man-of-war, of the weapons of the navy, of the repair docks, of the life and duties of the officers and men, both afloat and ashore, in war and in peace, and of the government's facilities for educating officers, and of its methods of enlisting and training the fighting personnel of the navy.

The central figure of the exhibit is a full-sized reproduction of the forward third of a United States man-of-war. The model is 118 feet long, and 46 feet broad at the point where the section begins. The freeboard is 7 feet 6 inches, and from the waterline to the top of the turret is 19 feet 9 inches. The figurehead is the original figurehead of the "Olympia," Admiral Dewey's flagship at Manila Bay on the ever-memorable 1st of May, 1898. On the upper deck are two 10-inch guns, mounted in barbette turrets; a 6-pounder Hotchkiss; a 1-pounder light automatic; a 30-caliber Colt, and a Gatling field piece. There are also the ship's anchors, windlass, and anchor gear complete; also the skylights, hatchways, ventilating cowles, and side ladders. On the berth deck are installed a torpedo-firing tube and torpedo, a 5-inch rapid-fire gun, and two 3-inch rapid-fire guns. The space on the berth deck is divided by water-tight bulkheads into compartments, the long-arm system of water-tight doors being electrically operated. Within the turret support, on the berth deck, are life-sized wax figures of the officers and enlisted men of a flagship, dressed accurately in their various uniforms. On this deck are also the cabins, officers' staterooms, men's rooms, berths, hammocks, mess tables and equipment, sick-bay, ammunition hoists, etc. Below the berth deck is a magazine 18 feet by 20 feet by 9 feet high, and in this are stored the various kinds of ammunition in use in the naval service. All the compartments are accessible to visitors, the object being to give them the realistic sense-impression, only to be had otherwise by going on board an actual man-of-war.

Another interesting feature of the department's exhibit is a working model of a drydock, the dock and basin together occupying a space 30 feet by 9 feet. In connection with the dock is a tank representing a basin or harbor, in which a model of the U. S. S. "Illinois" is floated each day. The process by which a battleship is placed in position for repairs on her hull below the water-line, and for the removal of barnacles, etc., is thus completely demonstrated. There is also a working model of a steel floating drydock, which is exhibited to illustrate the type recently installed at the New Orleans naval station and the Pensacola navy yard, and also the one under construction for the naval station in the Philippines. This model is afloat in a tank of water, which also contains a model of a battleship built to the same scale, one forty-eighth of actual size. All the operations incident to the docking of a vessel in a floating drydock are performed for the instruction of visitors.

Other features of the navy exhibit are a large map of the world, eight feet wide by twenty feet long, on which are placed 307 miniature lead models, each representing a battleship, cruiser, gunboat, submarine boat, collier, or tug of the United States navy. The position of each model upon the map indicates the whereabouts of the corresponding vessel of the navy each day.

The U. S. Naval Academy at Annapolis is represented in miniature by a model built on a scale of 1-32 of an inch to the foot. The model, which is 12 feet by 6 feet, shows the entire layout of the grounds, buildings, roads, etc. Another instructive and spectacular exhibit of the navy, afloat and ashore, is given in a series of about sixty biograph motion scenes of the life and duties of officers and crews of United States men-of-war, both in peace and war. Mention should be made of a very handsome display of accurate models of the various U. S. warships, built on a scale of 1-48 of actual size.

The main exhibit of the marine corps is a model camp on the Exposition grounds. These marines are regularly detailed to do guard duty in the government buildings, and it is a matter of remark that by their soldierly bearing and universal courtesy they add greatly to the dignity of the national exhibit.

WOOD PRESERVATION.

As timber becomes scarcer and more costly the importance of its preservation becomes greater. The decay of timber is principally caused by fungi, but bacteria and insects also play a part. Timber will not decay unless it be subjected to three conditions—air, moisture, and warmth; if any one of these conditions is absent there can be no decay. Timber submerged under water so that air is excluded will not decay; neither will it decay if continually dry, or where the temperature is uniformly low. But in ordinary use timber is subjected to all three conditions which favor decay, hence the importance to railways of artificial processes for preserving cross-ties, bridge timbers, etc. The Association of Railway Superintendents of Bridges and Buildings in a committee report submitted at the Chicago meeting in October, outlined some of the methods of preserving timber as follows:

Creosoting.—The creosoting process makes use of dead oil of coal tar, which is a distillate of coal tar, a product of the manufacture of illuminating gas. Green timber is subjected to a steaming process 200 to 250 deg. F. for several hours in a closed cylinder to liquefy the sap and to solidify the albumen in the cells. After steaming for some hours the cylinder is exhausted to a partial vacuum to expel the liquids from the interior. After this process is complete the cylinder is filled with dead oil of tar at a temperature of about 175 deg. F. and subjected to a pressure of 80 to 100 pounds per square inch to force the oil into the pores. This is sometimes called the Bethell process.

Burnettizing.—In the Burnettizing process the impregnating fluid used is chloride of zinc which is applied in a water solution similar in method to the creosoting process. After treating, the wood must be thoroughly dried to deposit the salt in the cells, but even when this is done exposure of the wood to water afterward will dissolve the salt and leach it away. While the process is fairly satisfactory for ties it is not good for structural timbers and has been practically abandoned by nearly all European railways.

Kyanizing.—In this process seasoned timber is soaked in a solution of bichloride of mercury (corrosive sublimate) which coagulates the albumen. The solution is very poisonous and corrodes iron and steel, hence is unsuited for structural purposes in which

metallic fastenings are used. The process is effective, but dangerous to the health of the workers employed.

Wellhouse.—The Wellhouse process also uses zinc chloride as does the Burnettizing process but adds a small percentage of glue. After the timber has been treated under pressure the zinc chloride solution is drawn off and one of tannin is substituted. The tannin combines with the glue and forms an insoluble substance that effectually seals the pores.

Allardyce.—The Allardyce process makes use of zinc chloride and dead oil of tar, the latter being applied last, and the manner of application being essentially the same for both as explained with the other processes.

Boucherizing.—Sulphate of copper in solution is forced into the timber under heavy hydrostatic pressure. Sulphate of copper attacks iron and is, therefore, objectionable from a structural standpoint.

Thilmany.—Sulphate of copper is first used in the Thilmany process and then a solution of barium chloride, but the process has not shown good results.

Hasselman.—The timber is boiled in a solution of copper, iron, and aluminium sulphate, to which a small quantity of kainit is added. The results in Germany seem to show that the process is satisfactory.

Creo-Resinate.—In this process the timber is first subjected to a steaming process at 200 deg. F. to evaporate the moisture in the cells; the temperature is then gradually increased to 320 deg. F. and a pressure of 80 pounds per square inch. The pressure is slowly reduced to 26 inches vacuum, and then a solution of dead oil of tar, melted resin, and formaldehyde is injected. After this process the timber is placed in another cylinder where a solution of milk of lime is applied at a temperature of 150 deg. F. and a pressure of 200 pounds per square inch.

Vulcanizing.—The vulcanizing process of treating timber consists essentially in subjecting it to a baking process in hot air which is heated to a temperature of about 500 deg. F. by passing over steam coils. The heat coagulates the albumen, expels the water from the cells, kills the organisms therein and seals the cells by transforming the sap into a preservative compound. This method is used with success by the elevated railway systems of several cities.—Machinery.

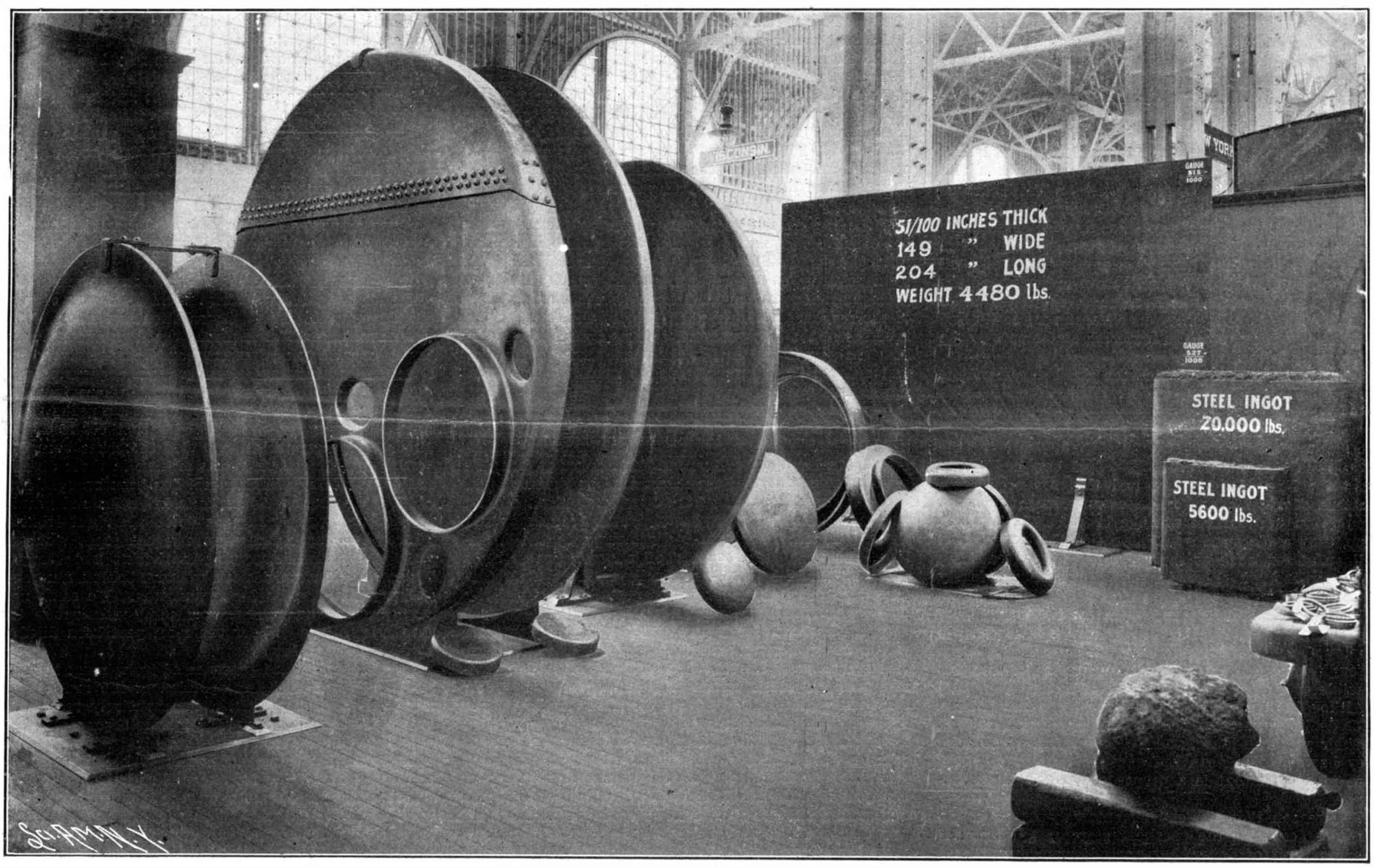
SIMULTANEOUS EMISSION OF N-RAYS AND N′-RAYS.—Jean Becquerel has found that in all cases where a surface emits N-rays normally, it emits N′-rays tangentially, and *vice versa*. This fact establishes a close correspondence between the emission and absorption of these rays, which leads the author to some interesting generalizations. A brick exposed to the sun emits N-rays normally and N′-rays tangentially. A patch or cross of the phosphorescent sulphide alternately brightens and darkens as successive surfaces of the brick are exposed to it. When the screen is observed tangentially instead of normally, it darkens and brightens instead of the reverse. When a body is compressed, it emits N-rays from the compressed surface and N′-rays from the surfaces perpendicular to it. The author lays down the following general rules: The rays produced by the compression of a body (N-rays) have the property of increasing the sensibility of vision, and produce on a surface capable of storing them the same effect as regards radiation as does a compression normal to that surface. And: The rays produced by the stretching of a body (N′-rays) have the property of diminishing the sensibility of vision, and produce on a surface capable of storing them the same effect as a tension normal to that surface. The author seeks the origin of the rays in the vibrations of the molecules attaining a new position of equilibrium. In looking for some regularity in the spectrum of the rays, he found that Blondlot's values may be arranged in two series, one of them containing multiples of 2.9 $\mu\mu$, the other containing simple fractional multiples of 4.9 $\mu\mu$.—Jean Becquerel, Comptes Rendus, May 30, 1904.

FINE EXHIBIT OF ROLLED AND FLANGED STEEL PLATE AT THE ST. LOUIS EXPOSITION.

By the St. Louis Correspondent of the SCIENTIFIC AMERICAN.

IN the Palace of Mines and Manufactures at the St. Louis Exposition there is an exhibit of rolled, flanged, and dished steel plate, that attracts considerable attention because of its excellence and the exceptional size of the work. The most conspicuous piece is a plate 51-100 of an inch in thickness by 149 inches in width and 204 inches in length, and also a circle 71-100 of an inch in thickness by 150 inches in diameter. Each of these pieces was rolled from ingots weighing 5,600 pounds each. In common with all the output of the exhibitors, the Worth Brothers Company, St. Louis, these pieces are manufactured from open-hearth steel. The mill in which the plates were rolled is the largest of its kind in existence. It is known as a three-high breaking-down and finishing mill. The top and bottom rolls are 42 inches in diameter, and the middle roll 25 inches in diameter, the length of all three rolls being 152 inches. Now, when it is borne in mind that there is a shrinkage of 2 inches in such large plates as those which are shown in our photograph, it will be understood that it was a difficult problem to roll such plates successfully, and it was only rendered possible by designing special appliances that are not known to have been used before on any mill in the manufacture of plates. This consisted in attaching heavy knives on the front and back of the roll housings in such a manner that, after the plates had been rolled out as wide as the mill would take them, these knives would shear off the bulge from the middle of the plate, thereby preventing what is known as "housening," or in other words, preventing the plate from lapping over the end of the rolls, and thereby causing trouble.

This mill has large straightening rolls set in tables directly in line from the mill. After the plate has been reduced to the proper dimensions, it is passed on through the straightening rolls, and thereby rendered perfectly true. From the straightening rolls it moves on over transfer tables until it reaches the shearing department, where it is cut up into whatever sizes may be desired. In our photograph are seen also a flanged head ½ inch thick by 145 inches in diameter, and a flanged marine head ⅝ inch thick by 144 inches in diameter, which are believed to be the largest heads of their kind that have ever been flanged.



Flanged marine head ⅝ inch thick by 144 inches diameter.

A ½-inch rolled plate 149 inches wide by 204 inches long.

5,600-pound ingot, similar to that from which the big plate was rolled.

FINE EXHIBIT OF LARGE ROLLED AND FLANGED WORK AT ST. LOUIS EXPOSITION.

EXPERIMENTS WITH THE AIRSHIP "MEDITERRANEAN II."

By F. PAYREY.

IT is at Palavas-les-Flots, a small whaling station on the Languedoc coast, that is situated the port at which the "Mediterranean II." is tied up. From afar in the offing, from afar on the pulverulent roads of Herault, barely shaded with trees suffocating under inexorably superposed strata of dust, the aerodrome is seen detaching itself from a dazzling horizon. At the foot of a shed 115 feet in height come to expire the last short billows of the Mediterranean Sea.

When I reached Palavas on board of the automobile of M. Paul Tissandier, the excellent pilot of the Aero Club, a feverish activity prevailed in the immense shed. M. Bachelard, the chemist, and M. Spielman, his assistant, were watching the generator that was to furnish the 119,000 cubic feet of hydrogen necessary for the inflation. M. Demay, foreman of the Mallet establishment, was bustling about the revivescent balloon and regulating ropes that suspend the car. Farther along, MM. Race and Romœuf, master-workmen of mechanical engineer Duhandt, were finishing the mounting of the mechanical parts under the direction of M. Hervé; while M. de la Vaulx was going from one to the other, everywhere casting the glance of the leader of the expedition, assuring himself of the proper operation of the pump that brings from Palavas station to the gas generator the fresh water derived at great expense from Montpellier, and watching the running of the dynamo that furnishes the electric light.

In one corner was a pile of iron turnings, and, near by, a host of carboys of sulphuric acid in thin baskets of osier. Here and there again were tubes of compressed hydrogen, the car and its rigging, piles of cordage, compensators, the conical anchor, life preservers of kapock, bags of ballast, stabilizers, etc.

Finally, thanks to strenuous labor, particularly meritorious under a blazing sky, the inflation, an operation always difficult and delicate, was finished without impediment on the eleventh of July.

The other members of the expedition, M. A. Vornviller, the distinguished sportsman to whom such scientific researches are fascinating, and who generously assumed a portion of the necessary expenses, M. Duhandt, manufacturer of the mechanical part, and Laignier, a naval officer, rallied in turn to Palavas.

Lieut. Cacqueray, commander of the torpedo-boat

destroyer, "La Pertuisane," who was commissioned to follow the aeronauts and convoy them, if need be, had anchored before Palavas in order to have an understanding with M. de la Vaulx as to the arrangements to be made, and afterward sailed for Cette ready for any emergency.

The preparations for getting under way were finished on July 12, and on the 13th, at a quarter to five in the morning, the "Mediterranean II.," with its screw thrown into gear, left the soil, and, obeying its propeller, advanced upon the sea, poised about 30 feet above the waves. Since at this moment there was scarcely any breeze, it was possible to estimate the proper speed of the balloon at 8 or 8½ miles an hour. At 5h. 58m. the spherical automobile veered with facility, described a circle around "La Pertuisane," and neatly changed direction. A breeze which had risen struck it amidships, but, despite this, thanks to its propeller, properly directed, it sailed parallel with the shore, deviating 45 deg. in the line of the wind. It made about two miles thus and was then submitted to some experiments in towing analogous to those of 1902. Finally, at a signal, at 1,970 feet from the coast, "La Pertuisane" cast off the tow-line, and the screw, thrown into gear again, propelled the balloon toward the shore, where, amid the plaudits of an enthusiastic crowd, it returned by its own means exactly to its starting point in front of the shed.

The issue of the next day's experiment was not so fortunate. At the very start, the car unluckily came into contact with the water. Did this contact with salt water cause disturbances in the operations of the magneto? Did the shock upon the surface destroy the synchronism necessary between the magneto and the motor? All that can be said is that the latter came to a standstill at once and could not be started again.

Through this fact alone, the aeronauts found it impossible to send into the compensating balloon the air that would have permitted the balloon proper to maintain its shape. A pocket that became larger and larger formed in the latter and acted as a sail. When "La Pertuisane" took the tow-line, quite a fresh breeze blowing into this pocket caused ascensional and descensional movements of great amplitude. This same cause prevented the effective casting of the conical anchor. It therefore became necessary to throw off the tow-line and allow the balloon to drift toward the coast, which it reached at Aresquiers, about ten miles from Palavas. The landing was effected very easily and without any damage to the material, statements to the contrary notwithstanding.

Such is, in sum, the log of the third aeromaritime cruise of the "Mediterranean II."

In the first trip, the automobile spherical balloon succeeded in returning to its starting point solely by the means aboard. MM. de la Vaulx and Hervé at the same time obtained a deviation of 45 deg. or 50 deg. from the line of the wind, and this rendered them masters of their direction in a very large measure, even in an unfavorable average breeze. At the same time, they made some experiments in the towing of a balloon at sea, such as the throwing off and catching of a tow-line, which confirmed the results previously obtained and are capable of practical application.

The outcome of the second experiment is incapable of proving anything against the value of the methods employed, and of the apparatus to be utilized, since through entirely fortuitous circumstances it was impossible at any time to make use of them.

Although they have a right to fume against ill luck, MM. de la Vaulx and Hervé have not lost the fruit of their stubborn labor, and the important results that they have obtained can but encourage them to persevere in a path that is a proper one, as facts demonstrate.

The reason that the experiments are not to be resumed at once, as the excellent state of the material would permit of doing, but are adjourned until next year, is perhaps due somewhat to the heavy expense that another inflation would involve, but more especially to the fact that it is impossible for the members of the expedition to again snatch a few days, or weeks, from their ordinary business occupations, in which each has a definite and necessary rôle to perform.

In their next experiments, MM. de la Vaulx and Hervé think of utilizing, as they had before intended, a very slightly elongated balloon with the same rigging, and which will suffice to considerably increase the speed while maintaining a great stability. This balloon, owing to its own speed, will be able to travel from one cloud to another, and may, according to M. Teisserenc de Bort, be employed for studying the phenomena of the formation of hoar frost, rain, ice, etc. There is here, as may be seen, a magnificent field of research that has yet been but slightly exploited.—Translated from La Vie Automobile for the Scientific American Supplement.

[Concluded from Supplement No. 1508, page 24167.]

ON MOUNTAINS AND MANKIND.

By Douglas W. Freshfield.*

In 1857 the Alpine Club was founded in this country. In the half century since that date the nations of Western Europe have emulated one another in forming similar bodies, one of the objects of which has been to collect and set in order information as to the mountains and to further their scientific as well as their geographical exploration.

What boulders, or rather pebbles, can we add to the enormous moraine of modern Alpine literature—a moraine the lighter portions of which it is to be hoped for the sake of posterity that the torrent of time may speedily make away with?

For fifty years I have loved and at frequent intervals wandered and climbed in the Alps. I have had something of a grand passion for the Caucasus. I am on terms of visiting acquaintance with the Pyrenees and the Himalaya, the Apennines and the Algerian Atlas, the mountains of Greece, Syria, Corsica, and Norway. I will try to set in order some observations and comparisons suggested by these various experiences.

As one travels east from the Atlantic through the four great ranges of the Old World the peaks grow out not only in absolute height but also in abruptness of form, and in elevation above the connecting ridges. The snow and ice region increases in a corresponding manner. The Pyrenees have few fine rockpeaks except the Pic du Midi d'Ossau; its chief glacier summits, the Vignemale, Mont Perdu, the Maladetta, correspond to the Titlis or the Buet in the Alps. The peaks of the Alps are infinite in their variety and admirable in their clear-cut outlines and graceful curves. But the central group of the Caucasus, that which culminates in Dykhtau, Koshtantau, and Shkara, 17,000 feet summits (Koshtantau falls only 120 feet below this figure) has even more stately peaks than those that cluster round Zermatt.

Seek the far eastern end of the Himalaya, visit Sikkim, and you will find the scale increased; Siniolchum, Jannu, and Kangchenjunga are all portentous giants. To put it at a low average figure, the cliffs of their final peaks are half as high again as those of Monte Rosa and the Matterhorn.

In all these chains you will find the same feature of watersheds or partings lying not in but behind the geological axis, which is often the line of greatest peak elevation. This is the case in the Alps at the St. Gothard, in the Caucasus for some forty miles west of the Dariel Pass, in the Himalaya, in Sikkim and Nepal, where the waters flowing from the Tibetan plateau slowly eat their way back behind Kangchenjunga and the Nepalese snows. The passes at their sources are found consequently to be of the mildest character, hills "like Wiltshire Downs" is the description given by a military explorer. It needs no great stretch of geological imagination to believe in the cutting back of the southern streams of Sikkim or the Alps, as for instance at the Maloya, but I confess that I cannot see how the gorges of Ossetia, clefts cut through the central axis of the Caucasus, can be ascribed mainly to the action of water.

I turn to the snow and ice region. Far more snow is deposited on the heights of the Central Caucasus and the Eastern Himalayas than on the Alps. It remains plastered on their precipices, forming hanging glaciers everywhere of the kind found on the northern, the Wengern Alp, face of the Jungfrau. Such a peak as the Weisshorn looks poor and bare compared with Tetnuld in the Caucasus or Siniolchum in the Himalaya. The plastered sheets of snow between their great bosses of ice are perpetually melting, their surfaces are grooved, so as to suggest fluted armor, by tiny avalanches and runnels.

In the Aletsch glacier the Alps have a champion with which the Caucasus cannot compete; but apart from this single exception the Caucasian glaciers are superior to the Alpine in extent and picturesqueness. Their surfaces present the features familiar to us in the Alps—icefalls, moulins, and earthcones.

In Sikkim, on the contrary, the glaciers exhibit many novel features due no doubt mainly to the great sun heat. In the lower portion their surface is apt to be covered with the débris that has fallen from the impending cliffs, so that little or no ice is visible from any distance. In the region below the névé there are very few crevasses, the ice heaves itself along in huge and rude undulations, high gritty mounds, separated by hollows often occupied by yellow pools which are connected by streams running in little icy ravines; a region exceptionally tiresome, but in no way dangerous to the explorer. In steep places the Alpine icefall is replaced by a feature I may best compare with a series of earth-pillars such as are found near Evolena and elsewhere, and are figured in most text-books. The ice is shaped into a multitude of thin ridges and spires, resembling somewhat the Nieves Penitentes of the Andes—though formed in a different material.

Great sun heat acting on surfaces unequally protected, combined in the latter case with the strain of sudden descent, is no doubt the cause of both phenomena. Generally the peculiarities of the great glaciers of Kangchenjunga may be attributed to a vertical sun, which renders the frozen material less liable to crack, less rigid, and more plastic.

A glacier, as a rule, involves a moraine. Now moraines are largely formed from the material contributed by subaërial denudation, in plain words by the action of heat and cold and moisture on the cliffs that border them. It is what falls on a glacier, not that which it falls over, that mainly makes a moraine. The proof is that the moraines of a glacier which flows under no impending cliffs are puny compared with those of one that lies beneath great rockwalls.

Take, for example, the Norwegian glaciers of the Jostedals Brae and compare them with the Swiss. The former, falling from a great névé plain or snowfield, from which hardly a crag protrudes, are models of cleanliness. I may cite as examples the three fascinating glaciers of the Olden Valley. The Rosenlaui Glacier in Switzerland owed the cleanliness which gave it a reputation fifty years ago, before its retirement from tourists' tracks, to a similar cause—a vast snow-plateau, the Wetterkessel.

One peculiarity very noticeable both in the Himalaya and the Caucasus I have never found satisfactorily accounted for. I refer to the long grassy trenches lying between the lateral moraine and the hillside, which often seem to the mountain explorer to have been made by Providence to form grass paths for his benefit. They may possibly be due to the action of torrents falling from the hillside, which, meeting the moraine and constantly sweeping along its base, undermine it and keep a passage open for themselves. There are remarkable specimens of this formation on both sides of the Bezingi Glacier, in the Caucasus, and on the north side of the Zemu Glacier, in Sikkim.

Water is one of the greatest features in mountain scenery. In Norway it is omnipresent. In this respect Scandinavia is a region apart; the streams of the more southern ranges are scanty compared with those of a region where the snowfall of two-thirds of the year is discharged in a few weeks. Greece stands at the opposite pole. By what seems a strange perversity of nature, its slender streams are apt to disappear underground, to reissue miles away in the great fountains that gave rise to so many legends. Arcadia is, for the most part, a dry upland, sadly wanting in the two elements of pastoral scenery, shady groves, and running brooks.

The Alps are distinguished by their subalpine lakes—

"Anne lacus tantos? te, Lari maxime, teque,
Fluctibus et fremitu assurgens, Benace, marino?"

of Virgil. But perhaps even more interesting to the student are the lake basins that have been filled up, and thus suggest how similar lakes may have vanished at the base of other ranges.

I know no more striking walk to anyone interested in the past doings of glaciers than that along the ridge of the mighty moraine of the old glacier of Val d'Aosta, which sweeps out, a hill five hundred feet high, known as "La Serra," from the base of the Alps near Ivrea into the plain of Piedmont. Inclosed in its folds still lies the Lago di Viverone; but the Dora has long ago cut a gap in the rampart and drained the rest of the inclosed space, filling it up with the fluvial deposit of centuries.

It is, however, the tarns rather than the great lakes of the Alps which have been the chief subjects of scientific disputation. Their distribution is curious. They are found in great quantity in the Alps and Pyrenees, hardly at all in the Caucasus, and comparatively rarely in the part of the Himalaya I am acquainted with.

A large-scale map will show that where tarns are most thickly dotted over the uplands the peaks rise to no great height above the ridges that connect them. This would seem to indicate that there has been comparatively little subaërial denudation in these districts and consequently less material has been brought down to fill the hollows. Again, it is in gneiss and granitic regions that we find tarns most abundant—that is, where the harder and more compact rocks make the work of streams in tapping the basins more lengthy. The rarity of tarns in the highlands behind Kangchenjunga, perhaps, calls for explanation. We came upon many basins, but, whether formed by moraines or true rockbasins, they had for the most part been filled up by alluvial deposits.

In my opinion, the presence of tarns must be taken as an indication that the portion of the range where they are found has until a comparatively recent date been under snow or ice. The former theory, still held, was that the ice scooped out their basins from the solid rock. I believe that it simply kept scoured preexisting basins. The ice removed and the surrounding slopes left bare, streams on the one hand filled the basins with sediment, or, on the other, tapped them by cutting clefts in their rims. This theory meets, at any rate, all the facts I have observed, and I may point out that the actual process of the destruction of tarns by such action may be seen going on under our eyes in many places, notably in the glens of the Adamello group. Prof. Garwood has lately employed his holidays in sounding many of the tarns of the St. Gotthard group, and his results, I understand, tend to corroborate the conclusions stated.

I desire here to reaffirm my conviction that snow and ice in the High Alps are conservative agents; that they arrest the natural processes of subaërial denudation; that the scouring work done by a glacier is insignificant compared with the hewing and hacking of frost and running water on slopes exposed to the open sky without a roof of névé and glacier.

The contrast between the work of these two agents was forced upon me many years ago while looking at the ground from which the Eiger Glacier had then recently retreated. The rocks, it is true, had had their angles rubbed off by the glacier, but through their midst, cut as by a knife, was the deep slit or gash made by the subglacial torrent. There is in the Alps a particular type of gorge, found at Rosenlaui at the Lower Grindelwald Glacier, at the Kirchet above Meiringen, and also in the Caucasus, within the curves of old terminal moraines. It is obviously due to the action of the subglacial torrent, which cuts deeper and deeper while the ice above protects the sides of the cutting from the effects of the atmosphere.

One more note I have to make about glaciers. It has been stated that glaciers go on melting in winter. Water, no doubt, flows from under some of them, but that is not the same thing. The end of the Rosenlaui Glacier is dry in January; you can jump across the clear stream that flows from the Lower Grindelwald

* Read before Section E of the British Association for the Advancement of Science.

glacier. That stream is not meltings, but the issue of a spring which rises under the glacier and does not freeze. There is another such stream on the way to the Great Scheideck, which remains free when frost has fettered all its neighbors.

I should like to direct your attention before we leave glaciers to the systematic efforts that are being made on the Continent to extend our knowledge of their peculiarities. The subject has a literature of its own, and two societies—one in France, one in other countries—have been constituted to promote and systematize further investigations, especially with regard to the secular and annual oscillations of the ice. These were initiated by the English Alpine Club in 1893, while I was its president. Subsequently, through the exertions of the late Marshall Hall, an enthusiast on the subject, an International Commission on Glaciers was founded, which has been presided over by Dr. Richter, M. Forel, and others; and more recently a French commission has been created with the object of studying in detail the glaciers of the French Alps. A number of excellent reports have been published, embodying information from all parts of the globe. There has been, and is, I regret to say, very great difficulty in obtaining any methodical reports from the British possessions oversea. The subject does not commend itself to the departmental mind. Let us hope for improvement; I signalize the need for it. Of course it is by no means always an easy matter to get the required measurements of retreat or advance in the glacial snout, when the glacier is situated in a remote and only casually visited region. Still, with good will more might be done than has been. The periods of advance and retreat of glaciers appear to correspond to a certain extent throughout the globe. The middle of the last century was the culmination of the last great advance. The general estimate of their duration appears to be half a century. The ice is now retreating in the Alps, the Caucasus, and the Himalaya, and I believe in North America. We live in a retrogressive period. The minor oscillation of advance which a few years ago gave hopes to those who, like myself, had as children seen the glaciers of Grindelwald and Chamonix at their greatest, has not been carried on.

Attempts are made to connect the oscillations of glaciers with periods of sun spots. They are, of course, connected with the rain or snowfall in past seasons. But the difficulty of working out the connection is obvious.

The advance of the ice will not begin until the snows falling in its upper basin have had time to descend as ice and become its snout; in each glacier this period will vary according to its length, bulk, and steepness, and the longer the glacier is, the slower its lower extremity will be to respond. Deficiency in snowfall will take effect after the same period. It will be necessary, therefore, to ascertain (as has been done in a tragic manner on Mont Blanc by the recovery in the lowest portion of the Glacier des Bossons of the bodies of those lost in its highest snows) the time each glacier takes to travel, and to apply this interval to the date of the year with which the statistics of deposition of moisture are to be compared. If the glacier shows anything about weather and climate, it is past, not contemporary, weather it indicates.

Another point in which the Asiatic ranges, and particularly the Himalaya, differ from the Alps is in the frequency of snow avalanches, earthfalls, and mudslides. These are caused by the greater deposition of snow and the more sudden and violent alternations of heat and cold, which lead to the splitting of the hanging ice and snows by the freezing of the water in their pores. I have noticed at a bivouac that the moment of greatest cold—about the rising of the morning star—is often hailed by the reports of a volley of avalanches.

The botanist may find much to do in working out a comparison of the flora of my four ranges. I am no botanist: I value flowers according, not to their rarity, but to their abundance, from the artist's, not the collector's point of view. But it is impossible not to take interest in such matters as the variations of the gentian in different regions, the behavior of such a plant as the little edelweiss (once the token of the Tyrolese lover, now the badge of every Alp-trotter), which frequents the Alps, despises the Caucasus, reappears in masses in the Himalaya, and then, leaping all the isles of the tropics, turns up again under the snows of New Zealand. I may mention that it is a superstition that it grows only in dangerous places. I have often found it where cows can crop it; it covers acres in the Himalaya, and I believe it has been driven by cows off the Alpine pastures, as it is being driven by tourists out of the Alps altogether.

The Italian botanists, MM. Levier and Sommier, have given a vivid account of what they call the macroflora of the central Caucasus—those wild flower beds, in which a man and horse may literally be lost to sight, the product of sudden heat on a rich and sodden soil composed of the vegetable mold of ages. Has any competent hand celebrated the microflora of the highest ridges, those tiny, vivid forget-me-nots and gentians and ranunculuses that flourish on rock island "jardins" like that of Mont Blanc, among the eternal snows, and enamel the highest rocks of the Basodano and the Lombard Alps? A comprehensive work on a comparison of mountain flora and the distribution of Alpine plants throughout the ranges of the Old World would be welcome. We want another John Ball. Allied to botany is forestry, and the influence of trees on rainfall, and consequently the face of the mountains, a matter of great importance, which in this country has hardly had the attention it deserves.

From these brief suggestions as to some of the physical features of mountains I would ask you to turn your attention to the points in which mankind come in contact with them, and first of all to history.

I fancy that the general impression that they have served as efficient barriers is hardly in accordance with facts, at any rate from the military point of view. Hannibal, Cæsar, Charles the Great, and Napoleon passed the Alps successfully. Hannibal, it is true, had some difficulty, but then he was handicapped with elephants. The Holy Roman emperors constantly moved forward and backward. Burgundy, as the late Mr. Freeman was never weary of insisting, lay across the Alps. So until our own day did the dominions of the House of Savoy. North Italy has been in frequent connection with Germany; it is only in my own time that the Alps have become a frontier between France and Italy. But questions of this kind might lead us too far. Let me suggest that some competent hand should compose a history of the Alpine passes and their famous passages, more complete than the treatises that have appeared in Germany. Mr. Coolidge, to whom we owe so much, has, in his monumental collection and reprint of early Alpine writers, just published, thrown great light on the extensive use of what I may call the by-passes of the Alps in early times. Will he not follow up his work by treating of the great passes? I may note that the result of the construction of carriage roads over some of them was to concentrate traffic; thus the Monte Moro and the Gries were practically deserted for commercial purposes when Napoleon opened the Simplon. The roads over the Julier and Maloya ruined the Septimer. Another hint to those engaged in tracing ancient lines of communication. In primitive times, in the Caucasus to-day, the tendency of paths is to follow ridges, not valleys. The motives are on the spot obvious—to avoid torrents, swamps, ravines, earthfalls, and to get out of the thickets and above the timber line. The most striking example is the entrance to the great basin of Suanetia, which runs not up its river, the Ingur, but over a ridge of nearly 9,000 feet, closed for eight months in the year to animals.

From the military point of view mountains are now receiving great attention in Central Europe. The French, the Italians, the Swiss, the Austrians have extensive Alpine maneuvers every summer, in which men, mules, and light artillery are conveyed or carried over rocks and snow. Officers are taught to use maps on the spot, the defects in the official surveys are brought to light. It is not likely, perhaps, except on the Indian frontier, that British troops will have to fight among high snowy ranges. But I feel sure that any intelligent officer who is allowed to attend such maneuvers might pick up valuable hints as to the best equipment for use in steep places. Probably the Japanese have already sent such an envoy and profited by his experience.

A word as to maps, in which I have taken great interest, may be allowed me. The ordnance maps of Europe have been made by soldiers, or under the supervision of soldiers. At home when I was young, it was dangerous to hint at any defects in our ordnance sheets, for surveyors in this country are a somewhat sensitive class. Times have altered, and they are no longer averse from receiving hints and even help from unofficial quarters. Since the great surveys of Europe were executed, knowledge has increased so that every country has had to do over again its surveys. In three points that concern us there was great room for improvement, the delineation of the upper region as a whole, and the definition of snow and glaciers in particular, and in the selection of local names. In the two former the Federal Staff at Bern has provided us with an incomparable model. The number of local names known to each peasant is small, his pronunciation is often obscure, and each valley is apt to have its own set of names for the ridges and gaps that form its skyline. Set a stranger, speaking another tongue than the local *patois*, to question a herdsman, and the result is likely to be unsatisfactory. It has often proved so. The Zardezan is an odd transcription of the Gias del Cian of *patois*, the Gîte du Champ in French. The Grand Paradis is the last term an Aostan peasant would have used for the Granta Parei, the great screen of rock and ice of the highest mountain in Italy. The Pointe de Rosablanche was the Roesa Bianca, or white glacier. Monte Rosa herself, though the poet sees a reference to the rose of dawn, and the German professor detects "the Keltic *ros*, a promontory," is a simple translation of the Gletscher Mons of Simler, or rather Simler's hybrid term is a translation of Monte della Roesa. Roesa, or Ruize, is the Val d'Aostan word for glacier, and may be found in De Saussure's "Voyages."

An important case in this matter of mountain nomenclature has recently come under discussion—that of the highest mountain in the world. Most, if not all, mountaineers regret that the name of a surveyor-general, however eminent, was fifty years ago affixed to Mount Everest. The ground for this action on the part of the survey was the lack of any native name. Some years ago I ventured to suggest that the 29,002-feet peak (No. 15 of the survey) was probably visible from the neighborhood of Katmandu, even though the identifications of it by Schlagintweit and others might be incorrect, and that since some at least of the summits of the snowy group east of that city are apparently known in Nepal as Gaurisankar, that name might, following the practice which gave its name to Monte Rosa in the Alps, legitimately be applied to the loftiest crest of the mountain group of which the Nepalese Gaurisankar formed a part.

Recently, by the kindness of Lord Curzon, acting on a suggestion of my own, Capt. Wood, a survey officer, has been deputed to visit Katmandu and ascertain the facts. He has found that, contrary to the opinion of the late General Walker and the assertion of Major Waddell, Peak 15 is visible from the hills round the capital, and that the two highest snowpeaks visible from the city itself in the same direction were known to the Nepalese "nobles" as Gaurisanker.

These latter peaks or peak are about thirty-six miles distant from Peak 15, but are connected with it by a continuous line of glaciers. According to the principles that have prevailed in the division of the Alps, they would undoubtedly be considered as part of the same group, and the name, which, according to Capt. Wood, is applied to a portion of the group, might legitimately be adopted for its loftiest peak.

But the chiefs of the Indian survey take, as they are entitled to, a different view. They have decided to confine the name Gaurisankar to one of the peaks seen from Katmandu itself. I do not desire to raise any further protest against this decision. For since, in 1886, I first raised the question its interest has become mainly academical. A local Tibetan name for Peak 15, Chomo-Kankar, the Lord of Snows, has been provided on excellent native authority, confirmed by that competent Tibetan scholar, Major Waddell, and I trust this name may in the future be used for the highest mountain in the world.* The point at issue is mainly one of taste. Indian surveyors may see no incongruity in naming after one of their own late chiefs the highest mountain in the world. But in this view they are, I believe, in a small minority.

I would urge mountain explorers to attempt in more distant lands what the late Messrs. Adams-Reilly and Nichols, Mr. Tuckett, and Lieut. Payer (of Arctic fame) did forty years ago with so much success in the Alps, what the Swiss Alpine Club have done lately, take a district, and working from the trigonometrically fixed points of a survey, where one exists, fill it in by planetabling with the help of the instruments for photographic and telephotographic surveying, in the use of which Mr. Reeves, the map curator to the R. G. S., is happy to give instruction. An excellent piece of work of this kind has been done by Mr. Stein in Central Asia.

There are, I know, some old-fashioned persons in this country who dispute the use of photography in mountain work. It can only be because they have never given it a full and fair trial with proper instruments.

Lastly, I come to a matter on which we may hope before long to have the advantage of medical opinion, based for the first time on a large number of cases. I refer to the effects of high altitudes on the human frame and the extent of the normal diminution in force as men ascend. The advance to Lhasa ought to do much to throw light on this interesting subject. I trust the Indian government has taken care that the subject shall be carefully investigated by experts. The experience of most mountaineers (including my own) in the last few years has tended to modify our previous belief that bodily weakness increases more or less regularly with increasing altitude. Mr. White, the Resident in Sikkim, and my party both found on the borders of Tibet that the feelings of fatigue and discomfort that manifested themselves at about 14,000 to 16,000 feet tended to diminish as we climbed to 20,000 or 21,000 feet. I shall always regret that when I was traveling in 1899 on the shoulders of Kangchenjunga the exceptional snowfall altogether prevented me from testing the point at which any of our ascents were stopped by discomforts due to the atmosphere. Owing to the nature of the footing, soft snow lying on hard, it was more difficult to walk uphill than on a shingly beach; and it was impossible for us to discriminate between the causes of exhaustion.

Here I must bring this, I fear, desultory address to an end. I might easily have made it more purely geographical, if it is geography to furnish a mass of statistics that are better and more intelligibly given by a map. I might have dwelt on my own explorations in greater detail, or have summarized those of my friends of the Alpine Club. But I have done all this elsewhere in books or reviews, and I was unwilling to inflict it for a second time on any of my hearers who may have done me the honor to read what I have written. Looking back, I find I have been able to communicate very little of value, yet I trust I may have suggested to some of my audience what opportunities mountains offer for scientific observations to mountaineers better qualified in science than the present speaker, and how far we scouts or pioneers are from having exhausted even our Alpine playground as a field for intelligent and systematic research.

And even if the value to others of his travels may be doubtful, the Alpine explorer is sure of his reward. What has been said of books is true also of mountains—they are the best of friends. Poets and geologists may proclaim—

"The hills are shadows, and they flow
From form to form, and nothing stands!"

But for us creatures of a day the great mountains

* See, for discussions of this question, Proceedings of the Royal Geographical Society, N. S., 1885, vii., 753; 1886, viii., 88, 176, 257; Geographical Journal, 1903, xxi., 294; 1904, xxiii., 89; Alpine Journal 1886, xii., 448; 1902-3, xxi., 33, 317; Petermann's Mitteilungen, 1888, xxxiv., 338; 1890, xxxvi., 251; 1901, xlvii., 40; 1902, xlviii., 14.

stand fast, the Jungfrau and Mont Blanc do not change. Through all the vicissitudes of life we find them sure and sympathetic companions. Let me conclude with two lines which I found engraved on a tomb in Santa Croce at Florence:

"Huc properate, viri, salebrosum scandite montem,
Pulchra laboris erunt præmia, palma, quies."

CURRENT WHEELS: THEIR USE IN LIFTING WATER FOR IRRIGATION.*

CONSTRUCTION OF CURRENT WHEELS.

THE practical experience of many irrigators in the construction and use of current wheels has been collected and is here presented as an answer to inquiries regarding their cost and efficiency.

In its simplest form a current wheel consists of a large skeleton roller made of wood, with paddles projecting beyond its rim. It is hung on a shaft and supported at both ends by piers or posts, so as to allow the wheel to dip into the water to the width of the paddles. The simplest device for raising water with such a wheel is a row of buckets placed on the rim so as to fill at the bottom of the wheel and empty into a trough near the top. A more complicated way is to connect the wheel to chain and bucket gear, or to a pump of some sort. These more difficult methods of construction are necessary in all cases where it is desired to raise the water to a height greater than the diameter of the wheel used.

THEORY OF POWER IN CURRENT WHEELS.

While a home-made undershot water wheel develops but little of the power in a running stream, still the action of the crudest wheel is governed by certain principles, an understanding of which will aid the builder in improving the design of his wheel, thereby increasing its efficiency.

Current wheels, unlike overshot wheels, do not act by the weight of the water, but by the impulse or dynamic pressure of moving water. The power contained in running water is expressed in terms of the distance through which the water would have to fall in order to attain the velocity observed. This distance is called the velocity head. A body falling freely 4 feet attains a velocity of 16 feet per second. Hence water flowing 16 feet per second has a velocity head

* Bulletin 146 of the United States Dept. of Agriculture.

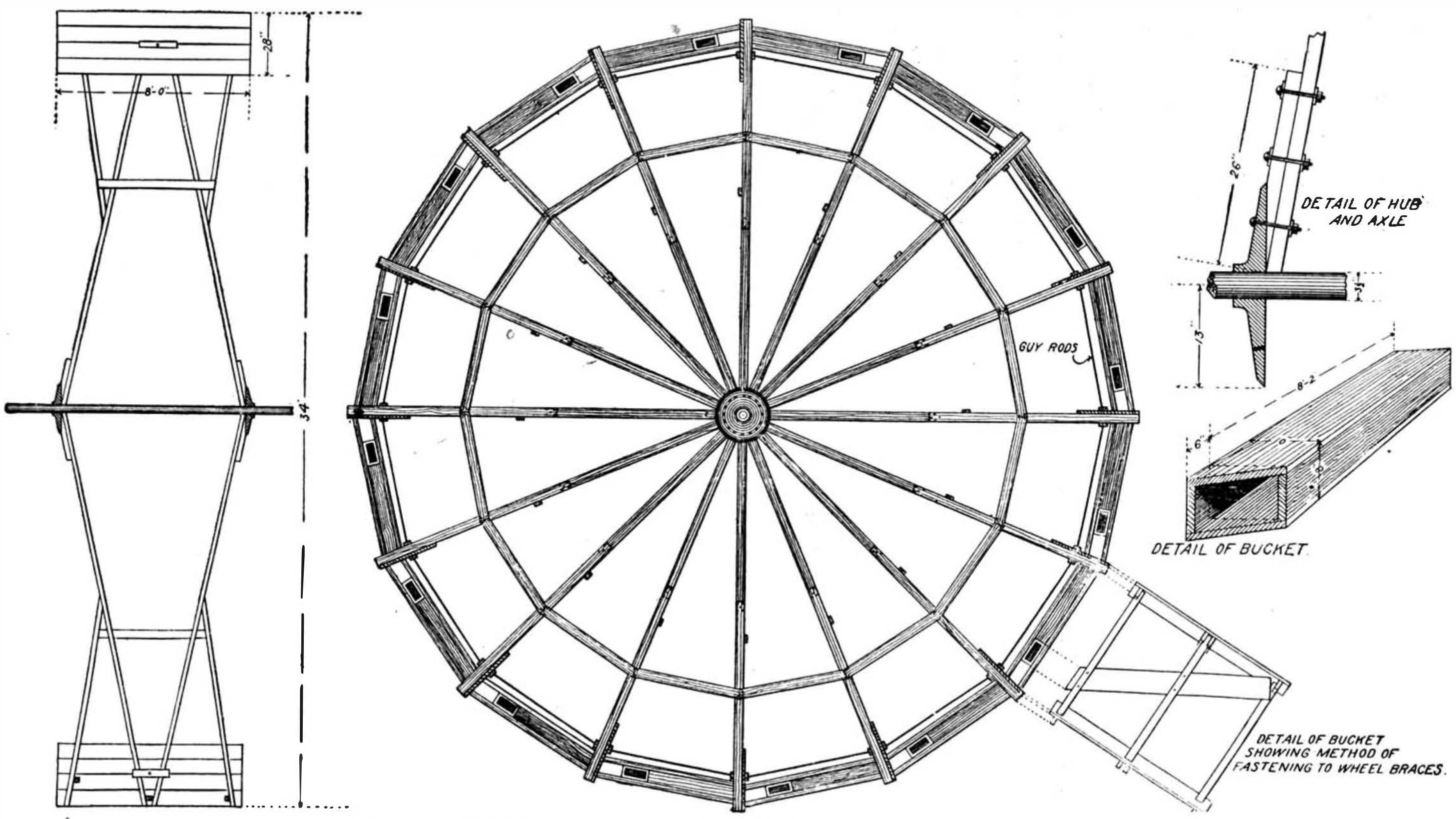


FIG. 2.—WHEEL ON GRAND VALLEY CANAL, COLORADO.

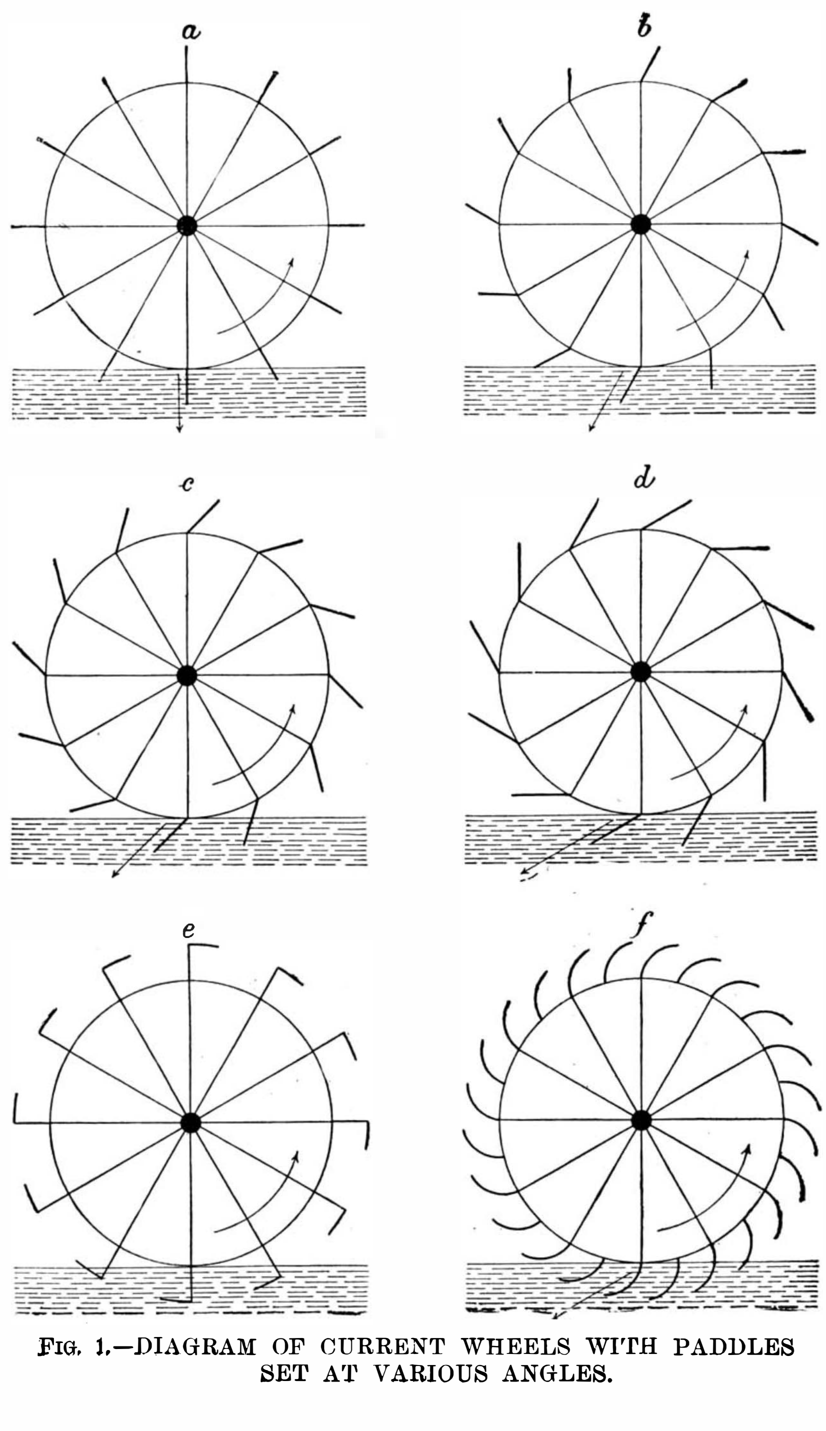


FIG. 1.—DIAGRAM OF CURRENT WHEELS WITH PADDLES SET AT VARIOUS ANGLES.

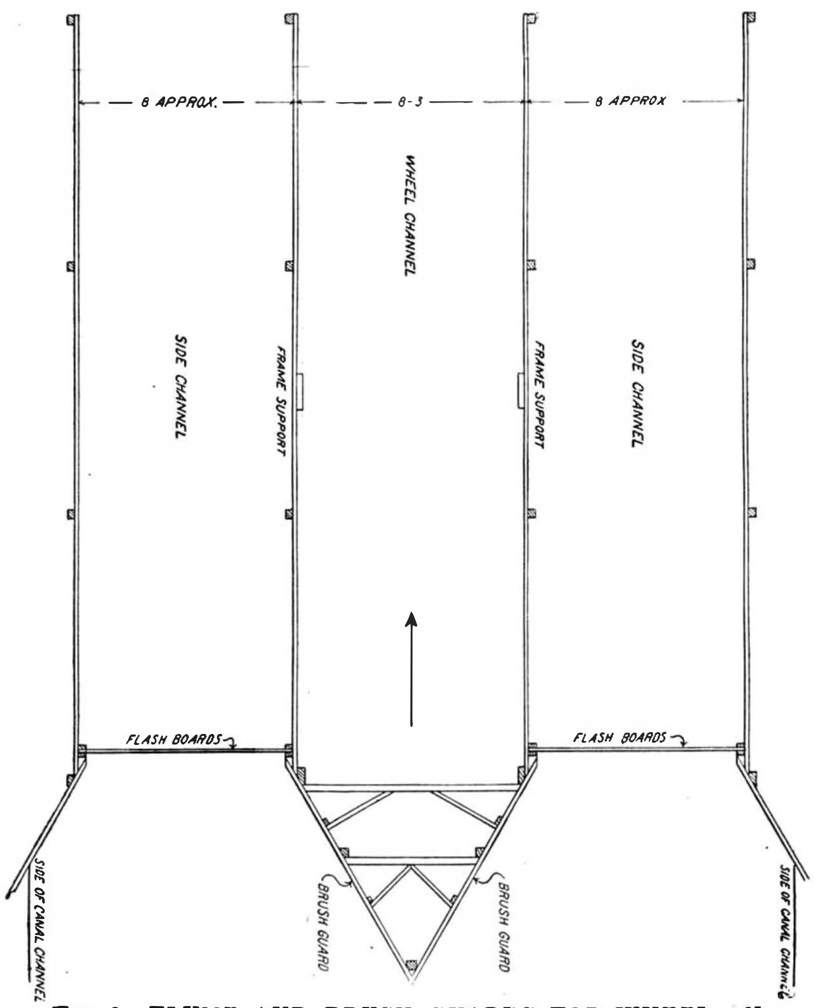


FIG. 3.—FLUME AND BRUSH GUARDS FOR WHEEL ON GRAND VALLEY CANAL, COLORADO.

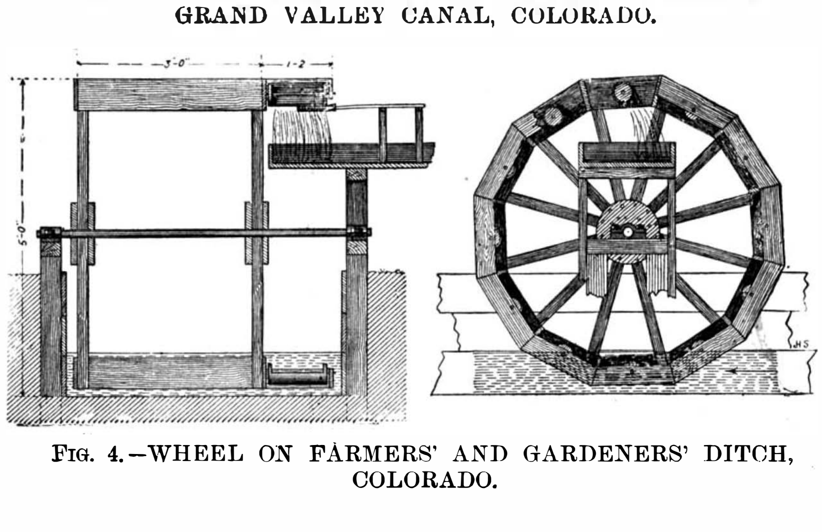


FIG. 4.—WHEEL ON FARMERS' AND GARDENERS' DITCH, COLORADO.

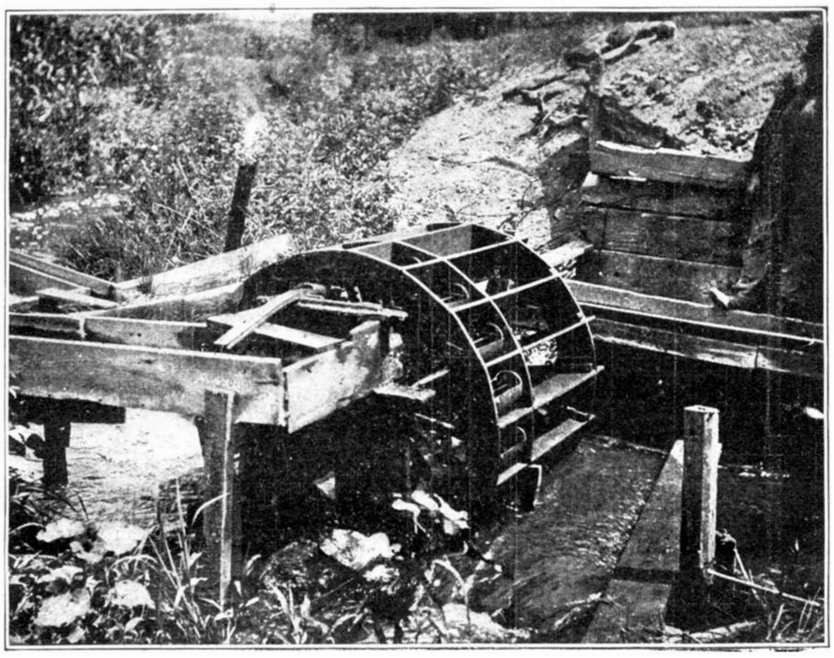


PLATE I.—CURRENT WHEEL, FARMERS' AND GARDENERS' DITCH, COLORADO.

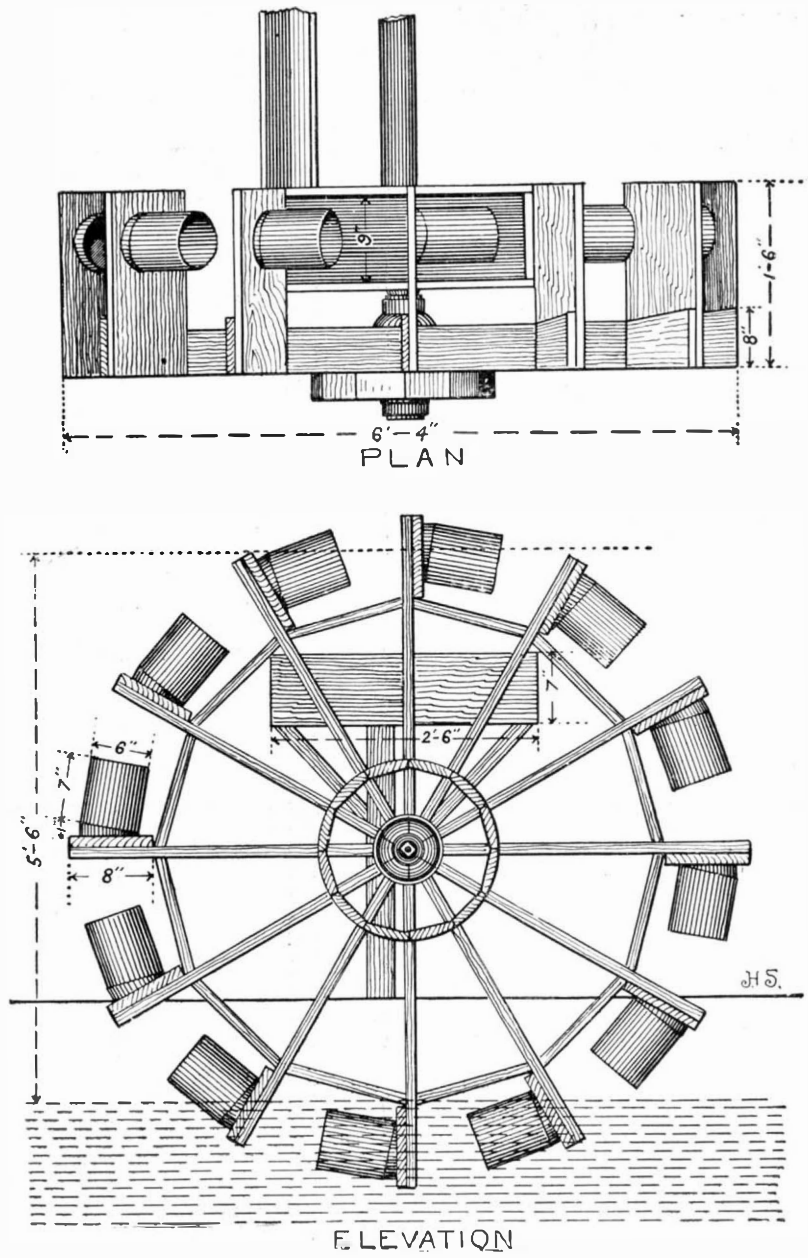


FIG. 7.—WHEEL NEAR MORGAN CITY, UTAH.

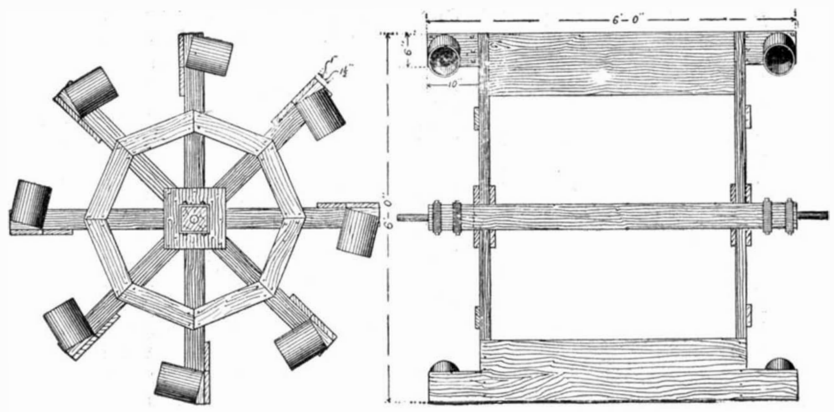


FIG. 5.—WHEEL AT NORTH YAKIMA, WASH.

of 4 feet. In other words, if an inclined plane were placed in such a stream, the water would run up it to the height of 4 feet before coming to rest. Thus the power contained in 1,000 pounds of water running 16 feet per second is exactly sufficient to raise a weight of 1,000 pounds 4 feet. This weight may or may not consist of the moving water itself. The usual velocity in streams is from 1 to 4 feet per second, representing velocity heads of from one-fourth inch to 3 inches, so that some means other than an inclined plane must be used to raise water to a serviceable level. In any case work is performed only when the motion of the water is checked. The current wheel, by checking the motion of a large quantity of water to some degree, raises a very small quantity of water to a height ten or a hundred times as great as the velocity head in the stream.

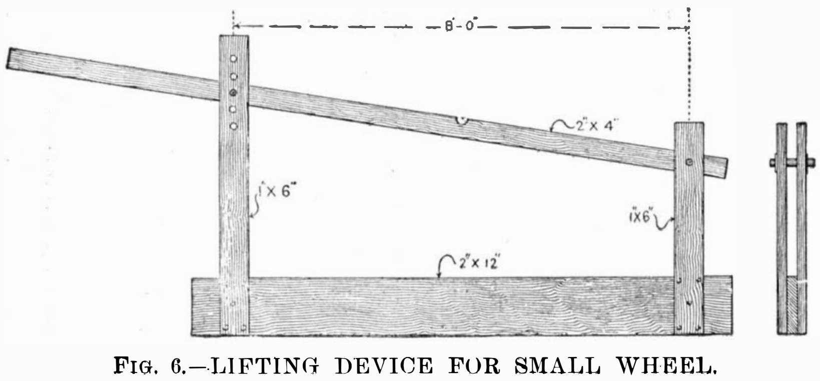


FIG. 6.—LIFTING DEVICE FOR SMALL WHEEL.

Theoretical Calculation of Efficiency.

The speed at which a current wheel revolves may be regulated by increasing or decreasing the number and size of the buckets on the rim. When the load is so heavy that the wheel does not start, it is evident that although the water strikes the paddles with great pressure no work is done. Again, if the wheel is not loaded at all, and turns as fast as the water moves under it, speed is developed, but no appreciable pressure is exerted on the paddles. Halfway between these extremes lies the mean of greatest advantage; therefore the wheel should be so loaded as to move one-half as fast as the water. Given a wheel the rim of which moves one-half as fast as the water, its efficiency depends on the design of the paddles. For the amount of work imparted to the wheel by the water depends on the change in its absolute velocity in turning the wheel, which is largely governed by the angle at which the paddles are set. But dynamic pressure of water varies with the square of velocity, and the work imparted will vary as the square of the initial velocity minus the square of the final velocity. This relation is expressed by the formula*

$$k = \left(W \frac{v^2 - v_1^2}{2g} \right)$$

in which k is the work imparted to the wheel, W is the weight of water that comes into action each second, v is the initial velocity of the water, v_1 is its final absolute velocity, and g is the force of gravity. In any given set of conditions W, v, and g have constant values. The only way, then, to increase the amount of work done is by reducing v_1. In other words, if the water could be made to leave the vanes with an absolute velocity of zero, the power imparted

* Merriman, Hydraulics, eighth edition, p. 406.

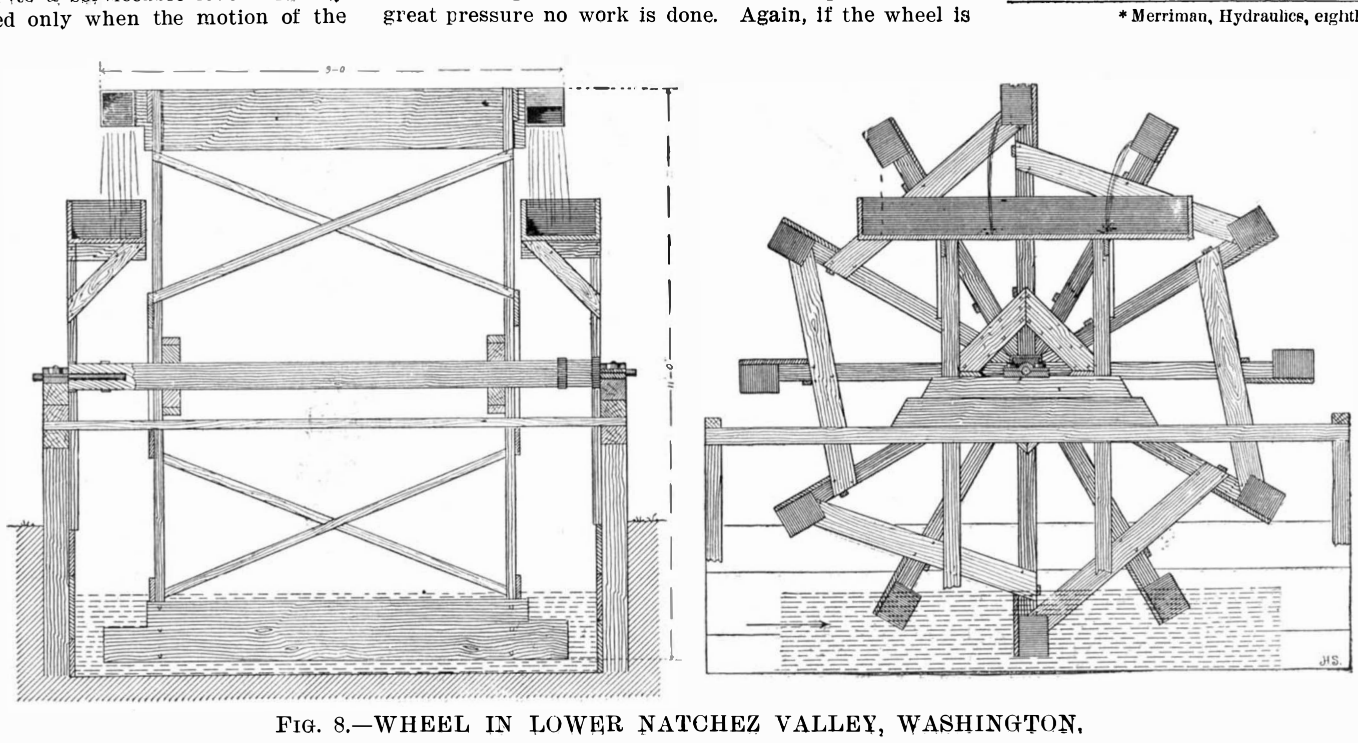


FIG. 8.—WHEEL IN LOWER NATCHEZ VALLEY, WASHINGTON.

to the wheel would equal the total dynamic energy of the stream, and the efficiency of the wheel would be 100 per cent. In Fig. 1 a series of wheels is shown with the paddles arranged at various angles. At (*a*) is shown the most common form, a wheel with plain radial paddles. Since the wheel moves one-half as fast as the water, the water will leave the paddle, in the direction of the small arrow, with a velocity one-half as great as that of the stream. Owing to the horizontal motion of the paddle, the absolute discharge of the water will be in a diagonal direction, and its absolute velocity will be the initial velocity divided by $\sqrt{2}$.

Since the energy in moving water varies with the square of the velocity, the water discharged has one-half of the energy of the water striking the paddles. Hence one-half of the energy is lost, and the efficiency of the wheel is 50 per cent.

Similar reasoning will show that in the wheel marked (*b*), the paddles of which slant upstream 30 degrees from vertical, the water is discharged with an absolute velocity one-half as great as the entering velocity, giving an efficiency of 75 per cent. At (*c*) the blades slant 45 degrees from vertical, giving an efficiency of 85 per cent. At *d* the paddles are set 60 degrees from vertical, giving an efficiency of 93 per cent. At (*e*) the paddles are supposed to discharge the water in a direction directly opposite to the wheel's motion, so that it leaves the wheel with no absolute velocity whatever. In that case the efficiency would be 100 per cent.

Practical Operations.

Certain practical considerations, however, of which no account is taken in the above theoretical discussion, prevent the adoption of several of the forms of wheel shown in Fig. 1. First, the loss by "impact," or the churning and eddying of water, is very great when the water strikes flat on a paddle, as at *a*. At *d* the eddy formed in the sharp angle between the paddle and the rim is equally wasteful. It is impossible to avoid impact altogether in any water wheel, but it is least detrimental in a wheel like the one shown at *f*, in which the paddles are curved. The intention is that the water shall strike the blades nearly at a tangent, and slide smoothly up them, coming to rest near the top. In sliding out, the reaction is in line with the motion of the wheel, and the absolute velocity of the tail-water is very low. A wheel of this design has reached a working efficiency of 68 to 75 per cent,* which is about twice the efficiency usually obtainable in a wheel with straight paddles. Impact is seen to be a leading factor in reducing the efficiency of wheels.

In all carefully built wheels where the water is run under the wheel through a flume, it is necessary to provide ample waste way for the tail-water. The fall in the tailrace below the wheel is of course light, so as to get the greatest possible fall above; but it must be great enough to make the tail-water flow away without checking the wheel.

In order to avoid unnecessary churning of the water, it is advisable to have not less than twelve paddles, in order that at least two may at all times be in the water. In the case of a large wheel set in a flume, more paddles should be provided to avoid the necessary loss between the flume and the paddles. They should dip into the water not more than one-tenth of the diameter of the wheel, for if they dip too deep, the pressure of the water is not applied tangent to the wheel, but at a less advantageous angle, and there is also a tendency to throw water on the lower side. When a wheel is placed in a flume, it is always well, where possible, to run the water under a gate, making the paddles somewhat wider than the depth of the water.

As a matter of practice, the form of paddles shown in Fig. 1, *e*, is entirely impracticable. The water discharged with no velocity would be in the way of the next paddle and the loss by impact and backwater would be so large as to make the wheel worthless. For wheels with straight paddles, the form shown in Fig. 1, *b*, is found to be most satisfactory. In this case the paddles leave the water vertically with no tendency to splash water. Perhaps the most effective easy construction out of flat boards is the one shown in Fig. 11, where the paddle bends at an angle. In this case the usual stiff rim may be omitted.

EXAMPLES OF WHEELS IN ACTUAL USE.

The foregoing considerations apply in general to all current wheels. In the descriptions of wheels in actual use, attention will be given to many points in their design and to constructive details. In the estimates of the cost of materials, lumber is put in at $25 per thousand and hardware at about 100 per cent above wholesale prices. The weight of wheels is computed on the basis of 4 pounds per board foot for lumber and 450 pounds per cubic foot for ironwork.

Wheels on the South Platte at Denver.

In the Farmers' and Gardeners' Ditch from the South Platte River at Denver, Col., are four wheels of the design shown in Fig. 4, and in Plate I. Each is 4 feet in diameter and raises water 3 feet for the irrigation of five acres in vegetables. The shaft is of 1½-inch iron pipe and works in wooden bearings. Two rows of 1 by 2-inch wooden spokes are placed 3 feet apart on the shaft. Stiff circular rims of ½ by 6-inch material connect the ends of the spokes, forming a rigid wheel for the support of the paddles. There are eighteen paddles of ½-inch boards 6 inches wide and 4 feet in length. The paddles extend 1 foot beyond the row of spokes at one end, where the buckets are swung between them. These projecting ends are braced by a third stiff rim which furnishes a bearing for the buckets. These are half-cylindrical in shape, being made of tin tacked onto round pieces of wood which form the ends. They are swung on pins of heavy wire run through the centers of the end pieces. Being free to turn on the pins, the buckets will always hang right side up unless forcibly turned over. In this case they are turned over when they reach the top of the wheel by a slender stick placed so as to strike each bucket

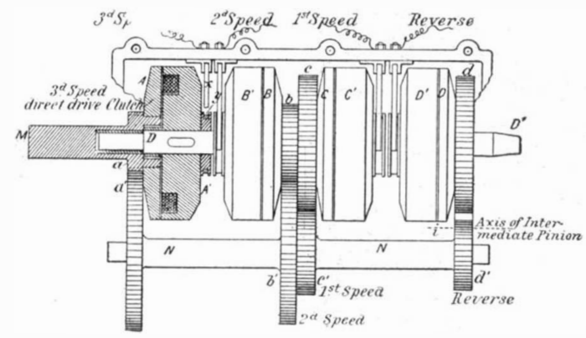
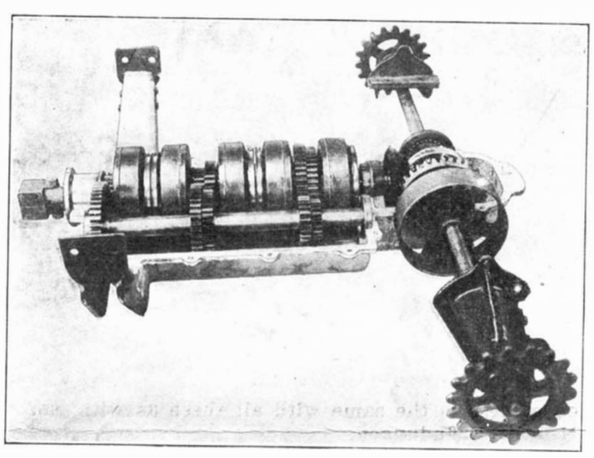


DIAGRAM OF MAGNETIC CLUTCH TRANSMISSION GIVING THREE SPEEDS AND REVERSE.

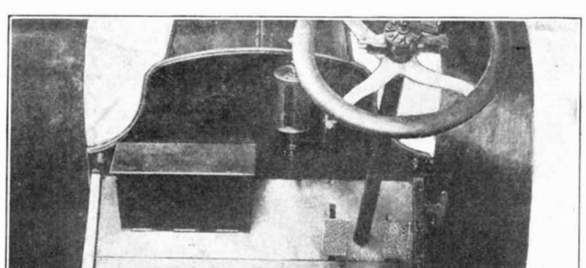
in turn. A piece of rubber hose covers the end of the stick, which springs down enough to let the bucket roll over it without checking the motion of the wheel. Each of the eighteen buckets holds 0.04 cubic foot, so that at each revolution the wheel raises 0.72 cubic foot. Turning once in 3½ seconds, the wheel raises about 0.2 cubic foot per second. No attempt is made to confine the water of the ditch to a flume so as to bring it all into action on the wheel.

These wheels are well constructed and are said to have cost $27 each. Most of the expense appears to have been for labor, since the amount of material required is so small. The plan calls for 42 board feet of lumber, 5 feet of pipe for the shaft, 8½ pounds of tin (D C), and 5 pounds of No. 1 wire. At fair retail prices the cost for material is $3.15. This estimate is exclusive of the supporting posts and the flume for carrying away the water.



TRANSMISSION WITH INDIVIDUAL ELECTRO-MAGNETIC CLUTCHES.

These wheels successfully water the gardens for which they were built and so entirely fulfill the purpose of the gardeners who put them in. With a little change in design, however, a wheel of this pattern could be made to raise twice as much water as these raise at present. In the first place, the wheel revolves almost as fast as the water that turns it, so that the water which strikes the paddles exerts about one-third of its power. The remedy is to increase the size of the buckets until the rim of the wheel moves about half as fast as the water. Another improvement which would increase the capacity of the wheel would be to slant the paddles about 30 degrees upstream, or, better still, a slanting board could be added to each paddle, so as to form an angle opening upstream.



CHASSIS OF "LA MAGNETIQUE" AUTOMOBILE.

The four speeds and reverse are obtained by moving the small switch on top of the steering column.

Of the total available power in the stream, the wheel observed used 20 per cent in "useful work." By running all the water through a flume 4½ feet wide and changing the design as suggested the amount of water raised would be largely increased. For $10 a permanent flume of 2-inch material with a substantial apron and wings could be built.

(To be continued.)

* Frizell, Water Power, third edition, p. 286.

"LA MAGNETIQUE" AUTOMOBILE—A SIMPLIFIED TYPE OF MACHINE WITH MAGNETIC CLUTCHES.

By the Paris Correspondent of SCIENTIFIC AMERICAN.

"LA MAGNETIQUE" automobile seems to be the first which has been able to use the magnetic clutch successfully for operating the mechanism. The new system has been brought out recently at Paris, where several cars are now running. The principle of the magnetic clutch has been known for many years past, but it is not until lately that it has been successfully applied to automobiles. Some years ago the question was taken up by different inventors who saw the advantages which it would give in suppressing part of the speed-changing mechanism and simplifying the action considerably by using the electro-magnetic principle. However, up to the present, none of these have been successful. This has been due to certain practical difficulties in operating the clutches, which arose as soon as the inventors came to reduce the idea to practice. The engineers who are now constructing the present system state that the success which they are having depends more or less upon the details of construction and the method of mounting. This they have been able to perfect after considerable experience and to realize what the larger and better-equipped constructors failed to accomplish.

The electro-magnetic clutch is adapted to the usual speed-changing gear-case of an automobile in the following way: The clutch is formed of two soft-iron disks which are attracted against each other by the current. A series of clutches is fixed to the shaft and each of them controls the action of a pair of gears. Thus, by sending current through the coils of the different clutches, any combination of gears that is desired can be obtained. This gives the different speeds and reverse of the car without recourse to the usual sliding gears, which are unmechanical and liable to chip or break. The gears in this case are always in mesh and constantly running.

This will be easily understood from the diagram and photographs of the gear-box shown herewith. The transmission shown in the diagram is designed for three speeds and a reverse, while that shown in the photographs has four speeds and reverse, the fourth speed being obtained by means of an additional clutch and pair of gears. The motor shaft is connected by a coupling to a short piece of shafting, *M*. This shaft has a socket bearing which receives the end of the differential shaft, *DD'*, and the latter thus revolves independent of the motor shaft. The differential shaft runs to the rear, where it is connected with the differential by a bevel gear mounted at the end, *D'*, as will be observed in the photographs. The shaft, *M*, has fixed to it a gear, *a*, which engages with a larger gear *a'*. The latter gear is mounted on the countershaft, *NN*. The motor thus drives the countershaft continuously, but does not operate the differential shaft except through the intermediary of the magnetic clutches. On the shaft, *M*, is also mounted the soft iron disk, *A*, which is fixed rigidly to it and forms one half of the main, or direct drive, magnetic clutch. The other half is formed by the heavy disk, *A'*, which is keyed to the differential shaft. This disk carries the magnetizing coil embedded below the surface in an annular groove. Current is brought to the coil by a brush, *x*, and contact ring, *y*. When no current passes in the coil, the disks *AA'* are separated and the motor only drives the countershaft through the gears, *aa'*, and is disconnected from the rear wheels of the car. On sending current through the coil, the plates *AA'* are attracted and locked together. This connects the motor shaft, *M*, directly with the differential countershaft by locking *M* to *DD'*, which drives the latter through a bevel gear; and so the motor drives the rear wheels of the car without any intermediate gearing and gives the maximum speed, the lay shaft, *NN*, revolving idle meanwhile.

On the shaft, *DD'*, are mounted three other clutches of similar construction, *BB'*, *CC'*, and *DD'*. The part, *B'*, contains the magnetizing coil as before and is keyed to the shaft. The disk, *B*, has the gear, *b*, mounted upon its hub. This disk is loose on the shaft and the gear, *b*, meshes with the larger gear, *b'*, which is carried on the lay shaft, *NN*. To obtain the second or reduced speed of the car, the clutch *AA'* is thrown out by cutting off the current, and *BB'* is thrown in by connecting the battery to the coil of this clutch. Gear *b* is thus locked to the shaft, *DD'*, thus causing *M* to drive *NN* by gearing *aa' b' b*. The speed of the car is still further reduced by throwing out clutch, *B*, and using clutch, *C*, which connects the gear, *c*, with the shaft, *DD'*, in a similar way. The motor now drives the car through the gearing *aa' c'c*. To reverse

the car, the last clutch, *E*, is used, together with an intermediate pinion, which connects the gears *d* and *d'*, and we now use *aa' d'd*.

As will be observed in the photograph, the speed-changing device is mounted in a tight aluminium case which contains the two shafts and the differential, where a chain drive to the rear wheels is employed. In the contrary case, a shaft with universal joints is employed, and the differential is contained in a separate case, and the disks of the clutches are clearly visible in the photographs we reproduce. Each of the disks carries a copper ring through which its coil receives current from a metal brush which is fixed to the side of the case. The system here shown contains another pair of gears and an additional clutch to provide four speeds and reverse. It will be remarked that all the disks, *A*, *B*, *C*, etc., although loose on the shaft, are in continual rotation when the motor is running. They turn in the same direction as the shaft upon which they are mounted and thus reduce the friction considerably, although they are mounted upon ball-bearings and in any case the friction is small. The plate, *D*, however, revolves in the contrary direction, owing to the intermediate pinion, *i*. Although the whole device is immersed in oil, the inventors find that this has no disadvantages as regards the electro-magnets, by constructing the coils to this end. The contact rings and brushes are found to work very well in the oil.

This form of speed-changing device is very simple in its construction and the gears work under their theoretical conditions and are constantly surrounded by oil. As regards the control of the different speeds, nothing is simpler, as it requires only a small five-point circular switch. This is mounted on the top of the steering wheel. The arm is pivoted in the center and moves around over five contacts. By displacing it an inch or more at a time the chauffeur obtains the different speeds of the car. One point to be specially remarked about the magnetic clutch is that the car can be reversed almost at once when running at full speed. The effect of the magnetic action is such that the two plates of the reversing clutch slide upon each other at first and act as a brake upon the car, up to the point where it is brought to a full stop, and from this on the two plates adhere to each other and reverse the car. This gives, in fact, a kind of progressive electric braking action which is quite automatic, and is analogous to that which is obtained on a tramway car when the motors are made to work as generators upon a resistance. In addition there is a brake on the differential and one on the rear wheels.

The present device has many advantages. In the first place it suppresses the use of the sliding gear set, which is the cause of so much difficulty in the ordinary automobile. The gears are always in mesh and are in a fixed position with relation to each other. The teeth can thus be cut according to the theoretical profile and work to a much better advantage than when beveled, as is necessary with sliding gears. Another point is the suppression of levers and rods for operating the gears. The car now passes from one speed to another without shocks and there is no danger of breaking off the teeth of the pinions. The direct passage from full speed to reverse is an important point which will be appreciated by chauffeurs. The usual friction-clutch is suppressed, together with its numerous disadvantages.

The current for operating the clutch is furnished by the battery which is already used for the ignition of the motor. Three small storage cells are quite sufficient. Where the motor uses a small dynamo for the ignition, this can also be utilized. In any case the energy used by the clutch is very small, as it requires but 6 volts and about 1 ampere to operate it.

"La Magnetique" system is now in actual operation on several cars which have been recently built. These cars have been running on the road for some time and have fully proved the advantages which have been claimed for the system.

Double Refraction.—The explanation of double refraction requires that in three directions at right angles to each other either the density of the body, or its elasticity, or its dielectric constant, should have different values. If the latter assumption is made it may be supposed that a number of conducting particles are embedded in a non-conducting medium. Lampa has made calculations bearing upon the case of conducting ellipsoids embedded in a non-conductor, or conducting spheres distributed with different frequencies in three directions. F. Braun now deals with another alternative. It is that a number of bricks are embedded in a medium of smaller dielectric constant, all the bricks being oriented in the same manner. Such a combination must show double refraction on the condition that it behaves like a homogeneous medium toward the incident wave system. If a block of the medium be placed in a uniform electric field, the potential energy of the system will be at a minimum when the longest axes of the bricks are parallel to the lines of force. Hence the capacity of the condenser and also the dielectric constant will have their maximum value in the same direction. The author constructed a grating of bricks of fireclay, 6 centimeters by 12 centimeters by 24 centimeters each, the area of the grating being 1 square meter. Ten such gratings placed one behind the other gave one nearly complete rotation of the plane of polarization. The difference of refractive indices was about 0.22, or larger than the difference between the ordinary and extraordinary rays in calcspar. The wave-length used was 68 centimeters, emitted by a Righi polarizer.—F. Braun, Physikalische Zeitschrift, April 15, 1904.

TRADE NOTES AND RECIPES.

Varnish for Wooden Ware.—A varnish for wooden ware which is said to withstand boiling water, is described as follows: Boil 24 parts linseed oil in a copper kettle, hanging a small linen bag containing 5 parts litharge and 3 parts minium (red lead) into the kettle in such a manner as not to touch the bottom. Boil until the oil takes on a deep brown color, take out the bag, and hang in another one containing a garlic bulb. The bulb is renewed seven or eight times during the boiling process. Then pour 16 parts amber, previously melted in a little linseed oil, into the kettle, and continue boiling three or four minutes. The lacquer is kept entirely in tightly-closed bottles, and may be mixed with any desired color before use.—Fundgrube.

Autographic Inks.—

	Pounds.
1. Tallow	58
Yellow wax	100
Grain soap	100
Shellac	16
Mastic	50
Pig's fat	16
Lampblack	50

The ingredients, with the omission of the lampblack, are fused together, set fire to, and allowed to burn for about two minutes. The lampblack is then stirred in. The ink is rubbed up with water, like India ink, and forms a kind of emulsion. It is written with on heavily-sized paper, from which the writing is transferred to the stone.

	Pounds.
2. Yellow wax	40
Gum lac	28
Mastic	10
Grain soap	22
Lampblack	9
3. Shellac	3
Soap	4
Wax	6
Tallow	2
Sandarac mucilage	6
Lampblack	6
4. Soap	10
Wax	10
Shellac	5
Mastic	5
Tallow	3
Lampblack	3

The process is the same with all these as with No. 1.—Neueste Erfindungen.

The Manufacture of India Ink.— The coloring element of all black dyestuffs is lampblack, which is produced through the slow burning of all combustible vegetable and animal substances under reduced admission of air. Vegetable oils, pine wood, the shell of pomegranates, rice, etc., are principally used by the Chinese for the production of lampblack. The famous India-ink maker, Li-Ting-Konei, who lived in the seventh and eighth centuries, employed the horn of the rhinoceros. The Chinese art of manufacturing India ink is more than two thousand years old. It is carried out as follows: In a porcelain dish filled with water, a number of small lamps are placed in a circle. Above each flame is suspended a hollow porcelain cone, inside of which the lampblack precipitates. The powder thus obtained is sifted through silk cloths, dried, and then kneaded together with very pure transparent glue. Formerly it was a glue made from the horn of the rhinoceros; now old white fish glue is used. Besides this, every maker of India ink claims to employ a third ingredient, which he professes to be his carefully-guarded shop secret, imparting to the product the gloss, hardness, and permanency. Whether or not there is any truth in these statements has remained an open question down to the present day. The main point is no doubt the extremely careful treatment which is bestowed upon the mixture of soot and glue solution. After a thorough kneading of the soot in the warm size, the mass is heated in a water-bath until a very intimate incorporation has taken place, and is then formed into balls. These balls are worked in a mortar with a heavy pestle until a doughy mass ensues, which is made into small bars and again heated a few minutes in the water-bath. Now each bar is worked with the hammer on an anvil. After two hundred beats it loses its dull color, and commences to become glossy. After four hundred beats it has received its full gloss, and after six hundred beats the mass has become as kneadable as bread-dough. Then thorough kneading is taken in hand, and after that the shaping of the well-known cakes of India ink, finally the decorating and drying. The latter is conducted by placing the ink in rice-straw ashes, and with the finest grades it takes two or three years. Then it has become so hard that two pieces tapped together will emit a metallic sound. The ink produced by the above-mentioned Li-Ting-Konei was so hard that, thrown in water, it would not leave a stain on the bottom of the vessel after several months. When the cakes have become sufficiently dry and hard (the hardness of the horn of the rhinoceros is the ideal of the Chinese ink-maker) they are still brushed vigorously, whereby they receive a glossy black appearance. The Chinese prescribe that the ink be ground with two or three drops of water in a porcelain dish in straight strokes; but to do it with a circular motion would be a grave mistake, they say.—Farben Zeitung.

ENGINEERING NOTES.

The cost of moving freight on railways is dependent to a large extent on the hauling power of the locomotives. English railways are handicapped in this respect by the limits of interspace, and the use of more powerful engines has not developed to the same extent as abroad, where conditions are more favorable. This is clearly shown in some figures published in a recent issue of the Iron Age. According to our contemporary, the average cost of moving freight in various countries is said to be as follows: Great Britain, $2.30 per 100 ton miles; Austria, $2.05; France, $2; Germany, $1.88; Russia, $1.75; and the United States, 72 cents. The London and North-Western Railway is one of the best operated of the English roads, and here the cost is placed at $1.49, the average train load being 72 tons. With an average train load of 387 tons, the New York Central Railway shows a cost of 41.5 cents, while the Pennsylvania Railroad, with 518 tons, operates at a cost of 40 cents.

Some years ago an important action was taken against the Glasgow Corporation which turned on the question whether clay was a mineral. In purchasing land for one of the reservoirs the usual reservation was made concerning minerals. A bed of fire-clay was found on adjoining land belonging to the same proprietor, and he insisted on his right to work it, although it was beneath the reservoir. The lawsuit was carried through all the Scottish courts until it was settled in the House of Lords. A corresponding case recently came before the Supreme Court of Pennsylvania. A railway company obtained a right of way, but all minerals in, under or upon the lands were reserved to the owners. A bed of sand or gravel might for years be considered as having little or no value except as ballast. But railways lead to the creation of towns and cities, and then the sand and gravel become most valuable material. A Pennsylvania land owner therefore brought action to prevent sand being treated otherwise than as a mineral which remained his property. In such a case judges generally give interpretations which might seem to favor future litigation. They did so in the Pennsylvania court. Sand was described as being sometimes a mineral and sometimes not. When it consisted of grains of silica, then it was a mineral; but if it were simply detritus and of a mixed nature, then it would only be considered as grains of rock. The court's definition of a mineral was, any inorganic substance found in nature having sufficient value when separated from its surroundings to be mined, quarried, or dug for its own sake or its own specific uses. Sand may or may not come under this head. A deposit of pure white quartz sand suitable for making glass or for some other use would be considered a mineral under this definition. But mixed sand, although useful for roads and many other purposes, could not be considered as being sand either in a scientific or commercial sense.—The Architect.

With the object of ascertaining the degree of immunity from the attacks of *Nausitoria*, commonly called *Teredo*, and other ship-worms, possessed by the well-known jarrah timber, of Western Australia (*Eucalyptus marginata*), a pile of 4 feet 3 inches circumference was sent by the government of that state to New South Wales, with a request that it should be subjected to a severe test. For the purpose of comparison, it was thought desirable to test the resisting qualities of the New South Wales turpentine (*Syncarpia laurifolia*) at the same time, so a pile 3 feet 6 inches in circumference was selected for the experiment. In August, 1897, both piles were driven, in about 10 feet of water, in the north harbor of Port Hunter, about two miles from the entrance. The range of tides at this spot is about 5½ feet at springs, and 3½ feet at neap tides, the water being quite salt, except when freshets occur; it is then more or less brackish for a few days, but never fresh sufficiently long to interfere with the health of the ship-worms. The greatest tidal velocity is from 1 to 1½ knots, and the velocity due to flood waters, possibly 2 knots. In February of 1904, or six and a half years after driving, the two piles were drawn, and sections cut between high and low-water marks. In the turpentine pile the ravages of the *Nausitoria* were confined almost entirely to about an inch of the sapwood, the remainder of the pile being as sound as on the day it was driven. The jarrah, on the contrary, was completely riddled between high and low-water marks, the tunnels of the worm having a longitudinal, transverse, or diagonal direction, quite irrespective of the hardness or grain of the timber. For some reason which is, at present, not quite clear, the northern side of the pile, or the side on which the ebb tide impinges, appears to have been preferred by the *Nausitoria*. Below low-water mark, both piles were practically sound, and beneath the ground-line they were in a perfect state of preservation. It cannot of course be claimed that this one test is conclusive, for unfortunately records do not appear to have been kept of the locality in which each tree was grown, the age of the tree, the time of year in which it was cut down, or the time that elapsed between the felling of the tree and the driving of the pile. Each of these items has an important bearing upon the life of a pile, and possibly upon its capability of resisting the attacks of ship-worms. It can, however, be said that the present experiment proves that the jarrah is not immune from the *Nausitoria* under all circumstances, but that the turpentine has here added another to the long list of proofs that it is impregnable under almost all conditions to attacks of ship-worms or marine borers.

SELECTED FORMULÆ.

Practical Receipts for the Making of Varnish.—

Bookbinders' Varnish. I.—To 10 kilogrammes of orange-colored shellac add 20 kilogrammes of light Manila copal, 1 kilogramme of oleine, and 45 kilogrammes of spirit.

Bookbinders' Varnish. II.—Take 25 kilogrammes of Manila copal, and to it add 5 kilogrammes light yellow shellac, 1 kilogramme oleine, and 45 kilogrammes of spirit.

Floor Varnish. I.—Take 20 kilogrammes of orange-colored shellac, with 10 kilogrammes pale Manila copal, 6 kilogrammes thick turpentine, 1 kilogramme castor oil, and 45 kilogrammes spirit.

Floor Varnish. II.—With 10 kilogrammes orange shellac mix 20 kilogrammes Manila copal (medium), 6 kilogrammes thick turpentine, 1 kilogramme castor oil, and 45 kilogrammes spirit.

Stock Varnish. I.—Take with 30 kilogrammes seed lac 3 kilogrammes thick turpentine and 45 kilogrammes of spirit.

Stock Varnish. II.—With 15 kilogrammes of seed lac mix 15 kilogrammes of Manila copal, 3 kilogrammes of thick turpentine, and 45 kilogrammes of spirit.

Varnish for Wicker Wagon Bodies. I.—12 kilogrammes bleached shellac, 18 kilogrammes light Manila copal, 12 kilogrammes thick turpentine, and 45 kilogrammes spirit.

Varnish for Wicker Wagon Bodies. II.—With 6 kilogrammes orange shellac take 24 kilogrammes of Manila copal (medium), 12 kilogrammes thick turpentine, 1 kilogramme of castor oil, and 45 kilogrammes of spirit.

Hamburg Varnish.—Mix with 60 kilogrammes of Manila copal, 20 kilogrammes of white resin (gallipot), 12 kilogrammes of thick turpentine, and 80 kilogrammes of spirit.—Farben Zeitung.

Paste Shoe Blacking.—From the many published formulas for shoe blacking we select the following, modifying several of them:

I.

Bone black	1¼	pounds
Molasses	1	pound
Olive oil	2	ounces
Vinegar	4	ounces
Water, enough.		

Rub the black, molasses and oil to a smooth paste, add the vinegar, and finally enough water to make a paste of the proper consistency.

II.

Dissolve casein in a solution of soda, add bone black and a little glucose and oil. The color may be improved by the addition of a small proportion of prussian blue.

III.

Tragacanth	1 ounce
Water	4 ounces

Make a mucilage and add

Neatsfoot oil	2 ounces
Bone black	2 ounces
Sugar	4 ounces

If too thin evaporate some of the water by a gentle heat.

IV.

Soap	120 parts
Potassium carbonate	60 parts
Beeswax	500 parts
Water	2,000 parts

Mix and boil together until a smooth, homogeneous paste is obtained, then add

Bone black	1,000 parts
Powdered sugar	150 parts
Powdered gum arabic	60 parts

Mix thoroughly, remove from the fire, and pour while still hot into boxes.

V.

White wax	18 parts
Spermaceti	6 parts
Spirit of turpentine	65 parts
Asphaltum varnish	5 parts
Powdered borax	1 part
Lampblack	5 parts

Melt the wax and add the borax, stirring well, and heating until the mass resembles jelly. In another vessel melt the spermaceti, add the varnish previously mixed with the turpentine, stir well and add to the wax. Finally add the lampblack previously rubbed smooth with a little of the mass.

VI.

Soft soap	4½	ounces
Linseed oil	6¾	ounces
Carnauba wax	1	ounce
Lampblack	1	ounce
Oil of turpentine	2	ounces
Water	3	ounces

Dissolve the soap in the water; melt the wax in the oil of turpentine, and then gradually stir in the soap solution and add the other ingredients.

Patent Leather Shoe Polish.

Yellow wax or ceresin	3 ounces
Spermaceti	1 ounce
Oil of turpentine	11 ounces
Asphaltum varnish	1 ounce
Borax	80 grains
Frankfort black	1 ounce
Prussian blue	150 grains

Melt the wax, add the borax and stir until an emulsion has been formed. In another pan melt the spermaceti; add the varnish, previously mixed with the turpentine; stir well and add to the wax; lastly, add the colors.—Drug. Circ. and Chem. Gaz.

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