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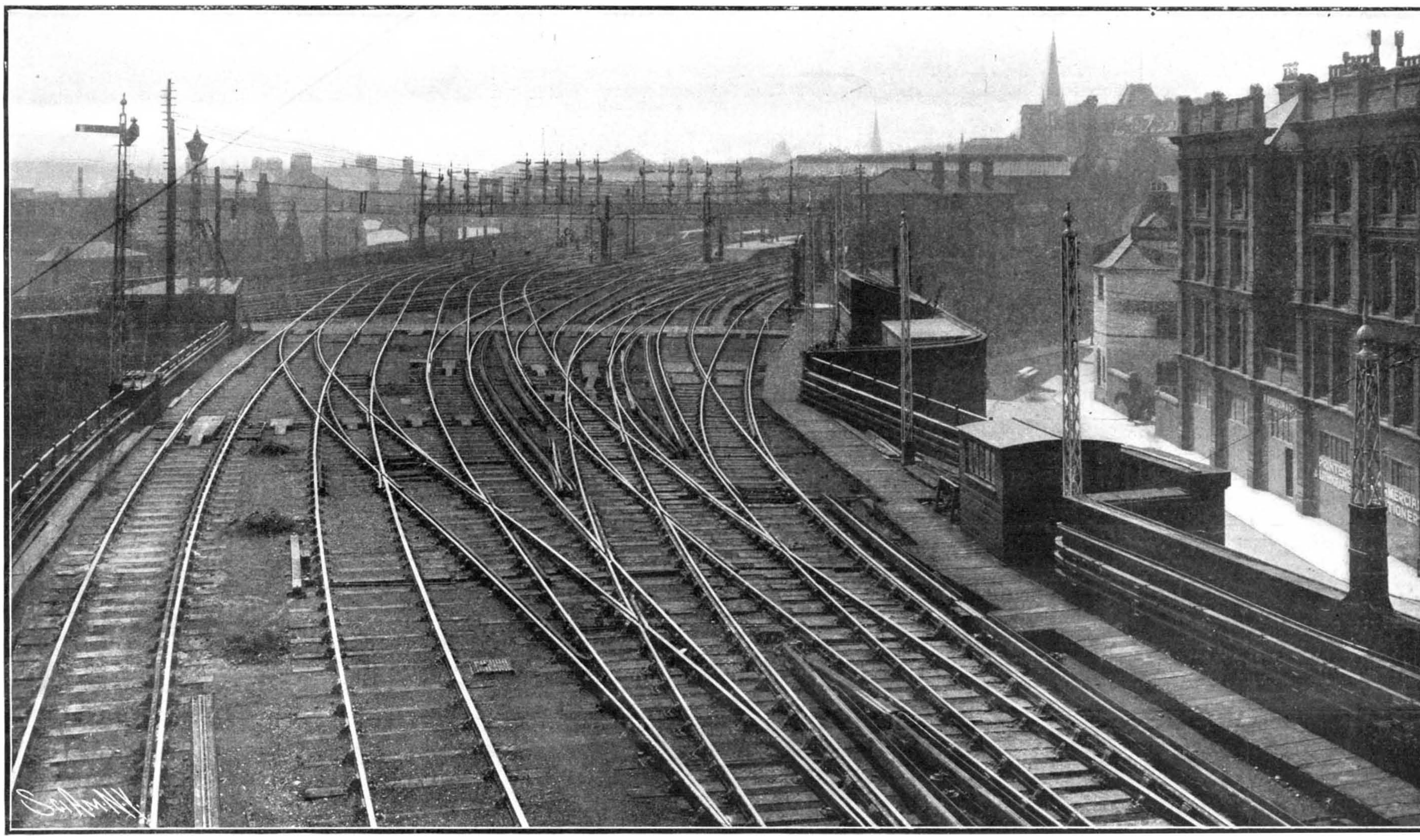


THE JUNCTION OUTSIDE THE NEWCASTLE TERMINUS.

GENERATING STATION WITH 7,000-HORSE-POWER PARSONS TURBO-ALTERNATORS.

THE ELECTRIFICATION OF THE NORTH-EASTERN RAILROAD OF GREAT BRITAIN.

ELECTRIFICATION OF THE NORTH-EASTERN RAILROAD OF GREAT BRITAIN.

By the English Correspondent of the SCIENTIFIC AMERICAN.

THE keen competition offered by the street surface electric railroads in the district of Tyneside, which is one of the greatest and busiest industrial and manufacturing centers of Great Britain, has proved seriously detrimental to the earning capacity of the Newcastle suburban traffic of the North-Eastern Railroad. In order therefore to retain this traffic, which constitutes an important factor in the revenue of the railroad, it became incumbent upon the authorities to introduce the same facilities that were already favoring the street railroads, such as frequent, rapid, and cheap services upon their local system. The only satisfactory solution of the problem was to convert the short-distance routes to electricity, and thereupon the most important suburban tracks were converted to this motive power.

For the purposes of practical experiment, some 37 miles of track were converted, and the electrification has only recently been completed. The scheme possesses great interest from both railroad and engineering points of view, for it is the first practical attempt to adapt electric traction in the substitution of steam upon a trunk railroad.

By this conversion the whole of the suburban passenger traffic on this section is now operated by electricity. The steam locomotives are now only employed for the haulage of the freight trains, except in the case of one short freight branch, with a radiant of 1 in 27, where an electric locomotive will deal with the traffic.

The project embraced the conversion of a route mileage of 37 miles single, double, and four-lined tracks, representing in the aggregate approximately 82 miles of single track. The main section of the scheme embraces a loop or circular route running from Newcastle through the manufacturing and industrial areas distributed alongside the river Tyne, to Wallsend, Tynemouth, Monkseaton, Gosforth—with a new branch extending from the latter point to Ponteland—and Newcastle. The street railroad runs practically parallel with the trunk railroad from Newcastle to the sea; and owing to the exceptional facilities, especially over short distances, afforded by the former, a serious decrease in the steam railroad's traffic has resulted.

The whole of the designs in connection with the electrification of this system have been carried out by Mr. Charles H. Merz, of Westminster. The scheme presented various complex problems. In the first place, the converted sections were not entirely given over to electrical operation, steam trains being still used over portion of the lines. There were also important junctions and crossovers, which had to be arranged for, more especially outside the central station at Newcastle, the intricate nature of which may be realized from the accompanying illustration.

The system adopted is the third-rail continuous-current system. The current generated is 6,000 volts three-phase, which is transmitted to the power house, where it is converted into continuous current at 600 volts.

THIRD RAIL.

The conductor or third rail is made of high-conductivity steel weighing 80 pounds to the yard and of Vignoles section. It is carried on reconstructed granite insulators supported on cast-iron pillars fixed to the wooden ties, and placed outside the gage line of the nearest running rail at a distance of 19¼ inches. In the case of double tracks, the separate conductor rails belonging to each track are for the most part laid between the two tracks. Wherever crossovers, level-crossings, or obstructions in the six-foot way occur, the third rail is placed outside of the track. The "live rail" is adequately protected wherever necessary, such as at stations, and so forth, where there is unavoidable foot traffic, by two creosoted boards bolted on either side of the rail against distant pieces. Otherwise, the conductor rail is left exposed.

A special type of feeder terminal and insulator had to be designed for this work. The feeder cable is run through the cast-iron pillar into a sealing chamber, which is filled with bitumen and a special insulating compound. There is a brass cap into which the end of the cable is sweated, and this fits on the top of the insulator. A terminal is bolted to this cap, and four bonds are sweated into this terminal, while their other ends are bonded into the conductor rail. By this arrangement disconnection can be quickly and easily accomplished when the exigency so demands.

Where the continuity of the conductor rail is compulsorily interrupted at cross-overs, switches, etc., tapering or nose pieces are employed, and the two sections are connected by underground cables. As it is also desirable that the continuity should be broken at approximately equal intervals throughout the track, so that in the event of an accident the current can be cut off from a section of the track, sectionalizing switches have been installed at the feeding points and at other convenient places. In this manner the live rail is divided into a series of sections of varying lengths. In the event of an accident, fault, or obstruction, the particular section of the track affected can be quickly isolated and rendered "dead" until the repair is effected. Another feature is that the up and down tracks can also be electrically separated at these points.

The return current is carried through the track rails, as this is considered to be the most economical method of fulfilling the official requisitions of the Board of Trade. Should, however, it be deemed necessary to install a fourth return current rail, sufficient space has been left between the track metals for this purpose.

In regard to the bonding of the track rails, it was found that the railroad company's standard tie (fish-plate) was not adaptable, as there was insufficient space between it and the web of the rail to enable protected bonds to be used. A new tie was therefore specially designed by Mr. Charles Harrison, the engineer to the railroad. This tie is made of mild steel, and constructed in such a manner that the bond is completely concealed and protected. The tie measures 21 inches long by 1½ inch thick, and weighs 19½ pounds. These are secured to the ends of the track rails by four ⅞-inch snap-head bolts. These new bonding ties were inserted in the track rails as the bonding proceeded.

The rail bond is an ingeniously-designed terminal embodying a new principle, the result of which is that perfect contact with the rail is assured. The terminal is expanded into the hole in the rail by a steel core, but by a new process. The core is in the form of a double-headed rivet, and in the course of manufacture it is cast in the terminal with the ends projecting about one-eighth of an inch beyond the copper on either side. The steel core is almost cylindrical between the flanges, but the shank, however, is slightly expanded in the center. In bonding, the terminal is inserted in the hole in the rail. Then, by means of hydraulic pressure of 20 tons per square inch, the steel core is upset by compressing it longitudinally, until the projecting end on either side is brought flush with the copper surrounding it. The result is that the copper terminal is forced with great pressure against the walls of the hole on every side by the expansion of the steel core. So perfect and permanent is the contact with the rail obtained in this manner, that it cannot possibly be deteriorated by electrolytic action or loosened by vibration under service. The heads of the core being hardened and the shank very soft in the center, expansion in inverse proportion results.

POWER HOUSE.

When the electrification was decided upon for the North-Eastern Railroad, the company resolved, after a careful investigation, that instead of erecting and installing a generating plant for their own exclusive necessities, they would draw it from the Newcastle Supply Company. Their reasons for this decision were manifold, but the paramount one was that they could purchase it more cheaply than they could generate it. In the first place, this company, which has extensive plant in the district, already supplies power to a multitude of manufacturing and industrial firms in Tyneside for a variety of purposes, and in view of its unique position would be able to cope with the variations in load much more easily and cheaply. Furthermore, the railroad company already draws considerably over 2,000 horse-power for lighting and various power purposes, at a cost of less than two cents per unit.

When this decision was made by the North-Eastern Railroad, the Supply Company found that its existing installation would require extending to cope with the fresh demands of the railroad company. A new generating station was thereupon designed at Carville, primarily for the supply of the requisite energy to the railroad, though it will also be available for other purposes to the extent of its maximum output. This generating station at Carville was also designed and equipped under the supervision of Mr. Charles H. Merz. The feature of the installation is that instead of ordinary reciprocating engines being used, Parsons steam turbines are employed. The generating station comprises engine house, switch house, boiler house, two economizer houses, and a pumping house. It has been designed upon carefully considered lines, so as to insure security of supply. The plant has been subdivided throughout, so that the extent of damage or breakdown may be reduced to the minimum. The most prominent features of the design are the adoption of a large size of generating unit; the utilization of water-tube boilers; and the adoption of electrically-operated cellular switch gear.

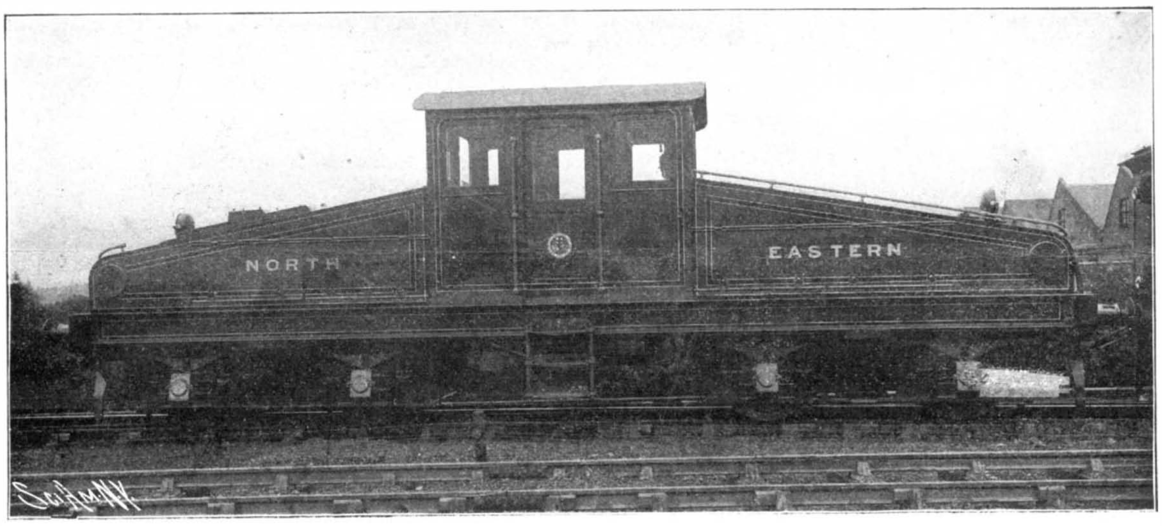
The engine house measures 148 feet 9 inches long by 65 feet 6 inches broad. There are four Parsons turbines, each developing 7,000 electrical horse-power, with a considerable margin for overload. These are the largest turbines of this type that have yet been placed in operation in Great Britain, and although they have not yet been tested with the full degree of superheat, trials with steam at 200 pounds pressure, superheated to 150 deg. F. and a vacuum of 95 per cent, have resulted in a steam consumption not exceeding 12 pounds per electrical horse-power at any load between 4,000 and 7,000 I. H. P. and 11 pounds at the most economical load, which is equivalent to 15 pounds of steam per kilowatt hour. Turbines of 7,000 horse-power have been installed, owing to the greater economy that can be effected by their use. With regard to these 7,000-horse-power turbines, their fuel economy is quite 15 per cent better than turbines of half the size. Another important advantage is in connection with the initial cost. Four units say of 6,000 horse-power involve much less capital outlay than six units of 3,000 horse-power.

One important feature of the station is that the plant is divided into a number of units, which may be operated independently. Owing to the small space occupied by the turbine as compared with the reciprocating engine, it has been found desirable to provide each turbine with a separate range of boilers running at right angles to the engine room. Each two ranges of boilers are combined in one centrally-fired boiler house, and are equipped with independent flues, economizers, forced draft fans, chimney, feed pumps, coal bunkers, and all auxiliary apparatus. The resultant advantage of this principle of design is that a very short and simple steam-pipe system is obtained, and the station plant is divided into a series of complete units, whereby a breakdown on any individual section only affects that particular unit, and not the whole installation, thus insuring a security of supply. Furthermore, if extensions ever become requisite, it is only necessary to duplicate the existing plant, without interfering in any way with the present installation.

The boiler house measures 115 feet by 64 feet and contains a battery of ten Babcock & Wilcox marine type water-tube boilers, each of 2,000-horse-power capacity. Each boiler has a heating surface of 4,600 square feet, while the heating surface of the attached superheater is 900 square feet. The normal steam output of the complete boiler plant is 200,000 pounds per hour, but the capacity can be increased if desired by fifty per cent. The steam is delivered to the turbines at 200 pounds per square inch pressure superheated 150 deg. Fahr. Induced draft fans are so fitted that the gas can be drawn through the economizers or diverted direct to the chimney as desired, a bypass being fitted for this purpose. Steel-plate flues carry the products of combustion into the brickwork flues surrounding the economizers. There are three induced draft fans, each of 75 inches diameter, which produce a vacuum of one inch at the flue side of each boiler's damper. Two of these fans serve to draw the combustion products when the economizers are in use, while the third operates in connection with the bypass flue to the chimney. Three feeds are installed, each of which can deliver 150,000 pounds of water per hour against the 200-pound boiler pressure. These pumps are driven by a special pipe system for saturated steam taken independently from two boilers in each section, though the pumps can be operated with superheated steam if desired.

The economizers, which are of the Green type, are accommodated in a building 80 feet long by 20 feet 9 inches wide. The temperature of the flue gases is reduced to 150 deg. Fahr., and the temperature of the feed-water supply is raised from 80 deg. to 212 deg. Fahr. On the banks of the river is situated the pump house, containing a battery of centrifugal pumps with a pumping capacity of 800,000 gallons of water per hour, through the condensers; also a 6-inch centrifugal pump for delivering the river water in tanks, a 2-inch centrifugal pump for driving the drain water into the hot well, and a three-throw pump with a delivery at 150 pounds pressure.

The switch gear has been ingeniously designed. In such a case as this, where the machines aggregating 20,000 horse-power may discharge their output into a fault or short-circuit, it is imperative that the switch



ELECTRIC FREIGHT LOCOMOTIVE.

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gear should be of such a character as to enable quick and easy disconnection of the faulty circuit without interfering with or handicapping the continuity of supply to the rest of the system. To insure this end, there must be ample clearance between the various parts, and a complete subdivision system adopted. At the Carville station this is effected by the separation of each 6,000-volt cable and individual switch, transformer, or other section of apparatus by substantial concrete partitions. The switchboard is mounted on a platform extending the entire length of the main power station, and consists of five galleries, each about 10 feet high. The bottom gallery is used for leading-in cables; on the second, which is level with the dynamo floor, are installed the instrument transformers, etc.; the third contains the main switches and the operation control board; while the fourth and fifth are reserved for the two sets of high-tension bus-bars built in special compartments.

The switchboards are made of enameled slate polished panels, each measuring 7 feet 6 inches in height and built in two pieces. The panels are assembled on vertical angle irons, and the equipment of each panel is self-contained. The board is divided into three distinct divisions. The first consists of eleven feeder panels for the North-Eastern Railroad and two panels for two banks of static transformers, each of 750 kilowatts capacity. The remaining two divisions are reserved for the control of the interconnecting feeders from the Neptune Bank power station of the company and the Newcastle Electric Supply Company respectively.

A voltmeter panel on swinging brackets is placed at either of the extreme ends of the switchboard. The switchboard panels carry only the low-tension apparatus, as all the high-tension switches are electrically operated, owing to their size, the small electric motors for which are controlled from a central control board. Oil switches are employed, the final break in the circuit being made under oil, and each is of sufficient capacity to open with safety a circuit through which the whole capacity of the station is flowing. A system of red and green signal lamps is installed to denote whether the switches for each panel are open or closed. There is a horizontal edgewise voltmeter and ammeter provided to each feeder panel, while a horizontal edgewise ammeter, voltmeter, power factor indicator, indicating and recording voltmeter, are fitted to each of the interconnecting panels of the Neptune Bank switchboard, and ammeter, voltmeter and recording voltmeter to the two transformer panels.

Small controlling switches and relays, automatically closing the controlling circuit in the case of overload or reverse current, serve to operate the high-tension switches from the panels. Each of the feeder, interconnecting, and transformer panels is also equipped with overload relays, with time limit attachments, and each of the generator panels is also complete with reverse current relays. Lightning arresters are placed in the gallery beneath the high-tension switches of the feeder panels, to guard against any abnormal rise in the voltage of the cables. These are connected to the three phases through isolating switches. Similar switches operated by a removable insulated handle are fitted close to each of the high-tension oil switches, so that the bus-bars may be quickly and easily removed for examination or cleaning while the bus-bars are alive.

The oil switches are of the oil-break type, which is of special design for heavy currents and high pressures. The three poles of the switch are composed of three elements. Two cylindrical vessels containing the oil and contacts form each single pole element. Each cylinder is mounted on a porcelain insulator, which together with the cylinders is attached to one sliding platform.

A U-shaped copper rod making and breaking contact in the oil acts as the connection between the two vessels, thus forming a single pole element. The switch is mounted in a brick compartment with soapstone top and bottom, adjacent poles being separated by a brick partition. A motor operates the switch through a worm gear, the transmission being through a friction clutch to a crank and crosshead. A single-pole double-throw hand-operated switch controls the motor. One throw opens and the other closes the oil switch, while there is also an automatic switch mounted on the base. By throwing the hand-operated switch the motor is started, and runs until the crank reaches a certain position, when the automatic switch opens the motor circuit and lights a lamp, thereby denoting to the engineer that the switch has operated.

The current transformers and potential transformers necessary for working the instruments and relays on the operating board or for synchronizing generator sets are situated in the switch gear building. Special iron pipes carry the secondary leads to the various instruments on the switchboard. Oil type potential transformers are used, and these together with the current transformers are so mounted that all danger of electric shock through accidental contact is avoided.

SUBSTATIONS.

The three-phase alternating current of 40 cycles per second at a pressure of 6,000 volts is transmitted to five substations, to be converted to direct current at the reduced pressure of 600 volts, at which potential it is supplied to the conductor rail. These stations have an aggregate capacity of 11,200 kilowatts. The largest substation contains four converter units of 800 kilowatts each; two others have three similar units, and two more are complete with two units each. The 6,000-volt feeder cables are provided with spark gaps, so that the cables can be relieved of any abnormal rise in the pressure. These are connected to the three phases by knife isolating switches, which enable any inspection to be carried out with safety while the feeder is alive but no current passing. Oil main feeder switches are used between the feeders, and the bus-bars are electrically operated from the low-tension board. Any of these switches is capable of breaking the maximum current of any substation. The high-tension switch gear and apparatus is placed on a fireproof wall, with each phase and circuit separated by a partition on one side of the station, while the low-tension board is on the opposite side. Heavy porcelain insulators tested to 20,000 alternating volts carry all live parts, and are carefully protected from accidental contact. The bus-bars are contained in fireproof chambers. There are two reverse current relays and solenoid in connection with the main feeder switches energizing the tripping coil and opening the oil switch in the event of the current reversing and supplying power to the high-tension feeders. The high-tension switch gear is controlled upon a nine-panel low-tension board divided into four feeder, four blank, and one load panels, and is complete with voltmeters, ammeters, controlling switches, indicators, and signal lamps. The electrically-operated oil switches interposed between the bus-bars and high-tension windings of the static transformers are fitted with time-limit over-load cut-outs, which operate in cases of over-load or breakdown. The time limit is in inverse ratio to the excess of current, so that if a dead short occurs, the break is instantaneous.

The high-tension current is stepped down from the 6,000 volts pressure in sets of three transformers in delta connection, and converted by three rotary converters. The high-tension switch gear for the converter sets is controlled from panels in a large direct-current board. Two panels for each converter set, one for the high-tension side of the transformers and the other for the direct-current side of the rotaries. Three transformers and one rotary constitute a unit, and all synchronizing is carried out on the high-tension side. The rotary is started by a small induction motor controlled by a knife switch on the high-tension panel. A direct-current moving coil ammeter, circuit breaker, knife switch, and rheostat face field plate for the rotary field are mounted on the direct-current panel, while an equalizer switch acting in conjunction therewith is mounted on a pedestal near the rotary. There is also a panel for the transformers supplying the induction motor that starts the rotaries. The total power supplied to the traction feeders is measured on the load panel together with recording instruments, while there are six panels for the control of the same number of 600-volt feeders, each of which is fitted with a moving coil, ammeter, circuit-breaker, and knife switch. A third switchboard contains Board of Trade, battery, and lighting panels. A large earth plate is sunk at each end of the substation, connected by a copper bar measuring 1½ inches by 3-16 inch, to which are connected the frames of machines, high-tension switches, transformer cases, etc.

The main transformers are of the Westinghouse type, each of 280 kilowatt 6,000-360 volts, 40 periods. They are oil-insulated and self-cooling, the corrugated iron cases offering a sufficient cooling surface to disperse the heat produced even at heavy over-loads. Spread coil windings are used, the ends being bent apart to expose a large area to the oil circulating round the coils, and conducting the heat away, while the oil also acts as a valuable and efficient insulator. Special precautionary measures are provided, to obviate any siphoning of the oil through the leads. Owing to the transformers being operated with rotary converters, there is a considerable reactance drop, adequate provision for which has been arranged. The rotary converters are each of 800-kilowatt capacity, and convert the 360-volt alternating current to 600 direct. Each rotary is a self-contained unit with the two bearings, lower half of the frame, and starting motor being mounted on one base plate. The field frame is horizontally divided. The armature is of the slotted drum type. The cores are built up of steel laminations of the highest magnetic quality, dovetailed accurately to the spider, and held securely between two end plates. The commutator is composed of bars of hard-drawn copper insulated with mica, which insures an equal wear of copper and insulation. The field frame carries the rocker brush, with strong and rigid arms carrying the brush holders. The carbon brushes are supported in simple and suitable holders. The field frame is composed of cast iron with laminated steel poles cast in. Massive copper dampers of the grid pattern are carried on the pole faces, which are slotted for the purpose. With these dampers any tendency of the magnetic field to move across the pole face is retarded. The rotaries are so designed as to have sufficient dampening effect to steady themselves, while at the same time a steadying effect is exercised upon the other apparatus in the system. The fields are compound-wound, with the shunt coils placed next to the pole tip. The shunt winding is of sufficient capacity to maintain 600 volts at the direct-current terminals at full load with a power factor 100 per cent at the alternating-current end. At no load the shunt field is adjusted for 550 volts, the armature taking a lagging current from the system. As the loads come on, the series field adds to the shunt, and compounds the rotary from 550 volts no load to 600 volts full load. Open ventilating channels are arranged throughout the armature spider core, and windings, and the spider is so designed that a forced air circulation is set up through these channels. When running at full-speed load, the temperature does not exceed 35 deg. Cent., while at 50 per cent over-load after three hours' run the temperature is not above 60 deg. Cent. A small Westinghouse polyphase induction motor starts the rotary converters. This motor runs the armature up to speed before the three-phase current is cut in. There are separate step-down transformers for the supply of these starting motors, which also serve to supply the lighting circuit. The combined efficiencies of the transformers and converters range from 91.90 per cent for half load to 98.94 for one and a half load.

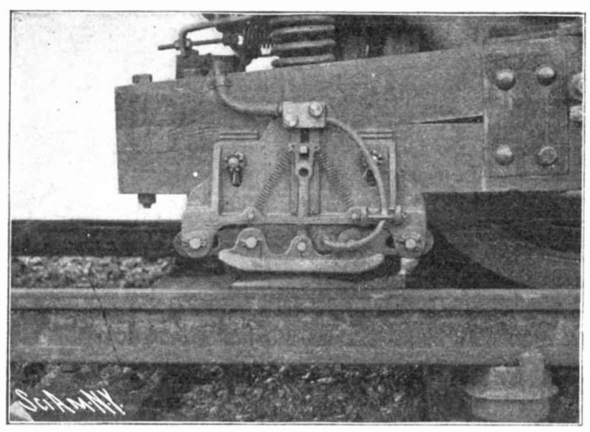
ELECTRIC TRAINS.

The electric trains consist of motor and trailing coaches of the ordinary open corridor type, mounted on two four-wheeled bogie trucks.

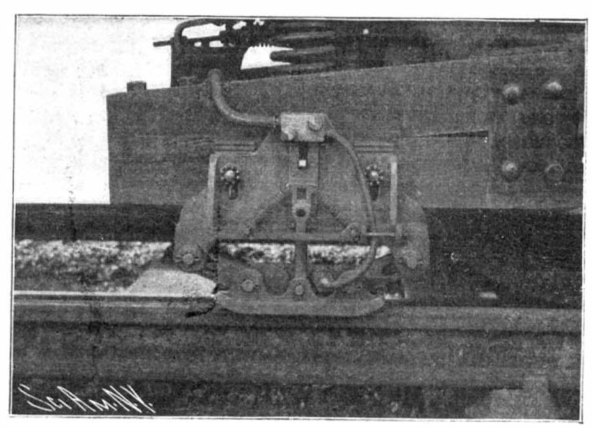
Each carriage is 55 feet in length, and has accommodation for 68 passengers in the motor coach, and 70 in the trailer coach. The motor and trailer bogie trucks, which are made of pressed steel with steel side frames, bolsters, cross-bars and end-bars, have a 7-foot wheel base. On each side of the motor truck there is an oak beam carrying a collector shoe. The beam is fixed to brackets cast on the ends of the journal boxes at the requisite height and distance from the track rail. Each shoe is protected by a magnetic blow-out ribbon fuse. Each motor coach is equipped with two G. E. 66 motors, each rated at 150 horse-power and weighing about 4,000 pounds. The trains are divided into units of two trailing and one motor coach. By this arrangement a train can be composed of an additional one or more units, each complete in itself. A driver's compartment is placed at one end of the motor coach, but a few of the coaches have a master controller placed in the vestibule at the other end also, so that the coach can be driven from either end.

The Sprague Thomson-Houston multiple-unit system is employed. Each motor coach carries beneath it a series of electrically-operated switches or contactors, which make the necessary connections with the motors, and for cutting in and out the resistances step by step. The contactors are actuated by current drawn from a nine-wire multiple cable running from end to end of the motor coach, and fitted with suitable coupling devices at either end. There is also a multiple cable with couplings fitted to the trailer coaches. The advantage of this system is that when the train is made up, no matter with how many coaches, there is a continuous nine-wire cable extending from one end of the train to the other; and by admitting the current into any wire of this cable, the corresponding contactors on all of the motor coaches are simultaneously actuated, and thereby the necessary combinations of motors and resistances are made simultaneously on either end of the motor coaches throughout the train. The master controller, which introduces the current into this nine-wire cable as desired by the engineer, can be placed at any convenient point. The master controller is similar to that fitted to street surface railroad cars, only it is of considerably smaller dimensions.

One notable feature of the control equipment on these motor coaches is the automatic accelerator, which enables the rate of acceleration to be maintained con-



SHOE ON MOTOR COACH RAISED FROM THE THIRD RAIL.



SHOE ON MOTOR COACH LOWERED ONTO THIRD RAIL.

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stant until the full multiple position of the controller is attained. The *modus operandi* is simplicity itself, the engineer having only to throw his power handle to full series or full multiple position, as desired, and to hold it at that point until he wishes to shut off the current. By turning the power handle forward, a spring is wound up which drives the control cylinder forward at a uniform rate. This cylinder, however, is checked in its action, so as not to move too quickly, by means of a special device, and the rate of current input is regulated by a current relay in series with the motor circuit. This closes a local circuit, and locks the master controller cylinder against movement until the accelerating current has fallen sufficiently to release the master control cylinder for the next notch. By this arrangement the same effect is obtained as if the motorman were advancing a manual accelerator notch by notch. The automatic device only comes into action when the rate at which the operating handle is turned would allow more than the requisite amount of current to pass motors if it were not limited. This automatic acceleration is immediately under the command of the motorman driving the train, the whole of which is synchronously controlled from the front car. The controllers are also provided with the "dead man's handle," the current being automatically shut off and the brakes applied immediately the driver removes his hand from the operating handle. Perfect safety is thus assured in the event of the engineer becoming suddenly incapacitated. The control operating current at 550 volts potential is approximately 2.5 amperes per car for an equipment of 200 horse-power motors. The current is collected from the conductor rail on each motor coach by four contact shoes. The whole of these shoes of each train are connected together. Thus there is no possibility of the train losing its supply of current when passing over switches and cross-overs, where the continuity of the live rail is perforcedly interrupted.

The present rolling stock equipment comprises 58 motor and 122 trailer coaches. The brakes fitted to the trains are of the automatic Westinghouse type, each motor coach carrying an electrically-driven air compressor.

The ordinary stopping trains will occupy about 23 minutes to complete the journey from Newcastle to Tynemouth, representing an average speed including stops of 22 miles per hour. The express trains, however, with no intermediate stoppages, will cover this journey in 15 minutes.

One of the very necessary precautions that has to be observed in the design of such a system as this, is that against fire, such as might result from the development of a fault. The importance of this problem will be realized when it is remembered that should a short circuit occur, the whole of the 10,000 or 20,000 horse-power of the generating station tends to maintain an arc until one of the safety devices comes into action, and materials which under ordinary circumstances are incombustible, burn readily. In this installation great care has been observed to keep the collecting shoes and connections to the main switch on each motor coach, the main wiring of the motor coach, to the motors and resistances, and the control, lighting, and air-compressor circuits, entirely separate and independent of each other, so that there is a complete avoidance of crossing of leads. The wiring of the motors from the contactors, and the control, lighting, and air-compressor circuits, are run in grooved fireproof insulated casing, with adequate clearance between wires, but the connection from the collector shoes, which carry very heavy currents to the main switch, and which are not directly under the control of the engineer, are run in solid-drawn steel pipes ⅛ inch thick and effectively earthed. All the wires and cables are inclosed in a fireproof coating, while the under side of the coach body is protected by a layer of sheet steel backed by a thickness of uralite.

As already mentioned, it is intended to operate the freight as well as the passenger traffic by electric traction, and experiments in this connection are being carried out on the Quayside branch of the system. The conversion of this ramification to electricity will be of inestimable value, owing to the difficulties of tunnel ventilation. For this traffic heavy electric locomotives are being used. They are equipped in the same way as the motor coaches with multiple-unit controller, motors, etc. By this means it will be possible for the haulage of abnormally heavy trains, to attach two electric locomotives together, and drive the train from one of them. Furthermore, the locomotives are adapted for both third-rail and overhead trolley systems. Each locomotive is capable of starting with, and hauling, a train weighing 150 tons up a gradient of 1 in 27 at a speed of from 9 to 10 miles per hour, or a train of 300 tons along the level at a speed of 14 miles an hour. The performance of these electric freight locomotives is being followed very closely by railroad engineers generally in England, as they are the largest and heaviest of their type yet used, and their successful application will solve a difficult problem in freight haulage.

PUMPING TAR AND OTHER HEAVY LIQUIDS.

IN many industries it is necessary to force heavy, viscous liquids through pipes. This involves difficulties not encountered in ordinary pumping, and requires machinery special in design and construction. When the liquid is heavy but not adhesive, as in the case of heavy oils, the action can be made fairly satisfactory and efficient by enlarging the valve openings, making the parts of the pump heavier, and so arranging the passages of the pump that there is little liability of choking or clogging. When, however, the liquid is at high temperatures and a gelatinous adhesive paste or a rubbery solid, clinging to all surfaces and choking openings through which it should pass, as the temperature is lowered, a design differing materially from the ordinary pump must be used.

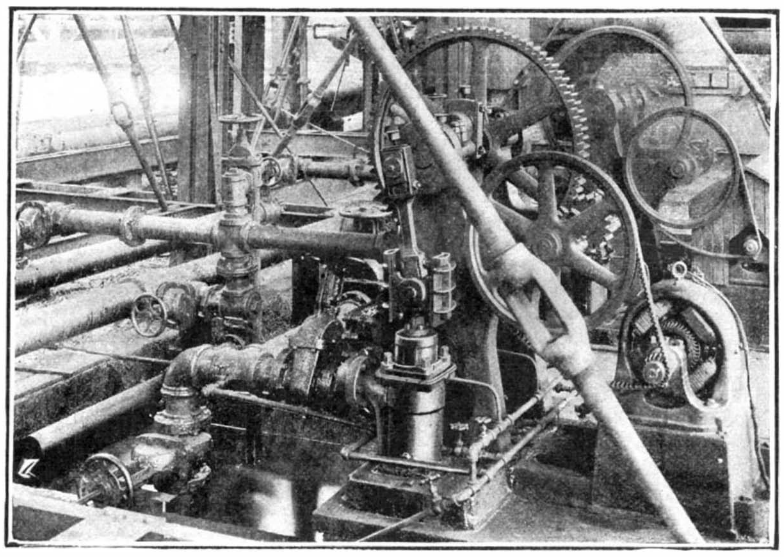


FIG. 1.—TWO GAS-TAR PUMPS.

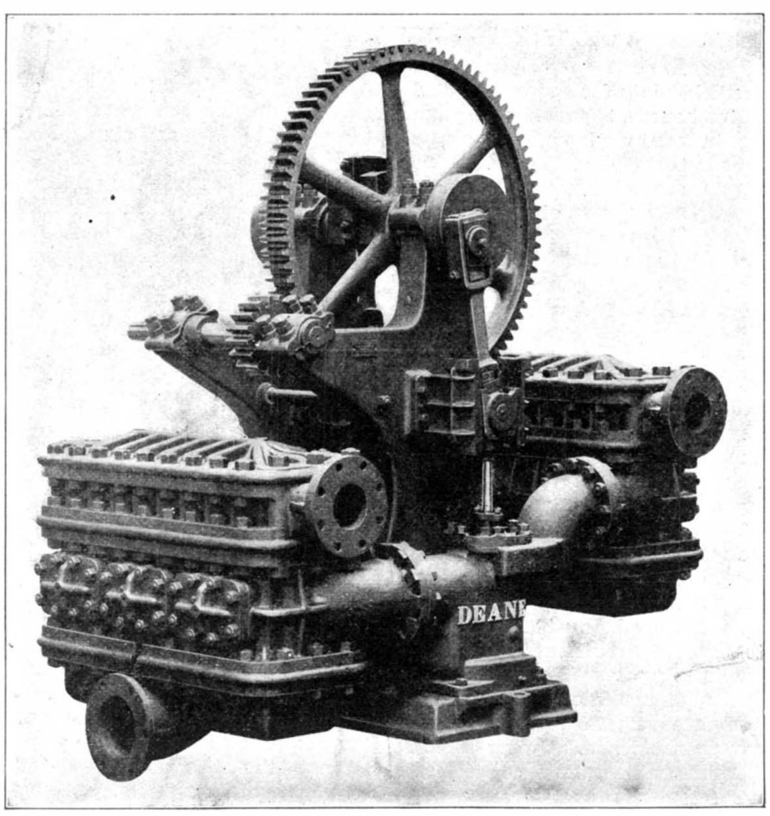


FIG. 2.—A PUMP FOR HANDLING OIL-REFINERY TAR.

Tar, molasses, and cocoa liquor present more obstacles to pumping than any other substances which it has been found feasible to move in this manner. Each of these liquids thickens into an almost solid mass when cold, rendering it very difficult to start the pump, if some special provision is not made and ample power provided. Another action which must be taken into account is the contraction of the area of the passages and valves as the liquid cools, and the consequent throttling, which interferes with the liquid's passage and which the pump is forced to overcome. The skin friction of a liquid of this kind creates heat enough partially to alleviate this tendency to throttling when the velocity of the substance is maintained above a certain point and the pipe is not in such a position that the surrounding air will lower the temperature of the liquid below the solidifying point. Although not a common practice, it is well to lag all exposed piping used for conveying heavy oils or other substances of a similar nature.

Gas tar has a number of characteristics rendering it exceptionally difficult to pump. Its condition varies from a solid to a penetrating fluid within a small range of temperature. Two pumps which have proved very efficient in lifting and forcing gas tar were installed a short time ago at the plant of the Maryland Steel Company, of Sparrows Point, Md. Fig. 1 shows the pumps in position, the one in the foreground being idle, and the one in the background working under its normal load. They were built by the Deane Steam Pump Company, of Holyoke, Mass., and are of the standard triplex type of that company, fitted with ball valves peculiarly adapted to this service. The exclusive use of gate valves in the piping system is also interesting. A very flexible power connection is obtained by the use of the Renolds silent chain and a four-pole alternating-current 3-horse-power motor. The gearing consists of an 18-tooth pinion running at 950 R. P. M. and a 120-tooth wheel running at 142 R. P. M. The chain used has links ¾ inch wide and 1½ inches long. It transmits the 3 horse-power generated at 950 feet per minute, giving an excellent efficiency when the service is considered.

A liquid peculiarly difficult to handle is oil-refinery tar, which is usually very hot when it reaches the pump. There is a large percentage of suspended particles of various sizes present in this tar, and also a certain amount of unrefined paraffin. The tar is sometimes heated to a temperature of 300 degrees, but quickly cools off if not properly handled, and coats the retaining valves and walls with layers of an adhesive substance closely resembling finely-divided particles of coke. To overcome the difficulties, the ordinary pump arrangement and design is materially changed.

Fig. 2 shows a specially designed pump installed by the Deane Company for handling oil-refinery tar at the works of the Atlantic Refining Company in Philadelphia. By a new arrangement, exceptionally large valve areas are made available, the valves being designed to permit the passage of the substance pumped with the least possible frictional resistance. The suction, discharge, and pulsation chambers can be taken apart without unnecessary expenditure of time or labor, and each is in a position where it can be readily reached for cleaning. The pump is of the triplex type, as shown in the figure, and is fitted with ball valves, which thorough test has proved best adapted for the passage of heavy substances. There are a number of large handholes for cleaning the valves. The figure shows the rigid crosshead guide system and the strong design of the chambers, rods, pistons, and bearings.

GAS TURBINES.

THE success which has been achieved in developing the steam turbine has given a fresh impetus to the investigation of the problem of devising a practical prime mover of similar type, with hot air or other gases as the driving force. The problem is not a new one; it had long been present to the minds of engineers, but had been put aside for the moment in favor

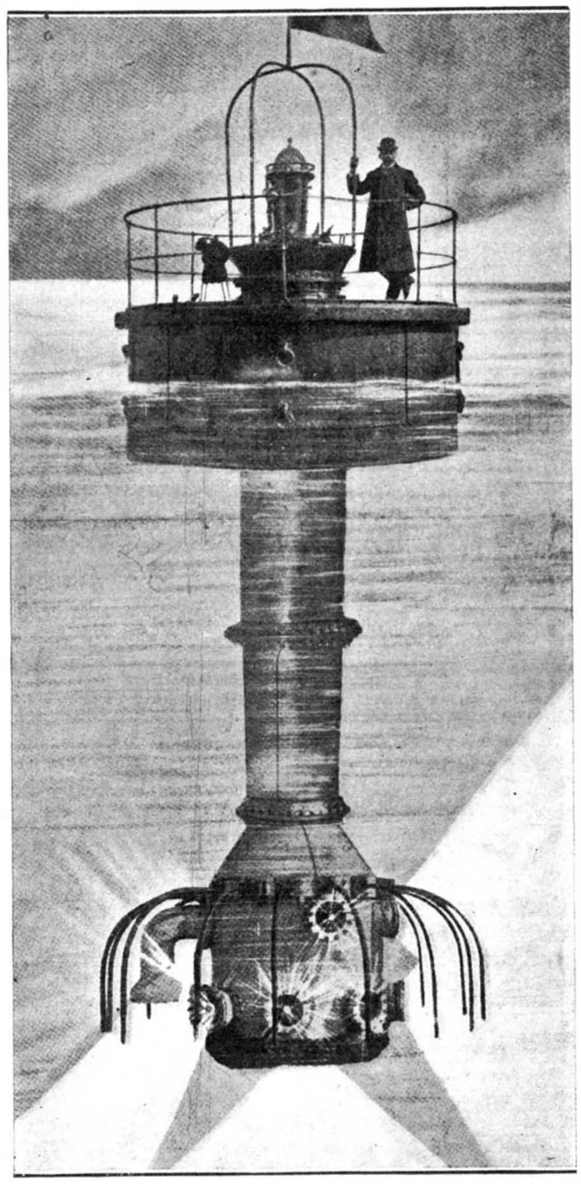
of others, which offered greater chance of commercial success, even if their solution should not lead to an engine of so high an efficiency as may be anticipated in the case of the gas turbine. To-day, however, the situation is somewhat altered, as the new experience gained from the steam turbine has placed us in a better position to cope with the difficulties which face us in attacking the old problem; and he would be a bold man who would say that these difficulties are too great to be overcome.

The first step of progress is made when we have separated out the different obstacles in the way, and have realized the precise nature of each and the direction from which it should be attacked; and that we are now in this position will be gathered from a study of the interesting paper communicated by Mr. R. M. Neilson to the Institution of Mechanical Engineers. The exact position of the problem to-day will be understood from the fact that Mr. Neilson, in discussing the possibilities of gas turbines and the different plans on which they may be devised, does not at any point refer to an actual engine of one or other of his types, which has done anything of practical importance. No doubt, if he had so chosen, he could have hunted out from the records of the British Patent Office, various specifications of inventions on this subject; but a patent is one thing, and a successful engine is another, and for the present we must confess that there is no immediate prospect of seeing a practical gas turbine on the market. In the end, however, it will come, and its coming will be hastened or deferred according as our engineers are able and willing to spend time and money on investigations of such practical problems as those mentioned by Mr. Neilson.

The theory of the different cycles on which the gas turbine might be worked is, as Mr. Neilson's paper shows, quite clear and fairly simple; but at several points we are brought almost to a standstill from want of experimental data by which to test the validity and practicability of our theoretical conclusions. Mr. Neilson places in the forefront in this respect the question of the losses in pneumatic compression to high pressures (a) with reciprocating compressors; (b) with rotary compressors; (c) with combination of the two types. The importance, for our purpose, of an investigation to give this information, is readily seen. In the ordinary reciprocating gas-engine, the gas is drawn into the cylinder, then compressed by the engine itself, and then exploded, thereby driving the engine. But in the type we are considering the compression cannot take place in the driving turbine, and a compressor must, therefore, be used, supplying compressed gas to a combustion chamber, from which after combustion it passes to the turbine. Now it would obviously be a great advantage to be able to use a rotary compressor, mounted on the same shaft as the turbine, as we should thus dispense altogether with reciprocating mechanism and be free also from many of the objections to which reciprocating compressors are subject—such as the heating of the gas by contact with the hot metal surfaces before compression commences, and the necessity to jacket the cylinder if high pressures are to be obtained. But at present we do not know enough about rotary compressors on the turbine principle to estimate their efficiency when high pressures are to be employed. Mr. Neilson points out that these engines seem as yet to have been employed only up to about 80 pounds pressure, and "whether or not they are suitable for high pressures is a point which we want very badly to know about." Mr. Meineke, in his paper "On a Process for Operating Gas Turbines," suggested that the compression should be obtained from a turbine mounted on the same shaft as the motor turbine, and it is said that "it should not be difficult to obtain very high pressure differences by inverting the process that takes place in a turbine." That may be true, but it rather misses the point; for it is not so much the mere compression to high pressure that we are concerned with, as the efficiency of the engine which does it. If the losses in this pump are very great at high pressures, then the practical success of the turbine is at once challenged, as the available power of the engine, after supplying the compressor, may be very small or nothing at all. The importance of this "negative work" in the compressor must be kept in mind, and it is very desirable that we should have experimental data on the losses incurred with the different types indicated by Mr. Neilson, when used for high pressures.

The second point which Mr. Neilson marks out for investigation is the expansion of hot gases in divergent nozzles. The importance of this investigation appears in connection with the admission of the products of combustion of gas-fuel and air into the buckets of the turbine. After combustion the temperature of the gases will be very high, and if they are to be admitted at once to the turbine it will be necessary to have the blades cooled by circulation of water or otherwise. This is in many respects undesirable, and it has therefore been proposed to lower the temperature of the gases before admission to the buckets by letting them expand in a divergent nozzle till a degree of temperature is reached which the buckets can stand. By this means the heat energy of the gases is converted into kinetic energy, but of course there will be losses by friction in the nozzle and by radiation. Experiments, then, are wanted to give accurate information on the expansion of hot gases in such nozzles, and part of the investigation must be to find the effect of the pressure of the medium into which the gases expand upon the velocity of the gas in the nozzle. We have here to deal with very high velocities; and it has been stated, as Mr. Neilson observes, that if the chamber into which the gases expand be at, say, atmospheric pressure, there is a limiting velocity for the issuing gas, which cannot be increased no matter how much the pressure of the gas on entering the nozzle be increased, and that this maximum velocity becomes greater as the outside pressure is reduced. It is of importance to have experiments made on this point, as from them we could determine whether the efficiency of the turbine could be increased by decreasing the pressure in the motor chamber below that of the atmosphere; and we have also to find out whether such high velocities as 4,000 feet per second, given by Mr. Neilson, can be obtained from gases issuing from divergent nozzles into a medium at atmospheric pressure. Here again, therefore, there is good scope for research work, with a view to the development of the gas turbine.

The third and last point indicated by Mr. Neilson for investigation is the determination of the losses from radiation and transference of heat from gases to metals at high temperatures. The importance of this is obvious when we remember that we have to deal with gases at high temperatures which remain practically the whole time during which they are in the turbine chamber in contact with metal surfaces, so that there must be considerable heat losses, and consequently loss of efficiency.



VIEW SHOWING THE HYDROSCOPE IN THE WATER.

At the bottom are the lenses arranged round the steel tube. Steel protecting arms keep the lenses from damage by collision with rocks or spars. Generally the hydroscope will be used in the daytime when the ordinary sunlight gives plenty of illumination.

When we have full information on these three points we shall have made a great advance toward a solution of the whole problem of the gas turbine, but there will still remain many matters requiring very careful consideration and investigation. A careful perusal of Mr. Neilson's paper will indicate some of these matters to the reader. The point we would emphasize, however, is that, although the practical difficulties at present seem great, none of them is of such character as to lead us to believe it to be insuperable. Rather do we gain the conviction that in time they will all be solved, and a practical gas-turbine evolved. Mr. Rankin Kennedy, in his work on "Modern Engines and Power Generators," has expressed much the same opinion when he says (vol. ii., p. 42):

"It is at present not the case that we do not know how to begin to make a combustion turbine for oil or gas; the difficulty is the great amount of time and expense required to bring the details to perfection—an operation which can be effected only by actual experiments on a considerable scale of magnitude."

Later, in the same volume, he says (p. 107):

"The stage has been reached where the enterprising capitalist is necessary to carry it to the commercial success which undoubtedly awaits the first successful turbine set to industrial work. It will be interesting to observe in the future whether the home or foreign engineers take up the subject first."

From some other remarks of Mr. Rankin Kennedy we think he rather underestimates the practical difficulties still in the way; but in the main he is right that capital and time will bring the solution, and we sincerely hope that our engineers will not be behind those of other countries in spending both time and money on this problem.—Engineering Review.

THE PINO HYDROSCOPE.

A very clever instrument has been devised by an Italian inventor, Cavaliere Giuseppe Pino, by which the bottom of the sea can be examined with a clearness and ease which has hitherto been difficult.

The hydroscope—such is the name given to the instrument for seeing objects in the sea or on the sea-bottom—is constructed of steel and in shape is like a huge telescope pointed downward into coral caverns or sunken ships instead of unward at the sun or the stars. Its complex system of lenses, twelve in number, answers to the objective glass of a celestial telescope. Together with the internal mirrors they produce a very clear picture of the sea-bottom, the rays of light passing up the tube to a sort of camera-obscura house at the top which floats above the surface and is capable of holding four people.

The amount of light under the surface is considerably greater than is generally imagined. The inventor of the hydroscope has himself been able to read a newspaper lying on the sea-bottom at a depth of 360 feet from the surface by the ordinary daylight penetrating the water. The area viewed by the lenses at the bottom of the tube varies according to the amount of light. The water at the bottom of the sea is very often clearer than at the surface, as the sediment is capable of sinking in the still water, whereas at the surface sand and other matter is kept in solution by the constant movement of the waves, the force of which is not felt a very few feet beneath the surface. This is peculiarly the case in the water surrounding the British coast.

The hydroscope is also likely to prove of very considerable use on war vessels. A tube can be fitted into the center of a vessel, one end of which will lead to the captain's bridge and the other will penetrate the bottom of the vessel and will have an extension portion which will be capable of being thrust out and drawn back as occasion requires. When the hydroscope lenses, which will be somewhat different to the apparatus illustrated here, are drawn up flush with the bottom of the vessel the water beneath the ship can be viewed to a distance of 60 to 90 feet. A private official trial of the hydroscope was made by the Italian government a few months ago in Portofino Harbor, where it proved very satisfactory.

One of the most romantic things yet accomplished by the hydroscope and the raising apparatus has been the bringing to the surface of an old Spanish galleon, one of a numerous fleet sunk in the Bay of Vigo in 1702 and recently brought to the surface by the aid of Pino's invention. Unfortunately during the night the old hulk proved to have so rotted away that it rolled over, broke in pieces, and again sank to the bottom. The metal bolts which held the timbers together had evidently rusted almost completely away. In addition to this attempt on the old galleon some successful experiments were made with raising heavy boilers which had been sunk in the sea for ten years.

CONTEMPORARY ELECTRICAL SCIENCE.*

Alternate-current Electrolysis.—A. Brochet and J. Petit have studied the solubility of various metals in a 4-gramme molecule solution of cyanide of potassium under the influence of alternate currents of various frequencies. They found that the popular impression of a uniform decrease of solubility with increase of frequency is incorrect. Platinum shows, in fact, a uniform though slight increase. Copper shows a well-marked and uniform decrease, whereas the metals of the iron group show a decided maximum at a frequency of 12 to 30 periods per second. The solution of lead in sulphuric acid shows a maximum at about 15 periods per second, and after that a slight decrease. The current density used was 20 amperes per square decimeter.—Brochet and Petit, Comptes Rendus, June 6, 1904.

Cathode Rays.—P. Villard has made some interesting observations with regard to those cathode rays which follow the lines of magnetic force. Broca and Pellat have shown that there exists a species of cathode rays which, if placed in a strong magnetic field, trace out the magnetic lines of force. Villard has photographed both kinds of cathode rays with one exposure, using oxygen as the gas, and obtained the ordinary cathode rays in the form of a screw about the magnetic lines of force, and the other rays, which he proposes to call the magneto-cathode rays, following the magnetic lines of force. He finds that they originate at a lower difference of potential than the ordinary rays. Their appearance is accompanied by a fall of potential at the electrodes, and a weakening or even an entire suppression of the ordinary cathode rays. For the magneto-cathode rays the field is not only directive, but also motive. If the discharge from the cathode is hindered by placing a small aperture in front of it, a discharge may be forced through the aperture by increasing the strength of the magnetic field. The author proves that the magneto-cathode rays have no electric charge. On repeating Perrin's experiment, in which the shadow of a wire exposed to cathode rays is enlarged on charging the wire negatively, no effect is produced. He describes an experiment based on Faraday's ice-pail experiment, in which either ordinary cathode rays or

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

magneto-cathode rays may be made to enter the inclosure. The former instantly produce a deflection of the electrometer corresponding to several hundred volts, while the latter produce no effect. The magneto-cathode rays are indeed deflected by an electric field, but in a direction perpendicular to the lines of force. There is, in fact, a perfect antithesis between the two kinds of cathode rays. The electric field acts upon one kind as the magnetic field acts upon the other, and *vice versa*. "I believe this is," says the author, "the first time that a Laplacian action of electric force has been realized."—P. Villard, Comptes Rendus, June 6, 1904.

THE CONSTITUTION OF PORTLAND CEMENT FROM A PHYSICO-CHEMICAL STANDPOINT.*

By CLIFFORD RICHARDSON.

THE determination by Le Chatelier and Törnebohm, with the aid of the microscope and petrographic methods, of the optical characteristics of the mineralogical entities which constitute a Portland cement clinker, the work of Le Chatelier and of the Newberrys in preparing synthetically the silicates and aluminates which might possibly exist in the clinker and of the Newberrys in the preparation of clinker in molecular proportions from pure chemicals, are noteworthy efforts, and their results, confirmed in several instances by others, are of great value.

For the study of clinker by microscopic methods it is necessary to prepare sections which shall be so thin as to be transparent. This is readily done by grinding down a suitable fragment on one side until it is flat, polishing this, then mounting it with balsam on a piece of glass and grinding down the other side of the fragment until a thickness is reached which permits the transmission of light. The section thus prepared is mounted under a cover glass and is ready for observation.

It is a peculiarity of minerals of crystalline structure that they vary in their optical properties according to the system in which they crystallize and especially in regard to their behavior toward polarized light. It will be impossible here to go in detail into an explanation of the phenomenon, but it is sufficient to say that different minerals can be differentiated and recognized by their greater or smaller optical activity. The methods are the same as those which are used by geologists and petrographers in the study of our crystalline rocks.

By this method of study Le Chatelier and, at the same time independently of him, Törnebohm identified in Portland cement clinker four distinct mineral constituents which Törnebohm described as follows, naming them Alit, Belit, Celit, and Felit.

Alit is the preponderating element and consists of colorless crystals of rather strong refractive power, but of weak double refraction. By this he means that alit in polarized light between crossed Nicol prisms has insufficient optical activity to produce more than weak bluish gray interference colors.

Celit is recognized by its deep color, brownish orange. It fills the interstices between the other constituents, being the magma or liquid of lowest freezing point out which the alit is separated. It is strongly double refractive, that is to say, gives brilliant colors when examined between crossed Nicol prisms.

Belit is recognized by its dirty green and somewhat muddy color and by its brilliant interference colors. It is bi-axial and of high index of refraction. It forms small round grains of no recognized crystalline character.

Felit is colorless. Its index of refraction is nearly the same as that of belit and it is strongly double refractive. It occurs in the form of round grains, often in elongated form, but without crystalline outline. Felit may be entirely wanting.

Besides these minerals an amorphous isotropic mass was detected by Törnebohm and Le Chatelier. It is called isotropic because it has no effect upon polarized light. It has a very high refractive index.

Törnebohm adds the important fact that a cement 4 per cent richer in lime than usual consists almost entirely of alit and celit.

The preparation of synthetic silicates and aluminates which might exist in Portland cement was carried out to a certain extent by Le Chatelier and the Newberrys, but in neither case were they characterized completely, especially as to their optical properties. This has been done by the writer within the last two years, and the optical properties and other characteristics of the following definite silicates and aluminates have been determined.

Mono-calcic silicate—SiO_2 CaO: A crystalline substance of high optical activity and little or no hydraulic properties. Specific gravity 2.90.

Di-calcic silicate—SiO_2 2CaO, or more probably $2SiO_2$ 4CaO: A definite crystalline compound of high optical activity and of very little hydraulic activity except in the presence of carbonic acid, but setting slowly in water, generally lacking volume constancy. Specific gravity 3.29.

Tri-calcic silicate—SiO_2 3CaO: A definite crystalline silicate of low optical activity and corresponding in this respect with alit. Its hydraulic activity is not great, but greater than that of di-calcic silicate. If fused and reground it sets slowly like Portland cement. Specific gravity 3.03.

Three definite silicates of calcium, therefore, appear to exist, the two more basic ones being strongly differentiated from each other by their optical activity.

Mono-calcic aluminate—Al_2O_3 CaO: This aluminate is a crystalline substance of high optical activity, but it is not sufficiently basic to permit of its existence in a material of such basic character as Portland cement clinker. Specific gravity 2.90.

Tri-calcic di-aluminate—$2Al_2O_3$ 3CaO: This aluminate is one of highly crystalline character and of great optical activity, making it readily recognizable. Specific gravity 2.92.

Di-calcic aluminate—Al_2O_3 2CaO: A substance crystallizing from a state of fusion in dendritic forms having no optical activity and being, therefore, isotropic. This differentiates this aluminate very sharply from the preceding one and makes the identification of the two materials very easy. Specific gravity 2.79.

Tri-calcic aluminate—Al_2O_3 3CaO: This aluminate crystallizes from the fused condition in elongated octahedra. It is isotropic and it might at first be assumed that it was not a definite compound, but merely the dicalcic aluminate crystallizing out of a magma of indefinite composition. It has been shown, however, by further investigations too lengthy to go into at this point to be undoubtedly a definite aluminate. Specific gravity 2.91.

Definite compounds of iron and lime and alumina and magnesia have also been shown to exist, but their consideration here is unnecessary, as the constitution of Portland cement can be better discussed, theoretically, by a study of clinker into which these elements do not enter.

Among the theories advanced as to the constitution of Portland cement there are those which assume the presence of certain so-called silico aluminates, such as $2SiO_2$ Al_2O_3 6CaO and others of less basic form. All of these proposed compounds have been prepared by the writer and found not to be definite chemical compounds nor to correspond in any way with any of the mineral entities found in industrial clinker. They are in fact only solid solutions, of aluminates in silicates, of indefinite structure.

This brings us to the point where the nature of a solution, especially of solid solutions, must be taken up.

SOLUTIONS.

Solutions may be defined as the merging of two or more substances in one another in such a way that it is impossible to recognize them by any physical means. In this respect they differ from the elements and definite chemical compounds. The elements cannot be or have not been differentiated by any chemical or physical means into other substances. Definite chemical compounds can be differentiated by chemical means into their constituent elements, but at the same time are always composed of these elements in a definite mathematical ratio, involving only whole numbers and depending upon the combining weight of each element.

Mixtures of gases, gases dissolved in liquids, liquids which are mixed together and salts dissolved in liquids are types of solutions. In the preceding paragraph mention has been made of solid solutions. We owe our conception of such solutions to Van't Hoff, a Dutch chemist, who, in 1890, having observed abnormal features in the behavior of certain solutions of solids in liquids when they were frozen, was led to believe that the solid which separates on freezing is not the pure solvent, but a mixture of the solid solvent and the dissolved substance forming a solid solution. Investigations have proved that the conception was justified. Roozeboom has shown from a study of mixtures of fused salts that on cooling solid solutions are often formed, especially if the salts have the same crystalline form and habit.

The constitution of our igneous rocks may be best explained by considering them as solid solutions, which, when the original liquid magma, from which they are derived, is cooled to a temperature at which freezing sets in, are formed by the crystallization of such mineral species as the constitution of the magma may permit, and which we recognize as quartz, mica, felspar, etc., the composition of which while in approximately definite proportions is more or less modified by the substances which they may retain in solution.

The structure of alloys has also been most satisfactorily explained by considering that different metals are soluble in each other in different proportions under different states of concentration and at different temperatures; that of steel has been especially thoroughly worked out in the same way, and it has been shown that it consists of a solid solution of carbon in pure iron, while that of cast iron is explained by the fact that the amount of carbon soluble in the molten iron is so great that a portion separates out, as graphite, on cooling.

Another type of solid solution is glass. In this material we have a solid solution of silica, lime and alkalies, in indefinite proportions, in which none of the constituents can be detected, and out of which nothing separates on freezing. This is regarded as a homogeneous solid solution and corresponds closely to a homogeneous liquid solution. In some mixtures of fused salts and in some of the alloys we have heterogeneous solid solutions, as more than one solid solution may separate on freezing. Such a separation is due to what is known as selective freezing. This is well illustrated by the freezing of a solution of salt in water. That portion of the solvent which becomes solid first contains less salt than anything subsequently separated. If we take a 15 per cent solution of salt in water as an example, as has been done by Howe in his excellent book entitled "Iron, Steel, and Other Alloys," to which the reader is referred for an exhaustive explanation of the theory of solid solutions and to which the writer is much indebted, it will be found that the solid matter that first freezes out is nearly pure water and that there is a corresponding increase in the concentration of the mother liquor. The solid which subsequently separates will contain progressively more and more salt in solid solution in the ice and there will be a progressive fall in the freezing point of this liquid, until when the temperature has reached minus 22 deg. C. and the proportion of salt in the mother liquor is 23.6 per cent, further concentration will not occur and the two elements, water and salt, solidify without selection and form what is called a eutectic. The freezing point remains constant at 22 deg. C. until the entire material is solid. The solid originating in this way is a mixed mass of crystals of water and of salt inter-stratified, the salt forming 23.6 per cent of it and ice 76.4 per cent. The same result would happen with a 20 per cent solution of salt, the selective freezing going on until the concentration of 23.6 per cent had been obtained and the eutectic ratio had been reached. If the original solution contained 23.6 per cent of salt it would not freeze until a temperature of minus 22 deg. C. had been reached, and then it would all become one uniform mixed mass of the solid known as the eutectic. If the percentage of salt is greater than the eutectic ratio, 23.6 per cent, then the material which first freezes will be salt containing some water in solution and the concentration in relation to salt would be reduced until the eutectic ratio is reached. That is to say, the composition of the eutectic is constant no matter what the initial ratio between the solvent and that which it dissolves is. Many alloys are quite parallel in their constitution to that of the solid salt water series. Tin and lead form a eutectic constituting 31 per cent of tin and 69 per cent of lead of constant freezing point. Any tin-lead alloy of other than the eutectic proportion will consist of lead with tin in solution and the eutectic, or tin with some lead in solution and the eutectic, in accordance with whether the lead or tin is in excess over the eutectic ratio.

In some cases, however, where metals or salts are not mutally soluble in the solid state, unselective freezing may take place, that is to say, the elements of the fused solution may solidify separately, and this may be regarded as a eutectiferous mixture.

The term eutectic means well melting, because the eutectic is usually the material which freezes out at the lowest temperature, no matter what the proportions may be of which the mixture may happen to consist.

Two salts which crystallize in the same form may separate from aqueous solutions in such a crystalline form containing more or less of both substances, depending upon the concentration, and in the same way a crystal consisting entirely of one salt may be built up with another by immersing it in a solution of a so-called isomorphous salt of proper concentration, that is to say, of a salt which crystallizes in the same form. These crystals are known as isomorphous mixtures or mixed crystals. Exceptionally a substance which crystallizes in a different form from another may assume the form of the latter and crystallize with it as a so-called isodimorphous mixture or solid solution. The salt which has changed its form must, of course, be under a certain tension in such a solution. Such a state of affairs will be found to be the case in a Portland cement clinker and an example of such an isodimorphous mixture among simple well-known salts will be instructive. The orthorhombic sulphate of magnesia, $MgSO_4$, $7H_2O$, for instance, can take up and hold in solution in the form of orthorhombic crystals as much as 18.78 per cent of the monoclinic ferrous sulphate, Fe_2SO_4, $7H_2O$, while the iron salt can take up 46 per cent of the magnesia sulphate and hold it in solution in the monoclinic form. Between these limits we find both forms of solid solutions or crystals present. The relation of the isotropic aluminates of lime to the anisotropic silicates will be found to be, in Portland cement clinker, similar to that which has been described.

The relation of materials to each other which are not soluble or miscible with each other in all proportions may be also illustrated by mixtures of ether and water. In such mixtures if they are shaken and the amount of ether present is not greater than what the water can dissolve a homogeneous solution is formed. As soon as the proportion of ether reaches a point where it will not dissolve on shaking, an emulsion will form and this will continue to be the case with the increase in the proportion of ether until the latter reaches an amount where it can dissolve the water present. If it were possible to cool ether-water mixtures so rapidly as to solidify them at once we should find, for certain concentrations, where the ether was only slightly in excess of what could dissolve, a solid solution of water and ether and an emulsion of water and ether corresponding in structure to a eutectic, but here the eutectic would not consist of separate particles of ether and of water, but of separate particles of ether saturated with water and water saturated with ether. This is a structure which will be met with in Portland cement clinker. Whether it is a eutectic or not is unimportant. It is the structure itself which is illustrative of what takes place when the components of the mixture are not soluble in each other in all proportions. In Portland cement clinker of certain concentrations similar emulsions are found.

It will be of interest here to consider a solution which bears some parallel to those which we are about to consider in Portland cement. Steel is a solution of carbon in pure iron. Carbon dissolves in the molten iron to a very considerable extent and remains in solution as long as the metal is molten. If cooling and freezing takes place, the structure of the solid metal

* An Address before the Association of Portland Cement Manufacturers.

will be found to depend upon the proportion of carbon which was dissolved in the original iron and the temperature at which it was cooled. If carbon amounts to but a few hundredths of one per cent the solid metal will be wrought iron; if it does not exceed that amount which will remain in solution in iron after cooling it is steel; if the carbon is greater than this some of it will separate as graphite and the solid metal will be cast iron. The structure of the metal in the solid state under these different conditions may be determined with the microscope, but, of course, not in thin sections as in the case of clinker, but by the examination of polished surfaces which have been etched in some appropriate way. The study of iron and steel by these methods has been carried out most elaborately and books published on the subject. The writer has already referred to one by Prof. H. M. Howe, of Columbia University, entitled "Iron, Steel and Other Alloys," in which the metallography of steel is considered and discussed at length. It will only be necessary to state here in a general way that when molten iron containing carbon in solution, in amount insufficient to cause a separation of graphite on cooling, is rapidly cooled from a very high temperature, the solid metal will be found to have definite properties, depending on the percentage of carbon present, the lower percentages furnishing mild steel, the higher tool steel with a structure which is so definite that it has been named austenite. It will be also found that when the steel in this condition is reheated, as in tempering, the austenite structure is lost, the metal being transformed into a material of quite a different structure with resulting changes in its physical properties.

The possibility that Portland cement might be, in a parallel way to steel, a solution of some aluminate in a tri-calcic silicate was evident in the early stages of the writer's investigations and the problem at once became the solution of the questions, what is alit and what is celit, the two essential constituents of a clinker. If they are solid solutions, what are the components of each, and is their structure changed like that of steel at a definite temperature?

The problem was approached in the following manner: Clinkers were made from pure chemicals, silica, alumina, and lime, in the proportions found in industrial clinker. In order to obtain these proportions it was necessary to determine what the molecular ratios between silica, alumina and its chemical equivalent iron oxide, and lime and its chemical equivalents the magnesia and alkalies were. Fortunately there are in existence two very exact analyses of industrial clinker which will serve for this purpose. If, in these analyses, the weight per cent of each constituent is divided by the molecular weight of this constituent, that is to say, by its combining number, the quotient will give the relative number of molecules of the different substances in the clinker. It is also possible by adding the molecular proportions of alumina and iron together and of all the bases together to discover the relation of silica, alumina and iron oxides, these being known as R_2O_3 bases, but here acting as acids, and the lime and other bases, known as the MO bases, to each other and by dividing each of these ratios by such a figure as will make that for silica equal to 1.0 to express this still more simply. It is also possible from these ratios to calculate by multiplying them by the atomic weight of silica, alumina and lime the proportions by weight and the percentages of each of these materials which it is necessary to use in order to produce a pure clinker having the same basicity and molecular ratio as the industrial clinker, but in which the unessential elements are absent. In this process, however, it is necessary to deduct the amount of lime which is present in combination with sulphuric acid as this plays no part in the formation of the clinker.

The molecular ratios for the two cements which have been mentioned appear in the following table, together with the percentage composition of the pure clinkers which were made in these proportions, calculating the R_2O_3 bases as alumina and all the remaining bases as lime.

ANALYSES OF CEMENTS.

1.

	Per cent.	Molecular ratio.		
Silica	21.66	.3586	.3586	1.000
Alumina	7.01	.0686		
Iron oxide	2.57	.0167	.0853	.238
Lime	63.95	1.1400		
Lime—minus SO_3 equiv.		1.1230		
Magnesia	2.69	.0666		
Potash	.51	.0055		
Soda	.25	.0040	1.1991	3.344
Sulphuric acid	1.36	.0170		
	100.00			

Alumina + iron oxide = R_2O_3.

Lime-sulphuric acid + magnesia, potash and soda = MO.

MO for R_2O_3 after deducting 3MO for SiO_2 = .344 for .238 R_2O_3.

2.

	Per cent.	Molecular ratio.		
Silica	22.64	.3748	.3748	1.000
Alumina	6.18	.0604		
Iron oxide	2.42	.0151	.0755	.201
Lime	64.89	1.1531		
Lime—minus SO_3 equiv		1.1305		
Magnesia	1.13	.0279		
Potash	.63	.0067		
Soda	.30	.0048	1.1699	3.121
Sulphuric acid	1.81	.0226		
	100.00			

MO for R_2O_3 after deducting 3MO for SiO_2 = .121 for .201 R_2O_3.

COMPOSITION OF PURE CLINKER.

	Per cent. 1.	Per cent. 2.
Silica	22.2	23.6
Alumina	8.9	8.0
Lime	68.9	68.4
	100.0	100.0

It appears from the above ratios that in cement 1 after deducting 3 molecules of lime for combination with silica as tri-calcic silicate but .344 of a molecule is left for combination with .238 of alumina in the form of an aluminate. This corresponds very closely to the ratio demanded by $2Al_2O_3$ 3CaO, and to the molecular formula 42 (SiO_2 3CaO) 5 ($2Al_2O_3$ 3CaO), a molecular ratio of 23.8 aluminate to 100 of tri-calcic silicate. This might be assumed to exist as a solution of such an aluminate in such proportions in tri-calcic silicate.

In cement 2 after the same deduction enough lime is not left to form even a mono-calcic salt with the alumina. This necessitates the conclusion that some di-calcic silicate must be present and on this basis the formula for the pure clinker may be written, 18 (SiO_2 3CaO) + 7 (SiO_2 2CaO) + 5 (Al_2O_3 2CaO).

Thin sections of clinkers of the composition which has been given were prepared. It was found on examination with polarized light that clinker No. 1 contained both alit and celit, that is to say, it was not a homogeneous solution of the aluminate, $2R_2O_3$ 3CaO, in tri-calcic silicate. In the pure clinker No. 2 the same structure was found, but a larger proportion of celit was present. This state of affairs opened up a new field of inquiry, as to what the structure would be of clinkers in which tri-calcic silicate and the various aluminates were present in a certain definite molecular ratio. The ratio 6 to 1 was chosen, it being well within the limit of what might occur in an industrial Portland cement and the following clinkers were made:

12 (SiO_2 3CaO) + 2 (Al_2O_3 CaO) = 38 CaO
12 (SiO_2 3CaO) + 1 ($2Al_2O_3$ 3CaO) = 39 CaO
12 (SiO_2 3CaO) + 2 (Al_2O_3 2CaO) = 40 CaO
12 (SiO_2 3CaO) + 2 (Al_2O_3 3CaO) = 42 CaO

Thin sections of these clinkers showed that the one corresponding to the substance present as mono-calcic aluminate contained a considerable amount of celit, that corresponding to the next higher degree of basicity, $2Al_2O_3$ 3CaO, contained less, that corresponding to Al_2O_3 2CaO still less, while that in which tri-calcic aluminate is supposed to be the form in which the aluminate is present contains no celit, but is a pure alit corresponding in every way with that seen in industrial Portland cement clinker.

The composition of alit is, in this way, entirely satisfactorily explained. It is a solid solution of tri-calcic aluminate in tri-calcic silicate. And on reflection it is readily seen that the di-calcic aluminate could not become dissolved in tri-calcic silicate without reaction going on and an interchange of base between the tri-calcic silicate and di-calcic aluminate to such an extent as to convert a portion of the di-calcic aluminate to the tri-calcic form and a corresponding portion of the tri-calcic silicate to the di-calcic form. The tri-calcic aluminate then dissolves in the tri-calcic silicate and the di-calcic aluminate in the di-calcic silicate, thus forming two separate and distinct solutions, the one alit and the other celit, which while no doubt miscible in the molten condition, are not so in the solid form. In the same way the interchange of bases in the clinkers of less basic form where the amount of lime was only sufficient to account for the presence of mono-calcic or tri-calcic di-aluminate, would result in a similar state of affairs, but with a much larger percentage of celit as the basicity decreases.

The formula for these clinkers and the calculated amount of celit which they should contain would be as follows:

Series 6 Silicate 1 Aluminate.

	(R_2O_3)	SiO_2	Al_2O_3	CaO
12 (SiO_2 3CaO) + 2 (Al_2O_3 CaO)	38 CaO	23.7	6.7	69.6
12 (SiO_2 3CaO) + 1 ($2Al_2O_3$ 3CaO)	39 CaO	23.2	6.6	70.2
12 (SiO_2 3CaO) + 2 (Al_2O_3 2CaO)	40 CaO	22.8	6.4	70.8
12 (SiO_2 3CaO) + 2 (Al_2O_3 3CaO)	42 CaO	22.1	6.2	71.7
Extreme difference in composition +		1.6	.5	2.1

	Alit.		Celit.	% Celit.
9 (SiO_2 3CaO)	(Al_2O_3 3CaO) +	3 (SiO_2 2CaO)	(Al_2O_3 2CaO)	23.9
10 (SiO_2 3CaO)	(Al_2O_3 3CaO) +	2 (SiO_2 2CaO)	(Al_2O_3 2CaO)	17.2
11 (SiO_2 3CaO)	(Al_2O_3 3CaO) +	1 (SiO_2 2CaO)	(Al_2O_3 2CaO)	12.[illegible]
12 (SiO_2 3CaO)	(Al_2O_3 3CaO)			0.

These experiments, therefore, explain thoroughly the constitution of a pure Portland cement clinker. The presence of unessential elements, such as iron, magnesia and the alkalies, will produce an effect which does not affect the facts essentially, it may merely provide for the presence of some other more complicated solid solutions, although this seems improbable since the unessentials in an industrial clinker are apparently in solution in the celit, and although the presence of felit may be, perhaps, attributed to them.

In the same way as above the relative proportion of alit and celit can be calculated for a series in which the relation of silicate to aluminate is as 3 to 1, 4 to 1 and 5 to 1, and these wide ranges will cover all that will occur in industrial clinker.

Series 3 Silicate 1 Aluminate, or 6 Silicate 2 Aluminate.

	SiO_2	Al_2O_3	CaO
6 (SiO_2 3CaO) + 2 (Al_2O_3 CaO)	21 5	12 1	68.4
6 (SiO_2 3CaO) + 1 ($2Al_2O_3$ 3CaO)	20.8	11.6	67.6
6 (SiO_2 3CaO) + 2 (Al_2O_3 2CaO)	20.1	11.4	68 5
6 (SiO_2 3CaO) + 2 (Al_2O_3 3CaO)	18 9	10 7	70.4
Extreme difference in composition =	2.6	1.4	4.0

Or as Alit and Celit.

				% Celit.
3 (SiO_2 3CaO)	(Al_2O_3 3CaO) +	3 (SiO_2 2CaO)	(Al_2O_3 2CaO)	43 3
4 (SiO_2 3CaO)	(Al_2O_3 3CaO) +	2 (SiO_2 2CaO)	(Al_2O_3 2CaO)	32 1
5 (SiO_2 3CaO)	(Al_2O_3 3CaO) +	(SiO_2 2CaO)	(Al_2O_3 2CaO)	21.5
6 (SiO_2 3CaO)	2(Al_2O_3 3CaO) All Alit			
Extreme difference in composition between two sets = 6 to 1 and 3 to 1	4.8	5 9		5.3

Series 4 Silicate 1 Aluminate.

				% Celit,
	Basicity of Al_2O_3 CaO			
5 (SiO_2 3CaO)	(Al_2O_3 3CaO)	3 (SiO_2 2CaO)	(Al_2O_3 2CaO)	34 1
	Basicity of Al_2O_3 2CaO			
6 (SiO_2 3CaO)	(Al_2O_3 3CaO)	2 (SiO_2 2CaO)	(Al_2O_3 2CaO)	24.7
	Basicity of Al_2O_3 3CaO			
7 (SiO_2 3CaO)	(Al_2O_3 3CaO)	1 (SiO_2 2CaO)	(Al_2O_3 2CaO)	17.1

Series 5 Silicate 1 Aluminate

				% Celit.
	Basicity of Al_2O_3 CaO			
7 (SiO_2 3CaO)	(Al_2O_3 3CaO)	3 (SiO_2 2CaO)	(Al_2O_3 2CaO)	28.1
	Basicity of Al_2O_3 2CaO			
8 (SiO_3 3CaO)	(Al_2O_3 3CaO)	2 (SiO_2 2CaO)	(Al_2O_3 2CaO)	21 0
	Basicity of Al_2O_3 3CaO			
9 (SiO_2 3CaO)	(Al_2O_3 3CaO)	1 (SiO_2 2CaO)	(Al_2O_3 2CaO)	11 2

It is evident that the relative proportions of alit and celit are dependent upon two variables, on the relation of silicate to aluminate and to the basicity of the clinker taken as a whole. It is also apparent that the ratio of 3 to 1 is an extreme limit in one direction, but that that of 6 to 1 in the other is not an extreme if industrial conditions could be accommodated to the production of such a clinker. It is also of interest to note that in the series 6 to 1 the extreme difference in composition between the different clinkers is so small, but 1.6 for silica, .5 for alumina, and 2.1 per cent for lime. In the series 3 to 1 the extremes are much larger and the differences 2.6 for silica, 1.4 for alumina and 4.0 per cent for lime. This points to the fact that the regulation of the percentage of the various constituents in a clinker containing a large amount of alumina requires much more care than in one low in alumina. Between the two extreme series the greatest differences in composition are 4.8 for silica, 5.9 for alumina and 5.3 per cent for lime. From this it may be calculated that the extremes of composition of an industrial Portland cement within the bounds of the above ratios, if the cement is perfectly burned, would be:

Silica	18.5—23.2
Alumina (R_2O_3)	6.1—11.9
Lime, without magnesia or alkalies	63.1—68.1

(To be continued.)

COLOR PHOTOGRAPHY BY NEW METHOD.

M. E. ROTHÉ describes a new method of obtaining photographs in natural colors in a paper lately presented to the Académie des Sciences. When the photograph of a spectrum obtained by the well-known Lippmann method is looked at by reflected light, we see that the two sides of the plate do not show the same colors, especially if the plate has been overexposed. On the glass side the colors of the spectrum are faithfully reproduced, but on the gelatine side the tints are often quite different and sometimes they are very near the complementary colors of the former. Moreover, the gelatine surface of a color photograph when underexposed shows, according to the length of exposure and the thickness of the gelatine, a series of varied tints. By rubbing the surface of the differently colored gelatine of the plate with the fingers or a piece of cotton, we are able to modify the surface, for after drying the plate the tints on the gelatine side are seen to have entirely changed in character. It seemed probable that the planes of the silver nearer the gelatine and the thin layer formed by the surface of the gelatine and the first plane of the silver come in for the greater part in producing the colors which are observed by reflection from the surface of the gelatine. But it is logical to admit that the air is not all driven out from between the gelatine and the reflecting mercury surface upon which the plate is laid. There is left a thin layer of air which is not sufficient to give an appreciable difference on the traversing rays, but whose presence can give rise to a reflection on the surface of separation of gelatine and air with a certain difference of phase. Thus there would be not only the reflection from the mercury surface, but a reflection from the air layer which can explain the varied colors which are observed in an overexposed plate. This leads us to suppose that by means of a long exposure we can obtain photographs in color by the light which is reflected from the transparent gelatine and air surface alone. Experiment confirms this idea, and M. Rothé presented a number of specimens of color plates he obtained, such as plants, birds, spectra, flowers, etc. These are formed by the Lippmann interference method in principle, but with the important difference that he suppresses the use of the mercury mirror and as a reflecting surface uses only the surface of separation of gelatine and air. The advantage of the new method will be appreciated when it appears that the photographic plate can now be placed in an ordinary apparatus, with the glass side toward the object. The plate has been previously prepared according to the Lippmann method. As for an ordinary photograph, the exposure is variable according to the light, ranging from 30 minutes in the sun and 2 hours in the laboratory. The spectrum of an arc lamp can be taken in 15 minutes, and moreover, the exposure can be reduced to a few minutes by treating the plate before using it with a solution of nitrate of silver in alcohol. Pyrogallic acid seems to be the best developer. It is a good plan to reinforce the plate with bichloride of mercury and amidol in order to bring out the darker tints. The colors thus obtained are not as brilliant as with the ordinary Lippmann process, but they are quite visible. All the colors from orange to violet are faithfully reproduced, but it is

more difficult to obtain the red in its true value, and sometimes it appears with an orange tint. It is necessary to sensitize the plate more especially for the red and to modify the nature of the film so as to increase the intensity of the reflected beam.

NEW APPARATUS FOR CHARGING AND DISCHARGING GAS RETORTS.*

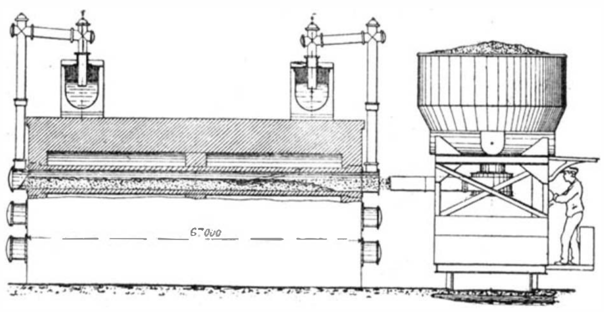
By Emile Guarini.

The fierce war that has for a long time been waging between gas and electricity has had two fortunate results, viz., a diminution in the price of gas and the introduction of improved apparatus for its manufacture. In this respect, the gas industry, one of those most affected by the advent of electricity, has made some great strides, which have been plainly necessitated by the primitive character that the manufacture of coal gas has long possessed. As for electricity, that has always shown itself a little too supercilious toward its competitor. So the efforts made and the results obtained with a view to lowering its net cost are insignificant as compared with what has been effected with gas. And this is not all; electricity has begun to borrow from gas, its competitor, a power which is often cheap and always easily utilized. The central stations in which the dynamos are driven by gas motors are already too numerous to be counted.

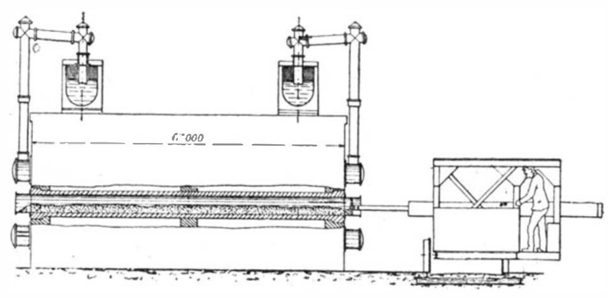
If electricity, the victor of the day, has cared so little for gas, it is because, leaving aside heating, for which it is almost everywhere unattainable, it furnishes the most economical means of transmitting motive power to great distances and of dividing it without trouble into small units. As for lighting, the use of incandescent gas burners is usually more economical than that of electricity. It must be remarked, however, that electric lighting by incandescent lamps presents such conveniences of installation and maintenance and such hygienic advantages, and lighting by arc lamps lends itself so well to the institution of great luminous units, that a sort of equilibrium is established between the general advantages of electricity and the economical advantages of gas. It remains, however, to be ascertained to what figures the price of gas will be able to descend. In fact, in our time, in which we are, before all else, practical, or, more exactly, pseudo-practical, since the sacrificing of health to money is not being practical, there is a tendency toward the abandonment of the hygienic and convenient arc lamp for the burner with incandescent mantle, which gives a light that costs, say, a tenth less than that produced by an electric lamp of equal luminous power.

Now with gas the method of charging the retorts may become the source of an important saving. So it is upon this that the efforts of engineers are being to slide from the heap and place itself in layers that are very uniform provided that the angle of inclination of the retort is equal to the angle of subsidence of the coal. Unfortunately, coal varies, and, with it, the angle of the inclination, while the angle of the retort remains invariable, without taking into consideration the velocity of fall of the coal and other causes that interfere with the regularity of the layers.

All these reasons and many others gradually induced the most ardent defenders of the inclined retort to turn their attention to charging and discharging machines, which, up to the present, have operated more or less after the fashion of the charging scoop.



SECTION OF THE RETORT, WITH COKE DISCHARGER ENTERING.



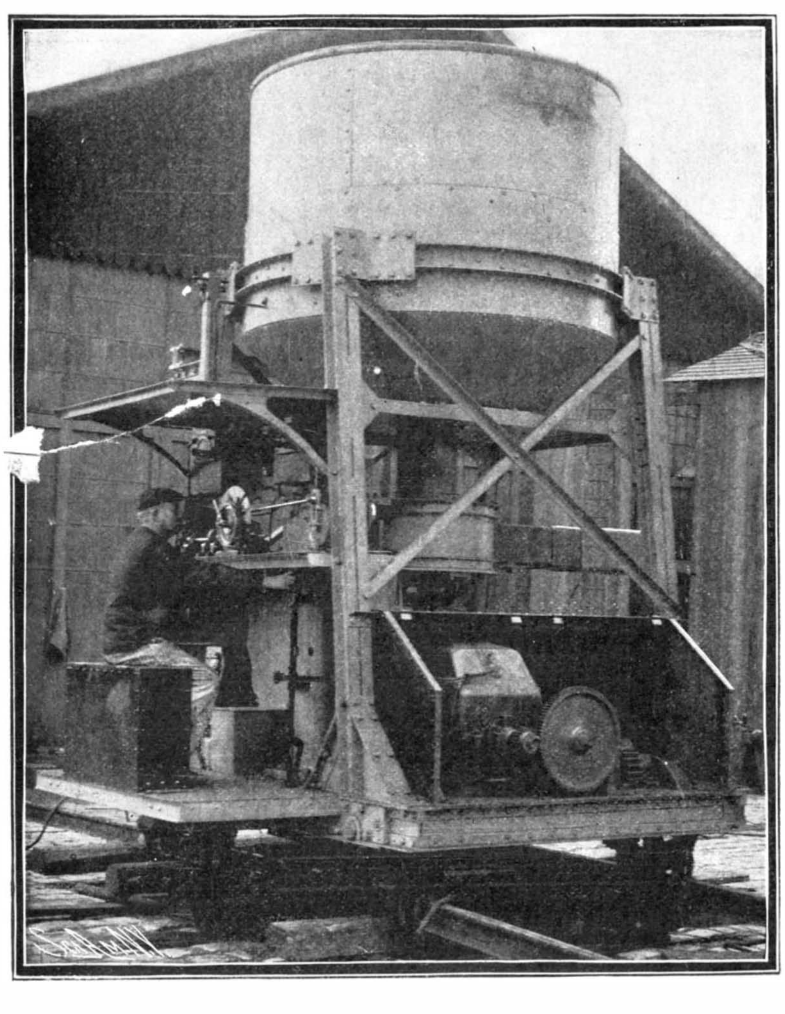
COKE DISCHARGER OF LA VILLETTE GAS WORKS.

The problem has at length been solved in an entirely different manner by the electric turbine charging and discharging machine of the Parisian Gas Company, and by the De Brouwer charger invented by the superintendent of the Bruges Gas Works. It is electricity to which the inventors have had recourse for the elaboration of these machines, two of the results of which are now certain, viz., a diminution in expenses and a betterment of the condition of the laborers.

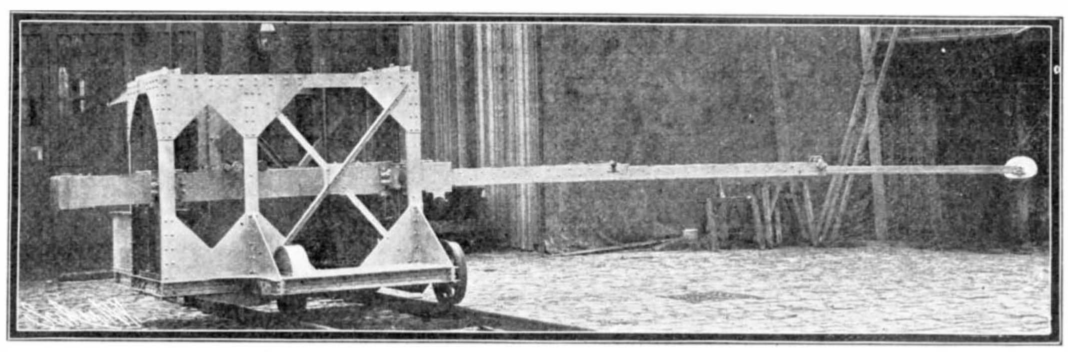
electric motor. The charge is thrown by centrifugal force through a tube into the retort in a continuous stream. The portion of the tube that projects outside of the frame of the machine can be raised. This portion closely approaches the head of the retort, but does not enter it. The turbine can be raised or lowered to the level of the different rows of retorts. The upper part of the apparatus consists of a coal hopper of a capacity of about four tons, which feeds the turbine through a telescopic column that permits the turbine to rise and descend. The passage of the coal into the turbine is regulated by two horizontal endless screws. The electric motor, which is of 4 horse-power, follows the turbine in its ascending and descending motions. Upon one of the sides of the machine there is established another electric motor (12 horse-power), which gives the machine its lateral motion and, by means of gearings, actuates the endless screw. The whole is mounted upon a simple carriage. The current is taken from aerial wires strung along the retort room. The electricity is generated by an installation actuated by a gas motor. The machinist has only to manipulate the interrupters and rheostats in order to put the apparatus in position and start the turbine.

At the beginning of the charging, the turbine makes 400 revolutions, and, at the end, 200. The starting is effected by a simple commutator, and the change of speed by the rheostat. This *modus operandi* does not meet with general approbation, and does not exist in the De Brouwer machine. The space occupied from the front to the back of the machine is seven feet. The weight, everything included, is ten tons.

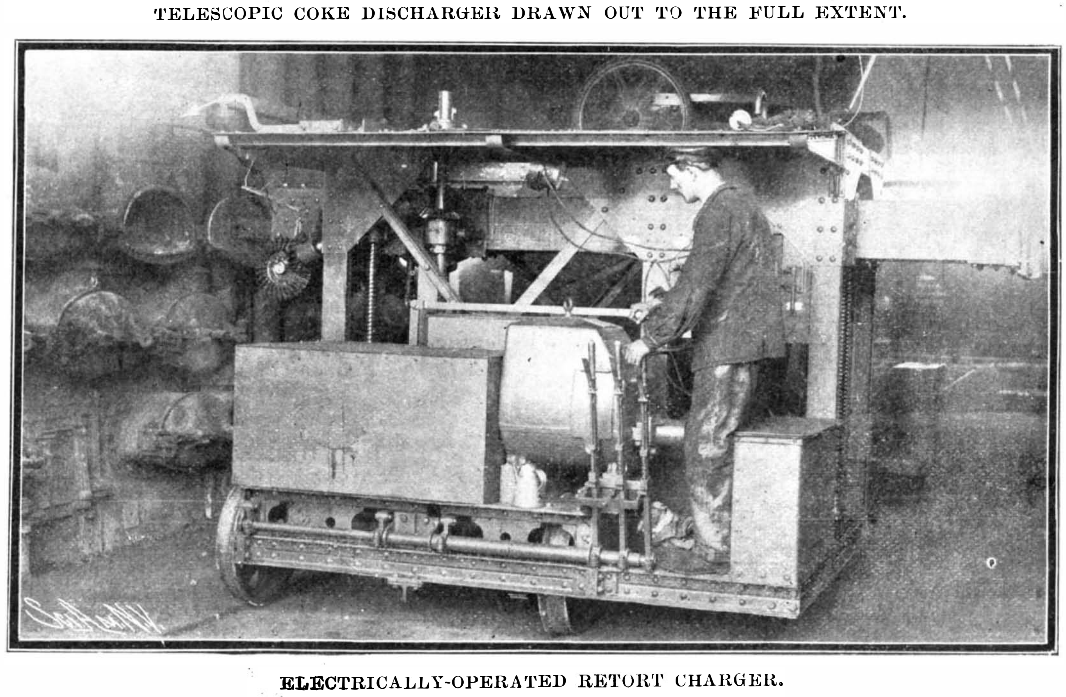
The De Brouwer charger has the advantage of not requiring an expensive installation, of costing little for maintenance, and of being capable of being operated by inexperienced hands. It is as applicable to small as to large works. The machine consists principally of a short belt passing over three idle pulleys with a great velocity. A fourth and larger pulley provided with a channel presses the back of the belt and forces it to follow its periphery for a quarter of a circle. The pulleys are actuated by a 4-horse-power electric motor placed upon the machine. The channel of the large pulley contributes, with the belt, toward forming a conduit. Between the large pulley and the one to the right there is a hopper for emptying the coal. This latter follows, with the belt, the periphery of the large pulley, to an extent of 90 deg. Centrifugal force during its passage into the channel of the pulley presses it against the belt and prevents it from scattering during the rest of the journey. As soon as the belt leaves the contour of the large pulley, the perpendicular direction changes to horizontal. The coal remains upon the belt up to the point at which the latter, in suddenly disappearing from under it, runs over the small pulley. At this moment, the coal



ELECTRIC TURBINE RETORT CHARGER.



TELESCOPIC COKE DISCHARGER DRAWN OUT TO THE FULL EXTENT.



ELECTRICALLY-OPERATED RETORT CHARGER.

NEW APPARATUS FOR CHARGING AND DISCHARGING GAS RETORTS.

concentrated. Originally, the charging was done by shovel—a long and troublesome process. The use of the charging scoop marked a progress, but it was inadequate. Then machines for charging and emptying made their appearance, but they were too heavy, and not at all economical. Next came the turn of the inclined retort, into which the coal is simply allowed

* Specially prepared for the Scientific American Supplement.

The machine of the Parisian Gas Works is in operation at La Villette works. As for the De Brouwer machine, that throws the charge into the retorts, but does not convey it to them. At La Villette, the retorts are 20 feet in length. The coke is discharged at the other side, as we shall see further along.

The central part is a turbine of two feet four inches diameter. It contains four blades formed of two riveted sheets of steel. The power is furnished by an

leaves the belt and is thrown with a certain velocity into the retort. The De Brouwer charger is therefore a sort of mechanical sling.

The charging is effected as follows: The compartment of the reservoir corresponding to the retort to be charged and containing about three hundred and thirty pounds of coal is opened by means of a lever. The coal descends into a funnel, falls upon the belt, slides between the latter and the large pulley, and

is then thrown in the form of a layer of uniform thickness into the retort to be discharged. As the coal is projected into the retort horizontally, the layer is of perfect regularity. The first part of the charge is thrown to the bottom of the retort, and, as the layer is formed from front to rear, it reaches the head of the retort at the moment at which the entire charge has passed the charger.

The charging of a 20-foot retort is done in a few seconds. The putting in position for a new operation requires seven seconds. Three retorts can be charged in one minute, and one person suffices for regulating the operation. For the charging of a 10-foot retort, the large pulley makes 200 revolutions a minute. The coal escapes with a velocity of about 2,000 feet a minute.

The vertical and lateral displacement of the machine is obtained by very simple means.

Although based upon an analogous principle, the two chargers differ from each other considerably. If the new machinery continues to do all that it promises, it will combine all the advantages of the inclined retorts without having their drawbacks. Such advantages may be summed up as follows: A very great saving in manual labor, a moderate net cost, adaptability to almost all gas works, a minimum of wear, an enormous capacity for work, and certainty in action. The fault found with La Villette machine is that it necessitates a close proximity of the jointed pipe and the head of the retort. The heavy draught of air caused by the running of the turbine keeps the head of the retort surrounded by a thick veil of flame. It is possible that if the pipe were not so close at the head of the retort this disadvantage would disappear, especially if the upper part of the pipe were abolished. The De Brouwer charger shows that coal can travel very well through centrifugal force without being confined in a closed canal.

Another advantage of the De Brouwer charger that has been noted, especially at the Bruges Gas Works, is the diminution in the accumulation of graphite in the retorts, no removal of this material becoming necessary for a period of six months. This quite unexpected result seems to be due to the fact that a certain quantity of air is carried along with the coal at every operation and burns the graphitic residuum produced during the preceding operation.

The turbine charger of La Villette has its natural complement in the electric coke discharger employed at the same works. This is telescopic and in three parts. To its head is secured a thrust-plate having the form of the section of the retort. In front of the apparatus there is a toothed wheel, of which the teeth are wide enough to give place to the teeth of the bottom of the discharge. The internal section of the latter engages with the teeth of the central section of the wheel; the second part of it with the second and fourth divisions, and the external part with the teeth of the first and fourth divisions of the wheel. The operation of the apparatus, its elevation and its lowering, are effected by means of a 12-horse-power electric motor. The apparatus is provided with three levers, one for the lengthwise displacement, one for the elevation and lowering, and the third for the control. After the apparatus has reached the end of its travel, it returns automatically to where it started.

The raising and lowering of the apparatus to the level of the rows of retorts are effected with great rapidity. The arrangement is compact and occupies but little space. In fact, the apparatus occupies but seven feet from front to rear. Without the telescope, the discharger for 20-foot retorts would necessitate a space of at least thirteen feet more for its operation.

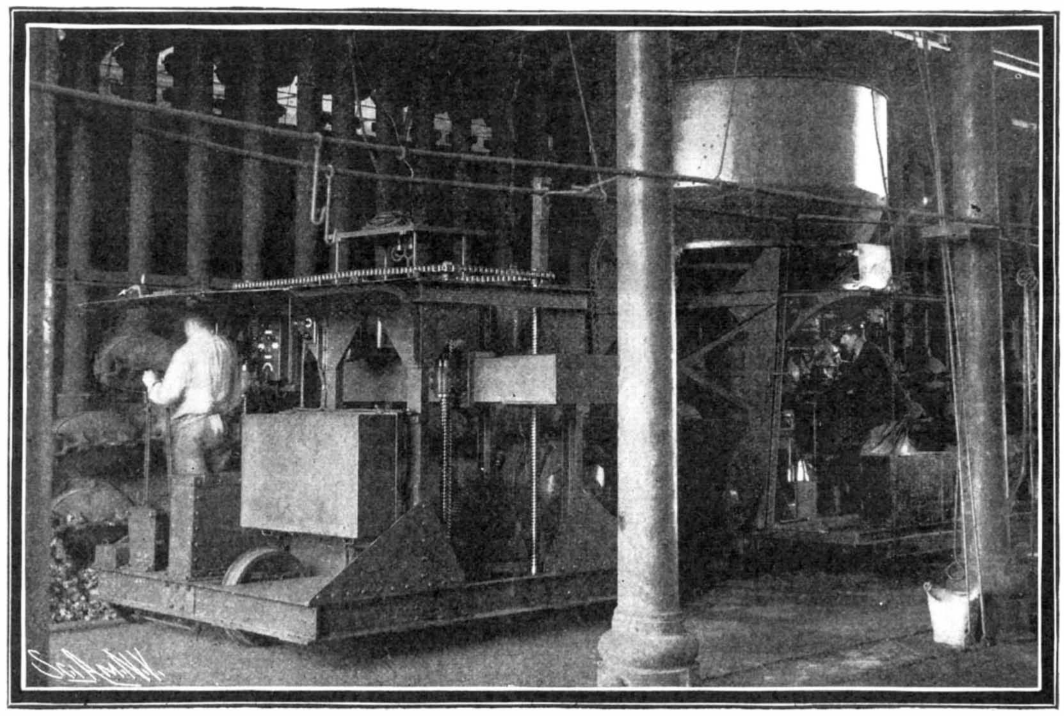
The machinist has nothing to do but manipulate the levers, and is thoroughly protected against flames and heat. As an advantage of this apparatus over other systems of discharging coke may be mentioned the possibility of filling the retort up to the top. In fact, it is not necessary when the retort is charged to leave any space for the expansion of the coal. This circumstance permits of reducing the surface with which the gas is in contact in the retort, and thereby of preventing the alteration of the illuminating power, the formation of naphthaline and the clogging of the upright pipes.

All these machines have given very remarkable results. This is especially the case with the De Brouwer charger, which has been in operation for more than a year at Bruges for furnaces of more than thirteen feet in length, the introduction into which of a charge of 400 pounds of coal requires but 9 seconds. At Bruges it has even been possible to charge four retorts in 54 seconds, the operation of lateral shifting included. By hand, the same operation would have consumed from eight to ten minutes.

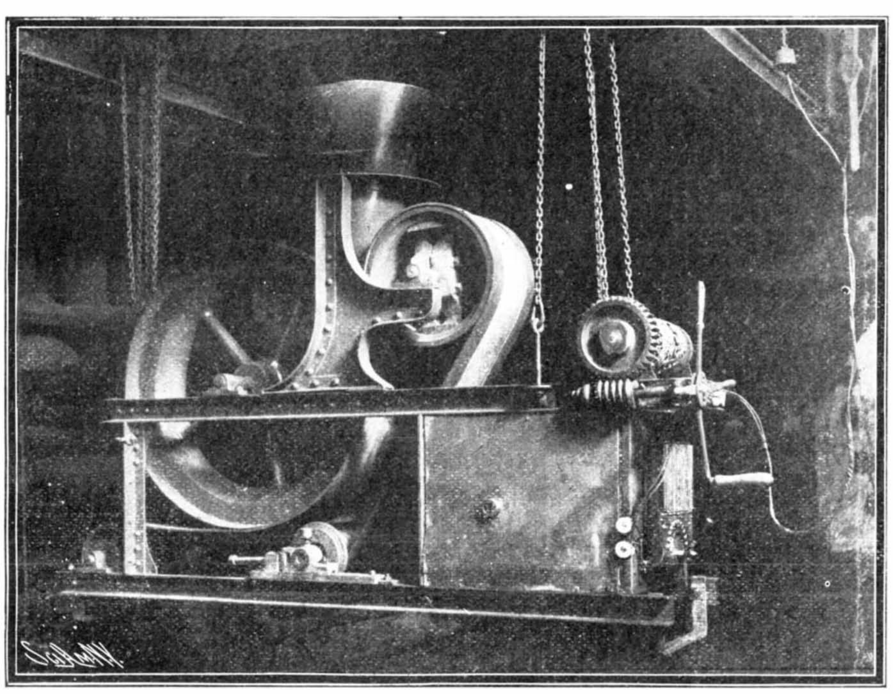
With La Villette machines, the results are no less interesting. When the charger is in position, a 20-foot retort in thirty seconds after the manipulation of the starting rheostat receives a complete charge of a thousand pounds of coal. Immediately after the manipulation of the lever, the thrust-plate of the discharger begins its motion and, in ten seconds, reaches the other extremity of the retort, and then returns to its initial position without any noise, hitch, or shock, without any heating and without any injury to the sides of the retort. The coke makes its exit from the retort in large pieces, and is received in trains of small cars of three compartments hauled over rails by a 4-horse-power electric motor. Each car receives 25.5 bushels. In measure as the trains leave the retort room, the coke is extinguished and emptied into a hopper forming part of an elevator that loads it into cars.

The results obtained by this system at Paris have been so satisfactory that the company has decided to extend the use of it.

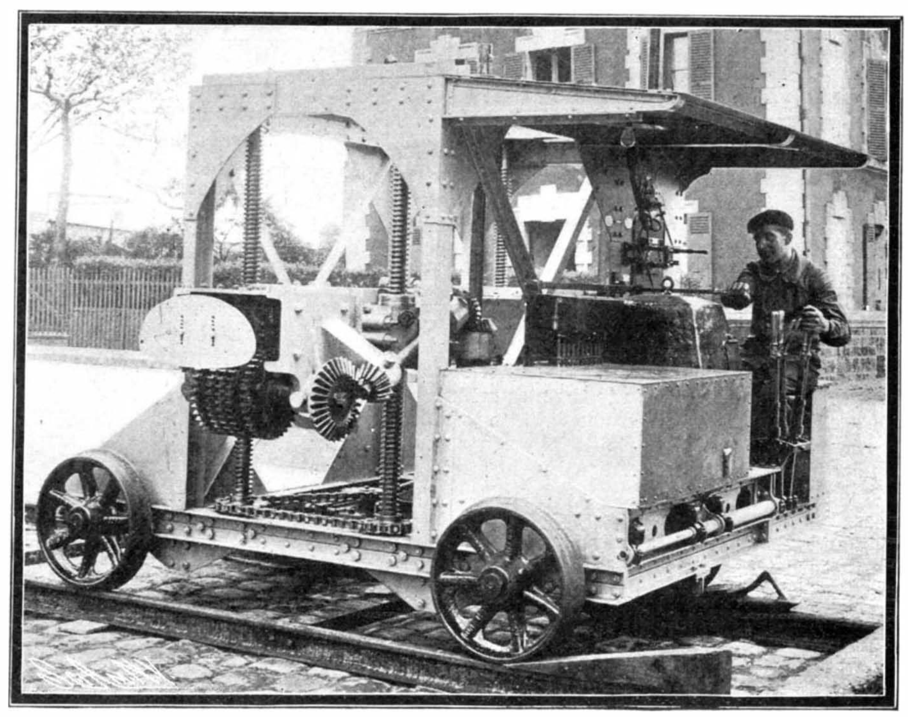
As for the De Brouwer apparatus, that, since its advent, has been put in service in a certain number of works, especially at Bruges, Toulon, and Barcelona. It is applicable likewise to the coaling of ships. It is therefore to be anticipated that the use of it will soon become general.



INTERIOR OF RETORT ROOM AT LA VILLETTE.



DETAIL VIEW OF THE DE BROUWER RETORT CHARGER.



ELECTRICALLY-OPERATED RETORT CHARGER.

NEW APPARATUS FOR CHARGING AND DISCHARGING GAS RETORTS.

NEW METHOD OF MANUFACTURING OXYGENATED WATER.

Hitherto oxygenated water has been produced from acid giving a decided acid reaction to litmus paper, and especially chlorhydric, phosphoric, oxalic or fluorhydric acid or mixtures of these acids.

The operation is conducted in acid liquor; the recovery of the acid is produced by means of sulphuric acid; the close of the operation consists in converting the baryta salts into soluble salts of potash, soda or magnesia, freeing them from iron, aluminium and other impurities by means of phosphoric acid, to the neutrality of the liquor and sometimes to its basicity. The clear liquor is acidified by means of chlorhydric, sulphuric or phosphoric acid, and the quantity should be sufficient to prevent the disengagement of oxygen while maintaining in the soluble state the impurities, iron and aluminium, which have not been completely eliminated, and which contain soluble salts, in greater or less quantity, the chloride, oxalate or fluoride of iron and aluminium. The purification of these solutions, in order to produce oxygenated water chemically pure, is long, costly, and difficult. When these industrial waters are put into basic liquor in the presence of matters, to be decolored or oxidized, the impure matters are gradually precipitated and form centers where the oxygen is disengaged and completely lost.

By the new method of manufacturing oxygenated water, the class of neutral oxides, acid or basic, which, while having a distinctly basic reaction to litmus paper, may under certain circumstances act the part of acids, are utilized.

Such are the oxides of aluminium, of chromium, of manganese, of lead, etc. By operating all the time in basic solution, it is easy to see that at each moment of the operation, and in proportion as it advances, all the impurities are precipitated, so that when the volume of water is attained, we have a water, distinctly basic, which is acidified after purification.

Thus from aluminium the aluminate of baryta is produced in basic or netural solution, regenerated or not by sulphuric acid, until the quantity of bioxide has been employed, which ought to yield the required

volume. At this moment, there is always a basic liquor in presence only of aluminate of baryta; it may be converted into soluble salts of soda, potash, or magnesia, but it is thought preferable to end with a water, chemically pure, both for industry and for other uses, and thus the aluminate of baryta is eliminated, making use of lime salts, suitably selected; sulphate of lime, carbonate of lime, etc. Thus, insoluble sulphate or carbonate of baryta, and insoluble aluminate of lime, are obtained; or the aluminate of baryta may be eliminated by employing a quantity of sulphuric acid, sufficient for dissolving the aluminium and baryta.

These different liquors are brought to basicity by baryta and filtered; they are brought from basicity to neutrality by means of sulphuric acid; they are filtered anew, and the clear, filtered liquor is acidified with phosphoric acid or pure alcohol. The phosphoric acid or the alcohol should be in very small quantity, for the water thus produced does not contain any impurities, and consequently is at its maximum of stability. In consequence of this absence of impurities, the new water, in basic medium or not, and in the presence of matters to be oxidized or decolored, no longer disengages oxygen uselessly, but will disengage it only in presence of the organic matter to be decolored or oxidized. There being no useless disengagement of oxygen in the absence of these impurities, the power of decoloration of this new water will be much greater than that of waters made by methods in use.

This water, chemically pure, is insensible to all the chemical reagents; it does not contain iron, or aluminium, or baryta, or sulphuric acid, or lime, or oxalic acid, or fluoride, or soluble salts.

Still, if the operator judge it suitable for industrial use, it may contain a certain quantity of aluminium, or aluminate of soda, or other soluble aluminate; in the preceding case of water chemically pure the water may be acidified by a pure acid, such as phosphoric acid, in such small quantity as not to be sensitive to litmus paper.

The chemically pure water may be preserved by putting into it, in place of acid, pure alcohol, a few cubic centimeters per liter. As residues of the process, we have aluminate of lime and sulphate of baryta or aluminate of lime and carbonate of baryta, which latter are formed in exactly the atomic proportion for obtaining, on heating to 1,200 deg. C., aluminate of baryta, which may serve for removing the scale from boilers.—Translated from La Revue des Produits Chimiques.

A NEW THEORY OF THE ORIGIN OF SPECIES.*

By A. DASTRE.

NEARLY half a century has elapsed since the appearance of Darwin's work "On the Origin of Species by Means of Natural Selection." It is unnecessary to recall the commotion which that publication produced and the effects which followed. It was the signal for a profound revolution affecting the natural sciences, secondarily other sciences, and even the mental attitude of individuals. The idea of the evolution of living forms, of their descent, or rather of their transformation, already advanced by Lamarck and Geoffroy Saint-Hilaire, was rescued from the oblivion or the indifference in which it had hitherto remained and was imposed, in a manner, on almost the whole scientific world. At present it is accepted with but slight opposition. It is, to be sure, only an hypothesis; but, as it is the only one that has any rational basis, it becomes, because of that fact, almost a necessity. As M. Yves Delage says:

"If there were a scientific hypothesis other than descent by which the origin of species could be explained, a number of naturalists would abandon, as insufficiently demonstrated, the opinions which they now hold."

This may be true, but there is no other scientific hypothesis, and the naturalists of to-day, willing or not, are transformists—that is to say, they are persuaded that living forms are not unrelated to each other, invariable, isolated, brought into existence by special acts of creation, and without any bond of union between them, but that they are, on the contrary, related—that is to say, derived one from the other.

Darwinism did not, however, consist merely in an affirmation of transformism, for this had already been advanced prior to Darwin. Transformism certainly arose from the application to the natural sciences of the idea of "continuity" introduced into science by the mathematicians of the eighteenth century. We may thus explain the course taken by that idea as well as the variations which it assumed. The mathematicians passed it on to Buffon, who was originally a geometrician and who entered the Academy of Sciences as such; he in turn transmitted it to Lamarck, who was one of his intimate friends, and from him it passed to Geoffroy Saint-Hilaire. It was, however, the illustrious English naturalist who first explained the mechanism by which, according to him, the transformation of one species into another might be effected, thus producing a continuity of living forms. This mechanism is natural selection.

Now it appears that, while Darwin succeeded in establishing the idea of continuity of living forms by means of generation—that is to say, transformism—he was much less successful as regards the means which he proposed. To speak plainly, he failed. There are but few naturalists at the present time who attribute to natural selection any rôle whatever in the filiation of species. As has been remarked by Herbert Spencer, it is not in this way that truly specific characters can be acquired. Besides, when once acquired, they could certainly not be fixed by heredity. It is some ten years since anyone has held to the fixed heredity of characters acquired by a living being in the course of its existence, or at least during ten years past that idea, formerly admitted without opposition, has been fiercely attacked and denied by naturalists of great standing, such as Weismann, Pflüger, Naegeli, Strasburger, Kölliker, His, Ray-Lankester, Brooks, Meynert, Van Bemmelen, and others.

A Dutch naturalist, Hugo de Vries, who has a wide reputation among the botanists of our time, has just given the finishing stroke to the theory of natural selection, already much shaken, and has proposed in place of it another hypothesis which he calls "the theory of mutation." The name in itself is not very significative and needs to be explained. We shall do that presently. The doctrine is founded on observation and experiments which by the sagacity, long and patient effort, and careful criticism of their author deserve to be ranked with the admirable observations of Darwin. On the other hand, it has been most favorably received by many naturalists. For these two reasons the scientific public is obliged to take it into consideration, and, at least, to become acquainted with it.

I.

Every new being resembles the ones from which it ascended, considering those in the widest sense. We say—and it is only a form of speech—that it owes this resemblance to heredity. Heredity, then, is simply the name by which we express the fact that an offspring resembles its parents. On the other hand, the resemblance is not absolute. For example, two animals of the same litter or two plants of the same sowing are never identical. We apply the term "variation," individual variation, to such divergences or to the tendency which produces them. It is, then, a fact that in new generations there appear new characters which it is impossible to attribute to a reversion to ancestral features—that is to say, they are truly new and undescribed hitherto. It is only as to the extent and importance of such characters that discussion arises.

We cannot deny that variation exists. Living forms have not the rigidity of stone; they vary incessantly, and these variations have been used by breeders for the creation of races. Modifications of this kind are restricted, however, within certain limits. Their amplitude is restrained by three conditions, as follows: Generally they are not permanent and they disappear at the same time as do the circumstances under which they are produced; they are not transmissible by generation to descendants; and finally, the modified beings have not lost the aptitude of crossing with those that have not been modified. This is what is meant by declaring that these individual variations cannot create a new species; for these three defects found in the modified being are exactly those which define a species.

Up to the present time no one has ever seen an animal or vegetable species engender another or transform itself into another. In other terms, no one, except perhaps Hugo de Vries, has perceived a living form arising from another form, yet differing from it by features having the value of those which distinguish species, and showing itself inapt for crossing with the parent, although capable of maintaining and preserving itself by generation. Such a profound transformation cannot be accomplished in a moment or by a single effort.

Darwin supposed that such a transformation could be accomplished by degrees. According to his view the cumulative repetition of certain small variations might effect a more considerable transformation. In order to do this it would suffice that they should always be produced in the same direction during a long course of generations. Breeders effect this by reproducing and maintaining the conditions of the original transformation and breeding together the individuals which present such transformation. This is "artificial selection." It is a judicious and methodical exercise of the two properties of heredity and of variation practised for the interest and advantage of man.

The supposition of Darwin is equivalent to admitting that nature, personified, acts like man, heedful of consequences and with a method, by "natural selection" having in view the interest and advantage of species. Certain slight variations appearing under diverse influences, for example, under a change in the environment, will constitute an advantage for individuals. Such individuals are thus better adapted to these new circumstances and have a better chance of survival; these are the ones which will pair and by heredity preserve the advantageous variation, fix it, accumulate it, until there is formed a race, a variety, and finally a new species. This automatic play of the best adaptation favoring certain individuals, permitting them to survive and to reproduce themselves, has here, in natural selection, the same providential rôle as the breeder plays in artificial selection. It is the best adaptation which designs and chooses the useful variation; it is that which favors the individuals that possess it; it is that, in fine, which degrades the others in the concurrence, either direct or indirect, which exists between animals and plants, in that sort of struggle for existence whose importance was perceived already by A. de Candolle and Lyell, and which results in the disappearance of the vanquished species and the effective triumph of the new one.

It may be noted that natural selection is not a single hypothesis; it is a linking together of three hypotheses. If we separate the links of this chain we can show that not one of them will stand test. The first hypothesis is that of the advantage in the struggle for existence which is given to an animal by the possession of a small, adaptive variation; the second is that of a preservation, by transmission, of this acquired character; the third is the progress, always in the same direction, of these profitable variations, which, accumulating, finally create a specific character. None of these hypotheses will support a searching examination.

In the first place, as to the benefit of a small, adaptive variation, it may be observed that it would be, in itself, too insignificant to give rise to selection. Let us take for example the transformation of an ungulate quadruped into a giraffe according to the Darwinian theory. In this system an increase of some centimeters in the length of the neck would be a favorable adaptive variation; it would allow the animal, in case of famine, to browse upon the verdure of trees some inches higher than his companions could. But with Mivart, Naegeli, Delage, Osborn, Emery, Cuénot, and others, we may affirm that in case of actual famine this advantage would amount to nothing and would not assure the survival of its possessor. The individuals who would die would be the youngest or the oldest, or, in a general way, the feeblest. The variation must be considerable in amount in order to constitute a real advantage and in order that the process of selection may be applied to it.

The second hypothesis is, then, to imagine that this variation, admitted, for the moment, as useful, may be preserved and transmitted by generation. We have stated above what naturalists think at the present time concerning the transmission of acquired characters. The least that one can say is that it is very much controverted.

The third hypothesis, grafted upon the first two, is the repetition of the variation. Even if we disregard the objections made to the previous hypotheses there are still others which present themselves here. It is, indeed, necessary that the variation should continue to be produced in the same direction during a great number of generations in order that it may be recognizable, since it is minute each time it occurs; many additional elongations would be needed in order to produce the neck of a giraffe from that of an ungulate. Lamarck, by placing the cause of variation in external conditions, makes this continual addition of effect plausible. The permanence, or better, the repetition of the processes of variation, will perpetuate itself as long as these external conditions are kept up. For example, in attributing the elongation of the neck of a giraffe to the habit of browsing upon the high leaves of trees and the effort of the animal to reach those which are still higher, Lamarck accounts for the definite and sustained course of variation. But it is exactly this resource that Darwin took away, since he did not accept the ideas of his illustrious predecessor as to the causes of variation. Decidedly, selection appears to be a process more adapted for preserving a state of things than for creating a new one. It is more conservative than revolutionary.

Besides, this is not the only objection, not even the most serious one, which affects this third hypothesis of Darwin. The principal difficulty with it is that it attempts to account for the considerable change which creates a new species by too slow an accumulation of inappreciable changes. When the Darwinists are pressed closely they demand time—much time; too much time. They require indefinite series of generations in order that the smallest species may be formed. Their adversaries have reproached them with having made our globe too old; this is also the opinion of Lord Kelvin.

In reality it must be that there is not so much delay in the creation of a new species. This is exactly what Hugo de Vries contends. He denies the gradual transformation of species by the addition of inappreciable variations; or, at least, he affirms that they may be produced by a process that is rapid, precipitate, sudden. The new species whose development he has observed have arisen abruptly, as one may say, explosively. This is what the Dutch naturalist calls "spasmodic progress."

II.

The main idea of the doctrine of Hugo de Vries is the abrupt mutation of living forms. The eminent naturalist does not advance it as an *à priori* proposition; he deduces it from his experiments, and he is not afraid of sharply opposing it to the universal view which accepts slowly-acting causes. In the course of the nineteenth century, geology was tossed from the cataclysms of Cuvier and his geological revolutions to the slow causes of gradual evolution pointed out by Sir Charles Lyell; and at the present time it is swinging back with Suess toward sudden transformations. It is interesting to note that a similar movement is occurring in biology; the attempt of De Vries is one of its manifestations.

A great number of zoologists, botanists, and paleontologists are inclined to adopt this notion of sudden changes as consonant with the teachings of experience. We may cite in this connection the well-known argument of Agassiz. This celebrated naturalist called attention to the simultaneous appearance, in the first fossiliferous strata, of a mixed fauna comprising representations of all the grand divisions of the animal kingdom. This is shown in the Upper Silurian or Devonian horizon in which the vertebrates make their appearance in the form of fish. In the most ancient fauna, and that which has become known most recently (that of the Lower Silurian or Cambrian), all the grand divisions are still found, except that of vertebrates, each represented by quite high types. It is a question to be decided whether, lower down, in the sedimentary rocks hitherto considered as azoic, there is really a living population, more widely scattered, and

* Translated from the Revue des Deux Mondes.

reduced to the most rudimentary animals and plants—that is to say, to protophytes and protozoans, as appears from the researches of MM. Barrois, Bertrand, and Cayeux. Yet it is none the less certain that the very important remark of Agassiz is true, and that, in the Cambrian horizon, all the principal types appear simultaneously. We perceive here a sort of explosion of universal life.

In consequence of this the transformists are obliged to admit that in the short space of time that corresponds to the deposit of the most ancient fossiliferous rocks the first living beings must have undergone all the evolutions necessary for passing from the state of a simple mass of protoplasm to that of types characteristic of all the grand divisions, the vertebrates only excepted. We are authorized to conclude that the time during which the most ancient fossiliferous rocks were deposited was short, because we can judge of it from their thickness, which is much inferior to that of the subsequent strata. Therefore, but a comparatively short space of time was required for the modifications by virtue of which the first living forms produced the principal grand divisions. The Lower Silurian epoch was one of rapid transformations, of active morphogenesis, of intensive mutations. If we wished to suppose that these were caused by the Darwinian mechanism of slow accumulation of minute variations, we would be obliged to throw back the origin of life into an epoch inconceivably beyond the most ancient geologic epoch now known.

In the same way, as other paleontologists have observed, among whom is Dr. Charles A. White, the extraordinary flora of the carboniferous epoch developed abruptly. We know nothing or but very little of the floras that preceded it. Its appearance and its extinction were sudden.

We might multiply these remarks relative to the abrupt explosions of creation in living things. Here is another. The dinosaurian lizards that abounded throughout the secondary epoch, forming, indeed, the dominant animal type, show an extreme variety taken from any point of view. There were some gigantic ones, like Brontosaurus, having a mass that was certainly equal to that of four or five elephants, others of small stature not larger than a domestic fowl. The group included carnivora and herbivora, aquatic species and terrestrial species, quadrupeds, and bipeds quite similar to birds, except as to the faculty of flight. By the variety of their types of organization they form, as aptly stated by Frederick A. Lucas, a sort of epitome of the class of reptiles. Now, their appearance and differentiation were comparatively abrupt and sudden phenomena. It does not seem probable that they were formed by the mechanism of natural selection and that they were destroyed because of their inferiority to other species in the struggle for existence.

We arrive at similar conclusions from an examination of the first placental mammals. They appeared abruptly at the beginning of the Tertiary period; they assumed a variety of forms almost as numerous as those of the mammals of to-day, and they finally disappeared.

Besides the paleontologists, many naturalists have pointed out the existence, in animals of our own time, of abrupt variations that produce a new type that becomes fixed as soon as it appears, and that has the value of a species distinct from that from which it was derived. Mivart and Huxley, Clos, Camerano, and Bateson have called attention to the existence of such discontinuous variations, which may afford an explanation of the discontinuity of species. Yet the greater number of the examples adduced by these authors may be referred to the category of monstrosities or teratogenic variations which have succeeded in becoming fixed. This is the case with species of Asterias having numerous arms, with crinoids having three or four divisions, with a certain number of levogyrate gastropods. However, abrupt transformations have been noted by entomologists under perfectly normal conditions. Standfuss, to whom we are indebted for some extremely interesting experiments on the heredity in butterflies, speaks of "explosive transformations," thus expressing the richness in new forms suddenly produced from a single parent stock.

III.

The origin of the new theory of Hugo de Vries must be sought for in this mass of observations, facts, and theoretical ideas relative to the abrupt variation of species in opposition to the Darwinian idea of slow variation. The Dutch naturalist has, in a manner, worked over all these ideas and codified them into a coherent system. This system already existed in embryo in the well-known little work which he published in 1889 on intracellular pangenesis. His views were, at that time, purely theoretical, for he had then only just begun his experimental verifications. Since then, however, some of his experiments have succeeded in an astonishing manner. To-day, therefore, it is the views that have been scrutinized and verified which the celebrated botanist presents to the scientific public in his work on the Theory of Mutation, recently published at Leipzig.

His doctrine consists, as might be anticipated from what we have said, in the denial of gradual transformation and the affirmation of abrupt transformation. Species in general do not enjoy that perfectly uniform and monotonous existence which has been assigned to them by naturalists of the school of Linnæus and Cuvier. Paleontology teaches us that they have a commencement and an end and that, during their term, they present periods of two kinds, periods of mutation and periods of equilibrium, times of calm and times of revolution. The observation of existing species confirms this view.

Ordinarily the principal "period of mutation" is found at the earliest stage of the species, at the time of its birth, but this is not absolute. However, the phase, or the entire group of phases, of plasticity, is more or less brief in comparison with the rest of its existence. It is only at these epochs that the living being is susceptible of mutations of a specific character; it is unchangeable for the rest of the time, that is to say, during the greater part of its term. Because of this the period of plasticity or of mutation usually escapes attention and we observe the greater number of species exactly at the moment when they have become really invariable—that is to say, susceptible only of those small, secondary, modifications which may, at most, conduce to the formation of varieties and races.

When, on the contrary, the species is in the period of mutation it offers an abundance of specific variations, distinct in character from the small, individual ones. They are, in fact, abrupt, clearly marked, permanent, fixed, and hereditary as soon as they appear, and the new forms are infertile when crossed on the parent stock. In a word they accomplish a transgression of the limits of a species.

Such is the new hypothesis of mutation. Before detailing the experiments on which it is founded, and furnishing the justification of its accuracy, it would be well to establish its signification, its scope, and its consequences.

This theory is a sort of rehabilitation of the idea of species. It does not, however, consider species as the fixed entity, the special and immutable category of the Creator's thought, conceived by the naturalist who followed Linnæus. It is truly a transformist doctrine; it admits the possible existence of an infinite number of species derived one from the other. Nevertheless it must not be denied that it confers on species an objective existence, a sort of reality that is foreign to the conception of the transformist school. "Species appear," says Hugo de Vries, "like invariable unities, such as are necessary in a systematic classification. Their existence is real, like that of individuals. A species is born, has a short period of youth during which it is subject to specific mutation, is maintained in an adult condition during a period which may be of great length, then finally disappears."

The doctrine of Hugo de Vries is opposed to that of Darwin in almost every point. The Darwinian theory has for its corner stone individual variation; the new theory, specific mutation.

Individual variations are progressive, usually guided by adaptation to the environment in a direction determined by the "survival of the fittest." They are continuous—that is to say, they are produced at all periods. Mutations are quite different. They are metamorphoses, not determined by adaptation; they are produced in various ways, without any direction; they are sometimes injurious, sometimes profitable, sometimes indifferent to the individual—they appear only at certain periods of the life of the species. Besides, both of these transformations occur from the action of causes which are determinate but whose nature is unknown. The first affect, more or less profoundly, all parts of the organism; the others affect in a special way the function of reproduction. In the Darwinian theory the first form is separated from that which differs from it specifically by a long succession of generations. According to Hugo de Vries the first form which engenders another, and, ordinarily, many others, coexists side by side with this daughter species. It is only after its formation that the latter enters into competition with the species from which it sprang, and circumstances decide which shall survive and which shall disappear. Here the struggle for existence and selection suppresses species but it does not create them. In brief, the most characteristic feature of mutation is that it is a manifestation of a physiological character, connected by special conditions with the function of reproduction.

In one point only the two doctrines agree, viz., that very marked differences in organization are the effect of the disappearance of intermediate links. In the case of mutation the new form, although quite markedly distinct from the parent one, does not necessarily show great divergence from it. Its differences may sometimes be anatomically very slight, although they are physiologically very marked, since they inhibit any crossing. Great morphological divergences always result, as in the theory of Darwin, from a series of repeated mutations. These changes are, however, crowded together in a time relatively short, since newly formed species are, at the very moment of their formation, in their phase of plasticity, in their crisis of mutation.

IV.

We have now to state the evidence in favor of this doctrine and the foundations on which it rests. We may count in its favor the advantage of its reconciling the transformist hypothesis, which is necessarily logical, with the immutability of species, which is, according to De Vries, a proved fact. It succeeds in doing this, as has been seen, by supposing that there is in the life of the species a period of crisis, so to speak—a temporary period of mutation which interrupts for a quite brief period the habitual invariability. In this it harmonizes with Darwin to a certain extent.

Hugo de Vries considers that the existence and invariability of species are facts supported by daily observation. He refers to the memorable experiments of Jordan and his followers, who made thousands upon thousands of sowings of vegetable species and never observed the passage of one into another—that is to say, a true vegetal mutation; they only obtained differences now classed under the head of individual variations. These, as is well known, are of such a nature that if we avoid artificial isolation, segregation, and selection, the forms revert to the primitive type. It is vain for transformism to deny this remarkable fixity and to replace it by an hypothesis of changes so slow, so minute, and so gradual that they become evident only after the lapse of centuries, and inevitably escape our observation at the moment.

Another fact that accords with the theory of mutation is the existence, in certain genera, of animals and plants of a great number of species that differ from each other but little anatomically. Botanists are aware that most Linnæan species are groups of living forms that are constant, hereditary, and usually infertile when crossed; that is to say, they are specifically distinct. Yet they differ so little in their aspect that many naturalists mistake them or confound them with each other. It would appear as if, at a given moment, in a crisis of mutation, the parent stock had become resolved into a multitude of secondary species which have persisted. For instance, the group of roses contains more than a hundred wild species so similar to each other that the most experienced connoisseurs make mistakes in their determinations. The thorn bushes, the willows, and the Alpine gentians are other examples of the same peculiarity, as are also the pansies and the sunflowers. In the animal kingdom many genera of insects present the same phenomena.

These, however, are merely agreements. H. de Vries has not contented himself with noting them; he has sought direct proofs of his hypothesis. The best one would be to find a plant that was actually in its period of mutation and that might beget, by means of seeds, a number of daughter plants in which there should abruptly appear the characters of a new species. We may readily apprehend the principles which would guide him in his researches. It would be necessary to experiment with genera of wild plants that have a large number of closely related species. Jordan has, indeed, established the fact that the greater number of wild species now found in Europe are specifically immutable. Yet it is possible that they may not all be so and that some may, at the present time, be undergoing a crisis of mutation. There would be more chance of finding such among the species that present a great many subspecies, this being a sign of plasticity leading to the presumption of mutation. H. de Vries, therefore, experimented with 100 plants that satisfied this condition—centauries, asters, cynoglossi, carrots, etc. He chose seeds from those which were distinguished by some peculiarity or deviation, like fissuration of the leaves, ramification of the spines, etc. He arranged for the sequestration of the plant as soon as the peculiarity appeared, and before flowering. In order to avoid hybridization he enveloped the floral beds with bags of transparent parchment and fertilized the flower with its own pollen. The greater number of his attempts failed. Only one fully succeeded, that which related to the onagra of Lamarck, the *Oenothera lamarckiana*.

This plant is well known as the biennial onagra, or ass's herb, brought from Virginia to Europe in 1613. It is a tufted, herbaceous plant about a meter in height, with simple leaves bearing some resemblance to an ass's ear, whence the name of the plant. It has handsome flowers, usually yellow in color. Its red tap root (red rampion) is edible. Introduced into Holland, it became acclimated and is cultivated there; it also grows there in a wild or uncultivated state, escaped from gardens and from cultivation.

One species of this genus, the onagra of Lamarck (*Oenothera lamarckiana*), was especially abundant around the little city of Hilversum. Now, in 1875 it was noticed that in this district this species showed unusual vigor and a remarkable power of multiplication and dispersion. Varieties were multiplied in profusion, and there was, therefore, reason to suppose that the plant was in its plastic crisis, in its period of mutation. H. de Vries cultivated it in his experimental beds at the botanical garden of Amsterdam, not for the purpose of favoring the production of organic forms by means of culture, but because by this means such forms could be preserved, aided, protected, and given more chances of maintaining themselves. These sowings were continued and the plants were observed during a period of fourteen years, from 1886 to 1900. In 1887 a new type made its appearance. In 1888 there were already two new species. In 1900, after eight generations, H. de Vries had obtained, from 50,000 plants produced from his several sowings, 800 new individuals belonging to seven undescribed species. There are, then, 800 individuals in 50,000 that are undergoing specific transformation. The activity of the mutation which this plant exhibits is, therefore, expressed by 1½ per cent.

The new species do not at all resemble the varieties of the parent stock. They appeared suddenly, without preliminary or intermediate forms. The care devoted to these experiments gives them a value which must attract the attention of naturalists. Their result furnishes a new and powerful argument in favor of the theory of mutation.

Lake Shore railroad officials have placed an order for seven thousand steel ties to be used as an experiment, probably near the eastern terminus of the road at Buffalo. Part of the order will be used on the New York Central, and if the results are satisfactory it is expected that a more general use of steel ties will be made by the Vanderbilt roads.

[Continued from Supplement No. 1509, page 24186.]

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

Another wheel in the same ditch is built on the same general plan, except the buckets are fixed rigidly

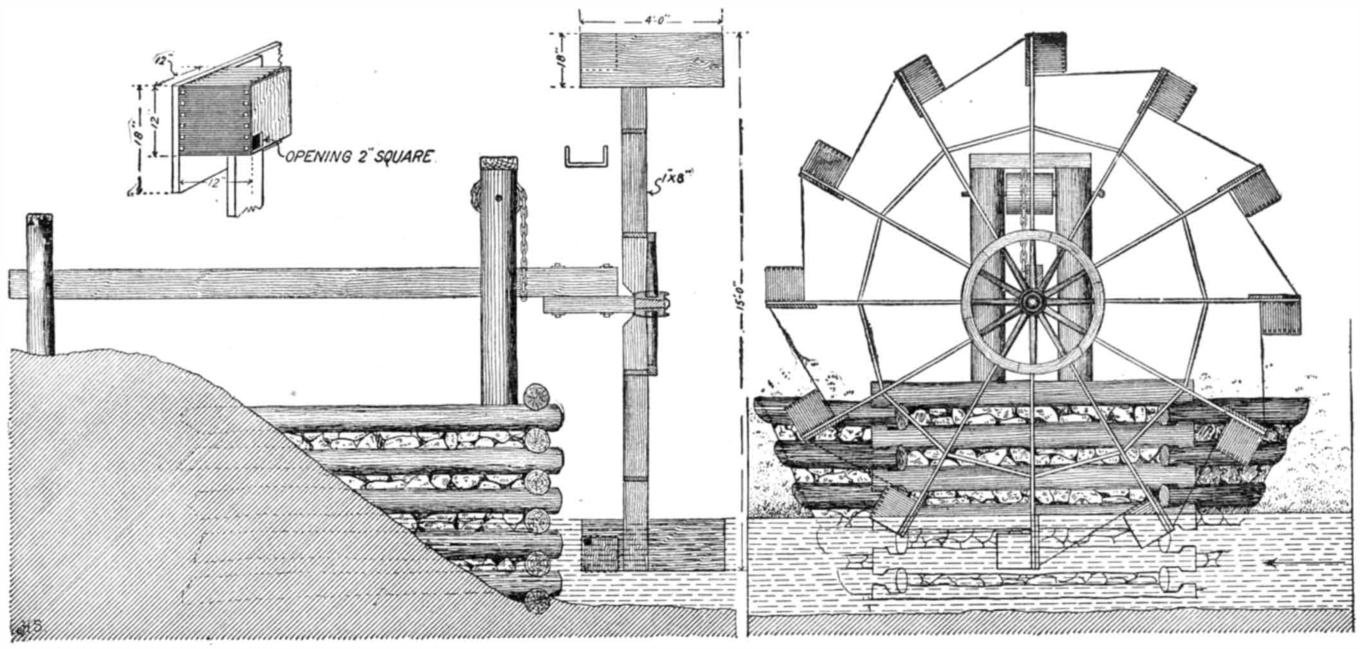


Fig. 9.—WHEEL ON SOUTH PLATTE RIVER, NEAR MOUTH OF BEAR CREEK, COLORADO.

in the rim. It is of less expensive construction, however, being framed from two buggy wheels with their rims removed, placed 3 feet apart on a shaft. The paddles, of ½-inch boards 6 inches wide, are nailed to the spokes. As before, rows of braces between the paddles form three stiff rims. The buckets are formed

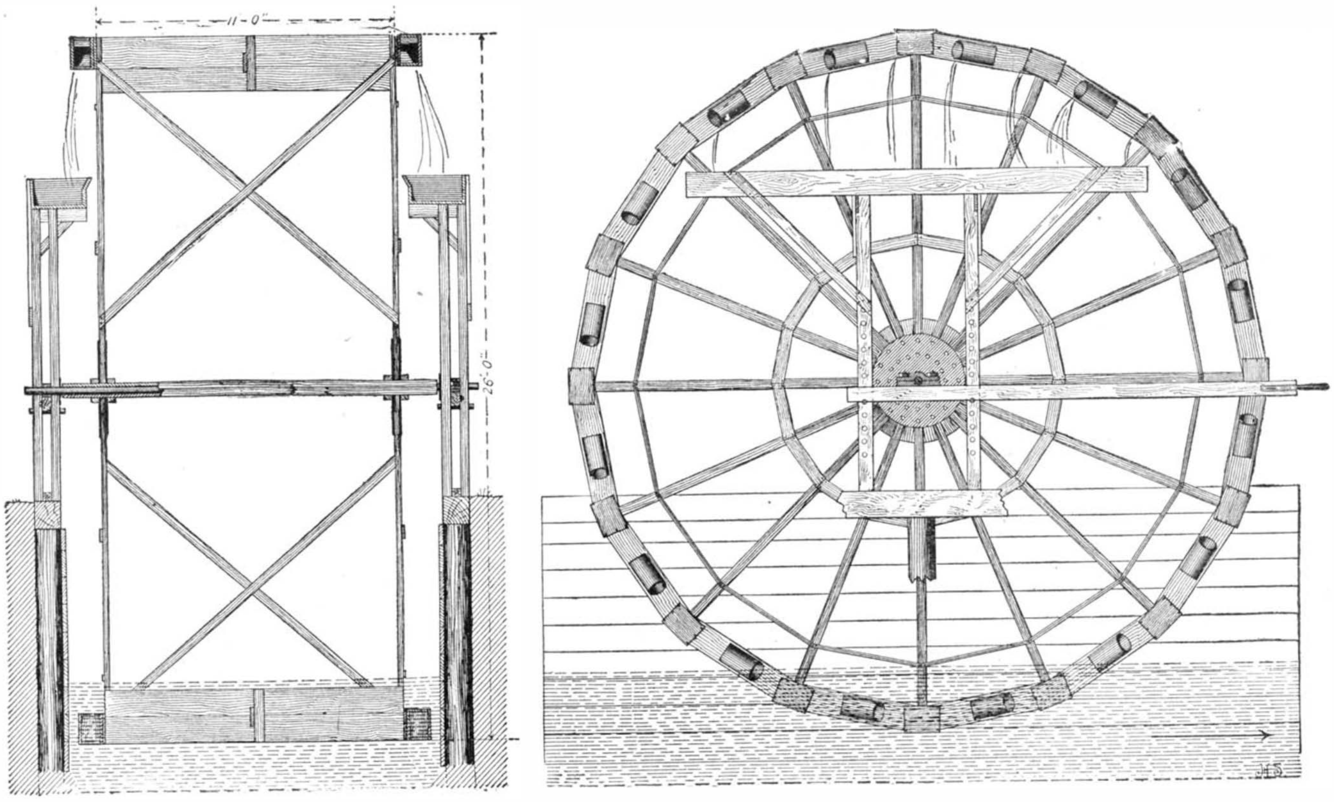


Fig. 10.—WHEEL ON YAKIMA RIVER, WASHINGTON.

by nailing sheets of tin to the inside and outside edges of the paddles so that the two rims form the ends and the paddles form the bottoms. The sheet of tin on the inside is cut narrower than the one on the outside. But for the fact that when the wheel is in motion the water tends to fly away from the center, nearly all the water would spill from these buckets before reaching the flume. For this reason a rather high velocity is necessary to make this wheel work well.

The cost of the wheel was given as $1.85, which is probably the cost of the shaft, tin, and nails. It was built by the gardener who uses it. It contains almost exactly the same amount of material as the wheel first described and, granted an indefinite supply of old buggy wheels, could be built for about half as much. But it cannot be made to raise the water quite so high, and, on account of spilling the water, is much less efficient than the first type. Its efficiency could be increased by slanting the blades, but not by increasing the load; because a high velocity is essential.

Each of these five wheels irrigates five acres in market gardens, an annual tax of $5 being paid to the ditch company by each gardener. The ditch has a very constant flow, so that there is always water enough to run the wheels. Since the water level changes so little, no device for raising and lowering these wheels is used.

A Big Wheel in Grand River Valley, Colorado.

A wheel in operation on the Grand Valley Canal, in Colorado, raises water 30 feet for the irrigation of forty acres of orchard. The wheel is 34 feet in diameter, the paddles being 8 feet long and 2 feet 8 inches wide. The spokes are secured at the center by means of castings and are set at such an angle to the shaft that they come to a point on the rim of the wheel, Fig. 2. To provide sufficient rigidity, a system of braces is adopted, making a very substantial construction. Braces are also run from paddle to paddle and between the arms of the wheel, so as to form a system of six or eight circular rims.

The buckets consist of long boxes made of 1-inch

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

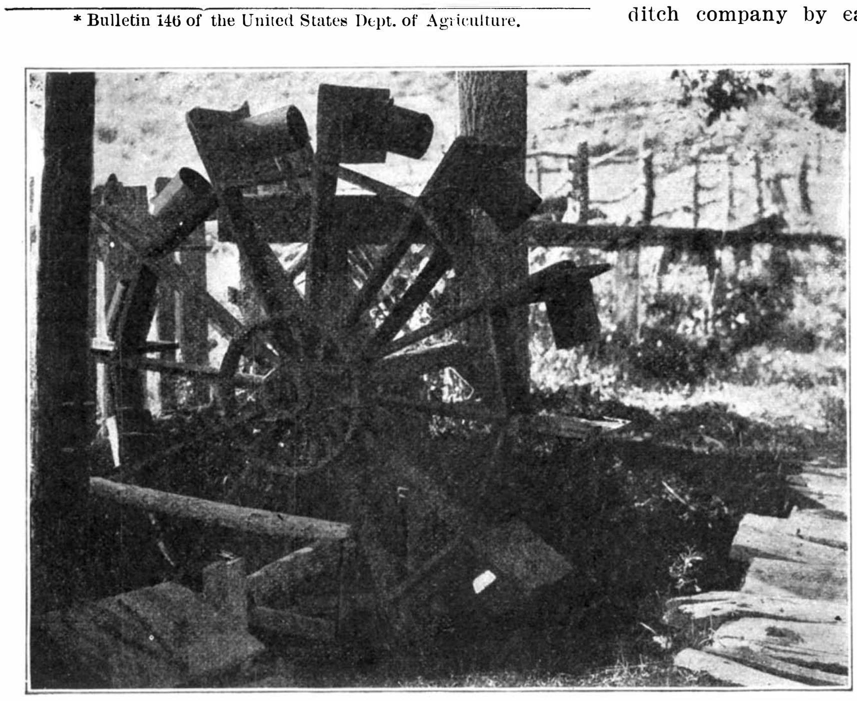


Plate II.—WHEEL NEAR MORGAN CITY, UTAH.

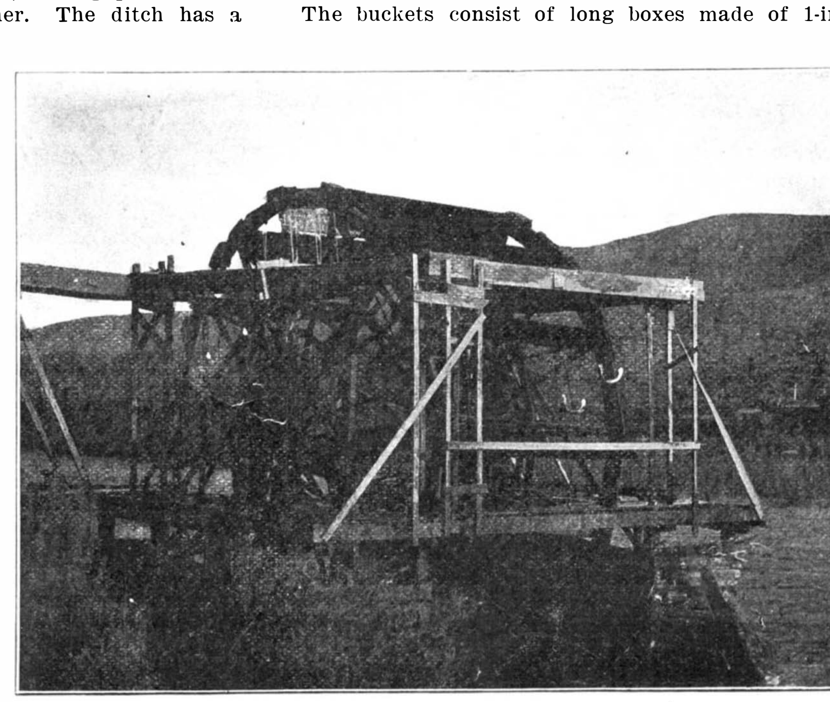


Plate III.—WHEEL ON YAKIMA RIVER, WASHINGTON.

stuff, set at such an angle on the rim of the wheel that they will fill nearly full and raise the water within 2 feet of the top of the wheel.

One interesting feature of this wheel is the method tried for adjusting it to the stage of water. The plan was to counterpoise the weight of the wheel, balancing it on two heavy supporting timbers. The adjustment was to be accomplished by means of a windlass, but, owing to the unexpected increase of weight which occurred when the wheel became water-soaked, the scheme was abandoned and the support was made rigid by additional braces.

The training flume for directing the flow of the canal against the paddles of the wheel is of somewhat unusual construction, Fig. 3. A flume with three channels was built in the canal, the wheel being set in the center; flashboards are inserted in the two side channels to control the flow. The effort to prevent the interference of floating matter with the action of the wheel, by means of a brush guard, as shown, is not altogether successful, owing to the fact that it checks the current to a considerable extent.

The quantity of water raised by the wheel was measured when all of the water was running through the center flume, and was found to be 0.36 cubic foot per second, which is the maximum capacity of the wheel. Under ordinary conditions, with the side channels open, it raised about 0.25 cubic foot per second. The wheel moved very unsteadily, being so heavily loaded that its motion was entirely checked each time a paddle entered the water, several seconds being required to back the water up to a sufficient extent to start the wheel. It turned over once in two minutes, having a rim velocity of about 25 per cent of the velocity of the water.

The cost of the wheel, which was built in 1895, was given as $400. It contains 1,750 feet of lumber and about 450 pounds of hardware, which together should cost not more than $90. The operating expenses are very low. The owner of the wheel is assessed by the ditch company at twice the usual rate charged the other users, with the stipulation that the water in the canal must not be appreciably checked. The assessment is usually about $2 per inch (38.4 Colorado inches equal 1 cubic foot per second).

Cheap Structures in Washington, Utah, and Colorado.

Need of Adjustment to Stage of Water.—A 6-foot wheel located at North Yakima, Wash., is shown in Fig. 5. It is heavily framed of eight 2 x 4-inch arms radiating from a 6-foot shaft of 5 x 5-inch stuff. The paddles are 1 foot wide and 6 feet long, each carrying a 1-gallon tin can on either end. These cans are nailed to a beveled seat, which tips them enough so that they are full or nearly so when they leave the stream. But even allowing that the twelve cans discharge their full capacity, the efficiency of the wheel when observed was only 9 per cent. This low efficiency is due mainly to the faulty design of the paddles. They are so wide in proportion to the size of the wheel, and they dip so deep in the water that the wheel wastes its energy in churning the water, both as the paddles enter and as they leave the water. The advantage of balancing a wheel of this size by placing buckets at both ends is probably too small to pay for the extra fluming required.

This wheel is nearly twice as heavy as the one first described, and it requires three times as much water to run it, yet it raises less water. It is very substantial and requires little attention. It cost $18. As it contains only 80 feet of lumber, it could easily be reproduced for less money, as its simple construction would require no special skill. Not being adjustable for high and low water, it runs to great advantage just when there is the best supply of water to operate it.

Cheap and Efficient.—Another wheel of the same design is small and well built, and, considering that it runs in a current moving only 1 foot per second, is remarkably efficient. It has a simple and effective device for raising and lowering the bearings, which is shown in Fig. 6. The buckets are all on one side and raise the water much higher than necessary to reach the flume. The wheel cost $13 and contains about 75 feet of lumber, including the supports but not the flume.

An Old Wagon Hub as a Basis.—An ingenious wheel installed in a ditch near Morgan City, Utah, is shown in Plate II. and in Fig. 7. It is built by inserting spokes of 1-inch material 3 feet long in an old wagon hub. The spokes are made rigid by two sets of braces. The paddles are 18 inches long and 8 inches wide, and the twelve buckets hold nearly one gallon each, being tilted slightly by wedge-shaped blocks placed beneath them.

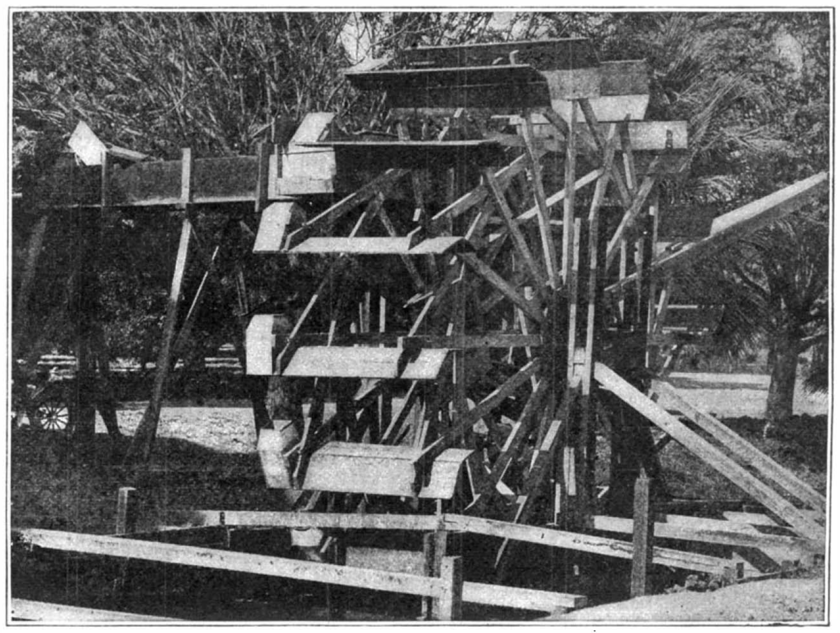


Plate IV.—WHEEL IN FANCHER CREEK NURSERY, FRESNO, CAL.

The shaft is supported on one side of the wheel only, being made fast to a tree at one end and resting on a post near the wheel. The wheel is but half the width of the ditch, a small gate closing the other half when the wheel is in use. This arrangement doubles the velocity of the water when the gate is closed and affords a means of regulating the amount of water raised. The wheel irrigates one-fourth acre of garden, and could be made to serve a much larger tract.

Irrigation for Twelve Acres of Orchard.—A very simple wheel is shown in Fig. 20. It is 14 feet in diameter with paddles 9 feet long and 2 feet 8 inches wide. It raises water 10 feet. The shaft consists of a 14-foot length of 1¾-inch gas pipe with four 2 by 8-inch pieces bolted around it for stiffness and to give a bearing for the arms. This gives the shaft alone a weight of over 300 pounds, or more than twice the weight of a 2-inch solid steel shaft the same length. The construction calls for 328 feet of lumber, but it could be built very much lighter without reducing its capacity. Its cost is given as $35. The lumber could be purchased for $8.50 and the galvanized iron for $3.50, making the cost of materials about $15, allowing for the gas pipe and bolts. The wheel raises 0.11 cubic foot of water per second, irrigating twelve acres of orchard and garden.

Buckets Made of Oil Cans.—A somewhat larger wheel in a ditch in the lower Natchez Valley, Washington, is shown in Fig. 8. It is 11 feet in diameter, having paddles 9 feet long and 14 inches wide. It raises water 7 feet. Part of the buckets are made of galvanized iron and part are made by cutting 6 inches from the bottom of 5-gallon oil cans. The wheel alone contains 328 feet of lumber. The method of bracing the arm is very effective. There are no data at hand for determining the efficiency.

Effective Use of Wagon Wheel and Axle.—An example of extreme lightness of construction in a 15-foot wheel is shown in Fig. 9, illustrating a wheel on the South Platte River near the mouth of Bear Creek, Col. It is built entirely of 1-inch lumber and an old wagon wheel. The arms are of 1 by 8-inch boards, and are braced by boards of the same dimensions about 2 feet from the outer ends. Baling wire connecting the outer ends of the arms helps to stiffen the wheel. The paddles are 4 feet long and 18 inches wide; the arms are not nailed in the centers of the paddles but a little toward one end, the longer parts of the boards serving to balance the buckets. The entire wheel contains about 85 feet of lumber and weighs scarcely 350 pounds.

Its most interesting feature is the method of hanging it and adjusting it to different heights of water. The wagon hub fits on its original bearing, half of the old axle being bolted to a 10-inch beam about 20 feet long. This beam is suspended between two posts set near the wheel, by a chain wound on a drum. The other end is free to move vertically between two smaller posts set as guides. The weight of the 10-inch log balances the wheel, and it can be raised or lowered easily by one man.

The velocity of the water was not measured, so it is not possible to get at the efficiency of this wheel. It raises 0.25 cubic foot per second 10 feet, which is five or six times the amount of work done by the small wheels of about the same weight.

A Contrast in Cost of Two Washington Wheels.—A much larger wheel than any of the foregoing is shown in Plate III., and in Fig. 10. It is in operation on the Yakima River in Washington. It is 26 feet in diameter, and the sixteen paddles are 11 feet long and 24 inches wide. It raises water 22 feet. In a wheel of this size and weight great strain comes on the center fastenings of the spokes. The heavy shaft and large cast-iron "rosettes" used in this wheel, with the wedges driven in between the arms, make it a model for rigidity and strength. The buckets of galvanized iron are placed on the outside of the rims and parallel to them, being beveled in such a way that they fill about two-thirds full and begin to spill when about 4 feet from the top of the wheel. Wooden buckets are also used, made as shown in Plate III.

The device for raising the wheel is shown in Fig. 10.

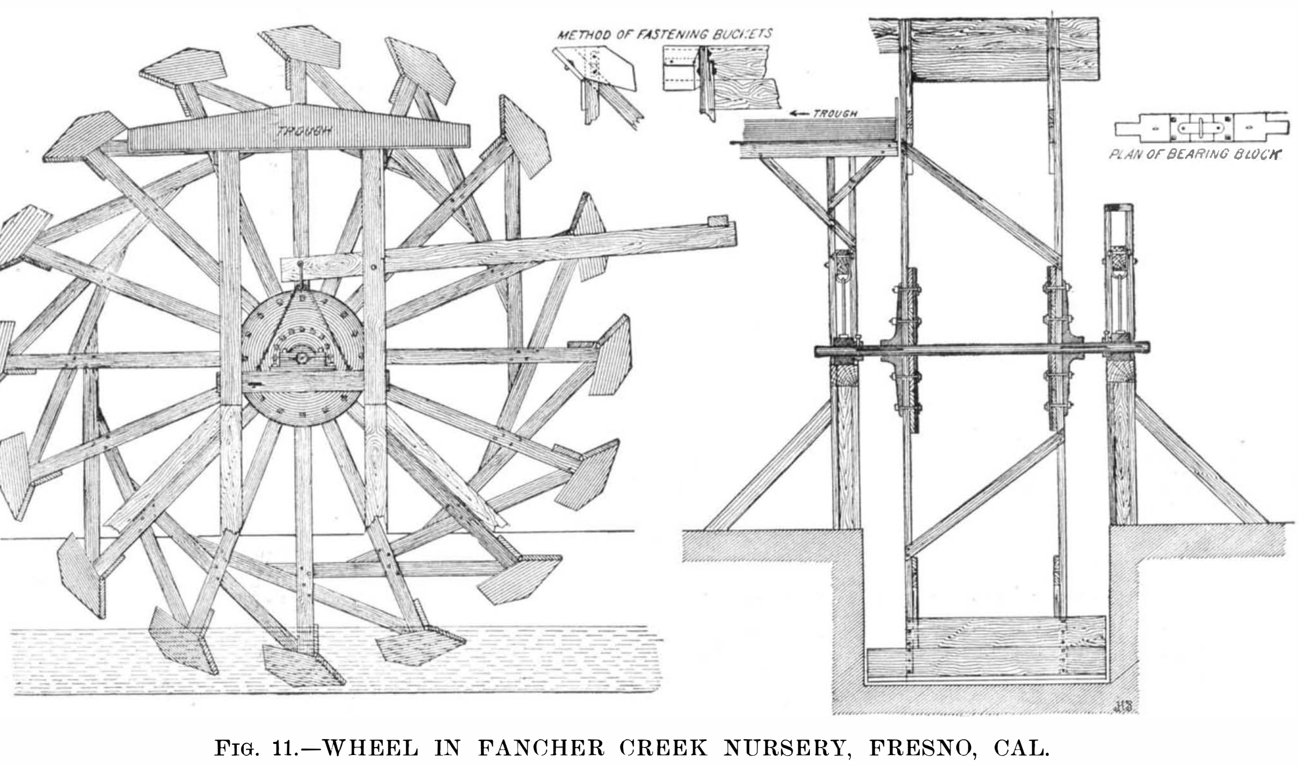


Fig. 11.—WHEEL IN FANCHER CREEK NURSERY, FRESNO, CAL.

Since the wheel weighs about 6,000 pounds it is evident that the lever will have to be rather long to make it possible for one man to adjust the wheel.

The materials used in the wheel are about 1,250 feet of lumber, 120 pounds of flat iron for the ties, a shaft weighing 260 pounds, 4 iron rosettes weighing together 200 pounds, 20 pounds of 3-inch bolts, and say 100 pounds of galvanized iron. Allowing 10 cents a pound for the iron and 50 cents each (13 cents per pound) for the cans, the cost for materials is $106 for the wheel alone. The cost was given by the owner as $600, this amount including the pier, platform, and fluming. In putting in large wheels it will usually be found that the cost of the wheel itself is a smaller item than the cost of a single crib pier for mounting it. The two cribs for this wheel were placed on a sandy bottom and rest on piles.

This large and expensive wheel irrigates but fifteen acres of fruit and alfalfa, making a total cost of $40 an acre for water. This heavy cost shows first that the advantage of a swift current may be largely offset by great expense for piers, and it shows also the rapid increase in the cost of irrigation, as the elevation of a piece of land above the source of water increases. The cost of materials for this wheel, disregarding the mounting of it, was about $7 for each acre irrigated, while the materials for the wheels described heretofore, which irrigated five acres each, cost a little more than $3, or say 70 cents per acre. In general, twice the height of lift means half as much water and usually four times as great cost for materials. Again, the annual repairs and cost of maintenance in the case of the small wheel were too small to reckon, while this large wheel requires $25 a year for maintenance and repairs, or nearly $1.70 per acre. So great is the disadvantage of a high lift that, unless the value of water for irrigation is very high, the building of large direct-lift wheels is not to be recommended.

There are two large wheels in the Columbia River at Ellensburg, Wash., which discharge into one flume, both being the property of one man. Though of the crudest construction, they irrigate forty acres of land. Their chief claim to interest is their great size, one 42 and the other 30 feet in diameter, and extremely low cost, one having cost the builder in cash $10 and the other $7.50. There is almost no iron work about them, the only money paid out being for nails and the lighter lumber. The heavy parts are built of drift logs and odd timbers. This low cost, as estimated by the builder, shows the difficulty in estimating the probable cost of reproducing any certain style of wheel. The necessary expenditure depends very largely on the ingenuity of the builder. The water is carried in two siphons under pressure to avoid a high flume. The upper flume was built on account of the great difficulty encountered in keeping the lower flume tight under a pressure of 30 feet. The pressure on the upper flume is about 12 feet.

Design by a Mining Engineer.

The wheel shown in Plate IV. and in Fig. 11 is in use in Fresno, Cal., for the irrigation of about twelve acres of shade trees and oranges. It is patterned after a design by a mining engineer, and is in some respects an admirable and efficient type of current wheel. It is 16 feet in diameter, raising water 12 feet. The stiff heavy rims found in most wheels are entirely absent, and instead a series of braces is used which cross the arms and support the paddles. Each paddle is made of two 24-inch boards set at a wide angle with each other. As is shown in the drawing, the angle is such that the paddle leaves the water in a vertical position, with no tendency to throw water.

The form of the buckets is also commendable. They are carefully designed to clear the bottom of the flume and the edge of the discharge trough, and to take in no more water than can be carried to the top without spilling. The entire construction requires 500 feet of lumber. The shaft is very heavy, 215 pounds, but not nearly so heavy as the two castings which, according to the drawing, must weigh 800 pounds each, making the entire wheel with the buckets weigh about 4,000 pounds.

The wheel is substantial, but is unnecessarily heavy and expensive. Admitting the necessity of a rigid center fastening, a disk of ¼-inch boiler iron would serve nearly every purpose of the heavy casting. This wheel could be reproduced the same size but made with 1-inch and ½-inch material, with an iron pipe for a shaft for less than half the cost. Under favorable conditions the Fresno wheel raises 0.5 cubic foot per second to a height of 12 feet. A lighter wheel would do more work.

(To be continued.)

The "Improvement of the Buffalo Water Works" is the subject of a valuable report by Mr. George W. Fuller, whose conclusions on the subject are as follows: The water of the lower end of Lake Erie, above the effect of the sewage of Buffalo and its suburbs, is safe for domestic use and satisfactory in every way except for its occasional turbidity. A new intake should be established, and all new work should be executed with a view to the eventual filtration of the supply. The enormous waste of water should be reduced at once. The necessity of a new supply is well shown by the fact that the typhoid fever epidemic last winter was largely due to the pollution of the water supply. The pollution was carried into the present intake by the undercurrents developed by the winds sweeping down Lake Erie. The change in the location of the intake which Mr. Fuller recommends will do away with the danger of this direct pollution.—Engineering Record.

Correspondence.

THE IONIC THEORY.

To the Editor of the SCIENTIFIC AMERICAN:

The first authentic account of the transmutation of metals is found in Suidas, a Byzantine author of the tenth century. In the fifth century, however, the Greeks who were living at that time in Egypt, were industrious seekers in the field of alchemy. Nearly all the genuine manuscripts found in many of the larger libraries of Europe come from Alexandria. The theory that the baser metals could be transmuted into gold or silver had many followers. There were many who believed in the theory, and many who even claimed that they had accomplished such a thing. In those times, when so little was known of practical chemistry, compounds were undoubtedly made which resembled gold and silver. As the knowledge of practical chemistry was limited, these newly-formed compounds could not be resolved into their component parts, hence they were very naturally considered as single elements; and as they resembled gold, and no means of differentiating them chemically from gold were known, it was only natural that the discoverers believed the secret had been found.

Jaffar, an Arabian scientist who lived in the eighth century, did not believe that the secret of the transmutation of metals had been discovered, but he did believe that such a thing was possible. As late as 1772 Schröder, a professor at Marburg and Wenzel, defended this theory. The articles of faith in which the alchemists believed are odd, and are here presented:

"1. There exists a preparation, solid in form and red in color, called the philosopher's stone, the grand elixir (*major magisterium*), the red tincture, which, when it is placed in very small doses on melted liquid silver, mercury, lead, or some other common metal, causes a transmutation of the same into gold. 2. The same preparation, used in very small doses as a medicine, cures all diseases, rejuvenates the old, and prolongs life; wherefore it is called the panacea of life, and since it contains the essence of gold, *aurum potabile*. 3. There is another preparation of a white color, called the stone of the second degree, the little elixir (*minor magisterium*), the white tincture, which is equal to the first in half a degree of perfection, and changes the common metals into silver."

The above sketch is given simply as an introductory, as it bears the closest relation to the subject of this article. The ionic theory is one which bears a direct relation to the transmutation of metals, and the discovery of the wonderful element radium by Prof. Curie and his wife has led to this new theory. The atomic theory, which is simply a bursted bubble if the ionic theory be true, is well known. The smallest particle of matter which can exist alone is called an atom, and these atoms of the same kind go to form metals or elements; for instance, an atom of lead can only form the metal lead, etc. The molecule is a combination of two or more of these atoms of like or of different character. This is the present status of the fundamental theory in chemistry.

Now the believers in the ionic theory hold that the atoms are composed of still smaller particles of matter, and that these particles, called *ions*, are all exactly alike. Hence the difference between an atom of Au and an atom of Pb is due simply to a difference of arrangement of the ions. There has been proven in the field of organic chemistry that certain compounds have the same chemical formulæ but are entirely different from each other in their physical, chemical, and physiological properties. This peculiarity has been called allotropism. Since the atoms act this way, why not the ions? Hence if the ionic theory is accepted, Au is simply an allotropic form of Pb, or of any other element, as we now call them. Then all matter whatsoever is composed of the same primary material.

We have been able to change atoms of like character or of different into different compounds. Thus O_2 is very different from O_3; HgCl is very different from $HgCl_2$. If such a thing is possible while atoms form molecules, why is not the same thing possible if ions form atoms, as they bear the same relation to atoms as atoms do to molecules, with the exception that ions are all alike, while atoms are not?

If there be no such things as ions, how is it that radium changes into helium under certain conditions? Can one metal change into another? It is possible that the change is brought about by a different, latent arrangement of the *atoms*. If this be true, then the ionic theory must be exploded for the time. O forms O_2 and O_3, two entirely different substances; this is due simply to allotropism of the same atoms. O_2 is O = O, while O_3 is

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If O acts this way, then it is possible that radium acts this way also. Radium may not *change* into helium, but the change may be due simply to allotropism. But if so, how account for the distinct color spectra that radium and helium give with the spectroscope? It is well known that each element gives distinct characteristics with the spectroscope, hence as radium gives one spectrum and helium another, and as radium gives the helium spectrum after its transformation, what can we conclude but that one element changes into another, and that the change is due to ions?

When the facts are known clearly, the ancients, as we dimly call them, knew a great deal more than we give them credit for; not so much in a practical way, but in a theoretical way, and to what does theory lead but to practicality? They thought that the baser metals could be changed into gold. A few years ago this idea was forgotten, or if remembered, it was ridiculed by all. Now there are many thinking men and scientists who believe the same theory, but the majority are not brave enough to say so. Or they remain quiet for the reason that they have learned and held to the atomic theory, and they would have to learn theoretical chemistry all over again, were the ionic theory proven true. We have gone backward to the theory of the ancients, but who knows but that it will be the cause of our going forward?

The elixir of life, which we have seen in the articles of faith of the alchemists, is being sought for even. It is a well-known fact that noted observers have made the statement that old age is due to bacteria; if this be so, then it is very possible that an antitoxin will be found, and this would be analogous to the philosopher's stone sought for so earnestly but vainly.

Noted men have hooted at the ionic theory, but noted ones have thought seriously of it. No matter what men say, there are certainly good grounds for believing the statement of the alchemists concerning the transmutation of metals, and though we may not be on the right track now, who knows what the future will bring forth? Things fully as wonderful have happened and are happening.

ALBERT R. HALLEY, M.D.

Nashville, Tenn., November 5, 1904.

MAN-TRACKING.

By STANHOPE SPRIGG.

THE men who breed bloodhounds are always puzzled by one problem. Whenever any mysterious crime occurs that baffles the most keen detective intelligence there is at once a demand from the public that bloodhounds should be sent for and put on the track of the missing fugitive. On all other occasions the interest in bloodhounds is practically confined to some fifty persons in England and Scotland, who have formed themselves into an Association of Bloodhound Breeders and a Bloodhound Club, and who are everywhere faced by the most extraordinary apathy as to the practical everyday virtues and qualities of their pets! How is this?

This hound with the dreadful name has played a prominent part in history from the very earliest times. Years ago, for instance, he was put upon the track of Dick Turpin, and that hero of half-penny fiction only escaped by a plunge into Epping Forest and a discreet retreat high among some trees. Sir Edwin Landseer, too, did his best for this breed. As everybody knows, one of these hounds forms the principal character in his celebrated picture, "Dignity and Impudence."

More than that: who does not recollect the doughty deeds attributed to bloodhounds in slave-hunting tales of the last generation—in "Uncle Tom's Cabin" and similar works?

It is said by experts, it is true, that the hounds used during those troublous times for slave hunting in the Southern States of America, although called bloodhounds, were not bloodhounds at all, but merely the foxhound of the country oftentimes crossed by the Cuban mastiff, or (as it was occasionally called) the Cuban bloodhound, and was more like an inferior Great Dane than anything else.

But what of that? The glamor and the excitement of those records remain in our minds; and to-day it seems extraordinary that the active-minded, dog-loving Englishman has not turned his early knowledge of the sport obtainable from these hounds to better effect.

A clever schoolmaster wrote to me only the other week and begged me quite earnestly to advocate the purchase and training of bloodhounds by young people. Undoubtedly, as he pointed out, excellent sport and exercise could be enjoyed by schoolboys by this means; and the advantages of bloodhounds in this connection are (1) that a couple would be sufficient, and (2) that humanitarian faddists would not be alarmed, as in the case of the beagles at Eton.

Indeed, it is wholly a mistake to suppose that bloodhounds are averse to their work of man-tracking, or are in any sense ferocious. As a matter of fact, indeed, they have remarkable natural qualifications for the work of man-hunting; for not only have they great speed, great scenting powers, and (unlike the foxhound) strong perseverance on an original line, but they have a natural enjoyment of the pursuit of man. Lord Cardigan suggests that this last leaning of theirs has been transmitted to them through a long line of criminal-hunting ancestors; and most people who have seen bloodhounds frequently at work find it hard to give a more reasonable explanation of the zest they throw into the chase.

Luckily, this zest does not degenerate into license; and although popular manuals may tell us "that the only chance for man or beast hunted by them is to take to the water—to start to jump three or four feet off the water's edge, and to leap far and fairly in," it does not follow that they will tear their prey limb from limb when he is caught. No. The tracking once at an end, they take little interest in the object of it, save to sniff him to assure themselves that they have got the right man.

Admittedly there is one drawback to the general use of bloodhounds as a means of sport. That is their present-day scarcity and consequent expense. Only quite moderate puppies can be procured at five guineas; and these run a great risk of dying from distemper, although, with that exception, they are hardy enough. Occasionally, too, adults may be picked up at seven guineas each; but they are as a rule indifferent specimens, and there are not many to be had at that price.

Apart from this, the acquisition and training of bloodhounds present few difficulties to men who, with a love for sport, can remember that kindness, firmness, and patience are the three most necessary attributes for teaching bloodhounds. Mr. Edwin Brough, the famous breeder, holds that it is quite practicable to give hounds short preliminary lessons in man-tracking at three or four months old, but adds:

"The more easy things are made for them at first the better; and they should not be allowed to tire themselves. For the first few times it is always better to let them hunt some one they know; but when they once 'get their heads down' properly, it does not matter how often the runner is changed. This man, however, should caress and make much of the pups, and let them see him start, but should get out of their sight as quickly as possible, and run, say two hundred yards up-wind on grass-land in a straight line, and then hide himself. The one who hunts the pups, too, should know the exact line taken, and take the pups over it, encouraging them to hunt until they get to the runner, who should always reward them with a bit of meat."

Mr. Brough and the men who have done the best work in England with bloodhounds (Mr. Croxton Smith of The Gentlewoman, for instance) do not believe that much use can be made of bloodhounds by the police at present in towns, but contend that in rural districts they are most valuable but neglected agents. They say that in cases where a well-trained, reliable hound can be procured within a reasonable time, and where he can be laid on a line which has not been foiled for a few yards, capture ought to be "pretty certain." Thus, in establishments like the penal settlement at Portland, at reformatories, and at asylums where the inmates make spasmodic bids for freedom, bloodhounds would bring more escapes to a quick and effective termination than telephone or telegraph.

Mr. East, of Chislehurst, who keeps the only pack of bloodhounds in England, and regularly hunts them one day a week in Hampshire, also urges that gamekeepers particularly ought to train and to value bloodhounds; and, in support of this, he tells a curious adventure of his own. One day a friend came to him while the pack were out, and complained bitterly of some recently discovered depredations of poachers. More in jest than earnest, Mr. East took his pack on the scene of wholesale robberies, and, to the general surprise, the hounds gave voice almost immediately, and ran the line at once to the next estate, to the front door of the head gardener's cottage.

It is also contended that most country-house dinner jewel-burglaries and hen-roost robberies could be traced with peculiar facility by the agency of bloodhounds. At all events, there is that well-known instance where Mr. Mudie's bloodhounds were requisitioned in the case of a poultry robbery, and promptly carried the line to an encampment of gipsies, where two men were arrested and confessed to the theft.

Bloodhounds, however, have not always been well served by the people who were thought to be their best friends. That is why separate bloodhound organizations exist—the Association and the Club; and they differ vitally as to the standard of the ideal bloodhound, and whether the hound ought to be used as a pack-hound at all. The consequence has been that, in their last report, the Association of Bloodhound Breeders urged, with quite uncommittee-like warmth, that "a bloodhound must be judged as a workmanlike hound, showing the points which indicate those properties which are the special attributes of the breed." Thus, "while fully recognizing that bloodhounds hunted in packs are capable of affording good sport, the committee consider that if such a practice became common it would tend to do away with the special style of man-hunting, which is one of the chief characteristics of the bloodhound."

Hence "the most desirable qualities in a bloodhound are abnormal scenting powers, freedom from change, individual perseverance, and reliability; therefore, the more he is trained as a pack-hound the more certainly will those special qualities of his, characteristics which have been jealously guarded for centuries, be lost."

As far as the general public are concerned, this protest, if correct, will find a very hearty echo. Although, as I have already pointed out, their knowledge of bloodhounds is really of the vaguest and flimsiest, sportsmen would assuredly be most loath to see the canine man-hunter become merely a stock accessory of the detective novelist and sensational journalist, or revert to a type of foxhound utterly incapable of individual initiative or effort.

At the same time, they ought to ask themselves quite seriously whether the time has not come for them, as patriotic citizens, to take a fair hand in this game of training man-hunters for public use, in addition to the regular breeders. They need not all be like Mr. Brough, who wrote to me the other day: "In my experience of thirty-three years, I find that the more you get to know of bloodhounds the more you find there is to learn, and the less inclined you feel to commit yourself to cold black and white."

Even Mr. Brough anathematizes the ignorance of the police, who on one occasion, when a shop in an important thoroughfare in the East End had been robbed in the early morning, sent for bloodhounds the following afternoon, although the shop had been crowded with customers for some hours.

After all, with a little knowledge and patience, a lot of excellent sport can be got out of bloodhounds. As Lord Cardigan has pointed out on several important occasions, they give pre-eminently "a sport unconnected with bloodshed or any inconvenience to the quarry, which affords plenty of exercise, can be undertaken with no more expense than the purchase and maintenance of one or two hounds, inflicts no damage on crops or fences, and yet supplies unlimited opportunities of watching fine hound work." More than that, in a case of crisis, even the perpetrators of serious crimes might be run down by an amateur who simply went in for man-hunting as a private hobby of his own.—Chambers's Journal.

ELECTRICAL NOTES.

The Naval Observatory will again send out time signals on the night of December 31, and will send them around the world. Four different dispatches will be sent, one at midnight and others at 1, 2, and 3 o'clock. Last year the signals traversed about 300,000 miles of wire and were heard in Alaska, Panama, Valparaiso, Buenos Ayres, Honolulu, Guam, and Manila. This year it is the intention to transmit the signals literally around the world, which will be possible by the co-operation of the telegraph and cable companies. Lieut.-Commander E. E. Hayden, United States navy, in charge of the time service of the government, has proposed that advantage be taken of important meetings in Washington, such as that of the International Railway Congress in 1905, to offer to send out to the world, as far as the telegraph and cable will carry them, a special series of time signals, in celebration of the meeting, and to invite to the observatory such members as care to be present to see them go out. It is also recommended that an effort be made to collect and publish as complete data as possible regarding the kind of time in actual use in various countries in the world.

It is well known that some types of carbon-filament glow lamp, when worked at constant voltage, slightly increase in candle power for the first 50 hours or so of their life. After that time a stationary period is reached, and then a progressive drop in candle-power takes place. The initial rise in candle-power is due to a gradual consolidation in the filament with use, which reduces its resistance; and the subsequent decay in candle-power is chiefly due to the deposit of carbon upon the bulb. The surface of an ordinary 16 candle-power incandescent lamp is approximately equal to that of a sphere three centimeters in radius, and may be taken roughly as 120 square centimeters. Accordingly, an ordinary small-bulb incandescent lamp is not very suitable as a standard lamp. The writer found, however, by inclosing the filament in a bulb of much greater diameter, say in a cylindrical bulb twelve centimeters in diameter and twenty centimeters in length, giving a total bulb surface of nearly 800 to 1,000 square centimeters, the deposit of carbon upon the bulb was greatly diminished; first, because the glass is further removed from the filament, and, therefore, the chances of a carbon molecule getting on to the glass are reduced; and, secondly, because the carbon that is deposited is spread over a much larger area of glass, so that its effect in interfering with the passage of light is greatly diminished. Again, it was found that by subjecting the carbon filament to a certain process of ageing in another bulb before transferring it to the large bulb, the rise in the resistance of the filament was, so to speak, anticipated. Accordingly, lamps were made to the following specification: Well-selected carbon filaments of the single-loop type of 10 candle-power or 16 candle-power were aged and adjusted to an efficiency of 3.5 watts a candle. These filaments were then transferred to large cylindrical bulbs of very clear glass and finished in the usual manner.

Such a large bulb-lamp may be called a photometric lamp. A mark is placed on the glass or on the collar of the lamp in such a position that when the lamp is mounted in the photometer with this mark facing the photometer disk, the axis of the lamp being vertical, the plane containing the horse-shoe filament is perpendicular to the line joining the lamp with the photometric disk. Each standard lamp is marked with the voltage at which it will give a certain candle-power in the above-mentioned direction and position. A lamp is then used as follows: Assuming it to be marked, say, 16 candle-power at 98 volts, the lamp is placed in the photometric gallery at a distance from the photometer disk of 4 feet—viz., the square root of 16—and by means of a potentiometer and variable resistance, the electric pressure on the terminals of the lamp is adjusted to be 98 volts. In these circumstances the illumination on the photometer disk is one candle-foot. This is balanced by placing on the other side of the photometer disk another incandescent lamp worked at about the same watts per candle, the distance of this last lamp (called the comparison lamp) being adjusted until a photometric balance is obtained. The standard lamp is then removed from the photometer, and its place is taken by any lamp the candle-power of which it is desired to ascertain at a certain voltage. The voltage having been adjusted, this last lamp is then moved to or from the photometer disk until it photometrically balances the comparison lamp. Let us imagine that it balances the comparison lamp at a distance of 50 inches. The candle-power of this last lamp is then equal to 17.36 candles, being to the standard lamp in the ratio of the square of 50 to the square of 48. Such an operation has been called by the author a "photometric double weighing," because it resembles the process by which the exact weight of an object can be ascertained by means of good weights with an imperfect balance. By following the above method no want of symmetry in the photometer vitiates the process of measurement, neither are we concerned with the exact value of the comparison lamp so long as it remains constant during the experiment. All that we are concerned with is the exact value of the standard lamp used for setting the comparison lamp, and with the ratio of the distance of the standard lamp from the photometer disk to that of the measured lamp. Hence, if the distances are correctly measured, we have the exact ratio between the candle-power of the standard lamp and that of the lamp being measured.

ENGINEERING NOTES.

A rumor obtains in British naval circles, and is believed to be well founded, that the Admiralty have decided to abolish the 4.7-inch and 6-inch guns in the navy, and to substitute for them the 9-inch gun. Exhaustive experiments have recently been made with this weapon, and results of the trials have, it is said, given the greatest satisfaction to the authorities, the penetrative power of the 9-inch gun having proved far greater than that of the smaller weapons. Hence the decision to which, it is said, the Admiralty have come.

The Knapp roller boat is to be remodeled into a coal carrier for service between Lake Erie ports and Toronto. The craft was constructed in the shape of a huge cigar, with the cabins for the use of passengers suspended inside the steel shell. It was intended to have the boat propel itself by rolling along the surface of the water, a series of fins extending in spirals about the hull, converting the whole ship into a huge screw. In remodeling the boat steel ends will be put in. The top will be cut open and deck houses and a pilot house built above the line of plating.

The mileage of the German standard gage railroads was 26,637 miles at the end of 1892, and 32,242 at the end of 1902, an increase of 21 per cent. Of the mileage in 1892, 24,145 miles, or 90.6 per cent, were state railroads, and 2,492 miles, or 9.4 per cent, were private roads, while in 1902, 29,394 miles, or 91.2 per cent, were state railroads, and 2,848 miles, or 8.8 per cent, private roads. In 1892, 15,543 miles, or 73.4 per cent, were main lines, and 7,094 miles, or 26.6 per cent, were local lines. In 1902, 20,284 miles, or 62.4 per cent, were main lines, and 11,958 miles, or 37.1 per cent, local lines.

The Great Central Railway, whose main line runs from London to Liverpool *via* Nottingham, has taken the initiative in substituting a large and durable style of freight car for the relatively small and frail kind which is now in general use on British railways. One of the new cars has just been finished for the Great Central Railway Company, and the others to be built will be of the same size and character. It is 41 feet 2¾ inches in length, 8 feet 3 inches in width, and 8 feet 8 inches in height—much the largest freight car ever used in Great Britain. It is constructed entirely of steel, has a capacity of at least 40 tons (of 2,240 pounds), and is equipped with specially designed buffers, in view of its great weight. In addition to an effective "either side" hand brake, the car is equipped with the automatic vacuum brake power, so that, when necessary, it may be hauled at passenger-train speed. The car has a "tare" weight of only 14 tons 19½ hundredweight (33,544 pounds), while its carrying capacity of not less than 40 tons is about four times greater than that of the present standard car used on the railways of Great Britain.

The use of petrol engines, which have been adopted to a large extent on small pleasure and racing craft, is now being extended to boats of larger size. In France several fishing boats have been equipped with this type of engine, and have proved very satisfactory. One of these boats, having a length of 118 feet, a breadth of 26 feet 9 inches, a depth of 14 feet 4 inches, and a tonnage of 209, is fitted with an engine having four cylinders, which, when working at 300 revolutions, develops 240 horse-power, and gives the boat a speed of 8½ knots. There is an additional petrol engine of 40 horse-power for working capstans and manipulating the nets, etc., as well as for driving the air compressors which supply the air for starting the main propelling engines. Heavy oil is used, with a tube ignition, and most manual labor is dispensed with, the engines letting down and heaving nets, trawling, raising and lowering masts and sails, dealing with cargo, etc. The consumption of oil is only 18½ ounces per horse-power per hour, and this at Boulogne works out to six-tenths of a penny per horse-power hour. This is the mean result over a season's working.

Appearances are of value, even in engineering works. The story is told, and this journal has it at first hand, of certain sewage precipitation works, situated on the earth, that once upon a time they were visited, without previous announcement, by a committee of a department of the city government at the instigation of certain disgruntled citizens. Now it happened upon this fateful day, as it had never happened before, that on account of delays of shipments of lime from the kilns, there was not a pound of lime left in the storehouse that afternoon, and so for a half day the sewage passed through the basins without receiving the usual dose. Notwithstanding this untoward circumstance, because the plant had been making good records day after day, and was so well kept up and so spick-and-span in all its parts, the committee went away deeply impressed with the efficiency of the plant and highly pleased with all they had seen. It is only fair to add that the success of the inspection was due in no small measure to the skill and engaging manners of the analyst at the works, who conducted the party about.—Engineering Record.

TRADE NOTES AND RECIPES.

Antiseptic Enamel for Brewers' Utensils.—Same consists of a solution of spirituous gum lac, rosin, and copal, with addition of salicylic acid, etc. Its purpose is mainly the prevention or removal of mold or fungous formation. The salicylic acid contained in the mass acts as an antiseptic during the painting, and destroys all fungi present.—Deutsche Brauer Zeitung.

Process for Preserving Pictures.—Oil paintings, aquarelles, etc., are coated with a thin layer of Canada balsam, and placed smoothly on a pane of glass likewise coated with Canada balsam, so that both layers of balsam come together. Then the pictures are pressed down from the back, to remove all air bubbles.—Maler Zeitung.

Paris Salts.—The disinfectant known by this name is a mixture made from the following receipt:

Zinc sulphate	49 per cent
Ammonia alum	49 per cent
Potash permanganate	1 per cent
Lime	1 per cent

The ingredients are fused together, mixed with a little calcium chloride, and perfumed with thymol.—Seifensieder Zeitung.

Burnt-in Designs on Light Wood.—A very old process of decorating wood is to burn in the design with needles of different shapes, whereby quite artistic effects may be produced, and which only requires little practice and a steady hand. The clean smooth surface of light wood is rubbed down well, and the design sketched on lightly or pounced on, so that the plate does not get soiled. Now a steel needle, which has been provided at the end with a covering of horn or wood, is made red hot over an alcohol flame. With this needle the sketch is worked, so that the design becomes burnt in and fixed. If it should be burnt in too deeply in places, the spot is rubbed with fine glass paper.—Maler Zeitung.

Watchmaker's Oil.—1. Put some lead shavings into neat's foot oil, and allow to stand for some time, the longer the better. The lead neutralizes the acid, and the result is an oil that never corrodes or thickens. 2. Stir up for some time best olive oil with water kept at the boiling point; then after the two fluids have separated, decant the oil and shake up with a little freshly-burned lime. Let the mixture stand for some weeks in a bottle exposed to the sunlight and air, but protected from wet and dirt. When filtered, the oil will be nearly colorless, perfectly limpid, and will never thicken or become rancid.—Deutsche Uhrmacher Zeitung.

Harness Jet.—The Farben Zeitung gives the following formula: Best glue, 4 ounces; good vinegar, 1½ pints; best gum arabic, 2 ounces; good black ink, ½ pint; best isinglass, 2 drachms. Dissolve the gum in the ink, and melt the isinglass in another vessel in as much hot water as will cover it. Having first steeped the glue in the vinegar until soft, dissolve it completely by the aid of heat, stirring to prevent burning. The heat should not exceed 180 deg. F. Add the gum and ink, and allow the mixture to again rise to the same temperature. Lastly mix the solution in isinglass, and remove from fire. When used, a small portion must be heated until fluid, and then applied with a sponge and allowed to dry on.

Iodine Soaps.—The following medicinal soaps do not discolor the skin, unless used very strong, and then the stains can be removed with ordinary soap:

1. A soap-paste soluble in all solvents except fatty oils.

	Pounds.
Iodine	15
Oleic acid	15
Alcohol	10
Strong ammonia	4

2. A soap soluble in oil.

Iodine	30
Oleic acid	60
Ammonia	10
Paraffin oil to consistency.	

3. Glycerine-iodine soap.

Iodine	30
Oleate of ammonia	30
Alcohol	130
Glycerine, quantity sufficient.	

—Augsburg Seifensieder Zeitung.

Production of Hectographs.—Soak 650 grammes of best glue for eight hours in 1 liter of water, preferably suspended from a string; then boil. When the glue is completely dissolved pour in 650 grammes of glycerine, and allow the mass to boil at least four hours. After the froth which forms during the boiling has been removed, the mass is poured in a box of zinc-plate about 50 centimeters long and 35 centimeters wide, the edge being 3 centimeters high. Allow to cool off twelve hours, after which time the plate can be used. Copying ink for this: Put some aniline violet in a glass about 4 centimeters high and 2 centimeters in diameter, filled with hot water, to which a little sugar is added. Whitish hectograph mass: Take one part glue or gelatine boiled in water, and stir into this a sufficient quantity of lithopone or permanent white. Then add as much glycerine as glue or gelatine had been used. When the mass is cold, it must be as firm as pure gum elastic of the softest variety. Repairing hectographs: Instead of remelting the hectograph composition, which is not always successful, it is recommended to pour alcohol over the surface of the cleaned mass and to light it. After solidifying, the surface will be again ready for use.—Papierzeitung.

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