at the World's Fair, and at right angles with the shore of Lake Michigan.

It was designed originally for the easy and rapid carriage up to the entrance of the Exposition, properly so called, of the numerous travelers who should arrive by Lake Michigan and land upon the wharf. Experience showed that there was little foundation for such anticipations, for it required but a small number of landings to receive the passengers, even on the busiest days. The utilization was, therefore, transformed. The means of effective carriage became for the visitors a means of agreeable and refreshing locomotion, which was highly appreciated during the summer, when the heat rendered the galleries almost unsupportable. There was nothing more delicious, and we have experienced it, than to pass an hour in being carried without jolts and almost without noise by this original means of locomotion, seeing the panorama of the White City unroll before one's eyes, sheltered from the rays of the sun by an awning and refreshed by the breeze from the lake or that produced by motion forward.

Our description would not be complete if we confined ourselves to the purely experimental movable sidewalk that we have just presented to our readers. The aims of the Multiple Speed and Traction Company, of Chicago, are more ambitious. It proposes, in order to remain faithful to its title, to employ systems with three, four and even five platforms, the latter to attain speeds of 6, 9, 12, and 15 miles an hour, with seats provided in each case for one, two, three or four passengers. The power of vehiculation would then reach unexpected proportions. Thus, with four open carriage platforms, and seats for four persons, there would pass no less than 84,480 places per hour at a given point. Such provisions exceed what will be needed for a long time to come. In more limited proportions, in confining one's self to a two-platform system with a single longitudinal seat, the number of seating places offered would exceed 10,000 per hour. A similar project has been studied for State Street, one of the most frequented thoroughfares of Chicago (Fig. 3). In this project the ascending and descending track are arranged parallel at the edge of each sidewalk, one on one side and the other on the opposite side of the street. Each rests upon a system of pillars, of which the aspect appears quite unsightly, but which lend themselves happily to modifications from a decorative point of view. The stationary platform, which the passengers reach by means of stairways properly distributed at the street crossings, is about 5½ feet in width, the low speed platform 32 inches and the high speed 5½ feet. As the lateral seat, which extends all along the movable sidewalk, occupies scarcely more than 24 inches, there remains in front of the persons seated a space 32 inches in width, quite sufficient to allow the passengers to reach the parts of the seat where it is unoccupied, if, in consequence of a false maneuver, they have entered the full-speed platform opposite places already occupied.

Transverse bridges are likewise provided to allow of access from the second story of houses.

At a speed of six miles an hour, and supposing a width of 24 inches per place, there would pass at any one point 16,000 sitting places per hour, and, in case of urgency, a larger number of places disposable, provided that the bolder travelers consented to remain standing.

However this may be, the movable sidewalk of the World's Fair has been a technical success, and also a success as regards curiosity. It is our conviction that such a mode of locomotion, established as an aerial line upon the wharves of the Seine, the down track on one side and the up track on the other, would constitute one of the surest attractions and one of the most effective innovations of our Exposition of 1900, in awaiting an elevated railway that we are ever hearing spoken of, but which we never see realized.—*La Nature*.

IMPROVED DUMPING CAR.

AMONG the Columbian Exposition exhibits was the Thacher compressed air dumping car which we illustrate, patented in 1889, and used in Colorado in the mines. It handled the material so cheaply that in 1892 a company was formed to build the cars for handling gravel, broken stone, ores, coal, etc., and, for the short time that the company has been formed, they have met with success. Our engravings and the following particulars are from *Engineering*. The first cars built were small and used on narrow-gauge roads, but all the late cars are standard gauge and hold 9 cubic yards, or 40,000 lb. The working parts are simple and cheap, and easily kept in repair. In the building of the cars, the makers have adopted the standards of the Railway Master Car Builders' Association.

It will be seen that the car body is pivoted on its center line, so that a small effort will tip it. Two 1½ in. air pipes running the entire length of the train enable the energy from a reservoir of compressed air on the engine to be applied on each car for dumping it, and returning it to the normal position. When the body is in the horizontal position, carrying its load, it is locked there by a latch bar, the catch being held on by a weighted lever. This catch is pulled off, when tipping is to be effected, by the driver admitting air to one train pipe, and through the connection to the latch cylinder. This connection delivers through a port close to the front cover of the cylinder, forcing back the piston and raising the latch. As the piston moves it uncovers the port leading to the pipe, which communicates with the bottom of the lifting cylinder. The piston of this cylinder is thus forced up by compressed air passing through the latch cylinder. and the car is dumped. In this position it can be retained as long as desired. When it is to be returned to the normal position, the air is allowed to escape from the train pipe, whereupon the counterweight pulls back the piston of the valve cylinder. The pipe is thus connected to the atmosphere through the hole in the latch cylinder. If air be now admitted to the other train pipe, it enters the opposite end of the latch cylinder, completes the stroke of the piston, if this has not already got to the end of its stroke, and finds access through the pipe to the upper side of the lifting piston. The car body then comes back to its usual position, and the supply of compressed air is cut off by the driver. The car body automatically latches itself

when it gets into the correct position; buffer stops are provided to stop its descent without shock.

When the car has to tip on both sides an oscillated cylinder is used, the normal position of the piston being in the center, so that it can travel either way, according as the tipping is to be to right or left. There are two semicircular latch bars, the two latches being operated together by a single latch cylinder. A three-way driver's valve is used, by which air is directed into either air pipe, and also evacuated to the atmosphere.

One great advantage of these cars is that they can be dumped while the train is in motion, thereby saving time. They will also handle more material with less cars, keeping the men busy all the time. The cars are working satisfactorily in several places in the United States and Canada, and are giving the very best of satisfaction. The trucks of these cars are of special design, and are strong, so as to stand the hard work of construction. They are not easy to derail in case the track is in bad shape, which is often the case on new work. The makers—the Thacher Car and Construction Company, 917 Havemeyer building, New York—are now prepared to build eight-wheeled cars having a

notification to the Royal Society. Scarcely do we find a more striking example of the great advancement in electrical science than when we note that this bright spark has grown in strength and beauty, until now there are required to feed its ever-spreading rays 200,000,000 of carbon pencils for the present year in the United States alone.

In electrical engineering, the term carbon is used to designate an artificial solid, which through mechanical or chemical means is derived from some of the natural forms of carbon. It is moulded under great pressure into cylindrical pencils for arc lighting or into rectangular blocks or plates for battery or other uses. It is not the purpose of this paper to describe minutely the process of making carbon, nor is it necessary, as there are published descriptions which cover the ground fairly well. However, an outline of the general principles may not be out of place.

The materials usually employed are coke and pitch. The coke should be as free from solid impurities as is obtainable. Petroleum coke is largely used, although other varieties are often sufficiently pure for the purpose. It is ground to powder, and the volatile compo-

FIG. 2.

IMPROVED DUMPING CAR.

capacity of from 60,000 lb. to 80,000 lb., and which will dump on both sides of the track, so that the cars can be used in general railroad traffic.

CARBON AND ITS USES IN ELECTRICAL ENGINEERING.*

By CLARENCE M. BARBER, C.E., Member of the Civil Engineers' Club of Cleveland.

PREPARED FOR THE INTERNATIONAL ENGINEERING CONGRESS OF THE COLUMBIAN EXPOSITION, 1893.

In the year 1810, Sir Humphry Davy connected the poles of a battery of 2,000 elements by two charcoal points, and produced one of the most brilliant artificial lights that had doubtless ever been seen.

So little value was attached to this experiment that it was merely entered in the note book of the great physicist, and remained there apparently unnoticed until twelve years later, when it appeared as a commu-

nents are driven off by heating in retorts. Melted coal tar pitch is then thoroughly mixed with it, and for some kinds of carbon lampblack is also added. The mixture is then cooled, again ground to powder, and is then ready to be moulded or forced.

The process of moulding consists of filling the material into steel moulds, which are made in two equal parts, so arranged that the lower half of the mould will contain a sufficient quantity of the material for the entire charge. The upper half is then placed in position upon its counterpart, the mould is placed in a furnace and heated sufficiently to soften the fusible ingredients. It is then put under a pressure of about 400 tons, after which the sixteen pencils, or carbons as they are called, are removed from the mould. After cooling they are ready for the next process, which consists in handling the carbons one by one, examining and trimming off the webs which usually occur between the individual pencils as they lie in the mould; they are then packed in furnaces holding from 30,000 to 50,000, where they are baked at a high temperature for about 100 hours. After cooling for a like period

* From the Transactions of the American Society of Civil Engineers.

they are sorted for straightness. A portion are then sent to the consumer, but a large portion are first coated with copper.

The process of forcing is proximately the same as that of moulding until the material is ready for the moulds; then, instead of being moulded, it is heated and made into cylindrical plugs, which are placed in a heavy iron cylinder, and, by means of a plunger driven by hydraulic pressure, the plastic material is forced through a steel-bushed orifice and comes out in the shape of a continuous cylinder, which is cut to the lengths desired. The carbons are then sent to the furnaces, and from this point the process is the same as for the moulded.

The forcing process permits of a wide range of shapes, as by changing the size of the steel-bushed orifice, cylindrical carbons can be forced having a diameter of $\frac{1}{8}$ in., and from this size up to or even above 4 in. in diameter. Many other shapes besides cylindrical can also be made, such as plates that are not much over 4 in. wide and of a thickness of from $\frac{1}{8}$ to 1 in. or over. These are cut into short lengths and used for dynamo or motor brushes. Plates as small as $\frac{1}{4} \times \frac{1}{8}$ in. are also forced for small generator or motor brushes.

There is a great difference in density and structure between moulded and forced carbon. The pressure under which moulded carbon is made is about 8,300 lb. per square inch, while by the forcing process the pressure required is double or three times as great. By the method of forcing, the material is crowded together as it is pressed toward the small end of a conical chamber and is finally forced out at the vertex, thus giving a combination of lateral and end pressure.

By the method of moulding, the carbons receive side pressure only. Under the side pressure, the material tends to laminate in planes parallel to the axis of the carbon; while under end pressure, the planes of lamination are at right angles to the axis. As usually made, the pressure is not sufficient to produce distinct lamination; but it is evident that the structure of the material is inclined toward this class of formation, as in the case of slate rock, which is laminated in planes at right angles to the lines of pressure. Under certain conditions, lamination may be observed both in moulded and forced carbon.

Carbons as they are usually made for arc lamps are about $\frac{1}{8}$, $\frac{1}{4}$ or $\frac{3}{8}$ in. in diameter, by about 12 in. in length. In some cases pairs are used, a carbon 7 in. and one 12 in. usually constituting a pair. Besides these there are several other sizes in use; for searchlights and for many of the large lighthouses, carbons as large as $1\frac{1}{2}$ in. in diameter and often larger are employed.

In addition to the ordinary pencils, many other forms may be moulded, such as cups or crucibles, or almost any design where the material can be retained in moulds and submitted to great pressure. Plates are made 12 to 14 in. square, and in thickness from $\frac{1}{8}$ in. to over 1 in.; and even larger sizes are often made.

In its physical properties carbon varies greatly, the variation depending upon its composition and treatment in the process of manufacture. The hardness may be from that of chalk to that of crockery, and its specific gravity may vary to about the same extent. It is quite brittle, and this property is retained through all its stages of hardness. The tensile strength and resistance to crushing increase with the hardness.

For cutting carbon the emery wheel is generally employed; it can be drilled or cut in the lathe with steel tools, but its effect is to wear them away very rapidly; even diamonds can be used as cutting tools but a short time. On the hardest specimens these operations are performed with difficulty even with the best of tools.

As applied to electrical engineering, the most important and interesting use of carbon is in the arc lamp; here we find phenomena that are wonderful even in the light of the most advanced science. If two $\frac{1}{4}$ in. carbon pencils be placed with their points in contact and are included in an electric circuit having a current of 10 amperes, a slight amount of heat will be developed in the body of the pencils, which will be greatest at the point of contact; if, while the current is still passing, the pencils be separated a few millimeters, an arc of great luminosity and heat will be formed. If the poles of a voltmeter be connected with the pencils, the voltage due to the resistance of the arc will be seen to vary directly as its length, or nearly so; at about 20 volts the arc will be scarcely visible, and will increase in brilliancy and heat as the points are separated until the voltage reaches about 50, when the light will appear to be the most brilliant. At a point somewhere above this voltage, possibly 70 or higher, the arc will go out with a snap.

In the above case, if the current be maintained constant, of course the watts required will vary as the voltage, and this variation of the total watts is employed by all makers of arc lamps as a means of moving the feeding mechanism. This, in some lamps, may be so delicately adjusted as to move the carbons toward each other when the distance between the points has increased an amount corresponding to 1 volt, while many lamps require an increment of 5 volts to cause the feeding device to respond.

One of the most notable points in regard to the burning of the carbon arc is that the temperature in the positive carbon rises much higher than in the negative. It is noticed that when we extinguish the arc by turning off the current, the point of the positive carbon remains incandescent after the negative point has become black; the intensely heated crater formed on the positive carbon radiates far more light than the incandescent point which is formed at the end of the negative. The consumption of the positive is about twice as great as that of the negative when burned in the air; if burned in a vacuum, then the positive only is consumed. These facts seem to indicate that the larger part of the energy of the current is expended upon the positive carbon. A large part of the energy expended upon the arc is doubtless used in maintaining a counter electro-motive force, and another portion is absorbed in the conversion of solid carbon into vapor.

The arc may be colored by the introduction into the carbon of almost any foreign substance, and the color is characteristic of the substance employed, as in the case of the Bunsen flame; and as there are but few substances which are not volatile in the electric arc, the

range of color is very large. The intensity of temperature is, without question, highest in the center or inner portion of the flame and lowest toward the outer circumference; for this reason the vapors of substances arrange themselves in concentric envelopes—those which volatilize at the highest temperature taking positions nearest the center, those which volatilize at the lowest temperature becoming the outer envelope.

The carbon flame affords one of the best subjects for spectrum analysis; it is therefore of great value for this purpose, and by its use the field of the spectroscopy has been greatly enlarged.

It is perhaps important to note that, aside from the color effect of foreign substances in the carbon pencil, there is in most cases a reduction of the light and generally a lengthening of the arc; this may be accounted for on the supposition that foreign substances usually volatilize at temperatures lower than carbon, and hence supply vapors which radiate less light, and, volatilizing more rapidly, the quantity of the vapor is increased and a corresponding reduction of voltage may also be noted. If the foreign substances are not homogeneously incorporated with the carbon, the arc will be unsteady and the light will be unsatisfactory.

In the burning of arc lamp carbons, there is always a quantity of carbon dust that falls from the burning points; this is not a product of combustion, but particles of carbon, which are detached and thrown off from the highly heated points by calcination. Many attempts have been made by inventors to reduce or prevent the loss of life of carbon; due to this cause. Some degree of success has been attained by introducing into the carbon ingredients which, fusing at a comparatively high temperature, become slag and mix with the detached particles and prevent them from falling off; and retaining them until they are consumed, the life of the carbon is prolonged to a very marked degree.

The hissing sound so frequently observed in the arc light carbons is a matter of importance. There seems to be a strong current of air and vapor moving between the highly heated points; when this current impinges in a certain manner against the point toward which it flows, hissing will be the result. To illustrate: if a jet of air be blown from a small tube, at high velocity, against a solid substance, a hissing sound will or will not be produced, depending upon the velocity of the air, the nearness of the solid and its configuration.

Many experimenters have endeavored to obtain a quiet, steady arc by the introduction into the carbon of foreign matter, which, by producing vapor more easily than carbon, will so modify the conditions as to prevent hissing; and, with a view of holding the arc in the center, a core is used. This core is simply a center, which may be $\frac{1}{8}$ in. or more in diameter, of a material that is different from the body of the pencil and contains more or less of the foreign matter.

Some of the most quiet and steady-burning carbons that are in use have been obtained by the use of foreign matter and a core. Carbons are also made with hollow centers, through which solutions of salts are simply poured, a sufficient quantity being left therein to produce the desired result.

As early as 1867 M. Carre coated carbons with metals, such as zinc and tin; and about the same time Mr. Joseph Van Maderon experimented with carbons electroplated with copper. Carbons have, therefore, been electroplated almost from their first introduction, and copper has been the metal used. The only reason the writer has seen assigned for this use of copper is that it reduces the resistance, conveying the current to the end of the pencil with but little loss of energy. The life of the carbon is increased by coating with copper from 8 to 10 per cent.

The total resistance of an uncoated pair of $\frac{1}{4}$ in. carbons, in a newly trimmed lamp, is about 0.20 ohm, while the total resistance of the lighted lamp is about 5 ohms. It is evident, therefore, that the resistance of the carbons is about 4 per cent. of the total resistance of the lighted lamp. The resistance of the lamp coils may be 2 per cent. The decrease of resistance due to copper coating will not account for the increase of the life; this is due, in the writer's opinion, to the fact that the copper tends to support and retain the particles of carbon that are detached from the points by calcination; to some extent, also, the fused copper forms in liquid beads, and, by absorbing the calcined carbon dust, tends to prevent its loss.

A comparatively new use for carbon is found in the carbon brush for dynamos and motors; here carbon is substituted for the copper brush, and hence retains the name, which appears like a misnomer. Carbon brushes reduce the cutting of the commutator and the sparking to almost nothing. The same commutator may be used for years with carbon brushes which, if copper were used, would be worn out in a few months. The quality of the carbon brush is of great importance; it must be of fine texture, sufficiently hard, and should act in some degree as a dry lubricant, and it should not give a squeaking noise. These are points that can be provided for by the manufacturer. Much difficulty is sometimes experienced by heating. This, of course, is a question of conductivity, and can usually be remedied by making the brush larger, or by coating it with copper, or by doing both.

The telephone is indebted for a large measure of its great success to artificial carbon. Here its value depends upon the principle that an increase of pressure produces a decrease of resistance. The writer is inclined to think, with Mr. S. P. Thompson and others, that the increase of pressure simply makes a more perfect contact. As the resistance of carbon is higher than that of metals, it is, in some cases, an excellent material for this purpose, and especially where moderate resistance is required.

Among the advantages of carbon for electrical resistances, we may note the fact that it can be heated almost to a red heat and held at this temperature, without undergoing any change whatever; and, being practically infusible, it will stand for a short time very high temperatures, even in the atmosphere, without suffering any deterioration. If held long at a red heat, however, in the air, it will calcine and sometimes oxidize. Carbon has also the remarkable property of showing a reduction of resistance as the temperature rises. At high temperatures this is very marked; for example: the decrease in resistance of an incandescent lamp filament at a white heat may be one-third of its resistance when cold. At temperatures below a red

heat, however, the change of resistance is of comparatively little importance.

Some of the difficulties that attend its use as a resistance material are as follows: the resistance of carbon varies between wide limits; two carbon pencils $\frac{1}{2}$ in. in diameter and 9 in. in length could be selected, of which one would have a resistance of 0.20 ohm and the other 0.07 ohm. The forced carbon being more dense is always lower in resistance than the moulded, other conditions being the same. The resistance, however, may be largely controlled by variations in the manufacture.

The connection between carbon and a metal conductor often becomes a troublesome point, especially if high temperatures are to be used. For low temperatures the carbon may be electroplated with copper and the metal conductor may then be soldered; but for high temperatures the connection must be made by some form of clamping device.

Carbon is not used as a resistance where calibrated resistances are required, owing to the difficulty of determining its exact resistance. For resistance purposes, carbon is used in the form of pencils as small as $\frac{1}{8}$ in. in diameter; larger sizes are also used; it has also been used in the granular form and as a powder.

As a contact piece, where contacts must be made and broken frequently, carbon has a great advantage in many places over metals; and frequently, where metals are used in switches for contacts for large currents, carbon blocks are successfully used as a last point of contact. In such places as these last mentioned, carbon often gives a long arc, but even where one pole is metal, instead of burning the metal the current seems to expend its energy on the carbon, which suffers but little and is renewable.

Carbon is almost universally used in primary open-circuit batteries for the positive pole, and for this purpose it is made in the form of cylinders or plates. It is not acted upon at ordinary temperatures by any acid or other liquid known to chemistry, and in batteries it is easily depolarized. Carbon is also used, to a limited extent, for crucibles; and when mixed with clay, stands very high heats without oxidization.

It is remarkable that while carbon is made in variety of forms, its uses are almost entirely confined to electrical engineering; and as we note the rapid advancement of this new department of scientific work, we may also note, as one of the changes it has brought to our century, this new industry—the manufacture of carbon.

A slight idea of its growing magnitude in the United States may be gained from the fact that it claims an investment of over \$1,500,000.

THE DISPOSAL OF THE GARBAGE AND WASTE OF THE WORLD'S COLUMBIAN EXPOSITION.*

By W. F. MORSE, New York City.

Two years since the report presented by the Committee of the American Public Health Association on the Disposal of Garbage and Refuse gave a clear idea of all the methods then in use for the disposal of city waste. Since that time the progress of destruction by fire has been by far greater than has been the employment of other devices. It is the purpose of this paper to briefly state what has been added to our knowledge on the subject, with special reference to the disposal by fire of the organic waste and garbage of the World's Columbian Exposition.

Total destruction by fire of city waste has been proved by six years' experience to be of great service to this country. So far as reports can be obtained, none of the garbage furnaces in use two years ago have been abandoned, but, on the contrary, the number has nearly doubled. New forms of destructors have been brought forward for experiment; novel ways of employing fuels are on trial; the utilization of the heat produced for obtaining power is found to be practicable; more convenient means for handling the material are used; the cost of operation is considerably reduced, and a general survey of the whole field shows a decided advantage both in number of furnaces constructed and their ability to perform the work required.

In Great Britain a still more rapid advance has been observed. From an exhaustive report to the City Council of Edinburgh made by a special committee, a paragraph may be quoted:

"There are now more than 310 cell destructors in use throughout the principal English towns, consuming 2,000 tons of refuse per day, at a cost varying from two and a half pence per ton at Bolton to three and a half pence at Southampton; nine pence at Ealing and Leicester, to one shilling at Derby, and one shilling three pence at Winchester."

It has been stated by competent authority that the present year there would be built in England 100 more cell-destructors, dealing with 250,000 tons of refuse per year. Thus, in Great Britain the process of destruction or disposal of town waste by fire has become a necessary part of the municipal sanitary work. No other new methods or devices appear to have been brought into use. There is a notable absence of the mention of any form of utilization of waste until the purification by fire has been first made.

Here at home there has been manifested a deep interest in this question; many cities and towns have sent out commissions for inquiry and examinations at places where various furnaces and process methods are employed, resulting in reports and recommendations for the erection of garbage furnaces. The individual yearly official reports of health officers have in a great number of instances included a concise description of garbage cremators, with estimates of cost of construction and operation, urging upon the attention of the city authorities the adoption of this form of waste disposal.

Perhaps the most instructive example of the disposal of waste by fire has been the work done for the past five months at the World's Columbian Exposition, and which is daily going on, affording an opportunity for a personal inspection of the value and sanitary usefulness of this means of getting rid of the "sins of the people."

When the plans for the World's Columbian Exposi-

* A paper read at the International Congress of Public Health, Chicago, October 11, 1893.—From the *Sanitarian*.