of these pavilions on the "Street of Nations" looking toward the Alexander III. Bridge. The first one is the palace of Austria-Hungary, which is a baroque construction. The United States building, of which Mr. W. A. Coolidge was the architect, and M. Morin Goustiaux the French collaborator, is a large and imposing structure, measuring 85 × 90 feet, and is 165 feet high from the lowest level. In a general way the building suggests without imitating the capitol at Washington and the Administration building at the World's Fair. The architect has done his best to make the building prominent, and his efforts have been successful, for none of the other buildings have such high domes, and the main entrance, which is under a large portico, also makes it very conspicuous, as it covers the thoroughfare along which visitors must pass. In front of the building is a boat-landing, which is ornamented so as to resemble a classic trireme.

The pavilion of Turkey, which is next, resembles the palaces which can be found along the shores of the Bosphorus. Its architecture is frankly Oriental, being a happy mixture of the most interesting types to be found in Constantinople; on the lower level is a Turkish café.

The pavilion of Italy is one of the finest buildings in the entire Exposition, and by reason of its dimensions is the most important of all on the "Street of Nations." Its architect has succeeded in masking the effects of the material employed. It is in somewhat florid Byzantine style, and resembles, to a certain extent, San Marco at Venice. Mosaics and marbles are freely used, and there are five great domes of bronze gilded.

ELECTRIC CAB SYSTEM OF PARIS.

The city of Paris is provided with an electric cab service which, although at first in a more or less experimental stage, is now rapidly coming into successful operation. The Compagnie Generale des Voitures, which operates all the cabs in the city, some time ago made an addition to its existing property just outside the city limits, and has erected a number of buildings to accommodate the electric system, including a power house, accumulator building, carriage-house, etc.

After a number of tests, the company decided to adopt the type of cab shown in our engravings. The cab body, which is interchangeable, is supported on a frame which rests upon the front axle by two elliptical springs and upon the rear axle by two springs placed longitudinally, this disposition being adopted to give more room to the motor and differential. The case containing the battery is supported underneath the frame of the vehicle, this arrangement permitting of an easy replacement. The motor drives the rear wheels by means of chain gearing, the wheels being of wood with solid rubber tires. To steer the vehicle the forward truck is turned by means of a hand-wheel in front of the motorman's seat. To the springs of the cab are attached four wrought iron arms supporting a bronze crown upon which turns a similar crown attached to the frame; a series of rollers is provided to diminish the friction between the two crowns, the lower one carries a central pin upon which it turns; this crown is toothed around its periphery and engages with a pinion on the lower end of the vertical steering shaft. This shaft passes up through an iron column shown in the front of the cab, where it ends in a pinion, this being turned by an endless screw worked by the hand-wheel; in this way the motorman steers the vehicle.

The lower engraving shows the general arrangement of the motor and back part of the cab. The motor is of the Lundell-Johnson type; it has four poles and is series wound. It differs from the usual type of motor

CAB ON RAISED TRACKS; TROLLEY WITH FRESH ACCUMULATOR BENEATH.

in having two commutators, one on either end of the armature, this latter having two series of windings. The field coils are also divided into two separate circuits, thus permitting several different combinations of circuits to regulate the speed without changing the battery connections. The weight of the motor is about 96 kilogrammes and it gives from 3½ to 4 horse power, with a speed of 1,500 revolutions per minute, when the cab runs normally at 16 kilometers per hour. The

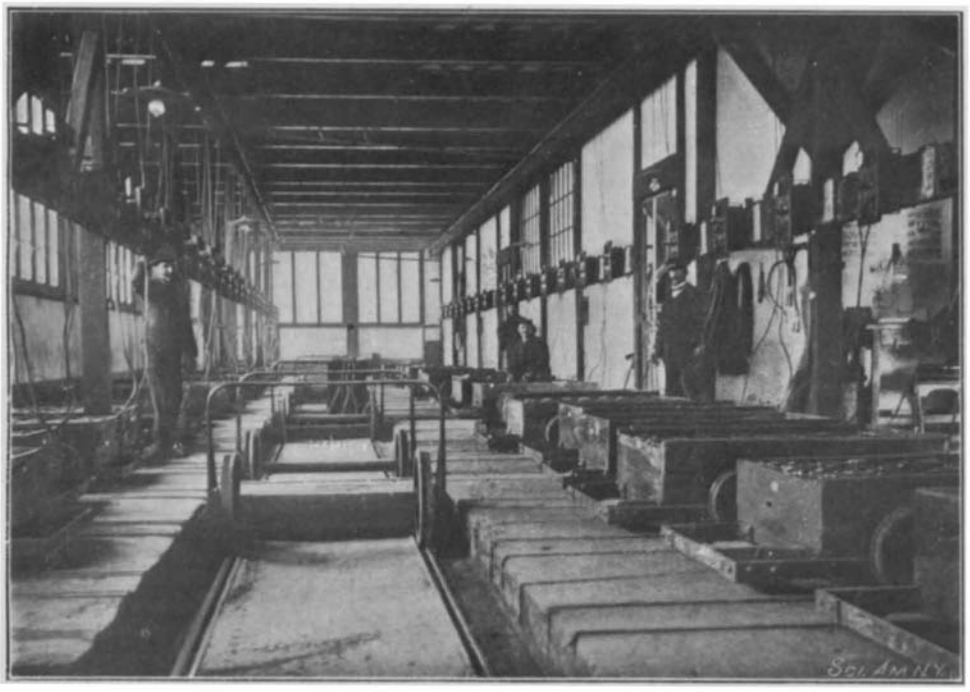
CAB WITH UNDER-HUNG ACCUMULATOR IN PLACE.

pinion seen on the left of the motor is of rawhide, having 22 teeth with steel end-plates, and engages with the large gear wheel of 81 teeth placed upon the crown of the differential. At each end, the shaft of the differential is supported by a long bearing, and carries on its outer end a chain wheel of 19 teeth, seen on the left, which drives the rear axle. The motor is supported on a bronze plate which in the rear is pivoted around a shaft placed in line with the centers of the driving wheels. This plate is supported on its inner end by a coiled spring resting upon a horizontal bar. The different circuits of the motor pass into a series of connecting posts at the top, from which a series of wires pass in front to the controller. The controller is placed under the driver's seat, where it is entirely enclosed. It consists of a small drum with rubbing contacts, of the usual type, placed horizontally. The shaft is provided with a pinion on the left-hand side, engaging with a toothed sector, the latter being connected to a lever on the outside of the box and within easy reach of the hand. The different speeds are obtained by combining the field and armature circuits of the motor. The battery connections remain unchanged. The two electric brakes are also operated by the controller, and the cab has one cylinder brake as well as the ordinary brake shoes, these are arranged to cut off the current when the brake-pedal is applied.

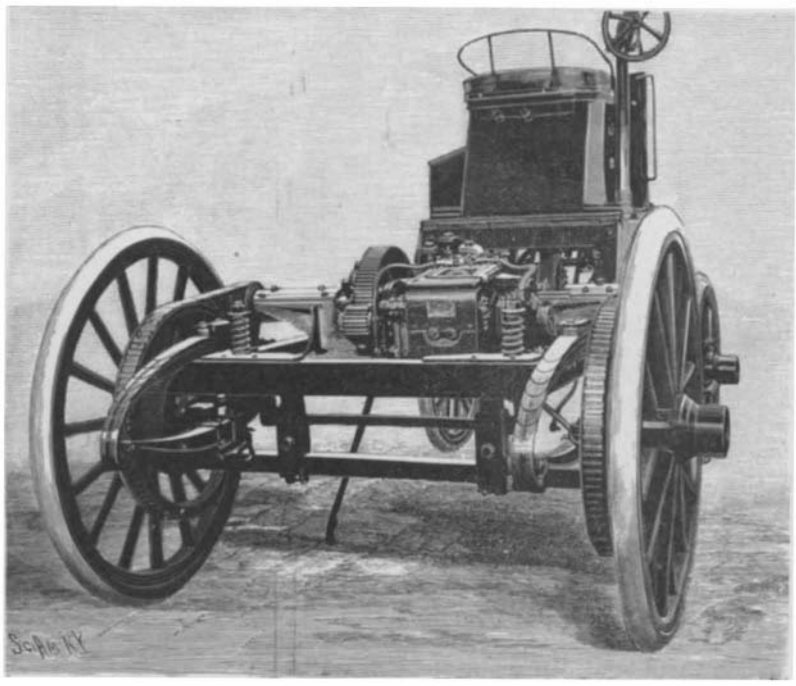
The electrical plant necessary to charge the batteries consists of a boiler room and a dynamo room. It contains two engines of 250 horse power, each driving a dynamo of the Alioth type. The dynamos have each a capacity of 1,200 amperes at 110 volts. From each dynamo four flexible cables of large section pass to the switchboard, which is in a gallery at one end of the station, and from there the conductors lead to the accumulator charging rooms.

The rooms set apart for charging the accumulators form one of the original features of the plant. They are arranged so that the batteries may be easily handled and the operation of charging carried out rapidly. Two charging rooms are provided, one on the ground floor and the other in the second story; the former is shown in the illustration. In the center runs the main track, bringing the accumulator boxes, mounted each upon its truck, to the desired points, where they are rolled out upon the elevated side platform, in front of the charging post. The latter consist of a number of panels placed along the wall above the accumulators, each panel being connected with the main circuit. The current is measured by an ammeter at the top, and the circuit passes to a rheostat below. The panel is completed by a switch and a pair of fusible cut-outs, from which the cables pass below to the accumulators. The lower floor has 54 of these charging panels and the second floor about the same number. The main current is distributed to the charging posts by a switchboard placed at each end of the room, and protected from acid fumes by a glass panel. The rooms, above and below, have cement floors, and tarred wood is used throughout. The accumulator boxes are carried to the second floor by a hydraulic elevator; for this two pumps are provided, each driven by an Alioth motor of 6 horse power.

The type of accumulators used is that controlled by the Société pour le Travail Electrique des Metaux. The elements are of the mixed type, the positive plates being composed of a number of flat and slightly corrugated strips of lead placed one upon the other and soldered at intervals to the central cores and sides of the plate; the negative plates are of reduced chloride of lead, contained in a lead grid; Ebonite cells are used, with a false bottom, and between the plates is placed a thin corrugated strip of ebonite, pierced with small holes. For each cab, 44 cells are used, weighing 750 kilogrammes; their capacity is about 175 ampere hours, and the current taken by the motor varies from 20 to



CHARGING ROOM, SHOWING ACCUMULATOR BOXES AND TRANSFER TRUCKS.



FRAME OF CAB, SHOWING MOTOR AND DRIVING GEAR.

60 amperes, so that a battery should allow a distance of 50 to 60 kilometers. The cells are placed in an iron-bound wood box, which is suspended by four chains, the points of suspension being supported upon springs. The battery has thus a double suspension, taking into account the springs of the cab. The box is prevented from swinging by a system of tie-rods.

The question of replacing the accumulator boxes in the cabs as they come in from service is an important one, as there should be no loss of time in changing the boxes. The cab, as it comes in with its exhausted battery, is brought under the gallery and rolled upon an inclined track. The battery is thus at a considerable height from the ground, and this permits the truck to be rolled under it upon a track arranged for the purpose. Below the cab is a hydraulic elevator, worked by a lever near by, which lifts the truck to the height of the battery; the latter is thus raised, as this permits the uncoupling of the suspension chain and tie rods. The latter is then lowered with its truck to the level of the rails and rolled into the charging house; a fresh battery, also upon its truck, is brought out and put in place by reversing the operation. In this manner the driver is not obliged to leave his seat while the battery is being replaced. During this time the motor is examined and put in order by a lid in the rear of the cab, or by removing the interior cushions of the cab and opening the seat. At present six of the inclined tracks or elevators have been installed.

DR. PUPIN'S IMPROVEMENTS IN LONG-DISTANCE TELEPHONY.

BY HERBERT T. WADE.

Soon after the laying of the first Atlantic cable, nearly fifty years ago, Sir William Thomson prophesied that it would not be possible to exceed a certain rate of speed in the transmission of signals, on account of the so-called capacity of the cable. This prophesy has held good, for notwithstanding multiplex and mechanical systems of telegraphy on land, the submarine cables are operated at an avarage speed of but twenty-five words a minute. The use of a submarine cable in telephony over a greater distance than twenty-seven miles in length (Dover-Calais) is not supposed to be practicable, and consequently telephonic communication is not available where a large body of water must be crossed. In telephone circuits where aerial wires are employed, there are also limitations, and yet long-distance telephony on such a scale as is desired, from New York to New Orleans, or San Francisco for example, has not been attained and is admitted by telephone engineers to be next to impossible.

After a series of experiments performed at the laboratory for electro-mechanics at Columbia University, Prof. M. I. Pupin has ascertained that with cables and air line conductors constructed according to a method thus far employed in the construction of long distance electrical conductors, which involves a somewhat radical but nevertheless a very simple departure from the methods, the efficiency of transmission of electrical energy is greatly increased, and that a number of the difficulties just enumerated may be readily overcome. The method may be stated broadly to consist in employing what Prof. Pupin calls non-uniform conductors in place of ordinary uniform conductors. In the course of his experiments he has made use of such conductors for long-distance telephony, and the researches in his laboratory have been marked with great success.

Electrical energy when sent over a conductor of such length as is used in long-distance telegraphy or telephony is transmitted in the form of electrical waves. The transmission of the energy under such conditions can hardly be called direct for it is first stored up in the medium surrounding the transmission line and from here it is then transferred to the receiving apparatus. If a periodic current is impressed on the circuit by the transmitting generator, we have periodic variations of current and potential along the transmission wire.

In the study of electrical waves it is found that the amplitude of the wave diminishes as the energy is propagated from the source. In short, a weakening of the current is caused which is styled attenuation, and for the constant of attenuation there is a mathematical expression in which the inductance, resistance, and capacity of the conductor, and the frequency speed figure. The loss of energy is due to the imperfect conductivity of the wire, and it is regulated by the inductance and capacity in the circuit. The most important feature of this regulation is the following: If a conductor has a high inductance, a given quantity of energy will be transmitted with less loss than over a conductor with a smaller amount of inductance. This fact was known to Oliver Heaviside, the mathematical physicist of England, and while his theory demonstrated the superiority of a wave conductor of high inductance, it did not indicate a way in which such a conductor could be constructed. The mere introduction into the circuit of a coil or coils has been tried without success, as there was no underlying mathematical theory to govern the experiments.

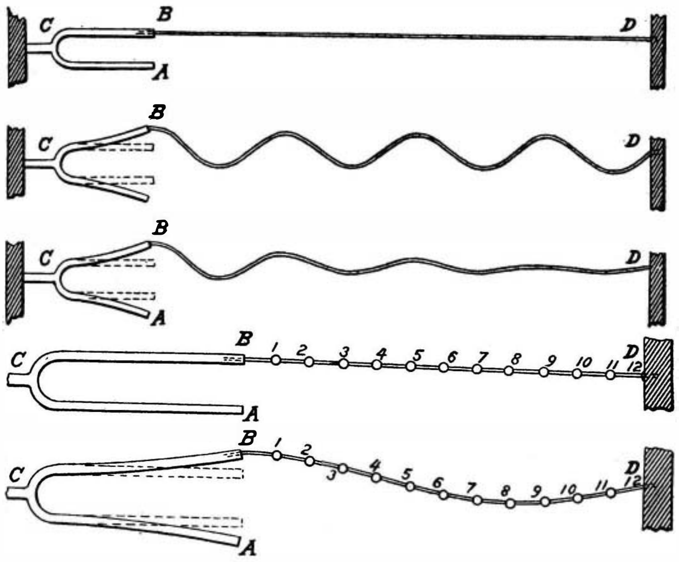


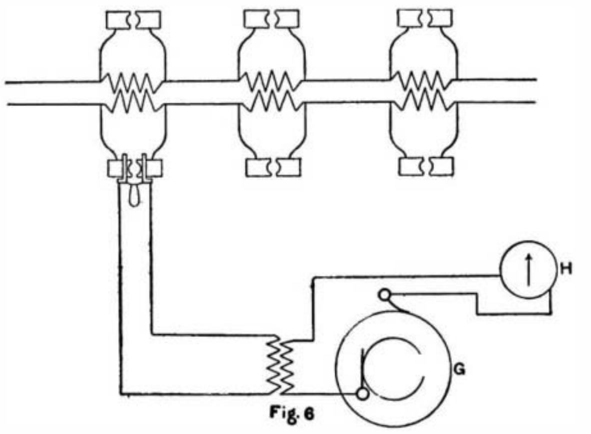
Fig. 1.

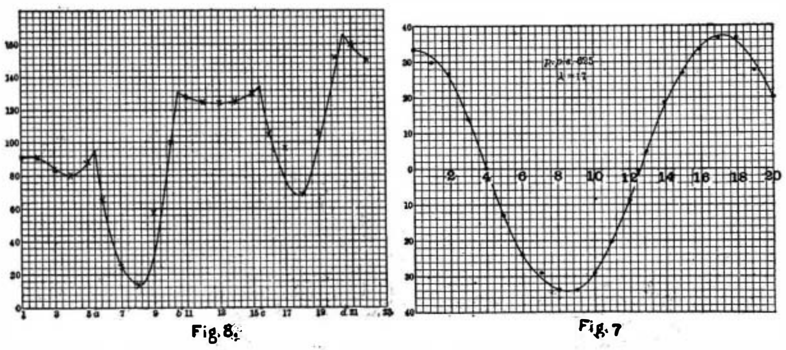
Fig. 2.

Fig. 3.

Fig. 4.

Fig 5.



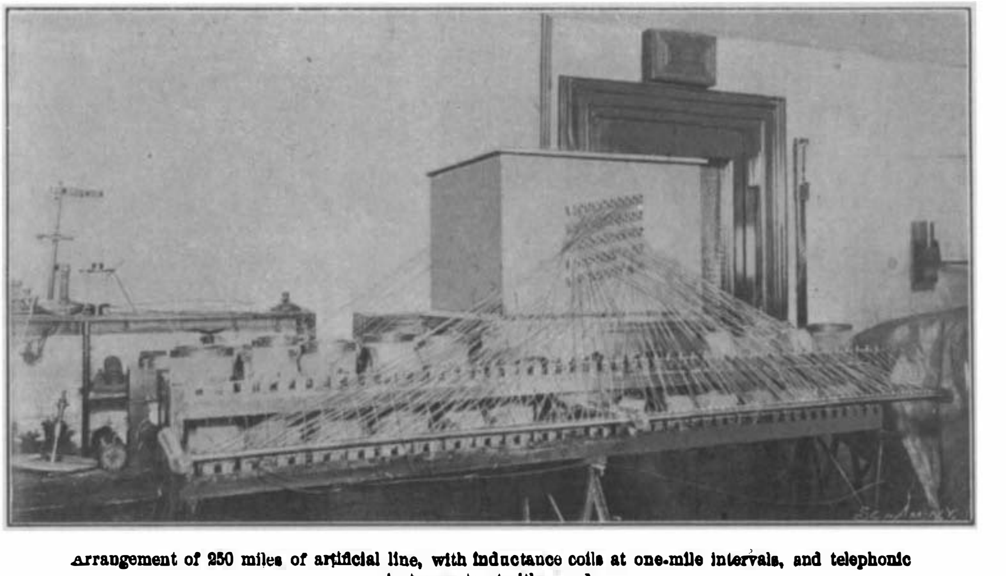


PUPIN'S INVESTIGATION OF CABLE TELEPHONY.

Prof. Pupin, however, has developed such a theory, which serves to explain the problem, and its main features are well shown in a mechanical illustration in which the same elements are present as are found in the question of the transmission of electrical waves. To one prong of a tuning fork rigidly fixed at C is fastened a cord whose other end is attached to some firm object as D, shown in the illustration (Fig. 1). Let the fork be set into vibration and a wave motion results, which, if the resistances due to friction are negligible, will take the form of stationary waves, as shown in Fig. 2. But assuming that the frictional resistances are not sufficiently small to be neglected, then the direct and reflected waves will not be equal, and instead of stationary waves there will be waves where the amplitude of the particles at the greatest distance from the tuning fork will be less than that nearer the source of motion, as shown in Fig. 3, the energy being dissipated by the frictional resistances in its progress along the cord. This weakening or attenuation, however, will be diminished if a string of greater density is employed, since a larger mass requires a smaller velocity in order to store up a given amount of kinetic energy, and a smaller velocity occasions a smaller frictional loss. Now let a weight, such as a ball of wax, be attached to the vibrating cord at its middle point so as to increase its mass. This weight will serve to occasion reflections, and there will be far less energy transmitted to the extremity of the string than before. Then, if the mass of wax be subdivided, and put at regular intervals, as shown in the diagram (Fig. 4), the efficiency will be increased. The further we proceed in this subdivision the higher will be the efficiency of transmission, but a point will be soon reached beyond which it is not possible to secure an appreciable improvement by further subdivision.

This point is where the cord thus loaded vibrates very nearly like a uniform cord of the same mass, tension and frictional resistance, as we may see by reference to Fig. 5. Therefore, to secure an increase in the efficiency of transmission over a cord thus loaded, we must properly subdivide the load and the distances, or otherwise the effects of reflection will destroy the benefits derived from the increased mass. In the experiments with the cord it was found impossible to load the cord in such a way as to make it equivalent to a uniform cord for all wave lengths, but if the load was distributed so that it satisfied a given wave length, it also answered for all longer wave lengths. The mathematical theory and law for the vibration of a cord under such conditions is exactly the same as that governing the distribution of the electric current over a wave conductor under the influence of similar forces, kinetic or mass reaction, tensional reaction and resistance reaction in the case of the cord being paralleled by electrokinetic reaction, capacity reaction and ohmic resistance reaction in the case of the wave conductor. Therefore, it will be understood that if inductance coils are introduced along the wave conductor at periodically recurring intervals, the efficiency of the transmission of electrical energy is increased. Prof. Pupin's conclusion is that a non-uniform conductor is as nearly equivalent to its correspondingly uniform conductor as sin $\frac{\varphi}{2}$ is to $\frac{\varphi}{2}$, where φ is the angular distance between the inductance points of inductance sources and the angular distance to 2π corresponds with the wave length. Here the value φ is inversely proportional to the wave length, so that for a given distance between the reactance points the degree of equivalence diminishes as the wave length diminishes. If the wave conducted be of complex nature, such as is met with in telephony where the overtones of the voice are present, then, if the approximation suffices for the highest essential frequency, the conditions will be even more favorable for the lower notes.

From theory to experiment was the next step in this investigation, and the study of these electrical waves was undertaken while they were passing over wave conductors. The experimental proof consisted in demonstrating that non-uniform conductors of the description just given will show the same wavelength and the same attenuation for a certain frequency and for all lower frequencies as a uniform conductor of the same inductance, resistance and capacity. The wavelength is of course conditioned by the frequency, and in the construction of the apparatus the periods used in long distance telephony were selected The conductor selected was the counterpart of a cable 250 miles in length, having the equivalent resistance and capacity. To construct such a cable was a task of much labor and



Arrangement of 250 miles of artificial line, with inductance coils at one-mile intervals, and telephonic instruments at either end.

Fig. 9.—EXPERIMENTAL CABLE WITH INDUCTANCE COILS.