operations; and as the instruments themselves were useless without an antenna of this height, the whole scheme was abandoned and prehistoric signals of the Neolithic age were substituted in their stead. The portable Slaby-Arco system is arranged to overcome the difficulties that actual experience earned so dearly has pointed out.

The portable induction coil (Figs. 3 and 4) is equipped with a vibrating interrupter of the usual type, 1, and the spark-gap, 2, is likewise of the ordinary character, being open in contradistinction to those inclosed in oil. The primary winding is shown in Fig. 4; 3 is the primary and 4 represents the secondary winding and terminals; 2, the spark-gap; 1, the interrupter; 5, the condenser of the coil; 6, the Morse key; and 7, the storage battery. One terminal of the secondary coil leads to the earth at *a*, and from the second terminal a conductor leads to the windlass, 9, where it is connected to the flexible metallic cord, 10, it in turn being attached to the box-kite, 11. The apparatus, 12, consists of what Prof. Slaby terms a microphone receiver. By this designation he distinguishes between two classes of receivers, namely, (*a*) those which require tapping to decohere the particles of metal and (*b*) those which are termed in this country self-restoring or self-righting; that is to say, that in the case of *a* the low resistance produced by the action of the electric waves will so remain until the normally high resistance is restored by some physical means, and in *b* where the restoring properties are self-contained, and the normally high resistance is instantly assumed the moment of cessation of the waves. Carbon possesses this property, likewise steel and iron, and so it is that the imperfect electrical contact discovered by Hughes in 1882, and which furnishes us with the modern telephone transmitter, now plays an exceedingly interesting part in wireless telegraphy in the form of the coherer, first made by Branly, of Paris, in 1890. Later Popoff used a microphone-coherer or a self-restoring coherer in which he mixed steel filings with carbon granules. The self-righting coherer for army and field telegraphy has a distinct advantage over those which require tapping, inasmuch as it does away with a vast amount of complicated and more or less delicate apparatus; again, the words can be received as rapidly as the operator can send. The improvement claimed by Slaby is that in his coherer of the microphone type a combination of steel and aluminium is used, either in the form of grains or of balls such as are used in telephone transmitters. In Figs. 3 and 4, 1 represents the steel aluminium coherer; 2 shows the cross section of the aluminium disks, and between them are placed the hardened steel balls. Atmospheric disturbances and electric waves emitted from lightning are avoided by placing the coherer in shunt to the wave system, 10 and 11 (Fig. 4), and not directly in series with it. The complete receiver is shown in Fig. 4.

The electromotive force actuating the telephone receiver consists of one dry cell, 6, only (Fig. 4) and this is connected in series with the double-pole switch, 7, and the choking coil, 8. By means of the key, 9, the current may be made or broken, the operator closing the circuit when listening to a message transmitted from another and distant station and releasing the key opening the circuit before transmitting a message. This is done to prevent the powerful radiations so closely to hand from welding the particles together and rendering the coherer worthless as a receiver for very feeble waves. When the electric waves from a distant transmitter are sent out the conductor cord, 10 (Figs. 3 and 4), receives the impulses and carries them to the microphone coherer, 1, when the high resistance is instantly lowered and now permits the passage of the weak battery current to flow through the coherer and also the telephone receiver, 16, for the period the waves are received, and the characteristic sounds of cohesion are heard through the variation of the electric current. Dots and dashes are distinguished by the length of time the cohesion exists or the variation of the current. In the half-tone the telephone receiver takes the form of a pair of watch-case or pony receivers connected by a flexible metal spring such as telephone operators wear during working hours.

The tuning of this receiver is accomplished by means of the inductance coil, 12 (Fig. 4), which is in tune with the receiving wire, 10. This coil is in shunt and is in tune with the emitted waves of the opposite station transmitter by the self-inductance, 11, and by the condenser, 13, grounded at 14, the capacity of which may be varied until the most suitable value is obtained by the handle, 15. The sensitiveness of a microphone coherer is much greater than that of a permanent coherer with the exception of the most carefully adjusted silver coherer, and for this reason it lends itself to the purpose of long-distance transmission; but since the maximum resistivity and minimum conductivity of a microphone coherer are not widely divergent, the current from the battery, 6, is insufficient to operate a relay, and therefore will not answer where a printed copy is desired.

The transmitter and the receiving apparatus utilize the same flexible cord as the receiving or emitting wire, and this angular antenna leads to the kite. Slaby employs various forms of kites for elevating the antenna; the American Blue Hill box-kite having a large sustaining surface is used in case of light winds; for stronger winds the box-kite is equipped with a much smaller surface. With winds so light that these kites cannot be used a special form of German kite having the shape of a bird is recommended. If there is no wind at all, small hydrogen balloons are provided having a capacity of one cubic meter. The weight of one station complete, including transmitters, batteries, receivers, auxiliary apparatus, etc., is 30 kilogrammes, and the greatest distance intelligible signals can be transmitted is 20 kilometers.

Through the generosity of Mrs. Joseph M. White, of New York city, the SCIENTIFIC AMERICAN for the year 1902 will be sent to the fire engine and hook and ladder companies of New York city. Mrs. White has been in the habit of donating the paper for a number of years in this manner, her object being as far as possible to provide reading matter of an educational and suggestive character for the men who are so often called upon to risk their own lives to save those of others.

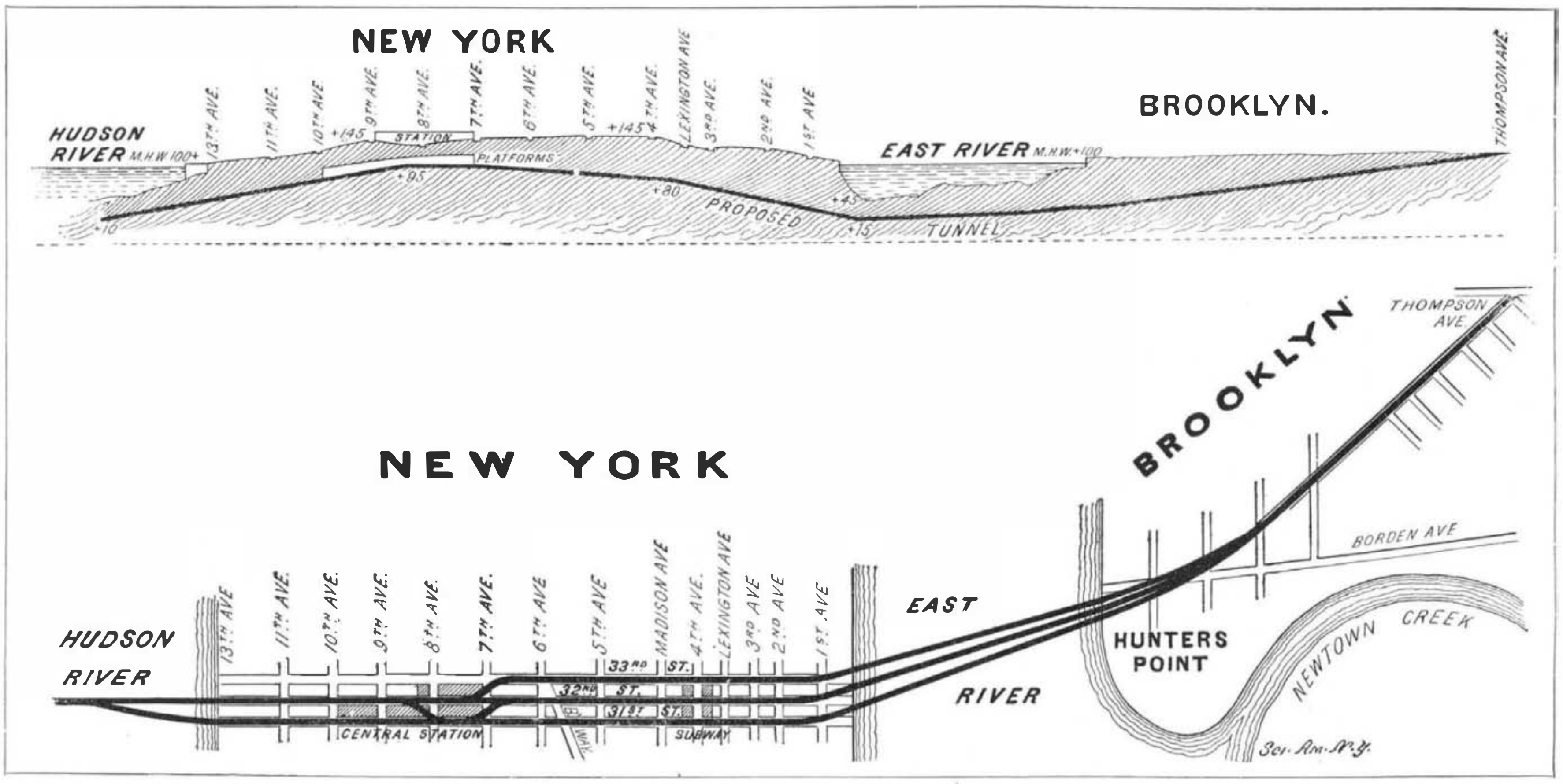
THE PENNSYLVANIA-LONG ISLAND CONNECTING RAILROAD TUNNELS.

The very topographical location which has rendered New York city one of the greatest seaports in the world has brought with it no end of trouble to the citizens who live within its borders. While the confluence of the Hudson River with the East River and the long stretch of shore line which extends between the exits of the Harlem River have provided the most magnificent line of wharfage in the world, it has brought about in the course of years one of the most difficult and complicated transportation problems on earth, a problem which is demanding a solution with increasing emphasis as the years go by. With the exception of the New York Central Railroad with its one terminal station (which, by the way, is already quite inadequate to the demands upon it) at the center of Manhattan Island, there is none of the great trunk lines of the United States that has its terminal within the metropolis. To anyone who is conversant with the history of passenger transportation, it must have been evident for many years past that it was only a question of time when not merely the great railroads, but the local trolley lines and the suburban roads, would be called upon to make connection of some kind with Manhattan Island, and land their passengers directly in the heart of the city itself.

The obstacle, of course, has been the great cost and supposed difficulty of making this connection. As far as the East River is concerned, it necessitates bridges of at least 1,500 feet clear span or tunnels of great length, considerable depth and presumably somewhat heavy gradients. The East River is already spanned by one completed and one half-completed bridge; but neither of these is designed or adapted to trunk line railroad service. Several years ago the Long Island Railroad commenced the construction of a bridge at Blackwell's Island, but the work never progressed beyond the foundations. Also, some twenty years ago an abortive attempt was made to drive a tunnel from Jersey City to Manhattan beneath the Hudson River, but although some 3,000 feet was completed, the work was ultimately abandoned.

The alternative problem of bridging the North River was rendered such a stupendous one by the requirements of the War Office that no pier should be placed between the government pierhead lines, thus necessitating a span of at least 3,000 feet, that no actual work has been done on such a structure. It is now about ten years since Gustave Lindenthal, who is to be the new Commissioner of Bridges, formulated plans for a great suspension bridge of 3,000 feet clear span, which was designed to carry eight railroad tracks on the lower deck, and, if traffic should demand it, four more tracks on an upper deck. The great cost of this structure, coupled with the even greater cost of the necessary terminal works, has stood in the way of its prosecution. Another suspension bridge was designed to cross the North River at 59th Street, but this also has never progressed beyond the paper stage.

After the acquisition of the Long Island Railroad by the Pennsylvania Railroad there was a revival of the rumors that the trunk lines, which have their termini in Jersey City, were contemplating joint action in the construction of a bridge. This time the



PLAN AND PROFILE OF THE PROPOSED PENNSYLVANIA-LONG ISLAND CENTRAL STATION AND CONNECTING TUNNELS.

Pennsylvania Railroad was mentioned as the chief mover in the project; but it seems that the failure of the other roads to come to an agreement as to the proper distribution of the expense of construction has led this corporation to abandon the idea of a bridge, and turn its attention to the connection of the Pennsylvania and Long Island Railroads with each other and with New York by a system of underground tunnels.

The accompanying plan and profile of the proposed tunnels is drawn from plans filed in the County Clerk's office by the Pennsylvania-New York Extension Railway Company, which has been authorized to build and operate the tunnels. The line of the tunnel, as shown in the plans, commences at the State line in the center of the Hudson River. As it approaches the Manhattan shore the two tunnels, each of which will be 18 feet in diameter, diverge until they are opposite the centers of 31st and 32d Streets. They extend with an easy rising grade of less than 1.5 per cent to about the middle of the block between Eighth and Ninth Avenues, where the line is level for about 1,500 feet, the surface of the tracks being about 45 feet below the surface of the street. From just beyond Seventh Avenue, the line falls again on an easy grade to a point between Fourth and Lexington Avenues, where the track will be about 60 feet below the surface. From this point to the East River the grade increases to about 1.5 per cent, the lowest level being near the New York side, 85 feet below mean high water and about 30 feet below the deepest level of the river bottom. From this point the ascent is by an easy grade of from about 0.5 per cent to 1.2 per cent, until the tracks come to the surface at Thompson Avenue, about 1½ miles from the East River.

The great central station with its underground "yard" (if that term may be used in this case) will cover more than four large city blocks. It will include all the space between Tenth and Eighth Avenues and 31st and 33d Streets, and between Eighth and Seventh Avenues and 31st and 33d Streets. It will also include a portion of the easterly end of the block bounded by Eighth and Ninth Avenues and 32d and 33d Streets. Easterly from the central station, a third track and tunnel will be added, the three tracks extending below 31st, 32d and 33d Streets, until First Avenue is reached, where they will swing to the north through 30 degrees, and will converge, meeting near the Long Island terminals. From this point the tracks will be carried in a single tunnel, finally reaching the surface at Thompson Avenue.

The construction of the tunnels is not expected to present any unusual difficulties where they extend below Manhattan Island and the East River, the driving having to be done largely through rock or firm material. Beneath the Hudson River, however, where the tunnels, according to the plans filed with the County Clerk, will descend to a depth of 90 feet below mean high water, the line will have to be carried through a soft material, which does not present the proper consistency for preserving the tunnel in true vertical and lateral alignment, especially under the heavy traffic which the tunnels are expected to carry. Of course, firmer material could be secured by tunneling at a lower depth, but this would entail the great disadvantage of steeper grades, with their attendant disadvantages in operating the road. To meet this difficulty, Mr. Charles M. Jacobs, the chief engineer of the company, has designed a special system of construction, in which the tunnel consists of a combined tube and bridge, having great transverse vertical strength, while the load of the combined structure is borne by piers, which are carried down by the caisson system through the underlying silt until firm hardpan or rock bottom is reached. By using this system of construction it is possible to build the tunnels through looser material at a higher elevation, and the grades to Jersey City and New York are kept down to the desired maximum for economical operation.

The great central station will contain twenty-five tracks, access to which will be gained by a broad causeway which will be reached from the street surface by easy grades at either end of it. This causeway will extend across and above the tracks, and easy stairways will lead from the causeway to the platforms.

In the operation of this system electric traction will, of course, be employed for all trains, and incidentally it may be stated that the confidence with which the Pennsylvania Railroad system is contemplating the use of electric motors for bringing trains into its terminal station, should act as a spur to the New York Central and New Haven systems in adopting the same method between Mott Haven and the Grand Central Station. If such power is feasible for one system, it is certainly so for the other. The ventilation of the tunnels will be secured by the passage of the trains, which will act with piston-like effect, keeping the body of the air in continual circulation. Regarding the advantages conferred on New York by the enterprise of the Pennsylvania and Long Island Railroads, it is scarcely possible to say too much. Not only will passengers be brought from any part of the United States without change of cars direct into New York, but the fact that the new tunnels will cross beneath all the north and south lines of the tunnel in Manhattan, including the new Rapid Transit tunnel, insures that travelers will be provided with most excellent facilities for getting quickly from the trunk lines to the immediate street or section of the city which is their destination.

At a later date we hope to publish full plans both of the terminal and tunnel construction.

NEW SUBMARINES FOR THE UNITED STATES NAVY.

The acceptance by the United States navy of the submarine torpedo boat "Holland," and the determination of the government to build half a dozen new boats of the same type of somewhat enlarged dimensions, marked the successful culmination of a long series of trials and disappointments which had attended the efforts of the inventor, Mr. Holland, to produce a successful submarine vessel. The "Holland," which was the first really successful boat constructed on the inventor's principles, is the sixth experimental craft which he has built. His first attempt was made in 1871 with a small vessel 3 feet by 2½ feet in cross section and 14½ feet in length. This was followed by a larger craft, built in 1897, which was 31 feet in length by 6 feet in diameter. It was driven by a 15-horse power engine and carried a crew of two men. In this vessel we see the first attempt to discharge high explosives, the Zalinski gun being fitted for the purpose of throwing dynamite shells. Then followed another craft 16½ feet long which met with various mishaps. The fourth boat, 40 feet in length and about 8 feet in diameter, was destined to bring Mr. Holland's invention more prominently into notice than any of his previous craft; and it was used in experimental tests which gave valuable data for future work.

On March 3, 1893, Congress authorized the construction of a submarine of the Holland type, and the contract for the hull and machinery was let for $150,000. Although the contract for the "Plunger," as she is called, was signed in 1895, the vessel is still uncompleted. She is in some respects a considerable departure from the Holland type, being very much larger (85 feet over all) and having a submerged displacement of 165 tons. For surface navigation she was to be provided with a triple-screw engine, and when submerged the vessel was to be driven by a single electric motor. Subsequent changes, however, have been made in these plans, and we understand that when the vessel is finally completed, she will conform generally to the standard Holland type.

The sixth Holland submarine, which was built at the Crescent Shipyard, Elizabethport, N. J., is 53 feet 11 inches in length, 10 feet in diameter and has a displacement of 74 tons when submerged. When on the surface she is driven by a single-screw, Otto gasoline engine of 45 horse power, at a speed of 8 knots an hour. When submerged, she is driven by an electric motor of 50 horse power. Her armament consists of a torpedo tube which lies approximately on the longitudinal axis of the vessel and a dynamite gun which is upwardly inclined and is intended for the discharge of high-explosive shells when the vessel is at the surface. The "Holland" was first placed in commission October 12, 1900. So far, she has been used mainly for training purposes, and in experimental tests by the Holland Company. Useful data has been gathered from her which will be incorporated in future vessels. On June 7, 1900, Congress authorized the construction of six more submarines of the Holland type. Of these two, to be known as the "Grampus" and the "Pike," are being constructed by the Union Iron Works, San Francisco, Cal., and the other four, known as the "Adder," "Moccasin," "Porpoise" and "Shark," are building at the Crescent Shipyard.

On the front page of this issue will be found a sectional view, showing the new type of Holland boats, as they will appear when submerged. The side being broken away, it is possible to see very clearly the method of constructing the boat and the arrangement of the various parts of her machinery and fighting equipment. The dimensions are as follows: Length over all, 63 feet 4 inches; diameter, 11 feet 9 inches; displacement, submerged, 120 tons. The motive power consists of a 160-horse power single-screw, four-cylinder, Otto gasoline engine, which is capable of giving the craft a speed of 8 knots on the surface, and a 70-horse power electric motor, which gives the vessel a speed of 7 knots when awash or submerged. The hull is circular in cross section and is divided by two watertight bulkheads into three separate compartments. There is also a thorough subdivision of the bottom, and every precaution is taken to localize any injury to the hull which might threaten the buoyancy. In the forward compartment is a torpedo tube for the discharge of 45-centimeter Whitehead torpedoes. The tube is placed with its muzzle in the nose of the craft and its axis inclined somewhat to the longitudinal axis of the vessel. The muzzle of the torpedo tube is closed by a watertight door, which can be lifted from within for the discharge of torpedoes. In the same forward compartment are a series of air flasks, a gasoline tank of 850 gallons capacity, a compensation tank which will be filled with a sufficient amount of water to compensate for the loss of weight due to the discharge of the torpedo, and one of the trimming tanks.

The central compartment contains in its double bottom the main ballast tanks and a circular compensating tank which will be noticed in our engraving between the two sets of batteries. Above the double bottom and below the axis of the vessel are located the storage batteries. These are charged by the gasoline engine running the electric motor as a dynamo when the vessel is at the surface. Above the storage batteries are carried the torpedoes, which are 45 centimeters in diameter by 11 feet 8 inches in length; and in the same compartment are a series of air flasks, in which air at 2,000 pounds to the square inch pressure is stored for the purpose of keeping pure the living spaces of the crew. In the rear compartment is the four-cylinder gasoline engine, which is rated at from 160 to 190 actual horse power, at from 320 to 390 revolutions per minute. Its net weight is 1,300 pounds. Its length over all is 9 feet 7 inches, and its total height above the crank-shaft center is 5 feet 6 inches. In these engines, which have given great satisfaction in the first Holland boat, the distribution of the cranks and the timing of the valves and igniters are so arranged that the operations in the four cylinders alternate; so that while one is on the expansion stroke the other three are on the suction, compression and exhaust strokes respectively. By this arrangement the engine is perfectly balanced and vibration is reduced to a minimum. The fuel consumption of the first engine proved from measurement to be 0.88 of a pound of gasoline, of 0.74 specific gravity (Baumé scale).

In the construction of the vessels care has been taken that all portions of the exterior of the hull shall be free from projection of a kind that might be entangled by ropes or other obstacles when submerged. The lines of the vessels have been designed so that there shall be a minimum of resistance when they are running at the surface. The radius of action at the surface is about 400 knots, and the storage batteries have sufficient capacity for a speed of 7 knots on a four hours' submerged run. Gearing is provided for driving the propeller direct from the gasoline engine or connecting the engine to the main motor, accommodations being effected by means of suitable clutches. The submersion of the vessel is achieved by means of ballast tanks and a pair of horizontal driving rudders at the stern. For keeping her submerged at desired depths, use is made of the trimming and ballast tanks above described, and it is claimed that the control in this respect is very satisfactory. The air supply and ventilation are secured by means of compressed air stored in the tanks referred to, while the gasoline vapors from the engines and, indeed, all noxious gases are carefully excluded by suitable devices, while safety valves are provided to prevent the pressure in the vessel from exceeding that of the atmosphere. Provision is also made for automatic control of the rudders; for the purpose of preventing the vessel from taking excessive angles when diving, or coming to the surface, and also for keeping the boat submerged at the desired depth.

In spite of the difficulties attending the whole problem of submarine navigation, it is generally admitted that the Holland boat has come as near to mastering them as any craft of the type that has been built. Just what the French have done we do not know with any degree of accuracy, but they appear to have made some successful long-distance trips without detection, although this is nothing more than the Holland type is claimed to be capable of doing. We understand that a trip of several hundred miles down the Atlantic coast is shortly to be undertaken. Although its fighting powers can only be determined in actual war, it is agreed among naval experts that the submarine will have a decided value as forming part of a system of harbor defense. Certain it is that a fleet of them would have the effect of causing a blockading fleet to retire at night-time much further from the mouth of a harbor than it would were no such machine as the submarine known to exist.

The Current Supplement.

The current SUPPLEMENT, No. 1356, has a number of articles of unusual interest. "Discoveries in Mesopotamia," by Dr. Friedrich Delitzsch, is accompanied by most attractive engravings. "Missing Links" is a lecture delivered by Prof. Thomas H. Montgomery and is especially reported for the SCIENTIFIC AMERICAN SUPPLEMENT. "Recent Experiments with Sound Signals" is by J. M. Bacon. It is a most valuable paper. "Nicaragua or Panama" is by a former Chief Engineer of the Panama Canal, Mr. Philippe Bunau-Varilla.