## AN IMPROVED ELECTRO-MAGNETIC APPARATUS.

Our illustrations represent an efficient type of electro-magnetic machine, invented by Francisco de Borja Pavon, of Caibarien, Cuba, the field of which machine is so constructed that the lines of magnetic force are concentrated to obtain a current of great strength.

The two opposite fields consist of a number of tubular cores arranged one within the other, the innermost tubular core receiving a cylindrical core. The cores are surrounded by windings, so arranged as to prevent contact of their walls, and are independently supported by uprights and bases forming complete magnetic circuits. The upper portions of the uprights are made in the form of yokes screwed to the lower portion, so that the sections of the polar inductors may be readily removed and repaired.

The winding of the cores can be made continuous, because the current for all the coils is the same. But for the purpose of easily separating the parts, the inventor connects the ends of each winding with binding-posts on the base and thereby attains the same result as if he had used a continuous wire. To facilitate the interior magnetization of the tubular cores, each is longitudinally slotted, parallel to its axis.

In this machine, the electro-magnets are excited by the same current, but each, with the uprights and
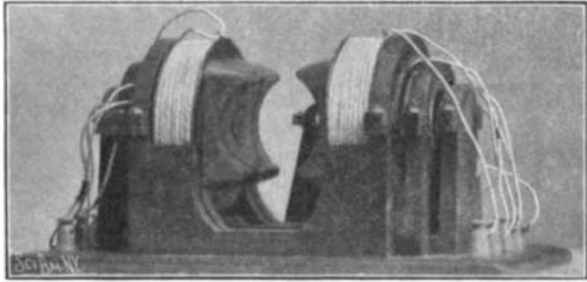


SINGLE CIRCUIT, BIPOLAR ELECTRO-MAGNETIC MACHINE.

bases, constitutes an independent system and magnetic circuit. But since the polar tubular ends are introduced one within the other, the magnetic force is concentrated toward the central core in the space between the opposite polar ends, thus producing an increase of the magnetic field as a result of the common action of the electro-magnets.

The principle can be applied to bipolar machines or
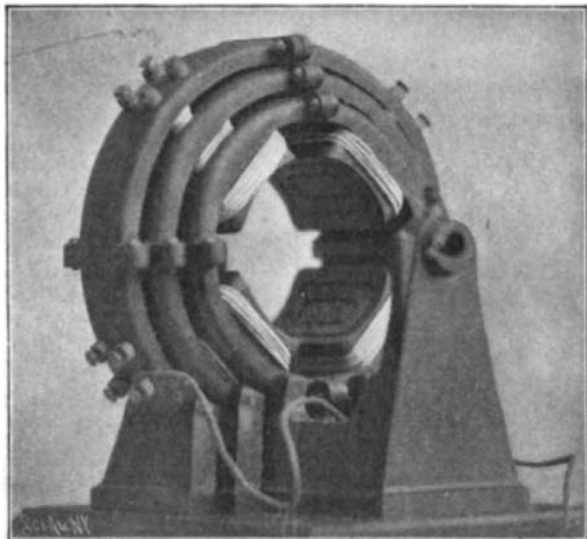


DOUBLE CIRCUIT, MULTIPOLAR ELECTRO-MAGNETIC MACHINE.

to multipolar machines with a double circuit, with tubular cores of circular, elliptical or square sections, and with armatures of any shape.

### Influence of X-Rays on Selenium.

M. Perreau has lately made a number of researches as to the effect produced by X-rays upon selenium, and has presented his results to the Academie des Sciences. He finds that selenium, which is sensitive to light, is also affected by this form of radiation. The experiments were carried out with a selenium cell made up in the usual way with brass strips $\frac{1}{16}$ millimeter thick separated by strips of parchment paper of $\frac{1}{10}$ millimeter. The cell contained in a zinc box, and covered by a sheet of aluminium, was placed in circuit with a Daniell element, a resistance box and a galvanometer. The resistance of the selenium was found to be 40,000 ohms in the dark, and when exposed to diffused daylight or to a gas burner at a distance or 1½ meters, this fell rapidly to 33,000 ohms, coming back to its original value in the dark. When exposed to the radiation of a Crookes tube, whose anticathode was about 5 millimeters distant, the resistance of the selenium diminished rapidly to 34,000 ohms; upon suppressing the X-rays, the resistance returned to its original value, but somewhat more slowly than in the former case. The action diminishes as the tube is further removed, but is still appreciable at 17 centimeters.

## STASSANO PROCESS.

BY FRANCIS P. MANN.

An interesting process has been lately devised by an Italian engineer, Stassano, for the production of iron and steel by the electric furnace, using the heat of the arc to reduce the oxides and fuse the resulting metallic mass. A series of tests has been recently carried on at Rome in which the process appears and has given satisfaction. The electric furnace used for this purpose has somewhat the appearance of a blast furnace on a reduced scale, and is formed of two truncated cones placed together at their larger base, as shown in the figure, in which $A$ is the chamber where the ore is reduced and melted. The fused metal is collected in the crucible, $C$, below, and runs out by the opening, $F$. The two carbons, $cc$, are each 10 millimeters in diameter and are about one meter long; their distance is regulated by hand, according to the indications of the ammeter and voltmeter of the circuit. The slag is taken out by a hole in the top of the crucible, while the gases given off by the reactions rise through the mass and escape by the openings, $tt$. These openings may be closed by a hydraulic valve, $B$, to prevent the entrance of air when the mouth of the furnace is opened; the cover, $TT$, serves to close this, and is opened to introduce the charge.

In this process it is necessary to give the ores a previous treatment before introducing them into the furnace. These ores are generally oxides or carbonates; the latter are first roasted. A certain percentage of carbon, lime, or silica is added, analysis determining the proportion of each necessary for the reduction of the ore in question and to obtain a metal of a given composition. The ore and all materials are powdered and well mixed together, with the addition of 5 or 10 per cent of pitch which serves to agglomerate the mass. The resulting paste is formed into bricks by a hydraulic press, each brick containing about 0·04 cubic meter. After drying, these bricks are fed into the furnace. When it is desired to prepare an iron containing manganese, nickel, chromium, etc., the oxides of these metals are added to the powdered mixture. By the heat of the arc the ore is decomposed and forms in the presence of carbon carbonic acid gas, which is then transformed into carbon monoxide, and by the combustion of this latter gas the process is facilitated. The energy necessary for the production of a ton of metal is estimated at 3,000 horse power hours. The following table will show how this calculation is reached:

| | Red Hematite, $Fe_2O_3$. | Magnetite, $Fe_3O_4$, or Roasted Carbonate. |
|---|---|---|
| Theoretical quantity of ore to produce one ton of metal | 1,429 kilos. | 1,380 kilos. |
| Theoretical quantity of combustible to produce one ton of metal | 357 " | 317 " |
| Heat necessary for the reduction of the metal | 1,707 calories | 1,600 calories |
| Heat necessary for the fusion of the metal | 400 " | 400 " |
| Heat developed by the transformation of C in CO | 773 " | 686 " |
| Heat necessary to be furnished to obtain the reactions | 1,334 " | 1,314 " |
| Electrical energy in horse power hours | 2,100 h. p. hours | 2,070 h. p. hours |
| Quantity of CO produced per ton of metal | 750 kilos. | 666 kilos. |
| Quantity of heat resulting from this | 1,826 calories | 1,622 calories |

For the reduction of $Fe_3O_4$, for instance, will be necessary $\dfrac{1,380 \times 48}{232} = 285$ kilos. of carbon, or 317 kilogrammes of a 90 per cent combustible. If it is desired to produce steel, a somewhat larger percentage of carbon is necessary, but that contained in the pitch must be also taken into account. It will require, then, 1,600 calories to reduce the 1,000 kilos. of iron contained in the magnetic oxide, and 400 calories to melt the resulting mass, or a total of 2,000 calories; deducting 686 calories developed by the oxidation of the carbon, 1,314 remain to be furnished by the electric energy; this corresponds, allowing 75 per cent efficiency, to 2,760 horse power hours. The 3,000 previously estimated will thus cover the energy necessary for producing a ton of metal; this may be produced in Italy for about 18 lire, and in spite of the cost of preliminary operations, maintenance of the furnace, etc., the great economy realized on the fusion permits of arriving at a much lower price per ton of bar iron. According to the inventor, this does not exceed 100 lire, as compared with 160 lire by the usual process. A part of this economy is obtained by using the excess of carbon monoxide to heat the furnaces for the ingots.

The principal ores found in Italy are hematites, magnetites, and spherosiderites. Red hematite is found in considerable quantities in the island of Elba; magnetite in the valley of Aosto, in the district of Ivrea, and at Cape Calamite. Extensive deposits of spherosiderites exist in the valleys of Camonica and Trompio, where numerous hydraulic plants could be economically placed. An experimental furnace of 100 horse power

has been established at Rome for the treatment of the Camonica ores; the energy is furnished by two dynamos of 300 horse power each, and the potential reduced by transformers to 50 or 60 volts. After passing the current for twenty minutes to heat the furnace, the charge was gradually introduced; the treatment lasted for thirty-five minutes. From time to time, the current varied on account of the differences of resistance encountered in the mass by the arc. A quantity of metal
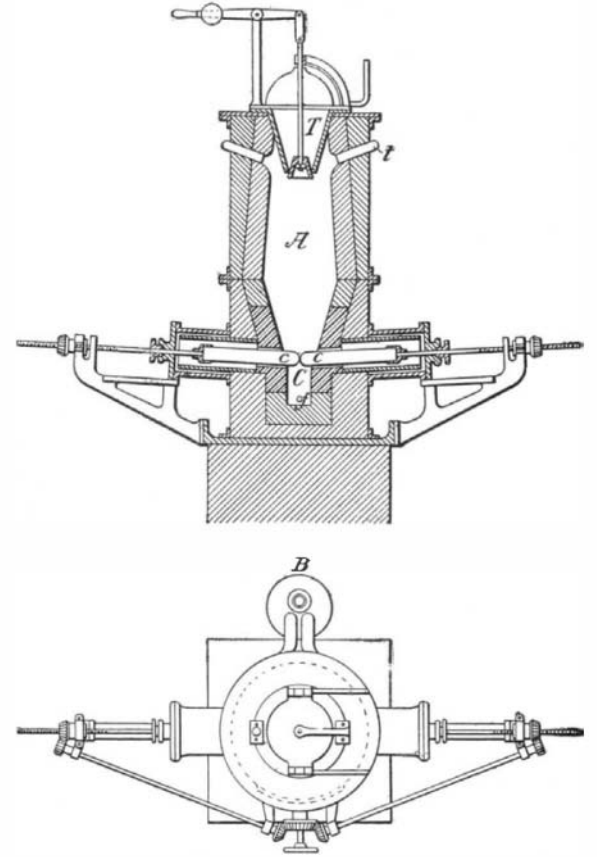


VERTICAL SECTION AND PLAN OF STASSANO ELECTRIC FURNACE.

equal to 8 kilogrammes was thus obtained, with an expenditure of energy of 2·7 horse power hours per kilogramme. The numerous tests carried out under these conditions have resulted in the formation of a company which will take up the process and in the near future will install three furnaces of 500 horse power each in the valley of Camonica, whose total yearly production is estimated at 4,000 tons.

## REPAIRING A PROPELLER SHAFT AT SEA.

There recently came limping into the port of New York, with a broken propeller shaft, the tramp steamer "Manica." Her torn and battered topsides and deck fittings bore eloquent tribute to the fury of the Atlantic gale in which she all but foundered; while down in the engine room and in the shaft tunnel she bore evidence, in the shape of many an ingenious makeshift repair, to the resourceful skill and indomitable pluck with which the engine-room staff had confronted impending disaster and saved the ship.

The "Manica" is a freight steamer of 2,733 tons gross tonnage, and 11 knots' speed, belonging to the Norton line. Ordinarily she runs from New York to the River Plate. On the present occasion she was on a voyage from Shields, England, to New York, and when about
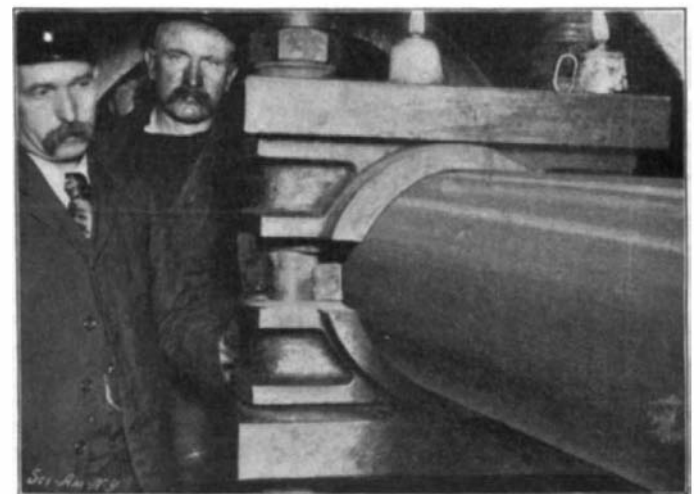


PROPELLER SHAFT REPAIRED AT SEA WITH TWO SPARE CRANK-PIN BRASSES, AND TWO CAPS AND HOLDING-DOWN BOLTS FROM THE MAIN ENGINE.

1,600 miles from her destination she experienced very heavy weather, in which she broke her propeller shaft cleanly in two. The fracture, which occurred on the second length of intermediate shafting from the thrust block, was what is known as a "scarf" break. It began about 4 inches from the coupling and extended diagonally for 34½ inches through the shaft. The

wedging effect of the forward portion of the shaft, coupled to the engine, riding over the after length, smashed three of the "stools" or plummer blocks and their caps, lifting the shafting out of its bearings. The force of the waves, as the ship rose and fell in the trough of the sea, was sufficient to drive the propeller violently against the rudder post, leaving 10 inches of opening at the point of fracture. The first thing to be done was to uncouple the after portion of the shafting and draw the broken ends together with screw bolts. Two spare crank-pin brasses were then placed around the break, two of the main-bearing caps from the main engine were placed above and below the brasses, and two spare holding-down bolts of the main

intermediate shaft. This was done by placing a series of large washers above the main brasses and trusting to the strength of the brasses to hold the crank shaft down in place. Steam was then turned on, and the vessel completed the remaining 1,600 miles of her voyage at a speed of 10 knots an hour, only two or three stops being necessary to tighten the bolts on the broken shaft.

The repairs were made in terrific weather, while the ship was lying helpless in the trough of the sea and was being boarded by occasional seas which smashed the upper works and found their way into the hold and the cabins. When the vessel reached New York, it was noticed that the tremendous wedging strains at

## THE NEW YORK RAPID TRANSIT TUNNEL.

Although the New York Rapid Transit Tunnel is such a really stupendous undertaking, far exceeding in magnitude any work of the kind elsewhere, the details of its construction and the manner of executing it are not so complicated but they may be easily understood by the average lay reader. The accompanying series of illustrations cover pretty well all the main features of the construction, the various views having been selected with the object of showing the general plan which will be followed throughout the major portion of the route and the various sections of the road where local conditions call for departure from the general plan.
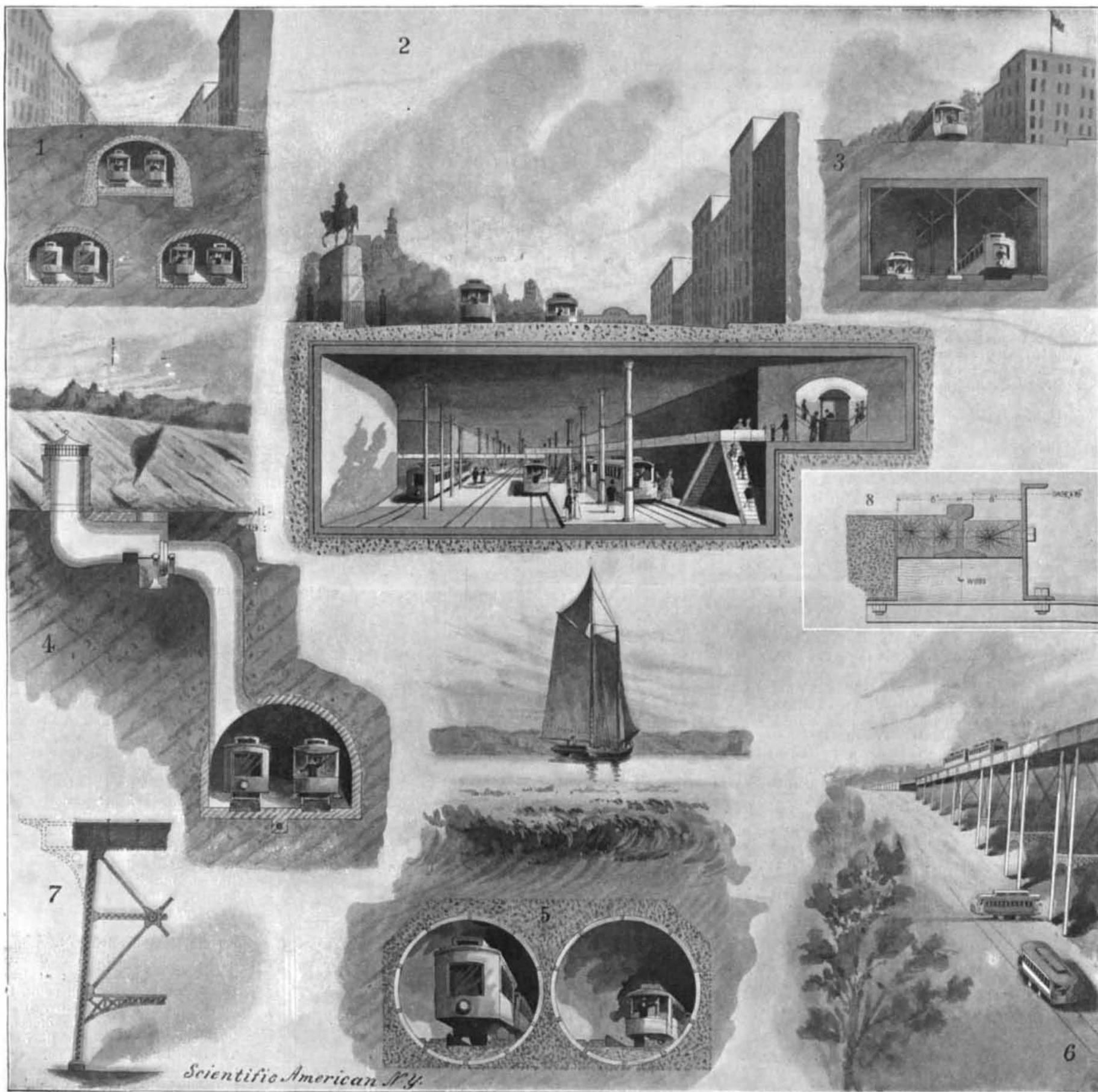


1. The four-track road in two tunnels below the Park Avenue tunnel.　2. Fourteenth Street station, looking north.　3. Two-track line below Lenox Avenue.　4. Ventilating shaft for tunnel beneath Central Park.　5. Tubular tunnels beneath Harlem River.　6. Elevated portion at One Hundred and Twenty-fifth Street.　7. Details of viaduct construction.　8. Details of track.

### THE NEW YORK RAPID TRANSIT TUNNEL.

bearings were used to bolt the brasses and caps together, as shown in the accompanying illustration, which was taken in the shaft tunnel after the arrival of the "Manica" at New York.

So far, so good. There still remained the three broken caps of the shafting in the shaft tunnel. It was impossible to replace these, and all that could be done was to utilize some sling-chains from the deck, winding several coils around the shaft and fastening them to the tunnel floor. The after portion of the shafting was then drawn up to place and the coupling-bolts inserted. Before steam could be turned on it was necessary to make some provision for holding down the main bearings, whose caps, as we have shown before, had been used to splice the break in the

the fracture caused the white metal of the brasses to squeeze out at the edges. The sling-chains, whose duty it was to hold down the shafting in its bearings, were also, of course, considerably worn, in spite of the fact that they were kept thoroughly lubricated. Great credit is due to Capt. C. G. Smith and Chief Engineer J. Gooding and his assistants for pulling their ship out of such an ugly and apparently hopeless predicament. We are indebted for our illustrations and particulars to Consulting Engineer A. McDermott, of New York, who had charge of the repairs.

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AN order from France for fifty pressed steel cars has been received. If these cars prove successful, it is expected that much larger orders will follow.

The route of the road, as shown in the accompanying map, starts from a large underground loop which will be built beneath the City Hall Park. The four tracks within this loop will be carried in two stories, two tracks above and two below, but at the point of junction between the loop and the main four-track line, the tracks will converge to a common level, and will continue at the same level practically throughout the whole length of the system. The four-track road will pass beneath Center Street and Elm Street to Fourth Avenue, which it will reach in the neighborhood of Ninth Street. Thence it will continue beneath Fourth Avenue and Park Avenue until it swings to the left into Forty-second Street, beneath which it will run to Broadway. The four-track road will continue underneath Broad-