

# The French "Tube."

(The Paris Metropolitan Railway.)

BY LIONEL WIENER.

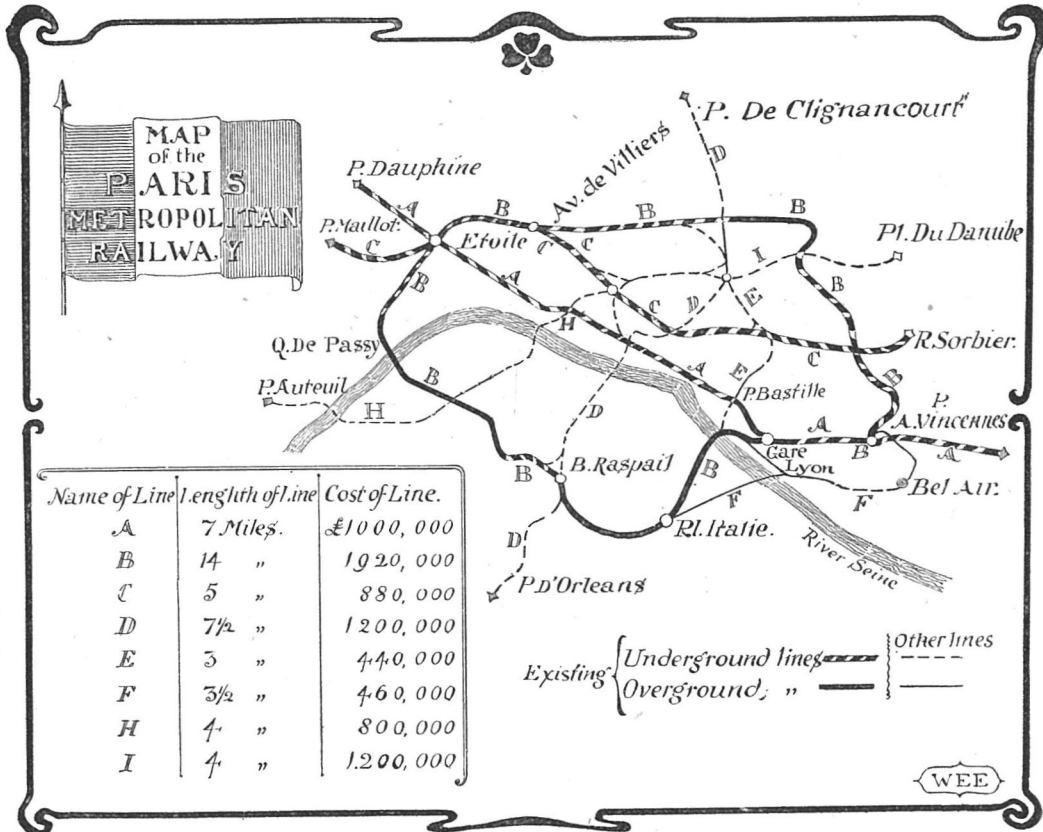


THE interest of the Paris Metropolitan Railway system lies in its being the outcome of a general scheme of urban railway communications, whereas in London numerous companies have been formed for working various lines.

As long ago as 1879 M. Manton, at that time general manager of the "Chemin

long delay. However, private enterprise has had a larger share than might have been expected, as the line is leased to and worked by a private company, though it was built by the Paris corporation.

The original idea was to establish a network of metropolitan lines under or over Paris, not only in the populous districts, but also to create traffic in the outlying



de fer de Ceinture," was asked to plan a metropolitan line similar to the one that had recently been opened in London. But it was only in 1900 that the first portion was opened to the public. The continental practice of State interference in railway matters was the principal cause of this

parts of the city, by bringing them within quick and easy access of the heart of the city. These were the town council's views. The State considered the system as the natural outcome of the existing lines, most of which have their termini at the outskirts of the city, and wanted the new

lines not only to serve the town, but eventually to provide a means of interchanging traffic between the various companies.

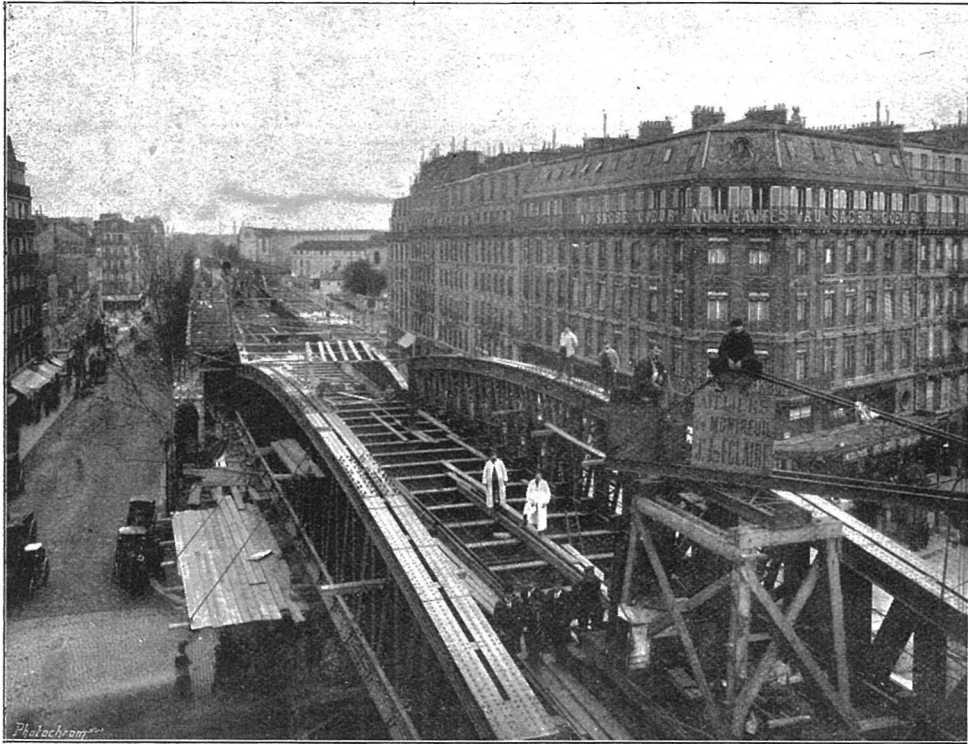
The Paris corporation feared these junctions might overcrowd the new lines with through trains and so prevent their fulfilling their purpose. Hence the conflict and delays. Had it not been for the 1900 exhibition the scheme would probably be in the same state to-day as it was forty years ago.

However, as a concession to the city for its important co-operation in organising the

mitted to the motors by a conducting rail and shoes.

After many hesitations it was decided that the town would build the greater part of the permanent way, tunnels, bridges, stations, etc., the leasing company providing the rest, such as electrical equipment, the stairways and passages to the various stations, the rolling stock, signals, etc.

In 1898 the town council raised a 65,000,000frs. (£2,600,000) loan, but Parliament, when passing the bill, put in a clause obliging the line to be laid with



ERECTING THE VIADUCT FOR THE RAILWAY IN THE RUE A LA CHAPELLE.

exhibition, the State altered its views and passed a bill (in November 1895) allowing the city of Paris to build a metropolitan railway system for local traffic only.

Narrow gauge was chosen for various reasons. It lessened the outlay, and, moreover, prevented any connection with the main lines which might be planned in after years.

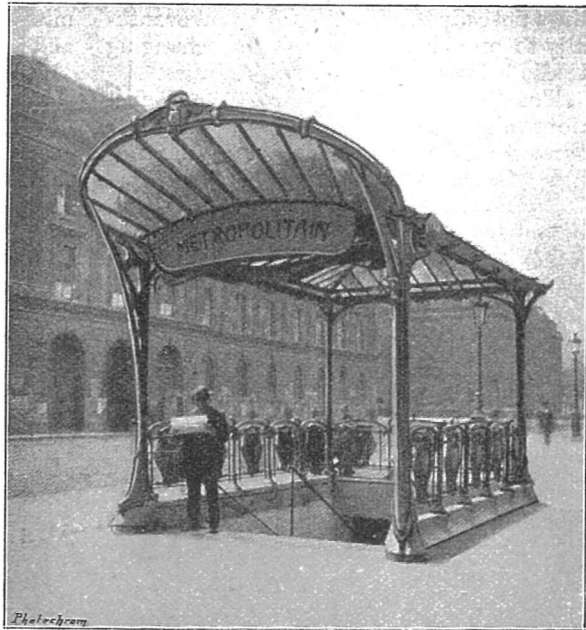
Electric traction was fixed upon as more economical for running quick trains at short intervals. The current was trans-

mitted to the motors by a conducting rail and shoes. Not wishing to renew the gauge fight, the town council turned this recurring difficulty by a rather neat dodge. The gauge is 1 metre 435 (4 feet 8½ inches), but the loading gauge is smaller than the railway loading gauge for the 4 feet 8½ inches rail gauge, and most of the overhead passages in the stations have been built so that they are too low to allow standard railway stock to pass under them; in a word, the whole line is built as a narrow gauge line with the one exception that the

rails are 1 metre 435 (4 feet 8½ inches) apart. Standard railway stock is thus effectually prevented from running over the system, although, on the other hand, the metropolitan trains can, if necessary, run out of town and so provide an exodus for the Parisian public without running the risk of having their lines over-crowded with express trains.

The lease is for 35 years, starting from the day the company takes over the last section built by the town council's engineers. If the company had had to build the tunnels, stations, &c., instead of just finishing off, the great outlay such a work would have cost would have been out of proportion with this short lease, and a period of 80 years at least would doubtless have been required.

The lessees, the General Traction Company, together with the Creusot firm, have undertaken to promote a company, "the Cie du Chemin de Fer Métropolitain," whose capital is £1,000,000, for building and working the metropolitan railways.

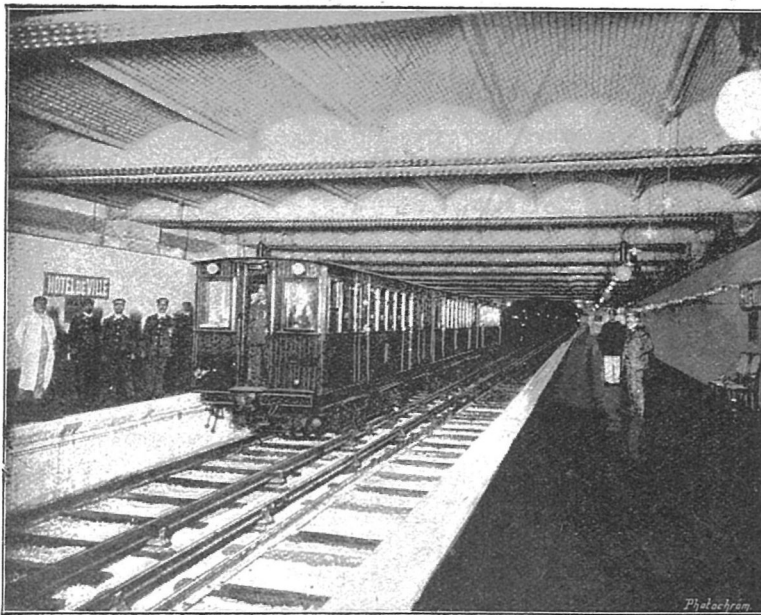


ENTRANCE TO THE HOTEL DE VILLE STATION.

The system is divided into three groups of two or three lines each, and comprises altogether 65 kil. (39 miles) of lines. Though each group's lease runs 35 years

only, the company will remain in possession of the whole system till the running out of the last of the leases, but will pay the town yearly 45,000 frs. per kil. (£2,934 per mile) for those portions that have become its property.

The town may buy up the system any time after the first seven years the company has held its lease. The latter pays the former a tax slightly inferior to ½d. per second-class and 1d. per first-class ticket, so long as it



THE HOTEL DE VILLE STATION.

Stations, such as this, which are only just below the surface, have a roof as shown in this illustration, but the stations some depth below the surface have vaulted roofs.

carries fewer than 160,000,000 passengers a year. Up to 190,000,000 passengers these taxes are slightly increased, but this increase is not excessive, if one considers that the greater part of the cost of the line was borne by the town. This percentage is used by the town to cover the expenditure of building the new lines and of paying off the loan.

The fares are as follows: 15 centimes (about  $1\frac{1}{2}$ d.) in second, and 25 centimes (about  $2\frac{1}{2}$ d.) in first class, any distance. Between certain hours, return tickets at a uniform 2d. fare are issued.

Of the three groups the system is composed of, the first contains three lines (A, B and C), and is opened to the public\*; the second, three lines (D, E and F) is building; the third, two lines only (H and I).

On the map on page 224, the names of the termini are marked, also the letters distinguishing the different lines.

It will be noticed nearly the whole system is underground; rather large portions of B and F lines, and a small portion of E line, are the only exceptions. There will be, altogether, three tunnels under

the Seine and three bridges over the river, which are the principal engineering difficulties. All the large French railway companies run from Paris into the provinces and have their termini at the outskirts of the town. It was stipulated the Metropolitan system was not to interfere with such junctions as might be built in the near future. These junctions are:—

(a) Orleans station (Cie. d'Orléans) with the gare des Invalides and Saint Lazare (Ouest). Two sections of this line are built: from the quai d'Austerlitz to the quai d'Orsay by the first of these companies; from the Champ de Mars station to Courcelles, by the second.

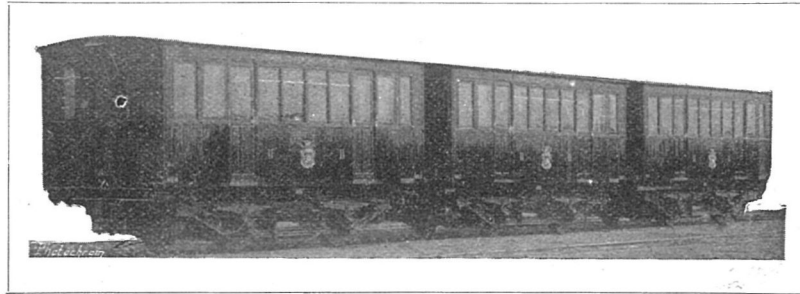
(b) The gares du Nord and Est, with those of Vincennes, of Lyons and Orléans.

\*Except the south portion of B line, the bridges over the Seine being the cause of the delay.

The cost of building the lines is £10,720,000; to this sum should be added £2,400,000 for various works on the roads, drains, etc., and £280,000 to cover the loan expenses, bringing the total to £13,360,000.

The third line of the first group was opened to the public last October, bringing the total to 42 kil. ( $26\frac{1}{4}$  miles) out of the total 70 kil. (49 miles) of the system.

The curves are 100 metres radius (5 chains) as a minimum; exceptionally as small as 75 metres (3 chains  $\frac{7}{10}$ ) or even 50 ( $2\frac{1}{2}$  chains). Two curves in opposite directions are always separated by a 50 metres (55 yards) portions of straight line. Gradients are often steep, but never more than one in 25. The stations are always on a level. These latter are usually formed by the widening of the tunnels brought to 14 metres 40 (47 feet 3 inches) their height to 3 metres 50 (11 feet



SECOND CLASS CARRIAGES USED ON THE FRENCH METROPOLITAN RAILWAY.

6 inches) save where overhead passages connecting the platforms, cross the lines. These crossings only just allow the trains under them. The platforms (raised 3 feet 2 inches) are 4 metres (13 feet  $1\frac{1}{2}$  inches) wide. In some parts of the system the stations are liable to be flooded. This contingency is provided against by furnishing them with flat metallic roofs, and so reducing their depth underground. The terminals are of the island platform type. The up and down lines are connected by loops, thus greatly facilitating the handling of the train.

As in London, no luggage is carried. The trains stop about 20 seconds at each station—double the "tube's" allowance—but an unheard of reduction on the Continent.

The stations comprise: above ground, a painted board above a stairway; next, two

offices, one for tickets, the other for exchanging money; then the footway, and lastly platforms on either side of the tunnel, which is lined with white enamelled bricks.

Vignole rails are used, a nearly general Continental practice. They are 15 metres (49 feet 3 inches) long, and weigh 52 kilos. per metre. (92 pounds per yard).

The maximum speed is not considerable and has been limited at 36 kil. (22½ miles) an hour. In reality, it is about 20 kil. (12½ miles) inclusive of stops.

The trains were at first made up of three non-bogie carriages, and shook one up frightfully. They were made up of first-class and second-class, or of composite carriages, but the latter have been done away with and turned into second-class cars.

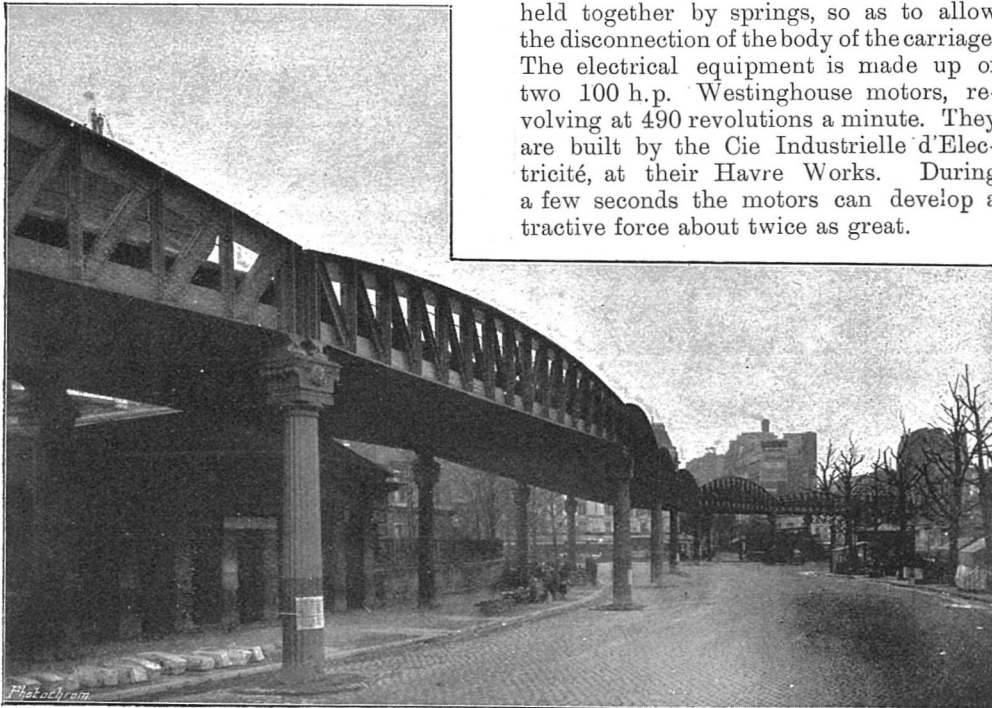
The length of the body is 8 metres 70 (28 feet 6½ inches) their width 2 metres 40 (8 feet) and height, 2 metres 20 (7 feet 2 inches) from floor to roof. The seats are placed back to back across the car and are divided by a 85 centimetres (33½ inches) passage which runs down the centre. Each carriage seats thirty

passengers, but standing accommodation (if such a word can be used) is provided for another twenty-five. The backs of the first-class seats are covered in brown leather; those of the second-class seats are of varnished wood, plainly finished. On either side, are two sliding doors, one for coming in, the other for going out. A special electrical circuit gives the necessary current to the lights, eight in number, besides four lanterns forming the four electric heaters, and to the station-indicators with which the carriages are provided. These various appliances are worked by the driver from the cab in front of the motor carriage.

As a result of the sharpness of the curves, there are central buffers only, rather an exceptional practice on standard gauge lines, but usual on narrow ones, and it must be remembered this is in reality a narrow gauge line.

The motor carriages are similar, in most respects. They have a cab at one or both ends, where all the electrical appliances are centred; a sliding door connects it with the interior of the carriage.

The latter has two frames, separated or held together by springs, so as to allow the disconnection of the body of the carriage. The electrical equipment is made up of two 100 h.p. Westinghouse motors, revolving at 490 revolutions a minute. They are built by the Cie Industrielle d'Electricité, at their Havre Works. During a few seconds the motors can develop a tractive force about twice as great.



SERIES OF VIADUCTS CARRYING AN OVERHEAD PORTION OF THE FRENCH METROPOLITAN RAILWAY AROUND A CURVE.

Two Westinghouse controllers bring the motors to work in series or in parallel. Each car is fitted with three brakes, a Westinghouse compressed air brake (for which a small dynamo has been provided), a hand brake, and an electrical one for emergencies.

Hall's automatic block system is used. There are signals at either end of each station and intermediate ones between them; the wheels pass upon an electrical commutator, and automatically close the circuit, thus bringing the signal to danger, and opening the preceding one.

Besides these blocks, telephone boxes are established at each station.

But since the terrible accident, which is still too fresh in all minds to be recalled, numerous safety measures have been taken, and the passengers' comfort attended to by rebuilding the old cars or building new ones on a new plan.

At the close of 1903, the company's rolling stock was made up of 132 motor, 221 second, and 109 first-class carriages. Since then, 167 motor, 28 first, and 28 second-class carriages have been ordered, and delivered for the greater part.

Amongst the new emergency appliances the principal are the following:—A new and complete electrical canalisation has been laid; the conduits are fireproof and sunk in concrete wherever it was possible to do so. Half the lights take their electricity from these new circuits. Lights have been placed along all the tunnels, and in the stations electric lamps, behind glass plates, with the word "sortie" written upon them. There are now intermediate telephone boxes between the stations. The lines are divided into 100 metres sections, each of which is provided with a circuit breaker, so as to cut off the current speedily, should it be necessary to do so, and not have to wait twenty-five minutes, as was the case in the Couronnes accident.

The multiple unit system, which is decided upon, will allow lower tension currents to be used, but of this more hereafter.

The new carriages are 14 metres (24 ft. 11½ in.) long, and run on bogies. Each of the motors develops 175 h.p. As the trains are made up of five carriages, both the end and centre are motors, these are 1,050 h.p. per train.

The new trailers are composite, and hold 80 passengers, part of whom stand on the three platforms that alternate with the compartments. They have clerestory roofs and metallic panels for the first-class portions, which are painted red; the others are fireproof wooden panels, plainly varnished outside. The bogie motor carriages have several new features.

The driver's cab has been enlarged, and its length brought to 2 metres 50 (8 feet 2 inches) instead of 1 metre 28 (49 inches) as previously. It is entirely built of steel and quite separate from the rest of the car, from which it can be removed. Next comes a platform with standing accommodation—this was originally intended for smokers, and instead of glass in the window frames is provided with wire gauze. Smoking is not allowed, but this compartment also is metallic and separate, and forms a kind of safety portion between the cab and the body of the carriage, which is 8 metres 35 long (27 feet 5 inches) and includes two platforms with sliding doors.

The old stock has been rebuilt, too, so as more or less to meet these requirements. The new frames are 11 metres (36 feet 1 inch) long and run on bogies. The driver's cab is quite similar to the new ones, and there is a small interval between the cab and the body of the old carriages, which is placed on the frame such as it was; the only difference is that it has been rendered fire-proof.

These alterations form a superabundance of precautions of which I have only enumerated the principal ones, but the company has had a severe lesson, which has borne its fruit, and excess in this direction is not open to criticism.

The trains are made up as follows:—On the A line, seven short cars, the end and centre ones motors.

B line: six short cars, the end ones only motors.

On C line, five new cars, the end and centre motors.

This brings all the trains very nearly to their greatest length (about 70 metres, or 77 yards). The station platforms are only 79 metres long (82½ yards), under existing circumstances it would be difficult to increase the carrying capacity of each train, which varies from three to four hundred passengers.

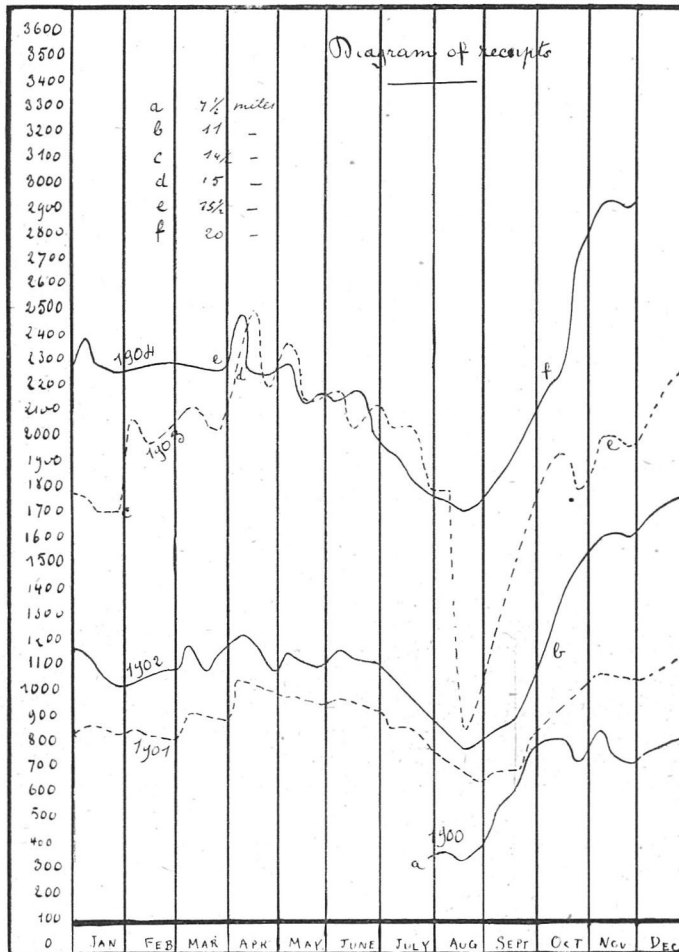
As shewn on the map on page 224, the greater part of the system is underground; to build it, a large use was made of the Chagnard shield, for tunnelling close to the

surface, but, as the progress was too slow, the cut and cover system was used wherever it was possible to do so without interfering with the roadway traffic too much.

The first line is very nearly parallel to the river. This situation was turned to profit by boring four side tunnels, which connected the line and the Seine, and allowed the earth to be carried off by barges without passing through the streets at all.

The tunnels have an elliptical section; their width is 7 metres 10 (23 feet 3½ inches), their height 2 metres 07 (6 feet 9½ inches), there is 44 inches clearance above the cars' centre, and 36 inches at the sides, save in the curves, where they are thrown out another 7 inches. Though the top of the tunnel is, as a rule, just below street level, the lower portion is often lower than the river. It was found necessary to build a waterproof flooring to prevent the flooding of the lines. This flooring is a very flat inverted arch, whose concavity is turned upwards. The lowest portion is only 6 metres 70 (27½ inches) beneath the lines. The tunnels have an inside coating of concrete, about one inch thick, which makes them quite watertight.

The running sheds are connected with the tunnels by inclines at the end of the lines. In order to ascend them the cars



The above diagram is, curiously enough, a very exact reproduction of Paris life.

In summer the Parisians are out of town: hence the low profits during the warm months. Traffic then rapidly increases during October; there is a kind of upheaval at the beginning of November, the result of "All Saints' Day" and the animation it gives the city. Next come Christmas and the New Year's visiting, then a slight fall, but a high average is kept, as the winter months are the height of the Paris season, with an upheaval caused by the carnival in February. In spring, the Easter holidays followed by Whitsuntide, and the "Concours" and races towards May and June; this brings us to the general summer exodus.

The very marked fall in August, 1903, was produced by the panic caused by the Couronnes accident on the railway.

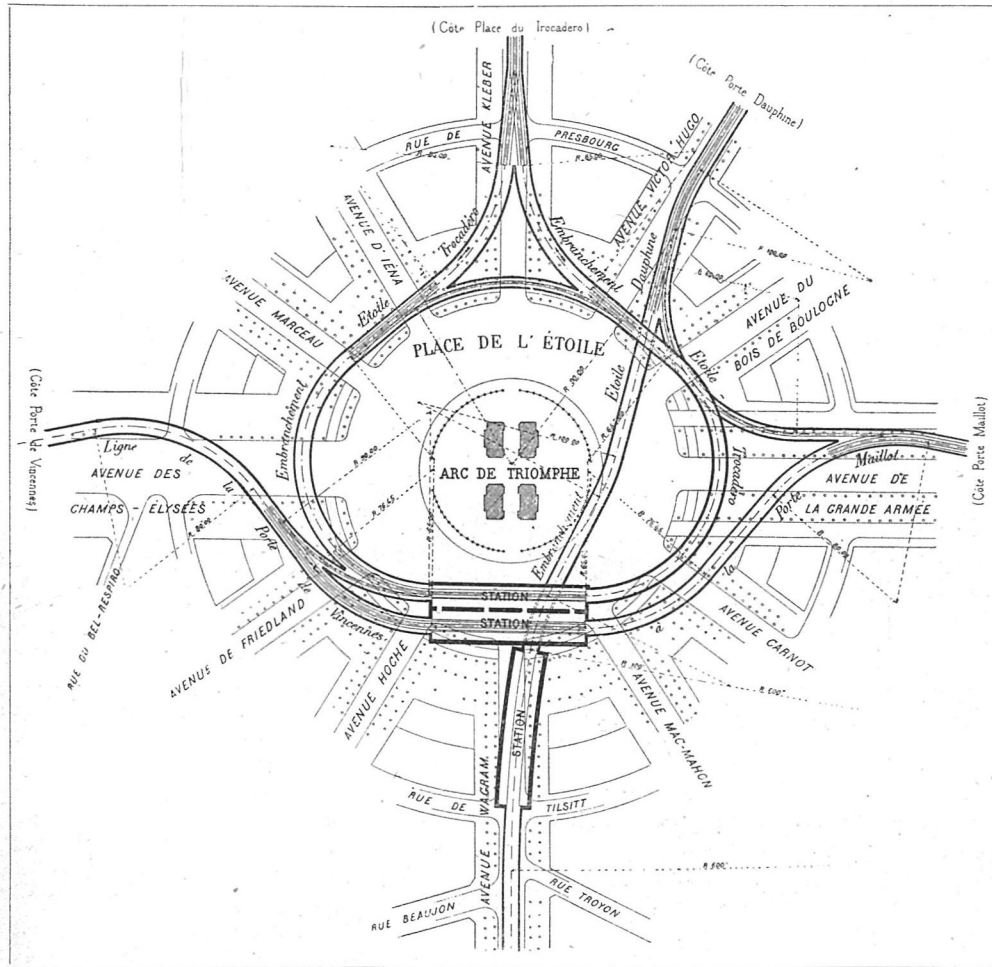
The letters a to f show the dates new sections were opened. They are always at the foot of a sudden rise produced both by Parisian curiosity—an important factor—and the larger traffic resulting from the increase of mileage.

are provided with an overhead trolley (which is removed when the shoes for collecting the current come into use).

The principal power station is at Bercy, near the gare de Lyon. It is of a horse-shoe shape, the offices in the middle and the machinery on either side. There are three series of six boilers each ; a 1,800 kilowatts engine and generator for producing

The 18 boilers are of the semi-tubular type, each is composed of two lower barrels connected in three places with the main barrel above. They work at 10 kil. pressure per square cent. (142 lbs. per square inch.)

The grate area is 3 metres 60 (40 square feet), the total heating surface 244 metres (2,630 square feet). Each of the



PLAN OF THE UNDERGROUND STATIONS AND JUNCTIONS AT THE ARC DE TRIOMPHE.

direct current under 600 volts pressure ; four three phase engines and alternators of 1,800 kilowatts capacity, and four of 2,100 kilowatts each,\* delivering current at 5,000 volts pressure, and a frequency of 25 periods per second, besides the necessary exciters, transformers, rotaries and storage batteries.

\* Totalling 14,000 kilowatts, or 20,000 H.P.

lower barrels has a 0.91 metre (3 feet) diameter and 0.0128 plates (1/2 inch), the upper barrel 2 metres 20 (7 feet 2 1/2 inches), and 0.026 (1 inch) plates. The tubes have an outside diameter of 0.018 (4 1/4 inches), the engines are vertical, compound, and condensing ; they are fitted with the Corliss valve gear ; they operate at 70 revolutions a minute ; the H. P. cylinders



have a 1.10 diameter (43.3 inches) and 1.80 stroke (89 inches). The L. P. cylinders 1 metre 80 diameter (70.9 inches) and 1.80 (59 inches) stroke. The fly-wheel's diameter is 7 metres 80 (24 feet 7½ inches), its weight 63,000 kg. (739,000 lbs.).

The dynamos and alternators are worked directly by the engines, and operate at the same number of revolutions as the engines, viz. : 70. There are two groups of exciters, each of two dynamos, one of which works as a motor at 600 volts pressure, the other as generator at 200 volts.

After passing through the 350 kilowatts transformers, the three phase current is turned into direct current by commutators operating at 25 revolutions and 780 kilowatts. There are four sub-stations for the existing lines : at the Etoile, Barbés, Pére Lechaise, and Opéra. They are all built on the same general lines, so a description of one of them will do for them all.

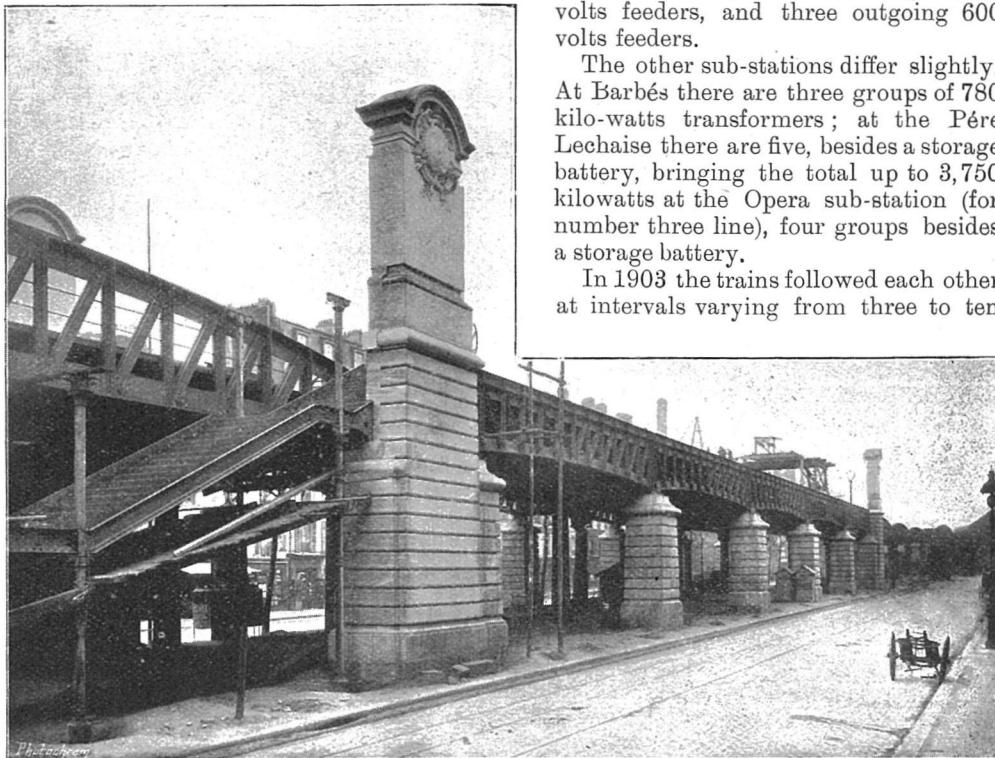
The station receives three phase current at 5,000 volts pressure, and gives out direct current at 600 volts. Each station

has a battery of Tudor accumulators, acting as regulator to the supply. The Etoile station is entirely underground and is made up of three large rooms, two of which are under each other. The first and largest is vaulted (34 yards by 15), and contains the transformers, commutators, etc. The two others contain the accumulators, and measure 28 yards by 8. Ventilation has received special attention, and an elaborate plant of air pumps, ventilators, etc., is the outcome of this problem.

Hydraulic lifts connect, not only these halls, but also the stations with each other and with the surface. Three lines cross each other at the Place de l'Etoile, besides the connections that have been built and interchange had to be provided for. The hydraulic plant has been centred in a separate "building," underground of course, 14 yards by 10. There are nine 250 kilowatts transformers, reducing the current from 5,000 to 360 volts ; three 750 kilowatts commutators working at 600 volts ; one storage battery of 1,800 amperes for one hour ; two incoming 5,000 volts feeders, and three outgoing 600 volts feeders.

The other sub-stations differ slightly. At Barbés there are three groups of 780 kilo-watts transformers ; at the Pére Lechaise there are five, besides a storage battery, bringing the total up to 3,750 kilowatts at the Opera sub-station (for number three line), four groups besides a storage battery.

In 1903 the trains followed each other at intervals varying from three to ten



STATION ON VIADUCT AT THE BOULEVARDE D'ALLEMAGNE.

minutes, and ran from five in the morning till one a.m. There were over 1,300 employees on the staff. A large and successful use is made of the premium system.

The total receipts for the last year were  $17\frac{1}{2}$  per cent. of the capital, the expenses being  $7\frac{1}{2}$  per cent., which, with an additional  $5\frac{1}{2}$  per cent. due to the town, left a very satisfactory margin as net profit.

In conclusion, I will add a few features of the existing lines:—

The first of these was opened to the public in time for the exhibition, a portion of which was at the Vincennes, whilst the main buildings were at the Champ de Mars. The line did not simply connect these two portions, but, running as it did across the heart of the city, occupied a situation somewhat similar to that of the Central London Railway. From the porte Maillot to the porte Vincennes, its length is  $10\frac{1}{2}$  kils. ( $7\frac{1}{4}$  miles). A small portion of C line (from the Etoile to the porte Dauphine), and of B line (also from the Etoile, to the porte Trocadero), were opened at the same time. It will be noticed several lines meet or cross each other at the Etoile. As originally intended, this was not to be the case. A line was to run to the porte Dauphine, passing over B line, which ran south to the Trocadero. The porte Maillot branch was to meet the B line north of the Etoile. There are 18 stations along the line, 3 and 4 on the two branches. The Bastille station is alone above ground, and was one of the most difficult points to build. The line was to cross the Saint Martin's canal, sufficiently high not to impede the boats, and yet not too high, or the open portion would be too considerable. A solution was arrived at,

by building the station over the canal, and connected with the tunnels by two S curves.

Next in order, is the northern part of B line, from the porte Dauphine to the place de la Nation, along the "boulevards extérieurs." Its length is  $12\frac{1}{2}$  kilometres, about  $7\frac{3}{4}$  miles. Some of the terminal loops and curves have smaller radii than the imposed limit, but this has been tolerated where empty trains only run. There will be junctions in two places with C line, at Bartes Station with D, and at the terminals with the first line. It will be noticed the line crosses three of the principal railways: Ouest, Nord, and Est. It was deemed advisable to pass over them, as deep level tunnelling had been rejected. This is one of the reasons why a long portion of the line is carried by viaducts, in the centre of the boulevards, like American Overhead Railways. A clearance of 6.36 metres was left under the bridges; it is 0.50 metres more than any French vehicle requires. Most of the trusses are 22 metres long, a few as much as 75 metres; over the East and Northern Railways; they are built on the Murphy-Whipple system, straight underneath and parabolic above. The sleepers are not fixed to the bridge; they rest on ballast, like on all ordinary railways. This was done with a view to deaden the noise; the drawback of ballasting on bridges is the considerable extra load.

The stations are 22 in number, at an average distance of 600 yards.

The rails are of the same weight as for the rest of the system, but they are 20 yards long. They rest on 22 sleepers.