

1875 - 1876

THE MONTRÉAL MÉTRO



PREFACE

by Lawrence Hanigan

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of the Montréal Urban Community
and
President and General Manager
of the MUC Transit Commission

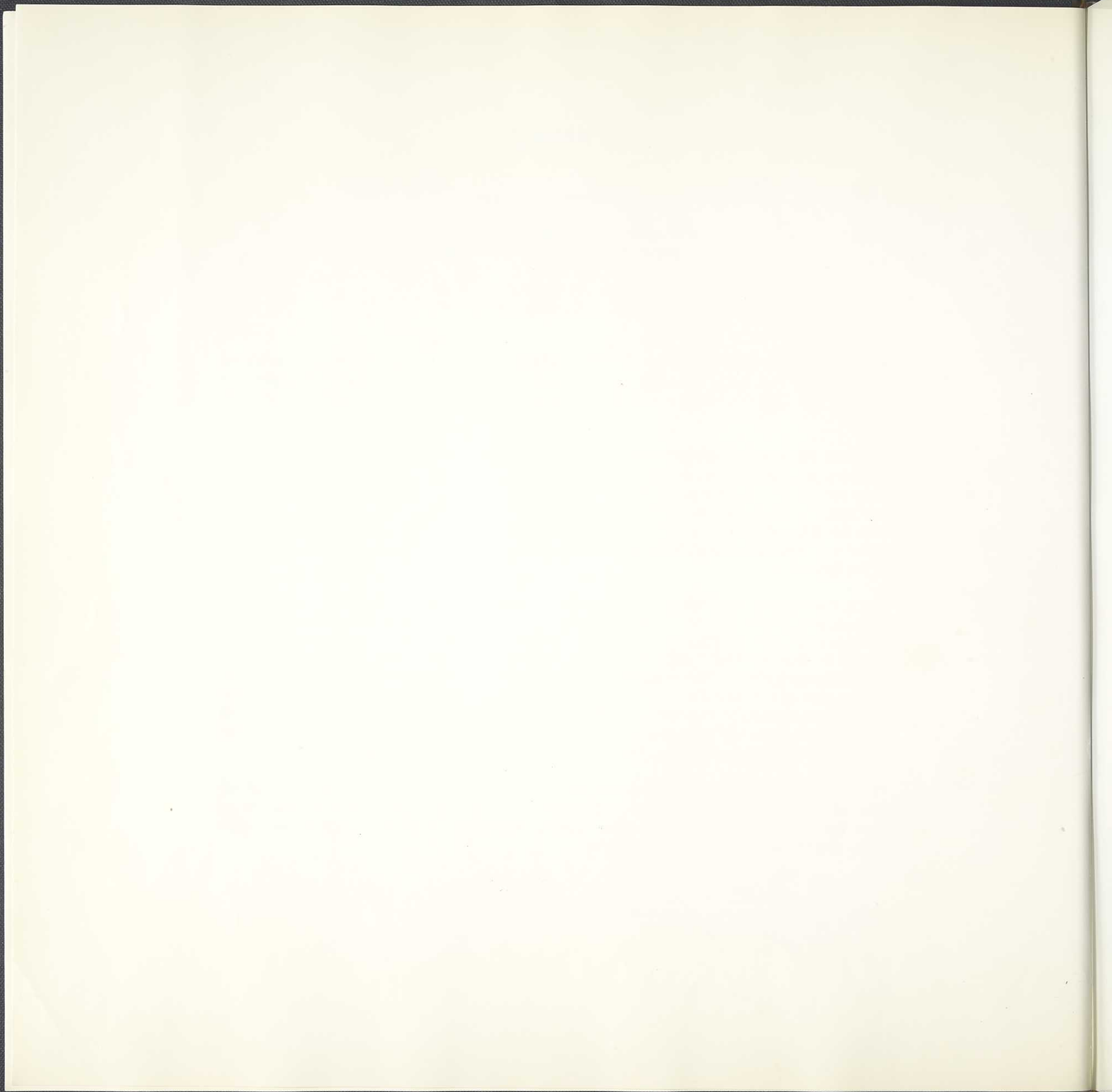
As of its inauguration in the fall of 1966, the Métro became an element of pride for all Montrealers. This initial network, of 13.7 miles (22 km) in length, was built within the limits of the City of Montréal and has already transported more than a billion passengers.

Because we realize the necessity of offering to the Community residents a rapid and comfortable public transit system and also because we were conscious of the economic repercussions of such a project, we have undertaken the construction of extensions to the existing lines. The work that was initiated in 1971 will permit adding to the initial network 37.8 miles (60 km) of line and 69 stations. Once this work is completed, the Métro will serve ten municipalities and will allow the easiest of movement within said part of the territory.

Since the decision was taken to build a Métro in Montréal at the outset of the 60's, the departments of the City of Montréal and, since 1970, those of the Urban Community in collaboration with the Community Transit Commission, have not ceased carrying out research so that our Métro will be the most modern in the world. The Montréal authorities had retained for the initial network the technology known as being the most perfected and proven at the time. Since then nothing has been spared to define the improvements to be implemented to this network and to the extensions underway. At the time of its construction, the Montréal Métro was at the forefront from the standpoint of safety. When improvements presently being instituted will be completed, it again will be.

The studies undertaken in the last few years have in effect led us to the adoption of additional safety measures whose cost is assessed at more than \$100 millions. While being desirous of offering the most efficient service, the safety of our passengers has always been and remains our first preoccupation.





This document was conceived and executed under the direction of the Métro Inter-Service Committee.

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MÉTRO



1 BIRTH OF THE INITIAL SYSTEM

NEED FOR PUBLIC TRANSIT ON THE ISLAND OF MONTRÉAL

In 1961 the City of Montréal proper had attained a population of 1 197 000. By comparison, the whole metropolitan area, commonly referred to as Greater Montréal, then comprised 2 110 000 inhabitants. The central business district, which lies between the Saint Lawrence River and Mount Royal, a peak of 750 feet (229 m), experienced the dawn of a prodigious development; important skyscrapers broke ground in 1960.

Traffic in the core area was snarled, with the risk that it would become even more so, given the foreseen construction programs. Bottlenecks were not limited to the central business district but extended to the few bridges spanning Rivière-des-Prairies and the Saint Lawrence River. Underpasses, traversing rail lines running the length and breadth of the Island, were, and still are, equally an obstacle to traffic.

The time required to cross by autobus or car from the north to the south end of the Island, because of congestion, was too long and only increased further in foul weather, particularly during snowstorms. All these elements amply justified the construction of a Métro in Montréal.

INITIAL-SYSTEM'S ROUTING

On November 3rd 1961, municipal council voted credits amounting to \$132 000 000 for building and equipping a 10-mile (16-km) system featuring:

- line no 1, from Atwater to Frontenac;
- line no 2, from Place-D'Armes to Crémazie.

The first public tender came out on April 2nd, 1962.

On August 6th, 1963, plans to extend the system to 15.5 miles, including the rear-terminal garages, were officially approved. It would now comprise of:

- line no 1, from Atwater to Frontenac;
- line no 2, from Bonaventure to Henri-Bourassa;
- line no 4, from Berri-de-Montigny to Longueuil.

The credits voted were now increased to \$213 700 000.

Inauguration of the Métro took place on October 14th, 1966.

MOTIVATING FORCE BEHIND THIS ACHIEVEMENT

The fruition of the Montréal Métro came about under the administration of Jean Drapeau, Mayor of Montréal, and of Lucien Saulnier, President of the Executive Committee of the City of Montréal.

The Public Works Department was placed in charge of the project. To this end, as of August 1961, some engineers and architects were regrouped in a « Métro Bureau », which was placed in charge of preparing plans and specifications for public tenders. As the work progressed, it became responsible for field inspection.

Some engineers and architects of the same department drafted plans for 11 stations; the 15 remaining ones were conferred to private Montréal firms of consulting architects and engineers.

Some architects and engineers of the City Planning Department participated in studies relative to station location and architecture.

The Transportation Commission, which operates the autobus system, shared in the discussions and decisions. It effectuated coordination of the bus system with the Métro. Moreover, it was charged with the responsibility for the prepara-

tion of plans regarding the construction of repair shops as well as the surveillance of this work.

Lastly, the Executive Committee of the City of Montréal sought the collaboration of La Régie Autonome des Transports Parisiens, thus making available its attendant experience in the rapid-transit field.



2 CHARACTERISTICS OF THE INITIAL SYSTEM

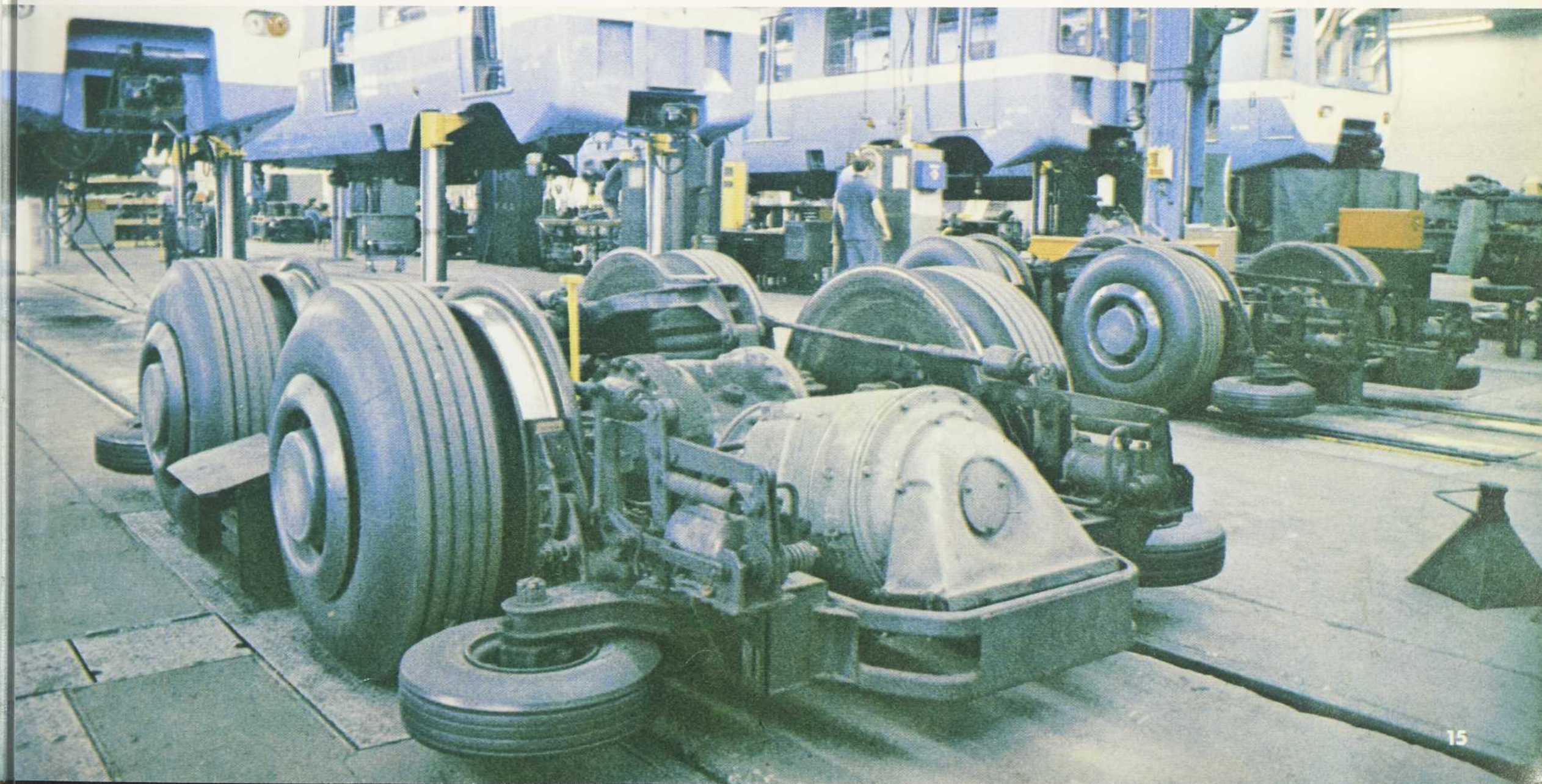
✓ good

ESSENTIAL DECISIONS

The decisions characterizing the Montréal Métro were taken in September of 1961 ; they are the following :

- the adoption of a small frame of 8 ft 3 in (2.50 m) for the cars instead of the American standard of 10 ft 4 in (3.15 m) made it easier to locate the structure under public streets and works of lesser importance ; ✓
- rubber tires instead of steel wheels has endowed the rolling stock with good adhesion, thus facilitating starts, stops, and climbs of slopes up to 6.5% ; ✓
- the adoption of autonomous Métro lines facilitating regulation of traffic according to the number of passengers to be transported but necessitating more elaborate transfer stations permitting the easy passage of riders from one line to the other ; ✓
- the choice of route which allows the central business district to be served with 2 lines, intersecting at Berri-de-Montigny, while avoiding the busy Saint-James and Sainte Catherine Streets. Likewise, towards the north, line 2 was routed under Berri Street in order to avoid disturbing the traffic along Saint-Denis and Saint-Hubert ; ✓
- adoption of a single fare on all the territory served by the Montréal Transportation Commission busses. ✓

THE BOGIE





TUNNEL

In view of the rigorous winter climate, the Montréal Métro was constructed totally underground. The designers employed 3 types of works for the running tunnel :

- the 2-track tunnel excavated entirely in rock and lined with concrete ;
- the 2-track underground of reinforced concrete, built in open cut ;
- the soft-ground tunnel (very exceptional).

Of the above products, the rock tunnel mainly prevails, which is not surprising considering that bedrock over most of the Island of Montréal is found immediately below ground level ; since this rock in general is of good quality, the rock-tunnel mode is the most economical form of construction.

The concrete-lined tunnel has an unsupported-span width of 23 ft 4 in (7.1 m). Excavation is accomplished with explosives. Rock bolts help in supporting the roof. Metal arches were utilized when the rock was excessively fissured and unsound.

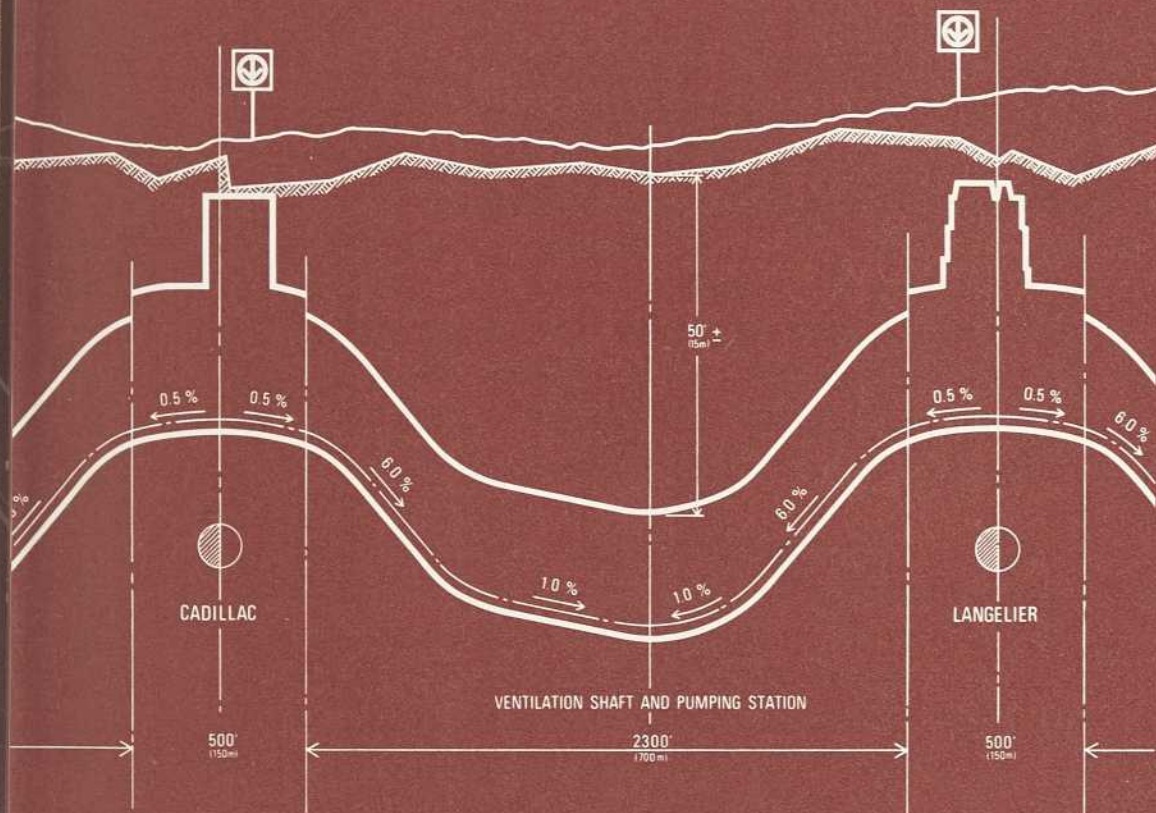
The depth at which desirable underground composition is attained has at times induced the engineers to adopt a humped-station profile, which, in itself, brings about energy savings with regard to circulation of trains.

In order to limit expropriations, the lines were routed as much as possible under public property. With few exceptions, the horizontal curves were built with radii of 1200 feet (366 m), in order to conserve the same tunnel cross-section as in the straightaways, and to avoid enforced reduction in train speeds when negotiating these curves. Rolling friction in curves, much lower than that obtained with steel wheels, permits the use of such configurations without any sensible cost increase, over the straightaways, in the maintenance of rolling stock and track — little extra wheel and track wear, attendant to, otherwise, the steel-wheel stock in these areas.

CHARGING THE DRILL HOLES
LINING THE TUNNEL WITH CONCRETE



HUMPED-STATION PROFILE



THE CONCRETED VAULT
OPEN-CUT WORK



CHAMP-DE-MARS STATION
PLACE-DES-ARTS STATION

STATIONS

The stations have side platforms, 500 ft (152 m) long. The distance between them varies according to the density of population and anticipated patronage. Station interspacings average 2 300 ft (700 m).

The Métro designers wanted to implant the stations close enough to one another that all the passengers along its route were within easy walking distance of the nearest station.

In principle, an architect was designated for each station ; the architect in charge of the design staff coordinated the works, ensuring that allowance was made for the numerous functional needs.

The 26 existing Métro stations may be classified into 3 types :

- stations with ground-level mezzanines ;
- stations with buried mezzanines, built in open cut ;
- stations tunnelled and built within bedrock with the access portions constructed in open cut.

The second and third types permit passengers to accede from the mezzanine to each side of the street or to the 4 corners of an intersection.

AN IN-ROCK STATION
THE LARRY ACCESS CONSTRUCTED IN OPEN CUT

The third type, in general, leads to wide usage of escalators. Typifying this case we find Henri-Bourassa, Bonaventure, and Frontenac stations, whose location with regard to ground level is conditioned by the necessity of making the termini tail tracks fairly horizontal.

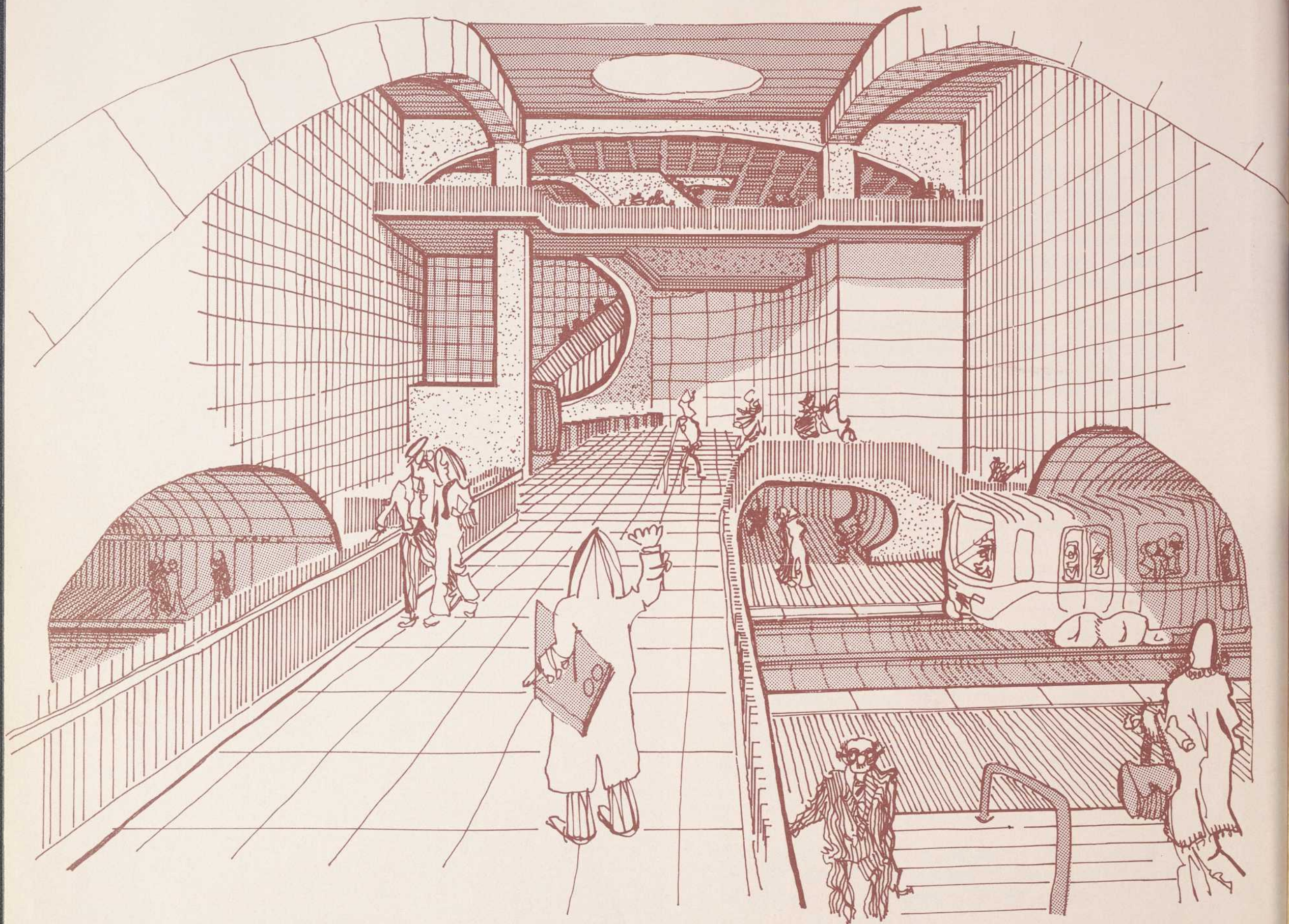
In general, from the station platform, the passengers have access via fixed stairs to a footbridge over the tracks and proceed from there to ground level by escalators. In total, the initial system incorporates 125 escalators, and two inclined moving sidewalks.

The exits are found either in kiosks or in office buildings bordering on the street. Around the exit, major buildings have direct access to the metro. Ground-level installations facilitate transfer to autobusses.

The initial system comprises a transfer station for the 3 lines : Berri-de-Montigny (28 escalators), which is adorned with a commercial center at mezzanine level.

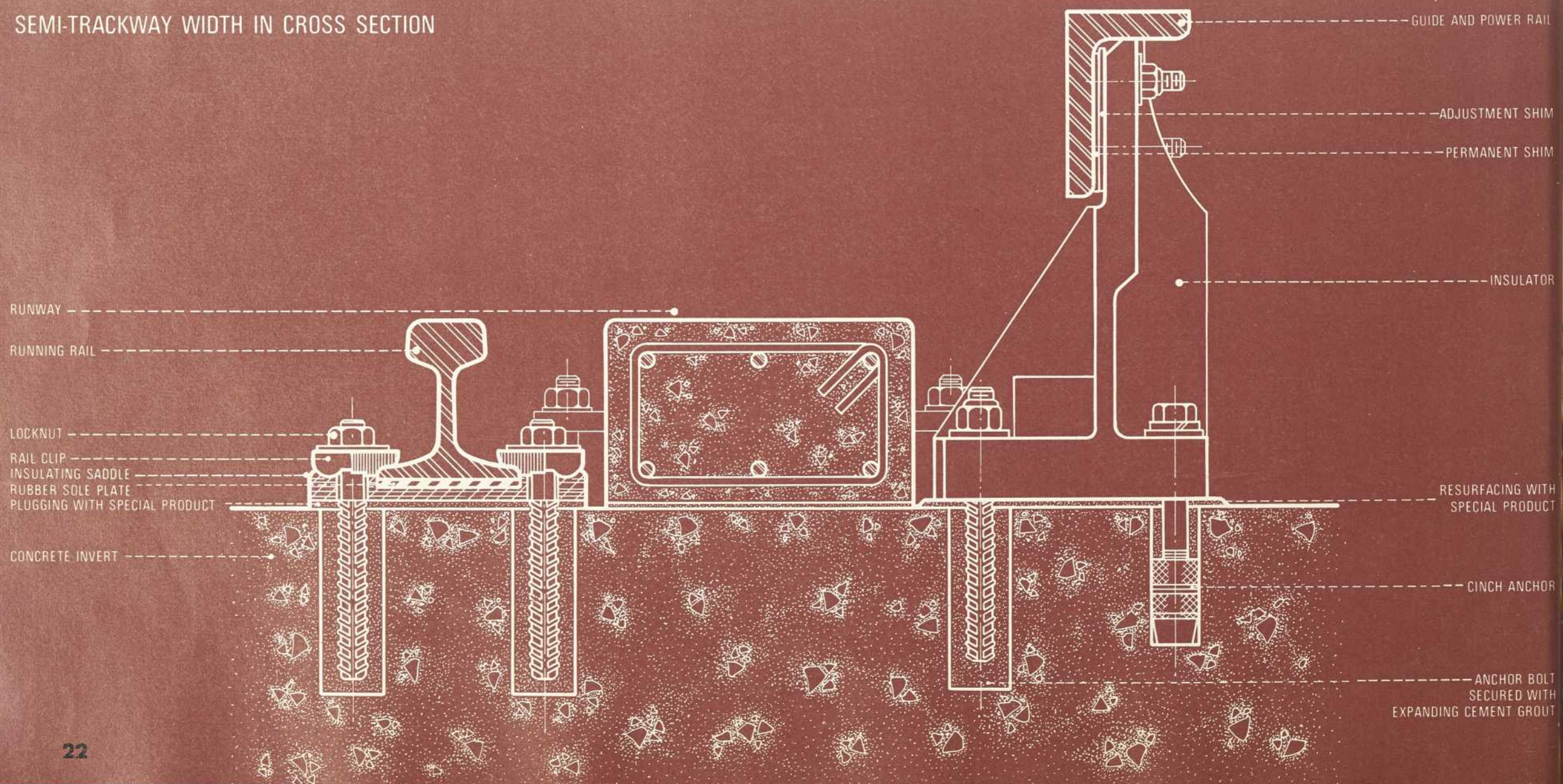
The station gear, lighting fixtures, doors to the outside, directional signs, graphics, and publicity were part of the standards which were imposed upon the various architects.







SEMI-TRACKWAY WIDTH IN CROSS SECTION



TRACK

The Montréal Métro was one of the first to lay the runways rigidly and directly on to the perfectly levelled invert of the tunnel. This solution was not effected in Paris owing to the obligation there of conserving the ballast of the old steel-wheel tracks, so that the transformation to the rubber-tire mode could be effectuated without interrupting traffic.

Track installation thus revealed itself as being an operation of mounting standard elements, which, with the elaboration of special jigs and tech-

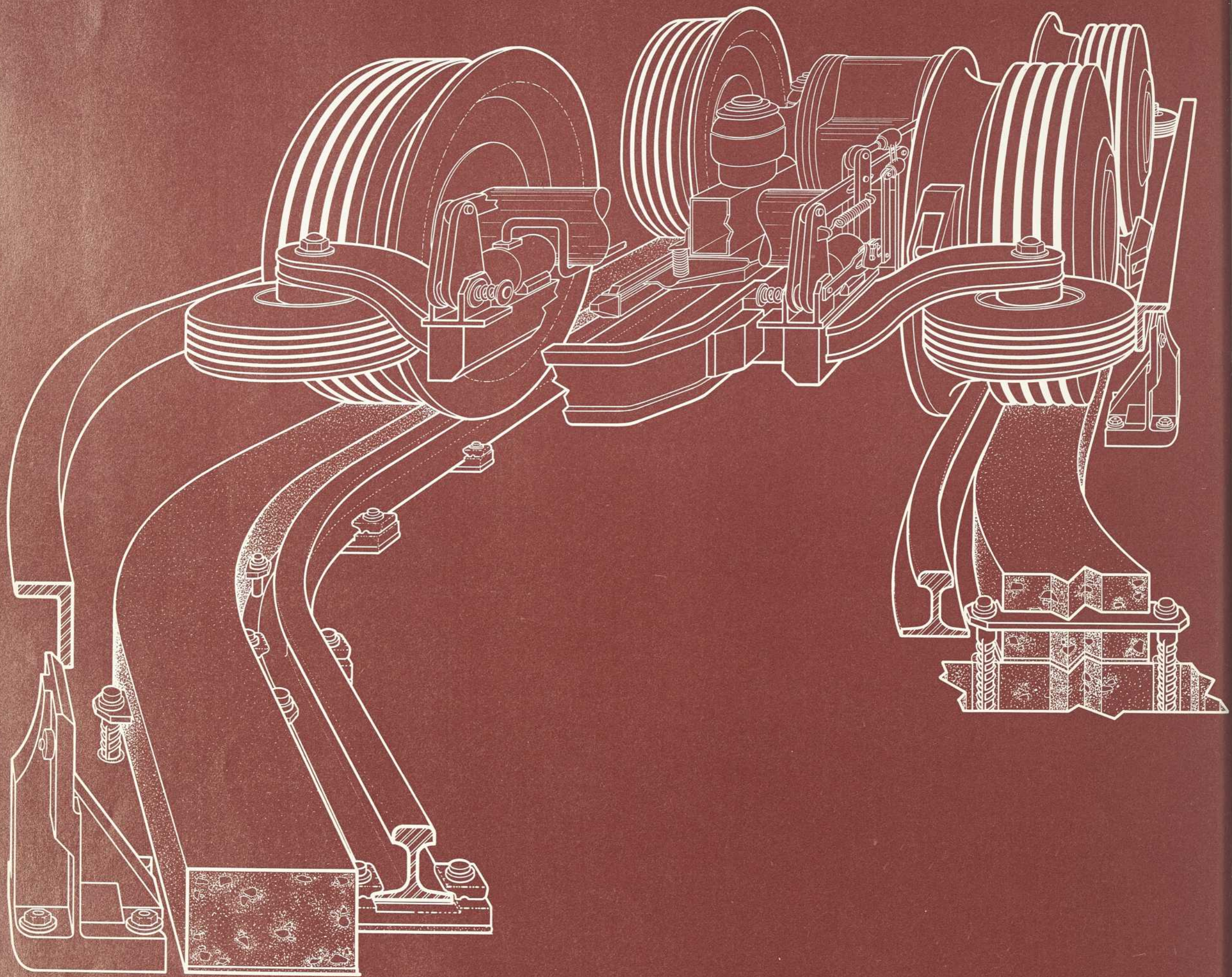
niques, permitted rigorous levelling and alignment of trackway thus guaranteeing a comfortable ride for the passengers.

Other innovations saw the light of day in Montréal :

- the design of track apparatus by juxtaposition of manganese-steel switch-castings for the purpose of guiding the safety wheels;
- the fabrication of guide-rail-support insulators made of polyester and fiberglass capable of resisting a lateral thrust of 13 000 pounds, that is 6 metric tons.

TRACKS AT BEAUGRAND TERMINUS





ROLLING STOCK

Métro trains roll on the right-hand track. They are composed of motorized elements which can be coupled to form units of the following lengths :

- train of 3 elements, 500 ft long (150 m)
- train of 2 elements, 333 ft long (100 m)
- train of 1 element, 166 ft long (50 m)

Each element comprises 3 cars — 2 motor cars which enclose a trailer car. This is one of the advantages of the rubber-tired stock, whereby high performance can be imparted to it without having to motorize all the axles.

Each bogie is guided in the running track by inflated horizontal wheels pushing against lateral rails. In interlockings, steering is obtained by the deep flanges of the steel safety wheels which mate with special grooves in the switch blocks. The safety wheel maintains guidance in case of a guide-tire flat, owing to the presence of the safety rail, which also serves to support the axle weight in the event of a support-tire flat.

There are 4 traction motors per motor car. The motoring effect is transmitted to each axle by a gear reducer and differential. Motor and traction-rheostat control is effected in the classical manner by a cam shaft which accomplishes the series and parallel connection together with field shunting. The master controller incorporates an automatic vigilance device commonly called « dead man » which trips the emergency brakes in case the motorman should become indisposed.

Control and indication are effected with 72 vdc, obtained from a battery on each trailer car. Battery charge is maintained by a solid-state charger, whose feed in turn comes from a 250-volt, 400-hertz, three-phase motor-alternator set.



MCGILL STATION

PLAN AND ELEVATION OF MOTOR CAR



TRAIN CHARACTERISTICS

TYPE OF CAR	NUMBER OF PASSENGERS			WEIGHT ESTIMATE		
	SEATED	STANDING	TOTAL	PASSENGERS	EMPTY	LOADED
MOTOR CAR	40	120	160	10890 Kg	26990 Kg	37880 Kg
TRAILER CAR	40	120	160	10890 Kg	20180 Kg	31070 Kg
1 ELEMENT	120	360	480	32670 Kg	74160 Kg	106830 Kg
2 ELEMENTS	240	720	960	65340 Kg	148320 Kg	213660 Kg
3 ELEMENTS	360	1080	1440	98010 Kg	222480 Kg	320490 Kg

A motored compressor produces compressed air to actuate the air brakes which jam the shoes against the tread of the safety wheels. Pressure control to the brake cylinders is assured by modulating electrovalves, the command logic being such that control-power failure triggers emergency braking.

Traction current at 750 volts is distributed, by the guide rails, to positive collectors, located on the bogies of the motor cars. All the cars incorporate negative collectors, which, sliding on the safety rail, provide for traction-current return and for negating of the car chassis.

One of the essential characteristics of this stock consists of the configuration and number of doors on each side of the vehicle. Each car embodies 4 lateral double-leaf type doors giving a useful opening of 4 feet 3 inches (1.3 m) complemented with free space on either side of the doors of 10 inches (0.25 m) destined to facilitate passenger movement in and out of the cars. Endowed as it is, with 36 bi-parting doors opening on to the platform, even the long 9-car train can achieve very short station dwell times.

Four series-connected ventilators, supplied from the 750-volt source, pump air into each car at an average rate of 10 000 cfm (4.7 m³/sec.).

INCOMING HIGH-VOLTAGE POWER SOURCE

System electrical energy derives from six 12 470-volt circuits, each with a capacity of 12 MW, emanating from 2 independent Hydro-Québec substations. The lines feed 2 separate high-tension substations within the same Providence building. From here feeders radiate to the various rectifier stations deployed along the metro lines; one rectifier station being fed from Providence North while the following draws power from Providence South.

Thus in the plight of a Hydro-Québec partial outage, the metro continues to be fed by a sufficient number of rectifier stations that operations remain steadfast. Before the change can usually

be felt, the breakers, which enable the traction bus to be joined on to the support-facilities bus, resume feeds to the rectifier stations previously dropped, such that in most instances it is possible to continue unconstrained operation of the system.

The conversion of power to 750 vdc, a form usable by the trains, is accomplished by 18 rectifier stations of 2 500 kW.

The supply of circuits for lighting and fixed-motor power (such miscellaneous loads are referred to as support facilities above) is accomplished by 2 high-tension cables, each separately deriving from one of the two Hydro-Québec feeds. Via a tap on each of these cables, each passenger station is catered for by two independent supplies, each of which separately feed a secondary distribution center for transformation down to the usage level of 600 volts 3 phase and 347 volts single phase. Both small transformer substations (also referred to as distribution centers) are adequately protected and independently controlled by an incoming high-voltage fuse and disconnect. Thus each metro station is provided with 2 distribution systems which cater to stagger-fed lighting fixtures, thereby palliating for a partial failure in the supply.

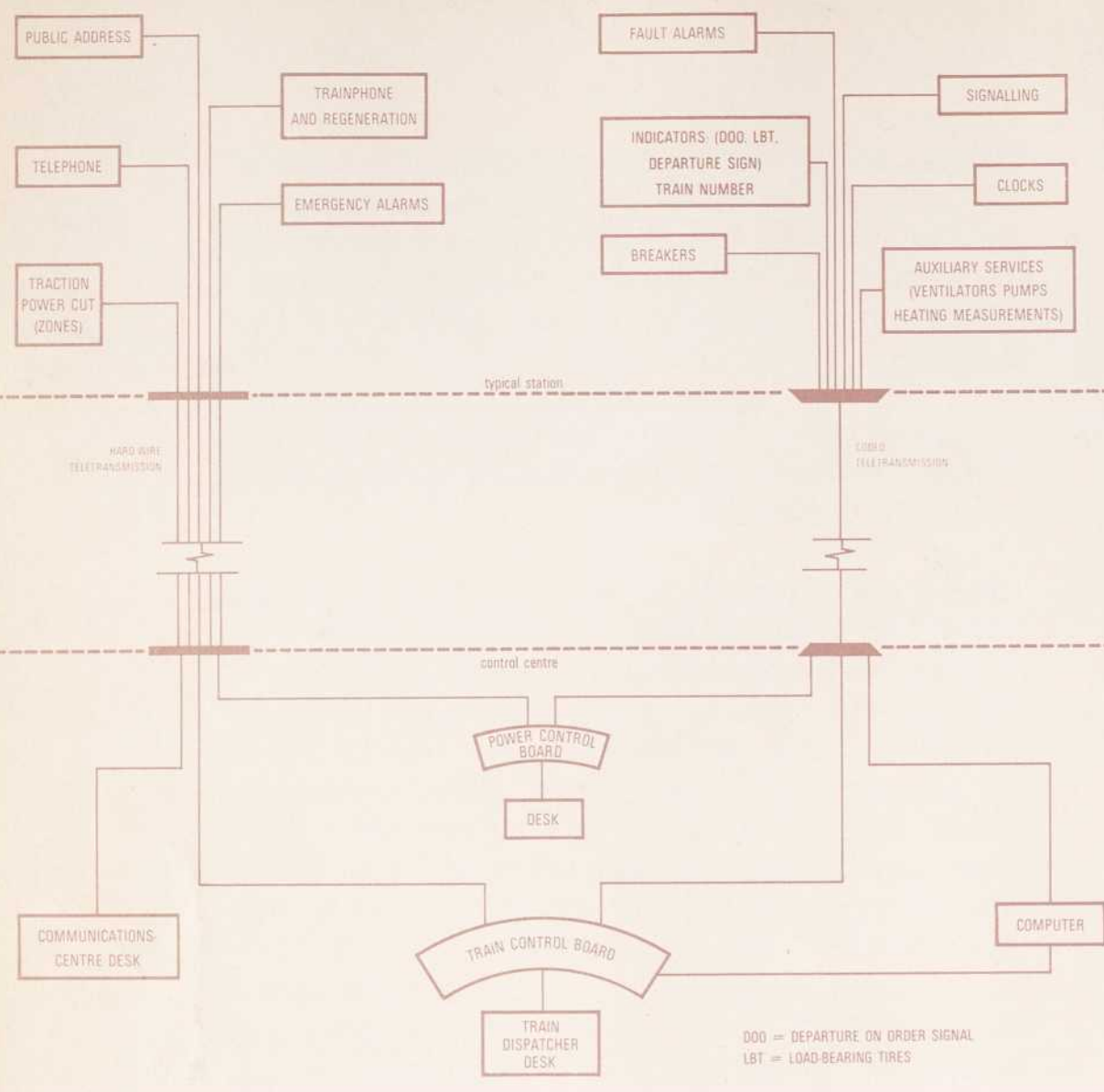
In the predicament of a total power outage, an emergency lighting circuit, fed by a set of batteries in each station, comes to the rescue.

PROTECTION OF TRAINS

For the 1966-vintage Métro, train protection against collisions was assured by standard track-circuit installations.

The track is split up into blocks by means of insulated railjoints. Impedance bonds on both sides of the joint provide unobstructed continuity to the passage of direct-current traction power but effectively stop the alternating currents of signalling (referred to in the next sentence) from spilling from one segment into the next. The track relay, which joins the two rails of a

CENTRAL CONTROL



section at the upstream end, traffic-wise, together with the alternating current source at the downstream end, constitute a track circuit.

Rolling-stock characteristics, desired minimum headway, line trajectory, all determine the lengths of track circuits and hence the implantation of signaling installations. In Montréal, the minimum headway is theoretically 90 seconds.

Occupation of a segment is detected, in a general way, by the shunting of the corresponding track circuit. In the case of rubber-tired coaches this shunting is obtained through the intermediary of the negative shoes on each bogie. Good shunting, in particular on the first pair of shoes at each extremity of a train, is obviously essential for safety. A device known as the shoe tester, situated at that line terminus equipped with a repair pit, checks, on each

round-trip cycle, the shunt resistance whose value should never exceed 1 ohm.

With each track circuit there is associated a set of red and green signal lights, assembled within a small case, mounted on the right-hand wall of the tunnel at the entrance end of a track circuit. The occupation of a track circuit makes the signal go red and it will return to green only after the succeeding track circuit has been liberated i.e. only when the rear end of the train has advanced beyond the third set of rail joints (when the set which made it go red in the first place is identified as the first). Thus a train virtually drags two red signals behind itself, the track between which remains unoccupied, to effectively prevent tailgating. Signaling parlance refers to this stretch of track as the overlap; but the present text, tailored more for the layman, calls it the buffer zone.



CENTRAL CONTROL

The length of a track circuit is evidently never less than the braking distance, which in part depends on the speed attained in the previous upstream circuit.

As an added safety measure, this signaling scheme includes an automatic-stop device which triggers emergency braking in the contingency where the train runs a red signal. Moreover, a speed control, obtained by interpreting as speed the run time over a short length of track, will trip the automatic train-stop if the authorized speed should be exceeded in approaches to terminal stations and through curves whose radii are small enough to mandate a slow-down.

The train-storage area beyond the reversing facilities of the terminal tail-tracks, as well as the ladder tracks to the Youville shops, do not contain signals. Trains cannot be driven in termini on a partially occupied section, for coupling or

parking reasons, without their having first been authorized to do so by a special white flashing call-on signal, situated in the approaches to such a routing. The passage through a call-on signal can be made only at low speeds and after coming to a complete stop, immediately before penetrating it, without which procedure the train would be halted by release of train stop.

CENTRAL CONTROL

The initial Montréal system is endowed with central-control facilities governing train departures and route set-ups in the termini by means of a program machine. On an illuminated track diagram, the regulator can follow the progress of trains, via each numbered track-circuit. The occupation of this track circuit by a train ends up by illuminating the train-identification number. As the train advances, the number displaces itself from track circuit to track circuit.



COMMUNICATIONS CENTER

The program machine permits, moreover, the regulation of trains on leaving the terminus. Elsewhere, along the line, regulation can be performed with the departure-on-order signals placed beside the exit track at both portals of all stations.

The system is such that, in case of a program-machine failure, the regulator at central control (PCC) can :

- issue direct commands by means of a control keyboard ;
- transmit to the signal cabins in the termini both control and indication. Thus a fault on subject equipment does not stop operations.

COMMUNICATIONS

In October 1966, the Montréal Métro was one of the first systems to have achieved a regulator-operator and vice-versa link which can be used while the trains are in actual movement. The system is based on the transmission of high-frequency signals in the power rails.

The motorman can, moreover, talk directly to the passengers within his train.

This trainphone network is complemented by a direct phone-line system, from central control to the interlocking signals, and by a private dial network.

All the passenger platforms are equipped with a PA system which permits central control to give out warnings to the public, provide background music, or emit a general call in station for any workman whatsoever on the network who happens to be in station.

COORDINATION WITH THE AUTOBUS NETWORK AND HOW FARES ARE COLLECTED

The Métro lines behave as if they were bus lines located in the middle of a group of bus lines. By means of a single payment, the traveller can take the autobus then the Métro, or, just as well, the bus or the Métro, then the autobus.

The passenger boarding an autobus receives from the driver a transfer for the Métro which embodies perforated codes. The Métro-entrance tourniquet reads the perforations by means of an electronic head which unlocks the turnstile allowing the traveller to pass.

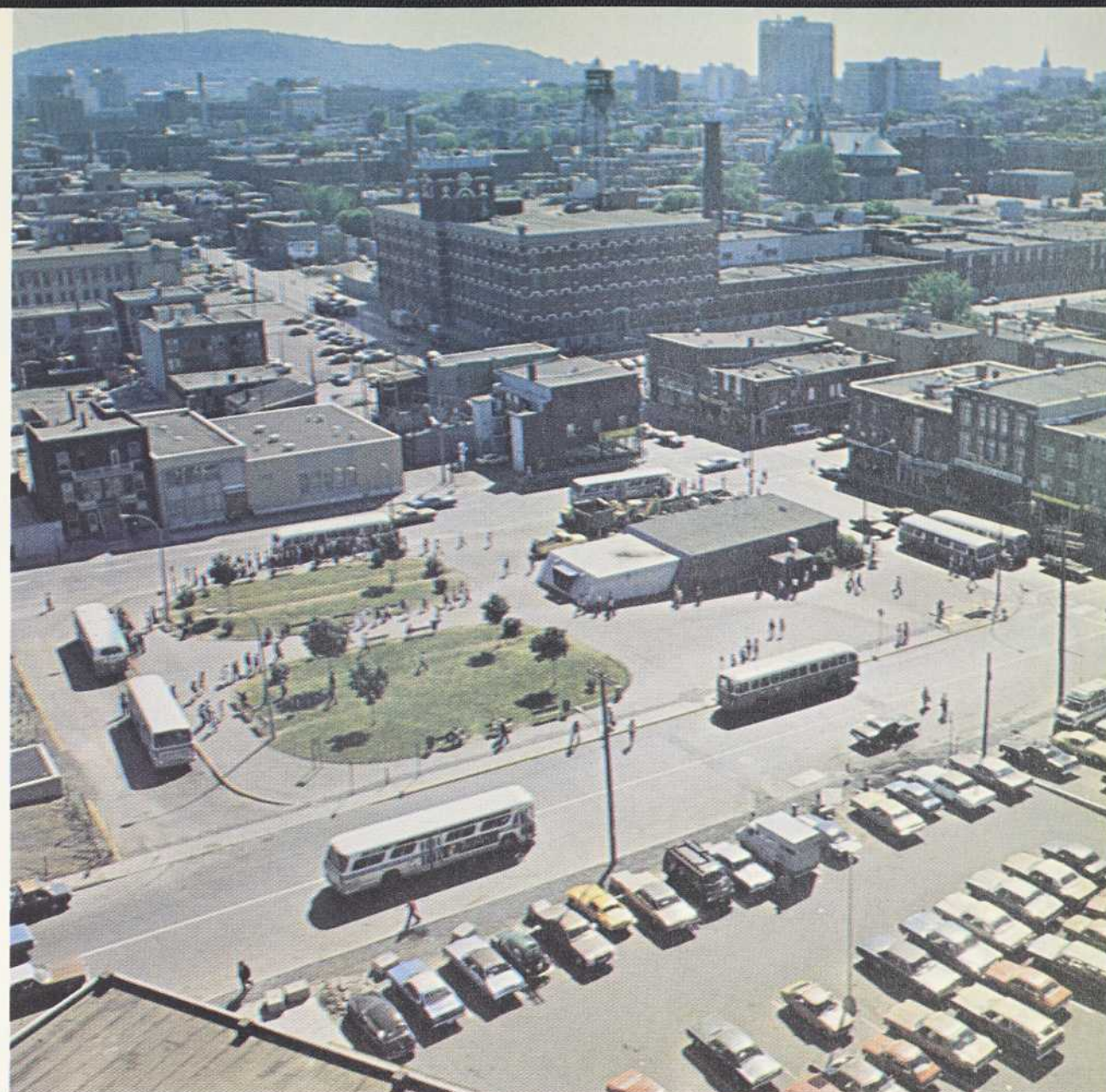
The passenger who wants to enter directly in the metro presents a ticket coated with magnetic ink and impressed by the registration of a certain-frequency signal. The ticket is deciphered by the reading head ; the unlocked tourniquet allows the rider to pass.

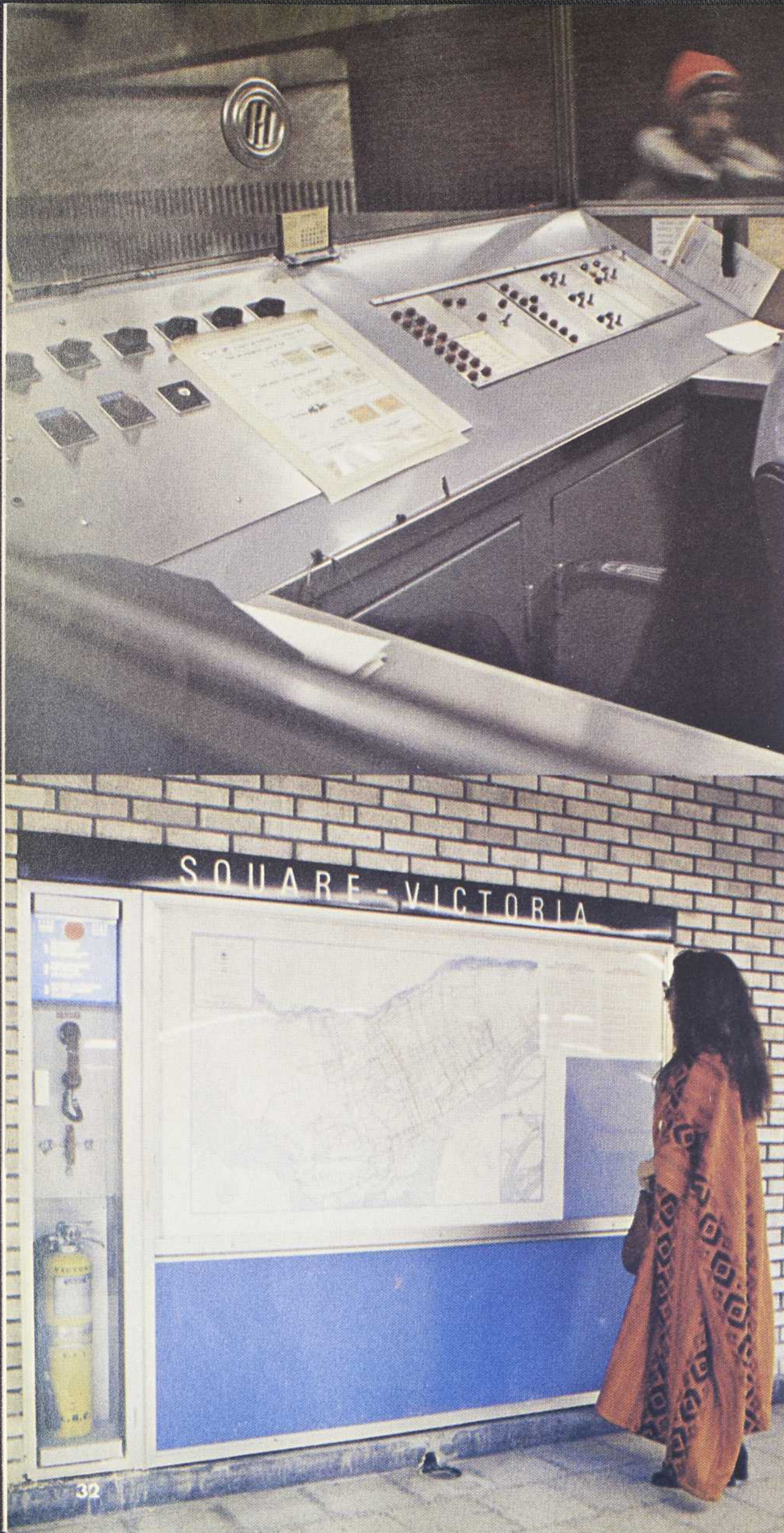
If on leaving the Métro the passenger wants to take a bus, he must, at the station where he enters, secure a transfer for the autobus. This transfer is given by an automatic dispenser located immediately beyond the station-entrance controls.

The sale and control of tickets is performed by the station attendant who occupies a windowed locale at the center or the right-hand side of the bank of entrance and exit turnstiles.

The station attendants (changers) are in direct contact with the communications center, situated in Providence next to the PCC (Central Control).

Coordination between these 2 modes of transit consists in serving the transport needs as well as possible by having the bus gather passengers and relaying most of them on to the Métro lines.





SUPERVISION OF THE WORKING STATUS OF INSTALLATIONS

In the initial system, installations' supervision was accomplished as follows :

- by the surveillance which the changer could exercise in each station. His locale was armed with supervisory indication of a number of installations : escalators, ventilators, pumping stations, turnstiles, emergency stations on platforms, fire alarms ;
- by the surveillance of rectifier stations, ventilation stations, and pumping stations as exercised by power control (PCM) in Providence.

MÉTRO SAFETY

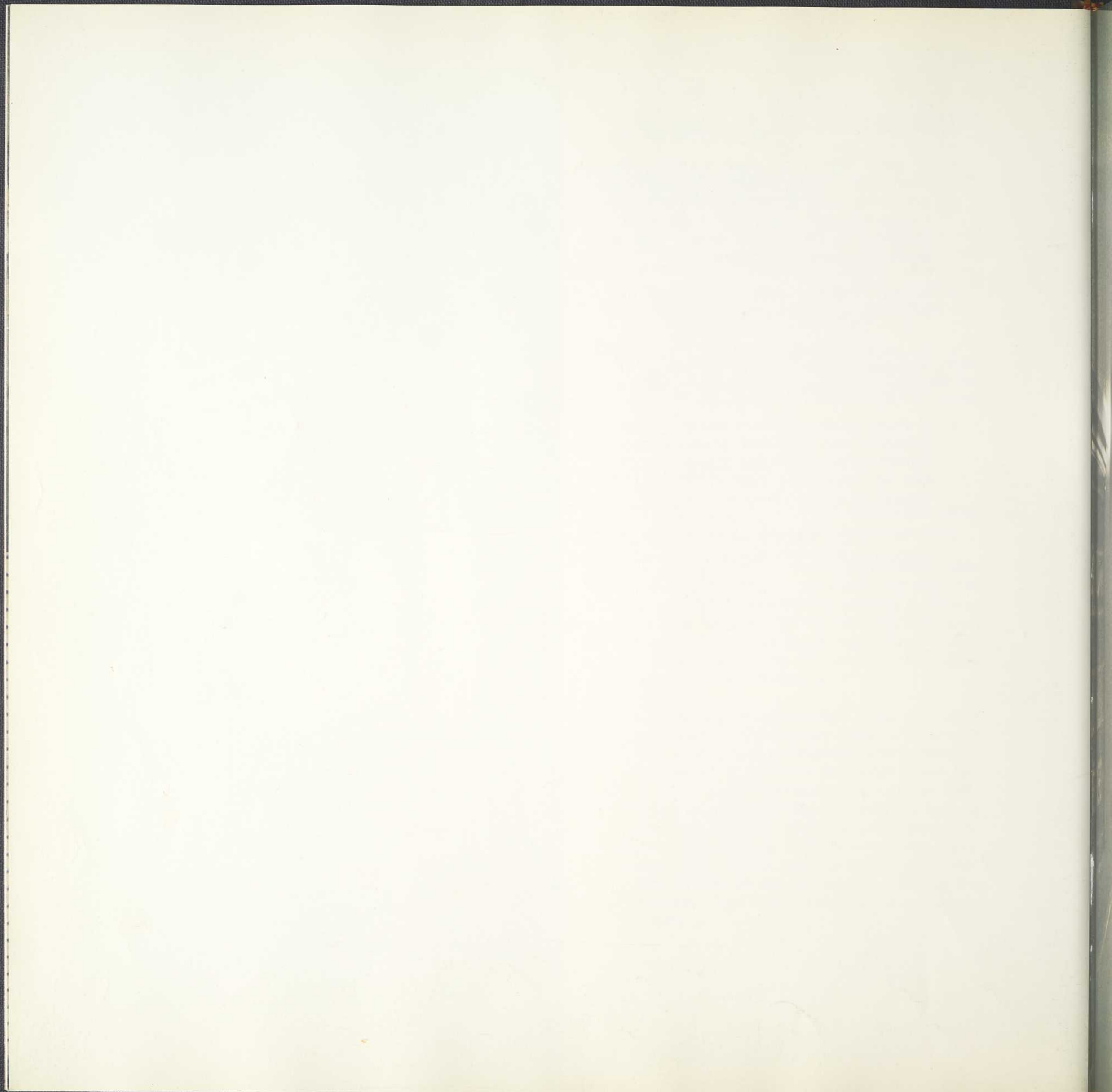
From the outset of operations, passenger safety and fire prevention in the Métro was assured :

- by the Security and Safety Department, looking after not only public safety but also that of all the Métro personnel working in various sectors. This department can also call upon the cooperation of the Montréal Urban Community Police. The members of this Métro department are uniformed.
- by the fire-fighting section. This workforce possesses the necessary training to control and inspect the fire detection and prevention equipment, to train the personnel in this line of work, and, if necessary, to combat fires. This staff possesses the equipment to face all eventualities with : chemical and water-pressure extinguishers, artificial-respiration apparatus, face masks, and fire hoses. Nevertheless, in case of fire, the rule prevails that the Montréal Fire Department be called immediately.

— by the availability of specialized equipment :

- in each station on each platform, an emergency niche containing a telephone permitting direct contact with the communications center, situated in Providence ; a cutout to kill traction power, and a chemical powder extinguisher ;
- in the motor-car cabs, a chemical extinguisher available to the motorman ;
- at approximately 400-foot (120 m) intervals, on each side of the tunnel, an emergency cutout to kill traction power ;
- in many locales of each station, smoke detectors can give out smoke-warning signals terminating in the changers booth and at Providence central-control. Extinguishers are also installed therein ;
- in the tunnel, ladders permit passenger evacuation in case of mishaps.







3 MONTRÉAL TRANSPORTATION COMMISSION

ORGANIZATION

The various urban-transit firms servicing the island of Montréal were amalgamated into one corporation in 1911 by the Montréal Tramways Company.

In 1950, the Legislative Assembly of the Province of Québec passed a bill whereby the City of Montréal was placed in charge of forming a Transportation Commission to be composed of 5 members. On June 16th, 1951, this commission was fully constituted and assumed control of the

SAINT JAMES STREET IN 1907





LEGENDRE BUS-GARAGE

Montréal Tramways installations with the attendant responsibility for urban transport in Montréal and other parts of the Metropolitan area.

The Commission was headed by a president whose function was that of general manager. The president was nominated by the Lieutenant Governor in Council ; a commissioner and two assistant commissioners by the City of Montréal ; a commissioner and one assistant commissioner by the other cities and towns served by the public-transportation system.

In 1965, the Commission was placed in charge of administering the Métro as a municipal asset.

The Commission was subjected to very severe administrative control from the City of Montréal, since the former had to seek approval from the latter for all expenses exceeding \$5 000. Salary scales and collective agreements also were submitted to the approval of the City Executive Committee President.

In 1970, the advent of the Urban Community brought about a certain number of modifications ; reduction in the number of commissioners, diminution of constraints.

To carry out the task conferred to it, the Commission in April of 1975 had a total of about 6 300 employees ; approximately 27% of this complement looked after the Métro. It was directed by a president and two commissioners.

Its performance is assured by the following departmental groups :

- The operating departments for the Métro and autobus networks including : Transportation, Protection, and Planning.
- The maintenance departments including : Vehicle-maintenance and Engineering.
- The administrative departments including : Purchasing and Stores, Treasury, Budget, Industrial Relations, Secretarial, and Public Relations.

It is fitting to look more closely into the composition of those departments which touch more directly upon the transport of passengers.

TRANSPORTATION DEPARTMENT

The Transportation Department is directly involved with the transportation of passengers both in the Métro and on the autobus.

It includes a Métro division, eight surface-network divisions, a personnel-training section, an administrative-services division (services relating to the staff, timetables), and a technical-studies division.

In 1975, the Métro division had a workforce of 479 persons : 10 supervisors, 53 inspectors, 213 train operators, 7 expeditors, 17 cashiers, and 179 changers.

PROTECTION DEPARTMENT

The protection department includes 3 sections :

- administrative and investigations
- accident prevention
- protection of property.

At the beginning of 1975, the fire-prevention section was transferred to the Engineering Department. The Protection Department was restructured to become the department for the protection of physical assets of the MUCTC. In what concerns the Métro, this department has a workforce of 55 men.

VEHICLE MAINTENANCE DEPARTMENT

This department assures the maintenance of autobusses and Métro vehicles.

It comprises :

- an administrative group of 49 persons which looks after all the personnel of the depart-

ment and prepares and supervises the budget ;

- a vehicle-repair shop with a workforce of 206 persons, 14 of them being foremen. 82 persons work on major repairs, 113 on running repairs, and 11 in inspection pits in tunnel ;
- an autobus division which is decomposed into a major-overhaul plant for busses, and maintenance teams for 10 bus garages ;

The plant also performs numerous jobs for the Métro rolling-stock : seat repairs, sheet-metal work, machining of parts, tool repairs. Its workforce constitutes 35 foremen for 440 employees ;

The service garages comprise 38 foremen for 411 employees. This division encompasses a specialized section for the maintenance of bus and Métro tires ;

- an industrial engineering division which is engaged in work methods for the two fields of activity ;
- a technical-studies division comprising a Métro section including 7 engineers, 5 technicians, and 3 draftsmen.

The department workforce in 1975 consisted of 1 159 employees.

ENGINEERING DEPARTMENT

This department assures the maintenance of the Métro fixed-installations, of the tunnel and stations and is in charge of construction, other than that of Métro extensions. Moreover, this department looks after all the buildings and installations associated with the Commission's surface network. It comprises :

- an electromechanical division with the following sections : vertical-transportation apparatus, ventilation-drainage, cables, traction, power and lighting, signalling, tele-

communications, and shops. Division total is 223 employees of which 5 are supervisors and 15 are foremen ;

- a building-maintenance division with the following sections : administration, general maintenance of buildings and accesses, mechanical maintenance, and heating and air conditioning.

In total 61 and 124 employees respectively look after the requirements of Métro and surface facilities ; of these 185 employees, 5 are supervisors and 10 are foremen ;

- a track division attending to track maintenance and cleaning of tunnel, comprising 116 employees of which 5 are supervisors and 9 are foremen ;
- caretaking division for Métro, comprising 187 employees of which 3 are supervisors and 14 are foremen ;

- a caretaking division for the surface network, comprising 82 employees of which 1 is a supervisor and 4 foremen ;

- an engineering division with the following sections : architecture, civil, general mechanical, building mechanical, and electrical, in total 42 employees of which 10 are supervisors ;

- an industrial-engineering division of 8 employees ;

- an administrative division of 21 employees of which 1 is a supervisor ;

- an estimating and inspection division of 8 employees of which 1 is a supervisor ;

- a fire-prevention division of 5 employees.

In total, the Engineering Department, at the end of April 1975, numbered close to 900 employees.



4 OPERATING RESULTS

STATISTICS

As of the start of operations, on October 14th, 1966, the Métro was widely used. The opening of Bonaventure and Victoria Stations, followed by the inauguration of line no 4 made the network complete in early 1967.

Expo 67, with its 50 000 000 visitors, elicited crowds quite out of the ordinary on the overall network. Ridership then established an all-time peak, still unequalled as of today. The success of Man and his World, inaugurated the following

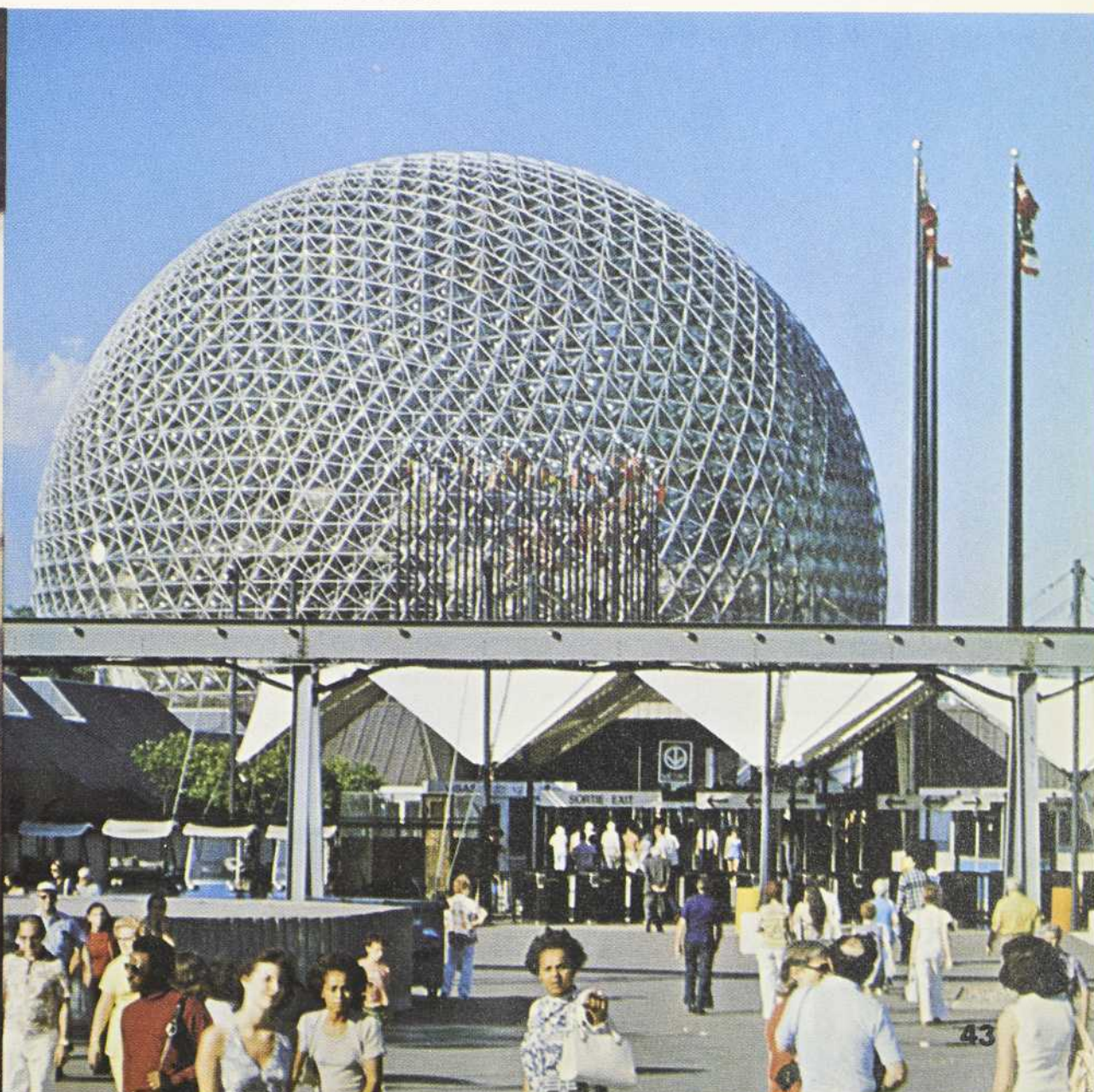
year, in 1968, has permitted a fairly high patronage to be maintained.

Since 1969, daily passenger throngs have not ceased increasing, so much so that only trying incidents and strikes have prevented an annual growth in traffic. This year, in 1976, despite important modifications being implemented on cars and artwork, the number of riders rises notwithstanding, to clearly demonstrate how much the Métro is necessary for Montrealers.

A BERRI-DE-MONTIGNY PLATFORM



THE STE-HÉLÈNE STATION SURROUNDINGS



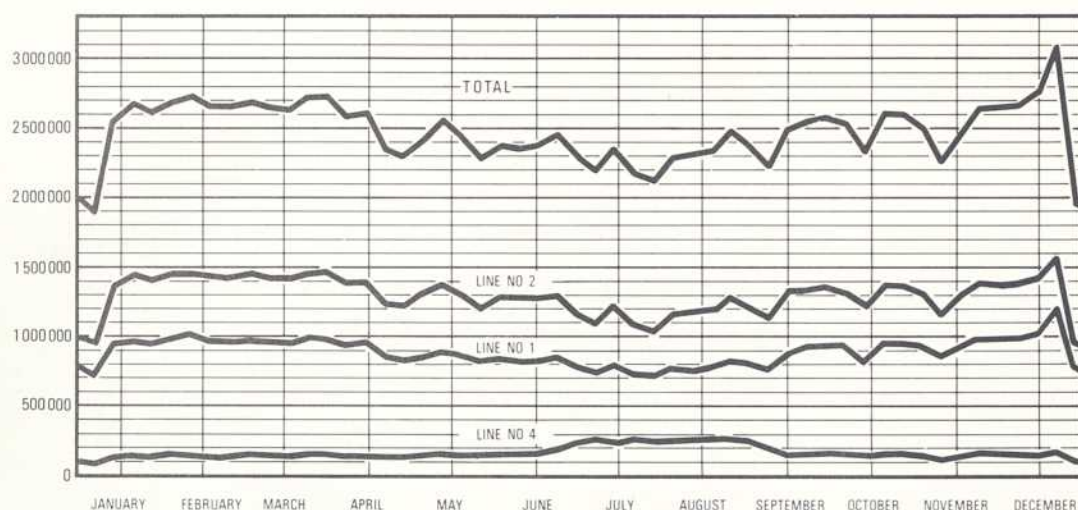
Number of Passengers Transported by the Transportation Commission from 1966 to 1975 :

Year	Commission Total	Métro Only	Remarks
1966	258 738 425	32 067 371	from October 14 Expo '67 & 1 month strike
1967	284 803 721	136 006 042	
1968	308 059 527	124 958 419	
1969	287 254 176	119 785 103	
1970	266 700 610	119 759 952	
1971	264 212 787	122 271 318	
1972	270 026 541	127 401 824	
1973	274 650 113	129 108 523	
1974	263 119 265	110 616 059	Strike Aug. 7-Sept. 20 23-Day strike
1975	264 305 817	122 559 948	
TOTAL	2 741 870 982	1 144 534 559	

Yearly Vehicle-Miles Accumulated Since 1971 :

Year	Buses	Métro Cars
1971	46 386 983	18 111 819
1972	47 701 810	18 828 129
1973	48 003 528	17 257 209
1974	46 477 289	14 180 313
1975	46 152 507	15 326 028

WEEKLY RIDERSHIP IN 1973



Electrical Consumption

— Consumption for a normal day (Thursday 2-6-75) :

traction energy	245 760 kWh
power and lighting energy	105 120 kWh
total energy	350 880 kWh
number of element-miles run	16 431 miles
consumption per element mile	14.96 kWh
number of passengers transported	495 212
consumption per passenger	0.496 kWh

— Average weekly consumption 2 286 000 kWh
 — Average annual consumption 128 000 000 kWh

SCHEDULE SPEEDS, TRANSPORTATION CAPACITIES, LOADINGS, NUMBER OF TRAINS

The schedule speeds (V_c), transportation capacities, the loading during rush hour, allowing for the fact that lines 1 and 4 are served by 2-element trains and line 2 by 3-element trains, are as follows:

Line	Active Length	Terminal to Terminal trip time	V_c mph	Headway in Seconds	Through-put trains	Places Offered per hour	No. of riders from count	% Load factor
1	3.7	11 mn 07 s	19.96	150	24.00	23 040	15 800	0.69
2	7.4	19 mn 33 s	22.71	130	27.69	39 873	31 500	0.79
4	2.6	4 mn 53 s	31.96	270	13.33	12 796	7 100	0.56

The heaviest interstation-run loading on line 2 is high. It is thus important that the assigned number of trains be adequate to permit an assured headway of 130 seconds for a sufficient period within the rush hour. Actually the maximum train-throughput, during minimum headway, endures 20 minutes.

During off-peak hours, in order to improve passenger service, the headway on lines 1 and 2 has been reduced from 6 to 5 minutes.

Train assignment by line is as follows :

Line	Round-Trip Time in minutes	Headway in mn & s	Theoretical number of trains required	Assigned no of trains for Service	Number of Elements
1	28	2 mn 30 s	11.2	12	24
2	48	2 mn 10 s	22.2	21	63
4	18	4 mn 30 s	4.0	4	8

Out of an existing total complement of 112 elements, 95 at any one time are assigned to lines.

Maintenance and shop spares presently account for 12 elements, 5 elements being utilized for testing of prototypes of both the future rolling stock and the automatic-train-control system.

It is appropriate to observe that the operating staff does not have spares on the line ; also, through conditions persist but a short while, in the order of one-half hour. If a train breaks down during that interval, it is practically impossible to have same replaced. The resulting annoyance to passengers is inevitable. It is however important that all available stock be allotted to the transportation department in order to lose the least possible number round trips on the line, which loss only adds to passenger discomfort.



MISHAPS AND ACCIDENTS

Any means of transport may be subjected to more or less frequent breakdowns ; the Métro is no exception. It is nevertheless designed so that repercussions besetting riders are the least possible. To this end, the most important equipment is generally made redundant, so that if a fault is apt to bring about delays according to the time table it can be rapidly eliminated by removing the defective part from service.

The number of misfortunes instigating train delays is 200 per year on the average. Their origin can be traced to defects on the rolling stock or the fixed plant, or to passenger behaviour in the train or on the track.

This figure is low if one compares it to the number of trainmen, 200. On the average, a trainman experiences but one fault per year giving rise to a delay.

As soon as the metro was placed into service, in 1966, a committee was created for the purpose of investigating operating mishaps and anomalies in order to seek remedy.

As in other Métros, mishaps have had a certain character of gravity, but the safety to passengers has been very high ; not one patron has died following an accident since the Métro was placed into service, and yet, more than a billion passengers have been transported.

The serious accidents befalling during the course of these years of operation, rather, translated themselves in havoc to the equipment, which has induced the Commission engineers and those of the BTM (Metropolitan Transit Bureau), to reflect and bring about, in the space of these first few years of operation, many improvements as set forth in the following chapters.

COLD, HEAT AND AIR-CURRENT PROBLEMS

The introduction of a Métro in Montréal, where the climate is varied — very cold winters coupled with hot humid summers — has brought to light certain problems which hitherto were little known and unresolved in most other Métros. As of the opening date, the heat was immediately felt in the tunnels, the stations, the cars ; the air-change rate, particularly in deep stations, was insufficient.

At the same time the rapid circulation of long trains impelled, in most stations, violent air currents through door passages. With the departure of trains from stations the doors were very difficult to open.

In winter, it was not possible to leave the outside air penetrate into the tunnel, as the infiltrating water froze in the ruts of the invert. Following the stoppage of ventilation, the piston effects made themselves felt even more violently than in summer and were highly disagreeable to the public ; moreover, the heating devices in the door grilles revealed themselves as being quite inadequate ; it was necessary to spread salt in the accesses so as to avoid ice formation.

Numerous improvements were applied to the situation ; one can now claim that the Métro is comfortable, except for a few accesses where a combination of circumstances makes it difficult to control the air currents. During winter storms the Métro is the ideal form of transportation — the only non-dislocated one.

SOUND LEVEL AND VIBRATIONS

Even if no sound-proofing material was used in the construction of tunnels and stations, the

sound level in the Montréal Métro revealed itself as most satisfactory for the public, maybe less for the technical people who feel that considerable improvement can still be gained. Efforts to this effect will be brought to bear on the new rolling stock.

Although it may have passed unnoticed, the most spectacular outcome is the total absence of vibrations transmitted to the buildings and skyscrapers bordering the Métro. All the steel-wheel Métros actually have monumental problems arising from the transmission of vibrations to surrounding buildings ; numerous committees exist, tests are carried out and extremely onerous solutions are appropriated in laying the steel track on the invert.

In modern Métro tunnels, the laying of track on ties and ballast is practically abandoned, because of the ensuing maintenance difficulties. As will be seen the maintenance of the tire-way itself, as opposed to a rail-way, is considerably reduced.







- Standards and Public Utilities. This section elaborates the standards of civil engineering, the specifications and plans of the various contracts ; details the requisite modifications to the public utilities ; verifies all the contract plans before going out for bids.

This division comprises 27 persons, including 14 engineers.

ARCHITECTURAL DIVISION

The architect answerable to the Metropolitan Transit Bureau

- directs architectural studies for elaboration of standards to be followed in the construction of stations and Métro accesses including their appointments ;



- directs the elaboration of graphic displays in order to maintain a consistency ;
- collaborates with architects of his own local office who are required to detail the plans and specifications of certain stations ;
- directs the studies and choice of exterior materials to be utilized in stations finish ;
- supervises station proposals deriving from outside architects involved in this work ;
- supervises propositions of artwork to be performed by outside artists, makes decisions relative to their installation ;
- directs the supervision of architectural specifications ;
- participates in the "committee detailed with the examination of operating incidents and anomalies" in order to maintain the archi-



tectural idea at the forefront and avoid the possibility that maintenance services take decisions which run contrary to this.

This division comprises 17 persons, including 6 architects and one artistic counselor.

CONSTRUCTION DIVISION

This division is directed by the Construction Engineer, assisted by an engineer in charge of coordination and supervision of quality control for concrete. It comprises 3 sections :

- Technical information : This section effectuates the gathering of all technical data required by construction and other divisions as well ;
- Rough-Work : This section supervises all the rough-work projects, from the call for bids right up to the start of finish work ;
- Finish-Work : This section supervises all the finish work of the various Métro jobs.

The total Construction Division complement consists of 96 persons, including 27 engineers.

Equipment Divisions

The three Equipment divisions, Rolling Stock, Mechanical and Electrical, Track, effectuate, each in their specialty :

- research studies taking into account improvements to be made on existing equipment ;
- elaborate specifications and plans with a view to the call for tenders ; once the contracts are given : the supervision of manufacture, the testing of prototypes and assemblies, the receiving of all materials, finally the placing of equipments into service.

To illustrate research studies, the following examples cite :

- that the Rolling Stock Division has already produced the initial drawings for negative carbon-collectors and has advocated their use, (in place of the former cast-iron ones).
- that the Mechanical and Electrical Division has, beginning with existing elements, devised a system of train control for the Montréal Métro.
- that the Track Division has redrawn and improved the switch locking mechanism.

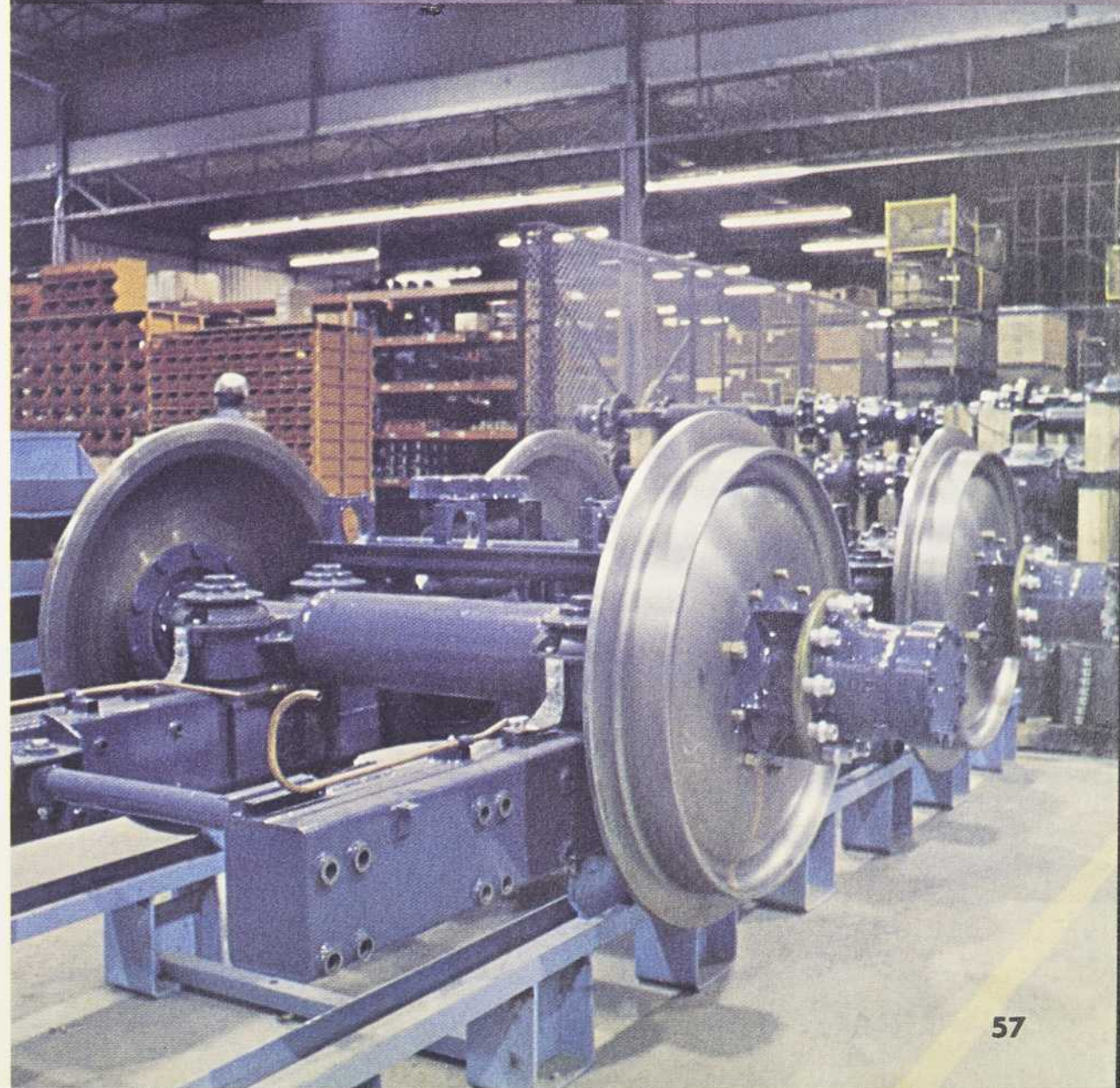
ROLLING STOCK DIVISION

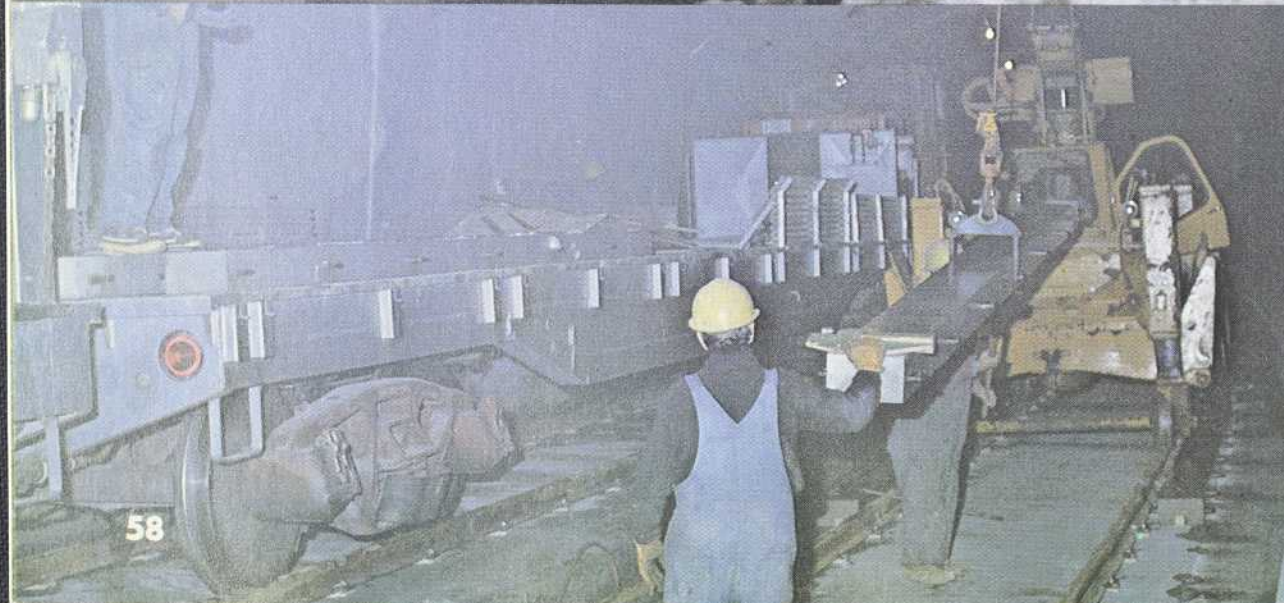
The Rolling Stock Division comprises 2 groups, one electrical, the other mechanical.

The responsibilities of the electrical group are traction motors, control devices for motors in traction or braking, various supplies on board the vehicles, auxiliary electrical equipment, interfaces between all the automations, electrical trainlining of cars, and air conditioning.

Those of the mechanical group are the bogies, the bodies, mechanical trainlining, ventilation and air conditioning, auxiliary equipment and braking.

This division comprises 35 persons, including 14 engineers.





MECHANICAL AND ELECTRICAL DIVISION

The division comprises 3 sections which have the following responsibilities :

- The Mechanical Section looks after forced and natural ventilation, ventilation of locales, air conditioning, sump pumps in tunnel (infiltrating and wash-waters), cess pumps in stations (wash-water), plumbing, escalators, moving sidewalks, tourniquets, exit turnstiles, doors and emergency diesels.
- The Electrical Section looks after high-tension supply breakers, control and measuring devices, transformers, rectifiers 750 vdc, breakers, disconnects, short-circuit detectors, measuring and control devices, traction cables, secondary distribution centres, auxiliary apparatus, ventilators, pumps, escalators ; normal lighting of stations, accesses, and tunnel emergency-lighting ; and fire detectors.
- The Electronic Section looks after telephone links, radio-telephone links, emergency traction-power cutouts, central control, computers, teletransmissions, station public-address system and train control.

The Mechanical-Electrical Division has a total workforce of 65 persons, including 27 engineers.

TRACK DIVISION

It comprises 2 sections with the following responsibilities :

- Concrete-and-Insulating-Materials Section : saddles, insulators, rail clips, bonds, insulation blocks, concrete runway ;
- Steel-Materials-and-Track-Layout Section : track devices, rails and guide rails, bolts, anchor bolts, switch locks, turntable for bogie, and layout of track.

This Division comprises 14 persons including 4 engineers.

Also coming under the Equipment Directorship, mention should be made of a laboratory which can be called upon to carry out mechanical, electrical and electronic tests and a consultant for the reception and inspection of materials and equipments.

The Metropolitan Transit Bureau in December 1975 comprised over 300 employees of which about 100 were engineers.

Each division is associated with a very particular technique in the art of railroading. The engineers of these divisions become highly enlightened specialists in all railroading problems, making them an asset to the Urban Community.

REASONS FOR EXPANDING THE MÉTRO

The population of the zone catered to by public transport of the Montréal Urban Community Transit Commission stands at about 1 900 000 inhabitants. The number of passengers transported in 1970 rose to 266 700 000, which equates to 140 trips per dweller per year. This relatively weak figure will tend to increase in the future, taking into account the growing automobile traffic and the impossibility of giving it greater space in the city. Improvement of surface routes demands considerable investment, and these installations, necessarily complemented by parking areas, devour urban territory, dislodging the city dweller to peripheral suburbs.

From a strictly transit viewpoint, the use of a private car in dense zones of cities is a regrettable fact. Its efficaciousness is for naught ; each automobile, despite its cumbersomness, transports but 1.2 riders on the average. It monopolizes one more parking stall in zones of high real-estate value. Finally, it pollutes the atmosphere.

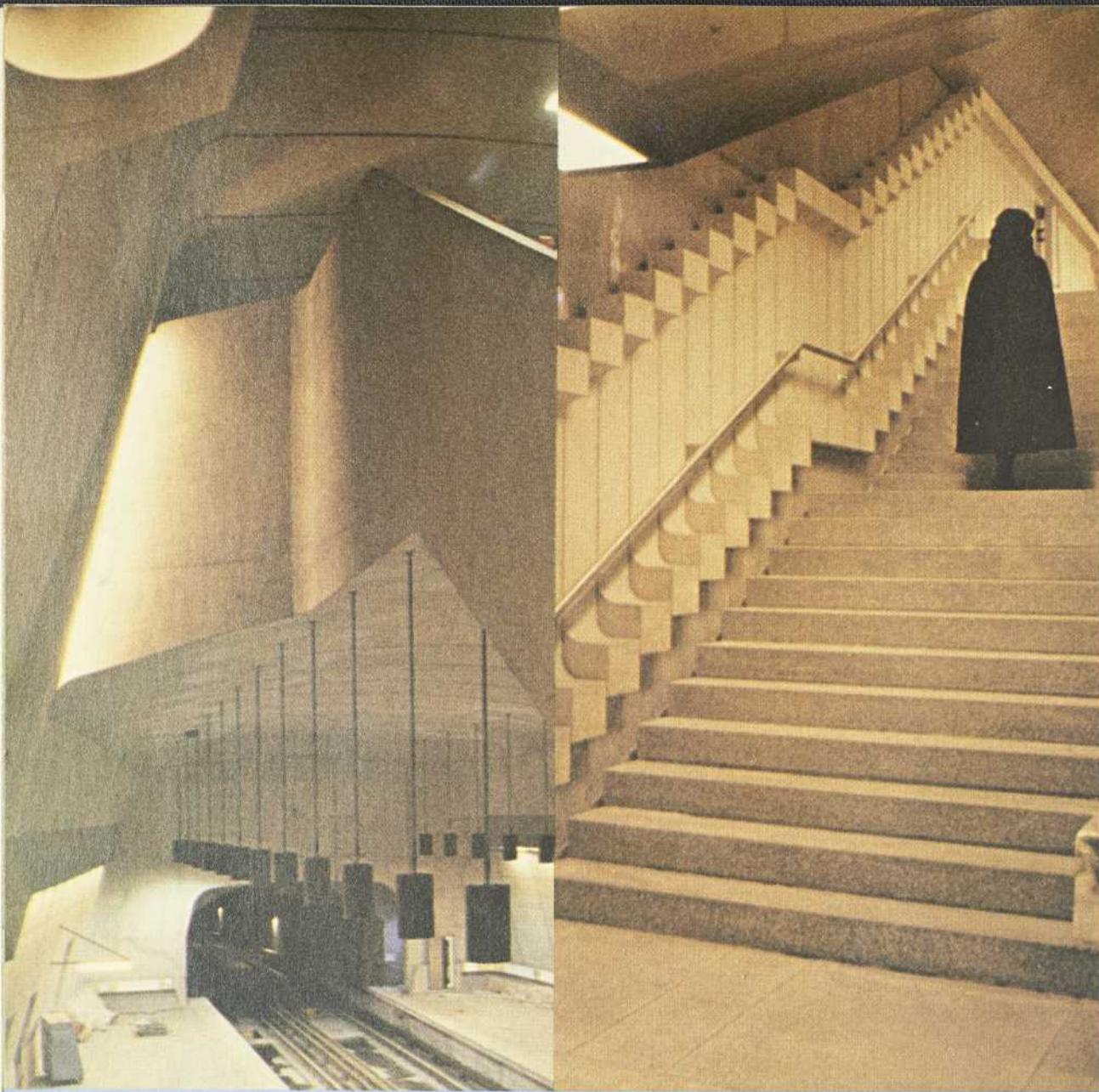
In 1970, of the 266 700 000 bus and Métro combined ridership, 119 700 000 travelled on the Métro, amounting to 45%. The accumulated bus



mileage was however 2.5 times that of Métro coaches.

The comfort offered to the Métro passenger is much superior :

- travelling below ground, the vagaries of surface traffic are foreign to the Métro ; bottlenecks, snow, rain do not impede its onward movement ; ✓
- wait time for the next Métro train is short ; the intervals are regular ; waiting takes place in a comfortable abode, well removed from the weather ; ✓
- the Métro procures for the rider an economy in time owing to its elevated schedule-speed and its regularity ; ✓
- underground transit, fed as it is by electrical energy, does not engender pollution ; ✓



- the Métro stimulates urban development along its lines and gives rise to major investments ;
- the Métro promotes commercial and industrial establishments by facilitating their accessibility to clients and employees alike ;
- by facilitating access to theaters, cinemas, sports centres, exhibitions, the Métro spurs activities connected with recreation and culture of citizens.

It is only just that a greater proportion of community inhabitants should profit from all these advantages. The longer the lines are, besides, the more the gain for the user is considerable.

The Métro attracts riders from suburbs if inexpensive parking is afforded at Métro line termini. Moreover, if judiciously conceived, bus gathering lines facilitate the citizen's trip between his domicile and the Métro.

COMPLETE NETWORK

On February 12 1971, the Montréal Urban Community Council authorized a loan of \$430 000 000 to effect extensions to the Métro.

On August 15 1973, the Montréal Urban Community Council authorized that this amount be raised to \$665 000 000, a boost justified by improved safety measures, price variations, modifications and extensions permitting installation of terminal stations complying with new standards.

On August 20 1975, the Montréal Urban Community Council authorized that the loan be raised to \$1 596 500 000, — a boost justified by a revision of estimates for the non-awarded contracts, by additions to extensions previously defined.



These extensions at the end of 1975 were as follows :

- Line no 1 towards the East prolonged under Hochelaga and Boyce streets, Assomption Boulevard, and Sherbrooke street up to Beaugrand (9 new stations) Length : 4.8 miles (7.7 km).
- Line no 1 towards the West prolonged under the streets Rose-de-Lima, Charlevoix, Wellington, Willibrord, la Vérendrye Boulevard, Allard Street up to Angrignon Park. (8 new stations). Length : 5.2 miles (8.4 km).
- Line no 2 towards the West extended under the C P R tracks, the streets : Saint-Antoine, Saint-Jacques, Lacasse, Sainte-Catherine, Northcliffe, Victoria, de la Savanne, Bougainville, Décarie, Saint-Germain, and de Salaberry (16 new stations). Length 10.2 miles (16.3 km).
- Line no 5 which will provide transfer facilities between the two branches of line 2 at the Jean-Talon and Snowdon stations and which will serve the municipalities of Montréal-North, Saint-Léonard, Hampstead, Montréal-West, Lachine and LaSalle (24 new stations). Length : 12.8 miles (20.5 km).
- P A T Line serving Longue-Pointe area, the cities of Montréal-East and Pointe-aux-Trembles. Length : 4.8 miles (7.7 km) 12 stations.

TRANSFER TRACKS — GARAGES

The work comprises moreover :

- the construction of garages at Henri-Bourassa, Beaugrand, Angrignon, and Salaberry ;



— the construction of a transfer track from line no 5 to the Youville repair shops.

To properly conduct this task, the Metropolitan Transit Bureau has since 1971 put out for ten-

ders which have permitted the awarding of close to 150 contracts.

Work is progressing rapidly on all lines.



⑥ IMPROVEMENTS BEING CARRIED OUT ON BOTH THE EXISTING NETWORK AND THE EXTENSIONS.

CIVIL ENGINEERING

The general design of the civil-engineering works foreseen in the extensions has changed little. Nevertheless, the following remarks can be made :

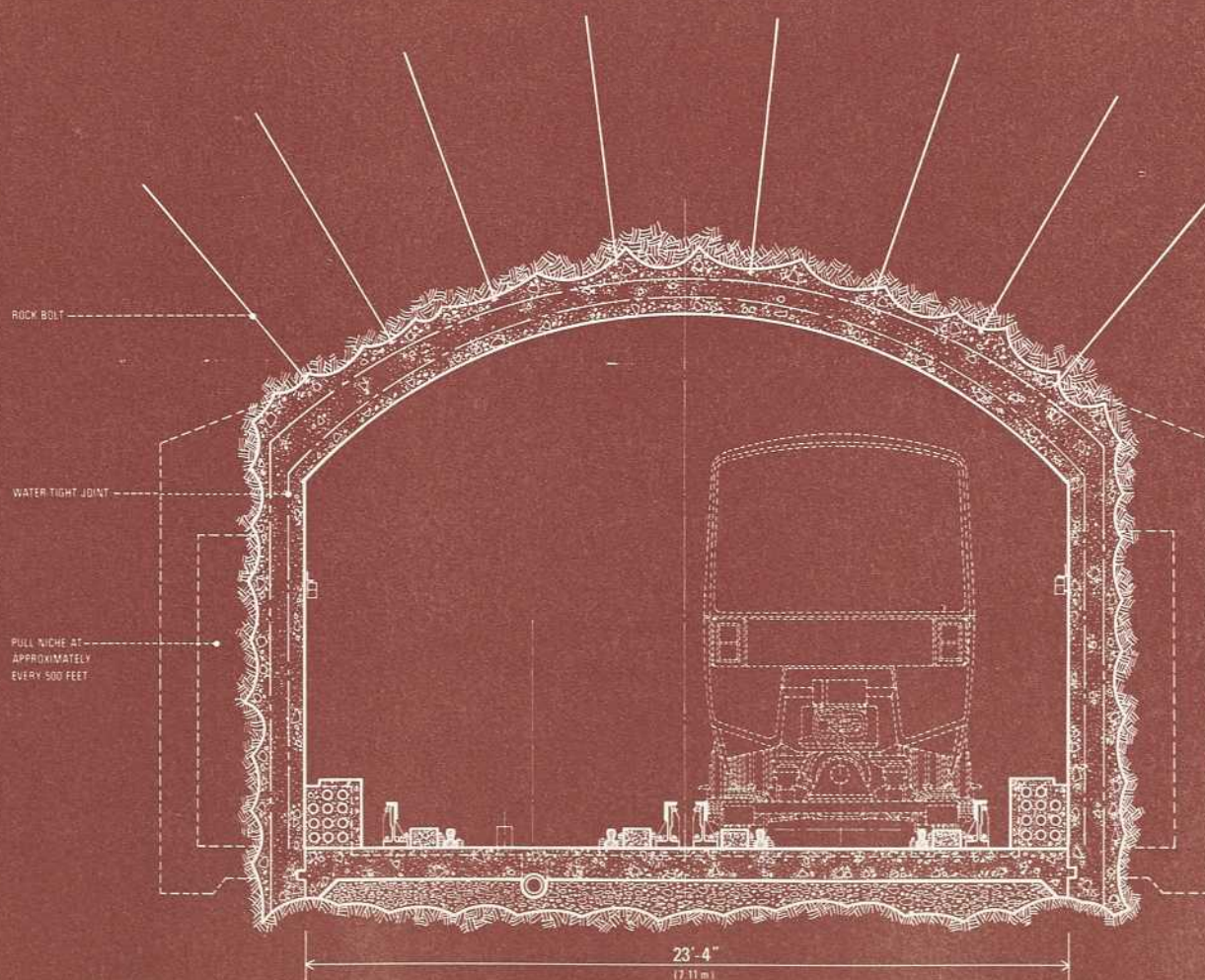
Tunnel

We have continued to search for the least onerous solution in building the Métro ; whereby the tunnel is located in bedrock whenever such is not too far removed from ground level. The station is in general placed

as high as possible, in order to curb the number and height of escalators, which often leads to erecting the heart of the station in open cut. Thus a humped-station profile is achieved for the Métro line. This profile exists whenever possible ; the extent of the dip between stations is optimized by computer simulation. Whenever bedrock level is too deep we avoid tunnelling in the soft ground ; we execute the work in open cut.

So as to limit water infiltration during the construction of a tunnel within rock, once the concrete of the job has been placed, we effect a series of injections in order to fill the

TYPICAL CROSS SECTION OF IN-ROCK TUNNEL



void between the work and the bedrock, which also serves to seal-off infiltrating water.

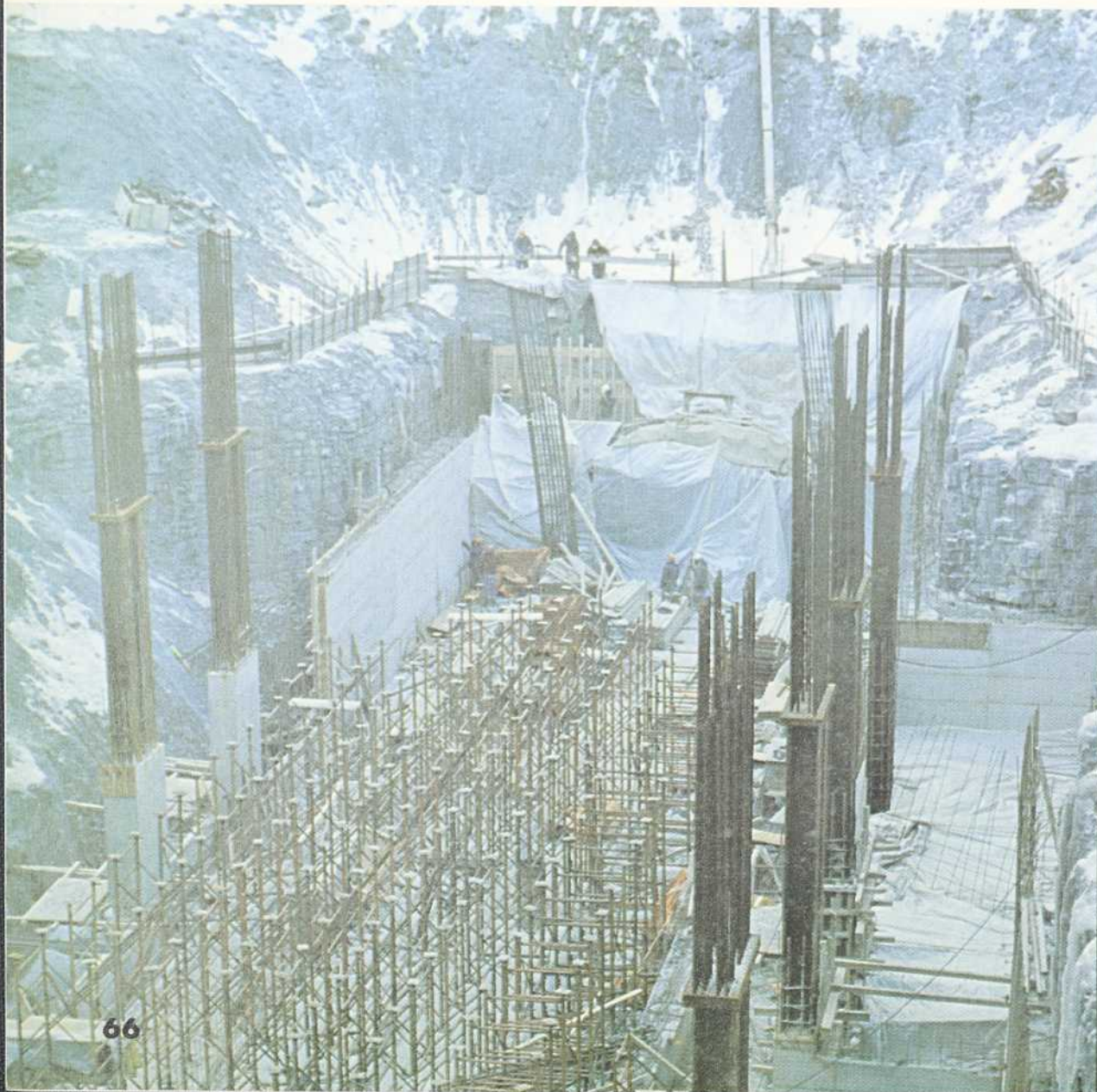
Waterproofing is, however, a delicate problem as we are never absolutely sure of the results. It is often necessary to return afterwards, even after the installation has been placed in service, to effect new injections.

So as to protect the cables in case of fire or derailment, a duct bank of concrete reposing on the invert, at both sides of the tunnel, is constructed. This concrete mass constitutes an elevated walkway, accessible from the train, thus facilitating its evacuation in tunnel.

At about every 500 feet (150m) in the tunnel, there exists niches containing manholes to service the cables placed in the duct bank. These niches also constitute safety centres where fire-fighting water outlets, emergency traction-power cutouts, and telephone are grouped together.

Modern boring techniques are utilized to reach the tunnel from ground level in order to equip the former with water outlets for fire fighting. These outlets are to be found every 400 to 500 feet (120 m to 150 m) on each side of the tunnel; these have now been installed on the initial system.

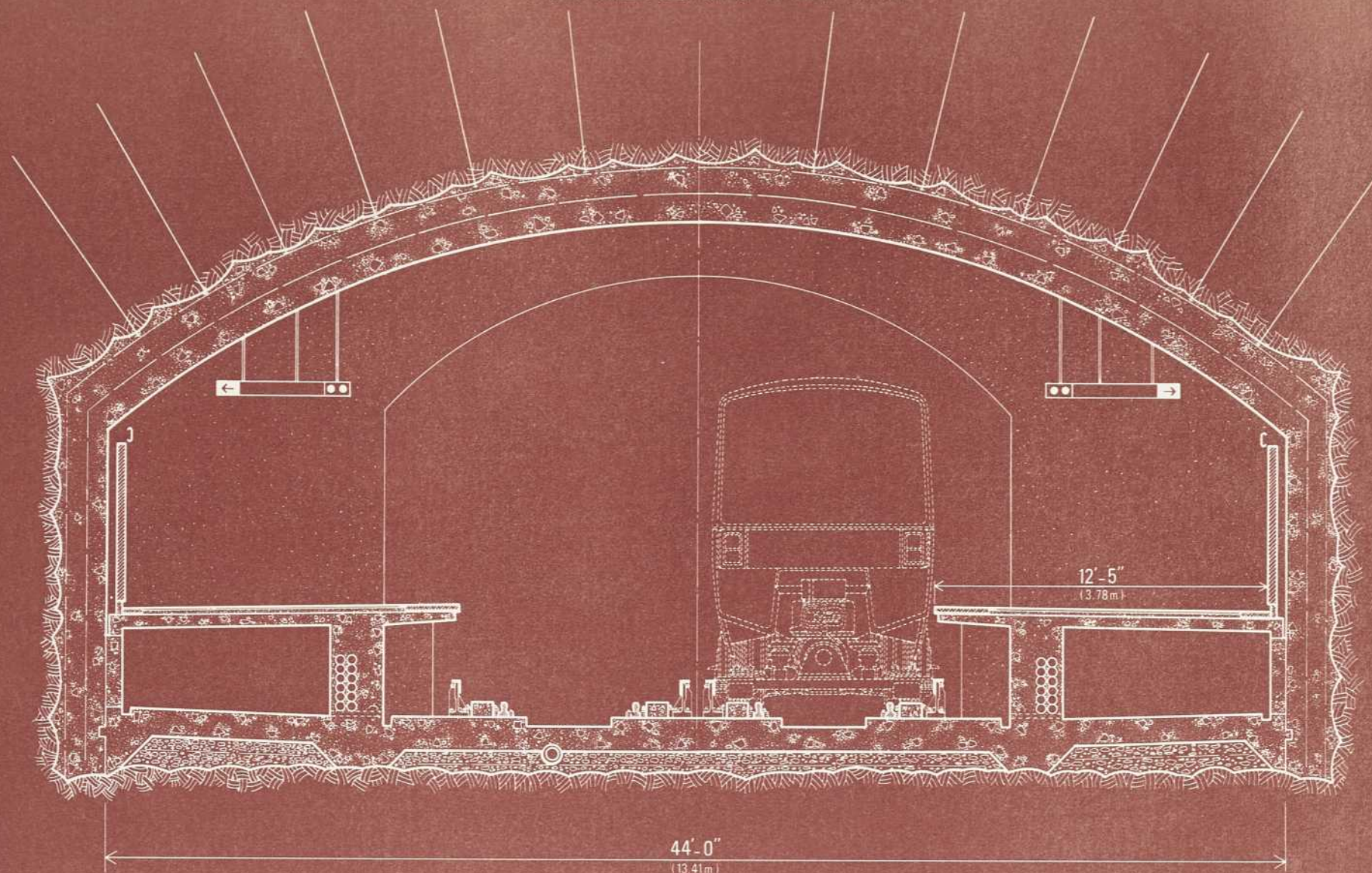
L'ASSOMPTION STATION



ANGRIGNON REAR STATION AREA



TYPICAL CROSS SECTION OF IN-ROCK STATION



Stations

Both station platforms were extended 10 feet (3 m) at both their extremities so as to provide 4 technical locales wherein is installed equipment for train control and for maintenance ; traffic in the tunnel for maintenance purposes is thus diminished. This facility has also permitted the stairs at the platform ends to be more comfortable for the public in case a train has to be evacuated in tunnel.

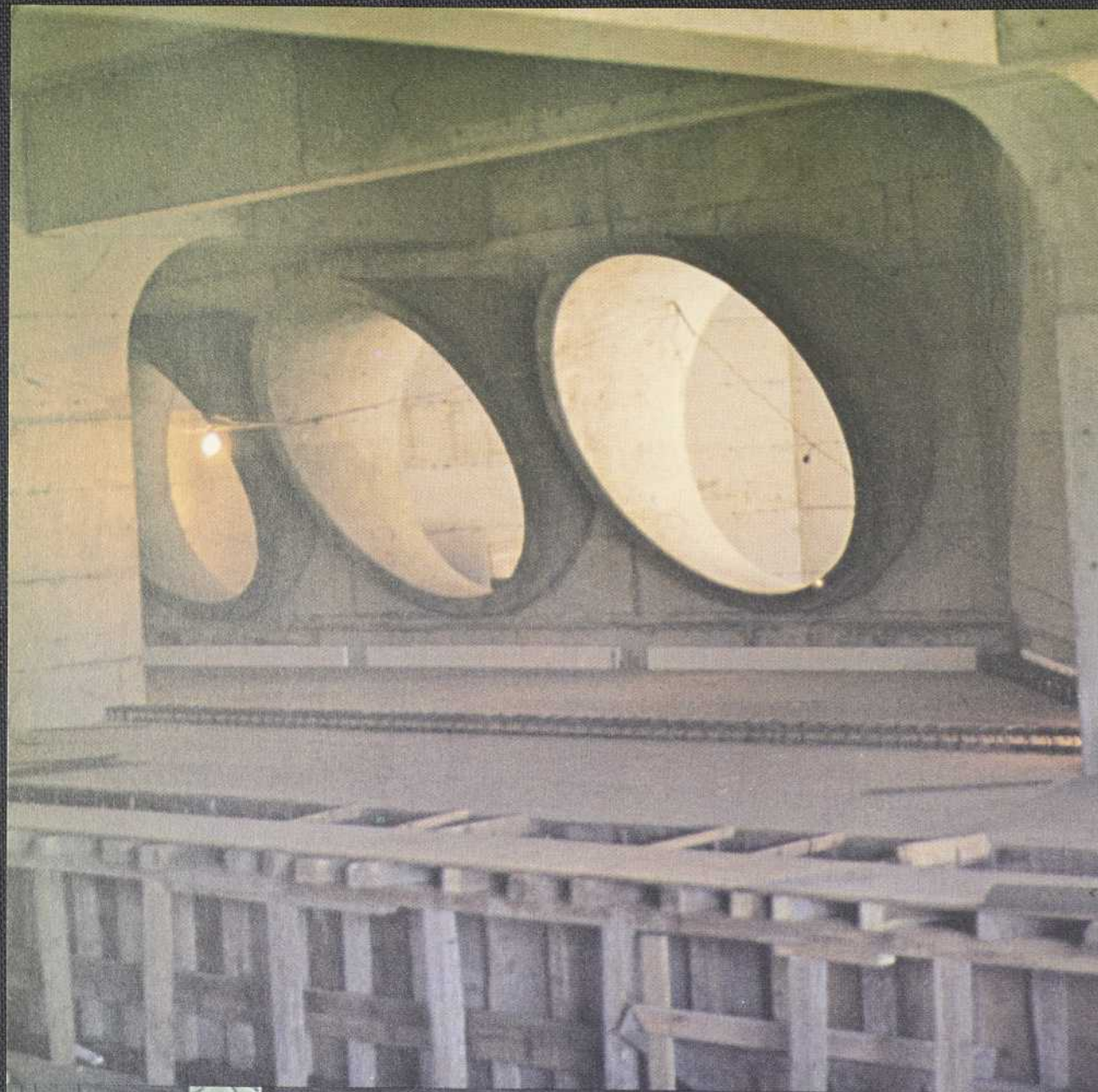
In order to facilitate the drainage of infiltrating water and for better layout of the electrical cables and water systems, the space under the platforms has been hollowed out. In the initial system, this space, forming a check in the bottom left and right hand sides of the station when viewed in cross section, was left unexcavated. The ser-

vice gallery, a passageway below and across the tracks from platform to platform, has been considerably enlarged ; it is now 8 feet (2.4 m) wide and 6.5 feet (2 m) high, this facilitates the installation of cables and ducts as well as their inspection and repair.

That part of the station which is built under the open-cut method constitutes a large volume which is now always equipped to give natural ventilation.

Fare collection together with the cashier's booth are now always placed on a mezzanine at the footbridge level over the tracks. Thus excessive chilling of these control rooms in winter is avoided.

Rest rooms and toilet facilities are always annexed to the cashier's booth.



VIAU STATION

Concessionaire facilities are planned so that space for storage, sales, and traffic will later-on be perfectly complied with.

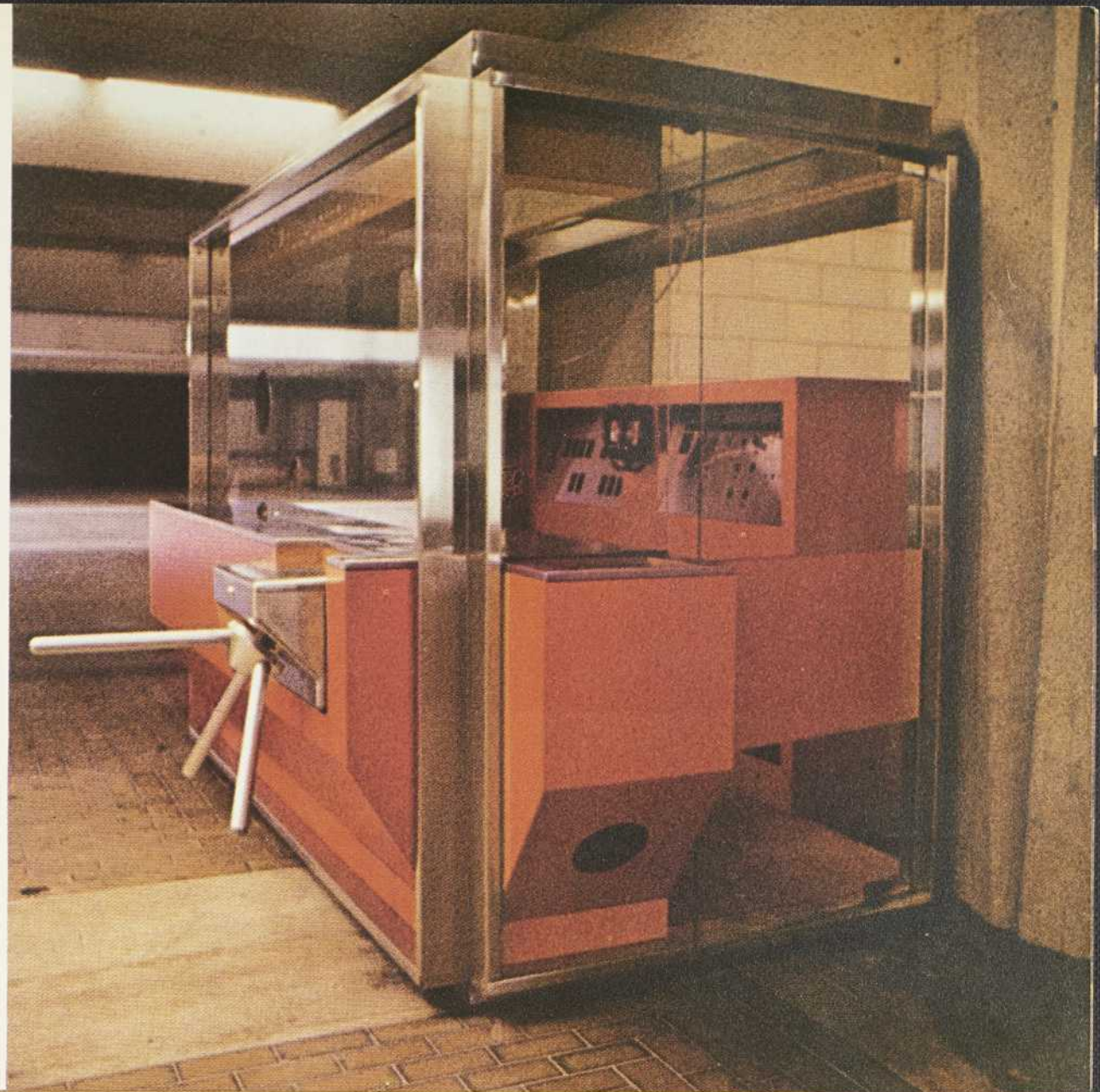
Moreover, each station possesses a furnished locale so that caretakers and maintainers who happen to be working in the station will have lockers and a lunch room.

In the termini, on the arrival platform as well as on the departure platform, there are to be found a rest room and toilet facilities for the use of trainmen.

The new termini have been standardized from a utilization standpoint. They comprise

a rear-station area equipped with reversing tracks, and tracks signalled for coupling and uncoupling purposes, and a garage able to receive in general 12 trains of 500 feet (150 m). The garage is slightly buried or at ground level. This solution permits an easy access to the garage, and facilitates ventilation and fire protection.

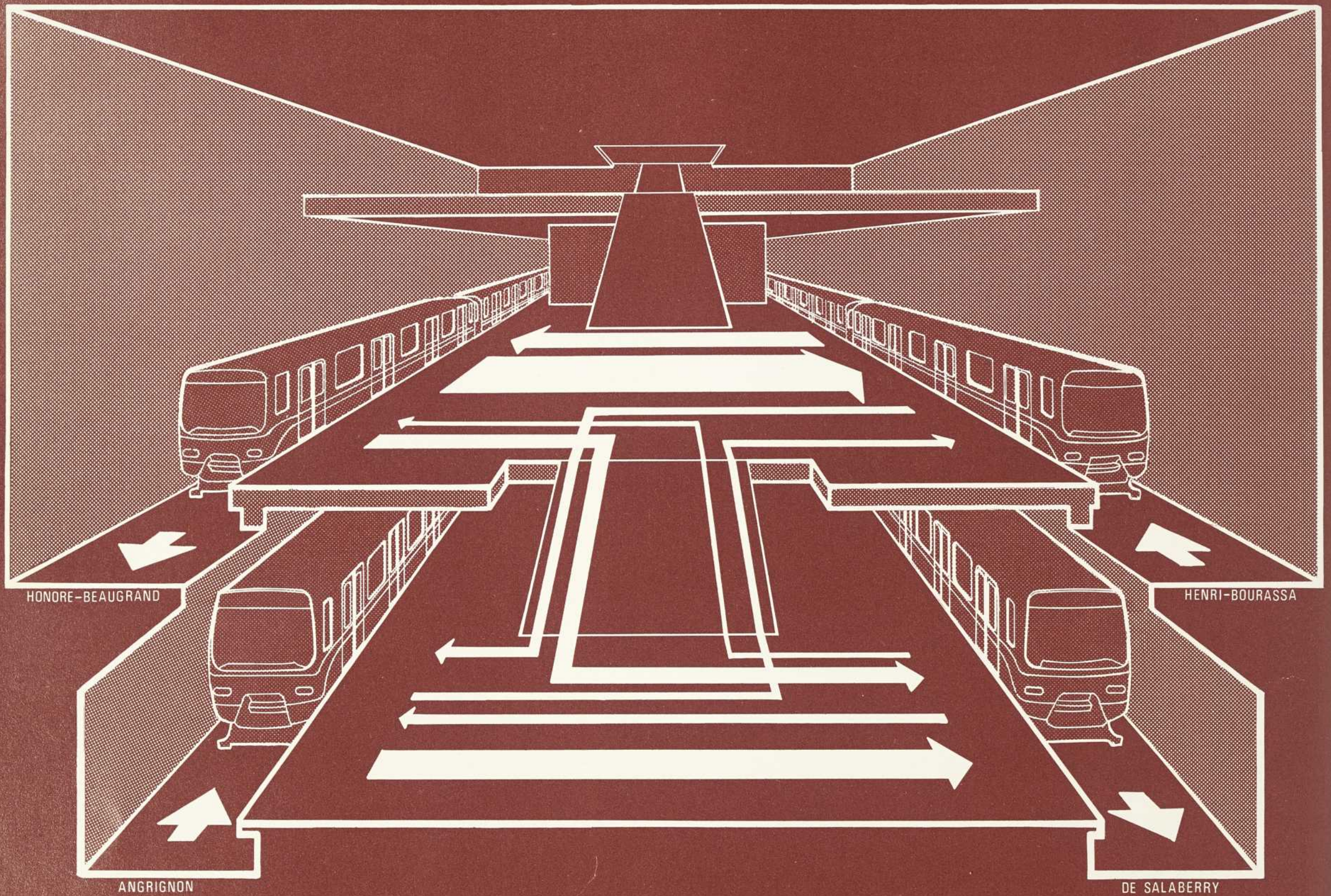
The new transfer stations of the network are of the central-platform variety. The trains undergoing passenger interchange pass on each side of the platforms such that the majority of riders have but to cross the island platform to exchange trains.



REAR-OF-TERMINAL TRANSFER TRACKS



TRANSFER STATION
LIONEL-GROULX



HONORE-BEAUGRAND

HENRI-BOURASSA

ANGRIGNON

DE SALABERRY

THE 2 TRAINS ON UPPER LEVEL GO TOWARDS CITY CENTER
THE 2 TRAINS ON LOWER LEVEL GO TOWARDS THE SUBURBS

Passenger movements at the level of the two platforms are organized in such a way that the major portion of uni-level exchanges does not for the most part conflict with bi-level transfers nor with entrance-and-exit traffic of the station.

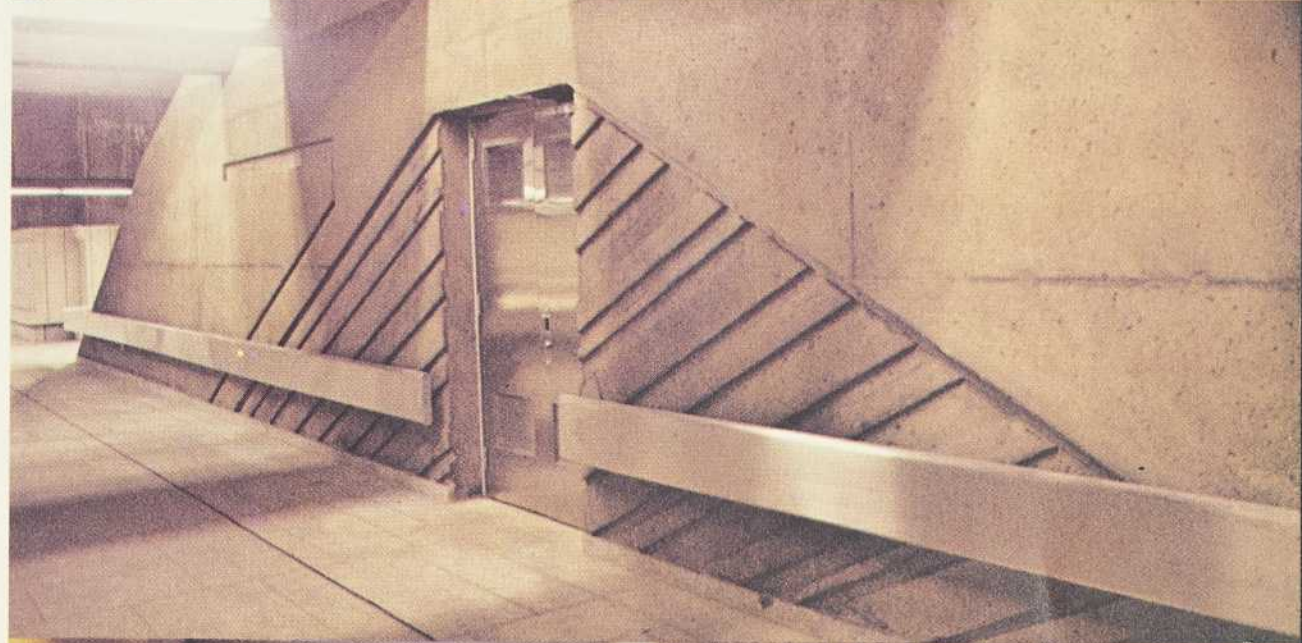
Transfer movements between the upper- and lower-level platforms are effected by escalators.

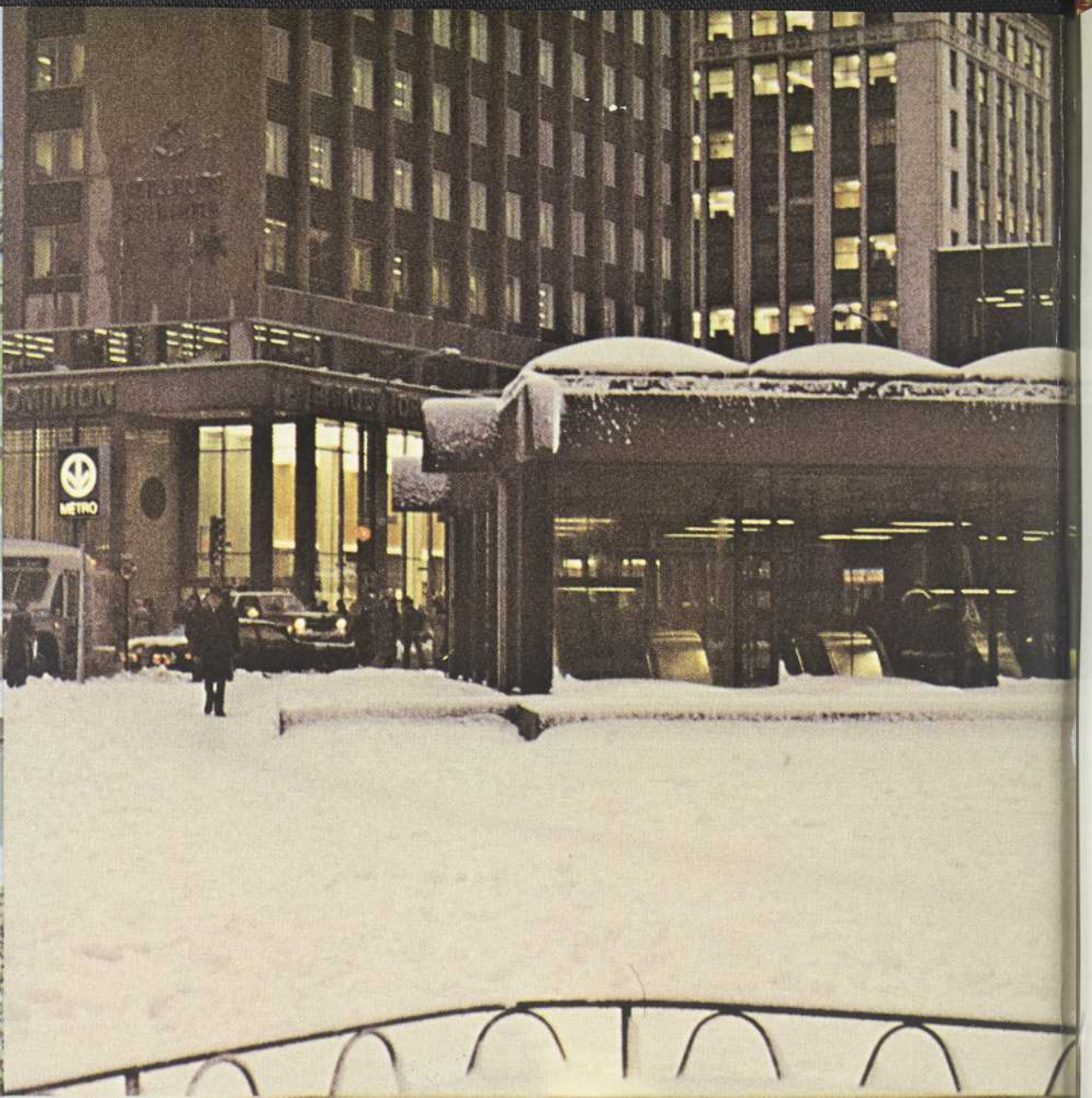
This solution permits an easy transfer for the greatest number of passengers.

Architectural research was pursued in order to enhance passenger movements and especially the ambiance in which they find themselves. The materials utilized (granite, quartzite, brick, tile) were chosen so as to obtain facings offering durability and increased safety.

Accesses

The accesses are always designed to give the utmost of coordination with autobus lines. The kiosks are no longer conceived as temporary shelters but as genuine kiosks.





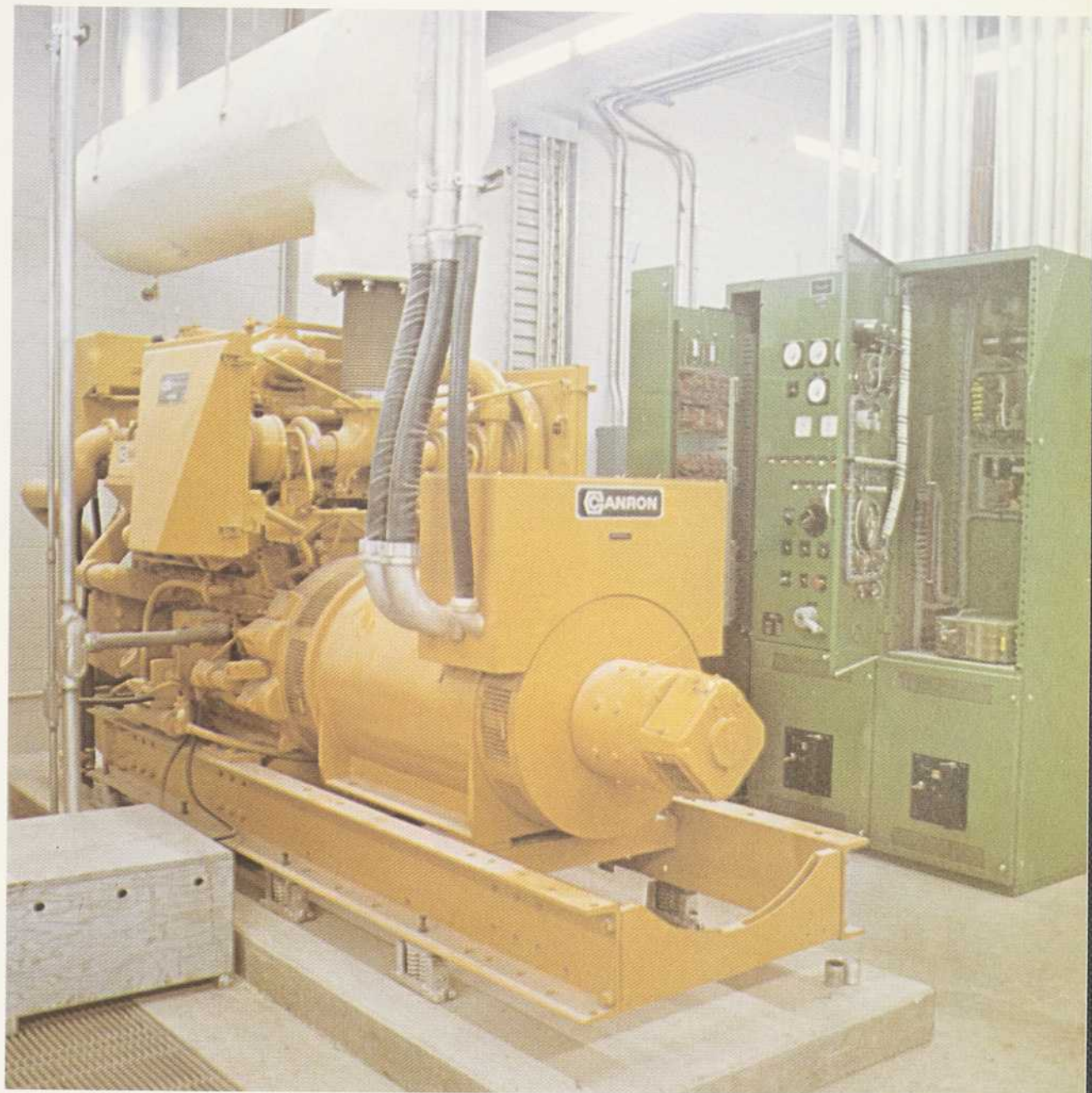
centre in one of the embracing stations — the other, from the diagonally opposed source which is the other centre deriving from the other Hv cable in the other embracing station. Each ventilator, moreover, can be fed from ground level by either a temporary Hydro supply or by a mobile diesel-generator set towed to the spot from one of various storage locations. Ventilator-motor protection is now accomplished by magnetic breaker trips instead of thermal ones in order that they will continue to operate as long as possible in the event of a fire.

In the existing network, since there is only one ventilator per installation site, a transfer switch is installed so that the feed can also come from the other distribution centre or, if need be, from a mobile generating set towed on location via city streets.

The two ventilators can operate to blow air in or out of the tunnel. The outblowing direction is their normal running mode, with exceptions under certain circumstances in winter. The two ventilators embody shutters permitting the total stoppage of air entry.

The large station-volume is linked to the outside by air shafts. Thus air-pressure variations, caused by the piston effect of train movements into and out of stations are reduced. Air currents through access doors are also curtailed. Establishment of natural ventilation in a large air-volume curbs localized cooling of the tunnel in cold weather, allowing the shutdown of natural ventilation to be postponed when winter arrives.

Nevertheless, experience has shown that it was impossible to leave the natural ventilation open in winter. Relevantly, the Metropolitan Transit Bureau (BTM) is studying and experimenting with a two-way valve (similar to a butterfly valve and nicknamed OKA) whose adjustment allows air intake and exhaust to the tunnel, as a result of the piston effect, to be delayed. Results appear interesting ; however, the tests are not complete. In very cold weather, the air-entry problem through the outside doors is difficult to solve ; the only answer to easement of door opening lies in the use of "butterfly" doors.



MOBILE DIESEL-GENERATOR



BUTTERFLY DOOR

Water Pumping

For certain pumping stations, which have considerable outputs, such as Bonsecours, Ile-Notre-Dame, Chabanel, there exists at all times a generating set within the station, which automatically comes into action in the plight of a failure in the two power sources.

The water sumps, in the extensions, have a greater reservoir capacity. The two pumps comprising the station come into play in the following way :

- float 1 : activates a pump on high level ;
- float 2 : stops the pump and establishes an alternative circuit to the other pump for the next high level, when float will again operate ;

float 3 : activates both pumps simultaneously if the maximum level is attained. An alarm signal is sent to the PCM ;

float 4 : if both pumps are insufficient, an alarm signal is sent to the PCM.

Like the ventilation stations, while one pump derives its feed from the distribution centre in an adjacent station, the other is supplied from the diagonally opposed source, which is the centre in the other embracing station fed from the other hv cable. Each sump is equipped with fixed ladders, and landings at 12-foot (3.6 m) intervals.

In stations, the pumping locales assigned to the sanitary sewage system are installed in leakproof sumps with the same power-feed and float-control principles as above.



Station Equipment ✓

The chief modifications adopted, as compared to the initial network, are as follows :

- on each platform, two emergency niches instead of one have been specified ; the niche's identification light has been improved so that it will be better seen by the passengers ;
- fire cabinets have been added with a constantly filled water pipe for use by Commission employees and a dry pipe for use by the City firemen. When a hose is prepared for action, power is automatically tripped ;
- centrally-pivoted doors appropriately named "butterfly" have been installed in accesses to the outside, in order to facilitate the opening of doors when inside-air pressure drops,

as a result of a train, or worse still two trains, departing from the station ;

- graphics have been made more legible by increasing the height of characters, by adopting a simple arrow instead of the Métro logogram for indicating direction ;
- the station name will henceforth be indicated on the outside, over the doors ; also on the inside, over the doors, will be shown the name of the street served ;
- the pictogram "do not smoke" is modified to make it more visible. A special ad warns the passengers that a penalty can be imposed on persons smoking in the Métro ;
- a pictogram is created for the end-of-platform small doors, so as to warn riders of the danger that exists in descending to track level.

**Improvements in the Reliability of Indication,
Control and Communication Systems.**

In the original design of the Métro the cables of these diverse systems were located in cable trays located on both sides of the tunnel. This manner of installing cables is employed in other subways. Experience has shown that said installation was particularly vulnerable in case of fire or collision. With a view to improving system reliability in the existing metro, we have allowed

that some of these cables, judged as essential in case of emergency, be doubled. The new cables are installed outside of the Métro, within duct banks of The Electrical Commission of the City of Montréal. The principal systems affected by this modification are the following: tele-transmission, control and indication of ventilation, certain telephone circuits related to the stations' PA system.



TRACTION-POWER SUPPLY

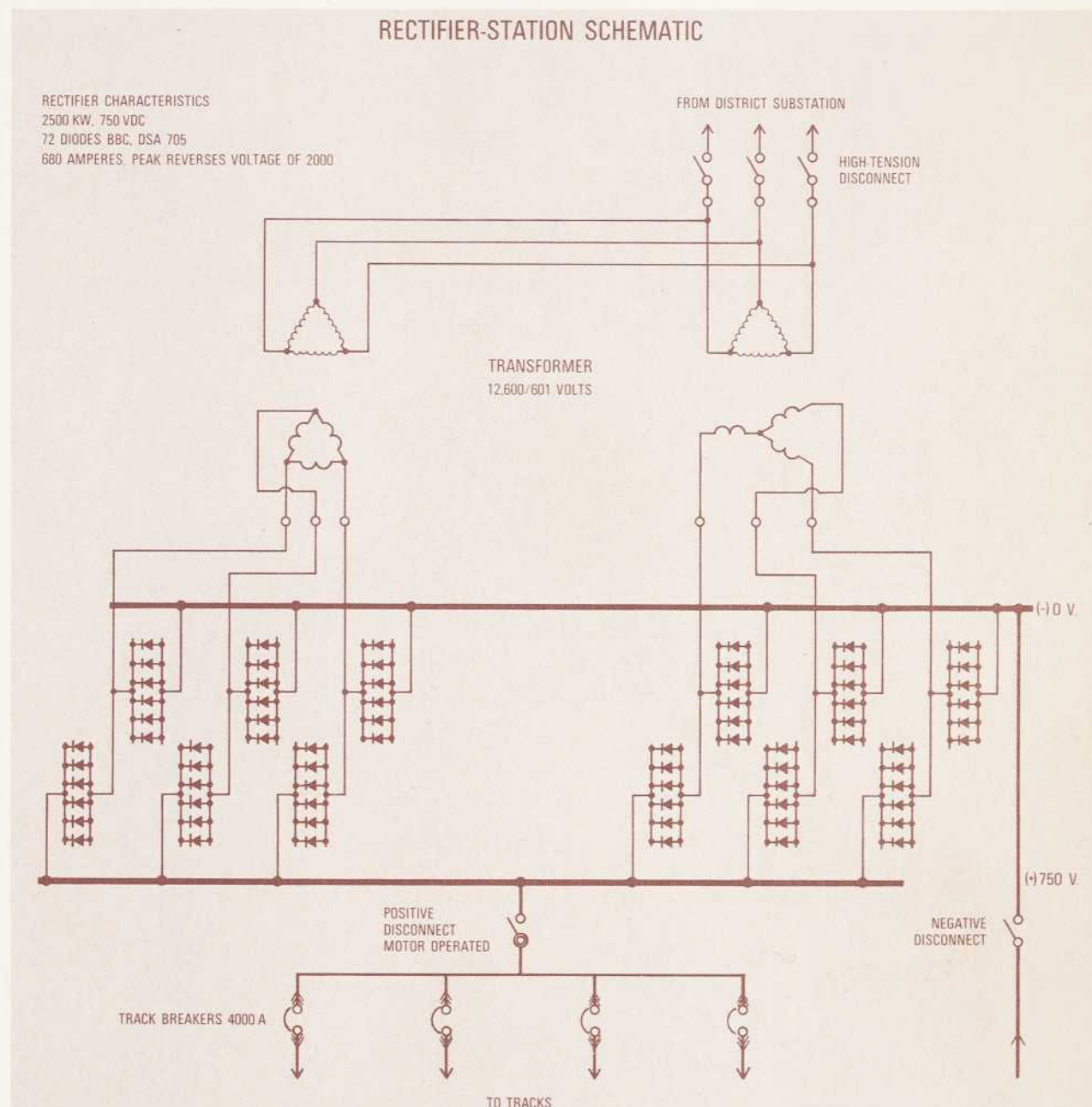
High Voltage

The extensions did not permit that the heretofore prevailing design be exactly followed. In the initial system all the power authority's cables came to Providence, where the high-tension breakers were also to be found. From here cables left, in general, by under-street ducts for the rectifier stations deployed along the Métro lines.

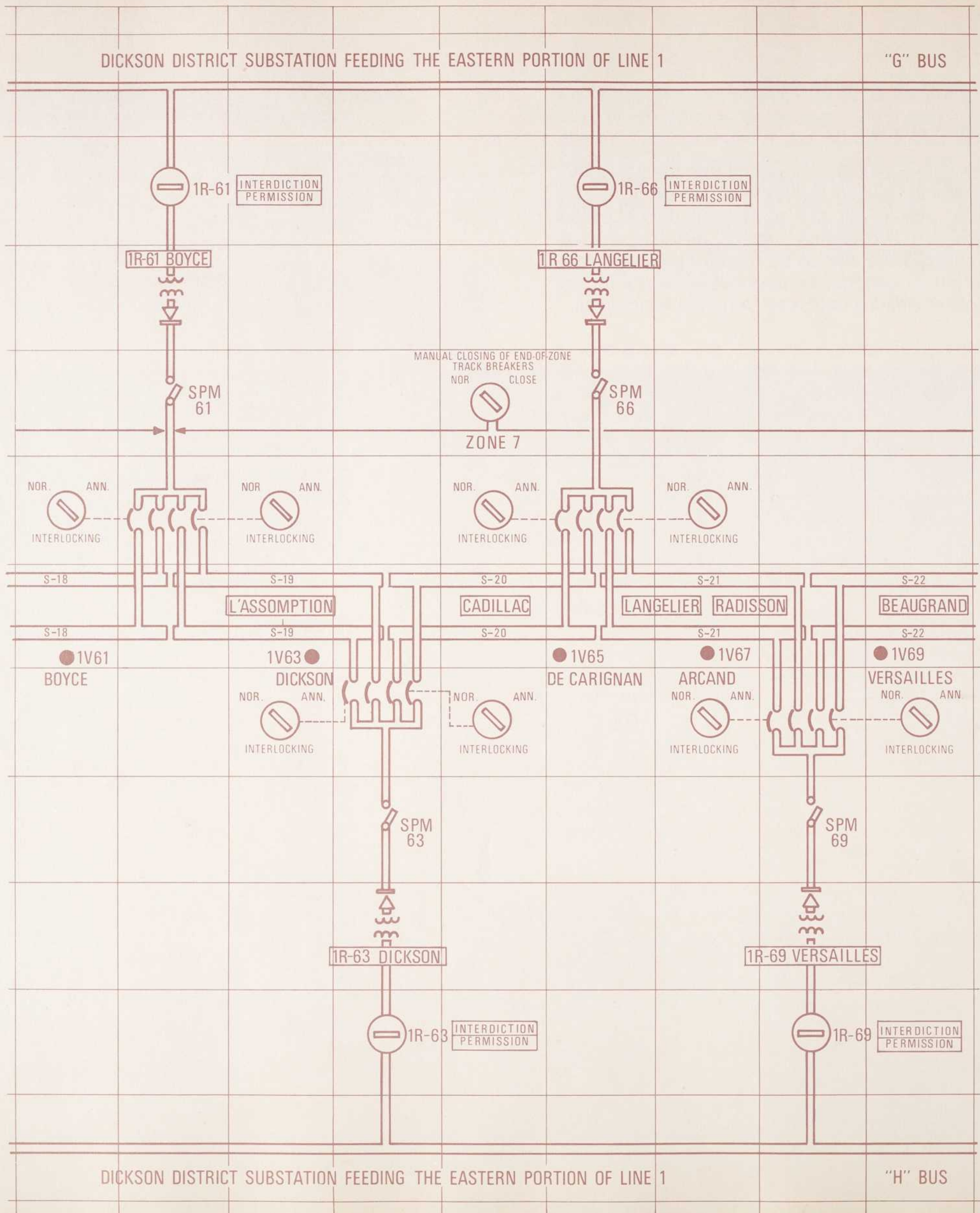
Distribution along each of the extensions is implemented by a new district substation analogous to Providence ; that is to say, it receives two distinct supplies from Hydro-Québec, feeding breakers which protect the rectifier stations strung out along the extensions.

Three important differences, however, should be mentioned :

- the principal (incoming) breakers and those for the protection of rectifier stations (outgoing) are remotely controlled, for closing and opening, from Providence. Power cut is however effected by a fail-safe hard-wire circuit from a constantly live circuit originating in Providence ;
- the cable runs from the district substation to the rectifier stations are lodged in concrete duct-banks located on each side of the tunnel. The cables are thus well protected against fire, shocks, jack hammers, and corrosion arising from salt on city streets ;
- cable composition, itself, has been improved ; this high-tension conductor is constituted of an assembly of three single-phase cables of cross-linked-polyethelene insulation with concentric neutral composed of a network of annealed and tin-plated strips.



PART OF THE POWER-CONTROL BOARD



Rectifier Stations

The rectifier-station design is similar to that of the initial project; however, even if its nominal rating is the same 2 500 kW, its graphically illustrated load schedule imposes five 60-second peaks of 10 000 amperes plus a 15-second peak of 15 000 amperes — all this taking place in two hours while the base load is 5 000 amperes.

By comparison, the existing rectifier station, in the one-hour interval while carrying a base load of 5 000 amperes, is designed to carry peaks of also 10 000 amperes but for only 20 seconds and recurring at 3-minute intervals.

Rectifier-station spacing in the extensions has been reduced and made more nearly equal. The maximum spacing has been fixed at 4 000 feet (1200 m). For the initial system, moreover, because of the excessive distance between the consecutive installations of Chabanel and Failon, it is envisaged that a rectifier station be added at the intermediate location of Guizot.

The new rectifier stations incorporate four track breakers, so that both track 1 and track 2 enjoy separate feeds in both the upstream and downstream directions. The former high-speed breaker has been replaced by a motor-operated disconnect, in the rectifier-station positive-output conductor. This switch falls under the jurisdiction of power control (PCM). A similar arrangement for the existing network is under study.

Traction-current Distribution Along the Métro Line

The track breakers, which replace the track disconnects, come under the jurisdiction of train control (PCC). In the event of a fault, however, they come under power control (PCM).

Opposite each rectifier station there exists a power break. That stretch of continuous guide rail lying between the breaks of adjoining rectifier

stations is called a traction section. The traction break itself is made up of an insulated guide-rail length which precludes any manner of bridging via the positive collectors whenever a train passes over the break.

The relatively short traction sections allow for better policing of the current through the track breakers. In effect, a traction section is fed by two track breakers; since there generally will not be more than one train in one section the arrangement admits to a very low adjustment of the overcurrent trip setting.

A section consuming an overcurrent will usually cause both its supply breakers to trip on their own. But if the location of the unduly heavy current drain is such that only one breaker discerns the fault then its opening will cause, via a transfer-trip arrangement, its companion feeding into the same section to likewise trip, thus deenergizing the section completely.

In the same manner, the tail tracks of the initial network have been equipped with magnetic yokes; these yokes play the role of an overcurrent relay. They can be set fairly low as they supervise only one or two trains in the terminus — trains which are not to exceed a speed of 10 miles (16 km) per hour. (The driver is confined to the lower-speed notches where the traction motors remain connected in series and the train can consume at most only ½ of maximum current).

The d-c distribution cables to the guide rails within ducts of the tunnel invert, were subjected to closer design scrutiny in order to avoid small-radius curves which can damage the cables at the moment of their installation. This has been done in the interests of avoiding certain cable-ignition incidents which have taken place along track of the initial network. Moreover, as mentioned before, the repercussions of such a fault are much reduced since the use of track breakers will henceforth permit a more minute segregation of track power.

Protection from Short Circuits

Modern high-performance trains have elevated current peaks (more than 6 000 amperes); two simultaneous train-starts call for about 12 000 amperes. A short circuit is an electric arc between positive and negative, or between positive and ground; it can be resistive and generate very little current, well below the breaker setting. It is for this reason that, in all Métros and electric railroads, safety systems have been devised so that train conductors, at any point of each line, can effect an emergency powercut in case of a persistent short.

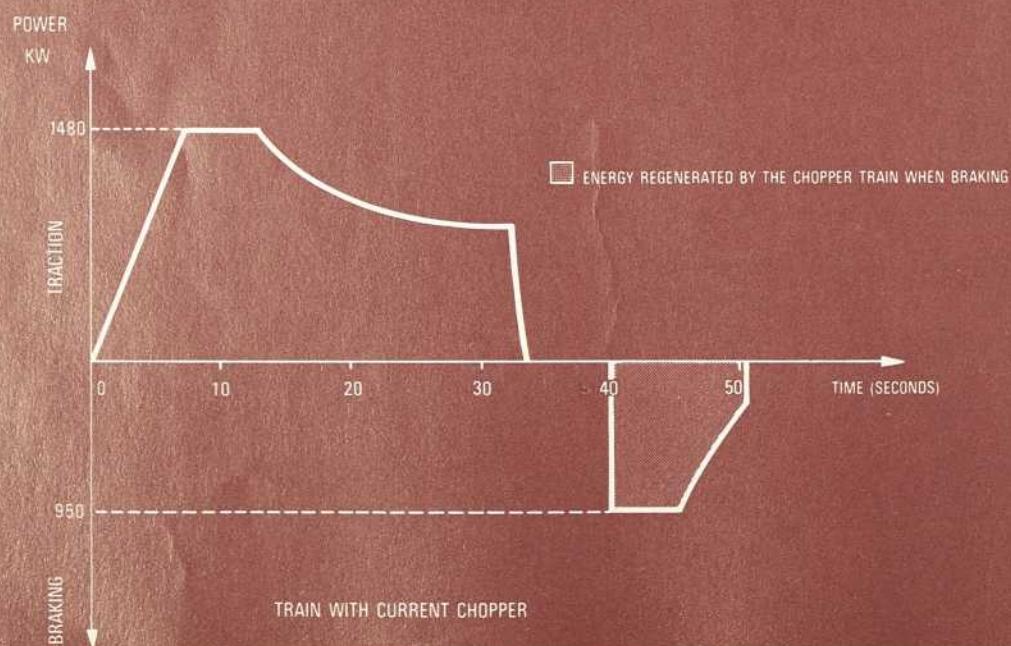
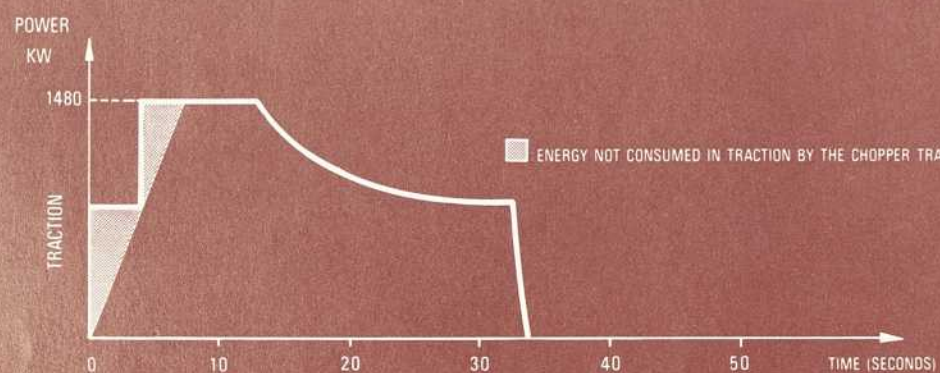
However, in order to enhance protection, we have given thought to complementing the operation of the breaker, which trips via overcurrent, by an operation based on the sudden current variation which a short circuit can breed. Unfortunately, the starting of a present 1966-model

train with its series-then-parallel-connection mode, provokes, when the series-to-parallel transition takes place, a sudden variation in current which is only amplified if the contactors involved in the above sequence operate exactly simultaneously. A program to desynchronize the in-step condition of the controls to the many traction motors of a train, as it accelerates, is underway.

The future rolling stock, where motor control is accomplished with choppers, does not suffer this inconvenience.

The di/dt current detectors were the object of very long research by various manufacturers and transportation agencies. Thanks to electronics one is able to compare an abrupt short-circuit current of almost whatever nature with the sudden variations which may be obtained on train starts. The tests effected on our system allow us to say that the detectors will be able to open the

POWER DRAWN BY CONVENTIONAL TRAIN AND BY CHOPPER-CONTROLLED TRAIN



breakers for short circuits summoning a contribution of as little as 1 000 to 1 500 amperes from the rectifier station wherein they are installed.

The MUCTC and the BTM have ordered detectors of this type for the present and future rectifier stations.

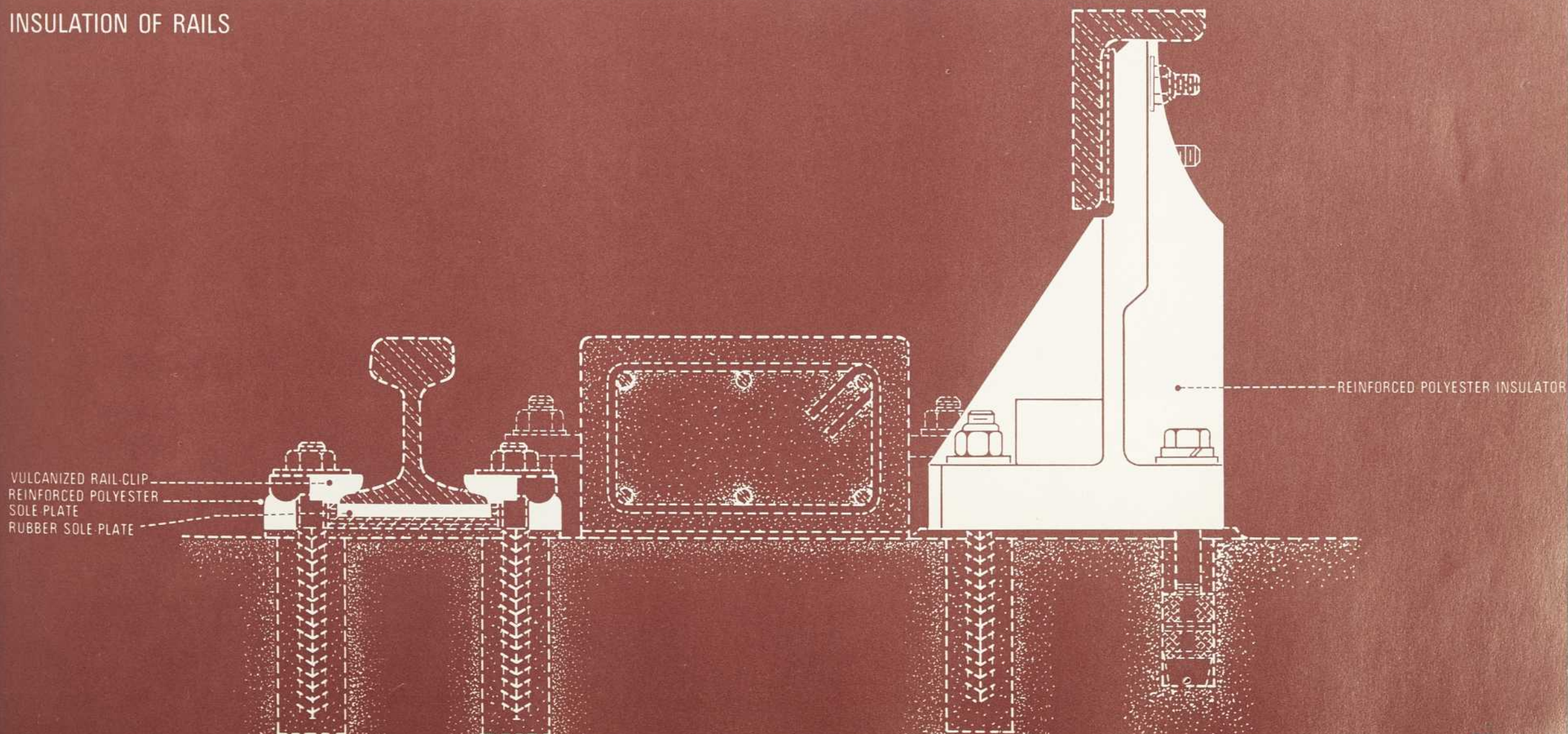
But despite all the advancements, one must remember that the emergency-power-cut line — a fixed-plant-located device — is designed to accommodate the situation where, for whatever reason, power cut would not automatically take place, and also, that — while on the move — the motorman can obtain an emergency cut from the PCC simply by asking for it on his trainphone.

Traction-return and Ground Circuits

Long high-performance trains have challenged electric-traction engineers with another problem ; it is that of the presence of a voltage relative to ground on the return rail. The safety rails and the impedance bonds, which permit current return, have feeble resistances, but since, during short intervals, they are subjected to high currents, a voltage to ground nevertheless results.

The return rails are insulated relative to ground ; some improvements have been made to this insulation — all this in order to avoid vagabond currents which bring about significant destruction of underground conduits and structures.

INSULATION OF RAILS



In a manner as to diminish non-dangerous but nuisance voltages, equipotential links between the 4 rails have been established. (This convenience is commonly referred to in the trade as cross bonding). Nevertheless, all personnel called upon to work on track has been equipped with insulating shoes.

Grounded circuits are also present in the Métro ; the ground connection is made with the main water-conduit from the City. All metallic objects in station or in tunnel are grounded, so that danger to personnel does not exist. But workers must always remember that the safety, or return-current rails, are electrical conductors, like others, which cannot normally be grounded.

Total Electrical Power Failure

A blackout on the part of Hydro-Québec triggers on the initial network an automatic train-stop, which takes place the moment the train, in its subsequent inevitable coasting mode of locomotion,

passes by the first and necessarily extinguished signal. These circumstances prevent many trains from reaching the succeeding station. In the new train-control system, the speed orders transmitted to the track will be maintained owing to an emergency supply deriving from batteries coming into play at the moment of the general power failure. If the line profile permits it, the trains employing the coasting mode could then reach the succeeding station ; thus, evacuation in the tunnel will be avoided to the utmost.

If the PCM and the PCC were forewarned as of the first load-shedding* by Hydro-Québec, the PCC could light the departure-on-order (DSO) signal and oblige the trains to stop in station before total power cut is instituted. As soon as the situation would right itself or become clear, the DSO would eventually be lifted and orders would be given by the PCC.

A request to this effect has been presented to Hydro.

*Load-shedding is a process which is sometimes resorted to by electric utilities as a necessary pre-condition for reestablishing power.

SUPPORT-FACILITIES POWER SUPPLY

High Tension

The high-voltage feed to lighting and electro-mechanical installations for the extensions derives from the support-facilities bus of the district substations. The breakers connected to the above bus are remotely controlled, as in the traction case.

In the initial network, the two high-tension support-facilities cables are routed within the tunnel, each in a sidewall groove. To improve protection in case of fire, the metallic plate that formerly covered the groove has been replaced by a superbestos plate.

In the extensions, the two support-facilities high-voltage cables are lodged in separate duct banks — one on each side of tunnel.

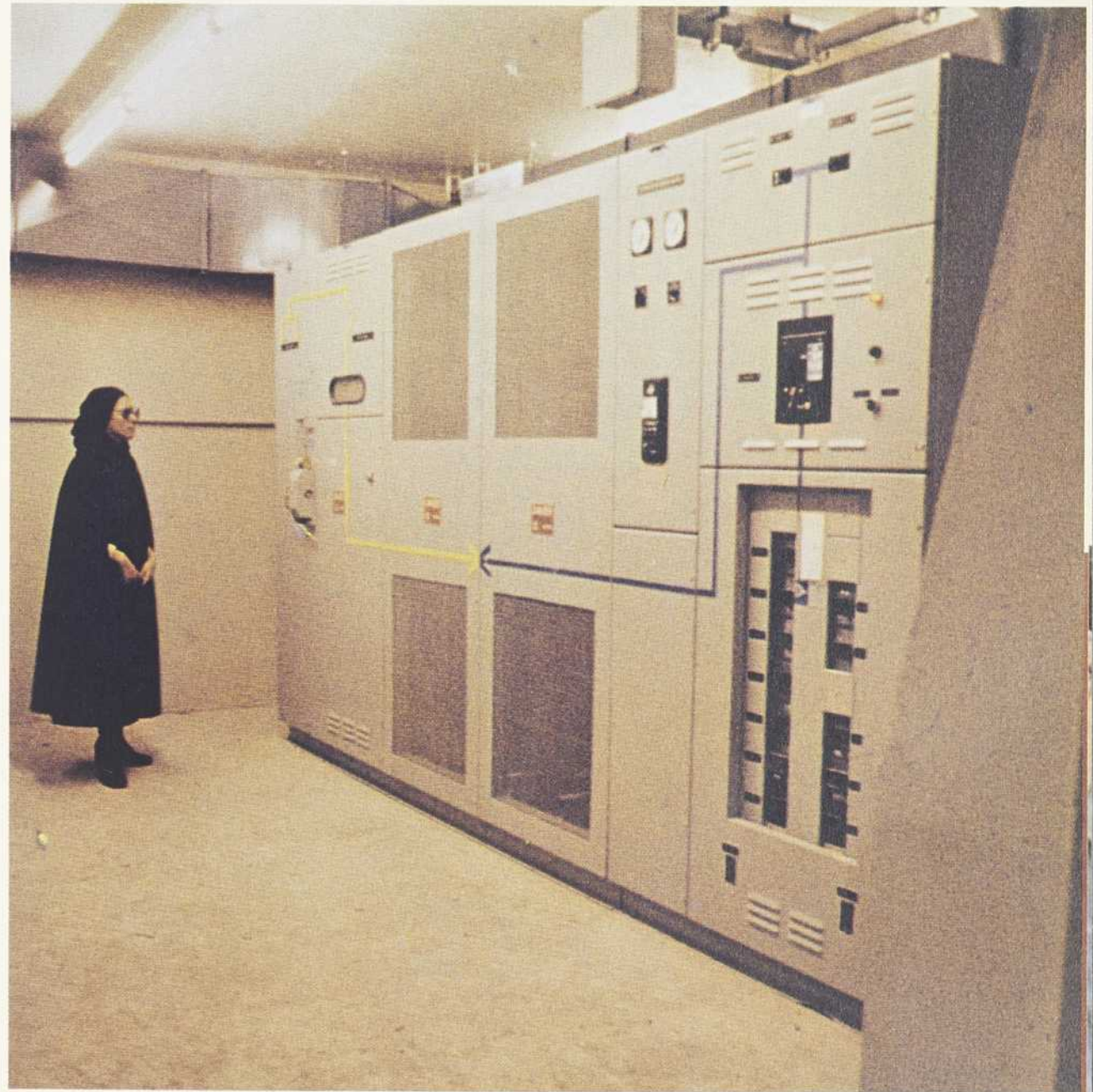
In order to reinforce emergency lighting in stations and tunnel, two motor-alternator emergency sets have been specified for each district substation (PD), of which at least one set per PD automatically comes on line in the predicament of a failure in its two feeds from Hydro-Québec.

Each motor-alternator set comprises a diesel driving an alternator feeding into a step-up transformer which supplies the support-facilities bus with 12 470-volt power. Each set is rated at 400 kW.

Secondary Distribution Centres

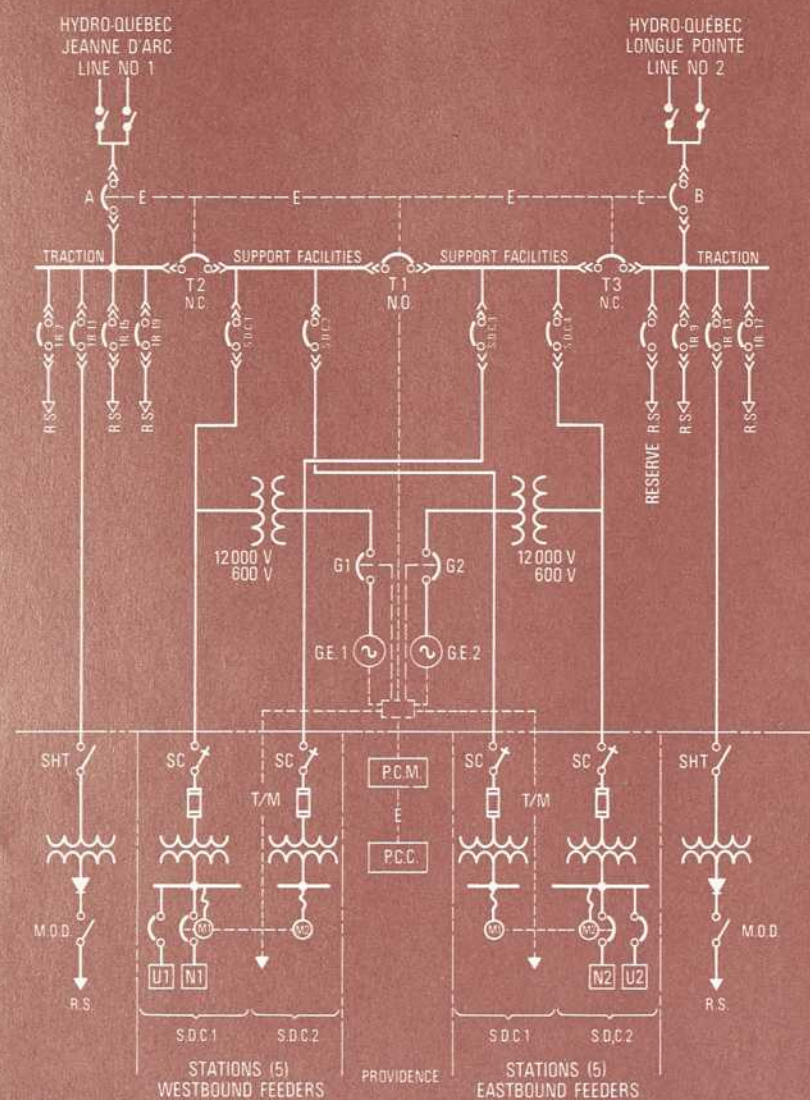
As in the first network, each of the above two high-voltage cables, routed in the tunnel, passes, via sectionalizing disconnects, into one of the two transformer-substations in a Métro station ; transformer is usually on same side of tunnel as cable is. Thus a distribution centre finds itself on one Hydro feed, the other on the second.

The secondary distribution centres are rated at 450 kva. while those of the initial network are rated at only 300 kva. Protection at the station



SECONDARY DISTRIBUTION CENTRE

ONE-LINE SCHEMATIC OF ELECTRICAL DISTRIBUTION
12 KV AND EMERGENCY MOTOR-ALTERNATOR SET



level is always assured by a high-voltage fuse. (As opposed to the cable level which is serviced by a breaker in the district substation).

Power Distribution and Emergency Lighting

In order not to exceed the available power from the motor-alternator set of the district substation, after a complete outage on the part of Hydro-Québec, the set reenergizes but only the essential circuits. Complete outage at the Métro level thus endures about 20 seconds. The circuits whose low-voltage breakers have opened as a result of power failure have their breakers remotely controlled and can be reclosed from Providence Power-Control (PCM).

During the 20-second interruption, emergency lighting is given by autonomous lighting fixtures of 40 watts, incorporating built-in rechargeable batteries. Twenty per station have been specified. Similar lighting has been added to the existing network. In the tunnel these fixtures are installed at approximately every 80 feet. All the non-physically-protected cables are of the mineral-insulated type, that is to say very resistant to fire.

TRAIN ANTICOLLISION DEVICE

Reasons for the Change

Signaling by track circuits with a buffer zone suffered the inconvenience of not being homogeneous; two consecutive red signals enclosing the buffer zone, a solitary red signal in interlocking territory, where precisely the risk of accidents is the greatest.

Moreover, the automatic stop in case of running a red signal had the inconvenience of halting the train belatedly, after the signal had been breached.

Speed control through interlockings and curves was but a punctual control — not able to stop an operator from resuming an accelerated speed once the control point was passed.

Moreover, no speed control existed at the rear of terminals and in garages.

New Train-control Characteristics

The protection of trains running over the same track is assured by the injection of stop or slow-down codes in the two zones behind any zone occupied by a train.

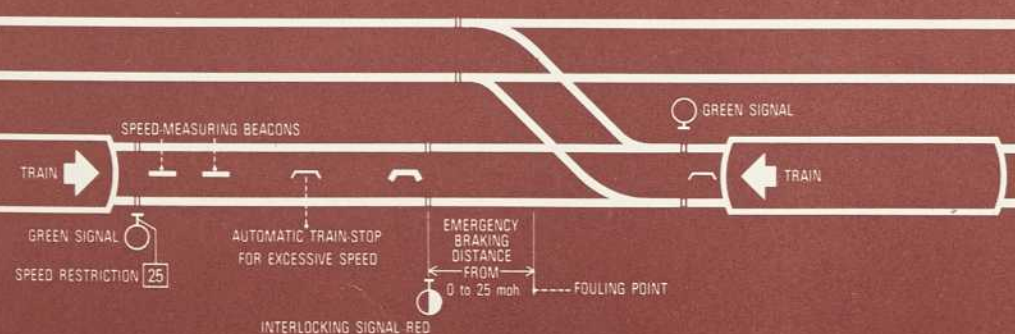
Each train, be it under automatic or manual control, is subjected to the compliance of speed rules at any point. If it does not comply with them, that is to say if train is overspeeding or if it brakes insufficiently, it automatically undergoes emergency braking.

Needless to say, this system of continuous speed control must be fail-safe, that is to say any

PRINCIPLE OF BUFFER ZONE AND DISCRETE CONTROL

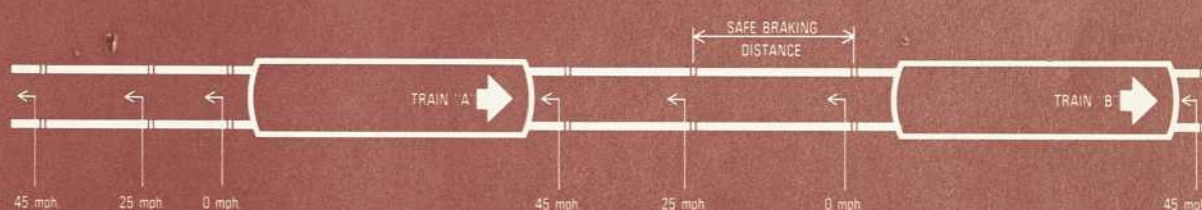


AUTOMATIC-BLOCK SIGNALING FEATURING THE BUFFER ZONE AND DISCRETE CONTROL OF TRAIN INTERSPACING

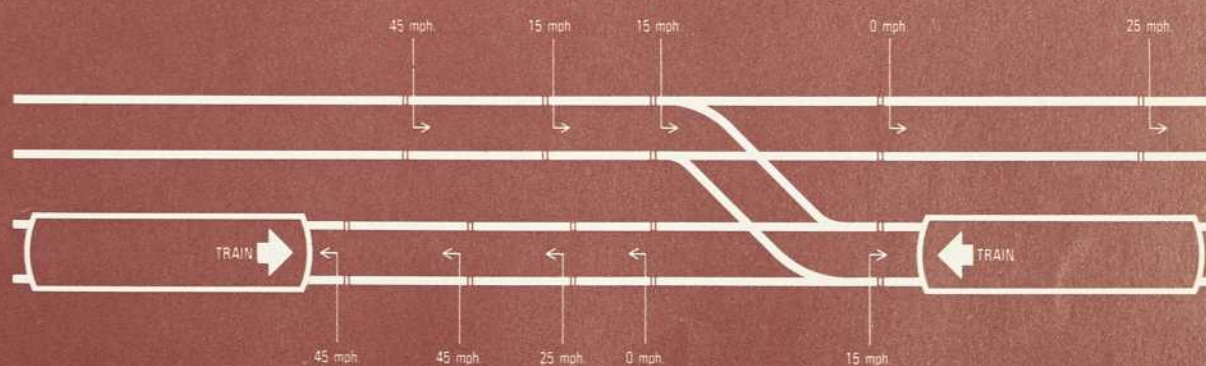


SIGNALING IN INTERLOCKINGS FEATURING DISCRETE-POINT ENFORCEMENT OF SPEED LIMITS

PRINCIPLES OF CONTINUOUS CONTROL WITHOUT BUFFER ZONE



AUTOMATIC BLOCK SIGNALING WITH CONTINUOUS CONTROL DEVOID OF A BUFFER ZONE



INTERLOCKING SIGNALING WITH CONTINUOUS SPEED CONTROL

disturbance must give rise to a more restrictive speed indication, and any disappearance of codes must immediately instigate a stop in the concerned block.

These principles carry to interlockings and even to garage zones where the motorman drives his train under continuous speed-control.

In the zero-code case or in the absence of codes, the motorman can advance his train under manual control :

- at 3 mph (5 km/h), under CR mode (adapted to coupling) ;
- under visual observation, without speed control, the speed being limited to a maximum of 25 mph (40 km/h).

However, these possibilities are evidently subjected to very severely restricted uses.

Benefits accruing from this anticollision device are :

- of being safe and homogeneous, whatever the train's zone of action ;
- of being linked to the track and to each station in such a manner that a disturbance can be but local ;
- of permitting a better approach to the preceding train thus allowing closer headways, translating itself into a greater transport capacity ;
- of easily lending itself to the installation of automatic train-control.

RUNNING OF TRAINS

Reasons which Led to Adoption of Automatic Train-control

The reasons are as follows :

- increase in the safety of passenger transport in seeking to eliminate any human failing ;
- facility of adopting timetable-regulation of trains at each station, which has the effect of better distributing passengers within and among trains ;
- ease of adopting in each interstation course a normal, accelerated, or economic run by actuating the coasting mode more or less late ;
- possibility of running one-operator trains ;
- possibility of automatically switching tracks in terminus, which permits reduction in layover time in the terminus and thus gives flexibility in the use of personnel.

Automatic Train-control with Single-operator Trains

The new rolling stock ordered for the extensions goes into service with automatic train-control featuring continuous speed-control. The existing stock is being modified to conform by the same date.

In automatic train-control, speed-control orders capable of being transmitted to the train are :

0, 15, 15S (special), 20, 25, 35, 45 mph (0, 24, 24S, 32, 40, 56, 72 km/h). The 10-mph code is reserved for traffic on garage tracks ; it is usable only in manual drive.

The code 15S is utilized in interlocking territory (for entry onto the line or departure from termini) ; this code prohibits all traction commands by train equipment.

Speed orders transmitted in the track are displayed in the cab.

Continuous Speed Control

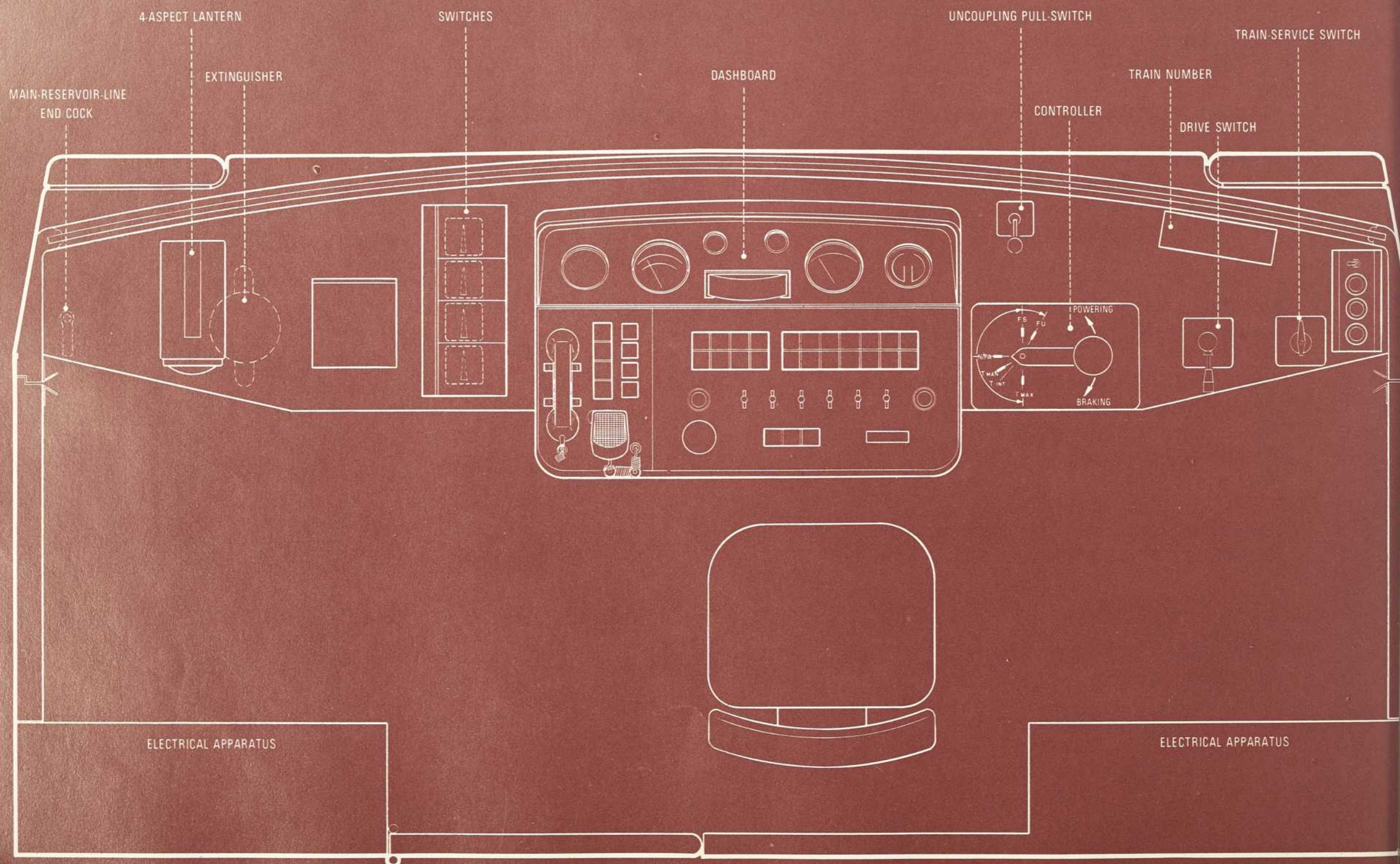
Continuous speed-control, which determines the protection of trains, is effective in automatic train-control and equally in manual drive.

The continuous-speed-control equipment of fail-safe design is redundant as of the reception of codes, in order to augment its reliability. A systematic check on its health status by actuation of the service key allows the transfer to stand-by equipment in case of fault.

In the event of overspeed, emergency braking is the type to be applied. If service braking is commanded (other than that used for stopping in station), automatic train-control verifies the deceleration rate ; if the requisite rate is not obtained and maintained, emergency braking is applied 4 seconds after the detection of overspeed.

Under manual drive with continuous speed-control, an audible signal makes itself heard in the drive cab in order to warn the operator that he must brake his train. Emergency braking is applied two seconds after the detection of overspeed if the motorman has not placed his master controller in the braking position — four seconds after the detection of overspeed if the predetermined deceleration rate is not attained and maintained.

TRAIN-CONTROL PANEL



Manual Drive with Continuous Speed-control Out of Service

Continuous speed-control (CSC) can, despite all the precautions taken, become defective.

The fault can come either from faulty on-board equipment, or from the absence of speed commands in the track.

If a defect appears in continuous-speed-control on-board equipment, automatic train control is by the very fact also unserviceable and the motorman must unseal the continuous-speed-control switch to put its circuit out of commission. He departs under safe manual drive (without CSC) with the on-sight running mode, the speed of his train being limited automatically to 25 mph (40 km/h). He must evacuate his riders on reaching the first station then proceed passengerless to the terminus, the train being withdrawn from service.

If the fault derives from an absence of command orders, all the trains in this case are blind on one or many track circuits. The trainmen are warned of the defect by signals placed on the headwall of the involved station. These flashing signals indicate SS or SSO and are lighted, on orders from the PCC, either by a train motorman or by an inspector.

The indication SS denotes to the trainmen that a track circuit is defective within the interstation run and that they must, whenever braked automatically, restart in the safe-running mode, that is to say, in this case take over manual drive in mode CD, which automatically limits them to 3 mph (5 km/h).

The SSO sign, when lighted, indicates that many track circuits are defective within the interstation run, the trainmen must assume the safe-running mode, that is to say, accomplish the inter-station course in manual drive with visual apprehension, the speed being automatically limited to 25 mph (40 km/h).



A TRAIN AT PLATFORM

Station Stop and Opening of Doors

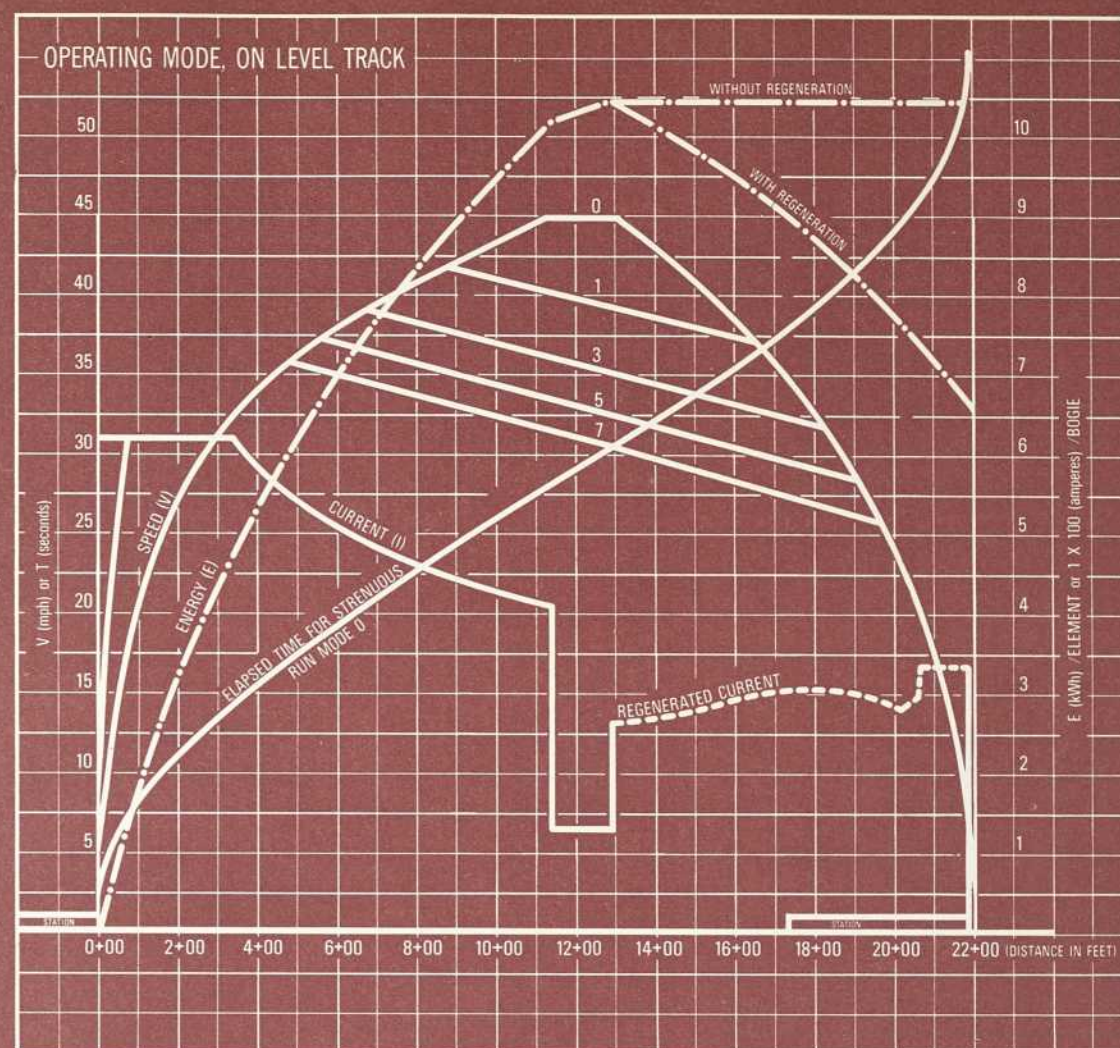
The station stop is programmed into the automatic train control on-board equipment.

The station-stop program can be triggered only when the downstream track circuit is free; it is given by an inductor (hereafter called a beacon) which commands the stop; at mid-run, a correction beacon controls the unfolding of this stop; lastly, a final beacon gives stop precision.

Short-train consists, with two or one element, necessitate an array of supplementary beacons, conveniently laid out in each station, according to where passenger accesses give out on the platform. In accordance with the train consist on the line, it is this or that arrangement which is activated by central control.

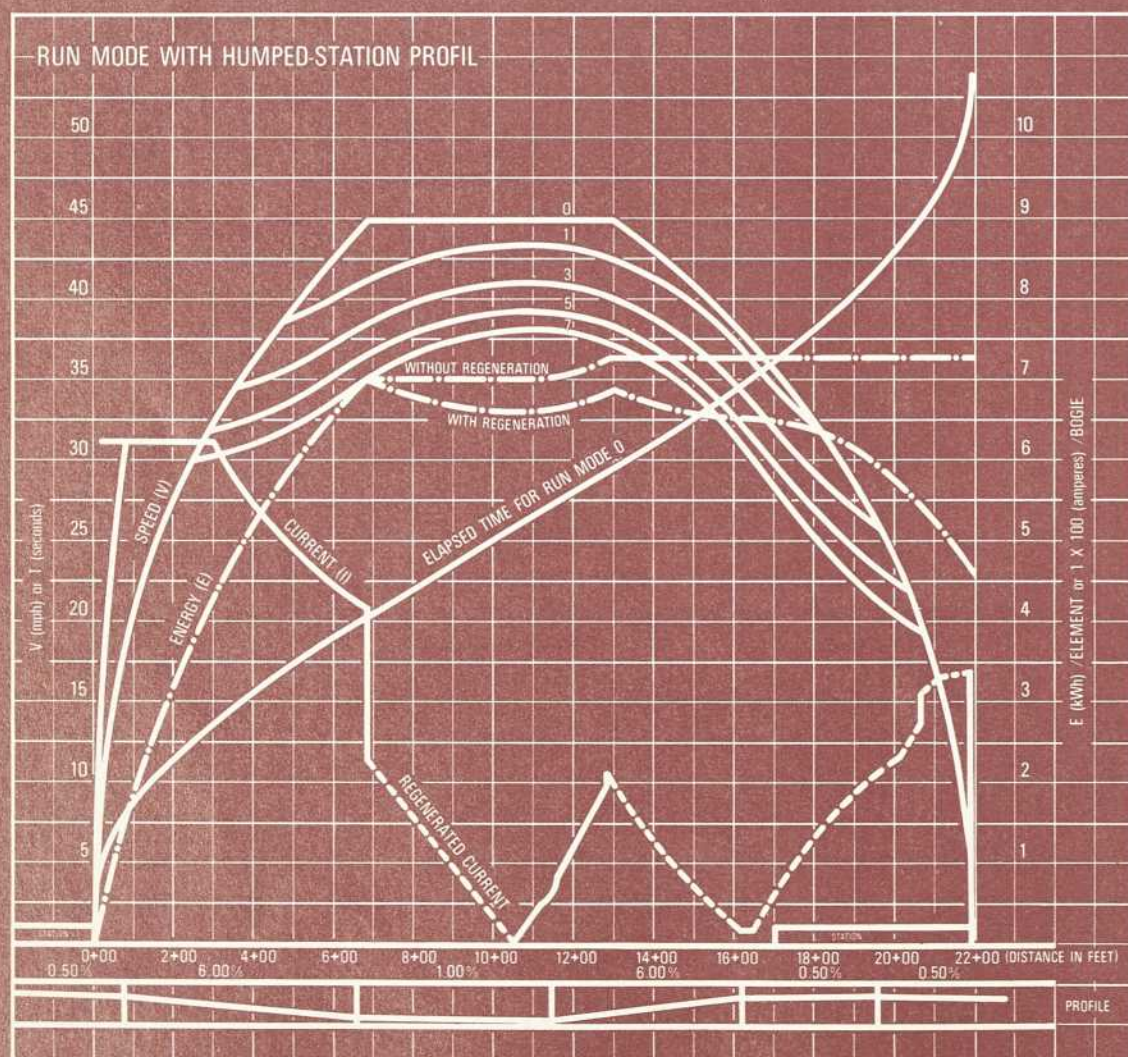
The setoff of the programmed stop is supervised by a frequency transmission which is received on-board train whenever the latter engages the station track-circuit. If, at that moment, the stop program is not triggered, an emergency braking takes place.

The automatic opening of train doors is given, in automatic control or in manual drive, when the service key is in the automatic position, by the capture of a door-opening frequency ; this order can be executed but when the train has received a door-opening code coming from the track and corresponding properly with the platform position relative to the train to the right or the left with the following supplementary conditions : the train has a speed of less than 3 mph (5 km/h), the train is entirely in the station track-circuit.



RUN MODE	SLACK TIME	RUN TIME
STRENUOUS	0	55.31
ACCELERATED	1	56.31
NORMAL	3	58.31
SLOW	5	60.31
SLOW	7	62.31

ENERGY (STRENUOUS RUN)
WITHOUT REGENERATION: 10.43 kWh
WITH REGENERATION: 6.58 kWh



RUN MODE	SLACK TIME	RUN TIME
STRENUOUS	0	54.16
ACCELERATED	1	55.16
NORMAL	3	57.16
SLOW	5	59.16
SLOW	7	61.16

ENERGY (STRENUOUS RUN)
WITHOUT REGENERATION: 7.25 kWh
WITH REGENERATION: 4.66 kWh

The doors are closed by the operator who additionally must supervise the platform on accelerating out of each station.

Coasting (Free Wheeling)

Some automatic train control systems in use on various foreign networks have the inconvenience of regulating train speed by too many brake-then-traction commands ; it follows that supplementary-power expenditures are engendered when one transfers from manual to automatic drive ; moreover there is excessive wear of brakes, without mentioning the discomfort likely to be felt by passengers. In order to palliate for this inconvenience in Montréal some beacons, placed in the track, impose the coasting mode more or less late, which gives a run time more or less long with regard to the most strenuous run. The possible slack times are 1, 3, 5 or 7 seconds.



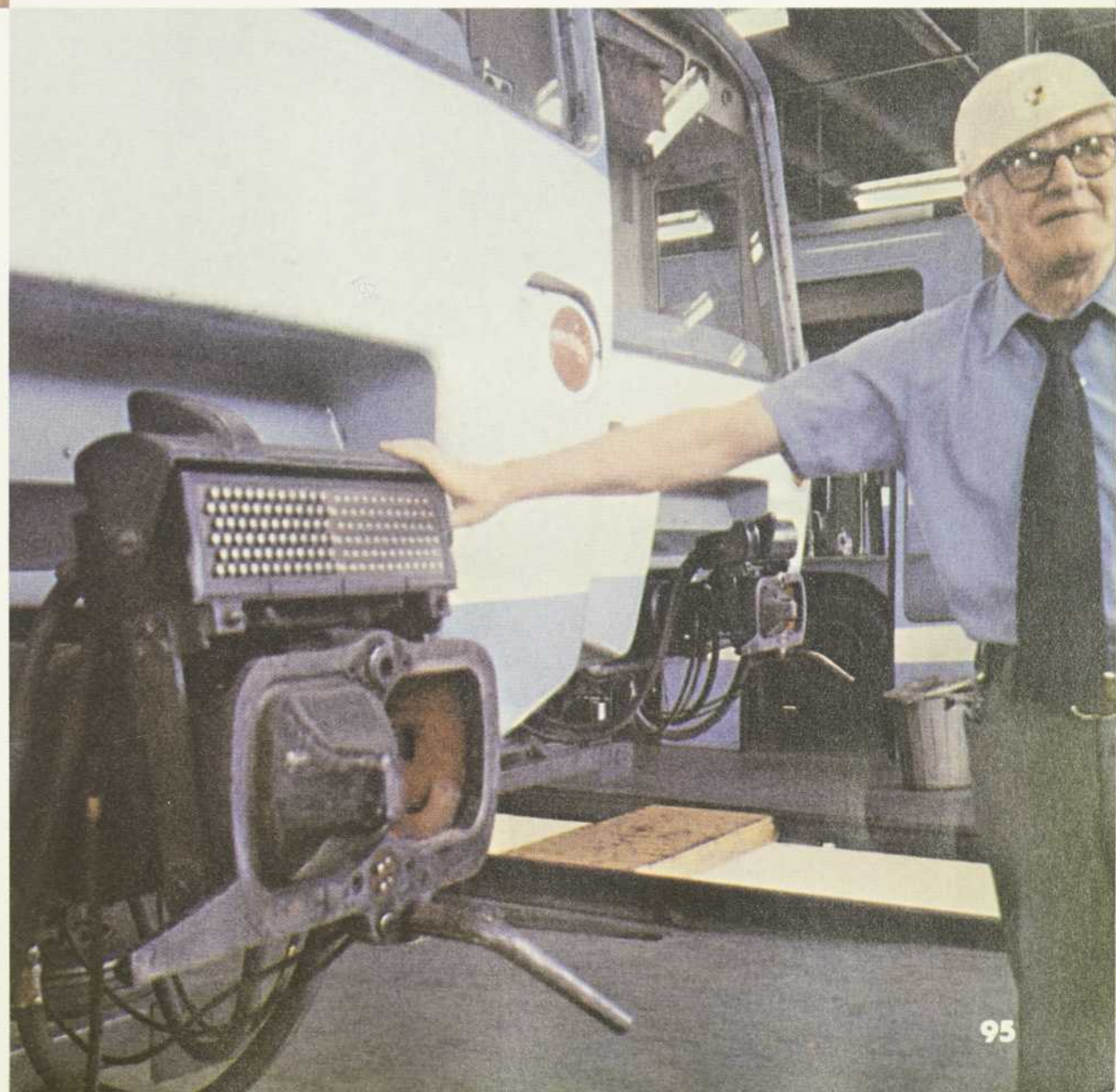
Circulation of Trains in Tail-track Areas and Termini

Experience has shown that accidents on Métro systems were relatively frequent in tail tracks, the termini, and in interlocking zones, as in these zones there often does not exist any control of trains. It is for this reason that a 10-mph (16-km/h) continuous speed-control will be installed in new termini where trains enter to park or go to shops or leave when unparking. A train will not, moreover, approach a parked train at a speed of over 3 mph (5 km/h) which speed limit will be imposed in an approach zone.

Track-switching Manoeuvres

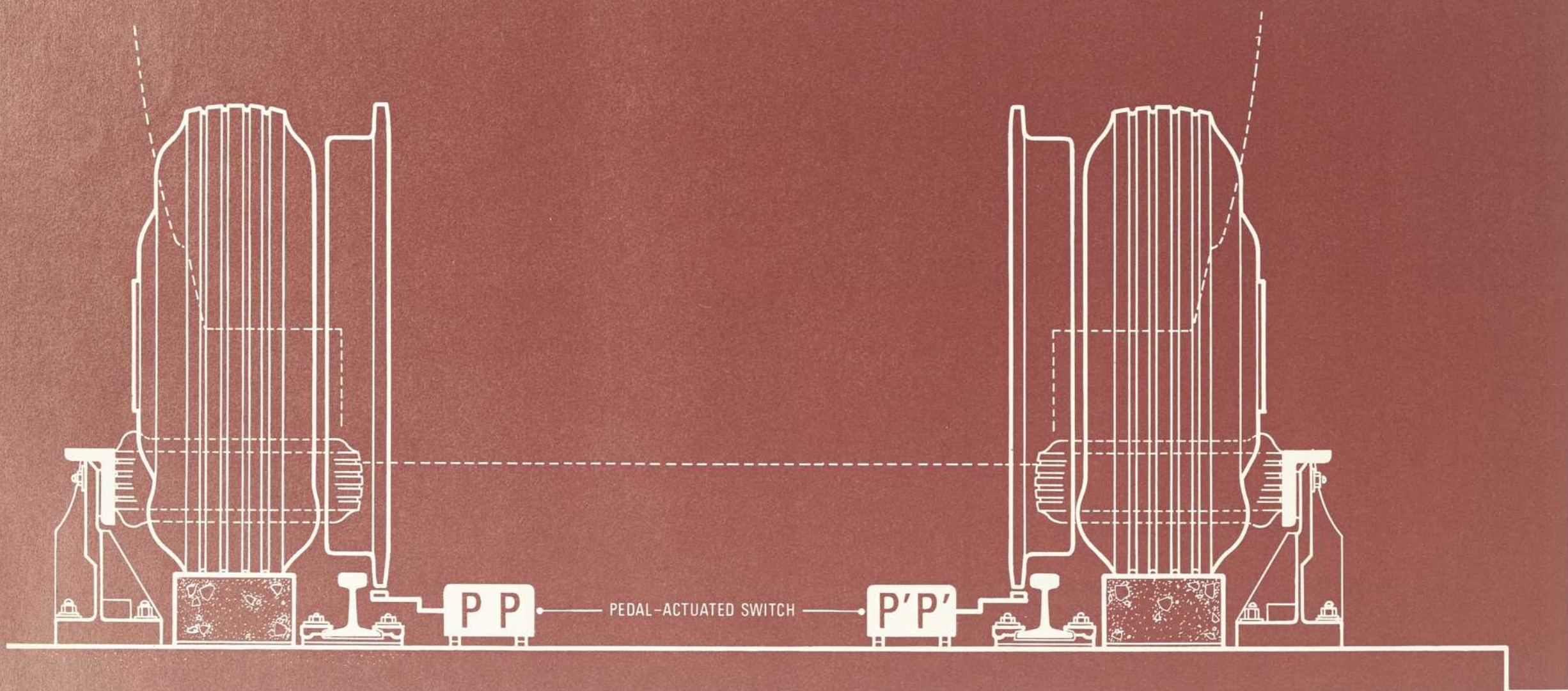
The trains in terminus must negotiate a reversing manoeuvre to pass from the arrival track to the departure track. This manoeuvre is vexing to the operator, as, in that train attended by a solitary trainman, it is necessary that he pass from the head cab to the tail cab. Moreover, if the line is long the operator needs a few minutes of relaxation while in terminus. It is furthermore advantageous that this respite take place on the arrival platform or the departure platform of the termini, where the requisite facilities are located.

It is for these reasons that Montréal has devised automatic turnback facilities for the new equipment as well as for the old.



X

FLATNESS DETECTORS FOR LOAD-BEARING TIRES



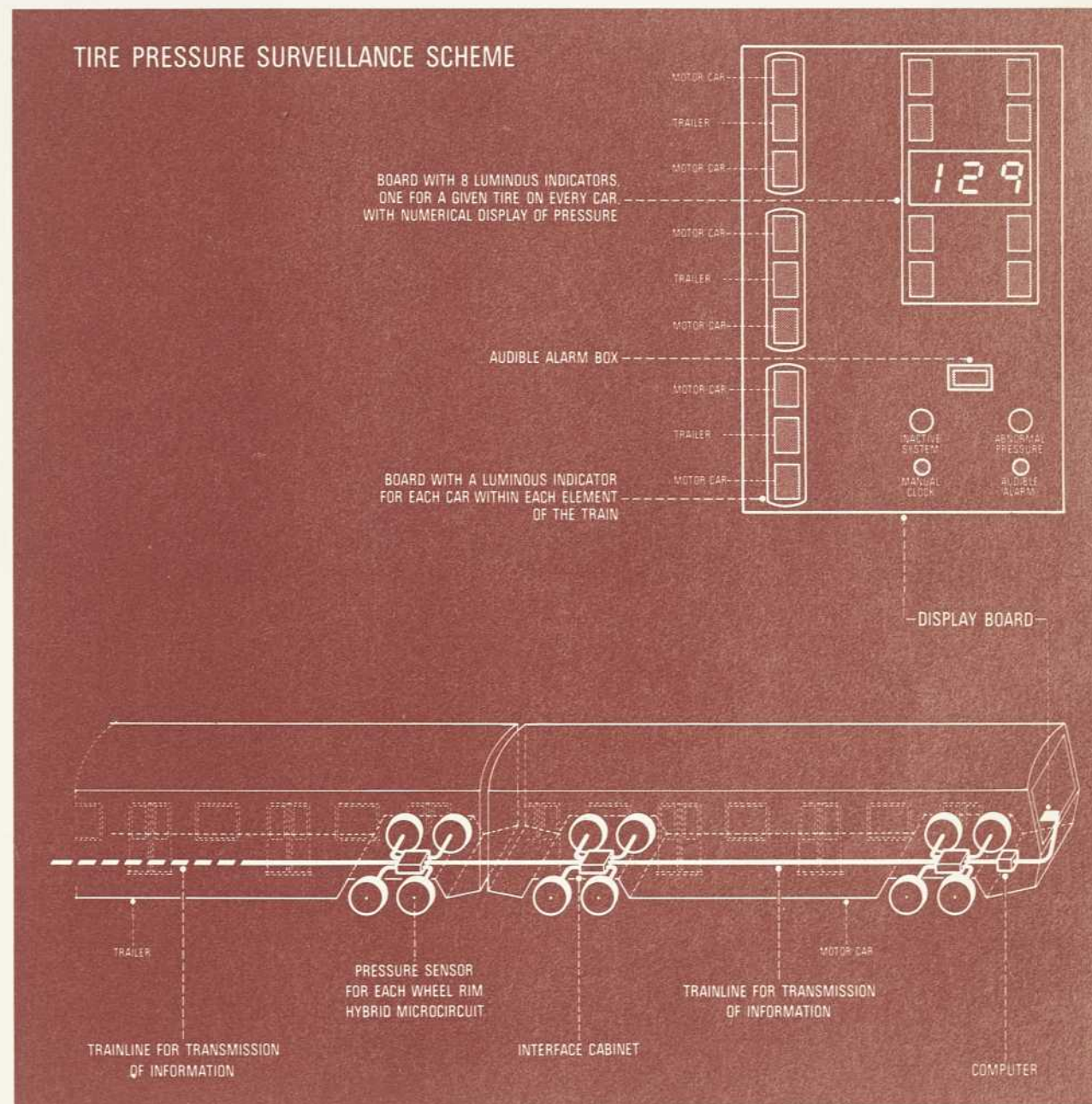
Coupling and Uncoupling of Trains

The coupling and uncoupling of trains had been well provided for on the old rolling-stock, but the facilities for effecting this work in the rear-terminal garages were non-existent.

Given the merits of uncoupling, permitting as it does, to tailor the length of the train to the load carried and thus to service the off-peak hours with a reasonable interval without rolling too much empty stock, it has been designated that the rear-terminals be equipped to readily accommodate all forms of uncoupling manoeuvres.

Test Devices for Surveillance of the Load-bearing Tires

Part of the safety of the rubber-tired Métro is based on rigorous on-line supervision of tire integrity. A few accidents befalling on line have taught us that it did not suffice that load-bearing tire punctures be detected but also that partial deflation should be discerned. A 30-to-40% deflation under load causes much tire fatigue and overheating, which brings about its progressive destruction. The normal temperature of a load-bearing tire on line is from 55 to 60° Celsius. If the temperature attains 70° Celsius, it is because something is abnormal and destruction of the tire commences. It is thus essential that on-line surveillance of the support-tire inflation-status be carried out. Some test facilities in front-terminal tracks have existed since the outset; they were completed in April 1974. Whenever the tire is lightly deflated, the safety wheel, integral with the tire wheel, dips slightly and may touch a track pedal which gives an electrical signal. This indication pedal has been installed in termini tail-tracks on the reversing track in a spot where the trains circulate empty; thus, all the trains are supervised at each half round trip on the condition that they execute the turnback manoeuvre in the rear-terminal. A front-terminal verification of the empty train has been envisaged. Such would be needful especially at the present time, when extensions are underway, or



at any time later for terminus alterations when all trains apply systematically the front-terminal manoeuvre.

Previous to launching trains on line in the morning, they have been parked all night in the garages with the possibility that a valve might have developed a slight leak overnight. The ensuing deflation merits early discovery. For this reason, all future termini will feature a supervision pedal on the garage exit tracks.

The test-device setting must not be too sensitive, as it could give rise to nuisance alarms. Experience has shown that once the proper adjustment has been achieved the device is effective.

The ideal would be to have continuous indication of the pressure from each tire; the BTM has elaborated a continuous tire-pressure surveillance scheme which is in the final study phase. The manufacture of a prototype is underway (in December 1975) and will soon be mounted on a

3-car element; thus the 24 load-bearing tires will be supervised. The results will permit judging whether wholesale implementation is opportune.

Other devices are equally under study. One compares the load carried by each of the two support tires of the same axle.

Another tire fault is possible; it is the blowout instigated by a foreign object. This failure besets the Mexico Métro as the track there is laid on ties and ballast. As a result of fortuitous circumstances, ballast stones can land on the tire runway. So as to be warned immediately of the blowout, it is foreseen in Montréal, by the time the extensions come into service, that on each track and in each station a supervisory pedal for the detection of a leaky tire be installed. In the event of detection, the DSO (departure on order signal) flashes and the signal "tire" appears, indicating what side, the right-hand or the left-hand row of tires, is involved.

COMMUNICATIONS

Direct Lines and Automatic Lines

When the network opened, the essential telephone needs via direct lines, of the private system and of the trainphone, were satisfied ; however, to improve the system, numerous links were added to the private network :

- at each emergency power-cutout in the tunnel ;
- in many technical locales of the stations ;
- at each emergency switch in the tunnel ;
- at the location of the disconnects in the tunnel.

The present electromechanical telephone exchange, with a maximum capacity of 800 lines, is insufficient ; its replacement is underway with a semi-electronic exchange of 1200 lines, capable of being converted eventually to 2400 lines.

By and large, telephone allocations will henceforth be as follows for each location :

	Inter-station	Station	Terminus	Rear Garages
Direct Lines	—	1	2	1 to 2
Automatic Lines	1	3	5	5 to 6

Which is substantially the same quantity as in the initial network but often with telephones on the same line employing different numbers.

Trainphone

The trainphone, which allows central control to talk with trainmen, was one of the first to be installed on a Métro ; it has been the target of certain criticisms :

- there exists dead spots at the foot of rectifier



TRAINPHONE CONTROL PLATE MODULE

stations preventing communication ;

- whenever the regulator is already in communication with a trainman, a second trainman has difficulty in being heard ;
- in case of an important and lasting short circuit from the positive collector of a motor car, the ensuing deterioration in communications prevents establishment of the train-to-PCC link ;
- if the operator leaves his train he is no longer in contact with the regulator.

For these reasons, it has been decided to replace the trainphone system by one which is independent of track.

The new trainphone network comprises a system for each Métro line and constitutes :

- a certain number of fixed bases comprising a transmitter and receiver, linked to radiating cable sections suspended in the middle of the tunnel vault ; in station the cable passes under the platform ;
- fixed transceivers with trainborne controls ;
- mobile transceivers for operators and foremen.

The regulator's loudspeaker diffuses in parallel all calls transmitted from any non-connected sector whatever. It is always in service, even during transmission from central control.

The operator of a train running in a sector can at all times take his microphone, depress the push-to-talk button, and speak.

The regulator receives the trainman's call in his loudspeaker and locates the sector from where the call comes by means of an identification light. He depresses the connection button of this sector and communication is established.

If the regulator was already in communication with another sector the call comes to him in the same manner. He can then at his pleasure either listen-in as a third party, or change correspondent, or send a beep signal on the first sector in order to invite the trainmen of this sector to listen.

Whenever the regulator wants to speak to the passengers of a train the operator of that train depresses the "PCC-voyageur" button of his cab and the regulator does likewise from a button "call to passengers" on his desk. The riders then receive the PCC message directly on the train's loudspeakers.

The portable transceivers permit communication between the worker who carries this set and central control. The regulator has the facility of connecting the reception and transmission of 2 portable sets together so that conversation can be established purely between these two.

The trainphone comprises the transmission of a frequency whose presence as received by the train authorizes regenerative braking. Without that frequency the train can apply only friction braking. Thus in case of a power cut in a section, the new trains, featuring the regenerative mode, when penetrating therein do not risk energizing the section upon the application of brakes.

Recording of Conversations

A multi-track tape recorder installed at the Providence Centre records conversations received by train control (PCC), power control (PCM) and communications (CCM).

The channel assignments are as follows :

Trainphone	PCC	7 channels
Dial telephones	PCC	7
	PCM	2
	CCM	2
	Supervisors	2
Direct-line telephone	PCC	7
	PCM	2
	CCM	2
P-A System		2
Recording of time		1
Spares		6
		Total : 40

The PCC and PCM operations are also recorded.

Station P-A System

In comparison with the initial network, the modifications brought to bear on the system have consisted in equipping the mezzanines and the station accesses with loudspeakers. Additionally, a supervision of the diffusion quality of messages is sent to Providence. At their convenience, the cashiers can eliminate the music, but the verbal messages remain notwithstanding.

CENTRAL CONTROL

The central control of train movements is totally changed and developed on both the initial network and the extensions. Nevertheless its philosophy has remained the same :

- transmit certain safety functions by direct wire ;
- reap all the necessary information, but always have the liberty of exchange solutions regarding its use, in case of degradation in the equipment.

Control and Indication of Traction Power

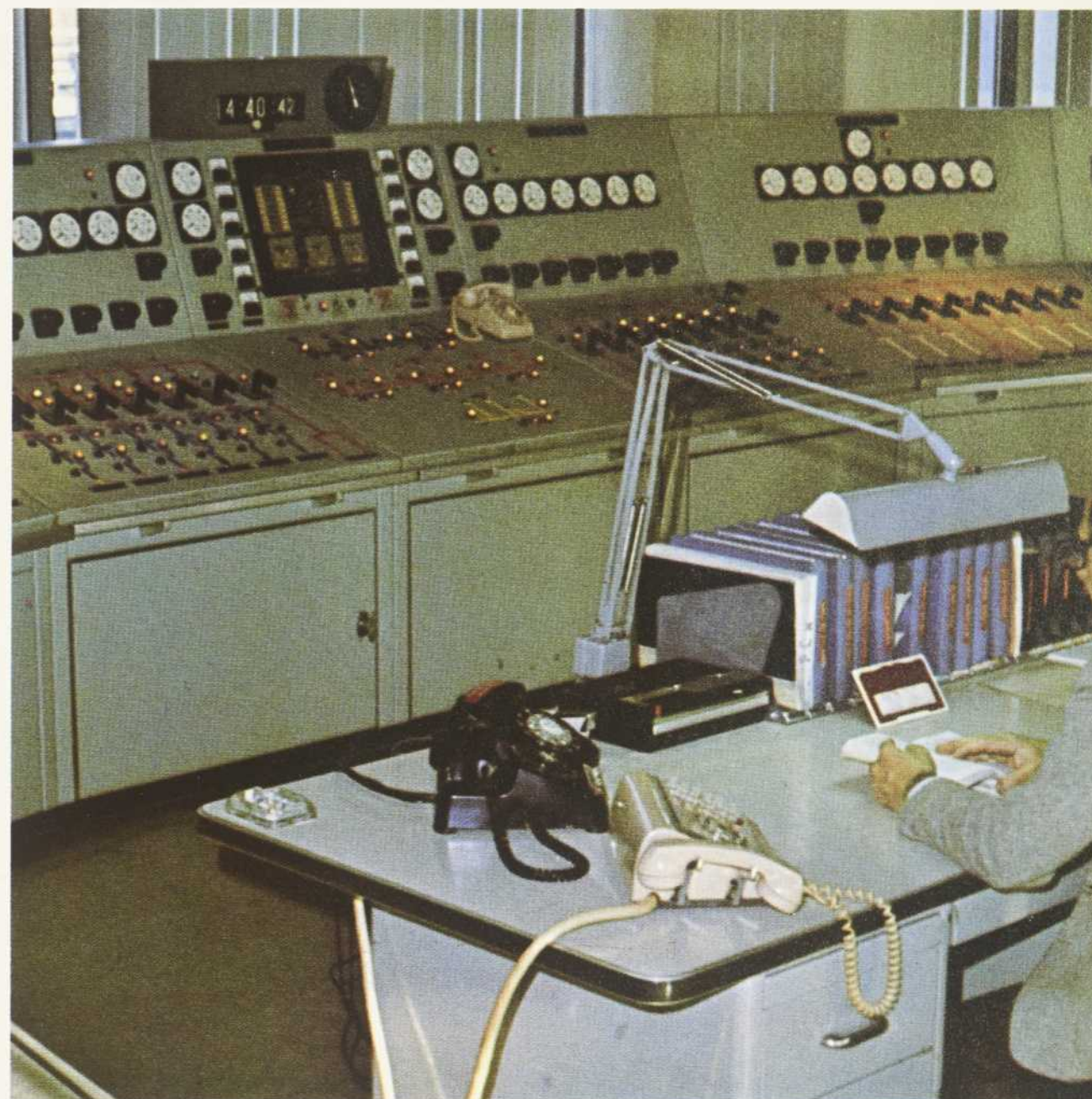
The initial network was not extensive, which permitted electrical power distribution to be concentrated in a solitary point, Providence. The high-voltage breakers were in the same building as the power dispatcher ; power cut and its reinstatement were made by direct wire.

Network growth has brought about the creation of distribution substations — the district substations. These substations are established along the same principles as the Providence sub :

- two feeds emanating from two different Hydro-Quebec sources ;
- rectifier stations spread out along the Métro line, with staggered feeds alternatively coming from one source then the other.

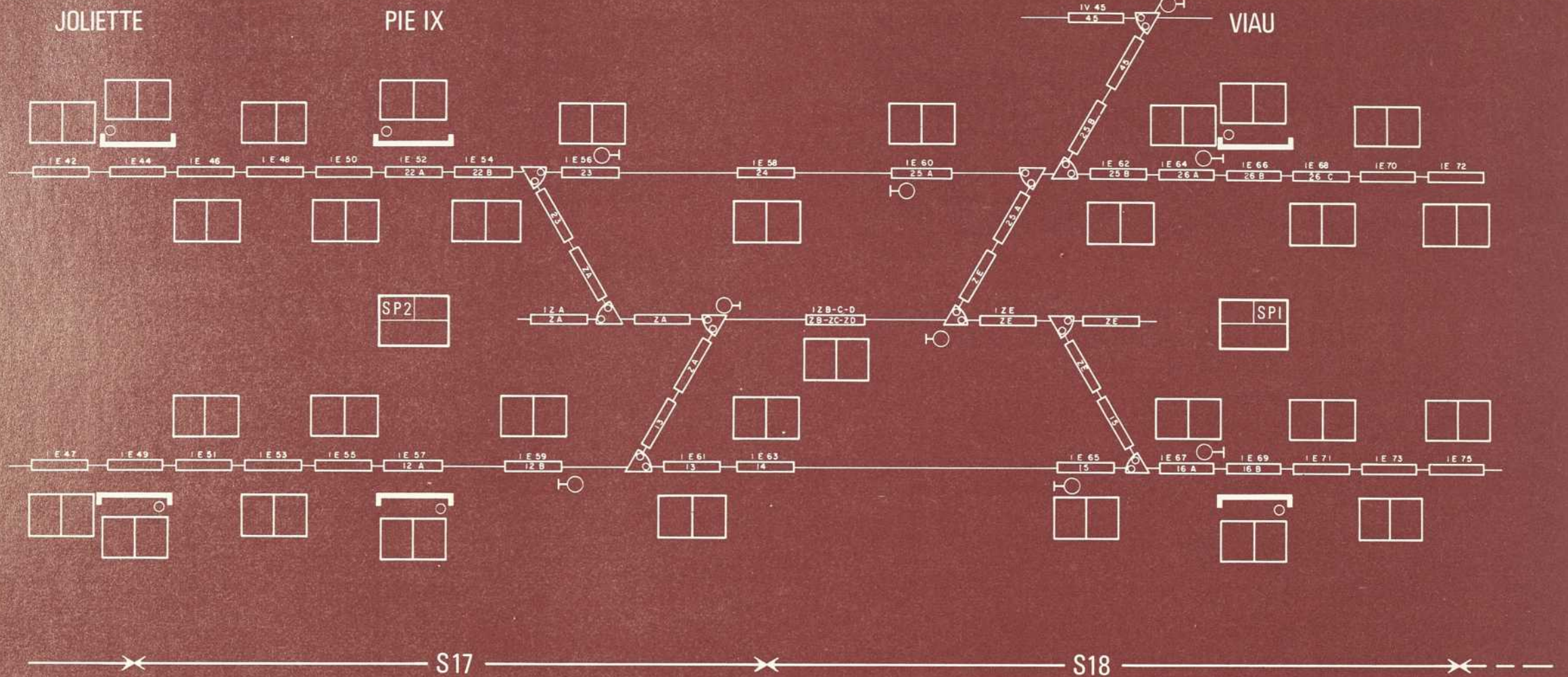
This time the line is divided into traction zones and sections.

The zones correspond to line sectors which can be isolated for the purpose of carrying on emergency services. (Their extent and primary function are directly related to transportation, rather than power — they are a transportation entity). Emergency-zonal-power-cut facilities are available to the regulator ; to this end, the regulator in depressing a button cuts a holding circuit which otherwise, under normal conditions, sus-

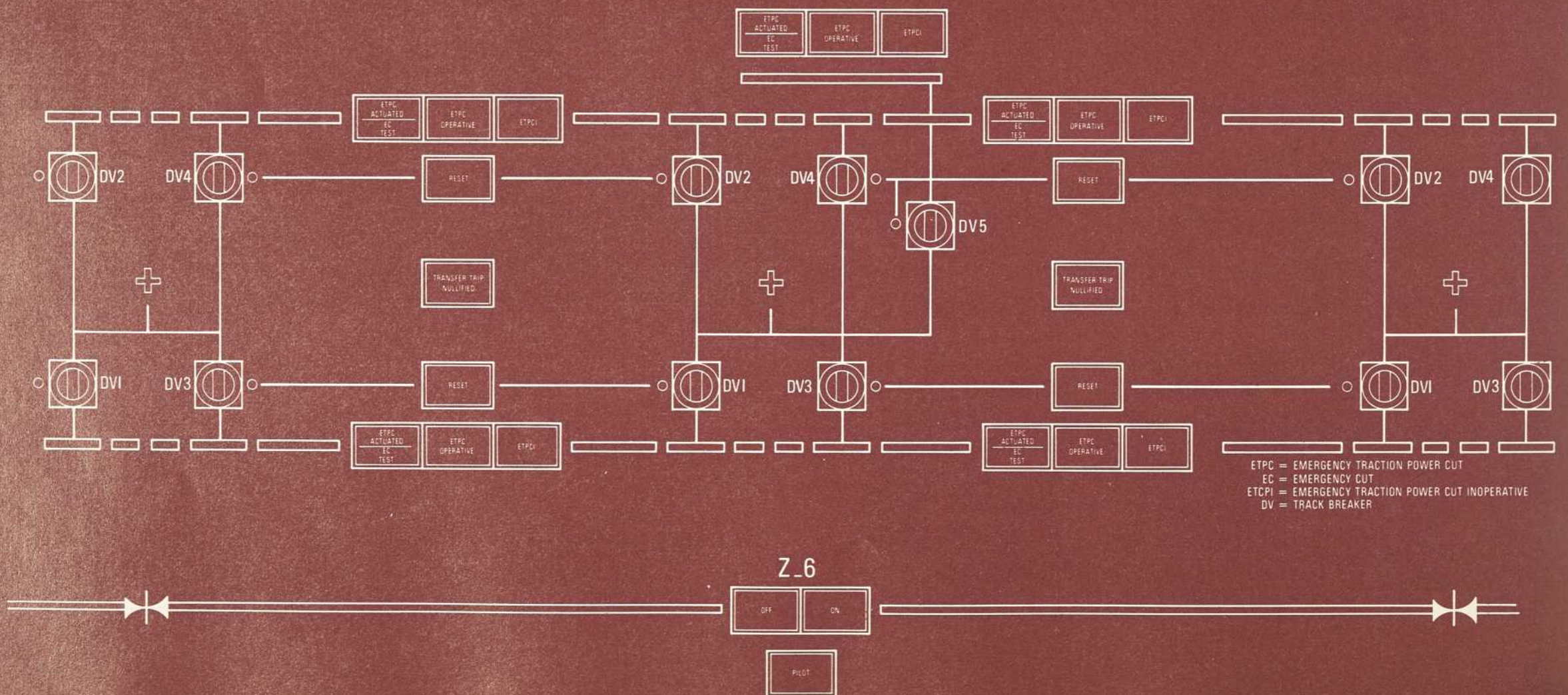


PROVIDENCE POWER CONTROL

ILLUMINATED TRACK DISPLAY AND CONTROL BOARD
AT CENTRAL CONTROL (PCC)
NEGATIVE-RAIL STATUS



POSITIVE-RAIL STATUS



tained both (a) the high-voltage breakers feeding the zone and (b) the track breakers, at the zone's extremities, which may otherwise energize the involved zone from others embracing it.

The holding circuit, in reality, energizes safety relays which control the high-tension breakers. Any defect makes the relay dropout. In case the holding-circuit loop is placed out of service for maintenance reasons, the PCM power operator can, by remote control, reset the safety relay permitting control of the breaker. The PCM can at any time nullify this reset, which action triggers a power cut.

The HT breakers, and the track breakers delineating the zone, are remotely controlled.

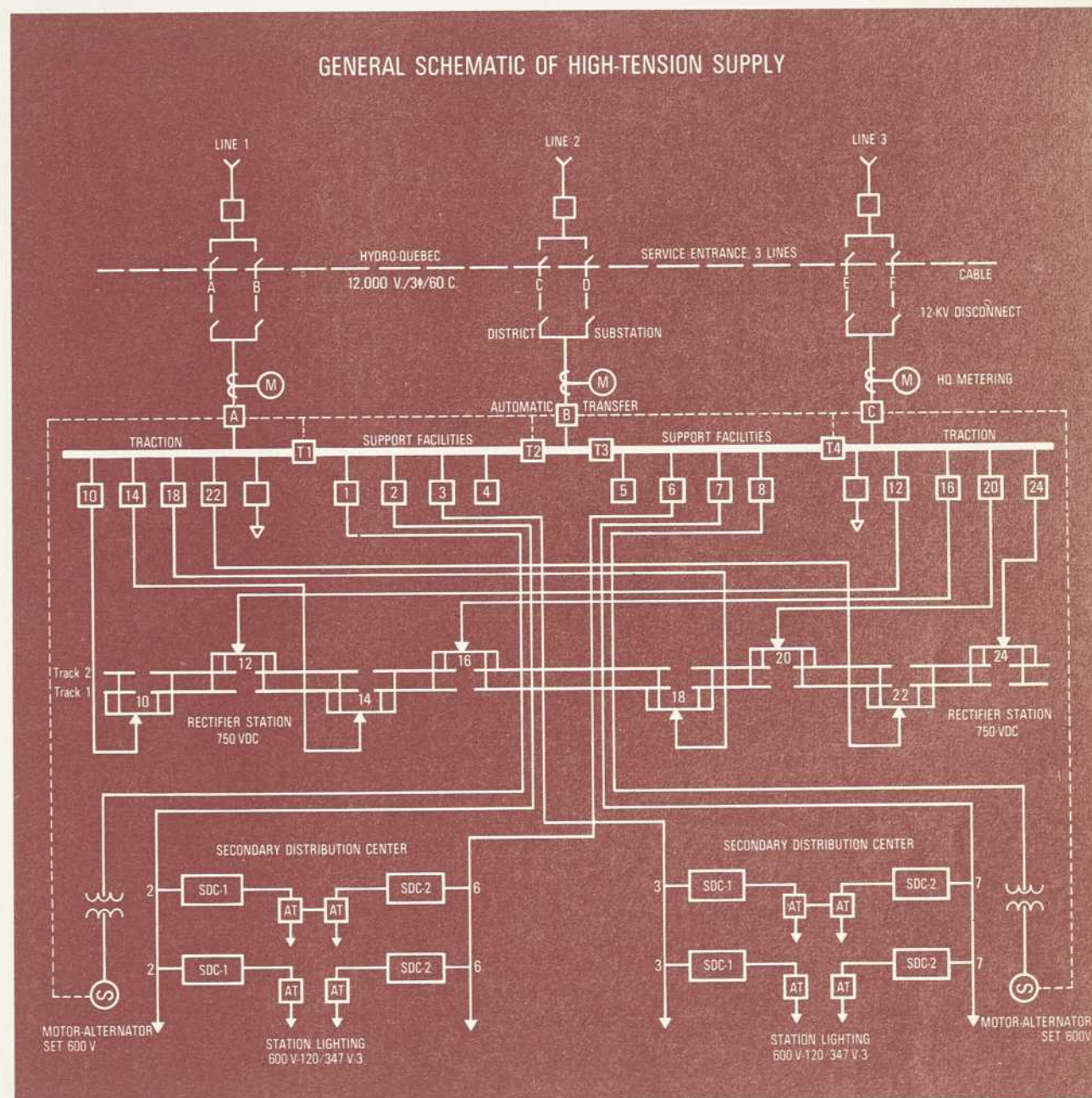
The sections are the shortest lengths of track. (As opposed to the zones, their delineation is a function primarily of power rather than of trains — they are a power entity, especially from the standpoint of protection). They can be deprived of power in three basic ways :

- manual-electric : (a) by the emergency-power cutouts in the tunnel (b) by central control ;
- automatic : by the tripping of track breakers as a result of fault detection (overcurrent or excessive current rate-of-rise) ;
- manual : by depressing a trip button on the breaker itself, which acts directly, in a mechanical way, on the trip mechanism. This operation would be unusual.

The track breakers are remotely controlled.

This decomposition in zones and sections was made :

- so that the circuit of the emergency-cutout zone at the disposition of the regulator be the simplest possible and as a consequence the most reliable ;
- so that the section deenergized as a result of an incident be the shortest possible, which



has the advantage that generally only one train might stall in tunnel — the others being maintained with power which allows them to proceed to the succeeding station.

The PCC regulator has the responsibility for the final link in supply of power to the line ; thus he controls the track breakers. Nevertheless when a zone has been killed as a result of an equipment fault, power can be restored only by power control (PCM) with authorization from train control (PCC). The addition of track breakers has but slightly modified the basic supply principles.

Under exceptional circumstances, the regulator could, by acting on the track breakers, feed only one track of a section. As mentioned above, a similar arrangement is under study for the existing network.

Route Control

In passing from the initial network to the extensions, route control is not fundamentally changed ; however, the program machines are being replaced by computers. In the event of defect on the computers, the operator must transfer route control to the local switch cabins.

The parking stalls in the new termini are framed by track circuits ; it follows that the parking and unparking of trains will be supervised by the computer and by the regulator in a much more precise manner.

When a route has been lined-up and all the approach conditions are good, the train-control device injects a speed code into the track circuit lodging the train so that the latter can get under way.

Timetable Regulation

On-line traffic regulation comes into play for all passenger trains under automatic control. Inductors have been introduced into the track to control more or less late the power cut to the traction motors.

As a function of the actual time of departure in terminus and allowing for the imposed run schedule, the computer calculates the theoretical departure time, being characterized by the first set of track joints engaged upon leaving the station.

At each station, the computer compares the actual joint-engagement time with the theoretical time.

Whenever the real time of real departure is late or early by a certain value (for example 5 seconds) the computer orders if late a rapid pace with a coast period of one second only — if early, a slow pace with a coast period of 5 or 7 seconds.

Whenever the lateness is greater, for example in excess of 10 seconds, there is effectuated on the train a reduction in run time which will involve a certain number of interstation courses. This number is determined as a function of the interval utilized at the moment of disruption. In effect, the larger this headway, the more the admissible lateness for an isolated train is large.

Headway Regulation

Headway regulation assures that the interval between trains at a given station does not vary in a discontinuous fashion whenever a considerable lateness besets the line. With this aim in mind, the regulation applies to the disrupting train and to a certain number of trains immediately ahead and behind the disrupting train. Precisely these trains are :

- the upstream trains, behind the dislocating train, which have to be delayed in station with the aim of avoiding their bunching up and consequent prolonged stops in tunnel ;
- the trains downstream from the disrupting train, which should be delayed in station in order to reduce time intervals between this front lot and the culprit train.

With the aim of maintaining the programmed headway between individual trains within that lot encompassing the culprit train, the computer according to appropriate algorithms determines :

- 1- if the dislocating train is able to reach the next terminus at the programmed time when subjected to the strenuous run mode in each interstation course between the station where it became late and the next terminus ;
- 2- the number and identification of the trains ahead and behind the disrupting train affected by the delay ;
- 3- the number and identification of the stations where there is a delay ;
- 4- a new time schedule for these trains with the object of returning the timetable discrepancy to zero at the end of a given time.

The computer performs this action on the trains upstream and downstream from the dislocating train by means of the "departure on order" DSO signals of the stations. The DSO restriction automatically ends when the new station-departure schedule is in force.

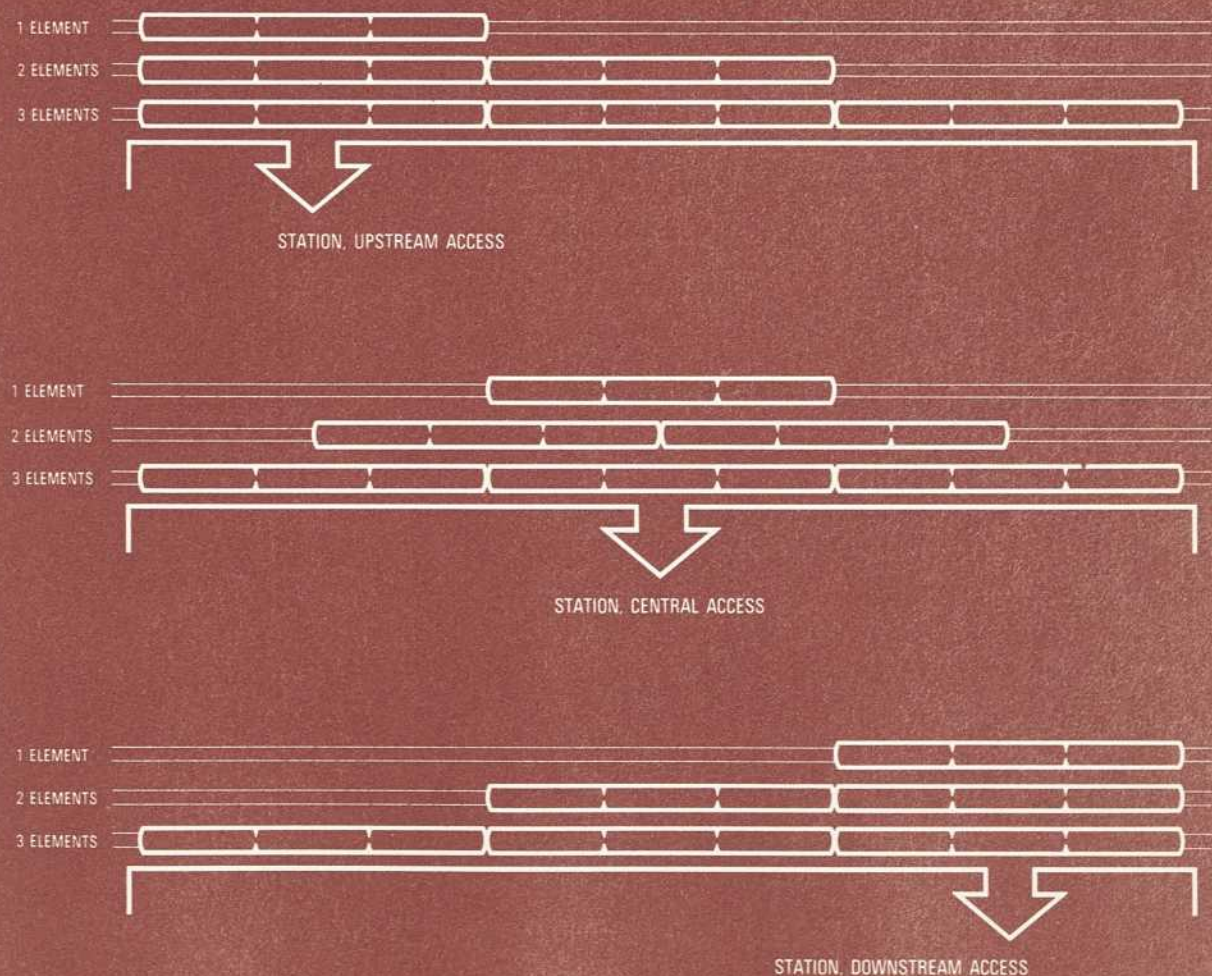
Station-stop Positions

When a train in terminus presents itself at the departure platform, an assessment of its consist is performed by an axle counter whose summation is heeded by the computer.

The computer then activates in the succeeding station the programmed-stop beacons triggering stoppage of the train for the consist presented. As of the previous train's departure, it lights the stop-position indicators to display the stop position of the next train for the benefit of passengers lining up on the platform.



STOP POINT OF TRAINS, ACCORDING TO THEIR LENGTHS AND TO THE LOCATION OF ACCESSES OPENING ONTO THE PLATFORM



Alarms

The central control of electrical power distribution, the central control of train traffic, the central control of support facilities altogether comprise a considerable number of equipments which can occasion faults. In case of a defect, the alarm is transmitted to the PCC or the PCM according to the department involved. A buzzer or a horn resounds to alert the interested party who can read the inscription of this alarm on both the cathode ray screen indicator and the te-

leprinter. The information given consists of time, place and nature of alarm. All this information is identified and memorized by the involved computer.

Certain alarms called emergency, such as the pumping-station and fire (protection and detection) alarms, are implemented with hard-wire links so as to increase safety — as opposed to coded supervisory systems, not quite as reliable, where numerous functions are transmitted over a single pair of wires.

ROLLING STOCK

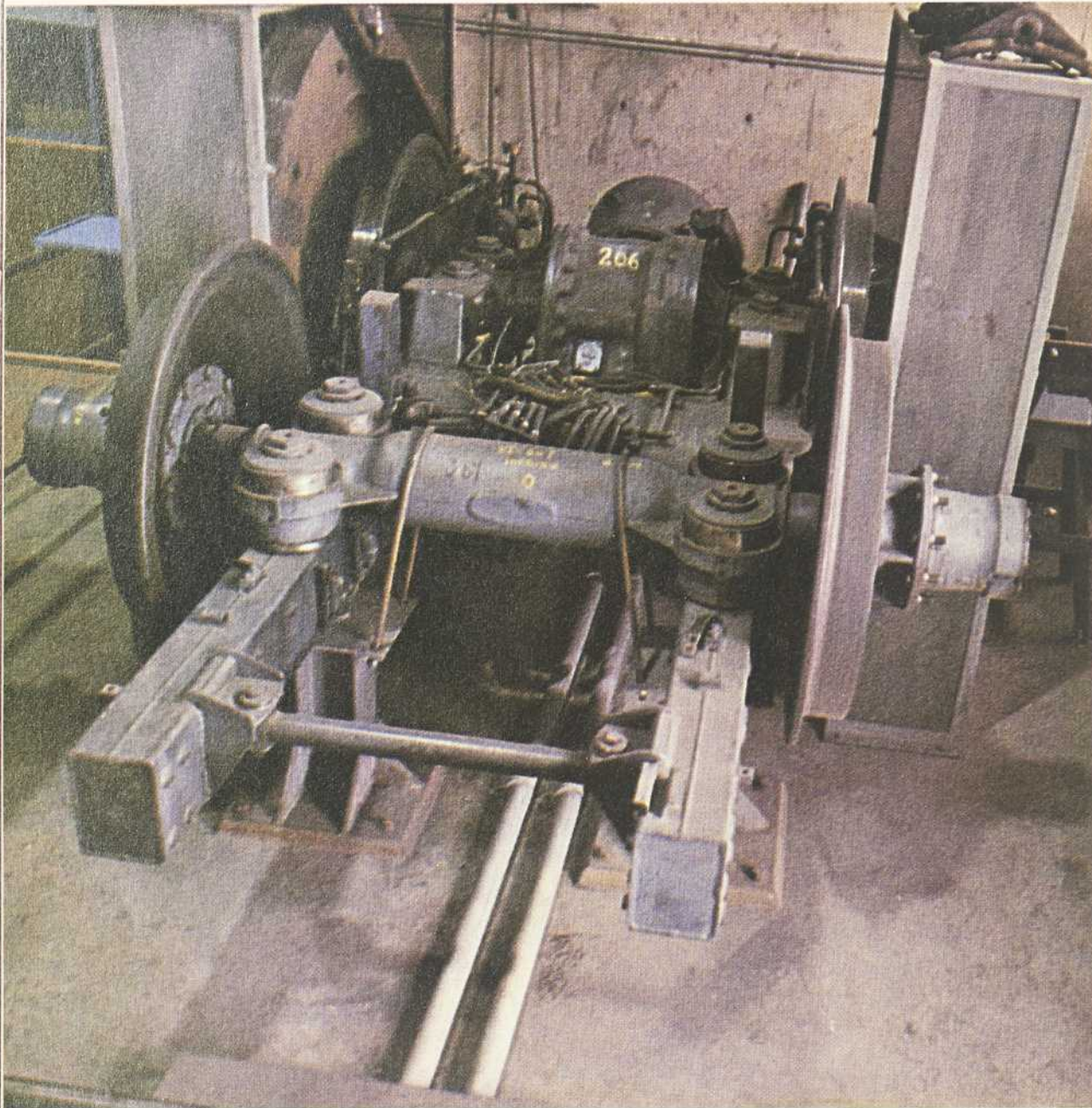
Traction

In its conception and realization, the new stock profits from the experience acquired in the initial network ; it moreover profits from the spectacular progress achieved in electronics. With the invention of thyristors, it has become possible to control traction-motor starting without using a

controller and starting resistors. Said development accrues first, in the savings of electrical energy. This equipment permits also regenerative braking, the second source of economy. Supplementary benefit — one obtains less tunnel heating, which, in summer, improves rider comfort, all the while diminishing ventilation expenses.

MR-73 AND MR-63 CARS





BRAKE-TEST BENCH

The traction circuits were modified as follows :

- high-speed fuses with controlled dissipation of heat have equipped the old stock since 1970. On the new stock, equivalent fuses are installed in immediate proximity to the positive collectors ;
- a mechanical protection of the cables passing under the present bogies has been implemented. On the new stock, these cables will pass inside the bogie chassis ;
- the braided shunts, by-passing the 2 mechanical articulations of the 3 entities composing the entire car and having different degrees of suspension, have been reinforced and doubled in capacity. This measure negatives the entire car body more effectively.

In manual drive the "deadman" device continues as a stipulation, for triggering emergency braking in case the motorman should become indisposed.

Braking

The present stock is fitted with electropneumatic brakes having shoes of wood composition impregnated with vegetable oil.

This shoe is excellent whenever it is utilized under the normal- or accelerated-running mode because in the two instances the train speed at the start of braking is nearly always less than 40 mph. Under minimum runtime, that is to say, when braking is exercised immediately after power cut to the traction motors, the shoes are applied to the safety wheel at high speed and many successive brakings, at high speed, run the risk of deteriorating the shoes by the formation of a thin coating of carbon on its wooden rubbing surface which then makes braking less effective. The train control regimen stipulated for operation of the new and old stock will avoid in automatic train-control the use of the demanding minimum-run-time mode.

With the aim of improving the braking performance, research and tests have relentlessly been followed since the inauguration of the Métro in 1966. Numerous composition-shoes have been tried. The inconveniences met with these shoes are the noise at the moment of braking and the more or less rapid deterioration of the safety wheels. Investigations are pursued. We already are assured of getting better wear resistance from the steel safety wheel, which will permit using certain composition-shoes.

In order to maintain good braking and to avoid a too frequent changeout of shoes, the present and future equipment will benefit from electrical braking in modifying the existing trains to add dynamic braking and in equipping the new cars with regenerative braking thanks to the choppers whose advantages in traction have been mentioned.

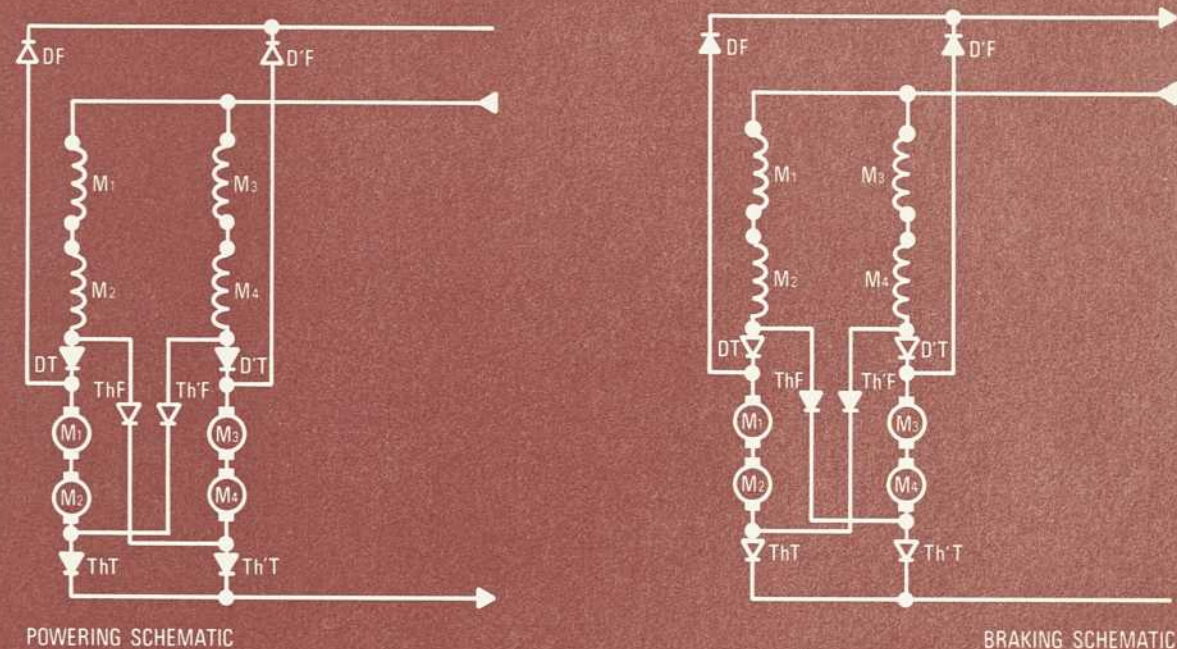
Positive and Negative Collectors

Since its placement in service, the positive collector has been surrounded by an insulated box in order to avoid water splashes from coming into contact with the collector's support-insulators. In the new stock, the fuse is incorporated in the insulating box which is itself improved.

The cast-iron soles (expendable sliding contact) of the negative shoes were very noisy. They wore track devices and were the source of excessive quantities of metallic dust in the tunnel. Their replacement with carbon collectors was little by little undertaken, which action has revealed itself as being very favorable from the standpoint of noise. As a supplementary benefit the life of the new soles is much greater than that of the former metallic ones. The wear to track devices has been reduced in a spectacular way.

SOLID-STATE SWITCHING CIRCUIT FOR POWERING AND BRAKING

(DARKENED DEVICES ARE IN THE CONDUCTIVE STATE)



Emergency Brakes

The braking established on the rolling stock is called fail-safe ; the brakes of each vehicle are served by the presence of current in a circuit. The emergency brakes for the use of passengers in the cars, as in coaches of most other railroads, cut the circuit when a rider pulls their actuator to trigger braking. The train may stop anywhere, in particular, in the tunnel between stations. The difficulty of rendering aid to a train, the impatience of riders — all these experiences show that it is preferable that the brake be applicable only on station departures — in the predicament when a rider gets caught in a train door. After door closure it is preferable that the action of pulling the emergency-brake trip merely warn the driver that something is abnormal in one of the coaches and that the train continue its uninterrupted run to the succeeding station. Thus if the train must be evacuated the operation will be facilitated, whereas, in the tunnel, such would be delicate and long. All the trains, old and new, will be equipped in this way.

On the other hand, if anything abnormal takes place in a car, it is well to avail a rider with the possibility of talking to the motorman. This device, specified for the new vehicles, will carry to the 1963-model stock if its use by the passengers proves worthwhile.

Tires

Trains rolling on tires are employed in Paris on 4 lines of their network whose separate inaugurations took place in 1957, 1963, 1969 and 1974. The 3 lines in Mexico were placed into service in 1970 and 1974 ; the vehicle stock is 537 ; 492 million passengers have been transported. In Montréal 3 lines, in operation since 1966-1967, have allowed more than a billion passengers to be transported.

The results are satisfactory on these 3 networks. The advantage of a rubber-tired Métro relative to the steel-wheeled Métro can be summarized as follows :

- the rubber stock is silent and its motion transmits to the civil works but a feeble level of vibrations which is not felt by the neighboring buildings ;
- No sound-proofing material is necessary in tunnels and in stations ;
- the track, as a result of the tire's presence, can have a very simple suspension system ; in curves and through track-appliances the wear is very slight ;
- the adhesion of the tires in tunnel permits a high performance ;
- this performance can be obtained with trailer cars included in the consist of rubber-tired trains ; and, even with these trailers, the rubber-tired trains can easily climb grades of 6.5%.

In the face of these advantages constraints do exist :

- a higher rolling resistance which justifies the use of tires but for lines with short interstation runs ;
- a load limited to about 5.5 tons per wheel ;
- a very strict surveillance of the state of the tires is necessary.

Radial tires presenting diverse advantages, one of which is a lower temperature rise when in use, have been undergoing tests since 1973. Experiments with these tires in Mexico and Montréal have permitted various improvements ; this tire is on the point of becoming operational.

Research by the manufacturing company in matters of Métro tires is constantly underway, and, for the manufacturing company, Mexico constitutes an important test bench, given that the average load carried by the support tires during the peak period and that the duration of this peak is well in excess of Montréal's.

Normal and Emergency Lighting

The lights in the present vehicles combined car lighting with that of advertising, lighted by trans-lucence. Unfortunately, the lens material, like that of the films, revealed itself in certain circumstances as a fire propagating agent. Also it has been decided to supplant this type of advertising in Métro cars, in the old as well as the new stock.

The acrylic lens of the 1963-model stock have been removed and replaced by metallic grills. Lenses of a polycarbonate material, which is autoextinguishable, are installed in the new stock.

All the tubes in the new stock are fed from the 72-volt battery charger in pairs via an inverter ballast which generates a frequency of over 20 000 Hertz such that it is inaudible ; 4 tubes, supplied directly by the battery, constitute emergency lighting.

Improvement of emergency lighting in the 1963-vintage cars is envisaged.

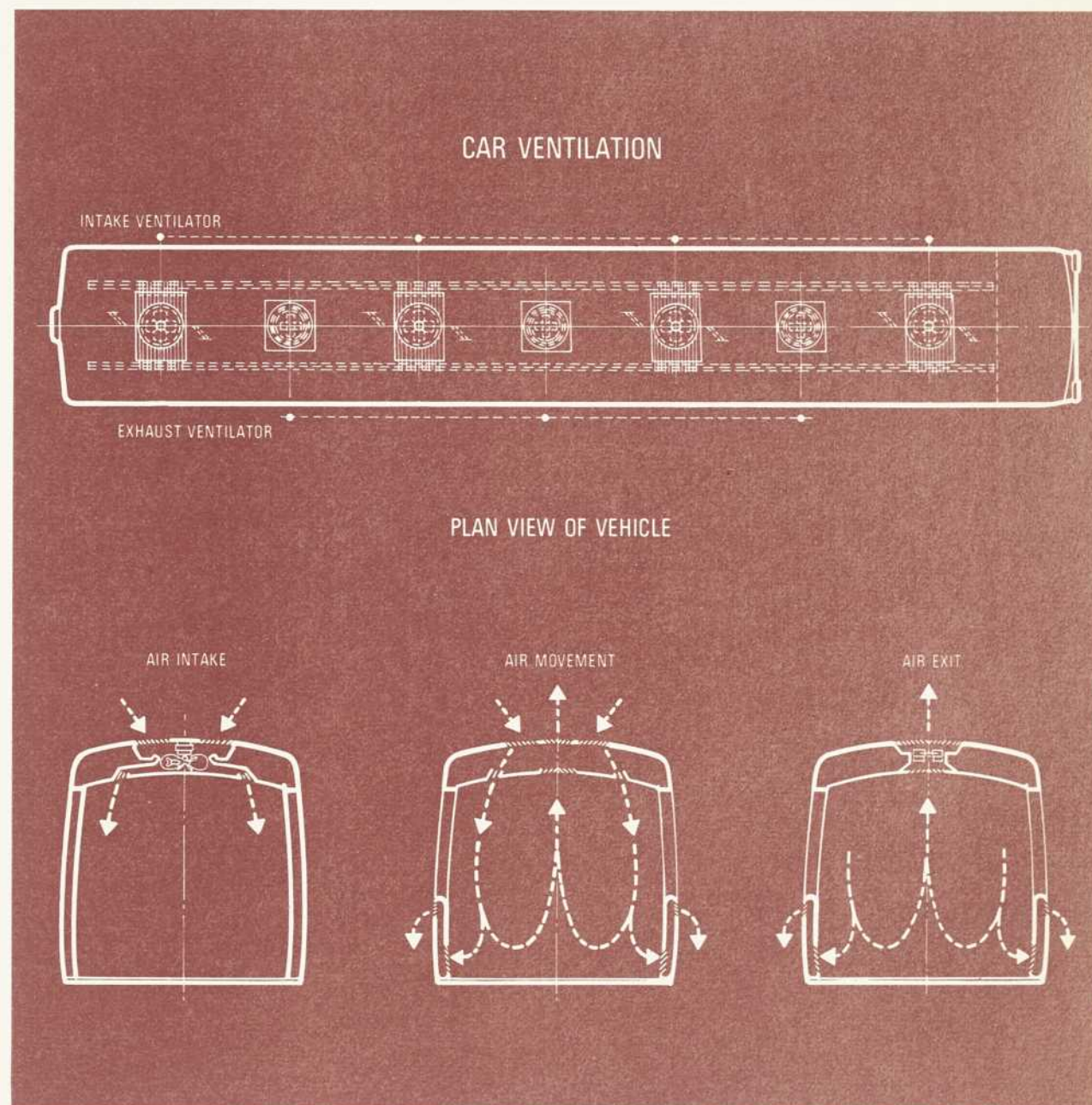
Ventilation of Cars

When the Métro was placed in service in 1966, the ventilation of coaches was largely insufficient.

This system was modified in 3 ways as of the first year of operations ; namely, by reinforcing ventilator power, by improving air outlets and by removing the pane in the rear-end door to have it replaced with grillwork.

In the drive cab, air conditioning was installed to augment operator comfort.

These modifications have brought about appreciable results in the ventilation of cars during summer ; nevertheless certain riders may complain of air currents and moreover the noises associated with locomotion enter readily into the vehicles.



The ventilation in the new rolling stock was redesigned to afford a more discreet and efficient air flow within the cars.

Air is introduced through the roof and pressured by four ventilators into a longitudinal plenum in the ceiling of the cars.

Air discharges from this plenum so as to give a washing effect of the ceiling and walls down to floor level. From here, part of the air leaves the car via openings in the wall ; the remainder is expelled by fans in the ceiling.

The exhaust openings are located near the wall base, between the single and double seats. The system is designed to give a maximum output of 12 000 cfm (5.7 m³/ sec).

The new-car ventilators for the whole train are controlled from the drive cab. Ventilators feature additional speeds of 2/3 and 1/3 of nominal. During traction power cuts a ventilator per car is able to stay in service, its feed coming from the 72-volt battery.

Door Operation

In certain stations of the new network, it is necessary to open the doors to the left, when facing the train's direction of movement. So as to avoid any false operation, door opening is made automatic by the installation of inductors (usually referred to as beacons) in the rail. In case the device becomes faulted and in order to improve safety, controls for the left and right doors are henceforth installed to the left and right in the drive cab ; thus an operator error is almost unthinkable.

The manual door-opening devices at the disposition of the operating staff have been ameliorated. On the outside, two devices for opening the lateral doors in each car have been relocated so that this opening be rendered possible from a station platform. On the inside the device is to be found within a compartment under a seat, which must be lifted for gaining access to this manual

opener. In order that no one should ignore this location, a notice is posted in all the vehicles ; thus in an extreme case the passengers are able to exit from a car by themselves.

Resistance of Car Materials to Fire

The various fires on the Montréal Métro rolling stock often broke out on a motored bogie — the outbreak setting fire to cable jackets and to the heating ducts. From these, the flames penetrated, through the floor, to the inside of the shell.

The vehicle maintenance department has undertaken a search for a fireproof material to protect the cables on the bogie and is carrying out tests. Presently all the useless heating ducts are being discarded and all openings capable of spreading the flames from the shell underside to the rider compartment are being blocked.

As of 1971 the MTB has undertaken studies on fireproof materials. The results are conclusive and will be applied to the new rolling stock. Thus the floor is an anti-fire floor. It is constituted of a sandwich, which, from the bottom upwards, is composed of :

- a bottom steel plate of 14 gauge (2 mm) over the bogies, and of a lesser thickness of 24 gauge (0.7 mm) for the portion extending outside the bogies,
- a corrugated 24-gauge (0.7 mm) steel plate of 19-mm-undulation amplitude. The cavities of this sandwich middle-layer are stuffed with a phenol-formaldehyde base called Esfen,
- the top layer is composed on an 18-gauge (1.3 mm) steel plate covered by an inorganic ceramic of quartz epoxy to constitute the actual floor walking surface.

This floor does not burn and does not give off any acrid smoke on contact with a flame. Tests performed according to standards ASTM E84 have borne this out.

MR-73 CAR



The particularly inflammable materials of the rolling stock are in the course of being suppressed and replaced by what is found to be the most fire resistant on the market. Accordingly :

- the acrylic lenses are replaced by polycarbonate lenses ;
- the seat cushions are replaced by a better fire resistant material.

For the new vehicles there are :

- for the walls and ceilings, polyester reinforced with fiberglass, stratified melamine ;
- for the seat framework, polyester reinforced with fiberglass ;
- for rubber, neoprene.

The cables for the rider compartment and the drive cab are insulated with Halar, a material which burns with difficulty. Cable passages through the floor are avoided as much as possible ; for each indispensable crossing, an appropriate anti-fire protection is installed.

Esthetics

The new rolling stock has been studied in detail in order to heed the functional aspect of the equipment without forgetting its esthetic value. Numerous full-size models have been realized in order to precisely determine the location of each appliance and the ease with which maintenance can be carried out. A colour harmony was sought so that riders find themselves in an agreeable fabric.

FIRE PREVENTION

In Tunnel

With the aim of combatting potential fires in the Métro, we find water outlets alternatively placed on each side of the tunnel at approximately 400-foot (120 m) intervals, in the initial Métro as well as the extensions.

Each water outlet comprises :

- a dry pipe of 2½ inches (6 cm) diameter which is terminated at ground level by a dry supply-terminal, with a double head for use by City firemen. These feed points, painted blue, are installed on the edge of the sidewalk.
- a two-inch (5 cm) diameter pipe connected permanently to a City water conduit. This pipe is fitted with a spray hose of 1½ inches (4 cm) diameter and of 100 feet (30 m) in length. Two other hoses of the same length are rolled up and available quite near the first.
- a cabinet enclosing the stop valve installed on the two-inch (5 cm) pipe. The door of this cabinet, which permits access to the valve and to the spray nozzle, cannot be opened without having previously actuated the power cutout.
- an advertisement of water outlet presence as pinpointed by a blue fluorescent tube and by a nameplate displaying the civic number corresponding to the location of the dry supply terminal, in order to serve as a guide-post to the city fire department. In case of an outbreak, a workman in the tunnel can thus advise the PCC the civic number whereto the firemen must proceed.
- a private-network telephone installed near each water outlet.

- plaques affixed at the water outlets and at approximately every 80 feet (24 m) on the two sidewalls to display the names and direction of the embracing stations.
- two pressurized-water extinguishers installed at each water outlet.

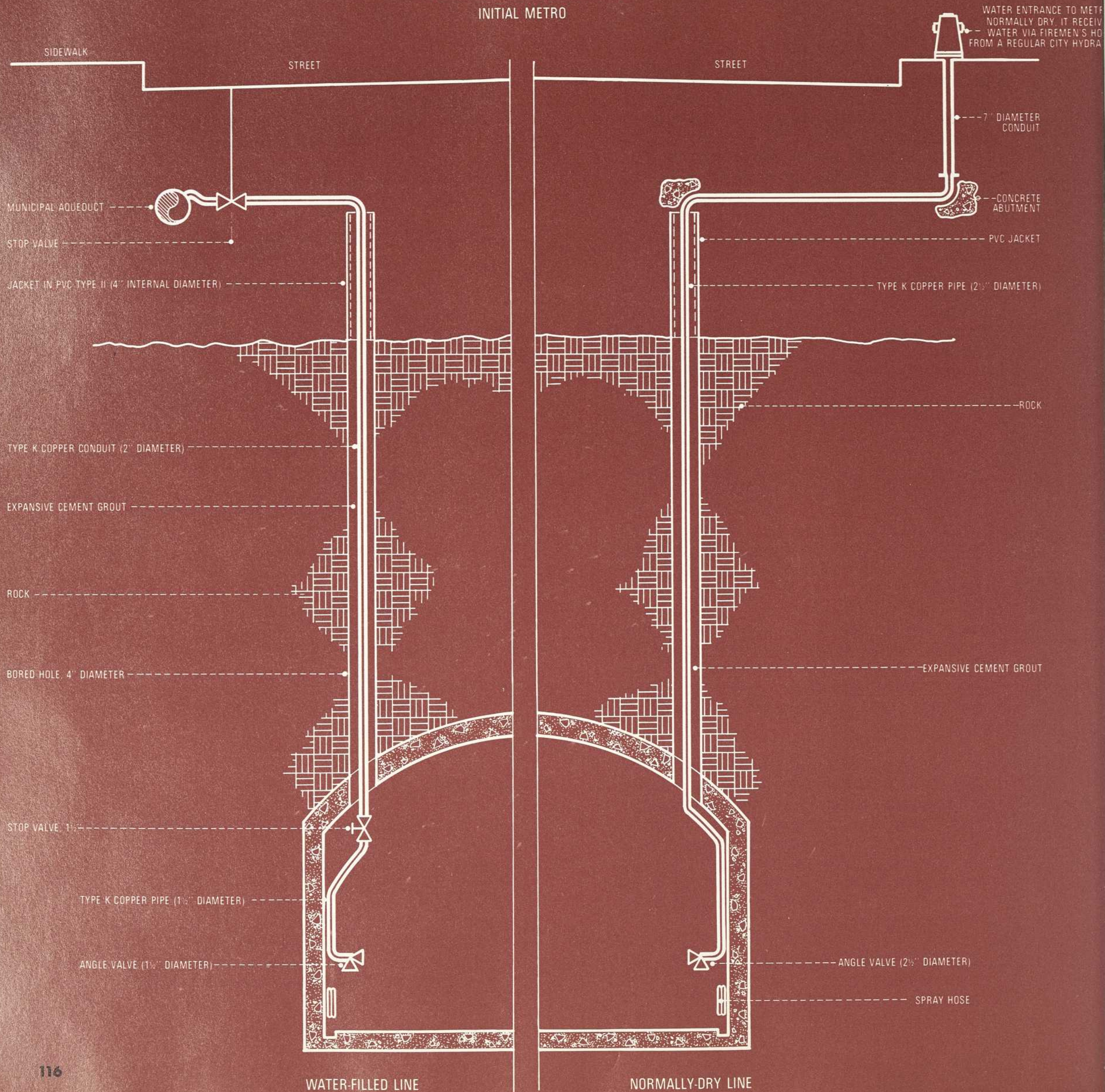
For the rear-terminals, there has been specified :

- an automatic sprinkler system with 3 heads at about every 10 feet (3 m) —a head at the centre of the vault with the other two near each sidewall.
- a series of detectors placed at the tunnel vault has the function of revealing the start of a fire and of performing the following operations :
 - a) transmit a fire signal to the PCM.
 - b) open the supply valves which will permit the pipes to fill with water. The heat given off by the blaze will automatically open the extinguisher heads whose task is to quell the flames.
- in the 1967 network and in the extensions, portable rescue ladders hung on the sidewalls every 80 feet (24 m), facilitate car evacuation in case of necessity. In the extensions, the concrete duct-bank, protecting the cables, serves as an elevated walkway to facilitate evacuation.

In Station

In the initial network, water outlets are installed at the extremity of each platform. These outlets are similar to those placed in the tunnel except that a cabinet entirely encloses the appliances. The opening of this cabinet's left-hand door simultaneously triggers an emergency traction-power cut by activating the cutout installed within. By so doing, the opening of this door gives access to the valve and to the equipment.

TYPICAL WATER-CONNECTIONS INITIAL METRO



In the extensions, three fire cabinets are installed in alternate fashion at the platform level. Two cabinets are at the extremities of a platform ; the third is on the other platform at the center of the station.

Each fire cabinet is linked, as in the tunnel, to a pipe which is connected to the city mains.

Within the cabinet, are found :

- a fire hose of 1½ inches (4 cm) and 100 feet (30 m) in length, tied permanently to the pressurized mains.
- two other hoses of 100 feet (30 m) rolled-up and available. These two hoses added to the first can cover a distance of 300 feet (90 m).
- a 2½-inch (6 cm) valve for the use of the city fire department on which the firemen can connect their own hoses. This valve is fed by the same fire mains on which a dry outlet on the station's exterior permits a supplementary water source from the fire department.
- an emergency traction-power cutout linked mechanically to the cabinet door, whose opening immediately triggers a power cut and gives access to the equipment within.

Each platform of the initial network is armed with an emergency closet containing a telephone, a traction cutout, and an extinguisher — all at the disposal of passengers. For the extensions, two such closets per platform exist.

Two chemical-powder and two pressurized-water extinguishers are deployed near the foot of the short stairs at platform extremities, making for a total of 16 so-placed extinguishers per station.



FIRE CABINET



In each station of the initial Métro there is a fire-detection system, displaying a network of detector heads, in most of the locales. Alarm indication is conveyed to the cashier's booth and to the PA-system center in Providence. All the circuits are electrically supervised and a fault-lamp lights up when there is a defect.

In the extensions, the fire-detection systems function in the same way, but indications are sent directly to the PCM.

Passageways from the Métro to outside buildings now mandate fire doors. Moreover, accesses are being added to serve as exits in case of fire. For the construction previously effected, studies are underway in order to improve safety if need be.

On Rolling Stock

Originally a chemical-powder extinguisher of 10 lb (4.5 kg) was installed in the cabs. A pressurized-water extinguisher of 10 liters was then added. The latter is required to quell incipient tire fires. In effect we have observed, on this subject, that when the tire is at normal temperature it is only with difficulty that it will take fire ; relevantly, if the tire sustains low pressure, its temperature after a fairly long run can attain 70 degrees Celsius and at that moment an electric arc is able to ignite same. However it burns but very slowly and if one acts right away with a water extinguisher, the fire is put out. These extinguishers are installed behind the motorman's seat.

Additionally, two extinguishers of the same type are currently being installed under a seat in each car. A notice on the wall details their location.

To inform the riders where emergency tools are stowed, indication plates are installed in each coach ; these tools are found in an underseat compartment.

The portable lights in the cab have been



increased in power so that they can serve better. A redesign of the present lamps is foreseen.

Personnel Training

Considering the importance of discerning fires and of combatting them if need arises, personnel training becomes one of numerous activities linked to prevention. A group of specialists, of the Fire-Prevention Division of the Engineering Department has the mission of looking after systems and equipment inspections, and of giving theoretical and practical courses on the prevention and manner of combatting fires.

For many years these courses have been given to the personnel of the Commission and practical exercises have been organized to which most of the employees regularly participate. Theoretical courses on the extinguishers and their handling are given to all bus chauffeurs.

However, with the safety improvement program in the Métro including as it does water outlets, it has been decided to give all Métro employees a 6-hour course. This course, given initially by instructors from the Montréal City Fire Department, has been taken over by specialized instructors of the Commission. A duplicate fire cabinet as well as the other apparatus is at their disposal. Finally, it has been designated that the abandoned rear-terminal at Henri-Bourassa, over a length of 300 feet (90 m), be equipped with all the elements which one encounters in reality, such as rails, runways, cable trays, cable bunches, vehicles. This center will permit not only employee training on the use of equipment for combatting fires, but also their familiarization with the inherent constraints of the tunnel, that is to say the exiguous locale, track obstructions, cabletrays, lighting including the eventuality of various system failures.

All employees, old and new, will participate in these exercises and will return for a refresher after a certain time lapse.

Collaboration with the City Fire Department

A committee of representatives of the City Fire Department and of the MUCTC has been formed for revision of directives in the intervention plan and for the preparation of a training program on the Métro, applicable to the firemen and the MUCTC employees.

The task of the committee consisted :

- of preparing the didactic material necessary for the training of firemen (manual plus audio-visual means) ;
- of collaborating with the City Fire Department in the revision of the intervention plan in case of fire in the Métro ;
- of elaborating a training program for the employees of MUCTC on preventing and combatting fires in the Métro.

The subjects treated, when giving theoretical courses, were the following : what is fire ? What are the elements of combustion ; the dangers of fire, smoke and combustion gases ? How to prevent fires ; the modes and classes of fire, the combustion of tires and of materials included in each class, and the type of extinguisher employed for each. Films and slides elucidate the explanations.

The practical courses concerned the use of extinguishers, hoses and respirators.

Apart from this, visits of Métro installations have been organized by the Chief, supervisory, and all the personnel of the Montréal Fire Department. Métro technicians have given courses on energized track conductors and the manner of killing power.

Instruction sessions for the city firemen are planned to take place at Henri-Bourassa as of when the place will be organized. Having termi-

nated its program, this temporary committee has been dissolved. A permanent committee is in the throes of being formed.

The fire-prevention division of the City of Montréal is regularly consulted on the various projects concerning the extensions as well as on the major modifications being made to the initial network.

Information to the Public

A series of measures have been taken to better inform the passengers :

- in the cars : on emergency brakes, calls to the operator, emergency-tools location, door-pull devices and extinguishers ;

- in station : on emergency-closet signs and fire cabinets ;

- in tunnel : on fire cabinets and direction signs.

The unwarranted use of the emergency devices in the vehicles or on the station platforms will be the object of a penalty, which will be mentioned on signs designed to inform the public.

It is forbidden to smoke in the Métro, in the stations as in the coaches. Pictograms recall this interdiction to passengers. Sanctions are prescribed for those contravening this rule.



7 MAINTENANCE DEPARTMENTS

The maintenance departments are essential to assure system performance and the transporting of passengers in safety via the Métro.

They comprise :

- the Vehicle Maintenance Department ;
- the Engineering Department, in charge of the maintenance of fixed installations, stations, tracks and tunnel.

VEHICLE MAINTENANCE DEPARTMENT

The vehicle inventory in the years to come will comprise :

- 112 elements (224 motor cars and 112 trailer cars), to wit, 336 vehicles ordered in 1963 and in service since 1966 ;
- 141 elements (282 motor cars and 141 trailers) namely, 423 vehicles ordered in 1974.

The Wherewithal to Do this Work

To effectuate the maintenance of this vehicle pack, the department has :

- both major-overhaul and running-repair shops situated at Youville, on line no 2, with underground test track ;

- a running-repair shop at Beaugrand (on line no 1-East) with underground test track ;
- two running-repair shops with inspection pits and wash-track bays accomodating the 500-foot trains (150 m). The Youville shop assures maintenance of vehicles on lines 2, 5 and 4 ; the Beaugrand shop of vehicles on line no 1 ;
- in-tunnel inspection pits, one on each line, at one of the termini at the disposition of repairmen on the job from 6h30 to 23h00 by shifts, seven days per week.

Maintenance Organization

A fault breaks out on line ; it is reported to the PCC by the train motorman who, in following the instructions of the regulator, conditions the train to proceed to the repair pit where the troubleshooter attempts to identify the trouble. In very simple cases he can intervene and repair the train ; if not, he dispatches it to the running-repair (PR) shop. The faulted 3-car element is withdrawn from service and immediately replaced by a healthy element, allowing the train to resume duty. From the defective element, the culprit motor car or trailer is withdrawn if necessary and is taken, with the help of a transporter-bridge, to a work station where it is repaired.

THE YUVILLE COMPLEX



SHELTER

TEST TRACK

LADDER TRACKS

LEGENBRE SUBSTATION

BOILER HOUSE

WATER-SPRINKLER ROOM

MAJOR OVERHAUL SHOPS

ADMINISTRATION

RUNNING-REPAIR SHOP

TRACK SHOP

VILLERAY SHOP

ELECTROMECHANICAL SHOP

INSPECTION

CREMAZIE SHOP FOR BUSES

In order to avoid mishaps out on the line, maintenance is preventive. Whenever a train has accumulated an integral multiple of 5 000 miles it is dispatched to the PR shop so that routine washing, the necessary greasing, and the programmed replacement of certain components can be carried out.

Each car, element, or train, undergoing an inspection at the PR or GR must be subjected to complete verification before being returned to the line.

The major overhauls, such as those of the bogies, the motor gear-reducers, the body pivots, the paint jobs are directed to the GR which is equipped with hoists and travelling cranes facilitating this work.

The repair of components from trains in the PR or GR is performed in specialized shops.

Each time a car is hoisted all the bogie parts involving safety are inspected for fissures or possible defects and note is taken of all the anomalies so as to follow their progression, if indeed there is any, at each inspection.

The maintenance of equipment is performed with the aim of ensuring the greatest safety at all times. The establishment of rapid repair methods and the return to a healthy state assures efficiency and an availability of the maximum number of vehicles to the Transportation Department.

To ensure maximum efficiency, the most perfected and exacting processes are utilized : ultrasonics, magnetic particles, oscillographs, etc. The healthy state and the proper functioning of certain circuits can be verified only with instruments and it is often experience which can dictate at what stage of life, different for each component, they have to be withdrawn to be rebuilt anew. This goal should be pursued while striving at the same time for efficiency, but, in case of doubt, safety prevails.





TIRE SHOP

Tire Surveillance

The present limit for removing the load-bearing tires of a motor-car is 190 000 miles (300 000 km). In 1973, this border point was 200 000 miles (320 000 km). This 10 000-mile reduction means that a greater number of tires, liable to suffer cleavages, are now retired from service.

The trailer-car tires can accumulate more mileage, as these vehicles are less heavy and their tires are not subjected to tractive effort. For this reason, the tires retired from the motor-cars after a certain mileage are placed back in service on the trailer-cars before retreading; a correction factor of 0.7 is then applied to the support-tire's journey, which signifies that a new tire placed on a trailer-car could run 271 428 miles (440 000 km).

The tires are examined completely every 5 000 miles (8 000 km). Two men are assigned to this inspection for processing 4 elements in a period of 8 hours. The least cleavage revealed by inspection is communicated and the tire is removed.

Other anomalies detected, such as circumferential cracks in the rubber at the bead, about 1 inch removed from the rim, are tolerated according to the advice of the manufacturer. However, following their recommendation, we remove them when they attain 180 degrees.

Fissures in the tread grooves are accepted by the manufacturer unless two cracks in adjacent grooves meet, which could cause the tread to release. The evolution of these fissures is very progressive and an examination with the aid of a probe, similar to an ice pic, permits their supervision.

With the aim of improving the surveillance of tires even moreso, the following modifications have been implemented :

- tire verifiers have been added to the existing ones ;
- separation of the assembly, disassembly, and

verification sections for the bus and Métro tires. For these two, the problem is not the same ; the Métro tires wear in a different way ; the defects, much more rare and less apparent, demand a far greater attention.

Surveillance was complemented by the installation of a pedal indicating the state of the tires at the Youville exit tracks before entering on the line. This pedal has proven to be effective and, on a few occasions, has given warnings of underinflated tires.

Punctured-tire Isolation Device

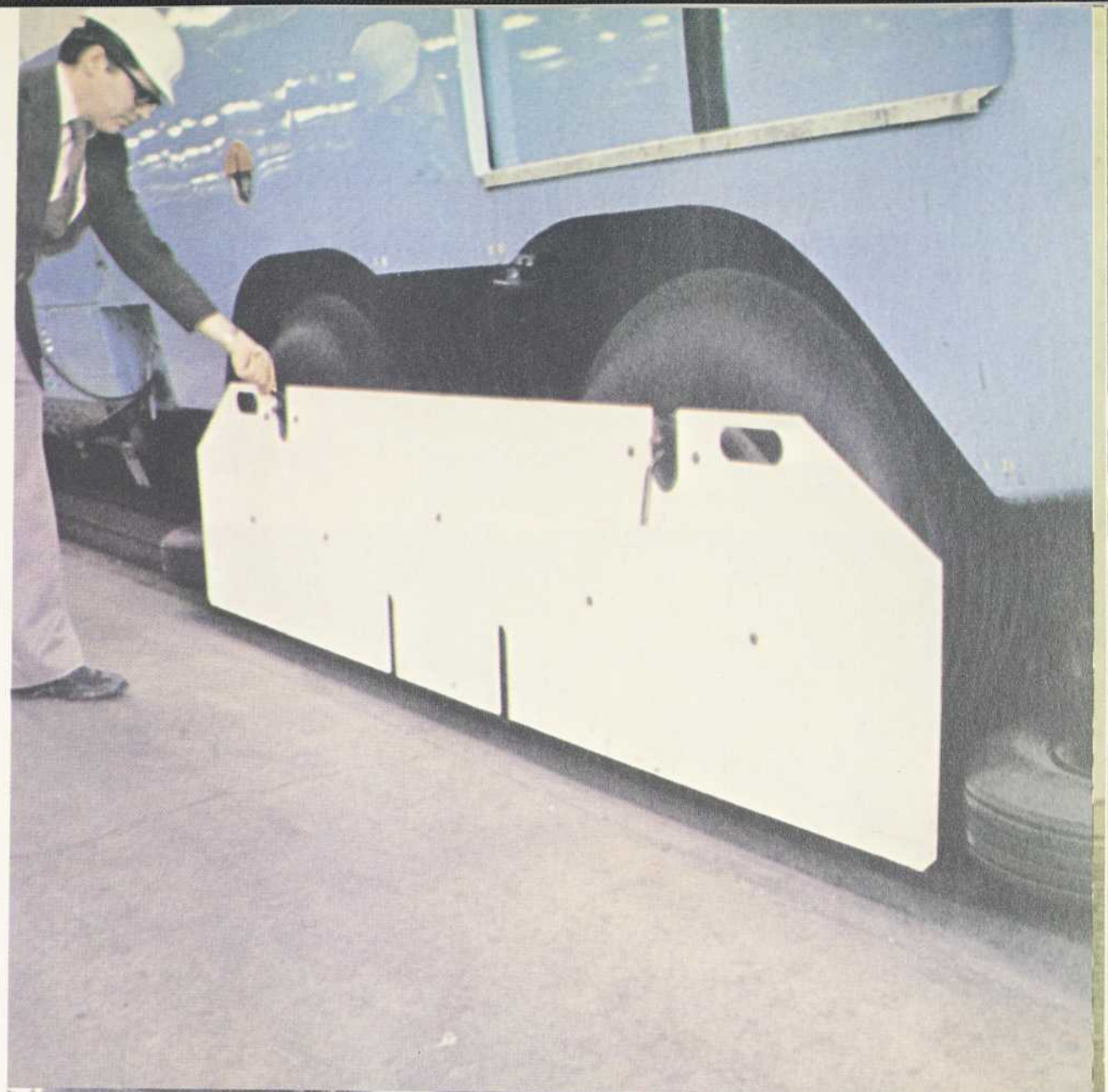
The personnel of the first-line-emergency truck is equipped and trained for on-line examination of deteriorated tires. If need be, they cut those steel wires which have freed themselves and eventually install an improved version of the Mexico-type shield — an insulated break on the side of the bogie to stop the steel wires of the blown tire from coming into contact with the power rail.

In order to diminish on-line delays, while waiting for the first-line-emergency truck crews, some shields are stored in a locale in each station ; the operating personnel has been instructed regarding their eventual use.

Vehicle-maintenance Department Staff Dedicated to Métro

The personnel assigned to service the Métro vehicles is very specialized. According to the categories, theoretical and professional knowledge is necessary ; however, there does not exist on the market qualified mechanics that one could hire to proceed directly into our shops. We have to instruct each rookie for the job he will assume. Next, refresher courses have to be foreseen for all the personnel in order to render it competent to maintain a more and more complex stock.

Presently, in 1975, 215 persons are allotted to Métro car maintenance, namely 9 engineers, 14 supervisors, and 192 tradesmen.



With the increase in the number of vehicles, a fairly considerable growth in this complement must be foreseen.

ENGINEERING DEPARTMENT

The Engineering Department is responsible for three types of installations :

- a) the fixed electromechanical installations including :
 - the electrical-energy supplies, high-tension cables, rectifier stations, transformer stations, distribution cables, power-isolation and protection apparatus ;
 - fixed electrical and electronic equipments for the control of trains, teletransmission and telecommunications, computers, fare-collection apparatus ;
 - escalators, ventilation and pumping-station installations ;
- b) fixed installations for track and tunnel ;
- c) stations and accesses (coating jobs and equipment).

Maintenance of Electromechanical Installations

This electromechanical apparatus is very diverse ; nevertheless, in each specialty, the process is similar :

- a preventive maintenance by regular inspection of the installations according to a particular program for each administrative section ;
- the repair of faulted or deteriorated equipment within the shortest of delay ;

- research for improvement of apparatus to curtail defects, and the testing of modified appliances still in the prototype stage of development.

The personnel in each specialty must be extremely well qualified ; owing to the complexity of equipment, the worker can be totally efficacious only when he has acquired much experience. Experience is acquired as a result of training courses, given by qualified engineers or instructors, together with years devoted in the trade. Continuous training of personnel is mandatory to teach maintainers the improvements and modifications wrought on equipments, to refresh their memories on a certain number of facts which rarely come into evidence in the normal course of work and which have not been demonstrated by experience.

The constant difficulties besetting this maintenance reside in the fact that the fixed installations are spread out all over the network. It is necessary for maintainers to displace themselves to the work spot while carrying tools, measuring instruments, renewal parts. In any case, much time is lost in transport and displacement.

It is difficult to adequately provide supervision for these employees who will inevitably work alone most of the time. It behooves, then, that these tradesmen be of high technical calibre such that they can perform alone ; executive command must have faith in them. In any case, maintenance will be costly and it is well to have the most reliable of equipment, even at a premium in price.

So as to diminish trip times, maintenance teams are attached to bases spread out

over the system, principally in the transfer stations of Berri-de-Montigny, Lionel-Groulx, Snowdon, and Jean-Talon. These centres must be perfectly equipped: small shop, stores, lockers, sanitary locales, finally garages for work vehicles.

A main electrical-services shop is installed in Youville next to the vehicle-maintenance building. It comprises sub shops specialized in the repair of certain parts.

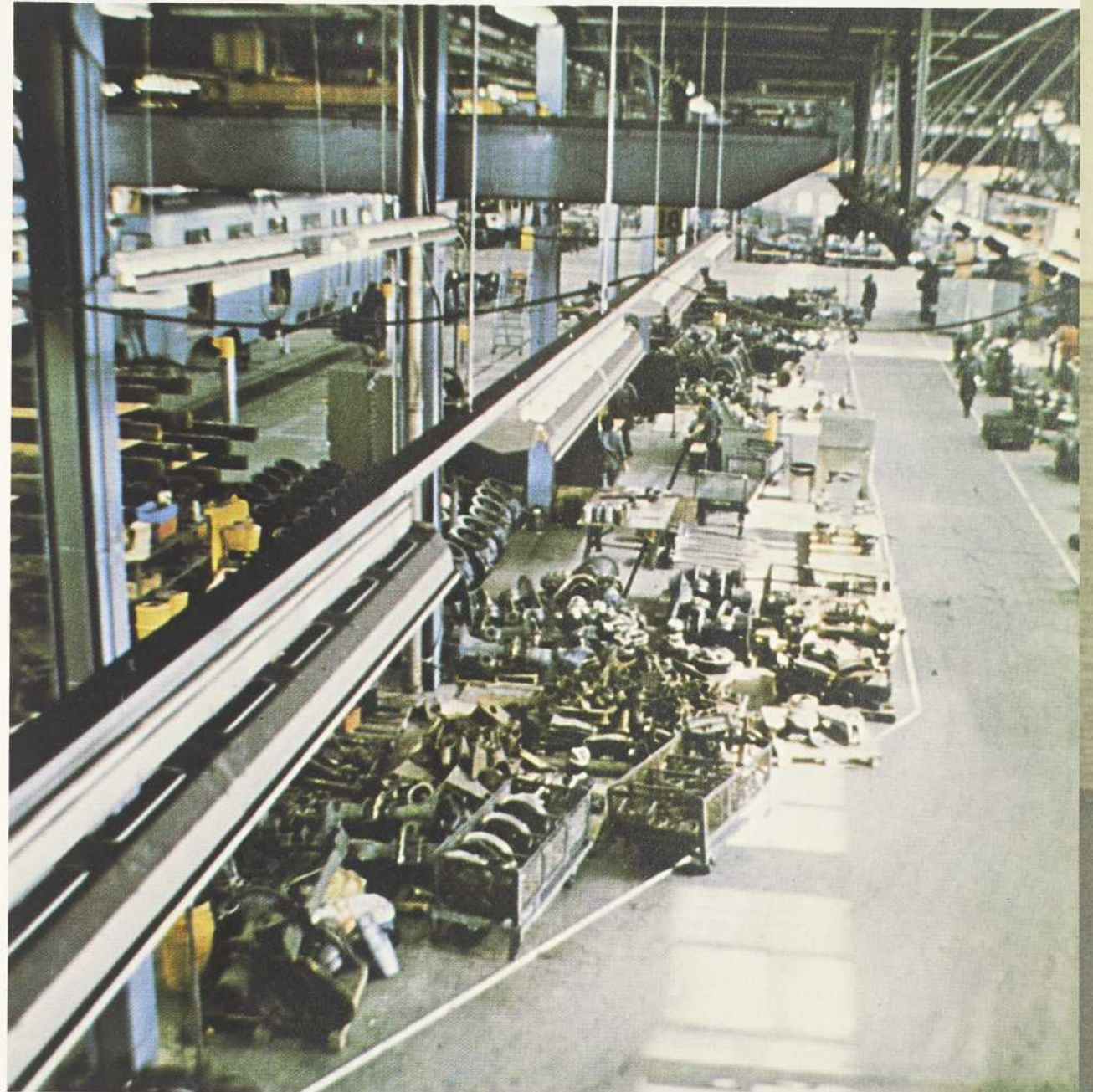
Track and Tunnel Maintenance

The maintenance of track and of tunnel offers certain particularities, as it relates to track and its natural complement, the tunnel. Maintenance tools, renewal parts can be carried, to the job spot, solely by trackbound vehicles — namely, work trains and speeders.

These transports are in general carried out at night and submitted to very strict rules of traffic imposed by central control (PCC). All the vehicles employed must shunt the track circuits, which facilitates supervision from the PCC by means of its illuminated display board.

All the convoys leave from the track shop, situated in Youville where one effectuates :

- the repair, fabrication and storage of all track-equipment components which are utilized in the tunnel ;
- the repair and maintenance of all vehicles and of all tools employed in the tunnel ;
- the preparation of work trains to transport workers, materials and re-



TRACK SHOP



newal parts which serve in the tunnel for the maintenance of Métro-fixed-installations.

The chief work related to track and to tunnel is :

— day work consisting in :

- supervising tracks and tunnels and thus, by so doing, being on hand to intervene in the plight of a serious mishap ;
- effectuating minor maintenance operations as requested by the Transportation Department ;
- garbage collection from station platforms at a given hour.

— night work consisting in :

- verifying, cleaning track appliances, locks and insulated joints (once per month) ;
- verifying, repairing, cleaning the safety rails, (conventional running rail), the runways, the third rail, the insulators and rail clips, sometimes performed as a followup to cues received.

— cleaning the tunnel with the vacuum train (one complete passage over all tracks of the network each month) ;

— suction of refuse in the sidewall gutters of tunnel with an industrial vacuum cleaner mounted on a speeder ;

— cleaning the in-station invert with a work train employing soapy water, then rinse water (once per year) ;

— cleaning track switches with vacuum

cleaner to pick up all iron filings, likely to degrade insulation ;

- cleaning the insulators and rail clips with steam jet ;
- cleaning of drains in case of poor drainage of infiltrating waters.

In the extensions, all track-appliance installations are devoid of ties, employed only in these crucial switching areas over most of the initial system. Rather, they are fastened to the invert via the interposition of polyester saddles, in like manner to the prototype of Berri, line 4. This new method of laying track-work will manifestly diminish its maintenance.

The placement in service of negative carbon shoes, as opposed to the former cast-iron ones, has moreover considerably reduced the wear to frogs and switch points of track appliances.

To effectuate the composite lot of these works, the Track Division has the following contrivances at its disposal :

- a vacuum train (a complete passage per month on all tracks of the network) ;
- a pickup train (mainly for daily garbage collection) ;
- 8 diesel tractors ;
- 11 flat cars ;
- self-propelled crane able to travel on rail or pavement ;
- 1 flat-car-mounted crane ;
- 1 large industrial vacuum cleaner for suction of refuse in gutters and track appliances ;



- wagon for washing of station inverters with soapy water ;
- 1 wagon for steam scouring of insulators, supporting rails of both polarities — the highly insulated ones of the guide rail and the smaller rail-clips of the negative rail ;
- many speeders and small flat-cars.

Cleaning of Stations and Accesses

The cleaning of stations and accesses is extremely important as regard to the public's assessment of the Métro.

The sanitary division is responsible for cleaning of stations and accesses and of those trains made available to the cleaners when they park in the termini.

The cleaners' work is spread out over three shifts during 24 hours, covering 7 days per week.

Lists of work to be done in each station have been defined and the employees must satisfy this program.

Equipments : automatic floor washers, dry or wet vacuum cleaners, high-pressure washing jets, are put at the disposition of personnel for effecting this work.

Related Functions

The Engineering Department includes also the following three divisions :

TECHNICAL STUDIES :

The technical problems arising from Métro operation frequently necessitate studies, often complex, which must be performed by specialized personnel such as engineers and technicians. The Engineering Division is responsible for carrying out these studies and for preparing the ne-

cessary plans to accomplish all modification and new-installation projects.

This multidiscipline division comprises the following sections : architecture, building-mechanical, general-mechanical, electrical for buildings, power, signaling, telecommunications, a section responsible for administration of contracts.

INDUSTRIAL ENGINEERING

The mission of this division is to :

- conceive, develop and recommend new work methods ;
- develop and recommend programs for maintenance and repair of fixed installations and of MUCTC property ;
- evaluate the production capacity of existing tools and equipment ;
- study the arrangement of available spaces for a rational distribution of installations and equipments relative to the workforces and the processes of manufacturing, maintenance repair ;
- plan, develop and recommend replacement policies of equipment or installations ;
- analyze the financial feasibility of diverse projects concerning the use of workforces, installations and service equipment ;
- develop jointly with the computer centre, systems or processes for production, information, and statistics for the control of operating costs, budget data for the department and for comparison with other similar organizations ;
- develop and recommend quality-control programs ;
- coordinate the department-personnel efforts in the realm of accident prevention.

FIRE PREVENTION

The personnel of this division is occupied with the inspection and verification of installations and with equipment for combatting fires, making pertinent recommendations in this matter and giving courses to all employees who, by their function, are apt to work in the Métro.

ENGINEERING DEPARTMENT WORKFORCE

The Engineering Department personnel is very diversified.

The « métro » complement is presently (1975) 652 persons, namely 14 engineers, 12 other cadres, 43 foremen, 45 technicians, 186 electromechanics, 61 building tradesmen, 89 track workers, 160 cleaners and 42 other persons.

An assessment of future needs can be only approximate. A fairly considerable increase is to be foreseen.







8 EVOLUTION OF THE TRANSPORT FUNCTION

MÉTRO TRAINMAN FUNCTION

The Métro trainman's trade is much different from that of a bus driver. The bus chauffeur drives his vehicle and accomplishes a certain number of repetitive tasks. In case of an incident, the driver parks his bus and awaits the troubleshooters ; the service to passengers continues with merely one less vehicle.

The Métro motorman has much fewer motions to make in driving his train as the vehicle is guided, but he has the responsibility of greater number of riders. In the event of an incident, he must have an elevated level of knowledge in a way as to rapidly find the cause of the incident, advise his regulator and proceed to isolate the fault. It is important that the mishap be resolved at the earliest, as the delay of a train on a Métro line has repercussions on all the trains of the line. Moreover, the safety of riders can pose very important problems, much more than those one risks having at the surface.

With the rolling stock of the initial network, the operator must drive his train manually and obey signals. Quite differently, train equipments of the new stock are automated to a greater degree by the introduction of automatic train control.

The new function of the motorman is :

- in normal periods, to supervise the running of the train and, in passing, the behaviour of passengers on the platforms, to effect at each station door service and command the departure, to inform the PCC regulator of

all abnormal things ;

- in case of incident, to understand what goes on, to inform the regulator, to isolate the ailing part which obliges the motorman to have a minimum of knowledge, to be thoroughly familiar with Métro rules, to assure if need arises the evacuation of passengers in tunnel or in station and to repatriate the train in manual drive, with or without continuous speed-control.

Automation risks increasing the monotony to the operator. The troublesome incident taking place only very rarely for a given motorman, his experience can come but from continuous training calling for a simulation of breakdowns.

When a mishap occurs on line, the central control (PCC) regulator should be able to count on the motorman of the concerned train as he himself can see merely the approximate location of trains and knows of the incident only from what the latter pretty well wants to tell him. The operator responsible for highly complex equipment must react quickly, not make errors, and, if need arises, show proof of initiative.

RECRUITMENT OF MOTORMEN

Métro operators are recruited from among bus chauffeurs by giving seniority the priority, with the condition of qualifying oneself physically and professionally.

The instruction period for trainmen extends over 20 days, namely 3½ days of theoretical

instructions, 8 days of practical work, 8 days of accompanied drive, and ½ day for a written test.

In the past, every Métro operator who so desired could, once per year, revert to bus driving.

It appears that conductor instruction was insufficient and that too high an operator turnover led to excessive training expenses in relation to the results obtained.

The last labor agreement has corrected this situation.

The advent of automation has obliged, moreover, the department head to rethink the criteria for selection and recruitment in order to assure motorman competence in his function.

INSTRUCTION CENTRE

In line with all transportation organizations, the MUCTC possesses an instruction centre for the training of its personnel.

The motorman in the presence of a certain mishap can call upon only what he has learned at training sessions, as in most instances it is the first time that he lives such an incident. It is thus necessary to instruct the trainman on elements similar to those which he will have before him every day, of putting him in the tunnel ambiance and of simulating the various breakdowns which are apt to occur.

To meet the requirements of automation and with the desire of reinforcing motorman schooling, the instruction centre has been further developed and comprises within its premises models of fixed and rolling equipment as well as simulation installations allowing the operator to be put in the exact ambiance of a drive cab and to confront him with all the incidents that can arise on line.

HIRING AND TRAINING OF INSTRUCTORS

It is essential that the recruitment and schooling of instructors be adapted to the problems to be solved. The hiring conditions are presently :

- degree of education equivalent to high school ;
- correctly speak and write French and reasonably master the English language ;
- ease of elocution ;
- possess at least 2 years of experience as train supervisor ;
- satisfy the medical requirements of the MUCTC ;
- submit to qualifying tests ;
- follow the instructor's course and qualify oneself.

The future enlistment of instructors will be improved by a search for candidates having a greater inventory of knowledge and teaching qualities.

CONTINUOUS TRAINING OF PERSONNEL

Once recruited and selected, the trainmen candidates must be schooled. They must learn what is the Métro, know the ambiance in which they will work, be warned of all possible dangers so as to assure their safety and that of the riders.

It is essential that the operator be instructed on all the incidents which can befall on the rolling stock, tracks, and station platforms.

For each possible mishap, the instructor must give a clear answer which must involve a practical exercise in a way as to be better memorized by the trainman. Simulation resolves the problem.

The training given to the operator at the outset of his career has a good chance of being forgotten at the end of a certain time, as for a great part (the resolution of mishaps) he cannot acquire any experience — the mishaps being very infrequent. It is befitting thus that continuous training be adopted, that is to say that at regular intervals the instruction centre must refresh the operator with knowledge he ought to possess.

REVIEW OF RULES

The rules to be used by the trainman have been revised for the new stock, featuring automatic train control with a single operator.

A manual is edited in pocket format, a size that can be easily carried by the motorman. It will regularly be updated.

RULES IN CASE OF ABNORMAL NOISE, OF SMOKE LIBERATION

The rules, taking into account experience, are much more complete and so are the procedures to be taken in case of abnormal noise, arcing, of smoke on board rolling-stock or fixed installations in the tunnel.

The trainmen should strive to determine the source of these noises, flashes or smoke. The operator of a train which meets another train is particularly well placed to see if there is anything abnormal on the encountered train.

Every trainman who notices anything peculiar must instantly advise the PCC regulator. The latter immediately issues a call to the line so that the nearest ranker will directly go on location. He requests that the first-aid vehicles get underway.

All procedures are so oriented that faulty trains stop in station if possible, so that passenger evacuation be extremely rapid.

The orders are explicit to pin down the task of the Transportation Department personnel who are to visit the train and attack the incipient flames by utilizing the specialized equipment deployed for their use in the coaches, in station, or in tunnel.

In case a fire has emerged the PCC immediately alarms the City Fire-Department.

PASSENGER EVACUATION

Rider evacuation should, as much as possible, take place in station; but an excessively degraded train, an electrical power failure, or, thirdly, a situation where the safety of passengers is at stake can impose an in-tunnel evacuation.

In the first two instances the safety of passengers does not hang in the balance and withdrawal takes place under normal conditions, well defined in standing orders.

The third instance is that of a serious accident — emerging fire on board train or in the tunnel; the riders are distressed by smoke, and panic can take hold. The rules have provided for an emergency evacuation of passengers towards one station and for a rapid attack of the seat of the blaze with the help of equipment to be found in the cars, in the tunnel and in the stations.





9 COORDINATION BETWEEN DEPARTMENTS AND INFORMATION EXCHANGE WITH OTHER MÉTROS

COORDINATION BETWEEN DEPARTMENTS OF MUCTC

The goal of the MUCTC is to transport passengers.

The president and the commissioners are in charge ; they give general directives and approve or refuse expense proposals of the departments.

The department really in charge of assuring passenger transport is the Transportation Department. It has all the responsibilities of this form of conveyance ; the client addresses himself directly to it as soon as he has to make a claim. In case of incident, of fault, it is the Transportation Department workers who have the responsibility of resolving the mishap as fast as can be and who must assure the safety of riders in all circumstances.

The Vehicle Maintenance and Engineering Departments must be of service to the operators mentioned above, and, by so doing, maintain the rolling and fixed equipment in the best possible shape. The stoppages must be short-lived so as to minimize annoyance to passengers.

Often in the event of a line mishap or of a defect the fault-finding problem is not simple, as the three departments may be involved. Actually, it is thanks to the collaboration of the 3 chief department heads — transportation, vehicle maintenance, engineering — that many of these problems are resolved. But if simple solutions do exist, others are not evident, especially when the information given is incomplete, hence the need for an exchange in views permitting a solution to be found.

COORDINATION BETWEEN DEPARTMENTS OF MUCMTB AND OF MUCTC

Cooperation between the Metropolitan Transit Bureau and the Transit Commission has prevailed since studies have begun on the Métro. The Métro committee which was formed as of 1961 and which took the decisions for the construction of the initial Métro included two representatives of the Transit Commission.

Since revenue operation of the Métro came into force, the operators and those who have the responsibility for maintenance have learned much as a result of : experience acquired, studies, research, and tests which they have performed. They have thus become excellent advisers for the engineers in charge of new construction. It is evidently essential that new rolling stock and new installations benefit from all the advancements which it appears logical to implement on the existing installations.

At the time when specifications and plans are being elaborated upon, numerous conferences between representatives of the two organizations allow the principles to be discussed ; the specifications and plans have always been approved by the implicated department heads of the Commission. Agreement is almost always reached by taking into account the objectives and the reasonable level attained in the expenses to be disbursed.

A committee of department heads of the BTM and the MUCTC (transportation, vehicle maintenance, engineering) has been created with the aim of preparing solutions to the diverse problems advanced. This committee has a statutory meeting each month and sits as often as necessary.

INFORMATION EXCHANGE WITH OTHER MÉTROS

The International Union of Public Transportation has formed a Métro committee which holds regular meetings each year. Important questions concerning techniques and operating methods of Métros are confronted; each profits from the neighbor's experience. Sub-committees are formed on occasions for studying particular questions. Thus a sub-committee of current choppers was created and it is the Montréal Métro which precisely was placed in charge of organizing a session on this subject for September of 1976 — the Montréal Métro having made particular strides in the refinement of the current-chopper technique.

The Montréal Métro is evidently very interested in effecting information exchanges of a more precise and frequent nature with operating rubber-tired Métros. In order to seek, as of now, information from transportation organizations confronted with the same problems, the Montréal Métro has entered into contact with the Mexico Métro. A first Mexico-Montréal Symposium has taken place in Mexico from June 16th to 20th, 1975.

This Symposium was attended by 26 Montréal representatives and more than 75 from Mexico. They discussed in workshops and general meetings all aspects of Métro. A second Symposium is scheduled for October 1976. The Paris Métro has been invited to join the Mexico and Montréal Métros.



10 CONCLUSION

Since 1966 the Montréal Métro has transported more than a billion riders without a single fatal accident to patrons. In 1970, a major extension program was launched. In 1976, the first length of these extensions is completed. It is for all purposes a new Métro which sees the light of day, so numerous are the modifications and improvements implemented on rolling stock and fixed plant, in the interests of improving reliability and safety.

The whole of this work constitutes an exulting task for Commission personnel and for that of the Metropolitan Transit Bureau. All are proud of the work undertaken and we are dedicated to its proper termination, much to the satisfaction of public authorities.

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