# *From Cable Drive to Computer Control— Glasgow's 83-Year-Old Subway Gets Rebuilt*

When Glasgow's Underground Railway opened for service on December 14, 1896, Queen Victoria was on the throne and the shipyards along the banks of the River Clyde were lined with the hulls of ships under construction. Scotland's largest city was a prosperous, highly industrial metropolis, and the 15-station loop line of the Underground served communities in the center of the city, on both sides of the river.

By modern standards, the Underground system left a great deal to be desired. It consisted of two trains, moving in different directions, around a double loop. Traction was provided by cables, which hauled the trains from a coal-fired power station in the Shields Road area.

After 41 years of service as a cable facility, the existing cars were electrified in 1935. Electrification did not solve other problems, however. Cable-drawn cars had been unlikely to break down at isolated points in the system, which probably accounted for the fact that the only provision for repair and maintenance was an overhead crane that removed the rolling stock through a hole in the tunnel roof in the maintenance depot. This system was retained, through necessity, after electrification.

The original 1.23-m (4-ft) gauge track was set on timber ties but, because of the small tunnel, these ties had only a small volume of ballast around them. This was barely sufficient to retain the ties in position, and maintenance of alignment has been a constant problem during the operation of the Underground.

General safety standards have also been heightened considerably during the past 80 years. In the original concept, each station was provided with a single platform 2.75 m (9 ft) wide between the two tracks. Since this was too narrow to provide adequate waiting and circulating space for passengers between two trains during busy times, the restriction on the number of people permitted on a platform has often limited the number of passengers who can use the busier stations during peak hours.

The physical limitations of the system, coupled with demographic changes in the Glasgow metropolitan area, spurred a drastic review of the Underground system in relation to other transport modes. The shipbuilding and heavy engineering industries have dwindled to a fraction of their former importance, and industry has largely migrated to the suburbs and neighboring cities, taking with it a large proportion of the city of Glasgow's work force and dependents. Although the population of the city declined during the 1960s from 1 058 000 to 898 000 and is forecast to decrease to 700 000 by 1980, the population in the surrounding metropolitan area, which covers 1961 $km^2$ (757 $miles^2$), increased during the same period by 129 000, giving a total population of 1 927 000 in 1971. The population has become more dispersed and has moved to the fringe townships on the periphery of the city or to the new towns of Cumbernauld, East Kilbride, and Livingston.

In 1973, the control of the Underground system, along

***The St. Enoch Underground Station building, a miniature castle in red sandstone, is listed as a historical building. It is currently being stored on this concrete platform until the below-ground facilities are completely rebuilt.***


ST ENOCH STATION
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with the system of buses and ferries that serve the metropolitan area, was taken over by the Greater Glasgow Passenger Transport Executive, a new authority created by the Strathclyde Regional Council. The Transport Executive decided to rebuild the Underground system completely, integrating it into the bus and suburban train services, thus allowing rapid and easy access between the inner city, the suburbs, and the neighboring communities in the metropolitan area.

As part of the $25 million modernization of the Underground, the rolling stock, communications and signaling systems, station facilities, and maintenance access and facilities were scheduled for a complete rehabilitation. For the first time in 78 years, the Underground Railway, which then carried 14 million passengers a year over 1.9 million km (1.2 million miles), was closed down in May 1977.

Two years later, as the October 1979 reopening deadline approaches, the modernization, including 15 new stations, modern workshops, and 33 modern self-propelled rail cars, is virtually complete, giving Glasgow one of the most modern Underground systems in Europe. Two new access ramps were constructed near the Broomloan maintenance depot so that trains will be able to run in and out of the Underground system to street level under their own power, without causing delays to the other trains in service.

In 1975 tests were carried out on a 100-m (330-ft) length of track that was taken up and relaid on a concrete bed by using Pandrol fastenings. Although this improved the quality of the ride, it increased the intensity of high-frequency noise. However, further experiments showed that much of this hiss could be absorbed by the use of perforated slabs to cover the mid-track drain. The final design consisted of precast concrete bases drilled to take Pandrol baseplates with the rails supported on rubber pads.

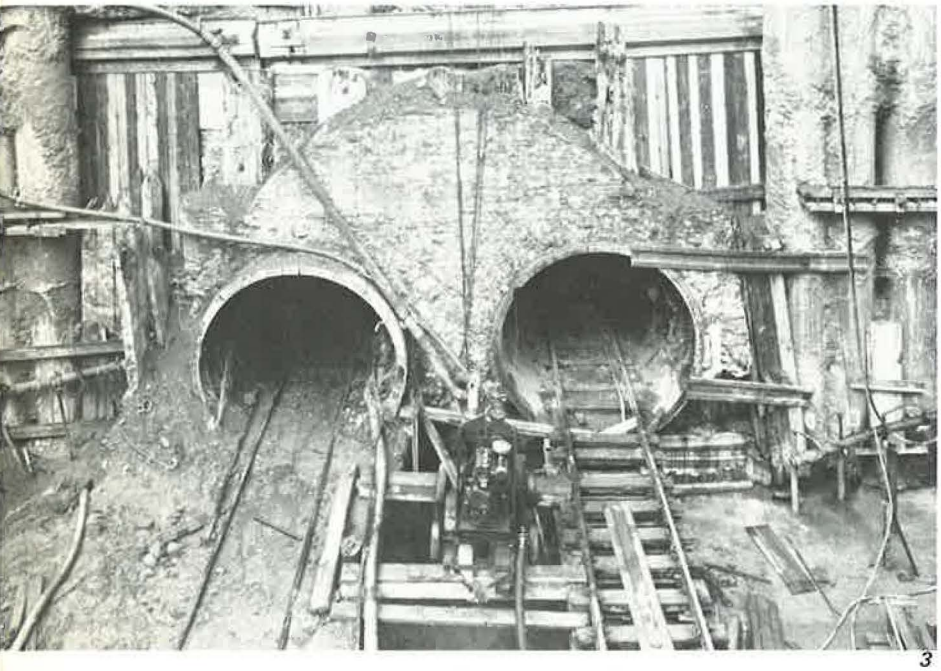
The entire tunnel system was accurately surveyed and a computer program used to establish the precise location of the track at 5-m (16.5-ft) intervals around the system to give the best possible track alignment within the con-

*1 Entrance to typical Underground station. Art deco styling reflects the period when the system was electrified in 1935, after 44 years as a cable system.*

*2 Track gauge of 1.23 m and cramped tunnels limited the size of the Underground stations before the Glasgow system was completely shut down for rehabilitation in 1977. Central platforms were only 2.75 m wide, which created safety problems at peak hours.*

*3 New tracks are being laid in the 88-year-old tunnels that connect the 15 stations on the Glasgow system, which is completely underground. New rolling stock has been specially designed to fit the small-bore tunnels.*

*4 Veteran car is hoisted from track by cables for repair at maintenance yards. Before rehabilitation started, there were no facilities for maintenance at track levels. All rolling stock had to be taken out of service in this manner.*



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fines of the tunnel. Because the original tunnel diameter is being retained, the full underground railway standards of safety, comfort, and reliability, as well as normal operating procedures, had to be provided in a total volume less than 60 percent of that considered normal. In addition, the new vehicles had to cope with a minimum curve radius of 50 m (165 ft) in the maintenance depot and 94 m (310 ft) on the main line. The result was an Underground car that had an overall height above the rail of 2.65 m (8.7 ft), a width of 2.34 m (7.7 ft), and a total length of 12.75 m (41.8 ft). Factors such as track wear had to be taken into consideration in estimating the exact position of the track within the tunnel, and precise adjustments were made possible by the use of eccentric inserts in the baseplate holes.

Automatic equipment for one-person operation is provided. In the event that the operator is taken ill or disabled, the train will proceed to the next station and stop. Automatic traffic control is provided through track-mounted beacons. The control unit on the train converts signals from these beacons into instructions to the conventional traction and braking control equipment. Automatic docking is provided through two beacons at fixed distances from the stopping point. A docking accuracy of ±1 mm (±0.04 in) is claimed.

Major reconstruction has been carried out at six of the busiest stations; the remaining stations have received an


*New cars are 12.75 m long, 2.34 m wide, and 2.65 m high. They will be operated at first as two-car trains, and later as three-car trains. They accommodate 36 seated passengers and 56 standees.*

architectural facelift and were provided with additional pedestrian areas so that crowding on the central platform did not become dangerous. Escalators were added at the deeper stations, including Buchanan Street, where previously passengers had to climb 139 steps from the platforms to the streets.

Closed-circuit television cameras have been installed to cover platforms and, at the busiest stations, the concourse, fare barriers, and escalators. The system-indicating panel in the control room accommodates 15 monitors, one for each station.

Operational control of the trains is by radio telephone, which also enables drivers to summon help in the case of emergencies or breakdowns. For emergency use, the Underground is provided with a standby communications system that consists of a pair of bare telephone wires through each tunnel, to which the drivers can attach a portable telephone. This attachment automatically trips traction power and triggers an alarm at neighboring stations and in the control room.

When the Underground goes back in service in October, a flat fare will be charged regardless of the number of stations traveled on the 16-km (10-mile) system.

At two of the stations—Buchanan Street and Partick—the subway system will connect with British Rail services. The Partick Underground Station is linked by a moving walkway with the British Rail station on the brand new Argyle line, which is scheduled to be opened concurrently with the Underground. The 8-km (5-mile) Argyle line will connect the British Rail systems north and south of the River Clyde for the first time.