Canadian Urban Transit Association
Conference 16th – 19th June 1986

cuta actu

RUNNING Tyne and Wear METRO

3089

D. F. HOWARD

THE FUTURE

Tyne and Wear has developed a high quality, integrated public transport system of which Metro is the key feature. The results in terms of passenger volumes speak for themselves and demonstrate the popularity of the network. Whilst there have been some complaints from those whose previously through bus journeys have been curtailed at interchanges these are outweighed by the number of people enjoying faster journeys to a wider range ot travel objectives and who, by virtue of through ticketing, are able to travel more cheaply than before.

Perception of Metro is good and local people appreciate the practical design of stations and vehicles and the high standard of cleanliness. Keeping the system in good shape is however a demanding task as it has not been possible to insulate public transport from vandalism and rowdy behaviour by youngsters. Like most Metros, Tyne and Wear's seems to attract more than its fair share of hooligans in the evening and at night. Fortunately they are boisterous rather than criminal and violent. Policing is being stepped up and additional roving attendants equipped with radio deployed in an attempt to remove the problem.

There have been no major technical problems beyond what might be expected with any system of its kind and the original design concept would be followed with little or no modification were one starting again. Metro is highly regarded worldwide and has therefore attracted a wide range of interest from those considering or building systems of their own. The Executive has provided consultancy at home and overseas, including Canada, and has trained staff for other undertakings.

In the normal course of events the integrated system would be being progressively developed and extensions to Metro sought, notably to the airport and to Washington New Town where the Nissan factory is about to open. However Government legislation in 1985 is changing the whole pattern of public transport provision.

In the first place, Metropolitan local government was reorganised on 1st April 1986. From 1974 Metropolitan County Councils had been the principal local authorities the conurbations and included amongst their responsibilities overall transportation policy and strategic planning. There was thus a single body capable of taking policy and investment decisions on the extent of road or public transport development, traffic management and parking supply and control, and of relating these to land use developments. As Passenger Transport Authority the County Council was also the policy body for public transport.

Since April the Passenger Transport Authority has become a separate body, whose finances are strictly controlled by central government. Highways, traffic management, parking and planning responsibilities have been disaggregated to District Councils so there is no longer any formal coordination between the various elements.

Secondly, as from October the bus industry is to be given a remit to act commercially. Services will be deregulated with operators free to compete with one another as they see fit. Passenger Transport Authorities and Executives will no longer be responsible for bringing about an integrated public transport system, nor will Executives be allowed to run buses any more - they will be transferred away to become a separate company leaving Tyne and Wear in a situation where the Executive runs Metro and the ferry service at the mouth of the Tyne.

Authorities' and Executives' duties will be:-

- Procurement of socially necessary bus services by tender where these are not provided commercially
- Support of rail services where they have a justifiable contribution to local movement
- Administration of concessionary fares schemes for the elderly, disabled and children
- overall promotion of public transport and passenger convenience.

All these functions must be carried out in such a way as not to inhibit competition.

Metro, whilst qualifying for financial support, will have to compete with bus operators, who have already declared their intention to run parallel with it. Metro will react forcefully, actively and will be able to procure feeder bus services either on a commercial basis or by tender, and which will preserve the through ticketing arrangements which have proved of benefit to the passenger. Indeed the Executive as part of its wider role will seek to promote through ticketing across public transport as a whole. However there is no doubt that Metro will have a very different part to play than was intended when it was built. The fact that it is an efficient and high quality system gives it the strength to survive in the new environment.

D.F. HOWARD

INTRODUCTION

A number of British urban rail developments are being built or are proposed. The Docklands Light Railways in London is at an advanced stage of construction and extensions are already being sought. Light rail systems design is proceeding in Manchester and to a lesser extent in Birmingham but Government funding is not yet forthcoming. Other cities wish to follow this lead.

Tyne and Wear Metro, which was opened in 1980 and progressively extended until early 1986 is the newest operating system in the country. Its construction was paralleled by the building of the Jubilee Line in London and the modernisation of the Glasgow Underground as well as extensions to British Rail suburban networks.

The purpose of this paper is to describe operational aspects of Metro, but it is first relevant to briefly describe the area it serves and how it came about.

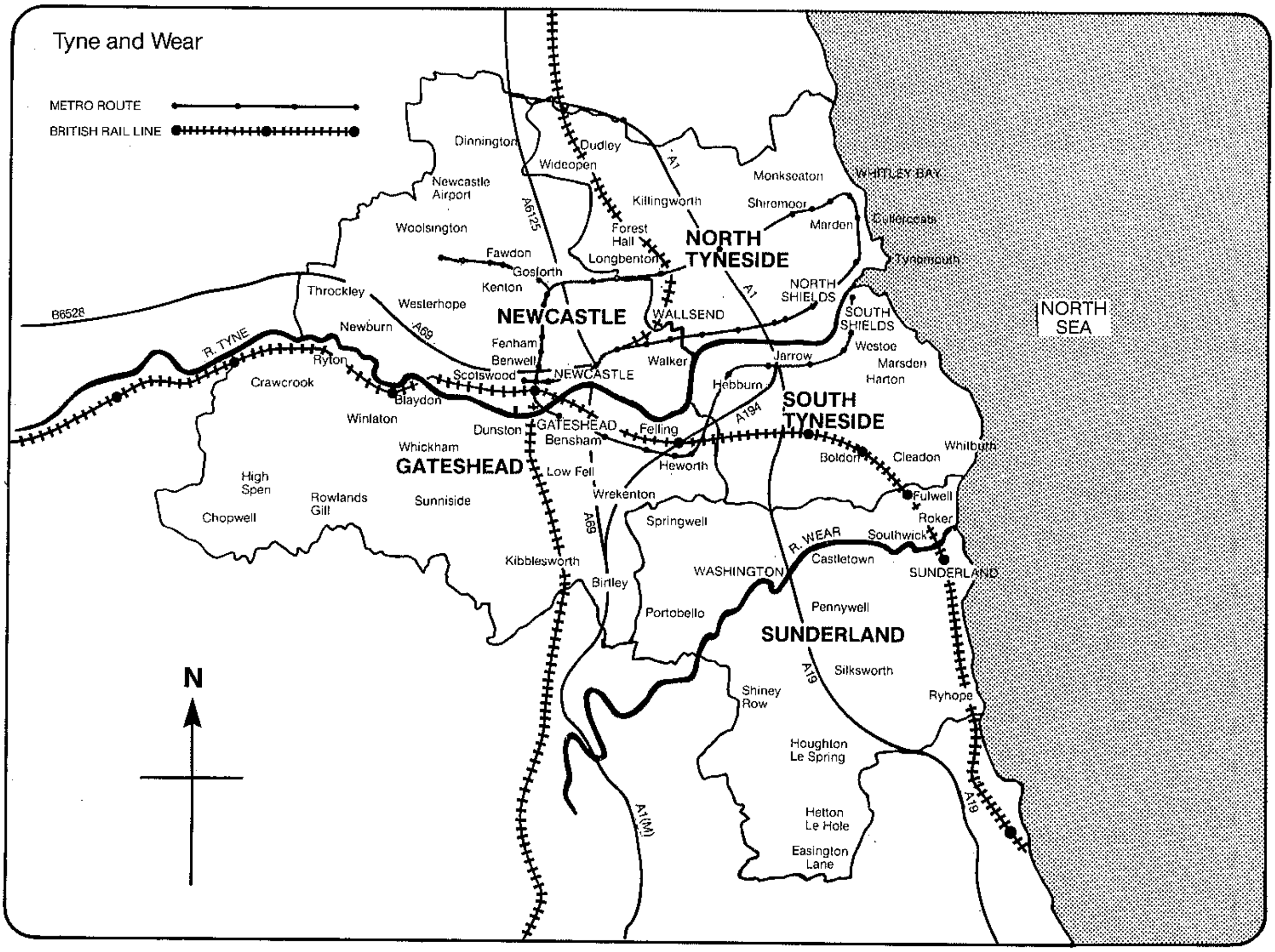


Fig. 1

THE TYNE AND WEAR CONURBATION

Tyne and Wear is the major industrial and commercial conurbation in North East England. It is 430 km North of London. Centred on Newcastle upon Tyne as regional capital it has an area of 54,000 Hectares and a population of 1.2 million. The conurbation is bisected east-west by the rivers Tyne and Wear, both of which run in deep gorges, presenting barriers to movement.

The area developed rapidly during the 19th Century when coalmining, heavy engineering and shipbuilding were the staple industries. What had been separate townships expanded into continuous built-up areas but with people living and working very locally. There was little commuting. During the 1950s new housing estates were built on the periphery of the main urban centres to replace high density inner urban dwellings. Subsequently the pattern of industry began to change with a rapid run-down in traditional heavy industry. Unemployment levels rose significantly and remain high. New industry is less labour intensive than old; it is locating in different parts of the conurbation and there has been a significant increase in service industry, concentrated mainly in Newcastle. Recently there has been a move to revitalise inner urban areas, assisted by grants and other financial measures from Central Government.

Transport developments have followed a traditional pattern. Newcastle has long been a river crossing point on the main route between London and Edinburgh. This was enhanced when the railways were developed; by 1900 the area had an extensive network of suburban services as well as being on the main line. Introduction of electric trams in the early 1900s provided a hitherto unknown level of mobility which caused the railway to electrify its busiest suburban line in 1904, to become one of the first electric railways outside London.

Bus services developed between the wars. Heavy renewals of tram and trolleybus equipment were needed after World War II but the money was not available despite the fact that public transport was paying its way. Where transport was municipally owned the councils found it preferable to spend the profits on other things like schools and housing and to keep the rates (local taxes) down. Trams and trolleybuses had disappeared by the 1960s and in 1967 electric traction on the suburban railways (other lines had been electrified during the 1930s) was replaced by diesel.

These developments were paralleled by a rapid increase in car ownership and road building; public pressure and financial incentives from Government to invest in new roads were great. Locally a high quality network of new roads was developed outside the main areas of population and ambitious plans existed for an extensive urban motorway (freeway) network.

DEVELOPING PUBLIC TRANSPORT

During the 1960s it became recognised that the problems of urban areas could not be solved by roads alone. To do so would create unacceptable social, economic and environmental difficulties. However the financial and administrative structure necessary for public transport to play its proper part was lacking. Operation was in the hands of individual organisations in a variety of ownerships. There was no overall planning; there were no provisions to allow payment of subsidy, nor was Central Government grant available for building public transport infrastructure whilst 75 percent was available for new main road building.

In 1968 Parliament gave powers for the creation of passenger transport areas in the main conurbations and introduced the concept of service subsidy. It also made available capital grant for public transport on a similar basis as existed for roads. What is now the Tyne and Wear Passenger Transport Area was created in 1969. Its political policy making Authority and professional Executive were given the responsibility of securing a fully integrated network of public passenger transport to meet the needs of the area. This was to be achieved through direct operations (the buses locally owned by Newcastle, South Shields and Sunderland Councils were transferred to the Executive) and through agreements with other bus operators and with British Rail in respect of suburban services.

The Executive's initial planning task was materially helped by its participation in the Tyne Wear Plan land use transportation study for the conurbation and its hinterland. The Study was conducted mainly by consultants for a range of Central and Local Government agencies. Its task was first to recommend a transport strategy up to the mid 1980s from which land use proposals to the turn of the century were a second stage.

The transport recommendations recognised the pitfalls of providing only for the car and called for a balanced programme of investment in roads and public transport. Public transport investment was needed in the short term to increase mobility, especially to and from work, and in the long term as an attractive alternative to the private car. The local railway system, which at that time was only carrying 5 percent of the 850,000 daily public transport journeys was generally conveniently placed outside central Newcastle and Gateshead. Provision of direct links under the conurbation centre would greatly enhance its potential; conversion to rapid transit operation would enable it to become the backbone of the integrated transport system.

INTRODUCING METRO

Tyne Wear Plan's strategic transport recommendations were accepted in 1970 and it fell to the Passenger Transport Authority and Executive to implement the public transport aspects. Metro was to be the principal feature and its implementation was approached in three stages:-

- Physical feasibility
- Financial justification
- Authorisation to construct.

Physical Feasibility

The Metro recommendation involved converting 42km of British Rail suburban line over which freight and other traffic operated to a new type of high frequency operation which would require, as far as possible, exclusive user of tracks. It was therefore first necessary to establish with British Rail that conversion could take place, with accommodation being made for other traffics either by re-routing or the provision of alternative facilities. This work was completed early in 1972.

Financial Justification

Investment in new roads is justified by a relatively simple form of cost benefit analysis which had by the late 1960s developed into a standard, national formula. Public transport schemes however require a specific and detailed analysis.

This led to comparing the investment solution involving integration based on Metro with a non-investment case relying wholly on conventional but comprehensive bus services. The analysis embraced both cost benefit techniques (which on a searching basis gave a rate of return of 10.8 percent) and wider but less easily quantifiable factors relating to land use development and the broad economic aims of the area. Government accepted the results and awarded capital grant late in 1972.

Authorisation to Construct

Local authorities have general powers to acquire land and build roads but, with some minor exceptions, specific approval of Parliament is necessary before railways can be built. It was therefore necessary for the Executive to obtain Parliamentary Powers - the Tyneside Metropolitan Railway Act - in 1973. As well as authorising the purchase of the necessary land, and carrying out of the required construction works. It also provided for agreements to be made between the Executive and British Rail regarding the ownership and operation of Metro, which at the time had not been resolved in the Executive's favour.

CONSTRUCTION

Within three years of having been formed, the Executive found itself faced with building and implementing the country's largest single urban transport development this century. At the same time it was a small organisation, comprising central functions including a relatively new planning department and two divisions running a fleet of some six hundred buses.

From the outset the Executive decided that it must take the lead in specifying the technical and operational requirements of Metro. It did not, however, wish to recruit a large organisation to design and engineer individual contracts; rather it preferred to employ key personnel who would eventually play a part in running the system and to appoint consulting engineers to design and supervise construction. Five such firms were appointed on the basis of their specific expertise but the Executive managed certain contracts having major operational influence such as signalling and communications.

The Executive's user-requirement was that Metro must above all be simple and reliable; as a result it should be based on the best available proven technology. Extensive research was conducted at home and overseas, principally Northern Europe, but for ticketing systems North America as well, to enable a design brief to be drawn up. A consultant architect working direct to the Executive was used to establish the overall design concept, with individual architects working with the consulting engineers to apply the concept to specific works. British Rail also had a major involvement in the works, principally where their own railway was concerned and set up a project team to work closely with the Executive.

The scale of the works and the number of consultants involved called for a high level of project co-ordination by the Executive. The difficulty of recruiting an established team expert in this task led the Executive to enter into a contract with a firm of consulting engineers to second a team to work as an integral part of its project management team.

The characteristics of Metro are such that specific design standards were developed for it with the aim of reducing cost and allowing it to be introduced easily into areas where rail rights of way were not already available. Main parameters are as follows:

TABLE 1

Gauge	1435 mm
Maximum gradient	4.0 %
Minimum curvature (desirable)	210 m
(feasible)	50 m
Running tunnel diameter	4.75 m
Station tunnel diameter	7 m
Platform height	900 mm
Maximum axle load	13.5 tonnes

The relatively light axle loading led, with the approval of the Railway Inspectorate of the Department of Transport which is responsible for railway safety, to the development of Metro's own bridge loading standards, enabling major structures to be built to the precise requirements of the system.

The first contract for the main system was awarded in 1974 although prior to this a short test track, separate from the rest of Metro had been opened for the testing of two prototype cars and the proving of systems and procedures. There have been about sixty main contracts on the system as a whole, mainly in the hands of specialist firms but with British Rail using their direct labour workforce on sections which involved their own operations.

The main civil engineering interest in building Metro centres on tunnelling and bridge building. The tunnels under Newcastle were driven mainly through boulder clay in good conditions although there were areas where water and sand lenses necessitated the use of compressed air. A feature of building the underground stations in the city was the extent of service diversions (gas, water, sewers, electricity, etc) and the need to protect historic buildings of good architectural quality. Where roads were affected by construction, the highway authority used traffic management measures to give bus priority to keep public transport moving smoothly.

Monument, the main station under Newcastle is linked directly into a large new shopping mall, and a pedestrian plaza at street level has been created where there was previously a busy traffic intersection.

The ground under Gateshead comprises alternate layers of sandstone and coal seams which were worked as long ago as the 14th Century. As a result, in contrast to the tubes under Newcastle, the tunnels are of an inverted 'U' shape. Gateshead Station (Fig. 2) was built by the cut-and-cover method in an area of filled ground; the bus station at its surface level is designed to be built over.

The Queen Elizabeth II Bridge (Fig. 3) spanning the deep gorge of the River Tyne is a double-track steel truss with a clear span of 164.5 metres. The Ouseburn Viaduct (Fig. 4) was built on a difficult site between Manors and Byker Stations. It is a slender structure consisting of 18 spans with a total length of 820 metres. Individual pre-cast concrete segments form a continuous pre-stressed concrete box carrying a rigidly mounted concrete slab track.

THE METRO SYSTEM

Metro comprises 55km of route (Fig. 5) made up of 42km of converted British Rail line and 13km of new construction. The new construction can be divided into two parts - the tunnels north/south and east/west under Newcastle and under Gateshead south of the Tyne, linked by the Queen Elizabeth II Bridge (Fig. 3) over the Tyne gorge and surface railway east of Newcastle city centre, and through the centre of South Shields.

The new section immediately to the east of Newcastle after crossing the Ouseburn Valley runs through the heart of an area of inner urban redevelopment where old housing has been replaced by new. The Metro route at this point is along an alignment which was originally earmarked for an urban motorway; beyond there the line runs through a short cut-and-cover section to join the existing railway east of Walkergate.

The new alignment in South Shields runs through the heart of the town, replacing a riverside route which had become inconvenient as a result of industrial decline in the area it served.

The north-western branch of Metro between South Gosforth and the terminus at Bankfoot involved double tracking a previously single track freight line, thus bringing passenger service to an area of rapidly expanding housing and office development, where there is also some light industry. The high performance and frequency of Metro trains is such that they do not readily mix with the main line freight and passenger trains. It is fortunate that over much of the British Rail system converted to Metro, local passenger traffic predominated so other traffics had not to be accommodated. The only section where there is joint operation of British Rail and Metro trains is between Benton Junction and Bankfoot where two freight trains a day in each direction serve lineside factories. Elsewhere British Rail traffics have been provided for either by building new tracks or by modifying existing capacity. Specifically a new line has been laid parallel to Metro between Benton and Shiremoor to carry freight traffic between the main

London-Scotland line and areas to the North East of Tyne and Wear. On the south of the Tyne, Metro uses two tracks of the four-track section between Gateshead Stadium and Pelaw with British Rail trains being concentrated on the other two; eastwards from Pelaw as far as Tyne Dock where the new section begins significant British Rail freight traffic has been accommodated by dividing the previous double-track railway into two single-track lines, Metro having long passing loops through the stations. These provisions help to ensure service reliability for both operators by segregating trains with very different running characteristics.

Metro has been designed to be convenient, reliable, attractive and efficient. These factors have a major influence on its characteristics.

FEATURES OF THE SYSTEM

Physical and technical features of the system can be categorised under the headings:-

- Stations
- Rolling Stock
- Signalling and Control
- Power Supply, and
- Track

Stations

There were 26 stations on the previous British Rail system; these have been increased to 44 on Metro. Stations vary from the five underground stations in Newcastle and one in Gateshead (Fig. 2) to a number of small purpose-built wayside halts (Fig. 6). Interchange between bus and Metro as well as provision for the motorist is important, so five stations have specifically been built as interchanges with extensive bus provision and car parking. Parking is having to be extended at a number of locations because Metro is attracting a larger number of car-users than anticipated.

All stations are unmanned. Surveillance by closed-circuit television relayed to the Central Control Room is being extended from underground stations and interchanges to the system as a whole; public address is provided throughout and enquiry points allow passengers to speak to the Station Controller at the Control Centre.

Station finishes have been designed to be light and attractive and make extensive use of the corporate colours of yellow and white applied to vitreous enamelled wall panels which are durable and easy to keep clean. Station facilities vary from those at major stations where there are large ticket halls, sales points for season tickets and kiosks for the sale of newspapers and confectionery, to simple shelters and ticketing areas at the small halts. A number of stations north of the Tyne have been converted from old stations thus retaining the best of what was available but incorporating new facilities. Provisions have been made for the disabled throughout Metro, with lifts supplementing escalators at main stations, and ramped footbridges elsewhere.

The operation of station facilities and services such as ticket machines, ventilation systems, fire detection, lifts and escalators is monitored by an automatic remote control indication system which regularly scans equipment and notifies faults or difficulties at the Station Controller's desk.

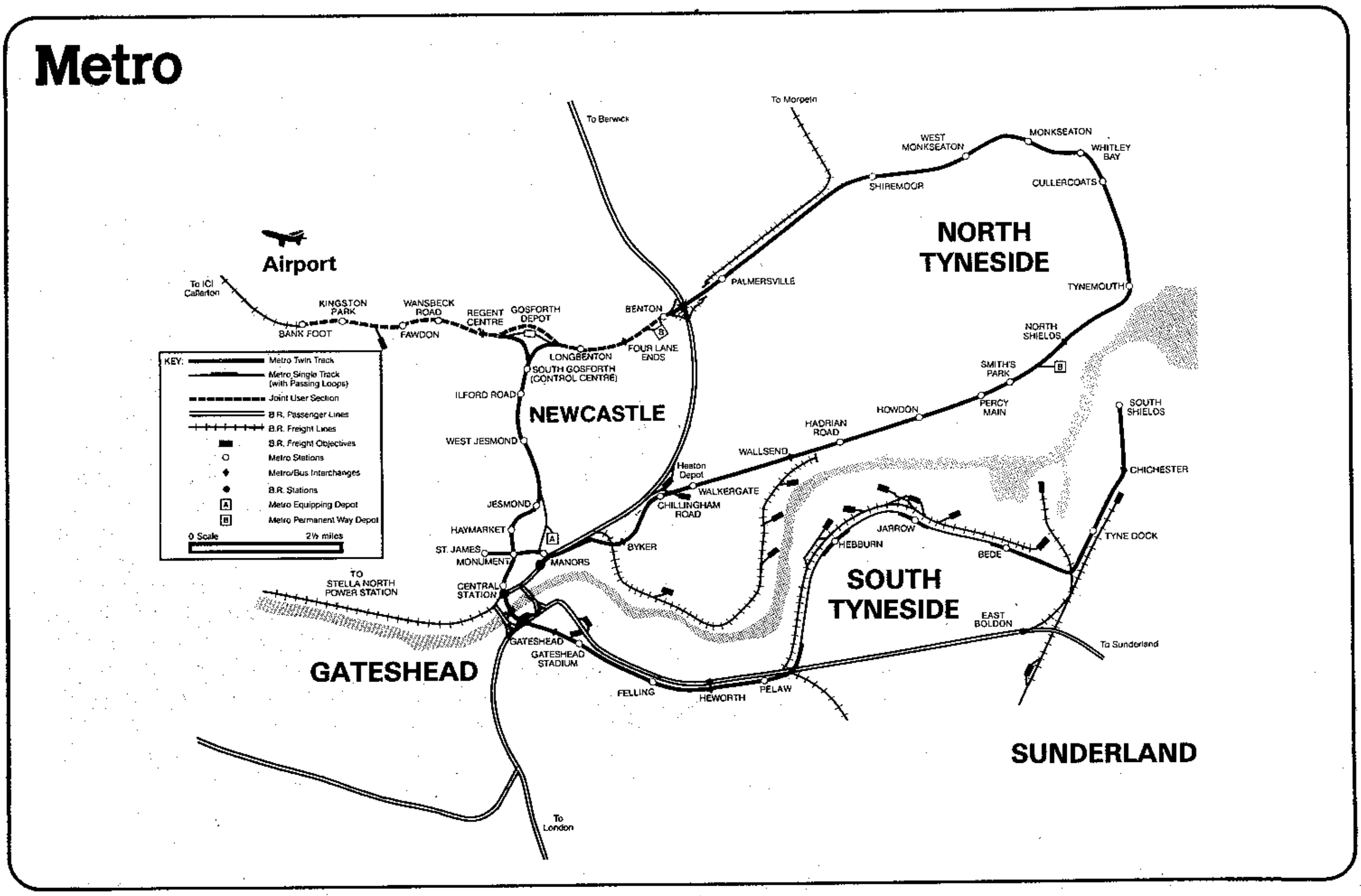


Fig. 5

Rolling Stock

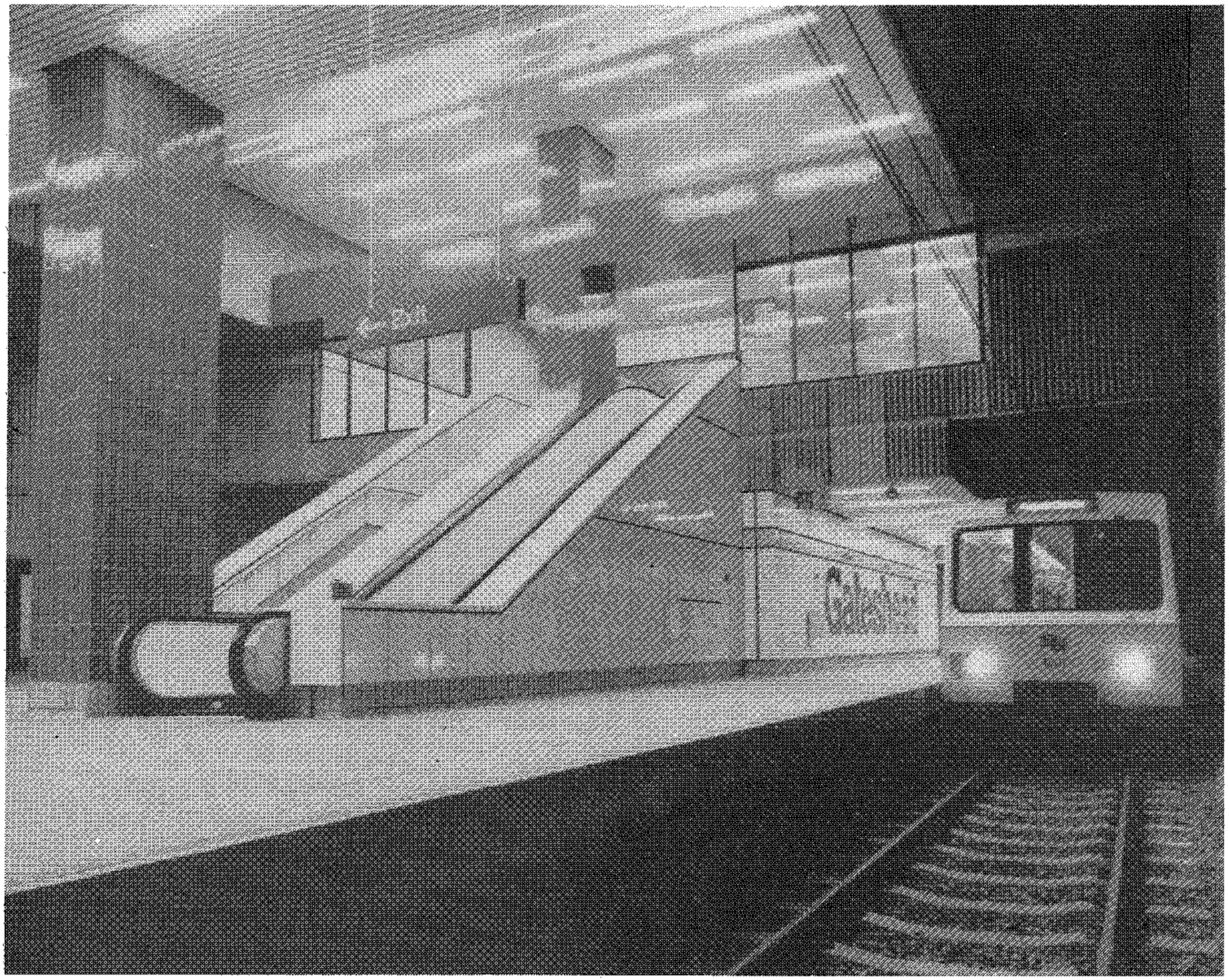
There are 90 passenger vehicles (Metrocars) (Fig. 7) which are a British derivative of the German Stadtbahnwagen B as used in Köln/Bonn. (Compare Canadian and United States use of the German U2). Each is a 27.4 metre long and 2.65 metre wide articulated vehicle with an unladen weight of 39 tonnes. The body units are of lightweight integral construction with a welded steel underframe, fabricated steel side frames panelled in aluminium and a roof/cantrail assembly of rivetted aluminium. Finishes have been designed to be attractive and easy to maintain. The flat floor is coved to the body sides and seat plinths for ease of cleaning. Passenger accommodation comprises seating for 84 arranged in facing pairs of ergonomically designed seats, upholstered in moquette. Generously dimensioned door bays and space in the articulation provide standee areas for the crush load capacity of over 200. The door-bay areas are also available for wheelchair passengers and prams, ease of boarding being assisted by the absence of steps from platform to Metrocar.

Pneumatically operated plug doors are released by the trainman but opened on demand by passengers; closure is by the trainman after the sounding of a warning tone, interlocks ensuring that the train cannot move off until the doors have been fully closed. Sensitive edges prevent passengers being trapped.

The trainman's cab occupies one third of the vehicle width at either end, placed on the nearside in the direction of travel. Access to it is by manually operated plug door from the outside or by hinged door from the passenger compartment. Controls include a combined power and brake master controller incorporating a 'dead man' device, radio, public address and positive train identification equipment which by means of a coded signal interfaces with the signalling system to route the train. Instruments comprise a speedometer, duplex air pressure gauge and fault annunciator.

Current is collected through a roof-mounted pantograph. Traction and rheostatic braking control is by oil/air campshaft developed from a British Rail application. A traction motor resiliently mounted longitudinally in each of the motor (outer) trucks, drives the axles via right angled gearboxes at either end of the armature and quill shafts. These motors are 4 pole self-ventilated compensated machines, continuously rated at 185 kW; they are wound for 750V operation but insulated at 1500V to ground. During motoring they are permanently connected in series; parallel connection is used during rheostatic braking.

Fig. 2 Gateshead Station



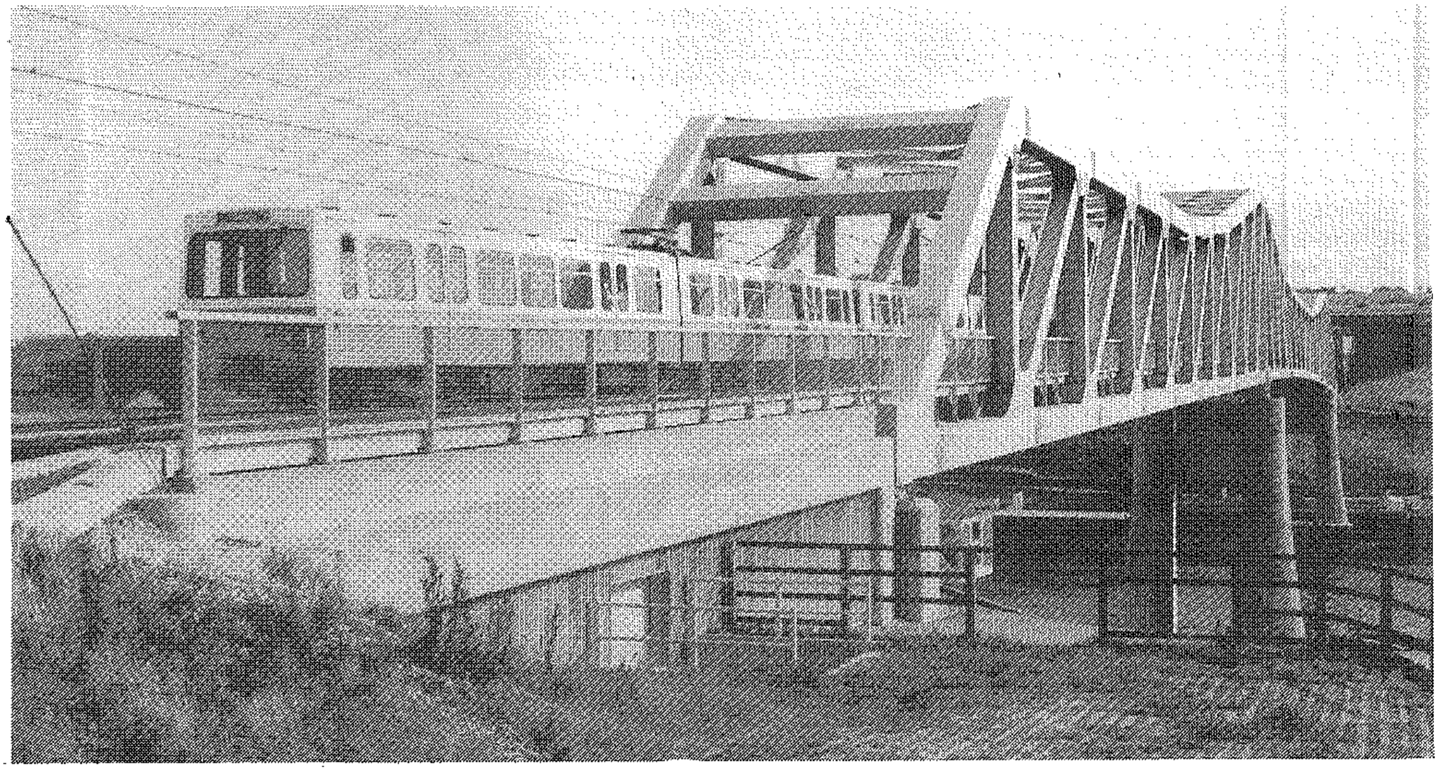


Fig. 3 Queen Elizabeth II Bridge

The brake equipment gives four rates of service braking, and emergency. Braking is normally a combination of rheostatic and pneumatic. Rheostatic braking operates between the maximum service speed of 80 km/h and 8 km/h and is blended with air braking on the trailer (centre) truck. Final breaking is by air brake alone but in the event of rheostatic brake failure, full service braking can be achieved by use of the air brakes. Two spring-applied air-released disc brake units are fitted to each trailing axle; one to each driving axle. Electromagnetic track brakes fitted in pairs to each truck, are availabe for use only in emergency.

Car suspension comprises resilient wheels with rubber inserts in compression between the steel tyre and wheel centre, chevron rubber primary suspension between axlebox and bogie frame and air suspension between trucks and car body. Air pressure is sensed as a means of load weighing to maintain consistent acceleration and braking rates between trains and between cars in a train. Wheel slip and slide sensing and control is also provided.

The normal train consists of two cars, with automatic couplers providing the air and electrical control connections between vehicles. Maximum speed is 80 km/h with an initial acceleration of 1m/sec^2 up to 40 km/h. Maximum service braking produces a similar rate of retardation, increased to 2.3m/sec^2 under emergency braking.

Engineers vehicles include five 427 HP 0-6-0 diesel electric locomotives incorporating exhaust gas conditioning equipment for use in tunnels and a range of bogie flat and ballast wagons.

Inspection, maintenance and repair is carried out at the rolling stock depot situated immediately to the north of the junctions at Gosforth.

Signalling and Control

Safety signalling is by two and three aspect colour light signals associated with high frequency a.c. track circuits. Inductive train stops located at every stop signal will actuate full emergency braking should a train overrun a signal. Thereafter the train can proceed at a maximum speed of only 30 Km/h until the next signal at clear is reached, when the trainstop will automatically be reset.

Train movements are monitored at an illuminated panel in the Central Control Room. There is provision for manual control of switches and signals but signal and route setting is normally automatic, with on-train equipment set up by the trainman transmitting running number (which is also the radio call sign) and route data via trackside transponders straight into the control computers. Nine local interlocking panels allow monitoring and control to be exercised 'on site' in the event of the failure of a link to the Control Centre. Train controllers can speak to trainmen on a dedicated radio frequency. Voice conversations are recorded and there is also a printout of key movement data.

The station controller is responsible for all station monitoring and control, using close circuit television and the remote control indication system which has already been described. Fault indications are immediately drawn to his attention and he can identify the precise location of a fault on his visual display unit to give accurate information to mobile inspectors or maintenace staff with whom he is in contact on separate radio frequencies. He, and the train controllers have a 'hot line' direct to the police and emergency services, and Metro has its own internal telephone system.

Electrical power control is located in the control room. The power controller has his own desk and can monitor the whole power supply network from substations downwards; he can also make control commands for remote equipment by keyboard. Equipment monitoring is via the remote control indication system which incorporates mimic diagrams, visual display units and hard copy data logging.

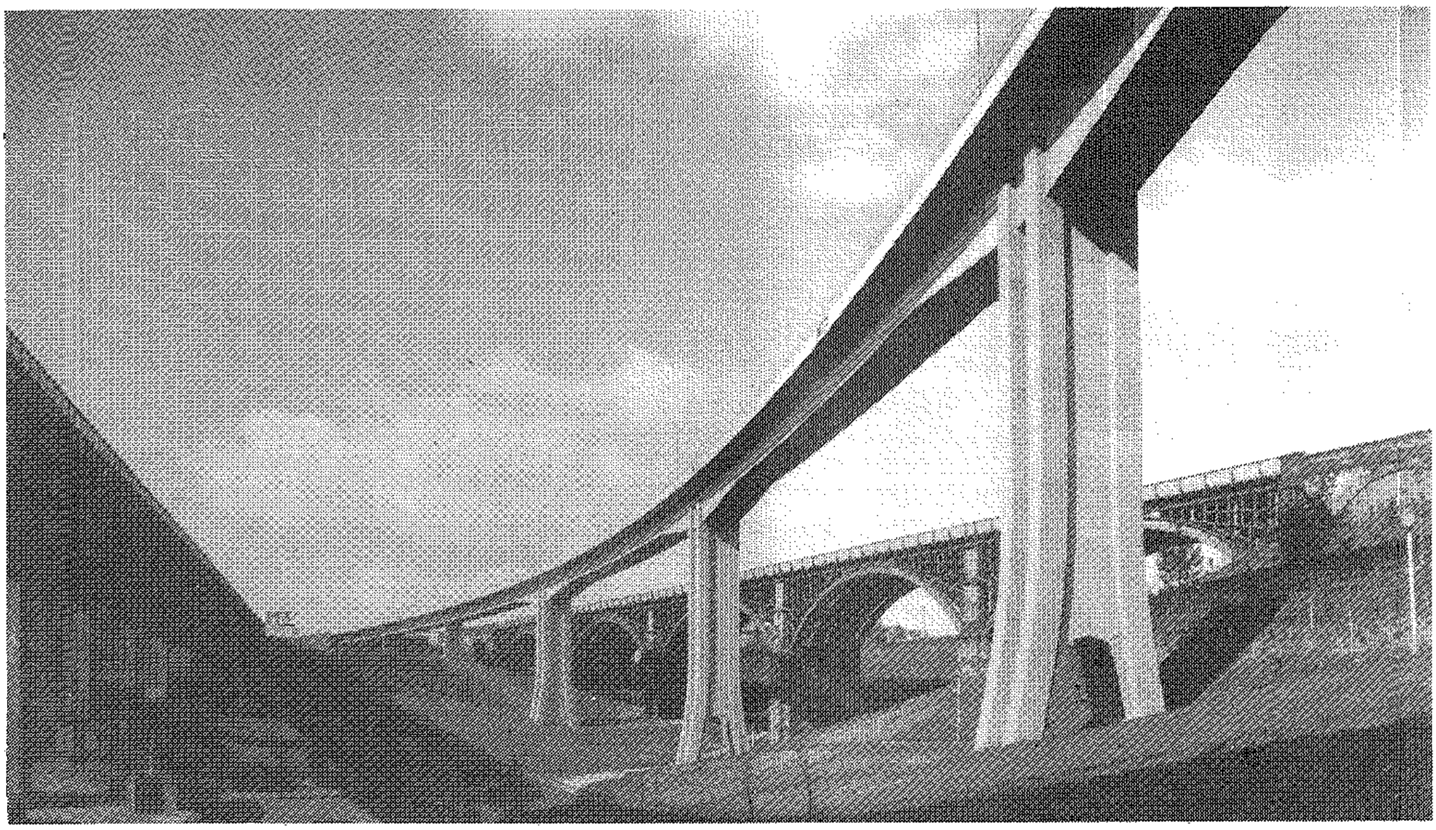


Fig. 4 Ouseburn Viaduct

Power Supply

Power to the trains is provided at 1500V d.c. from an overhead line; the choice of an overhead rather than a third-rail system being governed in part by the requirements of United Kingdom safety regulations for new electrified railways.

Power distribution is from nine substations rated at between 4.5MW and 2MW. The control area substations are supplied at 11 kV from a Metro primary substation fed at 33 kV via two 12/23 MVA system transformers from the national power supply network 132/33 kV bulk supply point. This Metro primary feeds the 3 × 1.5MW solid state rectifiers at each of the three traction sustations, and also eight underground passenger station substations by two-ring main circuits at 11 kV with inter-connections at 415V to ensure maximum security for station lighting. A third 11 kV ring main feeds the traction depot at South Gosforth, Regent Centre Interchange and the Control Centre.

The outer area traction substations have duplicate 11 Kv teed-feeders for the 2 × 1MW rectifiers from the nearest electricity board primary substation. These primaries are all fed from separate bulk supply points and in some cases derive their supplies from different 275 kV lines or generating stations. Each substation is equipped with a marshalling panel having a fault annunciator and passive mimic diagram, terminations for the supervisory system and a 125V battery charger cubicle.

The 1500V system is protected by high speed circuit breakers fitted with both direct acting series and timed overload units. These units, in conjunction with line current relays, where necessary, will cater for close-up and distant faults and persistent overloads and provide adequate discrimination between faults and train starting currents. The power system design enables operation to be maintained in the event of substation failure.

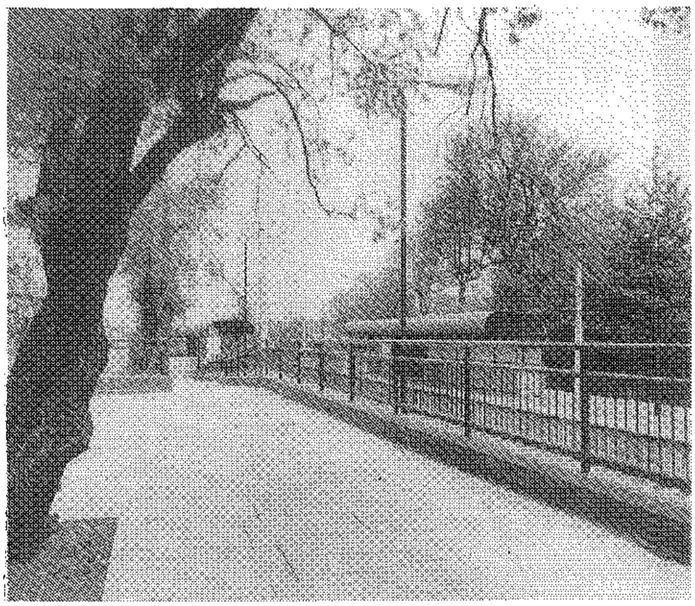


Fig. 6 Ilford Road Station

The overhead equipment uses standard British and European components and has been designed to minimise visual intrusion. Twin contact wires are used where clearances are tight, such as in tunnels and under bridges, also in surface stations where it is supported by spanwires. Elsewhere catenary with a single contact wire is the normal form of construction. A feature of the system is the use of irradiated silicone rubber insulators which are small and proof against vandalism.

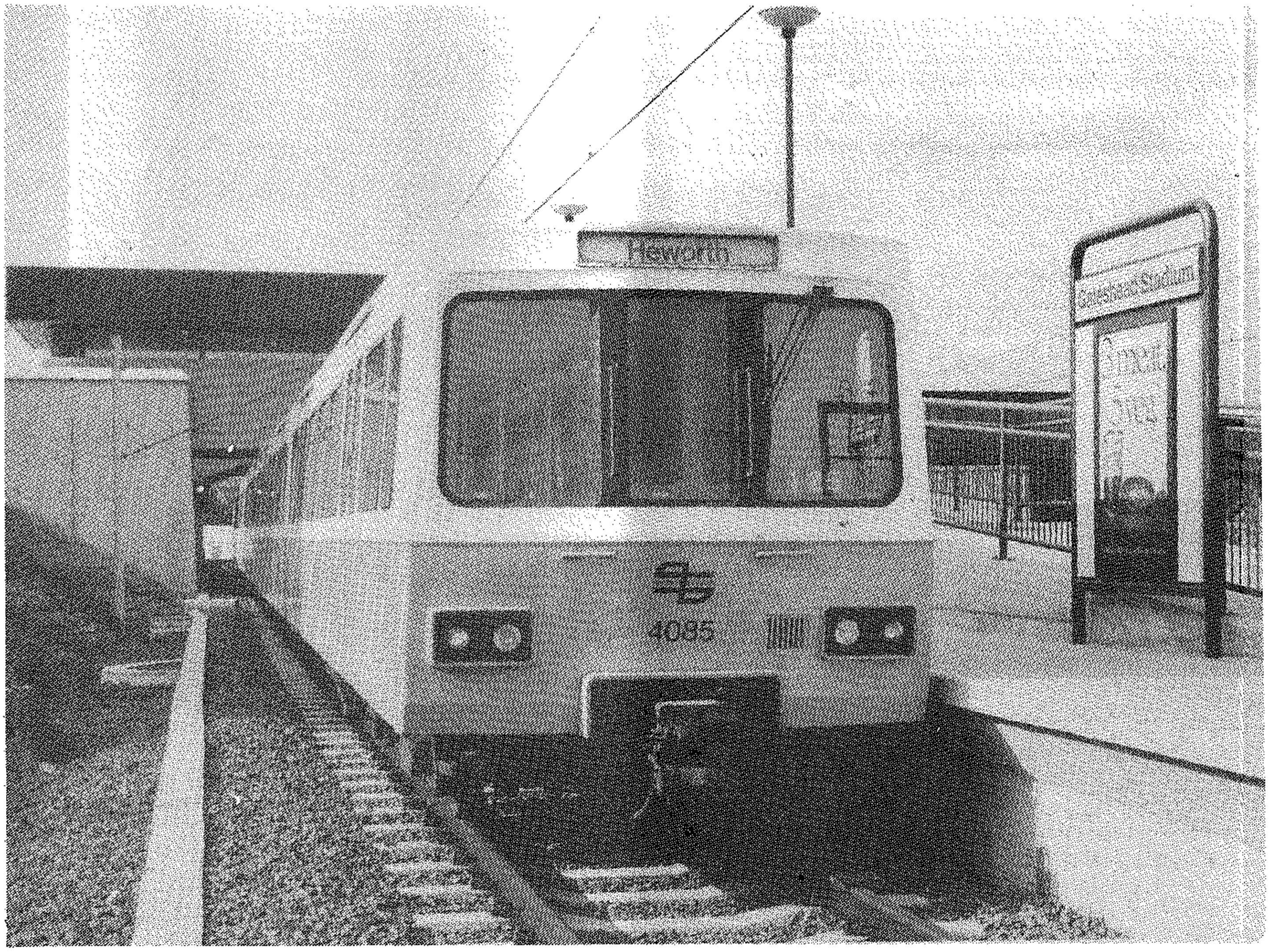


Fig. 7 Metrocars

Track

Metro uses standard British trackwork, principally continuously welded 54 kg/m flat bottom rail laid on concrete sleepers set in deep stone ballast. Track in the 4.75m diameter tube tunnels under Newcastle is laid on tied concrete block sleepers set in concrete, and to save weight on a continuous concrete slab over the Ouseburn Viaduct. Jointed track is used on the sharper curves together with high manganese rail where rapid railwear might otherwise take place. Track maintenance equipment includes a rail mounted ballast tamper, supplemented by a road/rail machine.

CAPITAL COST

Metro was built at a time of high inflation. The 1971 capital estimate inclusive of contingencies was £72 million ($150M) towards which Government awarded a 75 percent grant. The final out-turn price of £284 million ($596M) includes £9 million ($19M) for disabled provisions which were introduced after the original design was costed and three new stations costing £2 million ($4.2M). Stripped of inflation and comparing like with like the system has been built for 5 percent more than the original estimate, and this includes the effect of an eight month moratorium on awarding new contracts imposed by Government in 1976 at a time of severe national financial crisis.

At just over £5 million ($10.5M) per kilometre inclusive of rolling stock, Metro is a low cost system.

Grant rules changed over the period of construction with the result that the local area only received 65 percent grant from Central Government. This was to some extent offset by a £9 million ($19M) grant from the European Regional Development Fund. The balance of the cost has been met by local taxpayers as part of the overall investment in transport infrastructure.

INTEGRATION

Integration is a cornerstone of the Metro philosophy, as is its relation with highways, parking, traffic management and land use.

The Public Transport Network

The principle of public transport integration is that Metro, in the areas it serves, provides the backbone of the local public trasport system handling the heaviest flows by means of a fast, frequent and reliable service (Fig. 8). Bus services are restructured so as to feed Metro whilst at the same time meeting local travel needs - the consequent absence of specific rail-feeder services enables resources to be used to best advantage and buses to operate in areas which are relatively free from congestion. The higher average speeds and increased reliability so obtained are an added attraction to the transport system as a whole. In restructuring bus services the opportunity has been taken to eliminate parallel running whilst at the same time introducing new links which improve network coverage in an economical manner. Major benefits to road users have been the reduction of the number of buses in hitherto congested areas such as over the Tyne bridges and in central Newcastle and Gateshead.

Not all the county is served by Metro so steps have been taken to provide local services and fast bus links which as far as possible mirror the principles of the network in Metro corridors - 'Fastline' services using the main double-deck vehicles with high grade seating provide rapid, limited stop journeys between outer areas and major centres.

Highways

Metro was conceived as part of a total programme of road and public transport development which envisaged a high annual rate of investment. In the event road traffic and in particular car ownership whilst still increasing has not done so as fast as predicted. At the same time the availability of Government grant has tightened and strict controls are applied to local government expenditure. Environmental considerations also became more important.

These factors resulted in a reappraisal of the road proposals with the outcome that many urban freeway proposals have been discarded and other schemes postponed. By reducing the number of buses in central areas and at key river crossings the integrated network has eased congestion and made road space more generally available. Emphasis on bus priority is directed towards services from those areas which are not served by Metro.

The Motorist

Newcastle is the regional capital of a wide hinterland of North-East England. Parking supply in the central area is limited but demand is high, so the Council's pricing policy is aimed at encouraging the short-term parker whilst discouraging those such as commuters who wish to park for long periods of time. Car parks have therefore been provided at Metro interchanges and at or near other convenient stations, with provision for long-term free parking and for short-term (kiss and ride) parking.

It must again be emphasised that demand for facilities has been such that the number of parking spaces is now being increased at various locations.

PROVIDING THE SERVICES

Operationally, the Executive is not in a monopoly situation. It runs Metro, buses and a ferry service, with other bus services being provided by the National Bus Company (NBC) subsidiaries (Northern General Transport and United Automobile Services) and some private operators. British Rail operates local services between Newcastle and Sunderland as part of the integrated network and also other suburban services north and south on the East Coast Main Line and westwards.

In terms of bus mileage the NBC subsidiaries are the major bus operator, running some 60 percent of the services as compared with the Executive's 40 percent; however, the Executive's buses carry the greatest number of passengers thus reflecting their concentration in the more densely populated urban areas.

An Agreement with the NBC subsidiaries was essential to the creation of the integrated system. Under it the Executive carries out the conurbation function of financial and strategic planning, publicity and marketing, service planning and system monitoring, with operations being co-ordinated through a joint Management Committee.

Metro, all bus services and the local British Rail trains between Newcastle and Sunderland, together with the ferry at the mouth of the Tyne, are marketed as an entity with a unified timetable and common livery. Journey opportunities are further enhanced by a ticketing system, which is unique in the United Kingdom.

Fares and Ticketing

Tyne and Wear has a fully integrated ticketing system providing through facilities between bus, Metro and suburban rail. The system must therefore be considered as a whole.

The area has been divided into 32 fares zones (Fig. 9) each approximately 5km across. To overcome the traditional disadvantage of zonal fares systems whereby a short journey crossing a zone boundary incurs the financial penalty of a two zone fare up to the first 5km of travel can be sold in 1km stage but without the benefit of free transfer between vehicles. Transfers are available on all multi-zonal journeys.

Off-vehicles sales are an important means of increasing the convenience of the fares system and of speeding up bus journey times; also of reducing queuing time at station ticket machines. An extensive range of Traveltickets (season tickets) is available over a range of zones from two to the whole county area on an all-day or off-peak basis to give a total of almost 400 combinations. Individual tickets are available on a weekly, four weekly or annual basis and are associated with a photo identity folder (Fig. 10).

All through tickets are magnetically encoded for interrogation and where appropriate overprinting by the Metro station entry barriers. Single tickets which have a one and a half hour time validity are sold by change-giving multi-vendors (Fig. 11) at Metro stations which also code them; on buses pre-encoded magnetic ticket stock for transfer (Transfare) journeys is overprinted by the same machine used to issue paper flimsy tickets for journeys made only on the bus concerned. Passengers validate their transfer tickets by time-stamping them in a cancellor.

Five journey carnet tickets were in addition introduced in April. They are available from multi-vendors at Metro stations and major stores.

Season tickets, and also senior citizens' and disabled persons passes which are provided free by the County Council are issued at Travelcentres manned by transport staff located at main bus and Metro stations and other major transport centres. Key passes to enable parents with prams to use the special wide disabled gate at Metro stations in conjunction with a normal ticket are also available from these centres.

Roving teams of inspectors patrol Metro to provide revenue protection, overall surveillance and assistance to the public. Similar but separate arrangements apply on buses.

MANPOWER

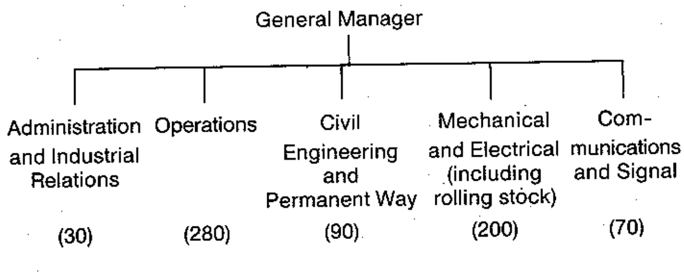
The basic concept of Metro was for an efficient and economic system with minimum manpower levels. These aims have been achieved and there is - in general - a high level of output which has been demonstrated by comparison with other systems.

The manpower implications of changing from a largely bus-orientated transport system to one in which rail plays a major part are significant. The concept of a 'total pool' of local public transport manpower was conceived within which transfer could take place to Metro by British Rail employees who would otherwise be made redundant by the replacement of the previous suburban services and by busmen (Executive and NBC) whose services would be reduced as Metro was progressively introduced. This meant breaking new ground as far as the Trades Unions were concerned. A comprehensive manpower policy based on standard hourly payments and co-ordinated negotiating machinery for Metro and bus staffs was agreed, giving good working conditions and a high level of flexibility and productivity. Metro opened on the planned date with the manning levels and practices which had been fundamental to the original concept.

Extensive training was necessary before the new system could be brought into use and it was first necessary to set up a training school and organisation to handle the work, with the assistance of local technical colleges and skill centres. Financial assistance was provided by the European Social Fund and the Metro Training School now provides courses for overseas organisations.

METRO ORGANISATION AND SERVICE

Metro is run as an operational and engineering entity within the Executive's organisation. Finance, marketing and planning are common services. Its structure follows a typical railway pattern under a General Manager who reports to the Executive.



The breakdown of the 670 staff is shown in parenthesis under each department. The civil engineering and permanent way figure is larger than strictly necessary for Metro alone as the section provides a civil engineering service for the Executive's bus operations as well.

The Metro engineering organisation undertakes all routine maintenance and repair functions but some tasks are put out to specialist firms, particularly where an 'in-house' facility could not be justified, for example the rewinding of rotating electrical machines. In other areas Metro's costs are tested against those of outside suppliers with the result that the direct labour organisation is responsible for only a proportion of station cleaning and ticket machine maintenance.

There is close working with British Rail, who provide certain specialist back-up including periodical track alignment checking, using one of their purpose-built vehicles, to supplement Metro's manual methods. Contractors are used for major track renewal programmes to supplement the resources of the permanent way section.

High frequency characterises Metro services, which start on a basic ten-minute headway on two of the four services at 0500 and continue until the last train returns to depot just after midnight. Supplementary short-working services between Benton and Pelaw and between St. James and North Shields operate between 0650 and 1900 to provide 3⅓ and 5 minute headways respectively north-south and east-west across Newcastle and the most heavily trafficked sections of the system. 37 trains are needed to provide the peak service.

THE RESULTS

Metro has been progressively introduced since August 1980 with the highlight being the official opening by Her Majesty The Queen accompanied by Prince Philip in November 1981 when Metro was extended south from Newcastle to Heworth.

Metro's achievements cannot be wholly separated from the performance of the integrated public transport system as a whole, and it would be misleading to do so. This section will therefore consider the performance of the total system in terms of passengers and operating factors and go on to comment on certain aspects which are specific to Metro.

Rather than give an operator's perception of the results, recourse can be had to data and comparisons prepared by others. Principal amongst these is the Metro Monitoring and Development Study undertaken by the Government's Transport and Road Research Laboratory and Newcastle University with the assistance of the Executive and the (then) Tyne and Wear County Council. There are also the comparisons of performance of Metropolitan Railways prepared by the International Metropolitan Railways Committee of UITP, and some figures produced by Greater Manchester Passenger Transport Executive.

Passengers

Since 1974 the area has suffered from population decline, increasing car ownership and rising unemployment resulting from the continuing run-down in traditional industries and general economic recession, to the extent that over 30 million journeys a year could have been lost to public transport: indeed over the country as a whole urban public transport lost 25 percent of patronage over the period.

The local figure has increased from 282 million passengers a year in 1974, before integration, to 316 million in 1985. This increase of over 12 percent is attributable to the introduction of Metro and to the integrated network which has been built round it, with through ticketing and comprehensive, aggressive marketing. Within this total it is significant that Metro accommodates some 52 million journeys, 16 percent of the total as compared with the 5 percent contribution made by the railways it replaced.

Accessibility

A key feature of the integrated network has been to improve accessibility across the area as a whole, whether by Metro alone, by Metro and bus or by the express bus services and better connections provided in areas not served by Metro.

The number of people living within 30 minutes by public transport of Newcastle city centre has increased by over 35 percent from 330,000 to 450,000. Overall there has been a 7 percent reduction in public transport journey time over the area as a whole; 17 percent where Metro is used for all or part of a journey with some significant time savings such as 35 minutes from the extreme North West to the South East. The average longer-distance journey is ten minutes faster than before.

These benefits have been enjoyed by people using public transport for work, shopping, educational and leisure journeys.

Road Traffic Conditions

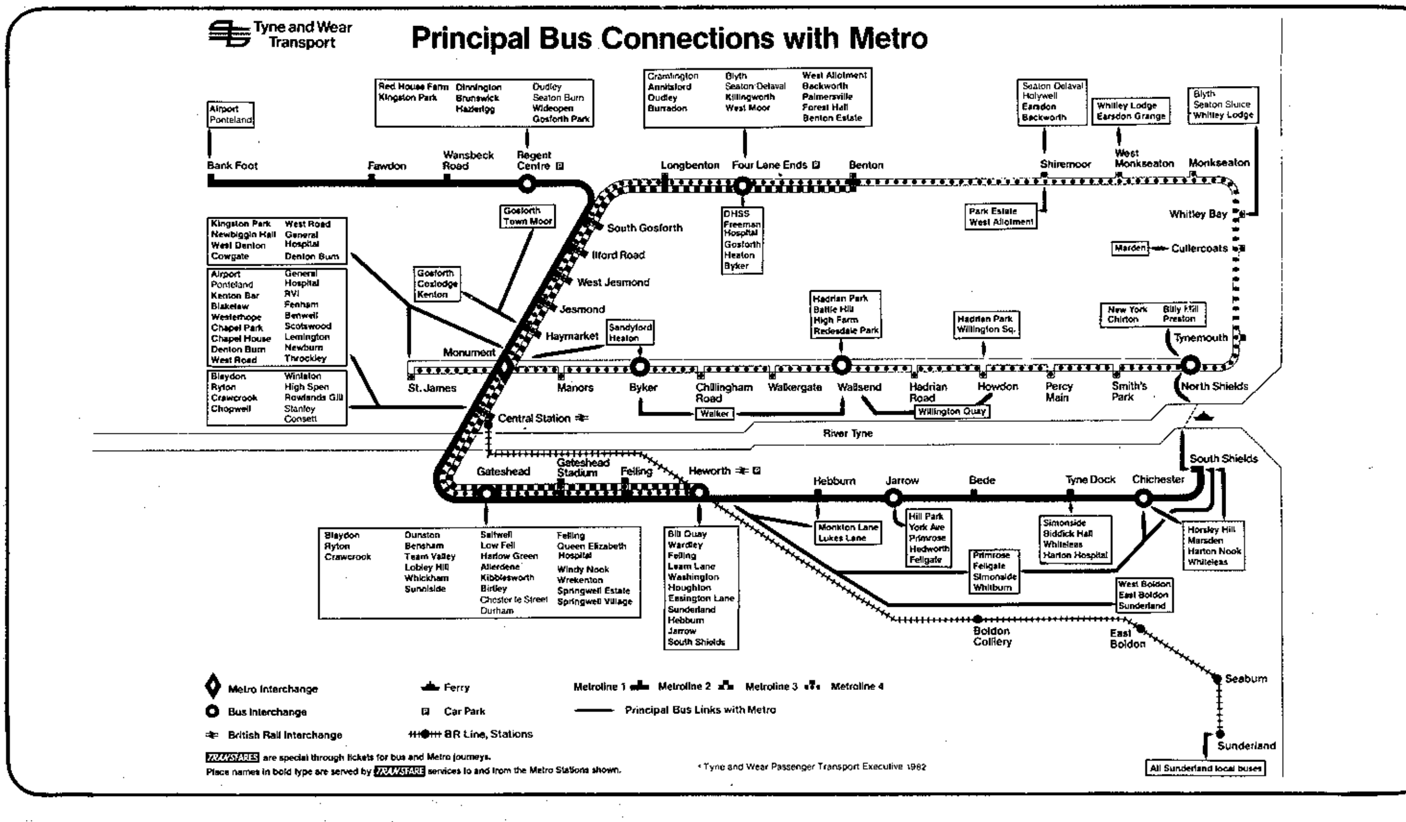
Metro has brought about a significant reduction in the number of buses in the congested centres of Newcastle and Gateshead and on the Tyne Bridges. This has allowed streets to be made over to pedestrians and, to some extent, buses from 'non-Metro' areas and at the same time has improved road safety and general traffic flow. It has prolonged the period when existing streets can handle traffic and has thus reduced the need - and cost - of new roads.

DEVELOPMENT

Metro is helping to make residential areas adjacent to it more attractive which is reflected in higher prices. Retail activity in central Newcastle has been boosted by the accessibility it provides and the most sought-after sites are adjacent to Metro stations. There has been a resurgence of what had been a run-down area adjacent to Newcastle's Haymarket station and contrary to the fears of some, district shopping centres have not lost out to the centre. Significant shopping developments have taken place adjacent to Gateshead and North Shields Metro stations and there has been a general uplift of shopping in South Shields.

Industrial development is proceeding slowly at present, but several firms opening new factories have chosen sites adjacent to or easily accessible from Metro. Nissan, the most significant newcomer, has built its factory with main road and rail communication as a high priority but with the benefit of integrated bus services to Metro.

Fig. 8



ECONOMIC PERFORMANCE

Metro has resulted in an overall saving in public transport operating costs after taking account of different bus and suburban rail costs resulting from its introduction. The overall flow of benefits is as follows:-

Benefit (+)/Cost(-)	£m p.a.	£m p.a.
Public Transport Operation		
Bus Operating costs	+ 12.50	
Metro Operating costs	- 14.90	
BR Operating costs	+ 9.20	
Revenues	+ 7.93	+ 14.73
Passenger Time		
Existing users	+ 12.34	
Generated traffic	+ 2.02	+ 14.36
Community Benefits		
Accident costs	+ 0.28	
Highway user costs	+ 0.48	+ 0.76
Total		+ 29.85

These give a first year rate of return on the net capital cost of Metro of 8 percent.

Tyne and Wear's public transport system cost £109 million ($229m) a year to run in 1985/86, of which £78 million ($164m) was met through fares including concessionary fare payments by local authorities for travel by the elderly and disabled. The remainder of the cost was met by subsidy recognising the overall contribution public transport makes to the area.

The relative cost per passenger km between the various modes is:-

	p.	c.
Metro	4.9	(10.3)
BR suburban	5.2	(10.9)
Bus	5.6	(11.8)

and public transport is well used in the area as compared with other European cities.

Tyne and Wear Transport Compared with Other Undertakings

Location	Use of public transport (km/person/year)	Passenger km/ per employee ('000)
Tyne and Wear	1590	255
South Yorkshire	1080	190
Merseyside	1020	189
West Midlands	870	249
Koln	800	260
Dusseldorf	760	222
West Yorkshire	760	140
Greater Manchester	650	148

The table also shows the transport system as a whole to be efficient.

Metro is itself efficient, when compared with other urban railways. The Metropolitan Railways Committee of the International Union of Public Transport regularly makes comparisons of statistics between member undertakings. These have been refined over the years to overcome the inherent difficulties of international comparisons. The 1985 results compared nine undertakings, including London, Paris, Madrid and Lisbon, from seven European countries and produced the following indices:-

	Train km/ Operating Cost	Train km/ Maintenance Cost
Best	870	679
Worst	100	100
Average	295	334
Metro	870	572

46 percent of operating cost is represented by wages, compared with over 60 percent for a typical British bus undertaking. The next highest single item is 22 percent for electrical power.

Fig. 9 Fare Zones

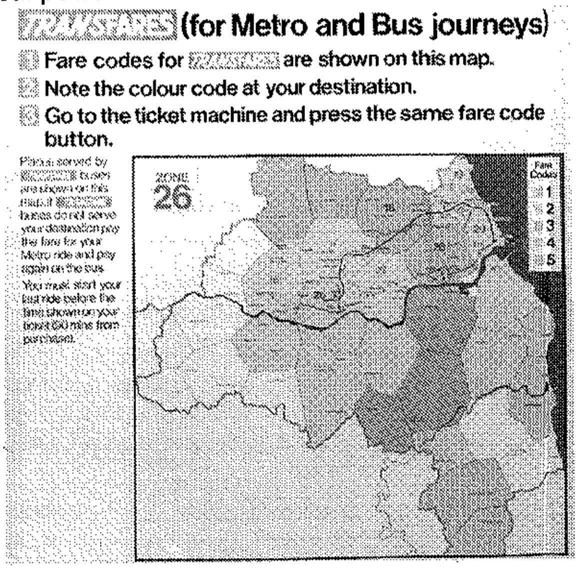


Fig. 10 Travelticket

Fig. 11 Metro ticket issuing machine