CLYDE TUNNEL

This drawing is based on Ordnance Survey Map - Glasgow Sheet 60

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CORPORATION OF GLASGOW.

CLYDE TUNNEL.

The twin tunnels which together constitute the Clyde Tunnel were constructed in order to reduce traffic congestion at the bridges over the River Clyde in the centre of the City of Glasgow, and also to provide the downstream river crossing for a proposed north/south route through the western half of the City. The first tunnel was opened on 3rd July, 1963 and initially some 18,000 vehicles per day used this under-river crossing. The second tunnel was opened on 23rd March, 1964 and already traffic flow has reached about 27,000 vehicles per day.

The length of each tunnel from portal to portal is about 2,500 ft. of which about 2,250 ft. represent the length of driven tunnel. The tunnel portals were constructed in cofferdam and the South Portal of the tunnels was extended as a reinforced concrete tunnel built in cut-and-cover to a total length of about 200 ft. The portals also provided the foundations for the North and South Ventilation Buildings.

The tunnels were constructed to a nominal internal diameter of 29 ft. with a primary lining of cast iron rings of 29 ft. 6 in. internal diameter. Each tunnel has a 22 ft. wide carriageway for vehicular traffic and at a lower level a subway for pedestrians and cyclists. The general grade of each tunnel is 1:16 with horizontal and vertical curves of about 3,000 ft. radius. The tunnel approaches at present connect to Dumbarton Road and Govan Road running westward from the City on the north and south banks of the river respectively. Provision was made for ultimate connection with the Main Tunnel Approaches, the construction of the southern one being due to commence shortly.

The tunnels and approaches were surfaced in mastic asphalt with road heating provided in the open sections of the work.

The River Clyde is 315 ft. wide downstream of the tunnel and 420 ft. upstream. At its present dredged depth of about 34 ft. below Ordnance Datum, 21 ft. of cover remain above the crown of the tunnel though this may subsequently be reduced to 10 ft. The river has a tidal range of about 12 ft. at spring tides.

GEOLOGY/

GEOLOGY AND GROUND TREATMENT:

The ground through which the tunnels had to be driven consisted of sandstones and shales of carboniferous age overlain by variable glacial and alluvial deposits. Ground of such a varying nature presented considerable difficulties to tunnelling, and it was necessary to carry out ground treatment in several sections of the work.

This treatment normally consisted of the injection of clay-cement grouts and alumina silicate grouts where the ground was water-bearing and too coarse to hold satisfactorily the compressed air in which the tunnels were driven.

On the south drives a mound of glacial gravel (probably an esker) opposite the main gates of Alexander Stephen & Son, was encountered during the tunnelling and was satisfactorily dealt with by forming a hollow box about 150 ft. long, with treated ground forming the four sides of the box; further treatment in the dome formed the lid and the underlying shale and boulder clay were utilised to form the base. These treated walls were nominally 10 ft. thick and driving was facilitated by carrying out a certain amount of pumping from the gravel during driving in order to limit the air pressure in the box.

TUNNEL DRIVING:

The main working shafts situated near the south bank of the River Clyde were about 100 ft. deep, 18 ft. internal diameter and sited about 40 ft. apart. All the tunnels were driven in compressed air and a compressor house on the surface provided a maximum demand of 28,500 cubic feet of air per minute at a maximum pressure of 40 lb/square inch. As a safeguard against simultaneous failure of two sources of electrical supply, 3 diesel driven generators could supply power to ensure 8,000 cubic feet of air per minute.

The full length of the first (West) Tunnel and the greater part of the length of the second (East) Tunnel were preceded by a 12 ft. diameter pilot tunnel from which a certain amount of ground treatment was carried out. Each main tunnel shield was erected in a shield chamber and driven towards a tunnel portal, where it was dismantled on completion of the drive under cover of a reinforced concrete collar formed by an extension to the portal. The shields were advanced by 40 rams which could each develop/

develop a maximum shove of 125 tons and the shields were also equipped with 56 platform and face rams. The cast iron lining was erected by a hydraulically operated erector arm attached to the shield. Each shield towed a travelling platform fitted with conveyor belts for loading the spoil into wagons, mechanical equipment for grouting and hydraulic pumping together with a roller table for handling tunnel segments.

All of the main tunnels were driven in shield with the exception of about 400 ft. of the East Tunnel where rock predominated beneath the river. This length was hand-mined and the additional shield chamber was constructed at its northern end under mid-river.

APPROACH WORKS, PORTALS AND REINFORCED CONCRETE TUNNEL:

All approach and portal works with formation level below the water-table were constructed in sheet piled cofferdams. The portals and reinforced concrete tunnels were built as massive box structures and the approach roads, below the water-table, were constructed between cantilevered retaining walls which incorporated, where required, a rectangular subway for pedestrians and cyclists; these structures resisted the upward vertical reaction from the ends of the interconnecting road slabs. The retaining walls were built in lengths of 22 ft. with intervening gaps 3 ft. wid which were subsequently filled with concrete to form a feature of proje ting pilasters.

Above the water-table the pedestrian and cycle ways emerge into open cut and these parts of the works were cast separately from the carriageway slabs, which were formed in bays 25 ft. wide by 20 ft. long with a central warping joint. The portal blocks were constructed monolithically and contained the carriageways, air ducts connecting the overlying Ventilation Buildings to the tunnels, stairs for pedestrians to gain access to the subways and passages to connect the pedestrian and cyclists' subway from the central position occupied in each tunnel to the position at the base of the retaining walls.

INTERNAL CONSTRUCTION OF TUNNELS:

Particular attention was paid to the design of the internal lining to the Clyde Tunnel, not only from consideration of appearance, but also

to/

to intercept any seepage through the primary lining.

A novel form of internal lining was adopted consisting of rigid sheets of P.V.C. secured to a framework of extruded section aluminium alloy members. Embossed aluminium alloy sheets were used for the false ceiling. The reflectivity from these materials considerably contributed to the appreciably high intensities of lighting attained on the vehicular carriageway.

VENTILATION BUILDINGS:

The Ventilation Buildings above each portal consist of steel framed structures clad in brickwork, aluminium sheeting and glazing. All ducts for ventilation emerge from the roof, with a chimney at each portal for the exhaust discharge.

The North Ventilation Building accommodates a Control Room for the centralised operation of the tunnel; each building incorporates an annexe to house switchgear and transformers.

ELECTRICAL SUPPLY:

Two electrical supplies from different sources are fed into small sub-stations at each end of the tunnel. The sub-stations contain H.T. switchboards of 6.6kV and 11kV capacity, supplying transformers and 415 volt 3-phase L.T. switchboards from which all the tunnel services are supplied.

In the event of a failure of either power supply, provision is made in each section of the L.T. switchboards for automatic changeover of supply to restore essential services, for example lighting, control instrumentation and fan dampers.

VENTILATION PLANT:

The ventilation of the tunnels is by an upward transverse system up to 50% of maximum supply and thereafter a semi-transverse system. The supply fans for each tunnel have a capacity of 500,000 cubic feet per minute and the exhaust fans for each tunnel 250,000 cubic feet per minute, the difference at high inputs being exhausted through the portals.

Each/

Each ventilation building houses six supply and three exhaust centrifugal fans including 50% standby capacity. Between each fan and atmosphere the air passes through a silencer of the cavity resonator type. At the tunnel nadirs, axial flow booster fans are installed taking air from the pedestrian and cycle way for delivery to the main supply ducts. Fresh air from these ducts is led to roadway level and passes through trilles in the walkway slabs immediately above kerb level. Exhaust air from the tunnel is drawn up through grilles into the exhaust duct above the false ceiling to the carriageway.

CARRIAGEWAY LIGHTING:

Over the major length of the tunnels, lighting of the carriageways is provided by 5 ft. 80 watt hot cathode fluorescent tubes spaced at 9 ft. centres. Over a length of 350 ft. from each portal 8 ft. 125 watt tubes are installed, the number per fitting increasing from 1 to a maximum of 4 at the portal.

Four-stage light level reconciliation units are provided at each end of the tunnel which automatically control the circuits to the additional tubes in these fittings in response to daylight conditions, and incorporate a time delay to obviate frequent changing due to cloud formation.

By this means, under conditions of bright sunshine, the lighting intensity is graduated from a maximum of 60 lumens per square foot at the entrance to 7 lumens per square foot over this transition length. At night, the entrance and main tunnel lighting are reduced to 7 and 2.5 lumens per square foot respectively.

TUNNEL MONITORING EQUIPMENT:

At third points throughout the length of each tunnel, visibility and carbon monoxide measuring units are provided by which the atmospheric conditions are continuously recorded by instruments situated in the tunnel Control Room. The maximum permissible CO concentration permitted is 250 parts per million and an alarm system operates when this figure is approached. To satisfy visibility requirements, CO concentration is normally below 70 p.p.m.

Electro-magnetic/

Electro-magnetic counting loops at the ends of each tunnel record the passage of vehicles, and summation and density metering equipment for this purpose is provided in the Control Room.

A fire alarm and a telephone are provided at hydrant points on each side of the carriageway every 300 ft. throughout each tunnel. The fire alarm system in the tunnels is directly connected to the two nearest fire stations, one on the north side and the other on the south side of the river.

Since the Control Room is situated overlooking the North Approach, a closed circuit television system is provided with the camera scanning the South Approach. It has also been decided to incorporate additional closed circuit television facilities for observation of traffic conditions within both East and West Tunnels.

ROADWAY HEATING:

The approach roads to the tunnel are provided with a low voltage heating system using expanded metal sheets buried beneath the mastic asphalt road surface. The mats in each approach are linked together into three separate sections, each section being fed from its own 6.6kV/11kV/66 volt 3-phase transformer.

These transformers are energised from the main H.T. switchboards where the relay-operated circuit breakers are controlled from air and road surface temperature and moisture detection equipment situated in the approaches. This installation produces approximately 10 watts per square foot of road surface.

TUNNEL CONTROL:

From the Control Console situated in the Control Room, the operation of every service is either indicated or controlled through a 50 volt D.C. battery-fed system. Together with the tunnel conditions equipment and the fire alarm console, also accommodated in the Control Room, provision is made for complete automation of tunnel operation. For example, should the CO concentration in the tunnel rise above the permitted level, the speed of the ventilation fans is automatically stepped up and remains at that speed until the carbon monoxide content has fallen to a safe level of concentration.

TUNNEL DRAINAGE:/

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Drainage sumps are provided at each portal and at the nadir of each tunnel with electrically driven pumps, automatically controlled by an immersed electrode system incorporating alarm circuits in the event of sump flooding.

TRAFFIC CONTROL:

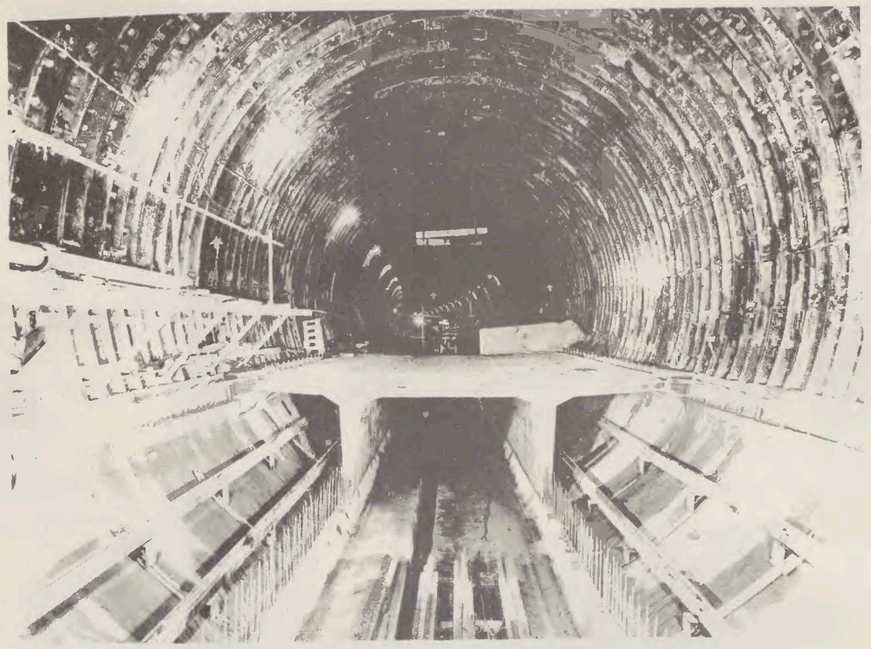
A height gauge is installed at the commencement of each approach road consisting of a light projector and receiver set at a height of 15 ft. 6 in. above road level. Should the light beam be broken by an overheight vehicle, traffic signs are illuminated which direct the vehicle to an "escape" lane.

Traffic control signals at the portals and at third points through the tunnels may be operated remotely from the Control Console or automatically in conjunction with the fire alarm system following an alarm call. In the latter case, the circuits are arranged so that approaching traffic is halted before it reaches the zone of a fire, but are also arranged to ensure that there is no interruption to flow of traffic which has already passed the fire.

The total cost of the Clyde Tunnel was about £10,500,000. Work commenced on 1st July 1957 and the West Tunnel was opened to traffic by Her Majesty the Queen on the 3rd July 1963, followed by the opening of the East Tunnel on 23rd March, 1964.

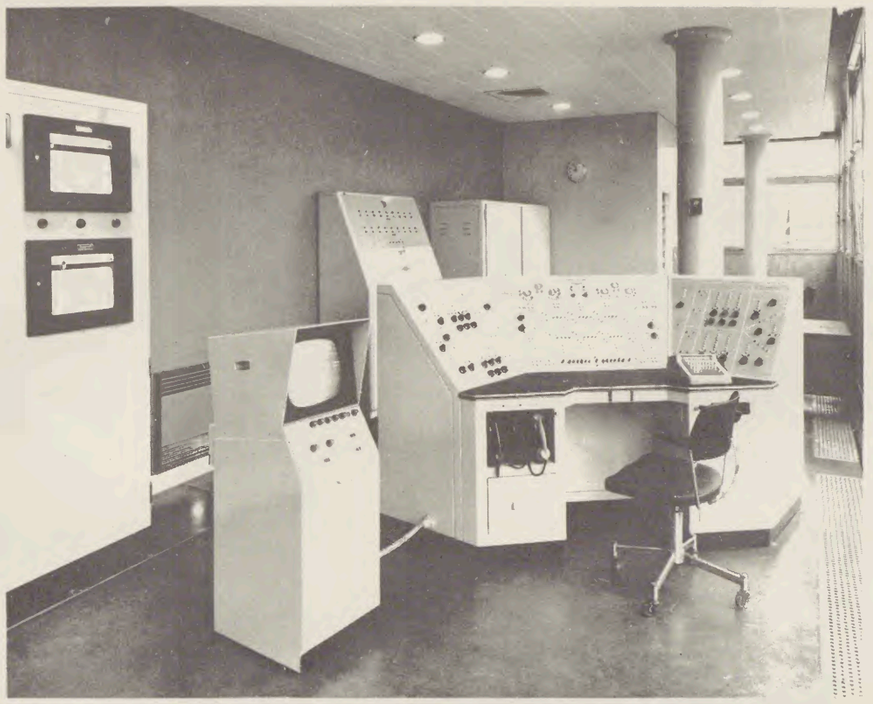
The Clyde Tunnel was constructed for the Corporation of the City of Glasgow (Master of Works and City Engineer: John Armour, M.I.C.E., M.I.Mun.E.)

Engineer	:	Sir William Halcrow & Partners.
Main Contractor (including Ventilation Buildings).	:	Messrs. Charles Brand & Son, Ltd., London.
Ventilation Plant Contractor	:	Messrs. James Howden & Co., Ltd., Glasgow.
Electrical Services Contractor:	:	Messrs. James Scott & Co., Ltd., Glasgow.

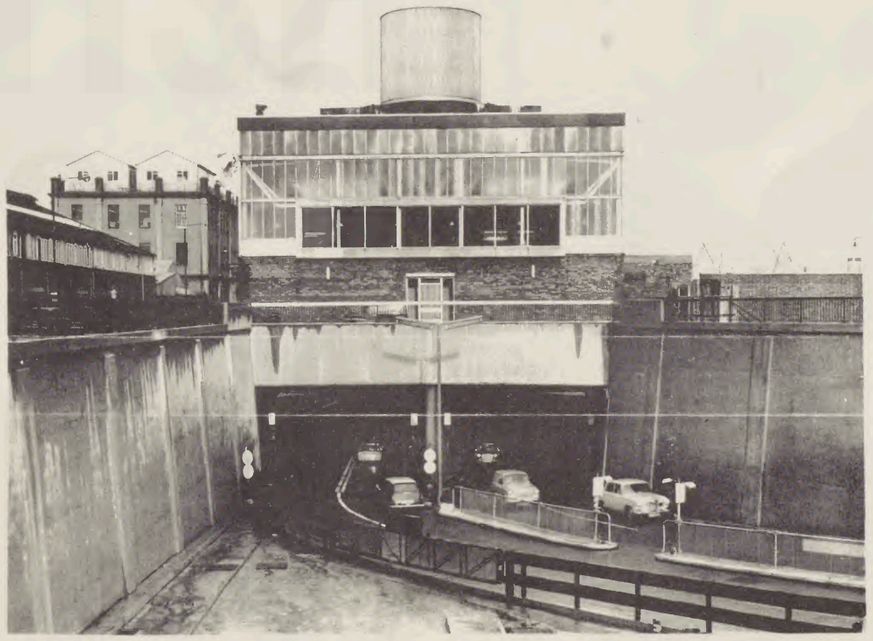


View of West Tunnel under construction.

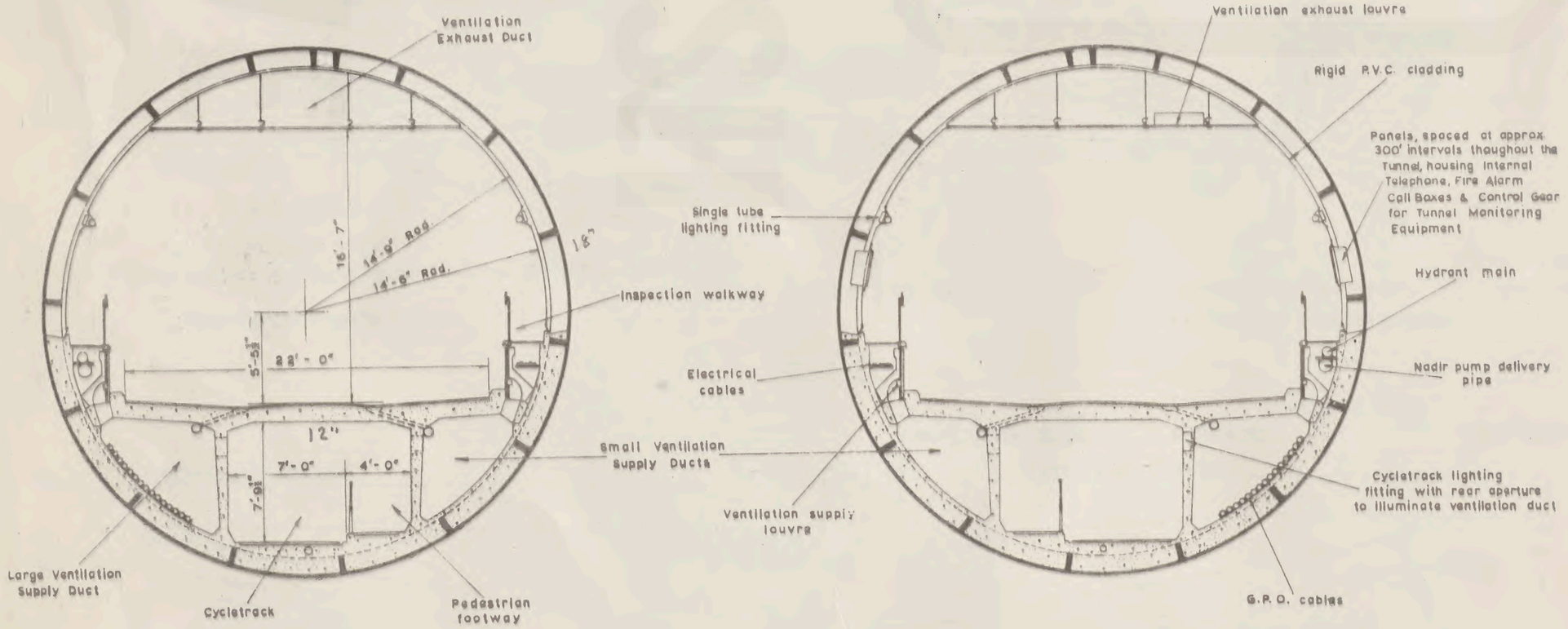
View of completed West Tunnel.



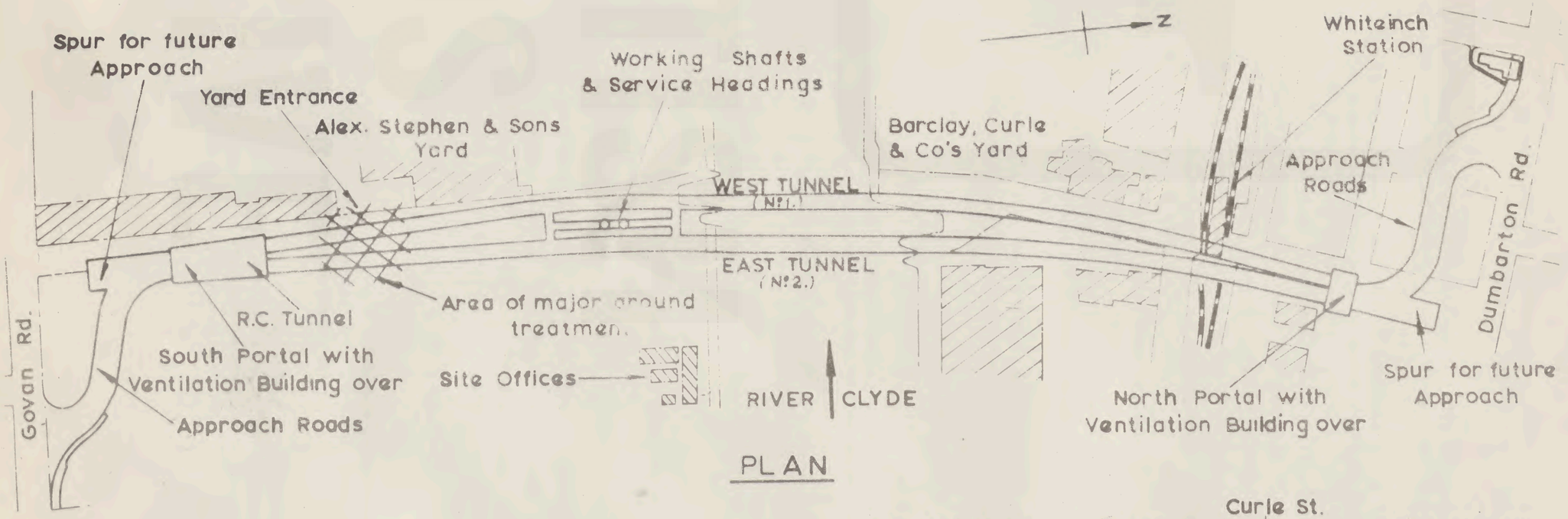
View of Control Room



South Ventilation Building and South Portal.



CLYDE TUNNEL CROSS-SECTION



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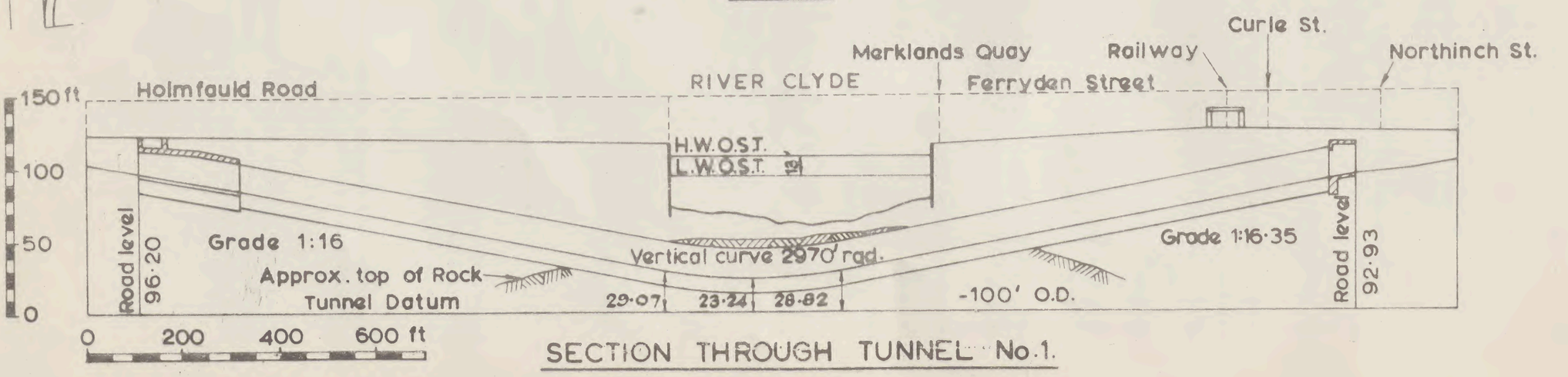


SECTION THROUGH TUNNEL No.1.

BYELAWS FOR THE REGULATION, CONTROL AND PROTECTION OF THE CLYDE TUNNEL AND OF PERSONS USING SAME AND FOR THE MANAGEMENT, REGULATION, DIRECTION AND CONTROL OF TRAFFIC USING THE TUNNEL.

The Corporation of the City of Glasgow in exercise of the powers conferred upon them by section 42 of the Glasgow Corporation Order, 1948, hereby make the following byelaws, viz. :—

(1) In these byelaws, unless there is something in the subject or context repugnant to such construction, the following words and expressions shall have the meanings hereby assigned to them, that is to say :—

"carriageway" means the portion of the tunnel constructed for the use of motor vehicles.

"the Corporation" means the Corporation of the City of Glasgow.

"cycle track" means the portion of the tunnel constructed for the use of pedal cycles.

"footpath" means the portion of the tunnel constructed for the use of pedestrians.

"motor vehicle" has the meaning assigned to it by section 253 of the Road Traffic Act 1960.

"police offence" has the meaning assigned to it by section 3 of the Glasgow Corporation Order 1948.

"traffic officer" means any person appointed or authorised by the Corporation to regulate, supervise and control the operation of the tunnel and the use of the tunnel.

"traffic sign" has the meaning assigned to it by section 51 of the Road Traffic Act 1960.

"the tunnel" has the meaning assigned to it by section 3 of the Glasgow Corporation Order 1948.

"the tunnelmaster" means the person appointed for the time being by the Corporation as tunnelmaster.

(2) The carriageway shall be used by motor vehicles only ; the cycle track shall be used by persons pushing or riding pedal cycles only and the footpath shall be used by pedestrians only.

(3) (*a*) No person shall take into the tunnel any animal (other than a dog) unless such animal is conveyed in a motor vehicle, or carried in a basket or other container on the footpath.

(*b*) No person shall take a dog into the tunnel unless such dog is conveyed in a motor vehicle or is on a lead or chain or carried in a basket or other container on the footpath.

(4) Every person driving a vehicle shall

(*a*) comply with the directions given by any traffic sign, or

(*b*) stop such vehicle or make proceed in or keep to a particular line of traffic or switch off the engine of such vehicle when directed to do so by a police constable or traffic officer.

(5) No person shall drive into or through the tunnel any motor vehicle

(*a*) the overall height of which (with its load, if any) exceeds 15 feet 8 inches, or

(*b*) the overall width of which (with its load, if any) exceeds 9 feet.

Provided that any person driving a vehicle, the overall height of which exceeds 15 feet 8 inches but is less then 16 feet 3 inches or a vehicle the overall width of which exceeds 9 feet but is less than 20 feet may drive such vehicle through the tunnel on such conditions as may be laid down by a traffic officer.

(6) No person driving a motor vehicle through the tunnel shall stop such vehicle unless he is directed to do so by a police constable or traffic officer or traffic sign or is prevented from proceeding by traffic or other unavoidable cause.

(7) No person driving a motor vehicle through the tunnel shall cause his vehicle to cross the line or marks separating the traffic lanes on the carriageways of the portion of the tunnel lying between the north and south portals unless he is authorised or directed to do so by a police constable or traffic officer or a traffic sign.

(8) (*a*) Subject to the provisions of byelaw (5) no person shall drive a motor vehicle in or through the tunnel at a speed of less than 8 or more than 30 miles per hour ; and

(*b*) No person shall drive a pedal cycle in or through the tunnel at a speed of more than 20 miles per hour.

(9) Except when stopped every motor vehicle shall be kept in gear while in the tunnel.

(10) No person driving a motor vehicle through the tunnel shall tow any trailer or any other vehicle unless the towing equipment provided is approved by a traffic officer as sufficient for the purpose.

(11) No person shall throw or drop in or upon the tunnel any article whatsoever.

(12) No motor vehicle shall be refuelled in the tunnel.

(13) No tyre or wheel change or repairs to motor vehicles shall be undertaken in the tunnel except by the tunnel break-down staff and vehicles unable to proceed shall not be removed from the tunnel except by the tunnel break-down staff.

(14) The following classes of vehicles are prohibited from using the tunnel, viz. :—

(*a*) vehicles conveying as a load or cargo

(i) inflammable liquids giving off inflammable vapours at temperatures of less than 150° Fahrenheit.

(ii) corrosive or noxious substances or inflammable substances other than liquids.

(iii) compressed or liquefied gases and dissolved acetylene.

(iv) cylinders suitable for the conveyance of compressed or liquefied gas.

(v) loose or baled hay, straw or other similar combustible material, unless completely and effectively covered with a tarpaulin or similar covering to the satisfaction of the Tunnelmaster or other authorised officer of the Corporation.

(*b*) Empty petrol or other tank wagons which have contained compressed gases or any inflammable liquid giving off inflammable vapours at temperatures of less than 150° Fahrenheit.

(15) No person shall take into the tunnel any loaded firearm or any explosive within the meaning of the Explosives Act, 1875, or any article or substance which may cause injury or fire or explosion in the tunnel or cause or be likely to cause any danger to any person in or using the tunnel : Provided that this bye-law shall not

(*a*) apply to safety cartridges, safety fuses for blasting, railway fog signals or percussion caps, or

(*b*) prohibit the conveyance through the tunnel of petroleum or other oil or spirit which is being used on a motor vehicle for the purpose only of the propulsion of such vehicle or petroleum or other oil or spirit up to a maximum of five gallons in a securely closed metal can or drum which is being carried on a motor vehicle for such use.

(16) No person shall sell or expose for sale any article or produce of any description in or upon the tunnel without the express permission of the Corporation.

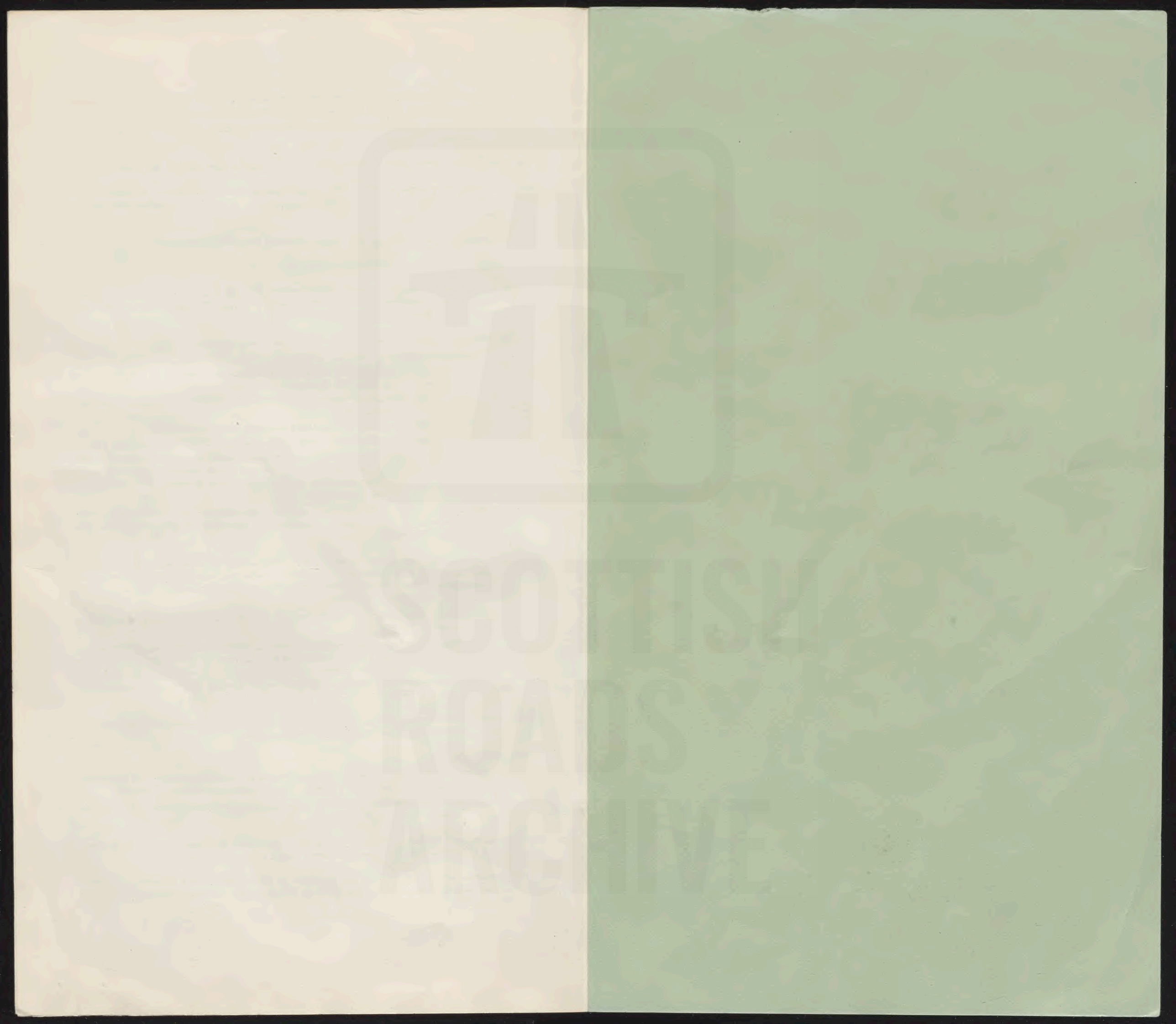
(17) No person shall

(*a*) climb upon or do any damage to or remove any part of the tunnel or any of its fixtures or fittings or any other property of the Corporation within the tunnel, or

(*b*) post any bill, placard or notice or write stamp cut print draw or make marks in any manner on any part thereof.

(18) Nothing in these byelaws shall apply to a motor vehicle while it is being used by or on behalf of the Corporation for the operation of the tunnel.

(19) Every person contravening any of the provisions of these byelaws shall be guilty of a police offence and shall be liable on conviction to a penalty not exceeding five pounds for each offence.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