



Price: £1.00

# THE INSTITUTION OF MECHANICAL ENGINEERS

RAILWAY DIVISION

## THE DESIGN OF DRIVERS' CABS

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Examines the operational role and environmental requirements of the driver with particular reference to structure, visibility, environment, controls and instrumentation. The basic characteristics for an optimum cab layout are suggested.

*This paper is intended for presentation at an Ordinary Meeting of the Railway Division in London on Monday 24th October 1977 at 17.30h. Communications are invited for publication in the Proceedings. Contributors should read the instructions overleaf.*

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**SYNOPSIS** The paper examines the operational role of the driver and the environmental requirements if he is to fulfil this role successfully. It then looks at the state-of-the-art, with particular reference to Great Britain, in the fields of structure, visibility, environment, controls and instrumentation, and concludes by suggesting the basic characteristics of an optimum cab layout.

## 1. INTRODUCTION

In the first half of this century, the cabs of electric locomotives and multiple-unit trains showed little integrated design approach, and even owed something to steam locomotive thinking. Under BR's massive 1955 Modernisation Plan, numerous diesel locomotive builders were able to apply some of their own thinking, with varying success in giving the driver a comfortable and convenient workplace.

Within recent years, as the less satisfactory designs have been withdrawn and a modest replacement programme started, experience with the existing fleet has been analysed in order to standardise on best practice and apply newer concepts. Conditions are changing, and traction design needs to keep pace with them.

It is therefore appropriate to examine current practice in Britain and overseas, in the light of the driver requirements, and to offer suggestions on the design of cabs, controls, and instrumentation which will most effectively meet the needs of traincrew on BR in the future. These proposals may require adaptation to meet other country's conditions.

The views expressed are those of the authors and are not necessarily those of the British Railways Board.

## 2. DRIVER'S ROLE

The driver is responsible for controlling his train within a speed/distance envelope which is partly spelled out by safety information from signals and other positional information. In doing this, he draws on his knowledge of the route and the performance of his train and updates this continually by visual and audible stimuli, in an attempt to optimise performance. He must also receive certain audible signals either as routine or in emergency.

Technically, the means exist to enable the driver to be dispensed with and the train driven within a performance envelope dictated by safety, economy and operational needs, with no more human intervention than a command to start the train

from rest (not necessarily from on-train staff). Nevertheless, there is understandable reluctance to remove the driver from the front of a train, partly because of possible public disquiet at moving without local supervision, and partly because of uncontrollable events which could prejudice safety. It is therefore likely to be a considerable time before driverless trains gain general public acceptance. The prospect remains of having to retain a driver on trains and to accommodate him in conditions conducive to his remaining alert and able to take over control of his train in case of equipment failure or other cause.

## 3. STANDARDISATION

A minority of drivers work only one type of traction unit. Standardisation (as distinct from optimisation) of cab layout is of little value to such men. Most, however, handle different types of traction unit on a day-to-day basis, or even within a single duty. Significant variations in cab layout reduce the ability to react correctly and rapidly to events, and also have training implications.

There is thus justifiable pressure for maximum standardisation of controls and indications. Probably nowhere has this been taken further than on the SNCF, where the cabs of diesel and electric locomotives are fully compatible. The same approach is now being adopted by BR, and multiple unit cabs are not excepted.

## 4. ENVIRONMENTAL REQUIREMENTS OF THE HUMAN BODY

If the driver is to be alert in controlling his train, certain environmental conditions must be met. Some driving work can be fairly monotonous, particularly in darkness when visual stimuli are much reduced or changed, and failure to provide a suitable environment will prove detrimental to the driver's vigilance. The accident reports of the Inspecting Officers of Railways have testified on numerous occasions to drivers 'nodding off' with dire consequences.

The comfort and background needs of the human body, in the sedentary and relatively immobile conditions of train driving are broadly:-

- (a) an ambient temperature of about  $19^{\circ}\text{C} \pm 2^{\circ}\text{C}$  with a temperature at head level lower than that at leg/foot level by not more than  $3^{\circ}\text{C}$ .
- (b) adequate replacement of stale air by fresh air (up to  $30\text{m}^3$  per person per hour) while keeping air movement below speeds which (depending on temperature) would be sensed as draughts.
- (c) ambient noise levels limited to below  $90\text{dB(A)}$  at the fastest speeds, together with a restricted noise profile over an 8-hour turn of duty to give an overall value not exceeding  $85\text{dB(A)}$  leq.
- (d) vertical and lateral accelerations within a ride index of about 3.5 maximum.

In addition, cab layout design must take account of certain inherent characteristics of the human eye if alertness is to be maintained, information absorbed quickly and accurately, and strain minimised. The driver's concentration on the very small visual field of the line ahead is continuously supplemented by information (much of it unconsciously gathered) on objects and movement in the peripheral field. Where objects in this peripheral field show a geometric moving pattern, as with railway sleepers, flicker effects can become distracting and with some drivers can have a mesmeric or numbing effect, though this is usually transitory. Deflection of the gaze from the area of flicker source has a strong cancelling effect, which may be consciously used by drivers. Furthermore, the need from time to time to seek information within the cab, calls for eye movement and refocussing which contributes to fatigue.

## 5. CAB DESIGN IN BRITAIN : THE STATE-OF-THE-ART

Railway rolling stock needs to be robust and easily maintained, and a life of 25-30 years is to be regarded as a minimum; indeed, many emu's in service are essentially pre-World War 2 in design, and in some cases, in construction too. There are considerable constraints, physical as well as financial, on retrospective modernisation.

Nevertheless, the standards and aspirations of human beings are steadily improving and those of twenty years ago are now regarded very critically. One has only to think of heating, lighting and insulation standards in the home to realise how attitudes have developed. In passenger transport likewise, the quality of ride, noise insulation, temperature and ventilation has improved rapidly. After all, twenty years ago, heaters were optional extras on many private cars!

In designing workplaces for the train crews of today, therefore, their acceptability in predicted conditions at the end of the century needs careful examination because current new construction needs to remain suitable, with little change, at that time.

The driver of a train spends long periods alone. He has time to wonder why his standards of home comfort and of the car he drives to work cannot be reproduced in his driving cab. We can no longer depend on the degree of tolerance which has been shown hitherto.

An examination of current practice can be made under five main design heads:-

- Structural
- Visibility
- Environmental
- Controls
- Instrumentation

## 6. STRUCTURAL AND LAYOUT DESIGN

### 6.1. General layout for locomotives

Locomotive cabs must be of full width primarily to enable the driver to look out on both sides of his train. The options exist, however, for cabs at each end or for a single cab, either at one end, or central with low-hood engine room(s).

The single end cab is now being discarded in Britain, after early enthusiasm, because visibility alongside the hood is very poor, particularly in yards and sidings. This has led to Trade Union demands for double-manning on safety grounds, and this is only avoidable on BR when such locomotives are used in multiple with cabs outwards.

The single central cab is only practicable with low hoods containing quick-running engines of modest power, thus limiting the locomotive's scope; duplicated directional controls may be needed.

The use of two end cabs with a hood-type engine room between, offers potential benefits in cab design as well as improved maintenance access. Cab doors from side walkways are invariably trailing, minimising draught problems and improving rearward vision.

### 6.2 General layout for multiple units

Full width cabs are usually provided at each end with side access, often via a cross-vestibule from which passengers are excluded. In certain circumstances, e.g. where through gangways give passenger access to adjacent units, it may be necessary to provide a (nominally) half cab only but these are unpopular with drivers because of mild claustrophobia and restricted vision towards the opposite side. (The recent NS adoption of elevated half cabs on new IC-111 trains to allow through gangway access is interesting but impracticable within the BR loading gauge). The best solution to the problem is the elimination of the cab inner side wall, together with a wide door which can be hinged back to exclude passengers from the area when the cab is occupied. The effect is then of a full-width cab (Fig. 1.) This arrangement will be a feature of new BR gangwayed multiple-unit stock.

### 6.3. The cab shell

Until recently the cab has been regarded primarily as a functional workplace for driver and equipment, with styling in a very secondary role. The result has usually been a traditional flat-fronted profile integral with the body structure sometimes with a lower nose section housing ancillary equipment.

The method of construction has involved welding a sheet metal skin to a light structural framing, incorporating heavy collision members to protect against buffer override. Such a cab requires skilled craftsmen to produce it and provides ready paths for transmission of noise. Welding, despite the most careful control, invariably brings distortion and the subsequent corrective treatment is costly and may itself weaken the structure. Repair of collision and corrosion damage is a skilled and time-consuming process.

Increasingly, as speeds increase, a streamlined form is required for both aerodynamic and commercial reasons. Once it becomes necessary to depart from predominantly flat shapes and simple curves, the needs of economical batch production have dictated a move away from metal fabrication towards glass reinforced plastic (GRP) moulding. A spin-off is the possibility of saving up to 30% of the locomotive cab shell weight.

The use of GRP construction allows intricate shapes of floor, rear bulkhead and front/sides/roof to be reproduced accurately and repeatedly from single moulds which are cheaper than the corresponding press blocks. On locomotives, these major units can then be assembled into a one-piece complete cab "pod". Additional fittings and attachments can readily be bonded on without distortion.

The cab of the BR, HST power cars shows what can be done (Fig.2). The floor and bulkhead are insulated with rigid expanded polyurethane or PVC slabs, while the remainder is insulated, between the outer and inner GRP skins, by pumping in polyurethane foam while still in the moulds (the resultant sound insulation is such that single detonators can not be reliably heard when running!). The wiring, pipework and most fittings can then be installed before mounting on the power car in a complete condition.

In multiple units, the cab (or at least the floor and sides) must necessarily be integral with the remainder of the vehicle for strength reasons, and the use of GRP is normally confined to moulding non-load-bearing complex roof and corner shapes.

### 6.4. Shell strength

Regrettably, modern design must provide adequate protection for the driver against vandalism in the shape of missile impact or bird strikes at high speeds. Compared with steel on a weight-for-weight basis, good GRP construction can give equal penetration resistance.

### 6.5. Mounting

Where the cab shell is separate from the load-bearing structure, it can be secured to the under-frame and body structure by rubber cushion mountings bringing immense benefit in minimising noise transmission paths from power equipment and running gear.

Where cabs are produced as GRP mouldings the resulting integral structure gives good draught-free characteristics, whereas joints in sheet metal structures are a potential draught hazard. Likewise, such structures will not corrode and should last the life of the traction unit.

## 7. DESIGN FOR VISIBILITY

7.1. It has been customary to give the driver the maximum view of his surroundings, both forwards and sideways, consistent with structural strength. In fact, this is undesirable; for instance, the single flat windscreen of the prototype (Class 252) HST power cars, 1150mm x 585mm, was enthusiastically accepted by all drivers handling the train as providing an adequate visual field.

### 7.2. The driver's needs

The driver basically requires:-

- a. a windscreen wide enough for him to observe the line ahead, with normal curvature.

This needs only about 15° visibility on either side, and this is adequate to enable accurate stops to be made at, for instance, position markers on platforms.

- b. sufficient upward vision to enable signals to be observed when standing about 5-6m from them.

This needs only about 25° visibility above the horizontal, even for signals on overhead gantries.

- c. sufficient downward vision to enable the track to be seen at about 10m from the cab.

This needs only about 15° visibility below the horizontal. Any nearer view may bring serious flicker problems.

- d. a side opening window for looking



back notably in stations and yards or receiving messages.

In multiple-unit trains, this facility can be dispensed with, provided the driver can be given clear instructions by other staff who can see the train's surroundings.

In practice, the first three of these requirements can invariably be achieved through a flat windscreen alone (Fig.3.). An apparent "blind spot" at the front corners is no detriment; multiple units built with 'wrap round' windscreens, which needed to be restricted at the front corners due to vandalism have brought no complaint since modification despite use on intensive stopping services. The demand by one Trade Union for corner windows in the cabs of the HST resulted in an unnecessary feature, and this is well recognised by drivers.

Any greater glass area than absolutely necessary is to be avoided at all costs, as it causes serious heat loss in winter and solar heat gain in summer. There is a marked tendency on the Continent with Metro stock to provide deep windscreens, following bus practice and to suit road conditions, but this would be undesirable for normal railway applications.

### 7.3. Driver's position in cab

The driver has traditionally been seated close to the cab side, to enable him to look back to observe handsignals etc., In practice, the contortions involved are such that most drivers get up from their seats for this purpose. Such a location also brings the driver within range of draughts from the adjacent side window, and limits his sideways vision.

### 7.4. Windscreens

The use of toughened glass or 'safety' sandwich construction for windscreens has been virtually universal. Unfortunately such windscreens do not give adequate driver protection against missiles, flying ballast or high speed bird strikes. Accordingly, the use of thick sandwich high-impact screens is now regarded as good protective practice; although expensive, they give almost complete driver immunity from injury (Fig.4). With an overall thickness of 12.6mm - 21.4mm, however, the need to avoid optical distortion dictates that they be flat and this may limit the designer in corner areas in providing an acceptable combination of structural (impact) strength and spread of vision.

The angle of the screen and its relationship to the surrounding structure can be important to the driver because the dynamics of air flow over the cab front affect the wiper performance at speed,

and the degree of fouling in summer by dead insects. The relatively bluff fronts of the 1960's are markedly worse than more steeply sloping screens in this respect.

### 7.5. Windscreen wipers and washers

Present practice causes more annoyance to BR drivers than almost any other item of equipment. Overall performance and controllability are usually very inferior to that of wipers in automobile practice. Very common faults are rain leakage along the motor spindle, loosening of the arm on the spindle, overtravel due to air pressure, and smearing from uneven blade pressure.

Best results are obtained with bottom-mounted motors, with a very rigid arm as short as possible. There is no justification for pantograph arms, which are more vulnerable to damage; adequate swept area can be obtained with a single arm. The delay feature now common on car wipers is very valuable in drizzle conditions and would be welcome.

A motorised washer spraying from the wiper arm is most effective, given careful detail design.

### 7.6. Sun visors

These are essential; many types have been tried with varying success, but there is now a marked preference for the top-hinged, see-through type, provided that it is enclosed in a rigid frame and has spring detents or friction hubs to retain it in selected positions. It can be of acrylic sheet or safety glass, tinted to an approved smoky grey.

Visors need adequate vertical adjustment and must also cover the full width of the windscreen to avoid low sun "sneaking" round the sides; particular care is necessary where two visors are mounted side by side.

## 8. ENVIRONMENTAL DESIGN

8.1. The requirements for human comfort and alertness which have been partially stated with such deceptive simplicity in para. 4.2. are by no means easily achieved in practice, and almost all drivers' cabs in Britain fail to achieve these standards in some respects.

### 8.2. Heating and ventilation

Under winter conditions at high speed, a full-width cab of 8m<sup>3</sup> with 2.5m<sup>2</sup> glass area, requires a heat input approaching 4-5kW to produce and maintain a temperature of 20°C, and temperature variations can be formidable. Thorough insulation and reduced glass area can almost halve this.

There are three methods of providing temperature control and ventilation:-

- convector heaters with natural ventilation.
- pressure ventilation/heating.
- air conditioning.

Convector heaters have proved unsatisfactory, despite much adaptation, since they do not contribute to ventilation and aggravate temperature gradients. All the ingredients of a 'fug' are thus produced with adverse effects on alertness.

Warmed air heating with pressure ventilation is a big improvement, given suitable intake/outlet locations. Drivers' knee-holes have been found to need special provision. It is particularly important that, on multiple units, heating is available in unused cabs to cater for turn-round services.

The provision of full air-conditioning is justified for some applications in the future, in order to give adequate control of temperature and fresh air intake, particularly under summer conditions. Its cost is about twice that for pressure ventilation.

### 8.3. Draughts

There are four prolific sources of draughts in cabs when running:-

- down draught of air cooled by window surfaces
- the fit of openable windows
- the fit of doors
- at pipe entries into the cab.

These are almost undetectable at a standstill, but cause purgatory to a driver at speed: design and maintenance must be impeccable.

Down draughts at windows can only be mitigated by suitable distribution of warmed air. While the fit of side windows is largely a maintenance problem, the standard of window catches, usually light metal pressings, leaves a great deal to be desired.

Cab door design and maintenance seldom receives the attention they deserve, particularly in respect of distortion, fit of latches, and sealing arrangements. No car driver would tolerate such a situation for a single day. The kick marks on paintwork on many doors also show a converse situation of brute force to open. Built-up doors inevitably sag and distort in various ways. GRP doors are not immune from distortion. L.T. practice, in providing a rigid cast light alloy door in a frame of equivalent construction, with heavy hinges and latches, and firm rubber

draught seals, appears to be the best available answer to this problem. Brush-type draught seals are useless at traction speeds.

The use of metal or smooth GRP surfaces which feel cold to the driver's legs needs to be avoided. Unofficial remedies of covering with moquette or other materials need to become official.

### 8.4. Noise levels

Recent British legislation is likely to require that noise in workplaces shall not exceed 90dBA Leq over 8 hours without ear protection. British Rail has, responsibly, set its long-term target lower at 85dBA, and most of its cabs are little above this ceiling when on full power at maximum speed. Nevertheless, it needs to be exceeded briefly in order that audible warnings may 'get through' to the driver.

A recent paper to this Institution 1. dealt with noise in railway vehicles, and while orientated towards passenger coaches, much of it is equally applicable to locomotives. There have been some classic cases of noisy auxiliary machines being mounted hard against cab bulkheads or body sides, with results which might be expected. Appendix I gives some examples of current noise levels in traction unit cabs.

The retention of an Automatic Warning System (AWS) designed for steam locomotives results in instantaneous noise levels of well over 100dBA, whereas a level 5-10dBA above ambient is adequate. BR will be changing from a  $\frac{1}{2}$  or 1s bell at clear aspects to a single "ping", and the air-operated horn at restrictive aspects will give way to an electronic "noise". For vigilance and similar warnings, distinctiveness can be assured by "bleep" and warble effects.

### 8.5. Seating

Drivers are entitled to comfortable, supportive seating and the SNCF philosophy of a tall padded stool is not satisfactory; it is also unstable. An adequate range of longitudinal and vertical adjustment is essential. The seat covering is normally of PVC coated cloth for durability, but this must be porous and preferably textured to minimise perspiration.

Some years ago, ergonomic studies led to the production of a driver's seat of tensioned net construction, which was used on the prototype EMT. Viewed with instant suspicion by many drivers, familiarity brought a very high acceptance rate, particularly under summer conditions. Nevertheless, the design has not been adopted by any established manufacturer.

There is a need for a third (tip-up) seat on the back cab bulkhead.

#### 8.6. Cab lighting

General cab lighting needs to be switchable both from the driver's seat and from the entrance doors. The only other lighting required is over the driver's documents on his reading surface; this must be completely shaded.

### 9. CONTROLS DESIGN

#### 9.1. Controls

Stagnation in control design over the last 50 years is only now giving way to change; locomotives less than 5 years old have power control handles 320mm long involving arm movement from the shoulder. A first step in the right direction has been taken in the HST cab by providing simple handles for power and brake control, working in the fore-and-aft plane and operating switching devices below desk level, but even here, movements of 360mm from idling to full power and 240mm from 'running' to 'full service braking' position are needed. Yet greater brake sensitivity is achieved by SNCF with a miniature joystick some 120mm high.

There appears to be a fundamental choice for future development in order to gain greater freedom in cab layout. The first approach, more suitable for multiple units working stopping services, is already appearing in Europe; it combines power and brake control in a single handle, working fore-and-aft. A travel of 250mm can cover the complete range required.

The other alternative is to retain separate controls but to redesign them in terms of miniaturisation. This seems the most appropriate method for main-line work. It has been common for many years in heavy crane practice to control all movement by miniature joysticks placed conveniently to the operator's hands, (Fig.6) and in some cases even mounted in his seat armrests. They need little more than 'finger-and-thumb' pressure to operate them. There is every reason to apply the same approach to locomotive controls: as a result, the cab is roomier with better seat access, even distribution of warm air, and less effort and reach by the driver.

#### 9.2. Philosophy on operation of controls

The operational requirement is for any natural slumping forward by the driver, when incapacitated to tend to apply the automatic brake and cut off power.

#### 9.3. Drivers safety devices

It is a statutory requirement for railways in Britain, that traction units

which are to be single-manned shall have a driver's safety device, (DSD) which will stop the train in the event of driver incapacity, etc. Traditionally this has taken the form of a footpedal on locomotives and a hold down feature in the power handle of multiple units.

The hold down power handle, while not foolproof - it is not unknown for weights to be hung on it - seldom fails if the driver collapses, because it is so uncomfortable to hold over lengthy periods. Its main disadvantages are the immobilisation of one hand at all times when moving, and the absence of a delay feature.

As one-man operation becomes more pressing, requiring (on passenger trains) the availability of driver/signalbox speech communication at all times, normally by radio handset - the availability of only one hand for braking, sounding the horn, AWS acknowledgement and other ancillary needs is no longer acceptable. It is now necessary to abandon the power handle DSD feature and provide a pedal instead.

Footpedal DSDs frequently fail to operate in emergency as intended. They require to be:-

- comfortable to hold down for long periods with light pressure
- naturally released in case of incapacity
- not inadvertently released owing to lurching of the traction unit.

A wide variety of sizes, configurations and surfaces has been used. Regrettably, the requirements are so mutually contradictory that none have been fully effective, nor can any prospects be discerned of designing a pedal which fully meets them. In addition, their position in relation to the desk is critical, because any ability of the driver either to cross his legs, or wedge his operative knee below the desk renders them virtually useless. Hence the requirement for a vigilance feature to be superimposed.

On most types of traction, the DSD can be neutralised by putting the reversing handle into the "Engine Only" or "Off" position. This avoids complete loss of brake pipe pressure at station stops etc, while enabling the driver to leave his seat. Equally, this can be done while coasting; though expressly forbidden, there have been isolated, potentially serious incidents where there is evidence of this being done.

Some constraint on the driver's freedom to neutralise the DSD in this way is now being examined and a speed-sensitive override appears to be the most promising option.

#### 9.4. Vigilance devices

Such devices normally require driver response to an audible warning to prove alertness i.e. by releasing and re-depressing the DSD pedal. In their simplest form, this occurs at fixed time intervals; the BR system, typically, uses a 60s cycle. While tolerated by drivers in open line conditions, it causes serious distraction in complex terminal areas and is heartily disliked.

There are vigilance systems available which also monitor driving functions, such as power notching, changes in brake pipe pressure, the sounding of the horn, etc., and these can be speed-responsive if so desired. The limits are only set by cost, complexity and reliability.

Where such actions are frequent - in an inner suburban area for example - the use of a vigilance device based on a time-cycle much shorter than 60s can be contemplated and at this stage, a DSD as such may become superfluous, the pedal then being nothing but an acknowledgement 'button' and designed for comfort only.

#### 9.5. Parking brakes

Parking brakes have traditionally taken the form of a hand-wheel with mechanical linkage to bogies. The presence of impediments on motor bogies leads to a complex linkage with cumulative lost motion and poor brake power in practice. This arrangement is impracticable with disc brakes.

Hydraulic parking brakes overcome this problem, pressure being pumped electrically, but the hydraulic systems have proved very sensitive to entry of dirt and manual release in the absence of power is cumbersome. Spring parking brakes have also been used, release being obtained by air pressure, and while reliable, manual release tends to be even less convenient.

The whole concept of fitting a parking brake in the driver's cab of locomotives is overdue for reconsideration. The General Motors' practice of fitting a rugged ratchet-type parking brake externally on locomotives adjacent to the access steps has much to commend it and could equally be bogie mounted on other types of traction.

### 10. DESIGN OF INSTRUMENTS AND INDICATIONS

#### 10.1. General

The display of numerate information to the driver takes up considerable space and needs to be strictly confined to that necessary for accurate control of his train. It must be so presented to him that it can be assimilated at a glance, since the driver's prime observations must be of the line ahead.

When there is any doubt as to its value, it should be omitted.

Information associated only with preparation, examination or fault finding has no place before the driver and should be displayed elsewhere in the cab (display in engine rooms of diesel traction will no longer be acceptable under the Health & Safety at Work Act in Britain).

Instrumentation needs to be carefully, positioned in relation to the relevant controls. The temptation to locate instruments to give a "tidy" symmetrical appearance must be resisted (Fig.7).

#### 10.2. Speedometers

The speedometer is the key instrument for the driver; it needs to be positioned centrally in front of him. Perception tests on drivers in brief observation of 150mm speedometer faces have been carried out by BR in connection with APT and the results broadly confirm the correctness of the recommendations made in a paper by Thorley (2). Moving band speedometers are less clear in their message.

#### 10.3. Brake gauges

The driver can judge his braking performance from a single brake pipe gauge, unless (on locomotives) dual braking, or an independent air brake for working partially braked freight trains are fitted. For vacuum braking, a 100mm dial is adequate and the recent use of 150mm dials for air brake gauges is not strictly necessary.

Air brake reservoir gauges have no place in front of the driver, being only observed during preparation or fault finding. Indeed, a simple "Go/No Go" indication would be adequate.

#### 10.4. Ammeters

On multiple unit trains, these can normally be omitted; on locomotives, however, they are usually essential as a guide to acceptable traction motor currents, onset of field weakening etc. It is general practice to mark green, yellow (for short-term ratings) and red sectors, and this is adequate for the driver, who has no normal need to read figures: these can be inconspicuous. In dealing with failures, markings can be read in relation to needle positions within the sectors.

Separate motor ammeters are not usually necessary and a single circular 100mm instrument is adequate. Where individual ammeters are required on high power locomotives, the multiple edge type linear ammeter is more compact. The pointer needs to be prominent.



### 10.5. Instrument lighting

This is a major source of driver frustration, since standards are usually below those on the average mass-produced car. The use of bulbs shining through peripheral slots between glass and dial is now totally discredited. Beta lighting, using a radio-active 'slug', appears to be the most promising choice to date, subject to careful choice of luminosity level for rapid transition from sunlight to tunnel conditions.

Reflections on instrument faces can cause reading problems. The authors would like to see the principal instruments deep-recessed in a matt panel.

### 10.6. Fault indications

There has been a tendency for designers to provide a number of "health" and fault indications in front of the driver in the form of plain 'on/off', 'dim/bright' or bi-colour lights, though Dowty type indicators have found some favour. Except in a few designs, any change has required the driver to leave his cab to seek more detailed indications, reset devices, etc., elsewhere.

The aim for designers should be to provide on the driver's panel, a single indication of the health of all traction equipment. On receiving a fault indication, he should then be able to look to a single panel elsewhere in his cab, visible from his seat, on which the particular fault is identified and can be rectified.

## 11. U.I.C. REQUIREMENTS FOR INTERNATIONAL SERVICES

Two U.I.C. leaflets, nos 617-5 and 617-6 are particularly relevant to cab design and are mandatory for new traction units crossing frontiers in international service. These leaflets codify a wide range of dimensional information, but are not very imaginative in other respects.

## 12. THE CAB OF THE FUTURE

The search for a "cleaner" looking cab has brought difficulty in getting maintenance access to equipment and an increasing problem in driver access to his seat while keeping controls readily to hand. The authors would suggest that the driver's desk as such has outlived its usefulness and needs to be reconsidered in the light of the general move towards thyristor control.

Earlier, attention was drawn to the SNCF miniature brake controller, and it is suggested that there is scope for equivalent treatment on the power side. What then remains is a number of small controls, switches, etc, which can conveniently be placed elsewhere than on a desk. A sloping instrument panel must remain. All the benefits mentioned in para.9.1. would then follow.

It is therefore suggested that the driver's seat should be the focus, with brake and power control joysticks located on pedestals immediately in front of the armrests, in a natural position for the driver's hands to move largely by wrist or finger action (Fig.8). The power pedestal would also contain the forward/reverse selector, master control switch and horn control, and the brake pedestal would also house the AWS reset button. Access to the seat would be from the front, round the control pedestals which would be suitably masked to prevent inadvertent movement.

The traditional type of DSD pedal, mounted within a sloping footrest, should be abolished, leaving a virtually flat floor surface in front of the driver's seat for easy access. With a vigilance system automatically recycled by any movement of controls etc., the cycle time could be reduced without being onerous to the driver, and the system could then take the place of the DSD as such. The vigilance acknowledgement could then be by a pair of simple pedals, one for each foot: it could take the form of "press-and-release", which is a more natural reaction than the present "release-and-depress" system.

### ACKNOWLEDGEMENTS

The authors are indebted to Dr. C.T. Newnham, Group Medical Officer (Special Duties) BR.HQ for advice on visual and environmental requirements, and to Mr. R. Arnott, Chief Operations Manager and Mr. K. Taylor, Chief Mechanical and Electrical Engineer, BR.HQ for facilities given in the preparation of this paper and for permission to present it.

### REFERENCES

- (1) EADE, P.W. and STANWORTH, C.G. 'Acoustic aspects of railway vehicle design'. Proc. Instn. Mech. Engrs., 1976, Vol. 190 No. 58, 515-525.
- (2) THORLEY, W.G.F. 'Traffic-oriented training for locomotive engineers'. J. I. Loco. Engrs., 1968-9, No. 324.

## APPENDIX I

EXAMPLES OF NOISE LEVELS IN DRIVER'S CABS

Unit	Type of Cab (integral with body structure unless otherwise stated)	Speed mile/h	Noise level at full power dB(A)
Class 207	Steel, 600 hp engine immediately behind	65	81
Class 310 EMU	Steel	80	70
Class 37 diesel electric locomotive	Steel, nose end containing two compressors, cooling group between cab and 1750 hp engine	60	85-87
Class 47 diesel electric locomotive	Steel, no nose end, cooling group or boiler compartment between cab and 2580 hp engine	95	82
Class 83 AC electric locomotive	Steel. Before modification of Arno converter mounting	Static	90
	After Modification	Static	79
Class 87 AC electric locomotive	Steel	100	84
Class 253 HST power car	GRP 'pod' separate from body. Cooling group between cab and 2250 hp engine	125	86.5

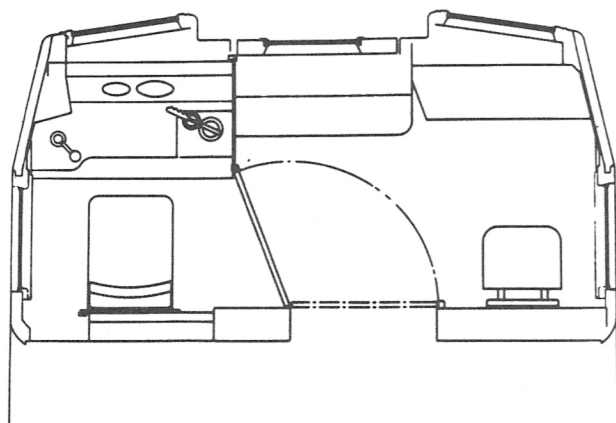


Fig. 1. Layout of cab for multiple-unit train

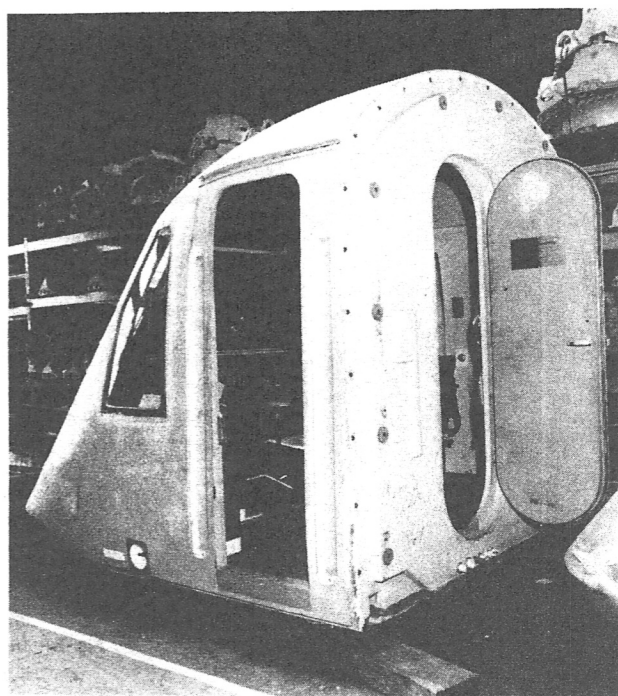


Fig. 2. Complete cab unit for High Speed Train

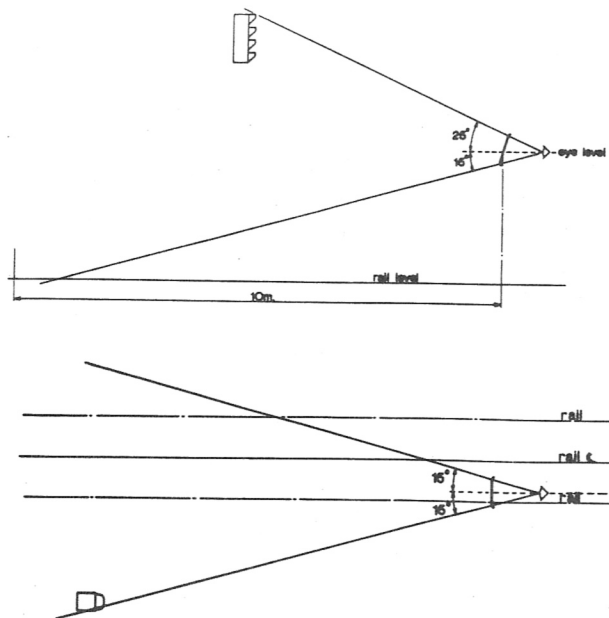


Fig. 3. Cab sight lines

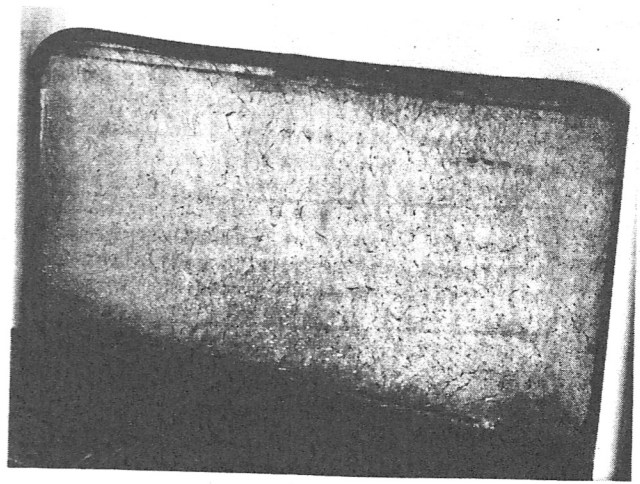


Fig. 4. High impact windscreen after impact

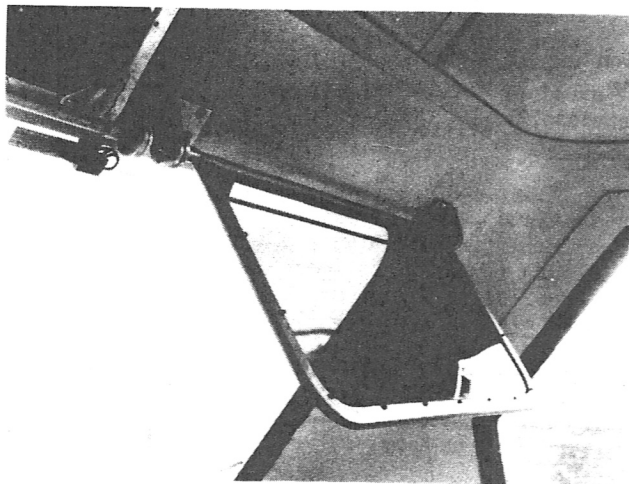


Fig. 5. Sun visors

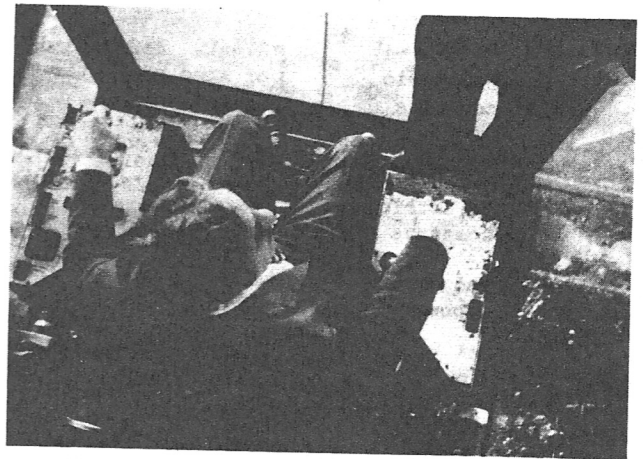


Fig. 6. Controls in crane cab

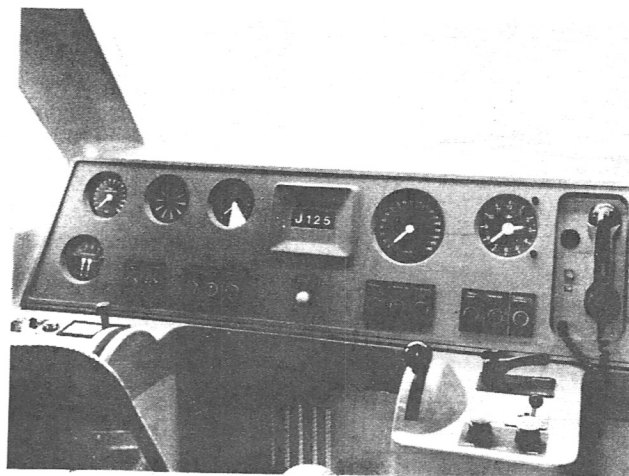


Fig. 7. Instrument panel layout