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Paper 8

Civil Engineering Aspects

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1 Introduction

The basic tasks affecting the Chief Civil Engineer in providing for overhead electrification projects are primarily four in number, viz.:—

(1) Provision of sufficient physical space to enable the overhead wires and the pantograph to be installed with the correct electrical clearances to structures and to effect improvements in track bed, alignment and layout, all in conformity with the requirements of the Ministry of Transport and of the Chief Electrical Engineer.

(2) Check and prove the designs for the construction of the overhead masts and the foundations for which the Civil Engineer is ultimately responsible.

(3) Make the track suitable, physically and in layout, for the operation of the new kind of traction.

(4) Provision of new Repair, Maintenance and Inspection Sheds for electric stock, sub-station buildings, etc.

2 Provision of Clearance and Safety Precautions at Structures

The small British structure gauge presents considerable problems and is dealt with in Paper 6.

It is the railway overbridge which presents the greatest difficulty in obtaining clearance. Each overbridge was originally built under an Act of Parliament which limited the variation on highway levels; so that if the Commission wish to alter the road levels, a further reference to Parliament by them is required in each case in this country.

The usual methods of obtaining these clearances are as follows:—

(1) Raising of bridge decks.
(2) Lowering of tracks or slewing of tracks inside arches.
(3) Combination of (1) and (2).
(4) Reconstruction of arches or other decks.
(5) Stripping off lower arch rings or replacing arch above existing extrados.
(6) Combination of (2) and (4), or (2) and (5).

Whenever overbridges require to be cleared, or tunnel profiles altered, the cost is high.

In cases of extreme difficulty, the voltage may be reduced, with or without accompanying reconstruction works. Where aqueducts cross the line, inverted syphons, in duplicate, may be provided with suitable penstocks.

The difference in spacing of bridges on various routes can be striking. Taking the density of bridges per route mile on the Sociéte Nationale Chemin de Fer Français, between Valenciennes and Thionville as unity, the density on the Great Northern Main Line of British Railways between King's Cross and Doncaster is 2.65, on the Great Eastern Suburban Lines traversing north east London 4·03, and on the London – Tilbury and Southend Line, between Fenchurch Street and Upminster 6·75. Figures on a similar basis on the London Midland Region Main Line electrification vary between 4·20 and 5·56, and on the suburban routes of the Scottish Region at Glasgow 8·00. It will be seen, therefore, how much more difficult is the clearance work of the Civil Engineer in this highly populated island when compared even with the French Railway scheme, which also serves an industrial area.

The restricted clearances have led to considerable efforts being made to overcome this problem.

2.1 *Raising of Bridges*

The inception of the Manchester Sheffield Wath Electrification in 1938 showed the serious difficulties that would arise. When the electrification project restarted in 1947, a survey confirmed that, unless some quite novel form of deck was introduced, great difficulties and expense would occur even with the lower D.C. voltage then in vogue. Meanwhile prestressed concrete construction had come into being so consideration was given to a system now known as 'partially prestressed concrete' which is associated with the name of Dr. P. W. Abeles.

'Partially prestressed concrete' entails the use of tensile stress in the concrete under live load, though compressive stress in the skin of the soffit of the deck beams obtains always under the dead load alone.

This system of 'partially prestressed concrete' has been used, in the main, on the Eastern Region of British Railways, though it is now being adopted elsewhere. It has been found to be most suitable for the bridge reconstruction works when used in conjunction with a composite construction suggested by Dr. K. Hajnal Konyi, MICE. The prototype bridge deck at Buck Lane Bridge in Worsborough Dale was the first partially prestressed concrete bridge ever to be erected, and a cross-section of the deck, together with stresses obtaining in the various parts of the composite deck, are illustrated in fig.1. This milestone in bridge deck construction was only used in that form in two or three instances, because it was quickly found that ultimate load conditions could be more conveniently covered by inserting some untensioned wires in the bottom flange of the precast inverted T beam, than by placing mild steel bars in the surrounding in-situ concrete, thus cutting down the time taken in working on the site. This modification, embodying the untensioned wires, was tried out at Mouselow and this heavily used bridge has been in use for more than 10 years, with complete satisfaction.

Reverting to Buck Lane; tenders actually received showed a saving in cost of 40 per cent. over a design embodying filler joists and worked out at only £12 6s. 0d. per sq. yd. of deck. The price for subsequent decks has fluctuated, but similar decks to that at Mouselow have been carried out during 1958/59 in the north east of London at only £12 10s. 0d. per sq. yd.

The composite deck, embodying in-situ concrete, keeps within manageable weights the units to be lifted and the construction has proved effective in practice, for the inverted T beams can be easily lifted into place by a road crane in between trains, and these form an adequate 'shutter' for the subsequent placing of the in-situ Portland cement concrete. Any disturbance to rail traffic is, therefore, kept to a minimum.

The higher A.C. traction voltage has increased the problem of securing adequate headroom for the pantograph and avoiding a disturbance in the level of the highway above. The straight-forward composite deck which had been used on the lower voltage schemes would not always suffice under the new conditions, and as a result a special thin partially prestressed composite slab, known as the 'wafer deck' was evolved for use on the Colchester – Clacton line and has proved effective.

The 1/30 depth span ratio of this wafer deck is achieved by prestressing in two stages.

Fig.2 shows a section of a wafer deck and the distribution of the stresses. It is essential for the inverted T beams to be supported over the whole of their length while the in-situ concrete is added, so that the stress distribution in the beams is unaltered by the addition of the in-situ concrete. This in-situ concrete contains the ducts through which cables are inserted and these are tensioned as soon as this concrete has hardened. This further tensioning affects the distribution of stress in the whole slab.

Much the same result can be obtained by the 'preflex' system at a much greater expenditure in steel.

After tests, it was found that by using metallurgical supersulphated cement, an excellent concrete could be produced which was highly resistant to the dilute sulphuric acid contained in the distillation of locomotive exhaust. Excellent cube strengths for this cement have been obtained, and figures as high as 10,000 lb. per sq. in. have been achieved in 28 days. Two inches headroom is saved by suppressing smokeplates.

These partially prestressed concrete designs are approved by the British Transport Commission, and their ability to stand up to the roughest treatment has been shown by tests carried out over a number of years, involving the application of millions of repetitions of dynamic loadings in beams in an uncracked state, or in others deliberately cracked, statically, before the dynamic loads were applied.

The tests were carried out at the University of Liège and at the British Transport Commission Research Laboratory at Derby, and a summary of the results is set out in Paper 6320, Mr. R. E. Sadler, AMICE, published by the Institution of Civil Engineers in February, 1959.

Quite apart from the dynamic loading tests at Liège and Derby, the Ministry of Transport 90-ton test bogey has been loaded on one of these decks at Stamford in Lincolnshire carrying the Great North Road, and an outline of the results obtained at that test are contained in the Paper referred to. Although the distribution steel at Stamford is only four No. $\frac{1}{2}$ in. diameter bars in the whole of the deck, the plotted deflection readings showed that this composite deck was effective in spreading the heavy test load; again, recovery was good, though it occurred over a number of hours.

2.2 *Overbridge Demolition*

On the Eastern Region the practice is as follows:—

In the case of a number of 3-arch bridges, the side spans of which are not occupied by tracks and are unlikely to be so used, stop arches have been provided in the side spans before the demolition of the centre arch and the substitution of a flat prestressed concrete deck. The work is straightforward and avoids the use of any metal ties which require maintenance from time to time, furthermore, the piers have withstood heavy blows which sometimes occurred in felling the arch.

In dropping arches, the track should always be closely covered by old railway sleepers and it is important to ensure that these are built up clear of the rails, chairs or base plates.

The speed of operation which can be achieved by blasting is such that only 100 minutes after blowing up, it has been possible to clear one line for traffic.

Many of the tight arches, when demolished, are found to be very sound inside the rings, and as a result steps have been taken to preserve a number of them and yet secure a clearance for the pantograph. This is achieved by stripping off one or more interior rings, after first placing a reinforced concrete relieving slab over the bared extrados of the arch. Before stripping, a number of holes are drilled right through the relieving slab and the brickwork, into which a 1-in. diameter bolt ragged at the top and provided with a long thread at the bottom, is inserted. Upon the thread is placed a 3-in. square washer plate, secured with a nut, and the long thread is protected by polythene. As the work of stripping proceeds, the shanks of the 1-in. bolts, one of which is provided every square yard of intrados, become further exposed. The exposed thread is then unwrapped and the washer plate and nut pulled up tight, as before, to secure the remaining rings. Any extensive collapse is thereby arrested, and apart from this, the system gives confidence to the men working underneath.

Should stripping work be incomplete at the end of a ' possession ', the cutting back of the rings can be stopped at a line of bolts and the whole made sufficiently secure to permit the passage of trains further until time can be found to complete the work.

The cost of carrying out this stripping work is often below that of renewing the deck, and in one case a saving in cost of 62 per cent. resulted, in addition to 35 per cent. in time.

Another method of dealing with arches and used on the London Midland Region is to construct an entirely new reinforced concrete arch, with knuckles at the quarter points, using the existing arch as centering, fig.3; after completion of the new arch the old structure is demolished, leaving a new structure having adequate clearance. This method was adopted in preference to the provision of a new flat deck, as the arch abutments generally were not sufficiently stable to support a superstructure having vertical reactions only. In the case of three span arches where it was unnecessary to alter the side arches, the practice was to tie them back to the abutments in order to maintain stability during reconstruction. Afterwards the side ties were removed.

2.3 *Safety Measures*

Safety measures laid down by the Ministry of Transport embody the following:—

(*a*) Raising parapets in the solid, up to 5 ft. above highway level.

(*b*) Raising parapets in woven mesh framework in cases of special difficulty.

(*c*) Filling in solid lattice girder work or making part solid and part mesh.

(*d*) Providing horizontal screens on sides of bridge where parapet cannot be raised on account of:—

- (i) aesthetic considerations;
- (ii) road sighting difficulties;
- (iii) insufficient lateral strength of parapet girder of bridge otherwise clear.

(*e*) Loading gauges and notices at level crossings.

Regarding loading or warning gauges at level crossings, the standard wire height is 16 ft. in the open country but at public highways the Ministry requires this clearance to be increased to 18 ft. 6 ins. when the Ministry usually requires only a warning notice indicating the presence of electric conductors above the highway. Should there, however, be a low overbridge in the vicinity of the level crossing, then the gradient of the contact wire relative to the track may result in a wire of substandard height at the crossing. Then a loading gauge, in addition, is required by the Ministry. So far small bells connected together by rail bonding wire and suspended from a catenary between two creosoted poles have been used, though one or two other designs were tried out initially.

The lip of the bells are hung 21 ins. below contact wire and the gauges must be erected 30 ft. clear of nearest rail.

3 Overhead Structures for A.C. Equipment

The Civil Engineer is responsible for the maintenance of track and structures, and has an overriding responsibility for the safety of the structures supporting the overhead contact system.

Experience in the maintenance and renewal of metal bridges and roofing dictates the approach to this problem. On the Eastern Region these structures are 7 ft. from the face to the nearest running edge on embankments and 8 ft. 6 ins. from face to running edge in cuttings, the latter allows for the track drainage.

The basis of design outlined in Papers 6 and 35 was agreed with the Chief Civil Engineers, and the Contractors' calculations verified; furthermore, tests have been witnessed, together with inspections of all structures during manufacture.

The structures must be capable of resisting torsion produced by the ' along track ' loads, also they must resist horizontal loads across the tracks due to wind and radial pull, together with the vertical loads from the equipment. Various kinds of structures have been devised, the four main types being:—

1. Portal structures.
2. Cantilever structures.
3. Anchor structures.
4. Anchor masts.

In the design of the structures, modern practice has been observed and in choosing types to meet the varying conditions, regard has been paid to economies in the weight of steel, standardisation and interchangeability of parts permitting mass production techniques in the fabricating shops and easy erection on site. The latter is of extreme importance in view of the necessity to minimise interruptions to rail traffic.

In general, welded steel structures have been adopted for rapid assembly and are fabricated in large interchangeable units in which bolted site connections are employed, though prefabrication has included a form of precast concrete base.

Special attention in design, detailing and workmanship has been given to ensure a high degree of resistance to corrosion, and also to aesthetical considerations in the appearance of the structures, not only in standard equipment, but in special designs connected with important station construction, so that the appearance of the electrical equipment will merge successfully with the architectural features of new station buildings.

3.1 *Maintenance*
In order to ensure a maximum period of service on these structures, it is necessary that the original section shall not deteriorate as the result of incipient corrosion, otherwise the element of safety will be progressively decreased until a critical condition has developed.

Within the limitations of economies, measures have been introduced to procure a maximum life in the structures. These take the form of effective anti-corrosion surface treatment by the hot dip galvanising process, depositing not less than $2\frac{1}{2}$ ozs. of zinc spelter per sq. ft. preceeded by immersion in acid to remove scale, the whole process being carried out to a rigid specification.

In areas subject to heavy atmospheric conditions, minimum thicknesses for steel sections have been adopted to minimise the effect of the accelerated corrosion under such conditions. The minimum thicknesses used in such areas are as under, and may be compared with the measurements shown in brackets which represent the corresponding thicknesses under clean air conditions:—

M.S. Angles and plates $\frac{3}{8}$ in. ($\frac{5}{16}$ in.).
M.S. Joist and channel webs $\frac{5}{16}$ in. (0·26 in.).
M.S. Sealed tubes No.7 gauge = 0·176 in.
(No.8 gauge = 0·16 in.).

Points of entry of steel into concrete are vulnerable to corrosion and are dressed with bituminous sealing compounds. Fig.4.

A great deal of effort has also been directed to evolving clean detail of design, to avoid accumulation of moisture and to ensure adequate access to all parts to provide facilities for cleaning and painting.

It is to be appreciated that maintenance of this kind will present, in due course, a problem of no mean order, since more than 50 per cent. of the work will have to be carried out with the current switched off and under possession of the line.

3.2 *Architectural Features*
Consideration of the aesthetics is important. The loading on the structures is relatively light and it is appropriate that they should be of corresponding appearance.

In the case of the angle/welded rod portal frame, this has been achieved and as a measure of the lightness, this form of construction in a span of 75 ft. contains only $1\frac{1}{2}$ tons of steel.

Although this form of structure has been accepted as suitable for general use, it has been considered desirable in important station construction work to give special treatment to the structures in order that they shall harmonise with the new stations. A case in point is the ' Harlow Town Station ', where frames are composed of main tubes braced with welded rods in conjunction with masts of twin tubes battened together with tubes at intervals. Fig.5.

3.3 *Attachments to Existing Structures*
Where the condition of overbridges is suitable for the attachment of supports for overhead line equipment, and where these bridges coincide with the desirable positioning of the overhead structures, the supports for the conductor wires are attached to the soffit of the bridges, or the abutments, wing walls, or piers. In the case of attachments to metal decking, the equipment supports are clipped to the girders to obviate drilling, and in the case of concrete or brickwork, the supports are attached by suitable rag bolts grouted into the sub-structure with resin based cement.

At viaducts, the attachment of the mast bases is made to seating channels projecting from the existing spandrel walls. Two main types of corbel are used. The first comprises two steel channels encased in concrete and located under the track and extending from one side of the viaduct to the other, projecting from the face work at each side sufficiently to form a seating. The second type is similar insofar as the form of the seating for the mast base is concerned, but instead of two channels extending the width of the viaduct, they are curtailed at each side, and terminate in an anchor block placed behind the parapet wall.

4 Foundations to Meet Exceptional Conditions

Several forms of special foundations have been evolved to suit varying ground conditions. Where abnormally poor conditions, particularly in clay embankment, are encountered, a form of foundation has been devised in order to preserve the stability of the structures should movement of the foundation occur.

The concrete bases are in the form of shallow precast reinforced concrete slabs. The structures are designed as rigid frames and any movement of the foundation would cause severe stress and distortion of the frame-work and interruption to traffic until rectified.

To overcome this situation, one support is provided with a standard hinged base and the other, on the side of the bank liable to movement, with a link base in the form of a cradle. These allow movement of the foundation without the corresponding movement in the rigid frame, thereby maintaining its stability. Repairs to a slip may then be carried out and the foundation replaced in its original position. Fig.6.

In a test made where a displacement of 9 ins. was made in one mast, it required only five men, using crowbars and track jacks for 20 minutes to rectify the displacement. In the time mentioned the men also rectified a tilt of 15° in the base slab.

For portal structures on embankments less than 10 ft. high and subject to earth slip, deep bored foundations are used, with the effective portion of the foundation in good ground, and the masts cast into the concrete.

Cantilever structures on embankments higher than 10 ft. are bolted to the foundations so as to ensure easy removal and replacement in the event of a slip occurring and requiring repair. For cantilevers on banks lower than 10 ft., the masts are cast into deep bored concrete foundations as for portal structures.

In peat areas, soft brown clay may overlay the peat in varying depths and in some cases a layer of clay will remain underneath the foundations and above the peat. In this condition, reasonable stability can be achieved by increasing the bearing area of the foundations and not exceeding a maximum pressure of between 500 to 600 lbs. per sq. ft. on the clay.

In most cases it is possible to construct a foundation in the overburden to the peat strata by inserting three bored piles to an approximate depth of 8 ft. and forming a large cap at the head, or providing hollow circular foundations of sufficient area to transfer the overturning moment into the upper layer of stable ground. In all cases where concrete is in contact with peat or water contaminated by the peat strata, slag based cement is used.

The slab type of precast base as described above is equally suitable in the areas of running sand, except that an increased ground pressure of up to 1,000 lbs. per sq. ft. is permissible.

Particulars of yet another type of foundation suitable for use on subsidence areas are given in Paper 35.

5 Attention to Track in Readiness for Electrification

The track structure must obviously be made suitable for carrying electric locomotive-hauled or multiple-unit stock travelling at high speeds and at frequent intervals. The process of electrification and general modernisation also involves further considerations, however, which are co-ordinated with the work of the Electrical and Signal & Telegraph Engineers, and this is dealt with in Paper 7.

It will be apparent also from Papers 7 and 33 that the effect of irregularities in the track upon the trace of the pantograph are of considerable importance. Up to the present it has been agreed with the Chief Electrical Engineer that, in the ordinary course of maintenance, deviations of 1 in. in alignment and $\frac{3}{4}$ in. in cross-level are regarded as the maximum permissible amounts. The overhead wire height will also permit the track to be lifted 3 ins. above its level when the wires were first erected during relaying operations, and in these circumstances alterations of up to 1 in. in alignment are permitted without consultation with the Chief Electrical Engineer. For alterations of more than 1 in. in alignment and more than $\frac{3}{4}$ in. in cross-level, the Chief Civil Engineer consults the Chief Electrical Engineer. In certain places, notably at low overbridges and at junctions, it is essential to maintain the track close to the line and level at which it was fixed when the overhead wires were first put up, and in such places the maximum permissible deviation in line is $\frac{1}{2}$ in, while the track may not be lifted more than $\frac{1}{2}$ in. above the prescribed level. Permanent metal plates are provided at such places to indicate the correct line and level of the track and similar plates are provided at all low overbridges.

Experience has shown that one of the major effects of electrification is that it compels reconsideration of the layout of the track in stations and yards before wiring commences. The heavy expense of altering mast layouts and wire attachments to structures after the overhead line is erected involves provision of such a design of track layout as will fulfil operating requirements efficiently, not only at the time of electrification, but into the foreseeable future. This is an aspect of electrification which, in the past, may not have been given sufficient prominence.

6 Provision of Additional Running Facilities

Designs are now available which will enable crossovers to be used at speeds up to 75 m.p.h. out of straight track. It may be, however, that for the time being the electrical difficulties involved in wiring such high speed crossovers, together with the signalling work involved, could make such high speed assemblies difficult to justify.

Where the provision of additional running lines to remove traffic bottlenecks is prohibitively expensive (as, for instance, where major viaducts or long tunnels are present), consideration may very well be given to 2-way working over the existing tracks and the adoption of high speed turnouts enabling the maximum use to be made of the present facilities in such cases, since trains could enter upon and leave the 2-way worked section with very little reduction in speed.

7 Running and Repair Sheds

Two large sheds are provided at Ilford and East Ham to service the whole fleet of 400 multiple unit trains for the Eastern Region Electrification scheme in the London area. In these sheds the columns supporting the flat roof are in prestressed concrete as are the main beams which span between the columns. The columns taken in a row transversely are designed to carry the wind load, and this was achieved by welding together steel bearings into which is fitted a shear pin between the bearing plates which were then welded to a steel base plate lugged into a column bracket. The columns were also designed to take temperature stresses and the welding was carried out at an average temperature.

In order to transmit any longitudinal movement of the roof to the columns, through bolts were provided connecting the tops of the beams to the column heads. These bolts are provided with spring washers to preserve the free ended conditions of the beams. The purlins which stand between the main beams at 36 ft. 8 ins. centres are formed of castellated steel beams.

The side walls of the sheds are composed of pressed aluminium sheeting which is easy to erect and gives a pleasing appearance as was required in a residential area. Aluminium, suitably waterproofed, has also been used for the roof decking between the roof lights. The latter provided the maximum of illumination in the shed when all the lines are occupied by trains and, moreover, easy access is given for cleaning the glass.

The Ilford shed has 16 parallel tracks and is 653 ft. long and 277 ft. 7 ins. wide. There is a clear headroom to the contact wire of 19 ft. 6 ins. and to the soffit of the beams of 21 ft. 6 ins. These heights allow for the testing of the pantographs.

In the two sheds referred to, pits of conventional design complete with strip lighting and services were provided. A radical change was made for a shed at East Ham because, in the intervening period, scrubbing machines had been introduced for cleaning the floors of the coaches. Therefore, raised platforms were provided between the tracks to allow for easy transportation of the machines between compartments and the floors below the platforms were provided at a depth of 3 ft. 0 ins. below rail level. This gives excellent access to the equipment below coach floor level and to brake blocks.

From the cross section, fig.7, it will be seen that in the base of the pit two angle irons are provided as a run-way for a trolley which distributes the brake blocks along the pit. These are accommodated in a detachable body which is lowered on to or removed from the trolley by means of a fork lift truck.

Aluminium hand propelled mobile platforms are being provided at Ilford to permit access to carriage floor level from the space in between the tracks. At East Ham, however, where the raised platforms prevail, short aluminium ladders will be used to reach carriage floor level in the tracks adjacent to the columns where no raised platform can be provided.

The functions of the pits and platforms can be indicated by the presence of the services in their respective positions. For instance, on the raised platform are provided outlets for hot and cold water associated with such cleaning down of the stock as is not undertaken in the washing plant. Cold water is used primarily for filling the lavatory tanks. There are also provided at platform level outlets for a compressed air tool, a jet for cleaning dust from the electric relays and servicing other equipment associated with train control; a 240 volt supply for a polishing machine; a 50 volt supply for a portable hand lamp, and inlets for a portable vacuum cleaning machine. High quality cleaning and minor repairs to coach work are, therefore, well covered at the upper level.

In and at the side of the pits which are located at 15 ft. 2 ins. centres transversely and are 4 ft. 6 ins. deep by 4 ft. 4½ ins. wide at the top and 2 ft. wide at the bottom, it is possible to secure a 50 volt supply for hand lamps and a compressed air supply as well from the underside of the raised platform. The two services are, therefore, available at both levels from one supply point.

General lighting in the pits is provided by cold cathode strip lamps let into the walls at 15 ft. centres, staggered, each lamp being about 5 ft. 6 ins. long. Fig.7.

Overhead Line Maintenance Depots
Electrical Control Stations

Figs.8 and 9 show the outline and layout of such Depots at Colchester and Pitsea respectively.

SUMMARY

After a general assessment of the Civil Engineering Aspects the Paper describes the various alternatives that are possible for obtaining the necessary clearance to the pantograph and contrasts the frequency of overbridges in Great Britain with that in France. It then describes in some detail the use of partially pre-stressed concrete for bridge reconstruction and gives particulars of special methods adopted on some brick arch bridges for avoiding complete reconstruction. The work necessary to comply with Safety measures stipulated by the Ministry of Transport is also described. The next section details the civil engineer's responsibility for overhead line supporting structures and the steps taken to reduce maintenance costs and to attain an attractive appearance. Particulars are given of some special foundation constructions for dealing with bad ground conditions and of the work necessary on the track itself to deal with more intense train services and to provide sites for the structures themselves. The Paper concludes with some particulars of two large running and repair sheds constructed by the author for the Eastern Region electrifications and illustrates a typical control room and substation.

RÉSUMÉ

Après un examen général des aspects des travaux aux ouvrages d'art, l'exposé décrit les différentes alternatives qui permettent d'obtenir le gabarit de pantographe et fait ressortir la différence entre les nombres de passages supérieurs en Grande-Bretagne et en France. Puis il décrit avec quelques détails l'emploi du béton partiellement précontraint pour la construction de ponts et donne les détails des méthodes spéciales adoptées pour éviter la reconstruction complète de certains ponts voûtés en briques. On décrit aussi les travaux nécessaires pour satisfaire les mesures de sécurité stipulées par le Ministère des Transports. La partie suivante de l'exposé traite en détail de la responsabilité des ingénieurs de génie civil pour les supports des caténaires, et les mesures prises pour réduire les frais d'entretien et pour obtenir un aspect attrayant. On donne les détails de certaines constructions spéciales de fondations en vue de considérer les conditions défavorables de terrain, des travaux de voie nécessités par un trafic plus intense et afin de procurer d'emplacements aux supports mêmes. L'exposé se termine en donnant quelques détails sur les deux grands dépôts d'entretien et de réparation construits par l'auteur pour les électrifications de la Eastern Region, et un aperçu d'un poste de commande typique et d'une sous-station.

ZUSAMMENFASSUNG

Der Bericht beschreibt, nach einer allgemeinen Betrachtung der Bauingenieur-Aspekte, die verschiedenen möglichen Alternativen um den notwendigen Spielraum zum Stromabnehmer zu erlangen

und vergleicht die Anzahl der Ueberführungen in Grossbritannien mit jener in Frankreich. Der Bericht erläutert ziemlich ausführlich die Anwendung von teilweise vorgespanntem Beton für den Brückenwiederaufbau und gibt Einzelheiten von angewendeten Spezialmethoden an einigen Backstein-Bogenbrücken an, um einen kompleten Wiederaufbau zu vermeiden. Die notwendige Arbeit, um den vom Transportministerium festgesetzten Sicherheitsmassnahmen nachzukommen, ist ebenfalls beschrieben Der nächste Abschnitt erläutert ausführlich die Verantwortlichkeit des Bauingenieurs für die Fahrleitungsmasten und die von ihm ergriffenen Massnahmen, um die Unterhaltungskosten zu reduzieren und das Aussehen der Masten zu verschönern. Einzelheiten über Spezial-Fundamentkonstruktionen für schlechte Bodenbeschaffenheiten, die notwendige Arbeit an den Geleisen, um einen dichteren Zugverkehr zu bewältigen und das Vorsehen von Bauplätzen für die Masten sind angeführt. Der Bericht gibt abschliessend einige Einzelheiten der zwei grossen Betriebs- und Reparaturschuppen, die vom Autor für die 'Eastern Region' — Elektrifikation konstruiert wurden, ferner werden ein typischer Schaltraum und ein Unterwerk beschrieben.

RESÚMEN

El documento trata primeramente de los aspectos de la ingeniería civil desde un punto de vista general y, acto seguido, aborda las diversas alternativas que se pueden emplear para obtener el espacio libre necesario en el pantógrafo y compara la frecuencia con que se dan los pasos superiores en la Gran Bretaña y Francia. Luego describe detalladamente el uso de hormigón pretensado parcialmente para la construcción de puentes y facilita información acerca de los métodos especiales que se han adoptado en algunos puentes de arco hechos de la drillo anteriormente, para evitar su reconstrucción completa. Se describe, asimismo, el trabajo que fué preciso efectuar para observar las medidas de seguridad estipuladas por el Ministerio de Transporte. La sección siguiente se refiere a la responsabilidad que recae sobre el ingeniero en la construcción de las estructuras de sustentación de las líneas aéreas, así como a las medidas adoptadas para reducir los costos del servicio de mantenimiento y para conseguir un aspecto vistoso. Se cita también información en torno a la construcción de cimientos especiales para superar condiciones adversas del terreno y en torno al trabajo que se debe realizar en la vía propiamente dicha para hacer frente al servicio más intenso de trenes y para preparar los lugares en donde se emplazarán las estructuras. El documento concluye proporcionando información acerca de dos grandes depósitos de recorrida y reparación de locomotoras construídos por el autor como parte de los sistemas de electrificación de la 'Easteen Region,' e ilustra finalmente una sala de control y subestación características.

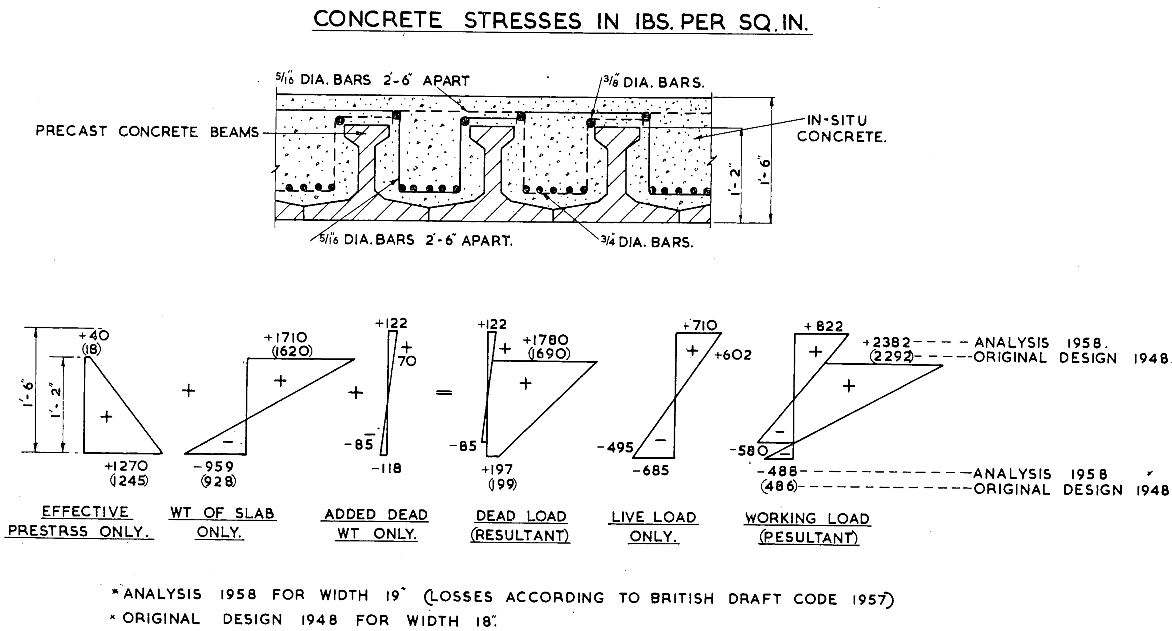

Fig.1 Bridge No. 7 Buck Lane

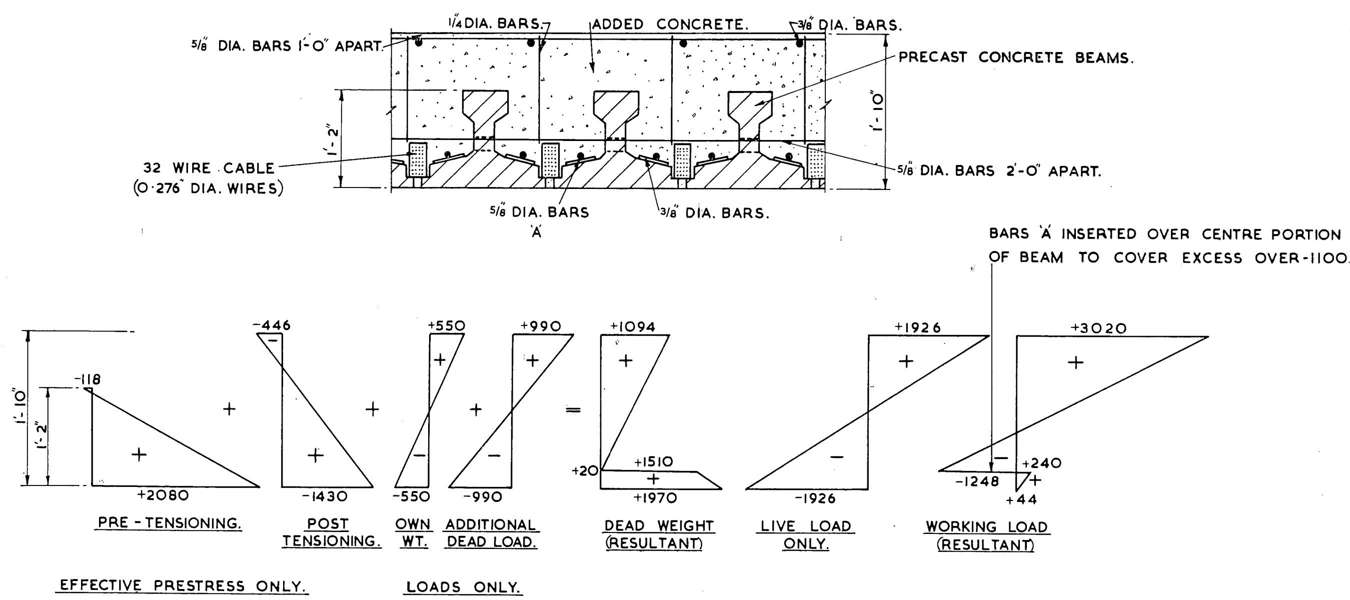

Fig.2 Bridge No.1002 Ipswich Road

Fig.3 Overbridge demolition

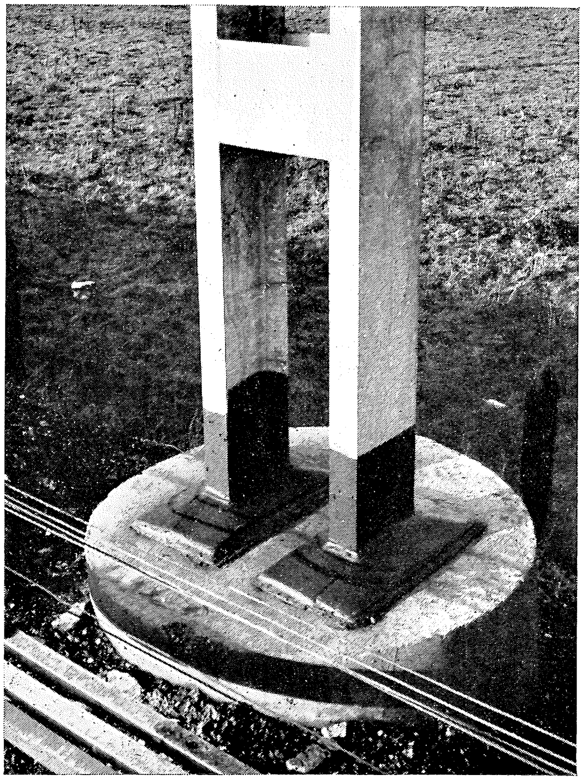

Fig.4 Maintenance

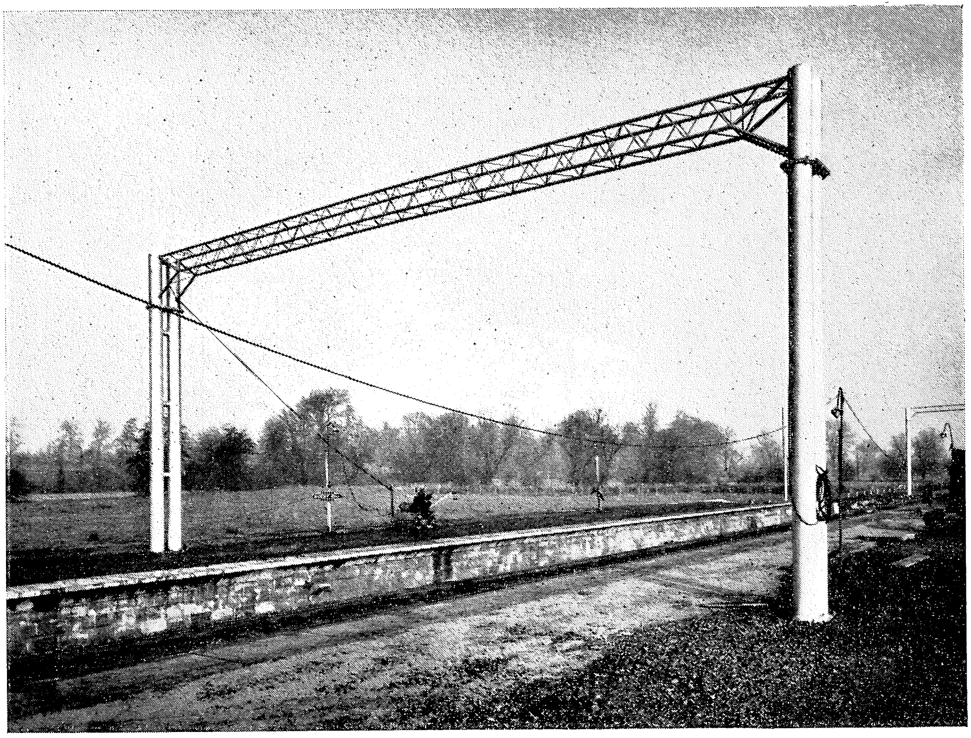

Fig.5 Architectural features

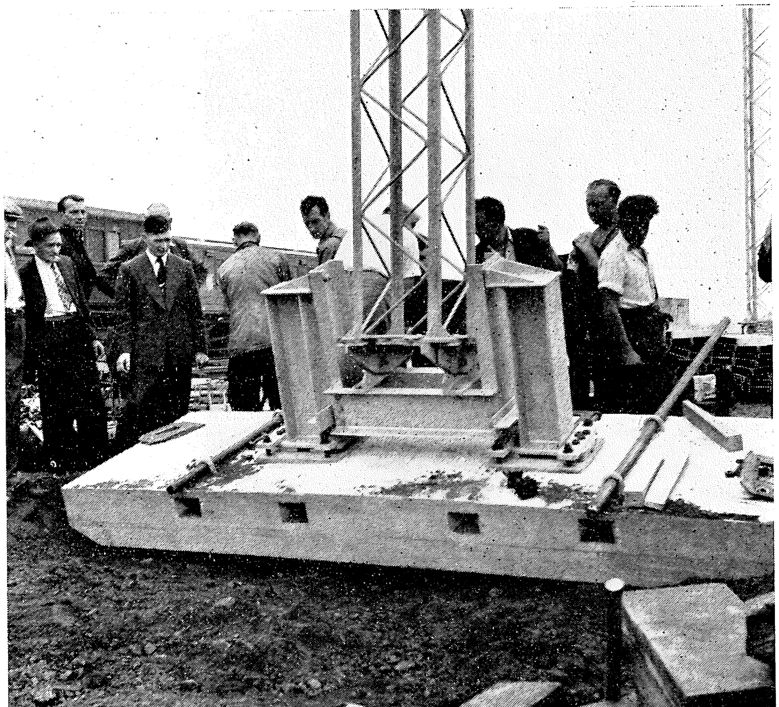

Fig.6 Foundations to meet exceptional conditions

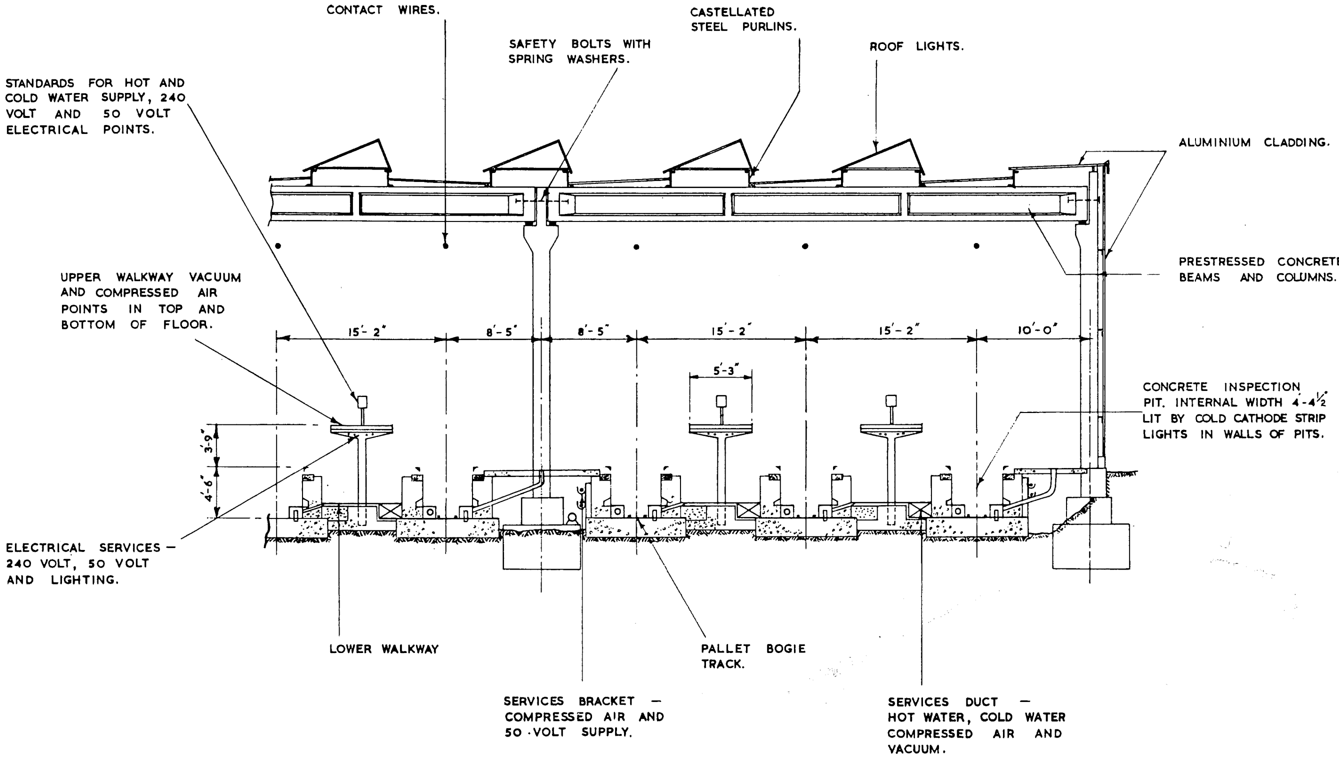

Fig.7 East Ham running shed for multiple unit trains.

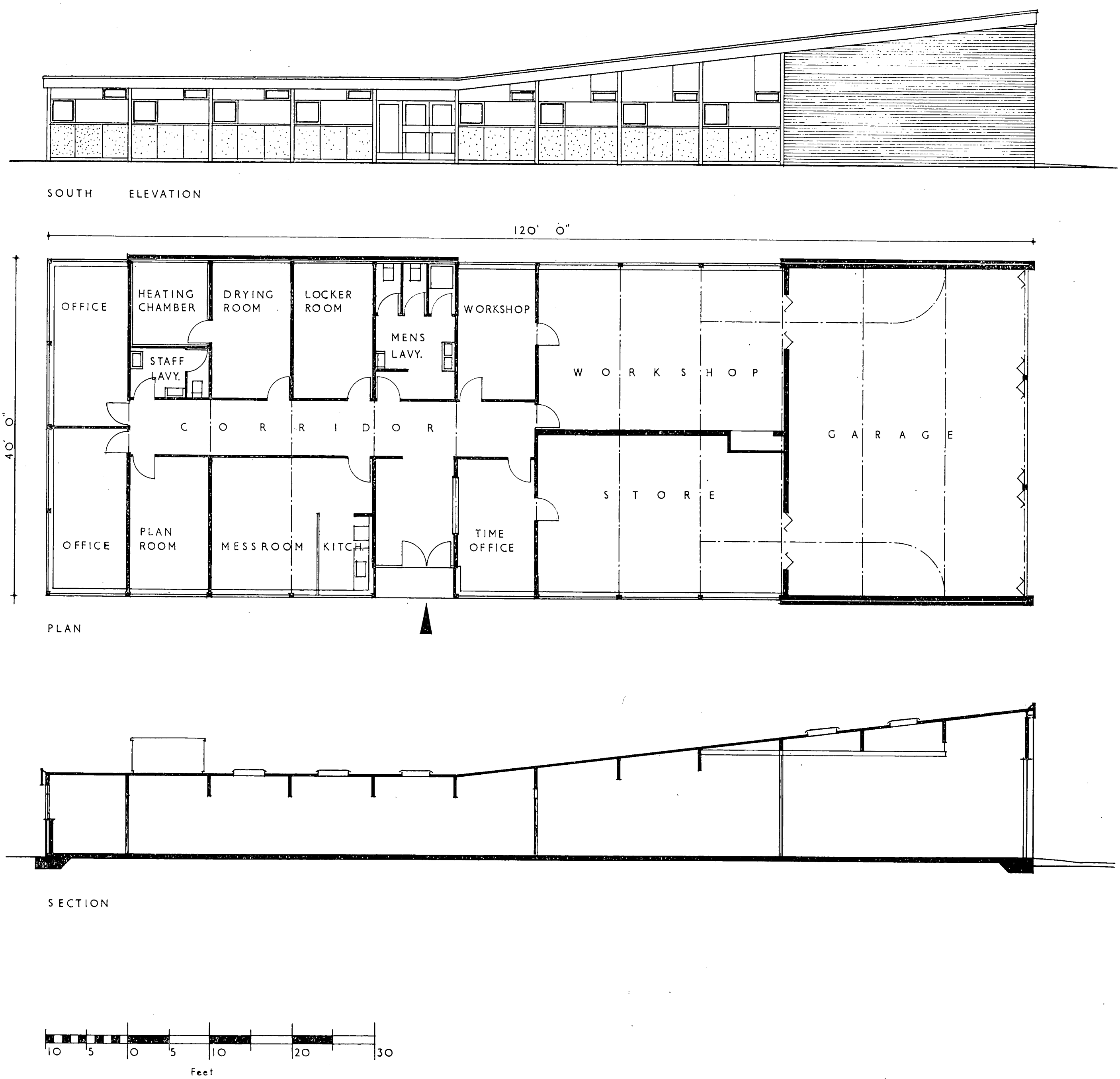

Fig.8 Overhead line maintenance depot at Colchester

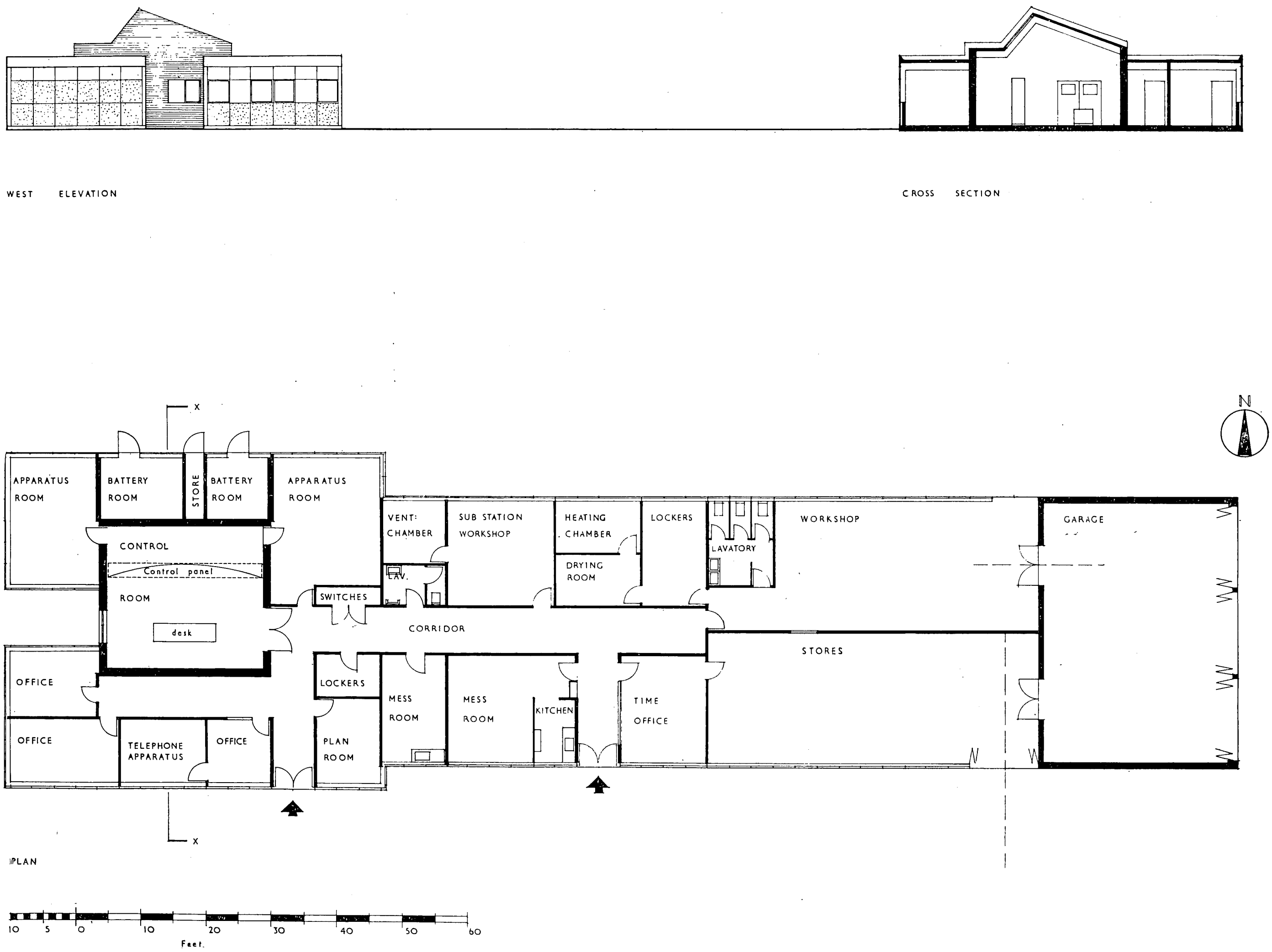

Fig.9 Overhead line maintenance depot and electrical control station at Pitsea

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