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Paper 7

The Erection of the Overhead Line Equipment

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1 Fundamental Difficulty of Approach to Installation Work

The major problem to be faced in the installation of overhead equipment for electric traction is that considerable occupancy of running lines is required. Total closure to traffic of the tracks to be electrified is the ideal and the more one departs from this the greater the time and cost of installation. Where multiple tracks exist much can be done but on two track sections single line working is necessary. Such an arrangement can be facilitated by the installation of temporary facing and trailing crossovers located at suitable intervals and worked by ground frames equipped with signalling instruments and telephones. These crossovers may be dispensed with when construction is completed or retained permanently to facilitate maintenance.

An enlightened Operating Department can contribute in a marked way to the success of an installation. Some traffic over the section may possibly be diverted to other routes or skilful adjustment of timing made to mitigate the delays in single line working. These and similar operating restrictions must be weighed against increasing the cost of construction by periods of occupation of tracks too short to be effective or by less efficient night work. There is a good deal to be said for drastic measures for curtailment of traffic for this installation work; an almost complete closure for a limited period is far better than a long continued, costly process to keep the wheels rolling.

2 Importance of Planning

It is therefore essential that the occupancy of the track or ' possession ' is kept to the very minimum for construction. Profound planning is required to ensure that every mast location is determined and in turn every process and every detail of material is available to avoid a return to site involving further possessions of the same track. This exact continuity becomes increasingly necessary as the lack of one small item, e.g. wayleave for a structure, may hold up the wiring of a complete tension length.

It should be made clear at this point that the Electrical Engineer is not alone in his demand for possessions. The Civil Engineer, responsible for the permanent way, bridges and all associated work, requires occupancy for maintenance and renewal while the introduction of electrification brings rigorous demands not only in line and level, to meet higher speeds, but in the establishment of clearances for live overhead wires. To a lesser degree the Signal Engineer makes demands in connection with new or resited signals and modification of track and telecommunication circuits.

It is the practice of British Railways to employ contractors for the installation of overhead line equipment. For competitive tendering it is necessary to present the potential tenderers with as complete a specification as possible. The preparation of this information by the railway is essential to

ensure that all matters affecting the installation are appreciated, co-ordinated and executed. This gathering together of data can be accomplished – indeed a good deal of it must be done for estimating purposes – before authority is given for the scheme to be carried out.

In the preparation of a scheme for approval it is usual for a co-ordinating ' Progress ' Committee to be set up comprising representatives of the Civil, Mechanical & Electrical and Signal Engineers, of the Operating and Commercial Departments under the Chairmanship of an Electrification Planning Officer on the staff of the Regional General Manager.

3 Basic Information

The first step in the electrification of a route is to find out and set down all the physical features including bridges, water columns, power line and level crossings. This work is done in the Eastern Region of British Railways by the staff of the C.M. & E.E. Department, which is responsible for the survey and installation work of the overhead contractor, in co-operation with a Route Inspection committee consisting of representatives from the technical and operating departments.

A single line diagram is prepared and the lines to be electrified agreed in committee together with any amendments or new layouts of permanent way. On this single line diagram sectioning of the tracks for electrical isolation purposes can be worked out in collaboration with the Operating Department. It is important that all switching requirements are settled at an early stage for the sectioning diagram is the key to the positioning of overlap spans which in turn form the basis of overhead structure positioning.

4 Route Inspection Notes

The Route Inspectors of the C.M. & E.E. Dept. chain through the route keeping to the Up Line inside rail (using a plastic covered steel tape) from a datum point agreed with the Civil Engineer. They mark in paint and record the location in miles and feet of all fixed points existing at the time, e.g. bridge abutments, signals and signal boxes, water columns, in fact anything at all with a bearing on the future electrification of the line.

It is during this inspection and the subsequent walkout by the Route Inspection Committee that attention can first be given to simplifying the track layout. Where clearances between tracks are not available for structure masts it may be possible to obtain sufficient space by slewing one or more tracks, by altering the position of point and crossing work or by omitting a redundant siding to reduce the structure span.

The Route Inspection Committee's Notes – continually amended as decisions are given and information built up – gradually become a checked factual statement of the line ready to put into the hands of the Overhead Contractor. As soon as particulars of the final signal locations under electrification have been included then the Notes are sufficiently advanced for constructional purposes. (See Appendix A for typical page of Notes). The Route Inspection Notes finally comprise two main sections:—

I. A general introduction giving standard clearances for the guidance of the Contractor and a running commentary throughout the route giving the exact location of all features of which the following are illustrative:—
   - (*a*) Civil Bridges, Cuttings, Drainage
   - (*b*) Signal Signal Structures, Open Wire Signal & Telecommunication Routes
   - (*c*) General Water Columns, Mail Bag Pick-up Apparatus, etc.

II. A number of Schedules, Recording every item:

i. Level Crossings	Location, Type, Minimum Contact Wire Height & General Remarks on possibility of closure or track lifting
ii. Power Line Crossings	Location, Voltage, Height of Conductor above rail
iii. Signal Locations	(*a*) Before Electrification (*b*) After Electrification
iv. Water Columns	Location, Line Served, Type, whether to be retained or resited or more generally removed
v. Bridges	Complete Bridge Schedule
vi. Slip Areas	Location of all bank slip areas and other places where special foundations may be required
vii. Track Maintenance	Location and length of track scheduled for alteration in line and level – slew and cant in the period up to and including construction
viii. Lateral clearance	(*a*) Location where additional lateral clearance required for signal sighting purposes, and (*b*) Location of areas in cuttings where lateral clearances are to be increased to allow for cess drains.
ix. Power Supply	Location of Feeder Stations and Track Sectioning Cabins and associated neutral sections.

Information is also given regarding areas where the atmospheric pollution may necessitate precautions in thicker steel work and greater insulation creepage paths. Requirements regarding return conductors and booster transformers are stated in general terms. The siting of booster transformers is related to the most suitable overlap span.

As soon as authority has been given for the electrification of a route it is essential to bring the permanent way to a high standard not only to meet a normally much increased service and one run at higher speeds, but also because the track must at all times be registered, in line and level, with the agreed limits see Paper 8 with the overhead equipment in which only limited tolerances may be available. The Civil Engineer has much work to do before the overhead equipment can be installed. Obtaining the necessary clearance for the wires at overbridges and elsewhere by lifting or lowering is perhaps obvious but it cannot be too highly stressed that the Civil Engineer should have his tracks in their final position before any overhead equipment work is begun.

5 The Contractor's Survey

The Overhead Line Equipment Contractor is now brought in; and armed with the Route Inspection Notes – the Single Line Diagram and the Sectioning and Switching Diagram proceeds to his Survey of the line. Plans of the whole route are available or are produced from an aerial survey. On open track sections they are on a scale of 1/2500 for the open line and 1/1250 for more congested areas. For all stations and groups of sidings not less than 66 ft to 1 inch plans are required.

The Construction Contract administered by Regional Engineers covers survey and erection. Supply of material and design are reserved for the Chief Electrical Engineer of the Central Services of British Railways. Standard designs of overhead equipment are available in the Regions and issued to the Contractor who makes known his requirements for special designs to fit particular locations during the course of his survey.

6 The Aim of the Survey

An intelligent survey with careful erection will give good current collection with the minimum of maintenance. The type of equipment chosen depends largely on the maximum speeds required over the section and for all normal conditions will be weight tensioned equipment.

The structure spacing and positioning will be dictated mainly by permanent way and physical features while the position of the contact wire itself is defined:—

Across track: by the width and collecting surface of the pantograph

Vertically: by overbridges, level crossings and gradient of the contact wire

The immediate object of the survey is to record the position of all structures and the layout of the equipment between them on scale plans of the route. This will naturally be based on the sectioning required and the tensioned lengths permissible leading quite naturally to the type of structure needed to support the equipment, e.g. cantilever, portal, anchor, at every location. From this knowledge a complete bill of quantity can be derived in due course.

7 Inspection Walk Outs

As soon as layouts both for station areas and open route are available ' Walk-outs ' are organised. Representatives of all interested departments and the Contractors inspect the section of line to be electrified and agree in the final form of layout. The party comprises about ten persons; a representative of the C.M. & E.E., a District and Headquarters representative for the Chief Civil Engineer; a Signal Engineer; Traffic Department representative and members of the Signal Sighting Committee.

On open route areas, i.e. where there is no wired point and crossing work a new form of layout plan has been developed which on the 1/2500 scale shows, in addition to normal survey information, steelwork and foundation details. A typical example is given in Appendix ' B '. All departments comment and agree as they proceed along the route and each plan covering the section of the work is amended signed as approved there and then.

In station areas and other places distinct from open route, larger scale layout plans are used, e.g. 40 ft to 1 inch. In these areas where the structures are more complicated, the type of foundation is allocated and the layouts agreed and signed as approved on the walk-outs. Subsequently Cross Sections are submitted by the Contractor for each of the structure locations and approved on a second walk-out.

It will be appreciated how much the detailed railway route inspection contributes to the Contractor's survey. Information regarding slip areas, soil conditions, etc. facilitate agreement on foundations, details of which must be approved by the Chief Civil Engineer in an accepted procedure.

The cross section not only gives particulars of foundations but also the steelwork required at that location. On open route the combined Data and Layout sheet gives the same information. The whole procedure to the end of the survey is given on a Chart (see Appendix ' C ').

When the layouts of track equipment and the location cross section or data sheets have been finalised and approved, special designs can be developed and Standard Design materials can be ordered with confidence for delivery to the Contractor's Depot.

8 Depots

It is very much in the Railway interest to establish efficient construction depots for use by the Overhead Contractor. It is often possible to adopt these for later use for the maintenance of equipment. The radius of operation of such depots should not exceed thirty miles. Over this distance service to and from the site is apt to be uneconomical. For a section of approximately 150 S.T. miles, the depot should comprise at least five sidings from 650 ft to 900 ft long on which to

marshal the Works Trains – foundation, steelwork and wiring. The area should also include a stacking ground, say 30 ft × 800 ft paralleled by rail and a roadway, for steel masts and booms. Adequate stacking space is also required for small part steelwork. An enclosed cable compound say 20 ft × 100 ft for drums of catenary and contact wire together with suitable oil and cement stores should be provided. Stacking bins for sand and gravel should be placed conveniently for filling from road and loading of the works train vehicles.

9 The Erection Programme

The Erection Programme should be developed to ensure that minimum amount of work is done on Sundays and that an even work load for the Contractor's staff is maintained by doing as much work as possible on weekdays as well as at week-ends without affecting the normal traffic flow over the route being electrified. This can only be done when a large number of layout plans and cross sections have been finally approved and the work covered by those plans allocated between weekday and weekend work. It is, of course, absolutely essential that supplies of standard material are available and that the manufacture of any structures which have to be designed for particular locations has been arranged for delivery at the appropriate time.

The erection plan is jointly produced by the Contractors and the District Electric Traction Engineer acting for the Chief Mechanical & Electrical Engineer. In the first instance, the Contractor is responsible for preparing, in detail, his proposals for the installation, these are examined by the Electrical Engineer who after agreement makes the necessary arrangements with the Operating Officer for possessions where they are required, for the protection of the Contractor's staff and the provision of lookout men. During the preparation of the Erection plan an assessment is made of such matters as the number of foundations which can be installed by mechanical plant and those which must be hand excavated. A high proportion of the larger foundations are hand excavated and require no special track possessions. By arrangement with the Operating staff Automatic Concrete Mixing Plant can be held in a siding or on a slow line and brought out between trains to pour foundation concrete. In the same way, certain steelwork can be erected between trains but the running of wire requires single or total line possessions. The full utilisation of line blocks is most important to keep down interruptions to railway service and to maintain economical use of labour and supervision e.g. train crews, lookout men and inspectors.

10 Planning Possessions

At the beginning of every week a possession meeting is held under the Chairmanship of the Operating Department's representative. All Departments of the railway concerned with electrification are represented to plan in detail the possessions and Work Train programmes for the following four weeks, the first week's work is planned in great detail and a Special Train Notice prepared giving full details of Works Train make up, timings, manning and arrangements for track occupation. Work for the second, third and fourth weeks is planned first in a preliminary way, and in due course, in increasing detail as the time approaches for the arrangements to be put into operation and the work executed. In this way the Operating Department controls all line possessions and can make the necessary arrangements for staffing Works Trains in addition and all Departments are fully aware of the agreements and take measures to meet their commitments. Certain overhead equipment work is carried out on site without track possessions and in such cases adequate protection of the Contractor's staff must be arranged.

11 Manning of Works Train

Works Trains are hauled by steam or diesel locomotives and involve two enginemen, a guard and a traffic inspector. The Overhead Equipment Contractor provides an Engineer or Foreman to supervise the gang executing the work. The Chief Mechanical & Electrical Engineer's Department is represented by a Technical Assistant or an Inspector whose function it is to see that the work programme is carried out to plan, to inspect the work as it progresses, and to act as liaison between the Contractor and the Operating Department to facilitate any adjustments to the programme found necessary as the work proceeds. Economies in staffing can naturally be effected if a number of trains are working in close proximity, e.g. in complicated junction areas.

In addition to the staff referred to above nearly all Works Trains require one or two lookout men to protect personnel when work is being carried out adjacent to running lines especially where single line working is in operation.

It will be appreciated that on a large Electrification project many vehicles as well as personnel are involved in providing the required number of Works Trains. The figures given below indicate hours expended on the installation of 200 single track miles of overhead equipment in the very complicated network of lines including the junction and sidings at Crewe.

Works Trains Hours	26,500
Lookout Man Hours	75,000

12 Types of Works Trains

12.1 *Foundation Trains*

These comprise three main types; a complete train for excavating, planting steel masts and concreting in one procedure and two concrete pouring trains.

12.1.1 *The Auger Borer Train* (see figs.1 and 2)

This train comprises three sections with locomotives at the front and rear.

The Auger Borer unit leads, next comes the steel erecting crane and wagons conveying steelwork, followed by a secondary concrete mixer unit.

On arrival at site the train engine deals with the auger unit, the self propelled diesel crane with the steelwork and the rear locomotive propels the concrete unit.

The required hole having been bored the crane places the

steel mast in the hole where it is held in a clamping jig for the concrete to be poured. In this way, during a four hour possession, masts can be erected on one track mile.

The Auger Borer driven by a 35 H.P. Diesel Engine is equipped with interchangeable heads to bore 2 ft, 2 ft 9 in. and 3 ft 6in. diameter holes.

12.1.2 *The Secondary Concrete Mixer Train* (see figs.1 and 3)
This train which can be embodied in the Auger Borer Train above, is used mainly to fill any of the hand dug holes not large in cubic content.

It consists of two Blaw Knox mixers mounted on Lowmac wagons with attendent 13 Ton Low Loader wagons containing sand and aggregate. Cement is carried in covered vans and water tenders connected by hosepipes to the mixers. Barrow runs are placed on the centre of the low loader wagons for running material to the mixers. Aluminium Chutes are manually positioned on trestles at the location and concrete as it is mixed is fed into the hole manually. The operation involves a considerable number of men, of the order of 20.

12.1.3 *The Automatic Concrete Mixer Train* (see figs.1 and 4)
This train has been developed to deal with larger foundations where considerable quantities of concrete are involved. It can also be used in association with the Auger Borer train if required. It consists of four hopper wagons with two continuous mixers mounted on a Weltrol wagon fed by conveyor belts. Cement is added by compressed air from bulk cisterns, Electric Power is supplied from a Generator. An initial mix can be stored on the unit so that work can start immediately on arrival at site. Only five men are required to man this train.

12.2 *Steel Erection Trains* (see fig.1)
There are two main types for dealing with:—

12.2.1 Masts for standard cantilever assembly.

12.2.2 Fabricated structures made up of either standard steel or lattice design and may require a certain amount of assembly on site due to size.

It is essential, of course, that steel is loaded for the correct order of work to avoid undue shunting and handling of steelwork during track occupation on site. The installation of standard masts is almost always carried out by the unit incorporated in the Auger Borer Train (see fig.5). The erection of more complicated structures, particularly booms which span many tracks is usually carried out between trains to avoid total blockage of tracks. The procedure demands close co-operation between the Operating Department and the Chief Mechanical & Electrical Engineer's representative. For this purpose a Diesel Electric Crane has been designed. With a jib 44 ft long, it is self propelled and has fairly high rates for lifting and lowering, with a sensitive control to facilitate rapid final positioning. Special lifting beams, trestles and other equipment have been developed to assist in the pre-assembly on site of large structures to shorten the time of installation between trains.

12.3 *Cantilever Erection Trains* (see figs.1 and 6)
The Cantilever Erection Train includes a flat top bogie vehicle with two different levels as indicated on the Bridge Train Arrangement and a special car carrying a hydraulic platform. Occasionally, cantilever assemblies are erected with block and tackle from the ground to avoid the use of Works Trains and the need for a possession.

12.4 *Bridge Train and Smallpart Steelwork Erection* (see fig.1)
This train is used for the erection of smallpart steelwork and for the under bridge equipment. It is particularly valuable in the cutting in of section insulators if required when wiring has been completed and also for the complicated registration requirements at Junctions where compound knuckling and registration exists. The train is often used with a Pantograph Wagon to facilitate checking and inspection of the overhead equipment after installation.

12.5 *Wiring Train* (see fig.1)
The wiring train is made up of a sufficient number of flat topped vehicles to span the full distance between locations. Catenaries are run out during full possession of the track and the gangs working from ladders between trains carry out certain registration and add further fittings, droppers, etc. During subsequent possessions the auxiliary catenaries and the contact wires are run and clipped into their fittings. Adjustment and alterations are carried out with a Pantograph Inspection train.

12.6 *Test Car*
In conjunction with the contractors a special vehicle has been converted from a bogie vehicle and provided with two pantographs, one at each end, for recording a continuous chart of the height stagger, upward pressure and acceleration of pantographs and other relevant information and is used for obtaining technical data on the performance of the pantograph for current collection purposes and for design data. The test car is indicated on Works Train Diagram as fig.1 (Y), and fig.1(Z) is a Generator car with ancillary equipment installed.

Fig.7 illustrates this special train which has produced considerable valuable data to help the design in perfecting overhead equipment and will be used for regular inspection purposes when the Electrifications are fully commissioned. The vehicle can be used on both the dead and live overhead equipment.

13 Summary of Progress

As will have been appreciated from the foregoing, work has and is currently proceeding on a number of electrification projects, the magnitude and progress of which can be readily seen in the following summary.

SUMMARY OF PROGRESS: 50 CYCLE SINGLE PHASE A.C. ELECTRIFICATION PROJECTS

Project Authorised	Single Track Mileage	Date for Completion	Percentage of Work Completed September 1960
Scottish Region			
Glasgow Suburban			
(*a*) North of Clyde	114	Autumn 1960	100%
(*b*) South of Clyde	49	Summer 1961	30%
Midland Region			
Manchester – Crewe	217	Autumn 1960	100%
Liverpool – Crewe	155	Autumn 1961	20%
Crewe – Birmingham – London (Euston)	1,408	1964	Erection has now commenced
Eastern Region			
Colchester to Clacton and Walton	50	Spring 1959	100%
London to Chingford, Enfield and Bishops Stortford...	105	Autumn 1960	95%
London to Tilbury and Southend	172	In Stages 1961/62	60%
Chelmsford to Colchester	49	Winter 1961	Erection commences October 1960
Conversion to A.C. operation of			
(*a*) London (Liverpool Street) to Southend Lines ...	154	Autumn 1960	95%
(*b*) Shenfield to Chelmsford line	20	Early 1961	15%

SUMMARY

The work of installing overhead equipment involves occupation of the tracks and interferes with the business of the railway. This restriction has to be kept to a minimum and a possible loss of revenue weighed against excessive expenditure on construction. Before any erection work is begun the fullest information regarding the route to be electrified should be available. The method of compilation of all significant data is dealt with at some length. Among the first essentials is the determination of the final layout of tracks to be wired and the way in which they are to be divided into sections for purposes of isolation. Where an erection contractor is employed his work is facilitated by early agreement on such items as the location of feeder stations and track sectioning cabins, and especially on final heights of all overbridges, agreed wire heights over occupational crossings, etc. A method of collecting this knowledge in the form of Route Inspection Notes is detailed and the process of survey examined. All tracks should be in their final positions before erection of steelwork is begun and structural clearances from the overhead wires obtained before any wiring is undertaken.

The installation programme should be planned to ensure that for the economical deployment of labour and material an even work load is maintained throughout the week as far as possible. Regular meetings are held with the Regional Operating Department to plan routine week-day total block and single line possessions and to make special arrangements for difficult work at week-ends. Special types of Works Trains have been developed in the mechanisation of foundation installation, the erection of the steelwork and fittings and the running of wire. Their use has shortened the time of installation and reduced its cost. In addition a special vehicle for the measurements of pantograph performance and the continuous inspection of overhead equipment under energised lines has been developed.

RÉSUMÉ

L'installation de la caténaire exige l'occupation des voies et, de ce fait, dérange plus ou moins l'exploitation du chemin de fer. Ces dérangements doivent être réduits au minimum et il faut peser la possibilité de pertes de revenu contre celle d'une augmentation du coût de la construction. Avant de commencer les travaux il faut avoir toutes les informations possibles en ce qui concerne la ligne à électrifier. L'exposé traite en quelque détail la méthode d'assembler les données nécessaires. Une des choses les plus essentielles est la détermination de la disposition eventuelle des voies à électrifier et des sectionnements nécessaires pour l'isolement de la ligne. Dans les cas où l'on emploie un entrepreneur pour l'installation, il faut, pour faciliter son travail, que tous les départements intéressés donnent leur assentiment dès le début aux emplacements des stations d'alimentation et des postes de mise en parallèle, et surtout aux hauteurs définitives de tous les passages supérieurs, du fil de contact aux passages à niveau privés, etc. Une méthode d'assembler les données nécessaires pour ces décisions, sous forme de Notes de Visites de la Voie, est décrite, ainsi que le métré de travaux. Tous les voies devraient être dans leurs positions définitives et toutes modifications nécessaires aux constructions existantes, pour avoir les marges d'air voulues, devraient être faites avant le commencement de l'installation des supports.

Il faut préparer le programme pour l'installation de telle façon que le travail à faire chaque jour soit sensiblement constant dans le but d'employer les ouvriers et le matériel d'une façon économique. Des conférences périodiques ont lieu avec des représentants du Département de l'Exploitation de la Région pour arranger les périodes d'occupation, ou d'une seule voie ou de toutes les voies, pour la semaine et pour faire des arrangements spéciaux pour entreprendre les travaux difficiles les samedis et les dimanches. On a développé des types spéciaux de trains-parc pour l'éxecution mécanique des terrassements pour les fondations, et pour l'instal-

lation des supports, leur équipement et la caténaire. L'emploie de ces trains a réduit et le temps nécessaire pour l'installation et son coût. En outre, on a mis au point une voiture pour l'étude du comportement des pantographes et pour la visite de la caténaire et son équipement quand elle est sous pression.

ZUSAMMENFASSUNG

Die Montage der Oberleitungsausrüstung hat eine Gleisbesetzung zur Folge und stört deshalb den Eisenbahnverkehr. Diese Verkehrseinschränkung muss so klein wie möglich gehalten werden und ein möglicher Verlust an Einnahmen gegen zusätzliche Ausgaben beim Bau durch spezielle Vorkehrungen abgewogen werden. Bevor mit der Montagearbeit begonnen wird, sollten ausführliche Unterlagen über die zu elektrifizierende Strecke vorhanden sein. Die Methode der Zusammenstellung aller bedeutsamen Angaben wird ziemlich ausführlich erörtert. Zu den wichtigsten Punkten gehört die endgültige Festlegung der mit Oberleitung auszurüstenden Geleise und die Art, wie die Oberleitungen für Trennungszwecke in Abschnitte zu unterteilen sind. Die Arbeit des Montageunternehmers wird durch ein frühzeitiges Uebereinkommen in Einzelheiten wie Lage der Speisungs- und Fahrleitungstrennstellen und speziell hinsichtlich der endgültigen Höhe der Ueberführungen und der Höhe der Fahrleitungen über Kreuzungen etc. erleichtert. Eine Methode der Sammlung dieser Unterlagen in der Form von Notizen, die anlässlich der Streckenbesichtigungen gemacht werden, wird beschrieben, und das Verfahren bei der Aufnahme geprüft. Alle Geleise sollten in ihrer endgültigen Lage sein, bevor mit der Montage der Stahlkonstruktionen begonnen wird, ebenso muss der Lichtraum für die Fahrleitungen vor Beginn der Installation frei sein.

Um Arbeitskräfte und Material wirtschaftlich auszunützen, sollte das Bauprogramm so geplant werden, dass, soweit als möglich, der Arbeitsanfall während der Woche gleichmässig bleibt. Mit der Bezirks- Betriebsabteilung werden regelmässige Besprechungen abgehalten, um die laufenden werktäglichen Besetzungen eines oder aller Gleise zu planen und besondere Vereinbarungen für schwierige Arbeiten während des Wochenendes zu treffen. Spezielle Arbeitszüge wurden entwickelt, um den Bau der Fundamente, die Errichtung der Stützpunkte und Ausleger, und die Anbringung der Fahrleitung zu mechanisieren. Die Benutzung dieser Züge hat Bauzeit und -kosten verringert. Ausserdem wurde ein besonderes Fahrzeug entwickelt zur Messung des Verhaltens des Stromabnehmers und zur regelmässigen Überwachung der Fahrleitung und ihrer Zubehörs, auch wenn sie unter Spannung steht.

RESÚMEN

El trabajo de instalación del equipo aereo supone estorbar el tráfico y dificultar la marcha normal del ferrocarril. Hay que mantener esta restricción a la mínimo y comparar una pérdida posible de ingresos con un gasto de construccion excesive. Antes de comenzar cualquier trabajo de mantaje es necesario conocer los datos mas completos acerca del recorrido que se ha de electrificar. Se explica extensamente el método de recopilación de todo dato significativo. De lo mas esencial es la determinación del trazado final de via electrificada y la manera que se ha de dividir con fines de seccionamiento. Al emplearse un contratista para el montaje, se facilita su trabajo llegando temprano a un acuerdo sobre datos tales como situación de cabinas de alimentación y de seccionamiento de via, y en particular sobre pasos a nivel de privelegio, etc. Se dan detalles de como se reunen estos datos en forma de notas de Inspección de Recurrido y se examina el procedimiento de estudio. Todas las vias deben de estar en sus posiciónes finales antes de empezar el montase de las armaduras de acero y se deben obtener las tolerancias eléctricas de estructuras a catenaria antes de empezar cualquier forma de cableado. Se debe de preparar el programa de instalación de forma a mantener una carga de trabajo lo mas constante posible durante la semana, lo cual resulta en el despliegue económico de mano de obra y material. Se convocan regularmente reuniones con el Departamento de Explotación Regional para plantear la ocupación de la via, por secciones completas o por via única, durante el trabajo rutinario de los dias laborables; y para tomar disposiciones especiales para el trabajo difícil los sábados y domingos. Se han desarrollado tipos especiales de trenes-parques para la mecanización de la instalación de cimientos, del montaje de estructuras de acero y accesorios, y colocación de la catenária. Su empleo ha cortado el tiempo de instalación y rebajado el costo. Además se ha desarrollado un vehículo, especial para medir el funcionamiento del pantógrafo y para la inspección contínua del equipo aéreo estando las lineas en tensión.

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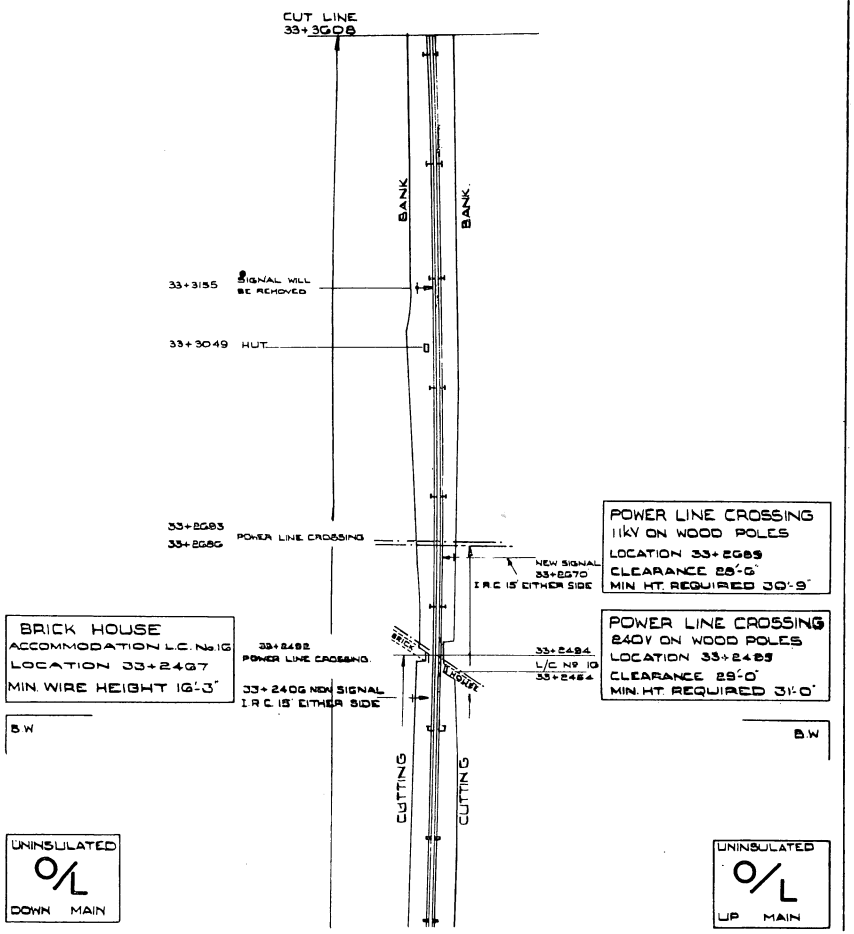
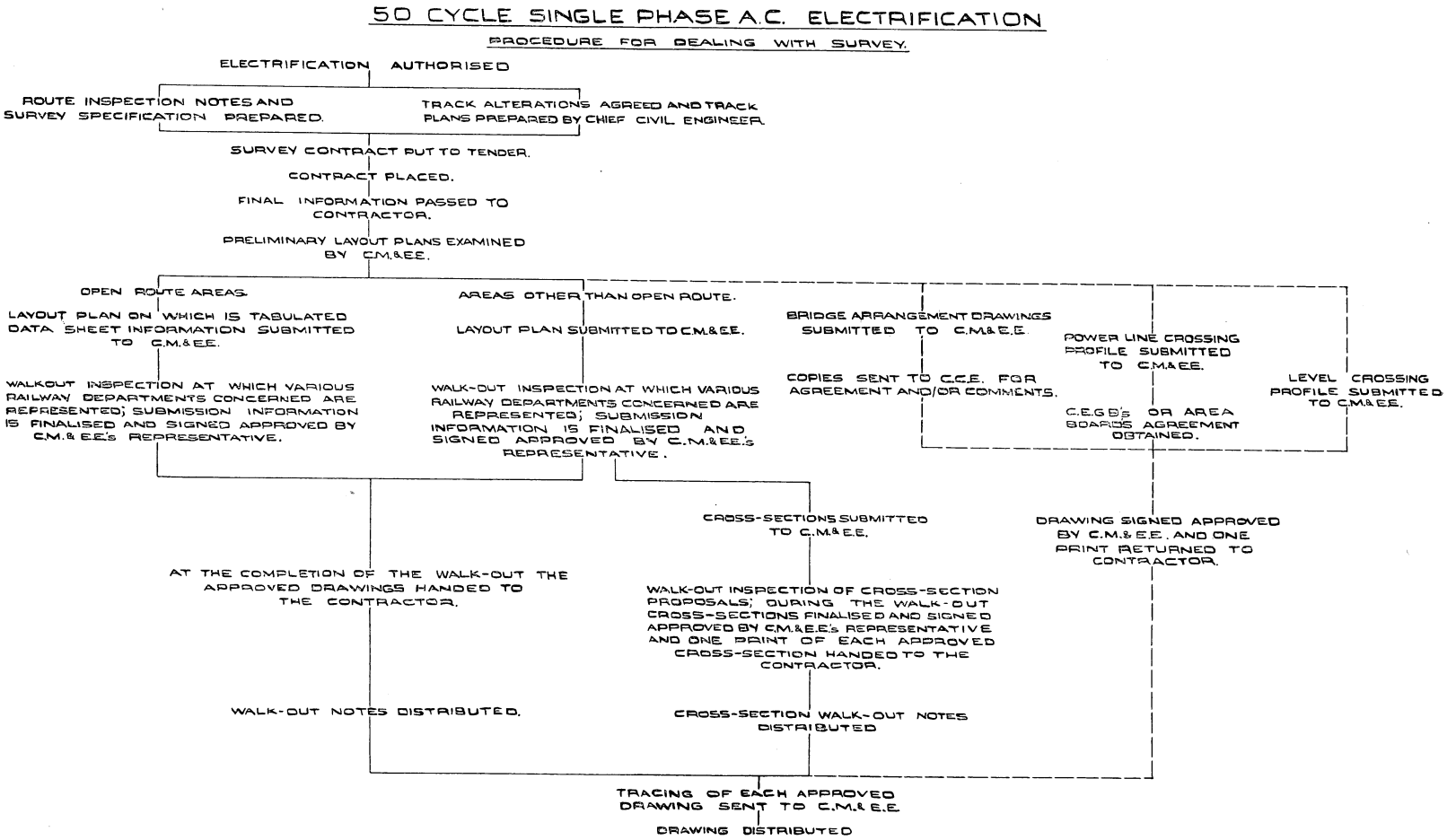
33 + 0298	Site of 33 mile post.
33 + 0446 to 33 + 0473	Overhead power lines. 132 KV. Steel masts. Refer to schedule 3.
33 + 0577 to 33 + 0970	Line in cutting, up side only. Masts shall continue at 8'-6" clearance on both sides, although there is strictly no cutting on the downside.
33 + 0970 to 33 + 2515	Lines in cutting, up and downsides.
33 + 2406	Position of new down colour light signal.
33 + 2467	Accommodation level crossing, No.16, skew. Refer to schedule 1.
33 + 2480 to 33 + 2515	Crossing keepers garden on up side. Easement obtainable if required.
33 + 2485	Overhead power line crossing, wood poles. Refer to schedule 3.
33 + 2515 to 33 + 2700	Line in cutting, up side only. Masts shall continue at 8'-6" on upside and revert to normal 7'-0" on the downside.
33 + 2670	Position of new up colour light signal.
33 + 2689	Overhead power line crossing, wood poles, guard wire. Refer to schedule 3. NOTE. This is the last overhead span of power line route, therefore possibility exists if necessary of replacement by underground cable.
33 + 3049	Platelayers cabin, downside, 7'-6" from track.
33 + 3155	Existing down semaphore signal. Will be removed.
33 + 3700	Underbridge No. 162. Footpath beneath.
33 + 4418	Culvert.
33 + 4520 to 34 + 2690	Lines in cutting, up and down sides. NOTE. Overhead line structures shall be at normal 8'-6" cutting clearance except where 10ft. is specifically required for sighting of signal at 34 + 1895, i.e. first 4 masts on country side thereof. Upside, in this section new drainage will be laid at standard clearance.
33 + 5030 to 33 + 5063	Overline Bridge No. 163. Possible future widening. Refer to Schedule 4
33 + 5091	Existing up semaphore signal will be removed. First two upside masts country side of signal, shall be at 10ft. clearance for interim signal sighting.
33 + 5100 to 34 + 1058	Chantry down refuge siding. See note under "sidings" re agreed removal.
34 + 0306	Site of 34 mile post.
34 + 0560 to 34 + 1030	In this section on the Up and Down sides there is an area where running sand will be encountered during foundation work. The Chief Civil Engineer's soil mechanics section are investigating the actual area and will submit a report on their findings.

Appendix A Typical page of route inspection notes

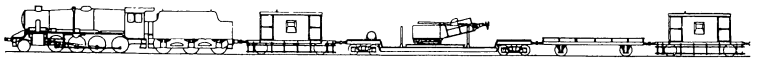


UP No.	LOCATION	EQUIPMENT HEIGHTS CONT. FT. IN.	CATY. FT. IN.	R.C. FT. IN	STAGGER CURVE CH	STAGGER INS.	MAST No & RAKE	REF.	HT. FT. IN	WTH INS.	FOUNDATION d FT IN	e FT IN	REF.	CANT PLATE INS	BOND INS.
	200														
	33+3578	16-0	22-6	21-6	200	3	7-5	55/48/34	24-6	9 GRD			40/4A		
	200														
	33+3378	16-0	22-6	21-6	200	9	7-5	55/48/34	24-6	9 GRD			40/4A		
	200														
	33+3178	16-2	22-8	21-8	200	3	7-5	55/48/34	24-8	9 GRD			40/4A		
	200														
	33+2978	16-6	23-0	22-0	200	9	7-5	55/48/34	25-0	9 GRD			40/4A		
	200														
	33+2778	16-10	23-4	22-4	200	3	8-11	55/48/34	25-4	9 GRD			40/4A		
	200														
	33+2578	17-3	23-9	22-9	200	9	8-11	55/48/34	25-9	9 GRD			40/4A	1"	
	210														
		T.S.A.H. 20-6					9-0	104/28R = TIE			1-9 ABOVE		41/1H		
	33+2368	17-3	23-9	22-9	T	9	9-0	55/GB/35T.	25-9	12			40/25A	0	
	200														
		18-0	23-9	OOR											
	33+2168	17-3	23-9	22-9	T	9	9-0	55/GB/35	25-9	12			40/25A		
	150														
	33+2018	17-3	23-9	22-9	T	9	9-0	55/GB/35	25-9	12			40/25A		

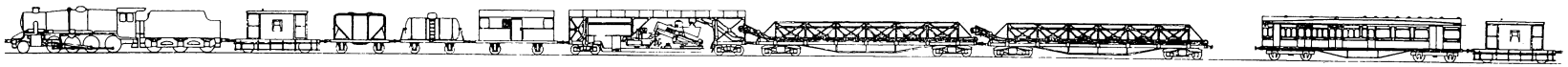
Appendix B Typical layout plan



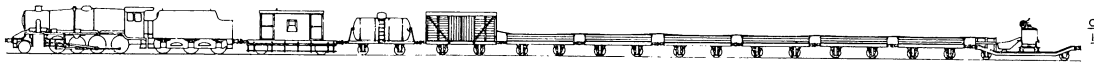
Appendix C survey procedure



EARTH BORING TRAIN



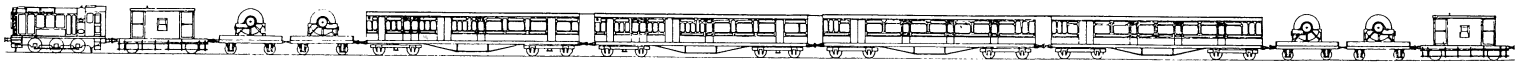
CONCRETING TRAIN (MAIN UNIT)



OTHER HALF OF TRAIN IS MIRROR IMAGE OF THAT SHOWN

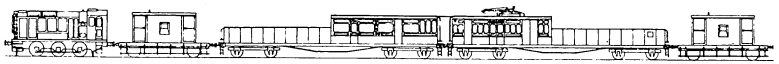
SECONDARY CONCRETING TRAIN

STEELWORK TRAIN

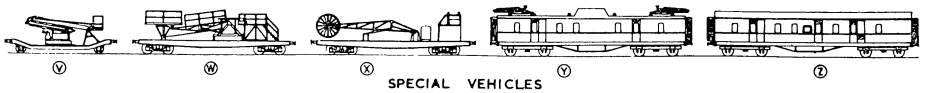


WIRING TRAIN

NOTE -
SMALL PART STEELWORK TRAINS AND SPOIL TRAINS ARE MARSHALLED AS REQUIRED USING NON-SPECIAL VEHICLES.



BRIDGE TRAIN
(AND OVERHEAD INSPECTION)



SPECIAL VEHICLES

Fig.1 Works trains

Fig.2 Auger borer train

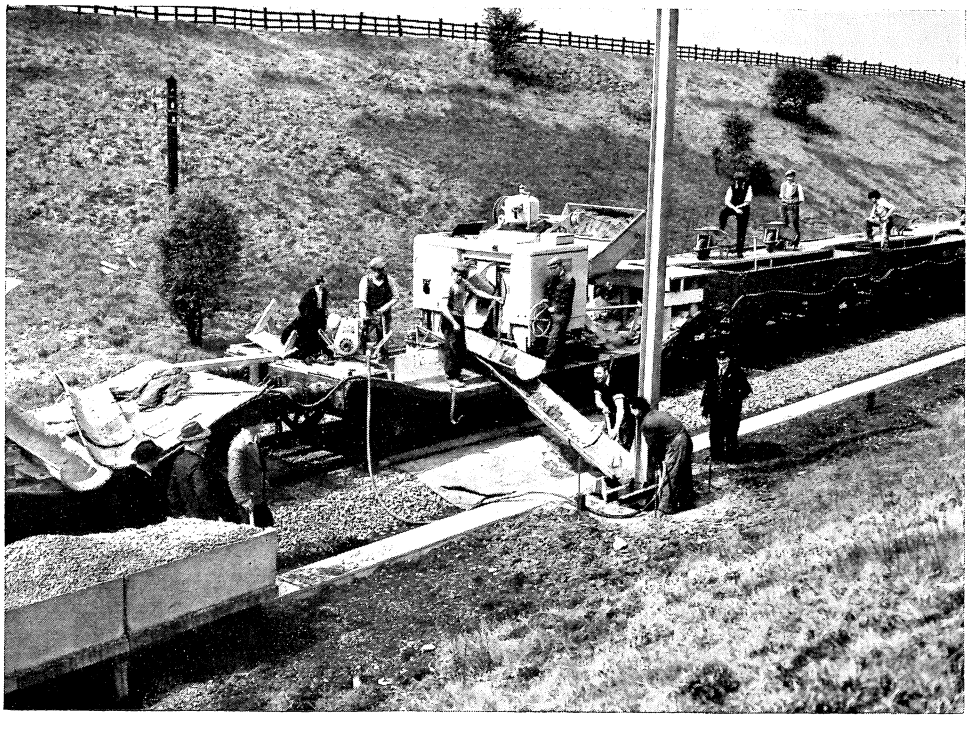


Fig.3 Secondary concrete mixer train

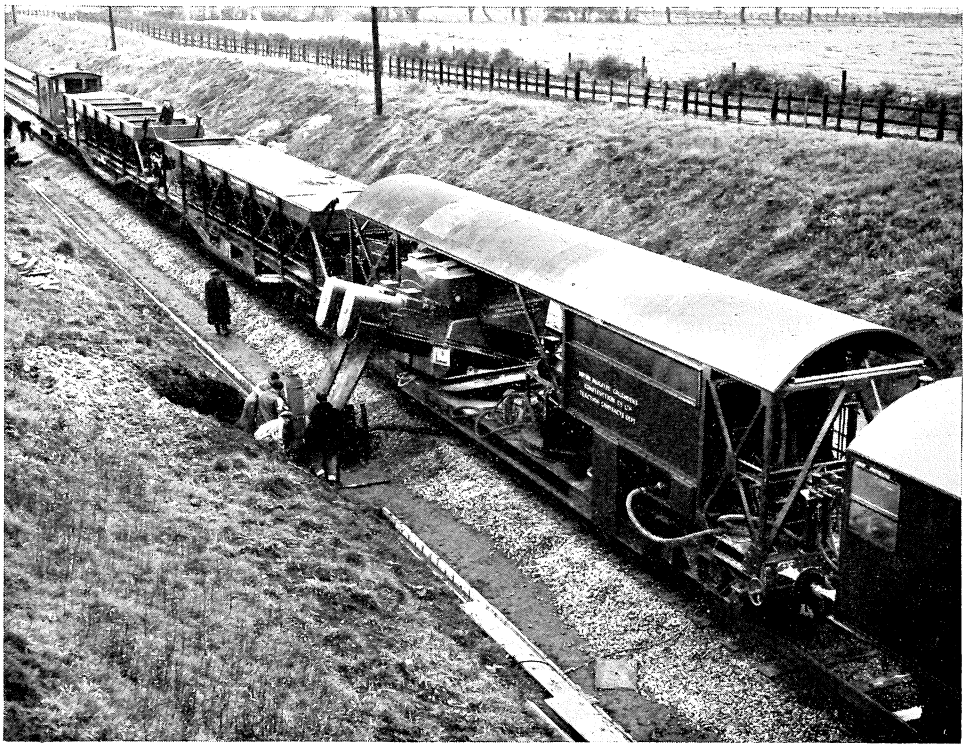


Fig.4 Automatic concrete mixer train

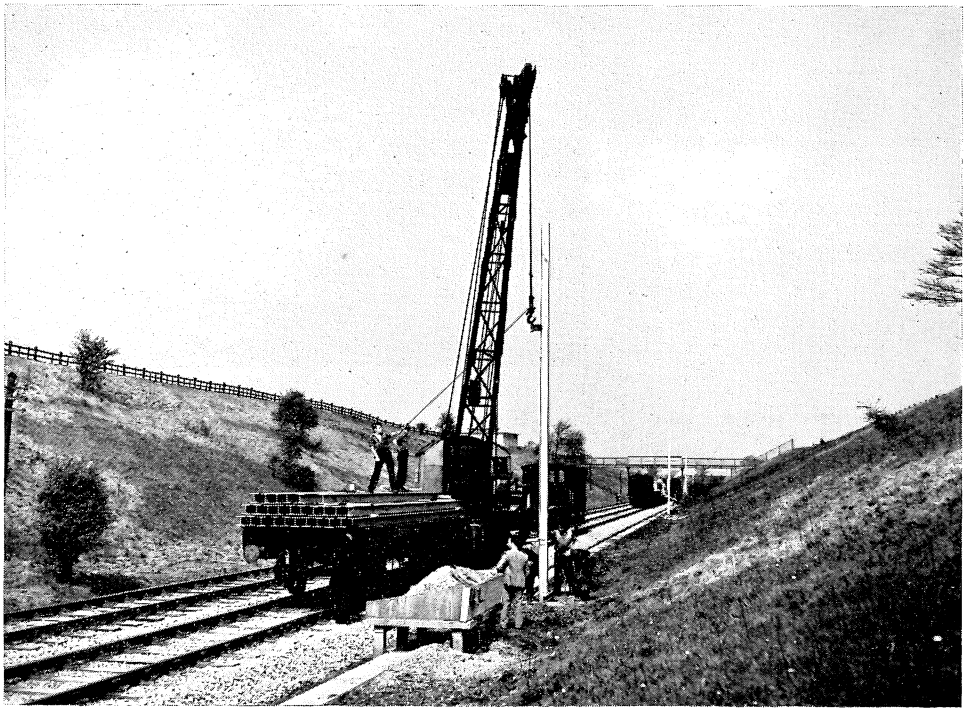


Fig.5 Steel train

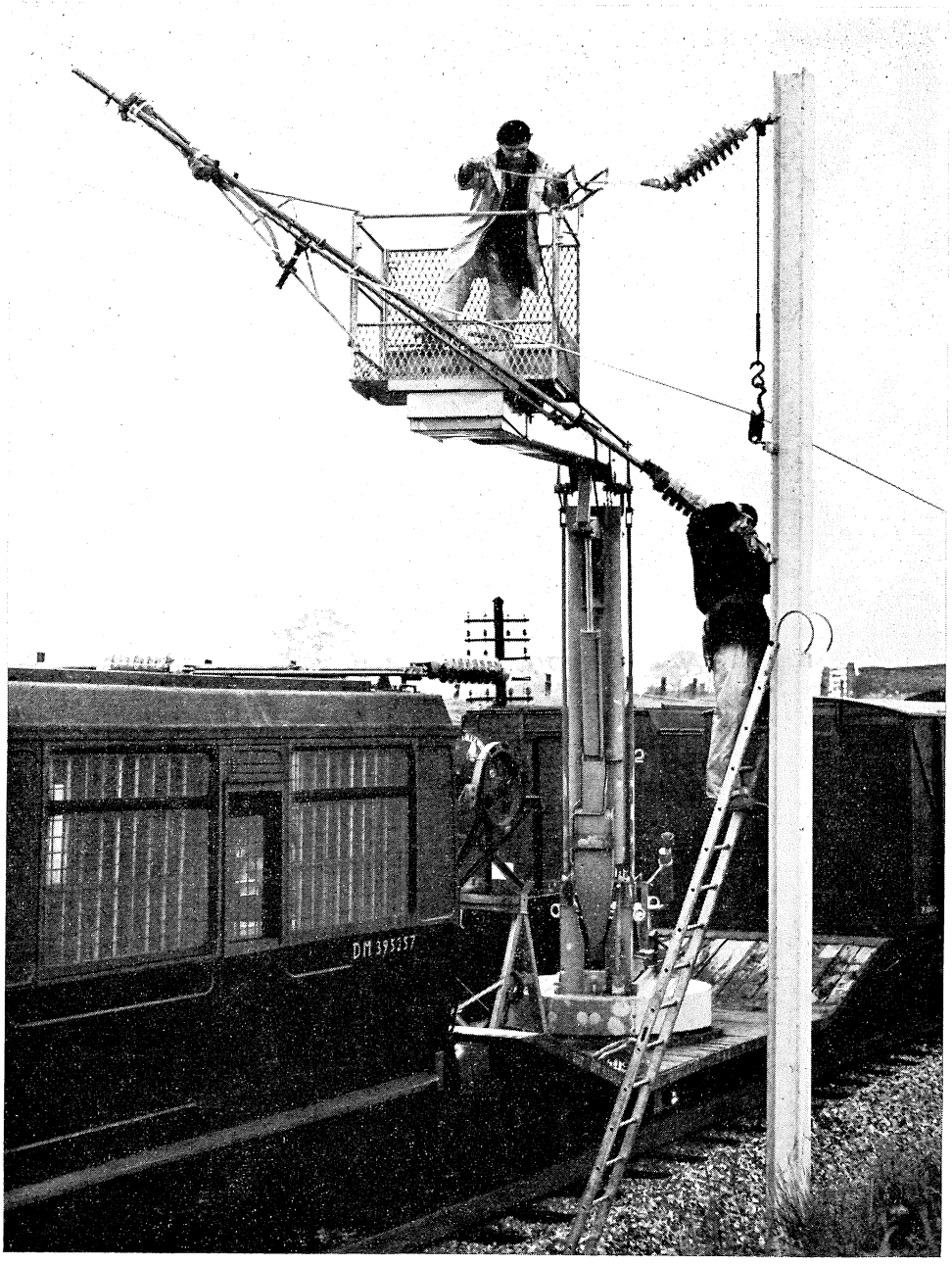


Fig.6 Cantilever erection train

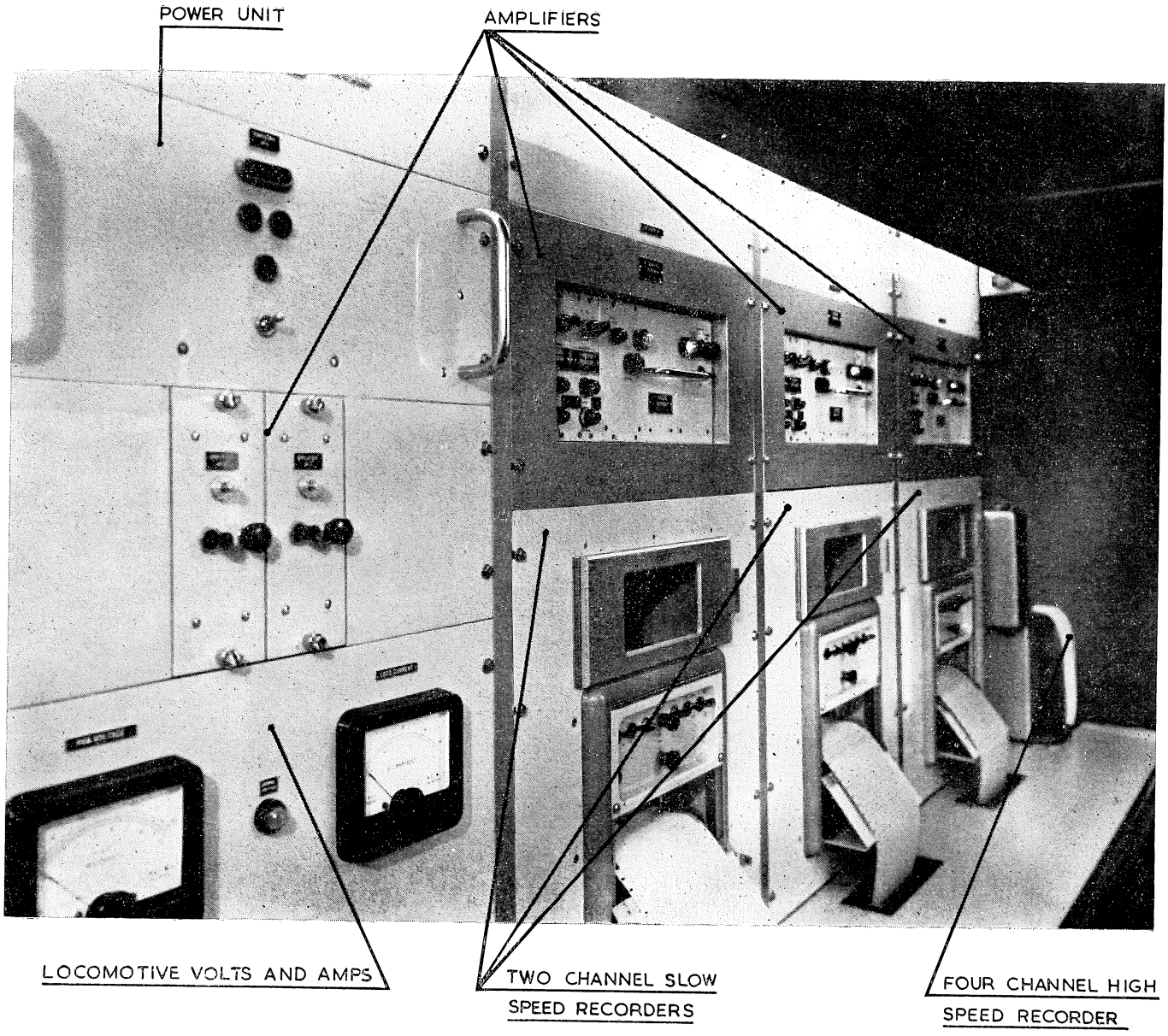


Fig.7 High speed pantograph testing vehicle — instrument console

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