Technical Meeting of the Institution

held at

The Institution of Electrical Engineers

Thursday, November 20th, 1958

The Vice-President (Mr. D. G. SHIPP) in the chair

Mr. Shipp said that he had been asked to take the chair at this meeting in place of the President, whose business had taken him temporarily out of the country and who had sent his apologies for being unable to be present.

The minutes of the Technical Meeting held at the Institution of Electrical Engineers, London, on Thursday, October 23rd, 1958, were read and approved.

Mr. Shipp introduced and welcomed to the meeting Mr. B. K. Cooper (Associate) and Mr. K. D. Brickham (Technician Member) who were present for the first time since their election to membership, and welcomed Mr. C. H. Cayzer (Member) from the Nigerian Railways who was present for the first time since returning to this country from overseas.

The Chairman stated that being in New Zealand and therefore unable to read his paper himself, Mr. Hardman had arranged for this to be done by Mr. W. R. Carslake, and Mr. Shipp then invited Mr. Carslake to read Mr. Hardman's paper entitled " Prefabrication of Railway Signalling Installations in New Zealand."

Prefabrication of Railway Signalling Installations in New Zealand

By W. A. HARDMAN (Associate Member)

Introduction

For some years after the end of World War II, the New Zealand Railways experienced considerable difficulty in carrying out signalling installations at localities away from the main centres. Labour tended to migrate towards the larger towns, and there was a scarcity of men willing to work in country districts as members of travelling installation teams.

The traditional method employed for the construction of railway signalling installations in New Zealand was to send a group of men to a particular locality, where the installation would be assembled piece by piece along the track. These men sometimes worked three or four miles from their base camp, which usually consisted of portable huts mounted on wagons. This method has the following disadvantages :

(1) It is not always possible to recruit suitably educated, and experienced staff, willing to work in travelling installation teams.

(2) Adequate supervision of isolated groups of men is not easy to arrange.

(3) The movement of materials to the site is sometimes slow.

(4) Inclement weather can delay outdoor work.

(5) Experienced workmen are often used inefficiently to carry out work on the site (for example, there may be excessive walking time, and delays due to handling of equipment).

(6) Difficulty is experienced in testing the installation prior to bringing it into use.

(7) It is not possible to use specialised tools and plant efficiently and to the maximum advantage.

About four years ago, when there was already a considerable backlog of signalling construction work throughout the North Island, powerful diesel-electric locomotives were introduced on the busy Wellington-Auckland main trunk line, and the extension of crossing loops and provision of associated signalling equipment became an urgent necessity, to enable 100-wagon trains to pass each other at stations along the single tracks.

It should be mentioned that many of the crossing loops in the central section of the North Island are capable of crossing trains of only 50 to 60 wagons, necessitating the breaking-up and shunting of longer trains. Delays to traffic movements therefore result.

When the crossing loop is lengthened to the extent required, viz., 700 yds., motor operation of the points at each end of the loop is the only satisfactory method.

The installation of a centralised traffic control system on the North Island Main Trunk railway is the objective on the 340-mile section between Frankton and Wellington (fig. 1). The section Wellington-Paekakariki has operated under CTC

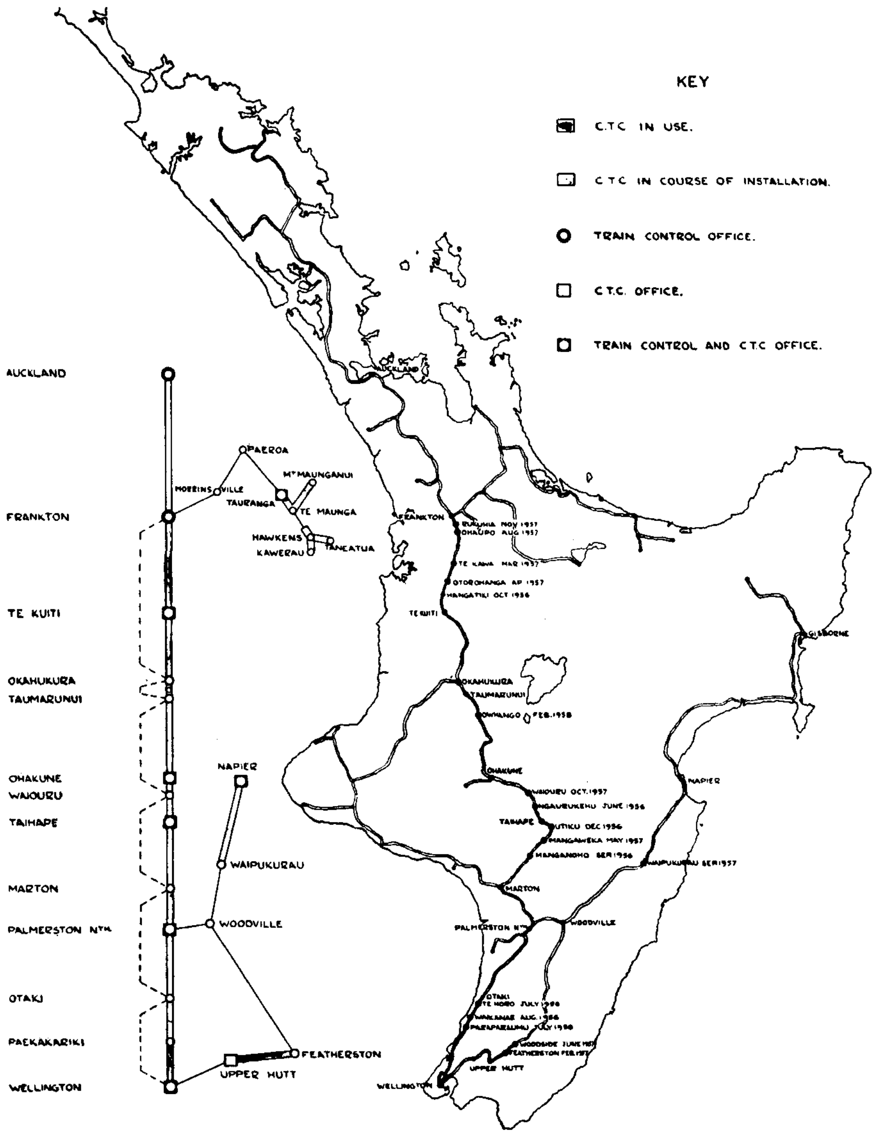


Fig. 1. Map of North Island New Zealand, showing Resignalled Crossing Loops and proposals to complete CTC Wellington to Frankton

for 20 years, and Taumarunui to Frankton (90 miles) has recently been completed. Work is in hand at many other points. As a preliminary stage each crossing loop is being resignalled and equipped for future control by CTC but until such time as sufficient stations have been completed to warrant the changeover, each interlocking is temporarily controlled by a station panel (fig. 2), and the token system for working between stations is retained.

Fig. 3 shows the layout of a typical centralised traffic control system. This system consists of two sections of apparatus :

(1) The supervisory control, which is designed purely to transmit the required control code to the locality, and to re-transmit back to the operator the actual condition of all signal aspects, position of points, and the situations of the various trains throughout the area controlled (fig. 4).

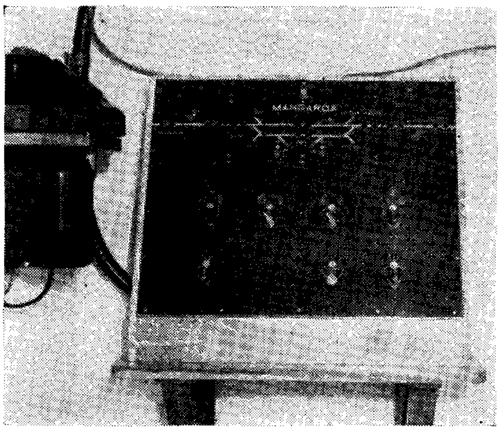


Fig. 2. Station Control Panel for typical crossing loop

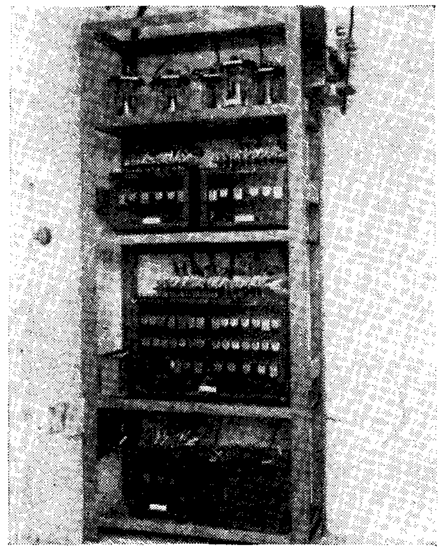


Fig. 4. CTC Supervisory equipment

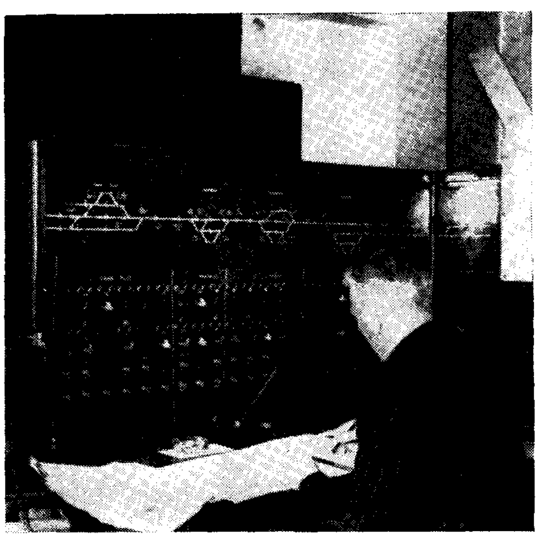


Fig. 3. CTC Control Panel, Wellington-Paekakariki N.Z. Government Railways

This supervisory control is usually designed to operate over two or three line wires, or, where practicable in some modern installations, by micro-wave transmission. Carrier circuits are used in New Zealand but not micro-wave as yet.

(2) The signalling installation, which is designed to provide the highest possible factor of safety.

Fig. 5 shows the signalling provided for a CTC single-line crossing loop at Otorohanga. The design of each signalling installation is based on the use of a 230 v. single-phase multiple earth neutral power reticulation, with diesel standby supply, fed from the main relay room to the centre of the block section on each side, a total distance of approximately 5 miles. A.c./d.c. track circuits are used throughout, and a 230 v. rectifier unit has been designed for the operation of the low-voltage d.c. points motors. Separate secondary windings with individual rectifiers are provided for each motor power circuit (30 v.), points contactor (24 v.), and points detection circuit (14 v.). This is in conformity with the policy of providing individual power supplies to external circuits.

For main-line and loop signals, 12 v. d.c. three-aspect searchlight signal units are used. Local Control Panels are situated at each loop-to-sidings turnout, and from these positions the station agent or guard may operate the main-line signals and points, after having obtained release from the CTC operator. The loop-to-sidings points are actuated by mechanical frame levers with electrical release. The plastic-sheathed and armoured cables are laid direct in the ground, as later described.

Development of Prefabrication

Having regard to the shortcomings of traditional methods of installation and the availability of trained staff, the equipping of crossing loops in the central section of the North Island with modern signalling systems would have taken many years to complete. It was therefore decided to carry out a trial project, making use of signal equipment pre-assembled in Wellington. This equipment was loaded on to a special train, unloaded at the site by crane, and installed by organised teams, the complete installation being brought into use within a few days. The experiment, which was undertaken in 1954, proved an outstanding success, and laid the foundations for a system of prefabrication which has facilitated the resignalling of crossing loops at the rate of one a month.

The re-signalling of Otorohanga crossing loop—completed on April 14th, 1957, at a distance of 310 miles from the base depot—is a typical example of the work now being undertaken.

Detailed organisation, and methods of production that have recently been developed, enable the prefabrication of the signalling system for a crossing loop of this type to be completed in one month at the Wellington Depot and then to be installed, and brought into use over a three-day period without any preparatory work having been carried out on site.

The organisation may be considered under the following six headings :

(1) Planning

(2) Prefabrication

(3) Loading of signalling equipment

(4) Positioning and unloading of train

(5) Installation on site

(6) Cable laying

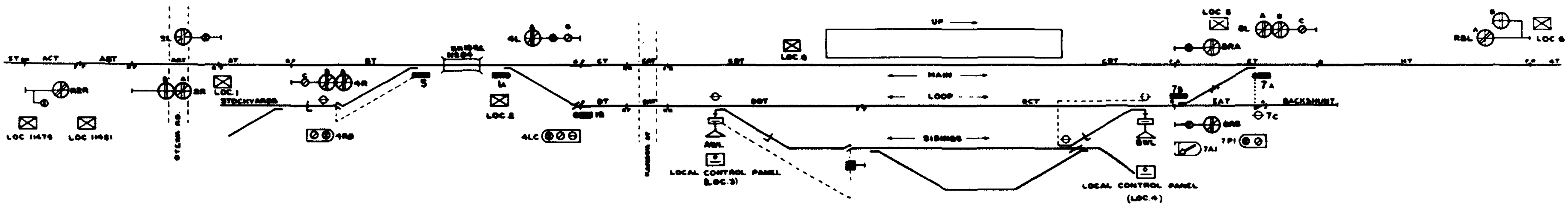
(7) Testing

Planning

Every effort has been made to carry out all preparatory work to the last detail. Regular meetings are held between engineers, supervisors and foremen, to ensure that those who take part in the operations have an opportunity to put forward new ideas. These meetings sometimes bring to light deficiencies in organisation and methods. Criticism is outspoken, but always constructive. Some recommendations can be implemented for the next operation ; other suggestions require fuller investigation.

Each member of the organised signals team has a sense of discipline which makes him feel that he has a moral responsibility to give absolutely of his best, and to take a pride in the work he is detailed to do. Without such spirit, an operation of this nature could not succeed.

During the first few installations, various phases of the work at the site, such as unloading and cable laying, were carefully investigated. Until a high degree of effi-



INTERLOCKING TABLE

Nº	Description		Released by Relays: Normal	Reverse	Normal (Reverse Converse)	Normal (Locked [illegible])	Nº
1	POINTS & TRAP	MAIN & LOOP	(8L on 7R)			4R.4L	1
2R A B	UP OUTER HOME	NS MAIN TO MAIN	8L 4L 5				2R
2L	DOWN DEPARTURE	NS MAIN TO MAIN	2R 5 (LBR LBKR OR 2L OFF)				2L
3	RELEASE	LOCAL CONTROL	(17) FROM R-N		AWL BWL 5	2R 2L 4R 4L 8R 8L	3
4R A	UP HOME	NS MAIN TO MAIN	4L (8R on 1 on 7R)				4R
4R B		NS MAIN TO LOOP	8L (7 on 1R)				
4R C		LS MAIN TO MAIN LOOP OR SIDINGS					
4RD	SHUNT	LS STOCKYARDS TO MAIN LOOP OR SIDINGS					
4L A	SHUNT & DOWN STARTING	NS MAIN TO MAIN	2R 4R (8L on 1R on 7)				4L
4L B		LS MAIN TO STOCKYARDS	(8R on 1R 7 on 1 7R)				
4LC	SHUNT & DOWN STARTING	LS LOOP TO MAIN OR STOCKYARDS					
5	POINTS & TRAP	MAIN & STOCKYARDS	2L 2R	3		4R.4L	5
6	SPARE						7
7	CROSSOVER & TRAP	MAIN TO LOOP & BACKSHUNT	(4R on 1R)			8R 8L	7
8RA	UP DEPARTURE	NS MAIN TO MAIN	(4R on 1 on 7R)(RBR RBKR OR 8R OFF)				8R
8RB	UP DEPARTURE	NS LOOP TO MAIN	(4L on 1R 7 on 1 7R) 8L				
8L A	DOWN HOME	NS MAIN TO MAIN	(1 on 7R) 4R (4L on 1R on 7) 8R				8L
8L B		NS MAIN TO LOOP					
8L C		LS MAIN TO MAIN, LOOP OR SIDINGS					
AWL	SWITCHLOCK	POINTS LOOP TO SIDINGS	(8L on 7)	3 (SEE NOTE)		(4R on 1)	AWL
BWL	SWITCHLOCK	POINTS LOOP TO SIDINGS	(4R on 1)	3 (SEE NOTE)		(8L on 7)	BWL

NOTE SHUNTING FROM LOOP TO BACKSHUNT OR SIDINGS CAN BE CARRIED OUT WITHOUT TAKING LOCAL CONTROL PROVIDED 1 & 7 POINTS ARE NORMAL. OPENING EITHER SWITCHLOCK DOOR WILL LOCK 1 & 7 POINTS NORMAL & FREE THE CORRESPONDING SWITCHLOCK. OPENING BWL SWITCHLOCK DOOR ILLUMINATES 7AJ & 7P1. 1 & 7 POINTS REMAIN LOCKED FOR 20 SEC AFTER BOTH SWITCHLOCKS ARE CLOSED

CONTROL TABLE

Nº		Operated by: CTC	Local Contr	Controlled by TC's: Clear	Occ'd	Locked by TC's Occ'd	Detects Points: Normal	Reverse	Norm - Rever	Approach Locked by TC's Occ'd	Approach Lock Release	Backlocked by TC's Occ'd	Control from Signal Ahead	Remarks	Nº
1		CTC	WHEN 3R			BT								SEE NOTE	1
2R	A	CTC		AAT AT BT						LEFT BLOCK TC'S (LBR)	JR (90 SECS)	AAT or JR	D BY 4RA O/H	MAY SHOW PREPARE TO REDUCE TO MS	A 2R
	B		WHEN 3R	AAT AT BT									D BY 4RB O/H		B
2L		CTC	WHEN 3R	BLOCK TC'S						AT BT (CT CAT CBT = 1N)	(JR ON AT OCC'D) 90 SECS	(AAT or 8LD 8RN) or JR	D BY INT D	CONTROLS BLOCK CCT'S	2L
3		CTC												AUTO RELEASE IN EMERG.	3
4R	A	CTC		BT CT CAT CBT ET			5 1			[(AT AAT ABT ACT) = 5N] (WHEN OPERATED = 5R)	JR (90 SECS)	[(AT = 5N) or BT] or JR	D BY 8RA O/H		A 4R
	B			BT DT DAT DBT DCT ET EAT			5 AWL: BWL	1					D BY 8RB O/H		B
	C		WHEN 3R	(4LS on	BT)		5 (BWL = 1R AWL N)		1 (AWL = 1R)				SHOWS M ONLY		C
	D			(4LS on	BT)		(BWL = 1R AWL N)	5	1 (AWL = 1R)				SHOWS MR ONLY		D
4L	A	CTC	WHEN 3R	AAT AT BT			5 1			(CT CAT CBT = 1N) (DT DAT DBT DCT = 1R) ET (HT or 8LR)(EAT W 7R)	JR ON (CT or CAT or CBT OCC'D = 1N) or (DT or DAT or DBT or DCT = 1R) 90 SECS	(BT = 3N) or JR	D BY 2L O/H		A 4L
	B		WHEN 3R	[(4LS on	BT) W 3R]		1	5					SHOWS M ONLY		B
	C	CTC	WHEN 3R	[(AAT AT BT) = 5N] [(4LS on	BT) = 3R]			1					D BY 2L O/H SHOWS MR ONLY = 5[illegible]		C
5			WHEN 3R			BT									5
6														NOT EQUIPPED	6
7		CTC	WHEN 3R			ET EAT								SEE NOTE	7
8R	A	CTC	WHEN 3R	BLOCK TC'S			7			(AT AAT or 4RN) BT (CT CAT CBT = 7N) (DT DAT DBT DCT = 7R)	JR ON (CT or CAT or CBT OCC'D = 7N) or (DT or DAT or DBT or DCT OCC'D = 7R) 90 SECS	(ET [EAT W 7R] W 3N OR 8RD 8RN) OR JR	D BY INT D	CONTROLS BLOCK CCT'S	A 8R
	B			BLOCK T.C'S				7					D BY INT D		B
8L	A	CTC		BT CT CAT CBT ET			7			RIGHT BLOCK TC'S (RBR)	JR (90 SECS)	(ET [EAT W 7R] OR HT) OR JR	D BY 4LA D		A 8L
	B			BT DT DAT DBT DCT ET EAT			AWL BWL	7					D BY 4LC D		B
	C		WHEN 3R	(8LS on	ET)		(AWL = 7R BWL N)		7 (BWL = 7R)				SHOWS M ONLY		C

Fig. 5. Otorohanga. Typical Centralised Traffic Controlled Single Line Crossing Loop.

ciency had been attained with unloading, the laying of cables was carried out during the previous month. Since the first *major* resignalling operation at Ngaurukehu in June, 1956, the following widely dispersed installations have been brought into use at monthly intervals : Te Horo, Waikanae, Manganaoho, Hangatiki, Utiku, Featherston, Te Kawa, Otorohanga, Mangaweka, Woodside, Paraparaumu, Ohaupo, Waiouru, Rukuhia, Owhango, Hihitahi, and Mataroa (fig. 1). With each operation there has been an increase in the scope of the work undertaken on the site at the time of

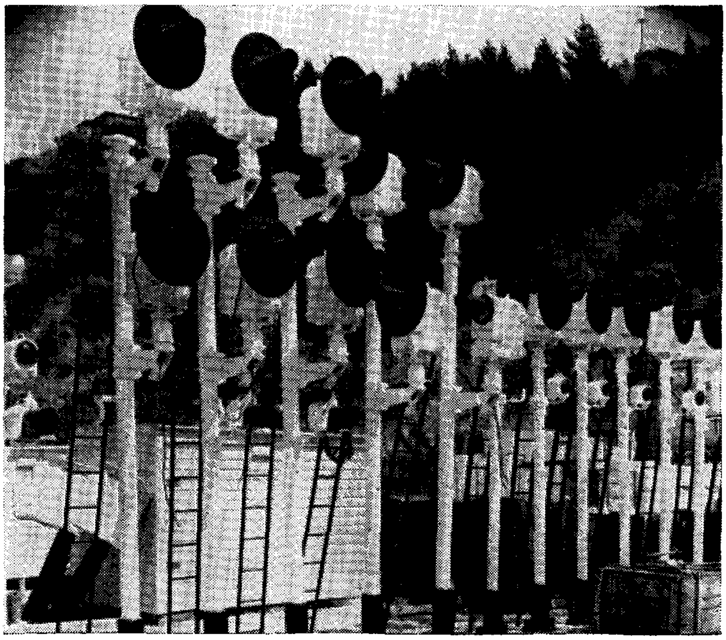


Fig. 6. Prefabricated Signals at Kaiwharawhara Signal Depot Wellington, N.Z.R.

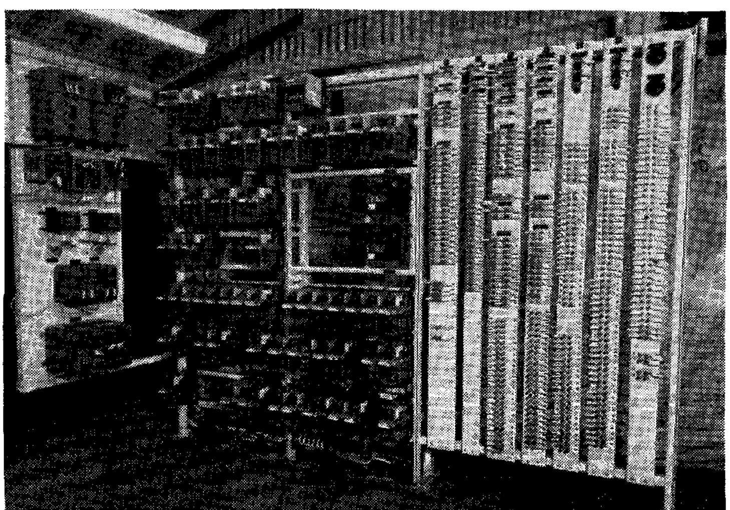


Fig. 7. Prewired Relay Rack

installation, and a reduction of manpower and hours of duty.

Prefabrication

Each separate unit of the complete installation has been carefully studied, and designs amended where necessary to suit the new proposed method of construction.

Signals (fig. 6)

Signals are assembled, painted, and wired from the signal head to terminals located on the base of the mast. If the signals are to be erected near a "location," the wires are cut to length and labelled ready for connecting at the site.

Point Machines

Point machines are cleaned, oiled, adjusted, and all internal wiring completed. Connecting rods for attachment to the rail switches, together with all small components required, are placed in a wooden tray, and loaded with each machine.

Main Relay Rack (fig. 7)

The main relay rack is manufactured and fitted with transformers, rectifiers, terminals, and signalling relays of the latest plug-in type.

Main Relay Room (figs. 8, 9 and 10)

The main relay-room building (20-ft. ×

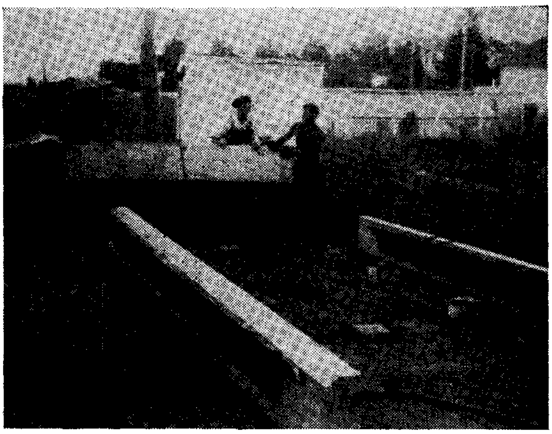


Fig. 8. Placing foundations for Main Relay shelter

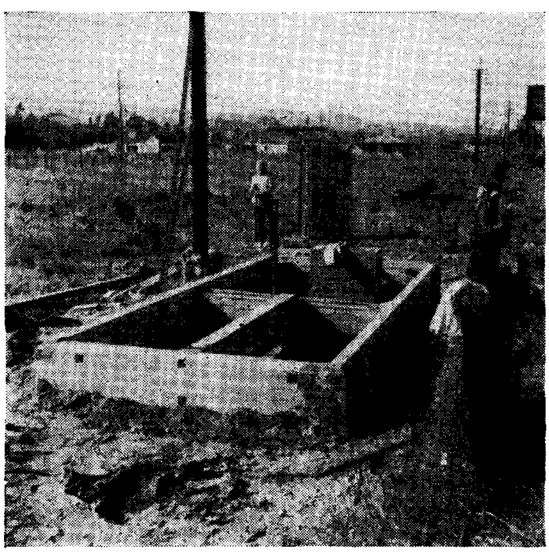


Fig. 9. Main Location foundations complete

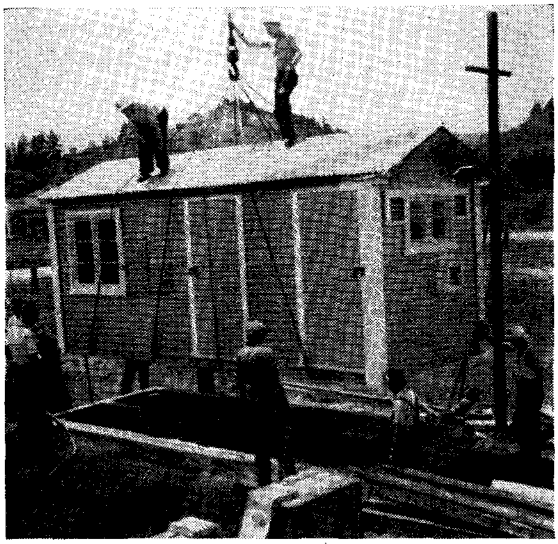


Fig. 10. Main Location containing Signal relay rack, and 230 volt 1½ kVA. diesel standby Generator

8-ft.) has been specially designed so that it can be transported on a well bogie wagon. When the main relay rack has been wired and tested, it is placed inside the relay room and the wiring to such components as batteries, pilot key, and point crank handle detector is completed prior to leaving the workshops in Wellington.

In an adjoining compartment, an automatic " start/stop " 230 v. 1½ kVA. diesel standby generating set is fitted and wired, the engine being temporarily mounted on steel brackets spanning a hole left in the floor for the foundation block.

Concrete foundations for the main relay room are precast in sections, and bolted together on site prior to the main relay room being lowered into position.

End-of-loop-Locations

The end-of-loop location (when positioned on site) is placed near one of the electrically operated turnouts, and houses a subsidiary relay rack for controlling the points machine and local signals. All internal

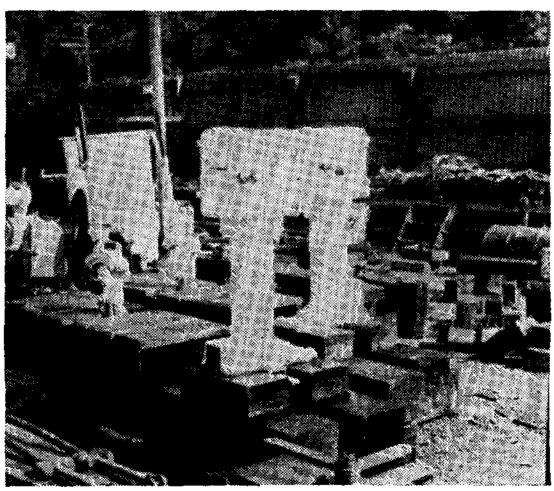


Fig. 11. Frame levers and switchlocks

equipment is wired and fitted prior to despatch from the Wellington depot.

Mechanical Signalling Equipment (fig. 11)

All frame levers and switchlocks are mounted on prefabricated timbers.

Point-rod roller foundations, rodding, compensators and crank frames are prepared ready for placing in the ground.

Concrete Work

Double and single-unit signal bases, legs for small locations, piles for end-of-loop locations, and foundations for the main relay room locations are cast in concrete.

Manholes are prefabricated complete with sides and cover, and are later placed in position where required. Four-inch galvanised tubing cut to the required length is used to protect cables laid under roadways. Previously, where it was necessary to run cable under roadways, concrete manholes were poured on site with individual boxing for each locality.

External Wiring Connections (fig. 12)

Until recently the individual wires from the locations to the signals, track circuits, points motors, and detectors, were measured and cut to length, and labelled with standard indented P.V.C. tubes. The wires were then formed into a cable and wound on to a cable drum. A plan was prepared showing the routes the individual wires would take, and the wooden trunking was laid on site in accordance with this plan.

The latest development has been the utilisation of four, seven, and eleven-core plastic cable for this purpose, buried 2-ft. 6-in. in the ground. The cables are colour coded, and a plan is drawn showing the colour and cable to be used for each individual circuit. No wooden trunking is now used, and in this way it is considered future maintenance costs will be considerably reduced.

Loading of Signal Equipment Train

Great care is taken to ensure that all apparatus is loaded on the wagons in order, and in the sequence which will enable the train to be unloaded with the minimum number of shunting movements

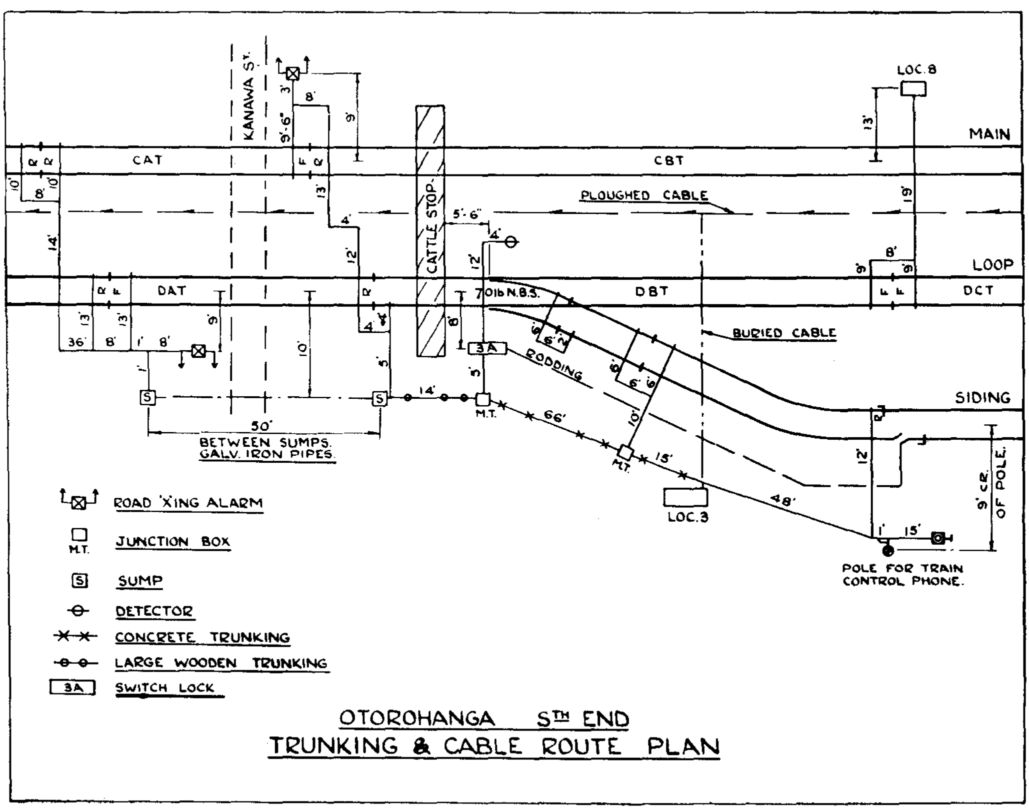


Fig. 12. Cable and Trunking Route Plan Otorohanga South End

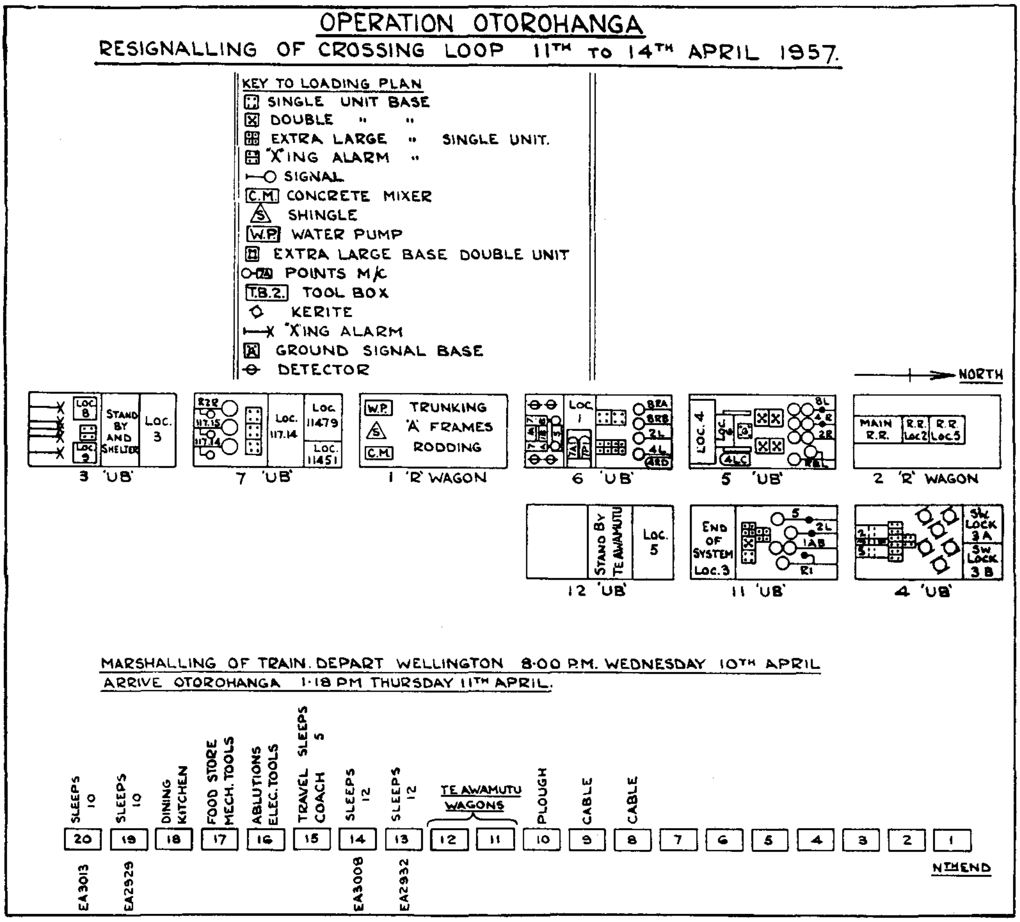


Fig. 13. Loading Plan for Otorohanga

and swings of the crane jib. Consideration is also given to ensure that the order of unloading will not unnecessarily interfere with the cable-plough train or the normal " through " traffic movement. To enable this important phase of the work to be completely co-ordinated, a comprehensive plan (figs. 13 and 19) is prepared, showing :

(1) The individual loading of each wagon.

(2) The marshalling of the complete train.

(3) Relevant details of the shunting moves when on site.

(4) Types of locomotive to be used, and the times they will be required.

Shunting a train can be very time-consuming, but with careful preliminary planning this work can be reduced to the minimum. In addition, to facilitate and speed unloading, wire or rope slings are left attached to all equipment after it has been loaded at Wellington. This saves time that might otherwise be lost during unloading through having to locate the point of balance, or to place a sling around a difficult object.

Each signal is temporarily fitted with a specially designed lifting bracket. Similarly the main relay room and end-of-loop locations are provided with temporary brackets in suitable positions for lifting. It will be realised that, with a total of 75 crane lifts (as for the Otorohanga installation), even two minutes saved on each lift will reduce

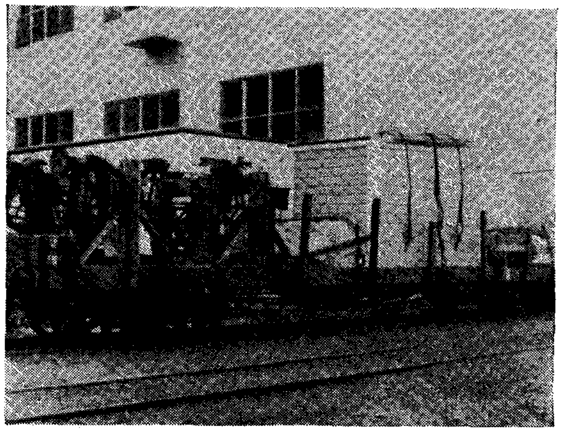


Fig. 14. Wagon loaded with Prefabricated Signal Equipment

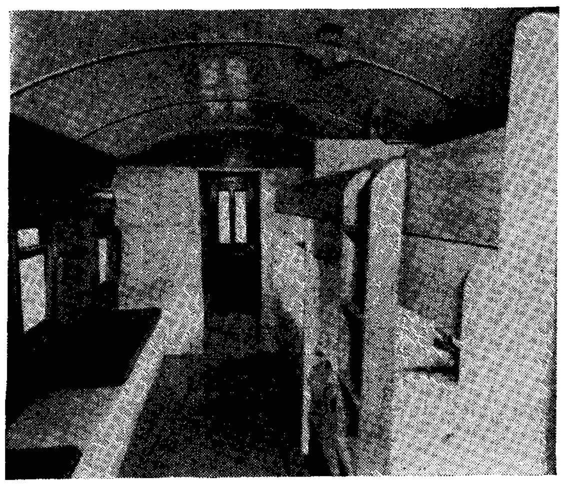


Fig. 15. Sleeping Accommodation on train

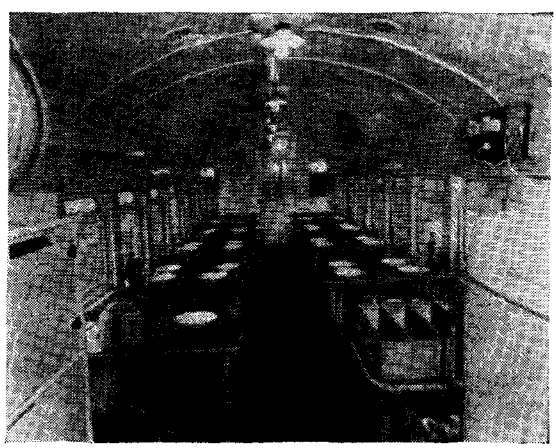


Fig. 16. Dining Car

unloading time by 2½ hours. Slings and lifting brackets are retrieved, and used on the next project.

All cable drums are supported on special racks on the wagons, so that cable laying can commence immediately upon arrival.

Fig. 14 shows a typical loaded wagon of prefabricated signalling equipment.

The complete train consists of the three independent units, as follows :

(1) 8 or 9 bogie wagons carrying the prefabricated signal equipment.

(2) Cable Plough and cable wagons.

(3) Eight converted coaches equipped with sleeping accommodation, dining facilities, kitchen, toilet facilities, stores, and workshops.

The train in use at present is capable of sleeping a total of 53 men in five coaches (fig. 15).

Coach "A" (figs. 16 and 17) has been converted to a dining and kitchen car capable of seating 48 persons. In the kitchen section is a double-oven coal-fired cooking stove complete with a hot-water system for dish washing.

Coach " B " (fig. 18) serves three purposes, providing space for amenities, a

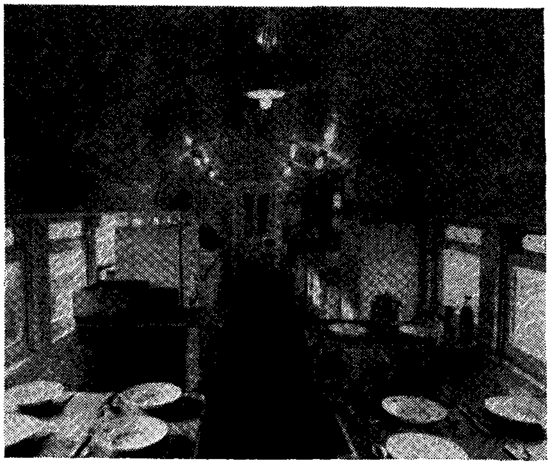


Fig. 17. Dining Car Kitchen end

Fig. 18. Mobile Electrical Workshop and 230 v. 7½ kVA. Diesel Generator for train lighting, and power tools

generating room, and an electrical mobile workshop and store.

Amenities include a shower, a bath, and several washbasins. Hot water is supplied from an electrically heated and thermostatically controlled hot-water cistern.

The generating room contains a 230 v. 7½ kVA. diesel generating set for train lighting, water heating, electric power tools, and flood-lighting during the winter months.

The electrical workshop and store is for use by all electrical staff working on the project. Spare electrical apparatus and tools are located in special compartments and racks.

Coach " C " has been divided into two compartments—a mechanical mobile workshop and a food larder.

The mechanical workshop is for use by the fitters and mechanical staff. Spare mechanical equipment and apparatus is carried in this compartment, together with the following : power hacksaw, electric and gas-welding equipment, drilling machine, double-wheel grinder, petrol-driven posthole borer, single and double rail-bond drilling machines, circular saw, water pumps, waterproof clothing, first-aid equipment, diesel oil, petrol, lubricating oil, and portable shelters for protecting staff and apparatus against inclement weather conditions while working on the electrically operated point machines.

Half the space in this coach has been allocated for food storage. Benches and sinks are provided for the preparation of food.

A complete schedule of the food requirements is prepared prior to the departure of the train from Wellington. This includes menus, meal times, and the number of men to be catered for each day during the operation. The catering organisation has frequently been called upon to cope with up to 70 men at lunch and dinner, with two sittings at half-hourly intervals, and it is essential that meal times be meticulously punctual to avoid delay and loss of time.

A schedule is prepared for each operation, detailing the times of departure and arrival of the equipment train, the general routine to be followed, meal times, hours of duty, estimated timings for the various phases of the work, special instructions, and lists of tools, plant, and spare equipment carried on the train. The names and grades of all staff taking part in the operation are scheduled on each of the days for the various work to be undertaken. A copy of this schedule is given to each member of the staff who will be present during the installation period.

To encourage the maximum effort, and to maintain a high standard of workmanship throughout each operation, staff are frequently brought together from various localities throughout the North Island and consolidated into teams, each working under a team leader who is responsible for a certain area or specialised section of the installation. In this way, only general overall supervision is necessary to overcome any individual problem that may arise.

With all equipment and food supplies loaded, and every member of the staff taking part in the operation fully conversant with his duties during the next three days, the train forms a " special," which is complete in every respect, and meals are served while travelling. There is therefore, no loss of time and the staff may begin work immediately on arrival, or at a suitable pre-arranged time, usually 6 a.m. in the morning, if the train has travelled throughout the night.

Positioning and Unloading of Train (fig. 19)

It will be realised that with two trains engaged at the scene of operations—one laying cable and the other unloading equipment—close co-ordination with other rail traffic is required if delays are to be avoided. A senior member of the District Traffic Manager's Office is therefore appointed to act as liaison officer, and it is his job to keep traffic moving as smoothly as possible. Immediately after arrival a temporary telephone and loudspeaker system is arranged through the area to assist with the movement of trains, overall control of the work, and final testing.

In view of the number of men working in the locality and the necessity for all trains to be hand-signalled over the points a speed restriction of 15 m.p.h. is imposed on all trains passing through the station yard.

It is essential that the positioning of the train be carried out expeditiously, and it is interesting to note the times which were logged during the Otorohanga operation (fig. 19). The cable plough wagon was

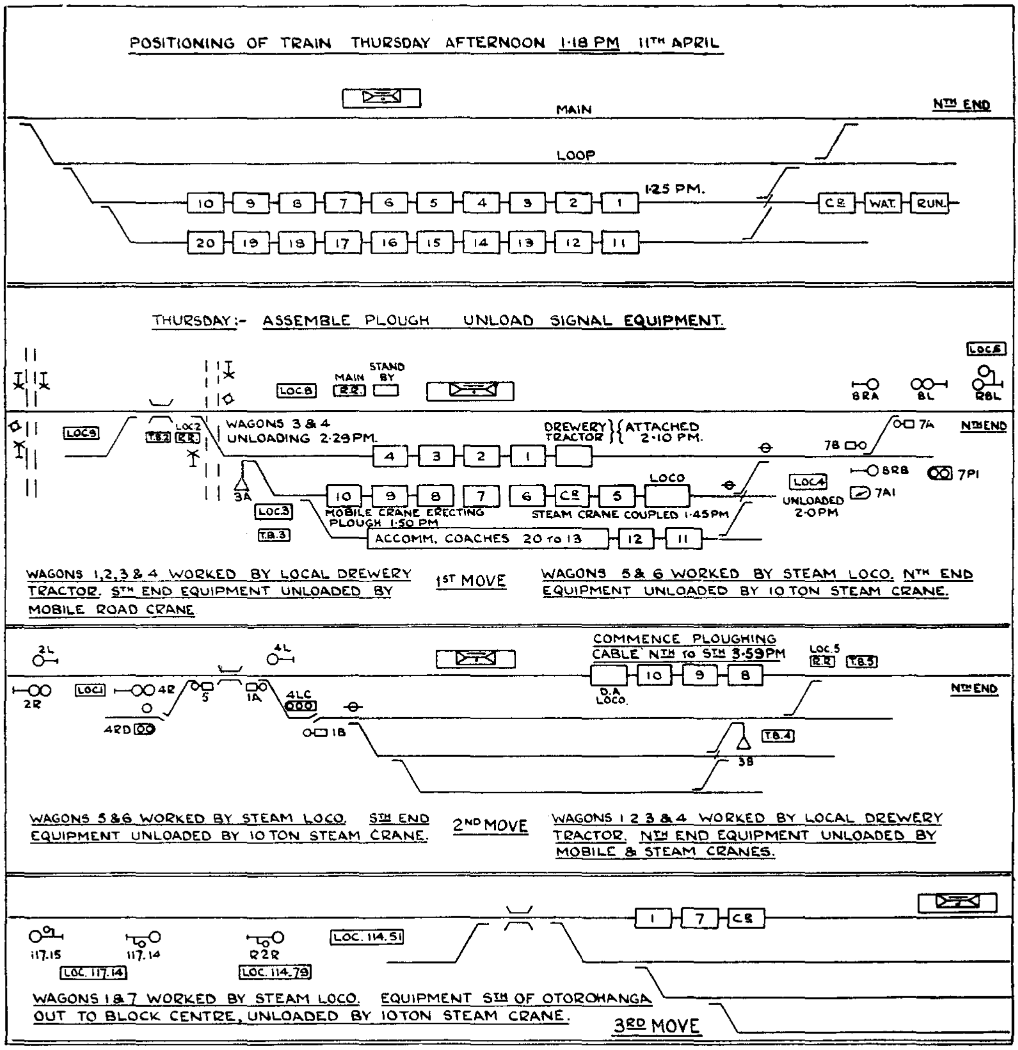


Fig. 19. Positioning and Wagon unloading schedule for Otorohanga

shunted to a position convenient for the erection of the plough, and the travelling steam crane was located ready to place itself between wagons 5 and 6.

Unloading of the various components of the installation by means of both steam and mobile diesel cranes commenced as soon as possible. At Otorohanga the first lift by the mobile crane was made at 1.50 p.m. and the first lift by the 10 ton steam crane was at 2 p.m.—that is, 32 and 42 minutes respectively after the train had arrived on the site.

At Otorohanga 75 crane lifts were required for the installation of the new signalling and 12 lifts for the recovery of the old mechanical equipment, and semaphore signals. The steam crane was in use for $12\frac{1}{4}$ hours, and the mobile crane for 3 hours, an approximate average time of 10 minutes per lift. (This figure includes travelling and waiting time for "through" rail traffic).

It is interesting to note that the time required to unload and erect a signal and concrete base has been reduced to as little as $3\frac{1}{2}$ minutes.

Installation on Site

It is essential for the following reasons that the time taken to install the equipment on site and to bring it into use be reduced to the absolute minimum :

(1) To reduce interference with through rail traffic.

(2) To minimise interference with shunting and trans-shipment of goods at the station where the equipment train is berthed.

(3) To reduce locomotive and crane time.

(4) To enable skilled technician staff, normally employed on district maintenance work, to be used during the installation period.

(5) To ensure that staff normally working at the Wellington depot are not away from home for too long a period.

Both the amount of work to be undertaken during the week-end operation and the travelling time to the site vary with the magnitude and geographical location of the individual interlocking. Generally, however, work commences simultaneously with the placing and unloading of the train on the following sections of the installation:

(1) Digging of all holes for signal bases with a petrol-driven post-hole borer, and the excavation of ground with a calf-dozer for the frame levers and switchlocks.

(2) Preparation of piles for receiving the foundation of main relay room.

(3) Laying cables.

Digging of Holes for Signals

To facilitate the work on site a ground installation plan is prepared showing the relative position of all holes to the track centre-line, and these are excavated in the order of priority required for the unloading of the equipment. At present a power 9-in. auger is used, but arrangements are in hand to procure a machine capable of drilling an 18-in. hole. After this larger machine has been tried out, consideration will be given to redesigning the signal base.

Preparation of Foundation for Main Relay Room

Small piles are placed in the ground, and upon these the prefabricated concrete foundations are laid and bolted together. The main relay room, complete with the relay rack and the 230 v. standby generating set, is then lowered on to the foundaation.

Cable Laying (Figs. 20, 21 and 22)

The cables are laid in the ground by means of the cable plough. This plough, consisting of the ploughing blade and cable guide-tubes, is lowered, raised or tilted hydraulically. The hydraulic system is powered by a 3½ h.p. Briggs & Stratton petrol engine.

The main hydraulic ram is 6-ft. long and enables the cable to be laid as much as 5-ft. below rail level. Outside station yards the ground often falls away from the trackside and may be 2-ft. below rail level at

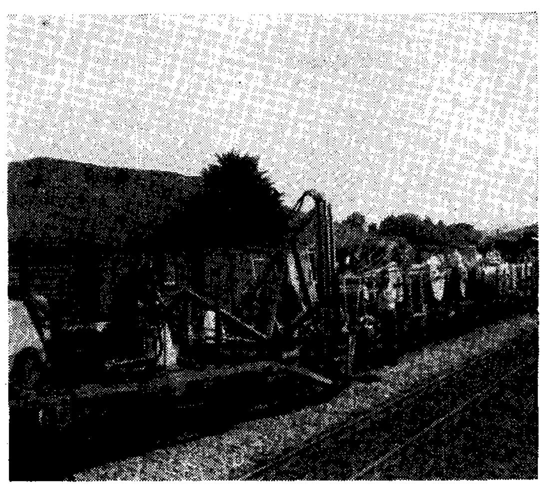


Fig. 21. Cable Plough in operation

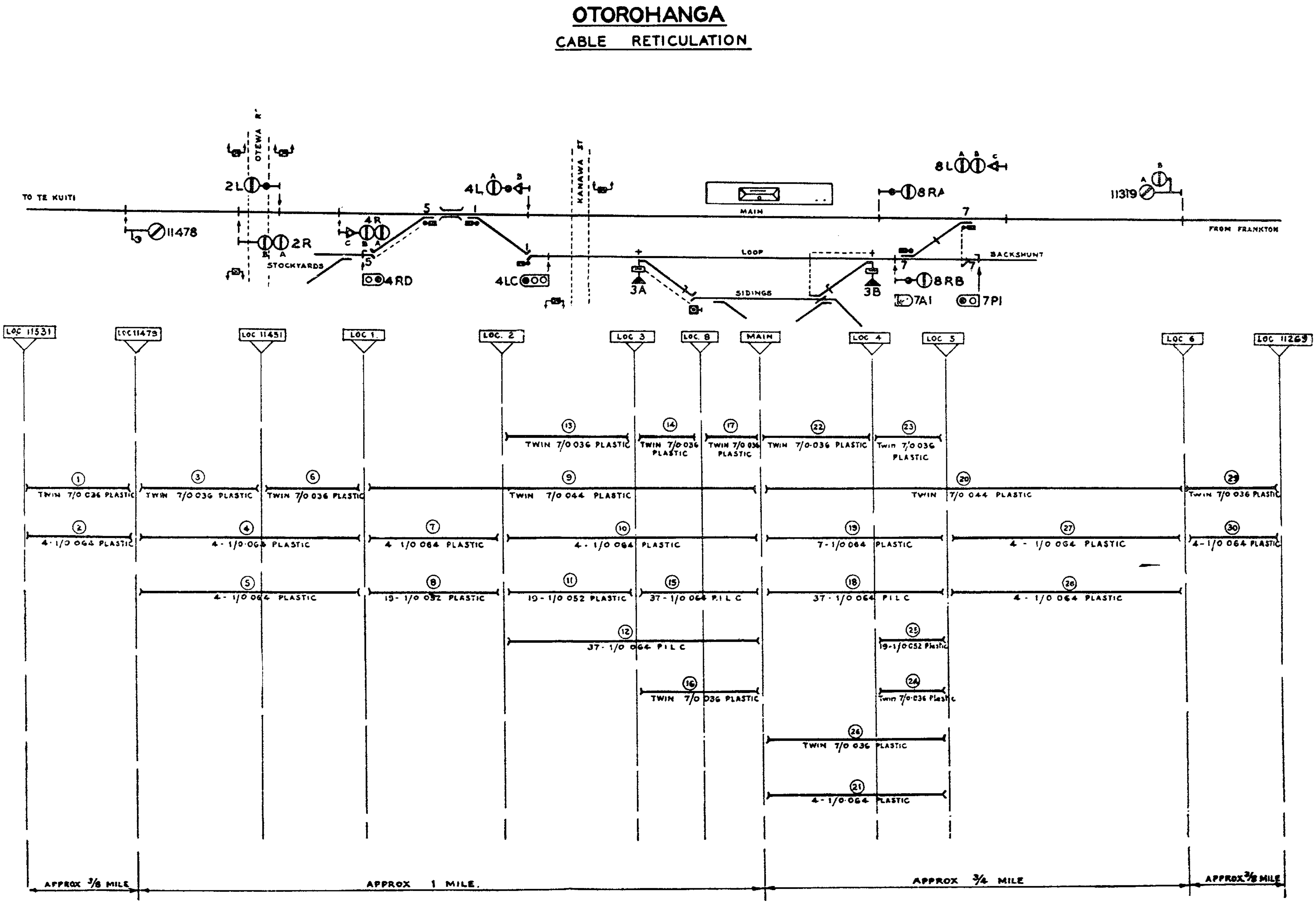


Fig. 20. Signalling Cables required for Otorohanga.

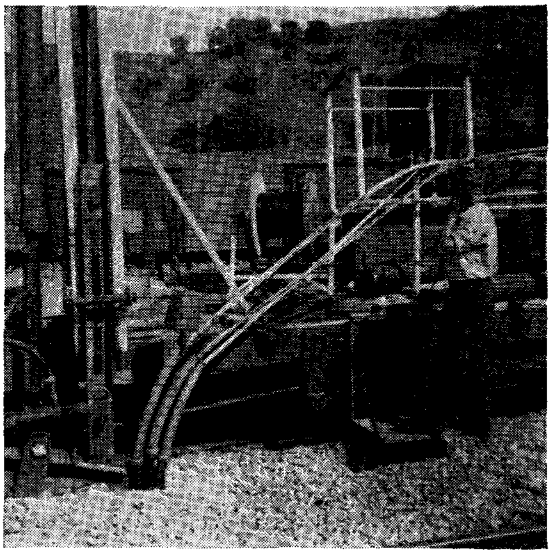


Fig. 22. View of cable plough at full depth

the normal ploughing distance of 5-ft. 6-in. from the track centre. The cables are then laid 3-ft. below ground level.

The total weight of the ploughing wagon, complete with its concrete ballast blocks, is 15 tons, but under certain ground conditions it has been known for the wheels to be lifted off the rails. The most satisfactory type of locomotive for hauling the cable plough is the 1,500 h.p. diesel-electric locomotive. This type of locomotive enables a smooth, even pull to be exerted.

The complete cable train consists of the locomotive, cable plough, and wagons carrying the cable drums. Telephone communication is provided between the officer-in-charge of the cable ploughing, the engine driver, the plough-control operator, and the person in charge of the cable drums on the rear wagons. With this intercommunication system, there is little likelihood of accidental damage to the cables or injury to the men working on the wagons.

A surprising number of obstructions are encountered, such as buried rails, the debris of old derailments, tree trunks, sewers, telephone cables, and water pipes, but prior investigation is always undertaken to ascertain the location of any known obstacle that may be encountered while ploughing.

In the event of striking a solid object, immediate action to stop the train may be necessary to prevent damage to the plough. In addition, one of the vertical struts of the plough has been designed slightly weaker than the others, so that no undue damage will occur. Brass shearing pins have also been provided in strategic positions.

The method of ploughing adopted is dependent upon the nature of the ground and the number and class of cables to be buried. Where there are several cables to be laid, or where rock is expected, the route is opened up by the plough prior to laying the cable.

The time taken to complete the ploughing of the cables varies with the geographical and geological nature of the locality, but the average time taken to lay 6½ miles of cable for a typical CTC crossing loop is 7 hours. As many as 22 plastic-sheathed cables have been laid at one time with this plough, utilising the three 2½-in. diameter tubes.

Fig. 20 shows the cable reticulation required for the signalling of the CTC crossing loop at Otorohanga, where the following lengths of cable were laid over a distance of 1¾ route miles :

8 cables each of 388 yds.=3,104 yds.
6 cables each of 170 yds.=1,020 yds.
5 cables each of 208 yds.=1,040 yds.
3 cables each of 2,179 yds.=6,537 yds.
Total length of cable=approx. 6½ miles

The time taken to open the ground within the interlocking area took 75 minutes, and a total of 5 hours 20 minutes was spent in laying the 6½ miles of cable.

Progress

Work usually ceases at approximately 5 p.m. on the Friday evening with all cables laid, and all equipment unloaded.

On Saturday the teams are augmented by district maintenance staff, and the main groundwork having been completed, the local labouring staff is disbanded and installation proceeds methodically during the remainder of the day.

It is most important at this stage for all phases of the work to progress in unison, and any section that may have encountered difficulty is immediately given assistance.

Strict supervision is maintained throughout.

Testing

The testing is divided into the following sections :

(1) *Testing of apparatus prior to loading*

All relays and searchlight signal units are inspected in the relay repair room, and the " pick-up " and " drop-away " voltages of the relays checked. The relay contact resistances are checked and, if necessary, re-adjusted. All adjustments must conform to the relevant British Standard Specification.

Upon completion of the wiring of the various locations and relay racks the senior electrician maintainer in charge checks to ensure that the labelling and number of wires on each terminal are in accordance with the circuit diagrams. This is followed by an engineering check involving the energising of each individual circuit, and the proof that each separate contact is actually in the circuit. The signal control panel is connected to the relay rack by the cable that will be used on site, and the electrical interlocking tested. External connections to signals, track circuits, and points motors are simulated from feeds controlled from a specially designed testing cabinet. The checking of a relay rack such as that shown in fig. 7 takes four days to complete.

Printed test record sheets requiring details of all mechanical and wiring checks with a record of all electrical adjustments are completed and initialled by responsible members of the staff. In this way a comprehensive testing certificate is built up for each installation, from the initial wiring check to the final commissioning tests. This test record sheet requires details of all mechanical and wiring checks, also records of all electrical adjustments.

(2) *Testing on Site*

When all wiring has been completed, each individual wire connected on site is checked for continuity, correct labelling, and number of wires per terminal. The apparatus is then examined for functional operation, signals are focused, and lamp voltages and track circuits adjusted. The insulation resistance of all cables, both between conductors and to earth, is also recorded.

As a final check before bringing the installation into use, a complete functional test of all electrical interlocking from the control panel is carried out.

The commissioning and testing of the installation takes from approximately 1.0 p.m. until 5.30 p.m. on the Sunday. Responsibility for checking on the site is undertaken by two engineers, each of whom is assigned one end of the interlocking. When these tests are completed, the final functional locking check is carried out. It is worthy of note that very few wiring errors have been found during testing.

Conclusion

Progressive work has enabled mass production methods of manufacture and assembly to be arranged, together with continued improvement in technique. Originally the prefabrication method of installation was devised to enable works to be undertaken away from the main centres, but the resulting overall economic benefit attained has enabled the scope of operation to be enlarged, and the method and organisation has been proved adaptable for any size of installation.

During the financial year ending March 31st, 1958, the expenditure on railway signalling installations installed using the Wellington prefabrication signals depot and the North Island signal equipment train described exceeded £220,000.

Practically all new signalling installations in New Zealand are now "prefabricated" and a second train for use in the South Island has recently been acquired.

The progress and success of the various works undertaken has been to a large extent due to the enthusiasm and *esprit de corps* with which all members of the staff have carried out their duties.

The writer wishes to express his thanks to the Chief Civil Engineer, New Zealand Government Railway for permission to publish this paper, and to the Publicity Branch of the Railways Department for assistance and photographs.

This paper in its original form was previously read in 1957 before the New Zealand Institution of Engineers

DISCUSSION

In announcing that the paper was open for discussion, the **Vice-President** said that it was many years since they had had a paper dealing with signalling practice in New Zealand, and he believed that it was the first paper that had been presented at any time that had dealt with prefabrication and pre-planning. For those reasons, the paper would form, not only a very useful and welcome addition to the proceedings, but would provide plenty of material for the discussion. Mr. Carslake would reply as fully as possible to any questions that might be raised, but there might be some that he would have to refer to Mr. Hardman, and presumably the complete answers would be dealt with by correspondence.

Opening the discussion, **Mr. J. H. Fraser** suggested that one of the weaknesses in the path of a young signal engineer was a tendency to be over-engrossed in technicalities and not giving enough attention to engineering management and execution of the work. It would pay any young engineer to study thoroughly such a paper as Mr. Hardman's as it was a matter of detail and how to get work done cheaply. The cost of signalling was one of the handicaps suffered in this country. If signalling were cheaper, twice as much could be done. The method described in the paper was one of the ways in which the cost of signalling could be reduced.

It had been mentioned in the paper how important it was from the author's point of view, to plan the work so that it could be done with minimum interference to traffic. Mr. Fraser thought that it was even more important for signal engineers in this country, because one of the biggest handicaps which occasioned great cost, was interference with traffic, particularly as the programme of new works would have to be accelerated in the next 75 years. This was one of the reasons why the paper was one of the most important that had been read for a long time.

In reply, **Mr. Carslake** stated that there was necessity to deal with the organisational side as well as the technical side. What he had seen in the profession was that emphasis, in many cases, was on the technical side, but it could not be detached from organisation, The interesting part of the paper was, not because they set out with an objective to achieve the results in the first place, but it was forced on them absolutely by circumstances. It appeared likely that their programme would be 10 years in arrears and, some action had to be taken. It materialised by having to resort to invention, and certain aspects did show that local inventiveness was a very good thing indeed. Mr. Hardman could give no idea of the saving in cost—it was impossible, because on site installations the records were difficult to analyse and it was hard to analyse comparisons between one job and another—by carrying it out the new way, as compared with previous methods. He considered that they had made quite a substantial saving, of approximately 25%.

Mr. M. E. Leach said, on the Western Region, a little prefabrication was carried out in connection with the intermediate block signal sections, in that prefabricated locations were made at Reading, taken to site and installed. It was not on the same scale as the matter covered by the paper but it did show some attempt at prefabrication had been made on British Railways

Mr. Leach saw no mention in the paper of floodlight equipment or night work, and he presumed there was none. Were the men employed on the work railway staff, or contractor's men ? Was there any scheme afoot on the New Zealand Railways for the use of electronic CTC ?

Replying, Mr. Carslake said that the work was planned on the basis of three days of, roughly, 11 hours. They started operations at 6 a.m., had one lunch break at 12 for half an hour, and then the gang continued until 5 p.m. Another gang started at 6.30 a.m., had lunch at 12.30 p.m. and finished at 5.30 p.m. He believed this arrangement gave sufficient man-hours to get the work completed. If, for any reason at all, they encountered trouble on any section, there was an adequate margin to rectify matters the same evening, before going on with the programme next day. On work where public safety was concerned, if one flogged the men on day and night shift working, under conditions such as those described in the paper, the men on day shift would get little rest at night, and the men on nights would be fatigued. Adequate men on the job gave spare capacity, so if the work became delayed, it could be accelerated. Particular care was taken to complete each day's programme that day, and starting the next day with everybody on schedule. There was provision for floodlighting, as artificial lighting was needed, even in the working times mentioned. Sometimes cable ploughing had to be carried out at night.

Regarding administration, no contractor's men were employed; they were all railway staff. They were paid standard rates, for the hours that they worked. For overtime they were paid at overtime rate. They were not paid any allowance for off-duty time. They received all their food and accommodation, but they did not get any special payment or any payment for the time which they were not employed on the work.

(The CTC question would have to be referred to Mr. Hardman),

Mr. M. E. Leach, referring to fig. 21, said that the countryside looked very sparse and unpopulated, and it struck him as rather unusual that there should be a 230 v. power supply in that apparently unpopulated area.

Mr. Carslake said that New Zealand, far from being a backwood, had quite a good deal of water power, particularly in the North area. A great deal had been done to provide power in rural areas. Basically, it was farming country and, in many ways, far more progressive we than are in this respect. The provision of power to rural areas was a policy pursued by the Government, because it served their basic industry. There was no situation where provision of power from ordinary batteries was necessary.

Mr. L. H. W. Lowther asked if the location shown in fig. 10 was carried on a rolled steel carrier. In setting-up the location on a prefabricated concrete foundation, was the steel carrier left there and drawn afterwards ?

Referring to Mr. Carslake's statement that there was a saving of about 25% on the installation, was that after taking into account some charge for the capital cost of the fairly expensive works train ?

In reply, Mr. Carslake said that the first question would be referred back to Mr. Hardman for clarification.

So far as saving was concerned, Mr. Carslake was not aware how the figures were arrived at. They might not include the capital cost of the train; it might be that Mr. Hardman was dealing with the man-hour saving point of view. It would be interesting to have further details with regard to savings.

Mr. L. J. Boucher enquired if there was any financial incentive to the men working on the project ? He was interested in the comments on signal bases and asked for some information on their design. His reaction was that they were erected in 3½ minutes, but how soon did they come down ? He also asked for some information with regard to the arrangements made to overcome any setback which might be occasioned by an accident occurring.

Mr. Carslake replied that there was no incentive for the men. It seemed that their wages were very high; the skilled men who were installing and testing would perhaps be earning as much as any technical staff in this country. There was what we would call a very high basic rate. He did not say there was no need for an incentive, but perhaps there was less need than for people in this country. Regarding signal bases, Mr. Carslake was not certain whether the concrete base was circular or square. He had a feeling that it was a square section tapered and that it was lifted up, dropped in the hole and grouted in with wet concrete. As to the possibility of accidents, they were very concerned about that point, particularly accidents to staff or accidents on the site. They had obviously gone to great care in operating protection, which was the normal traffic responsibility, but they had gone to particular care in the handling of everything, to prevent somebody picking up and dropping one of the essential pieces of equipment. That was the explanation of the extreme care taken in preslinging. They had put in a total of over 70,000 man-hours with the train, without a single off-work accident. The train had been held up as a model to all other departments.

Mr. F. W. Young said that the paper was an excellent example of method study. Careful planning of material was necessary and also of man-power. It was necessary to give to all staff concerned with any major installation a detailed schedule of what they were required to do, when they were to do it and how they were to do it. There were many works which had failed in minor respects merely because of lack of that information. Mr. Young was very interested in the opening remarks of the paper in which seven difficulties were listed. In spite of the different geographical conditions, it was true to say that those difficulties were, by and large, met with today in this country, particularly in regard to staff of the right experience, in the right place, and at the right time, and the provision of material at the right place. This was especially so in the present situation when the electrification of major parts of British Railways was scheduled. The problem of material was considerable. As a basis, arrangements could be made to prefabricate as much material as possible in a workshop before feeding it to the line where qualified staff were scarce.

Automatic train control equipment was being installed on parts of British Railways. A great deal of this equipment had to be installed within the shortest possible time. A little was no good at all; a great deal had to be installed before it became effective. It had to be arranged so that all items, such as line-side locations, were prefabricated in the shops and planned, in order that the local man would have only a minimum amount of work to do. On larger signalling installations, where racks were prewired, this technique had to be increasingly developed, so that the number of men on the line were able to carry out a greater amount of work, with the least amount of trouble and lesser number of hours.

It was interesting to see that Mr. Hardman was making the fullest use of power tools, but economic facts had to be considered. Before introduction it was necessary to ensure that full value would be received.

The use of plastic cable of four, seven and eleven conductors, was interesting and that the cable was buried directly in the ground. On British Railways, they had developed a cable of one to eleven cores of the same type.

Mr. Carslake said that Mr. Hardman did not plan the length of time for a specific job. He did not plan from start to finish; he planned the starting date, but left the finishing date to take care of itself. The case was that it was impossible to plan details too closely. The influence of train movements through the station was such that it could not be forecast. Interference was such that the work might be far behind where it had been planned to be. On the other hand, pages of detailed instructions were prepared for work the staff had to do, on the various days.

Mr. F. L. Castle, who had recently visited New Zealand, had had an opportunity of talking with Mr. Hardman and of seeing some of the details described in the paper. He was much impressed with the enthusiasm and thoroughness with which the problems had been tackled, Mr. Castle had walked through the train, from end to end, and the amount of study that had been put into it was astounding. Everybody knew what was going on, and knew what they had to do when they got to the site. The time spent in the office must have been considerable, but it paid dividends on the site. The train had just arrived from having completed a crossing loop, which Mr. Castle saw later If anyone had any apprehension as to the possibility of a signal falling, he could assure them that the standard of installation in New Zealand was second to none anywhere in the world.

Mr. Carslake said that there was an interesting point which he found extraordinarily difficult to believe. Having heard Mr. Castle's experience, it was probably true. He had asked in correspondence how the installation was handed over; he imagined that a man was left at site. He was told that they did their testing, swept the place out and handed it over there and then to the local maintenance man.

Another point which was very interesting was that Mr. Hardman, who designed and developed the scheme, did not go out on installations. It was now an organised plan, carried out as normal routine. Mr. Carslake then read out a communication from Mr. Lovat, who had requested him to do so, as an addition to the paper.

Mr. F. G. Hathaway, referring to the typical station described in CTC territory, thought that the time allotted for cable laying could not possibly take into account cable to be installed from one station to another for CTC lines and block control. because that would be a total of some 6½ miles in 7 hours. If it did not, how was it planned ?

In reply, Mr. Carslake said that the paper referred to the installation of cable for the sectional passing loop and its distantly protected signal. Basic communication between stations would presumably be dealt with under ordinary telecommunications.

Mr. C. P. B. Hodgson said that prefabrication was not really new; in fact, it went right back into the early days of mechanical signals. He had a photograph of the first signalling at Cannon Street Station in 1866, in which the whole gantry was fabricated in the manufacturer's yard and sent in very large sections to Cannon Street Station, where it was erected. The same procedure had been adopted throughout signalling history and now the subject had appeared again.

Mr. B. Neill said that it appeared that traffic density was such that the Signal Engineer could only have complete occupation for a very short time. Why, in that case, was a complete train used instead of road transport ?

Mr. Carslake stated that the actual occupation of the running lines was relatively small. What they did was to accept the fact that all passenger trains must have priority. Traffic were prepared to accept delay in freight trains; on the first day they tried to get all their equipment unloaded at site and all the cable laying completed. The signal department train was worked as next priority after the passenger service, and traffic accepted delay for freight. Work could not commence until material was unloaded at site. This explained why emphasis had been placed on pre-slinging and cutting down of shunting movements. Regarding the use of road vehicles, they were dealing with territory where, in many cases, access for them would not be possible.

Mr. W. Owen proposed a very cordial vote of thanks to Mr. Hardman for his very valuable paper and to Mr. Carslake for reading it and dealing with the discussion. This was carried with acclamation, and was acknowledged by Mr. Carslake.

The **Vice-President** then proposed that a letter of appreciation should be sent to Mr. Hardman.