THE

Institution of Railway Signal Engineers

(INCORPORATED)
1912.

FOR THE

Advancement of the Science of

Railway Signalling

Proceedings, 1941

WITH

INDEX OF PROCEEDINGS

AND

List of Officers and Members.

Reading:

GREENSLADE & CO. (READING) LTD., KING'S BRIDGE.

1942

Contents

A Message to Members.

From T. S. LASCELLES, Hon. Editor.

Although no papers were submitted to the Institution in the ordinary way during the year 1941 the Council felt it advisable to issue one number of the Journal of Proceedings, containing the Annual Report and Statement of Accounts for 1940, with a report of the Annual General Meeting and other official information. In order that the volume might, as far as possible, be similar to those to which members have long been accustomed, I have included a number of other items which it is hoped may prove of use and interest, in an endeavour to keep the work of our Institution and profession in evidence in these difficult times. In this task I have been greatly aided by Mr. L. J. M. Knotts, Member of Council, and Mr. T. C. Elliott, Associate Member, who have been good enough to provide contributions dealing with subjects of much importance to signal engineers and for which my best thanks are tendered to them. I have also received, or been promised, similar assistance from others in connection with the next issue, in which I hope it will prove possible to include some papers of the ordinary form, with discussion thereon, as in the published volume covering 1940. I have again to express my acknowledgments to Mr. P. C. Howell, of the Institution's printers, for the attention given to the production of this issue and the kind readiness with which my every wish has been met.

Institution of Railway Signal Engineers

(INCORPORATED).

SESSION 1941.

OFFICERS AND COUNCIL.

		Presidential Year.
President :		
J. BOOT	London	1939-1940-1941

Past Presidents :

A. T. BLACKALL	(Deceased)	1913
J. SAYERS, O.B.E.	Derby	1914
A. HURST	(Deceased)	1915-1920
C. H. ELLISON	York	1921
W. C. ACFIELD, O.B.E.		1922
R. J. INSELL	(Deceased)	1923
W. J. THORROWGOOD	(Deceased)	1924
A. F. BOUND	London	1925
F. DOWNES	London	1926
E. F. FLEET	(Deceased)	1927
W. S. EVERY	(Deceased)	1928
R. G. BERRY	(Deceased)	1929
W. WOOD	London	1930
J. PUNTER	London	1931
C. CARSLAKE	York	1932
W. CHALLIS	(Deceased)	1933
R. S. GRIFFITHS	London	1934
H. E. MORGAN	Crewe	1935
W. S. ROBERTS	Liverpool	1936
H. M. PROUD	London	1937
G. H. CROOK	Reading	1938

Vice-President **:**

H. W. MOORE (until June 25, 1941) ... ... Glasgow.
R. F. MORKILL (from June 25, 1941) ... ... London.

Hon. Treasurer **:**

T. S. LASCELLES, 26, Voltaire Road, Clapham, London, S.W.4.

Council :

L. J. BOUCHER	London.
F. L. CASTLE	London.
R. DELL	London.
F. J. DUTTON	Derby.
H. H. DYER	London.
J. H. FRASER	York.
C. H. HILLS	London.
F. HORLER	London.
W. R. JONES	Southport.
L. J. M. KNOTTS	London.
P. LOMAS	London.
R. F. MORKILL (elected Vice-President during Session)	London.
A. MOSS	Edinburgh.
L. PRESTON	London.
S. W. SPENDLOVE	Manchester.
A. W. WOODBRIDGE	Reading.

Hon. Auditors **:**

F. EDWARDS. T. AUSTIN.

Hon. Secretary **:**

M. G. TWEEDIE,
29, Conisboro Avenue, Caversham, READING.

Institution Announcements.

BANKERS' ORDERS.

For the convenience of members and to facilitate the collection of Subscriptions, the Hon. Treasurer will be pleased to issue on demand Bankers' Orders to those members who wish to avail themselves of them.

REMITTANCES.

Overseas and other members are reminded that when remitting their Subscriptions by Money Order they should write informing the Honorary Treasurer so that he may know who has sent the money. In a number of cases he has been unable to forward receipts through not knowing the name of the sender. The Paying Office should be stated as "Clapham Common, London, S.W.4." All remittances should be made payable to the "**Institution of Railway Signal Engineers**," not to individuals, and **crossed**. Subscriptions should not be sent to the Hon. Secretary, as it only causes him unnecessary work. The Hon. Treasurer's office is at 26, Voltaire Road, Clapham, London, S.W.4.

The Honorary Treasurer draws the attention of members to the great risk involved in sending Treasury Notes in unregistered letters, or uncrossed postal orders. Many members send postal orders without filling them in or crossing them ; this is not safe.

ARREARS OF SUBSCRIPTIONS.

The attention of members is particularly directed to Article 16 of the Articles of Association, under which neither notices nor copies of proceedings may be sent to those who are in arrears with their subscriptions beyond a certain time. Many members are now in arrears and their attention to the matter is particularly requested. Complaints of non-receipt of proceedings etc., are often received from members who have not realised that the provisions of the Article have had to be applied to them.

APPOINTMENTS REGISTER.

The Hon. Sec. is notified from time to time of appointments suitable for members of the Institution and he would be glad if members requiring such appointments would communicate with him, furnishing him with full particulars, etc. Members having vacancies are invited to make use of the Appointments Register.

CHANGES OF ADDRESS AND DESIGNATION.

It is realised that a certain number of addresses and designations given may be inaccurate, and the Hon. Secretary would be glad to receive corrections as soon as possible.

It will much facilitate the work of the Hon. Treasurer if he is notified at the same time.

ADDRESSES ON LEAVE.

Members on leave are requested to advise the Honorary Secretary as to their address on leave **and for how long the address holds good.** It is regretted that owing to this information not being supplied communications and publications from the Institution have not reached members in some cases.

DISTINCTIVE LETTERS.

The attention of the Council has been drawn to the unauthorised use of the distinctive letters M.I.R.S.E., A.M.I.R.S.E. and Associate I.R.S.E. Any members of the Institution who may be aware of this practice are requested to report the matter to the Hon. Secretary, giving any available particulars.

RAILWAY SIGNALLING HISTORY.

The Council desires to create a collection of prints, portraits, photographs, printed notices, books, etc., which describe or refer to railway signalling in the early days of railways. Members are invited to present to the Institution any records of the above kind which they may have and they will be carefully preserved by the Honorary Librarian.

The official opening notices relating to the more important signalling installations are now regularly forwarded to the library by the railway companies for record purposes. Details can be obtained from the Hon. Librarian, who will be pleased to give any particulars of the works covered, on request. These notices, however, are not available on loan.

LANTERN SLIDES.

To assist members and others giving lectures, etc., the Council invites members who have lantern slides illustrating signalling matters and who are willing to loan them, to communicate with the Hon. Librarian, giving particulars of the slides they have.

ASSOCIATE MEMBERS.

Associate Members are reminded that the class of Member is open to them should they now be qualified in accordance with Article 4 of the Articles of Association. In case of doubt, the Hon. Sec. will be pleased to give further particulars and forward the necessary Transfer Form.

IMPORTANT TO STUDENT MEMBERS.

Student members are reminded that in accordance with Article 6 of the Articles of Association they are required, on reaching the age of 24, to apply to the Council for transfer to the class of Associate Member. The Hon. Sec. will be pleased to give any further particulars and forward the necessary Transfer Form.

A.S.L.I.B.

The Institution is a member of the Association of Special Libraries and Information Bureaux. In consequence, members in need of information, of a non-confidential character, but not easily obtainable, may apply to the General Secretary, 16, Russell Square, London, W.C.1, saying they are members of the I.R.S.E., and they will be told, if possible, where the information can be obtained.

The Institution Librarian, Mr. T. S. Lascelles, 26, Voltaire Road, Clapham, S.W.4, will also be pleased to assist members in this way. A copy of the A.S.L.I.B. Directory is in the Library.

INSTITUTION OF LOCOMOTIVE ENGINEERS.

The Council is pleased to announce that an exchange of Proceedings, advance copies of Papers and Programme Cards has been arranged with the Institution of Locomotive Engineers, address: 10, Park Hill Court, East Croydon. If any meeting is held at which a subject is dealt with of interest to signal engineers, members of this Institution are cordially invited to attend.

Notices of these meetings are published in the Railway Press which should be consulted.

When applying for Visitor's Tickets for such meetings reference should be made to membership of this Institution.

NOTICE TO AUTHORS OF PAPERS.

Drawings and Diagrams.—When making drawings to accompany papers to be submitted to the institution, authors are particularly requested to bear in mind that they will have to be reproduced to a size not more than 7 inches in depth and 14 inches in length and if larger, be reduced by photo-lithography to those dimensions. Any drawings whose proportions differ from these will have to be reduced so that the larger measurement will come within the corresponding measurement above quoted, with the result that the other one will be proportionately smaller. Any occasional drawing which, by reason of extreme length or depth, or minuteness or closeness of detail, cannot be got into the above size will be reduced as conveniently as possible. All lines, lettering and figures should be firm, but not heavy, and any lettering or figures where much reduction is necessary should be as clean and sharp as possible and not too small. Drawings smaller than the above dimensions will present little or no difficulty, if they are drawn clean and sharp. By conforming to the above conditions, authors will greatly assist the institution in reproducing drawings so as to be as readable and useful as possible.

LIBRARY.

In consequence of damage sustained by part of the library from enemy action, and to enable its contents to be protected as much as possible from further harm, the lending of books and other publications has been temporarily suspended. Notice will be given when this facility is again available. Contributions to the collection may still be made, however, and should be sent to the Hon. Librarian, at 26, Voltaire Road, Clapham, London, S.W.4., who will arrange for them to be taken proper care of.

MEMBERS ON ACTIVE SERVICE.

Many members are now serving with H.M. Forces but the names of all of them are not known with certainty to the Hon. Editor. It would be appreciated if all who are serving, or who know the names of any who are doing so, would notify him at their convenience, so that a complete list may appear in due course.

The Institution of Railway Signal Engineers.
(Incorporated 1912).

TWENTY-EIGHTH ANNUAL REPORT.

SESSION, 1940.

February, 1940, to February, 1941, inclusive.

Membership. It is gratifying to be able to report that notwithstanding abnormal conditions membership has been maintained in a satisfactory manner, being only 3 down, the number of registered members standing at 891 on January 1st, 1941.

It is with deep regret we have to announce the loss during the past session of Mr. W. S. Every, Past President; Mr. E. W. Hallam, Member of Council; and Messrs. J. H. Nicholson, A. S. Hampton, R. Dormer, F. G. L. Knibbs, and R. J. F. Harland.

MEMBERSHIP, 1940.

	New Members elected during 1940.		Died.		Re-signed.		Lapsed or Struck off.		Trans-ferred from lower class.		Registered Membership Jan. 1st, 1941.			As on Jan. 1 1940.
	Home (*h*)	O'seas. (*o*)	(*h*)	(*o*)	(*h*)	(*o*)	(*h*)	(*o*)	(*h*)	(*o*)	Home	O'seas.	Total	
Hon. Members	—	—	–	–	–	–	–	–	–	–	6	5	11	11
Members	—	1	5	–	5	–	–	–	–	3	178	126	304	310
Associate Members	7	4	1	–	4	1	–	–	8	1	364	110	474	463
Associates	1	—	–	–	3	1	–	–	–	–	45	5	50	53
Student Members	1	3	–	–	–	–	–	–	–	–	50	2	52	57
	9	8	6	–	12	2	–	–	8	4	643	248	891	894
	+17				−20				12					

Meetings and Papers. The Annual General Meeting was held on March 4th, 1940, at the Institution of Electrical Engineers at which, in spite of the unfavourable conditions obtaining there was a good attendance.

No meetings have been held for the reading and discussion of papers but interesting communications have been received, one from Mr. H. E. Cox (Member) entitled "Signalling Developments on the Great Indian Peninsula Railway," and another from Mr. A. C. Rose (Member) on " Signals and Maximum Track Capacity." Both were issued in the form of papers. Written comment was invited and the remarks received will appear in the forthcoming issue of our Proceedings.

Awards for Papers. The Council decided, that owing to the small number of papers received, no prizes for them would be awarded but it expresses its appreciation and thanks to Messrs. Cox and Rose for their contributions.

Proceedings. The Council again appeals to members for contributions to our Proceedings so that the high standard of that publication may be maintained. It is felt that much useful information could thus be collected, and although it may not be possible to hold meetings for discussion, written comments would be welcomed.

It has been found necessary to publish one issue only of the Proceedings for the year 1939-40, owing to the shortage of paper. For the same reason the library catalogue has been omitted.

Finance. The accompanying statement of accounts shows that the financial position of the Institution is satisfactory. The revenue from subscriptions has, however, been falling for the last three years and many arrears still remain unpaid, causing much unnecessary work and expense. Members are requested to give this matter their immediate attention. The cessation of meetings and reduction in the size of proceedings have enabled the expenditure to be reduced, and the Council has also been able to reduce it in other directions. Printing and postage costs are, however, increasing and it is essential to the efficient conduct of the business of the Institution that subscriptions should be maintained. The Council is taking every care to carry on the work as economically as possible. It has invested a further £100, this time in 2½ per cent War Bonds.

Affiliated Societies. It is understood that the Signal and Telegraph Technical Society, three branches of which are affiliated to our Institution, has been obliged to suspend its activities for the time being.

South American Section. Reports received from the South American Section show that its activities have been fully maintained. Its financial position is also satisfactory. The officers for 1940 were :—Chairman, O. T. Wood ; Vice-Chairman, J. Runnett ; Hon. Secretary and Treasurer, F. E. Goss.

Annual Summer Meeting and Dinner. Owing to war conditions it was found impossible to hold these meetings this year. Members will realise that with the necessity of their remaining in close contact with their business it would not be possible to hold such meetings under present circumstances.

Thorrowgood Scholarship. Awards were made during the session to the following Student Members :—Messrs. R. C. Dale, J. R. Gardiner, J. B. S. Lockey, R. James, M. E. Edwards, P. Lamb, and A. N. McKillop. One or more of the above have since joined H.M. Forces, but their grants are being held available until such time as they are able to resume their duties. Similar conditions will apply to future grants.

The Council have noted with pleasure the excellent work done by those who have benefited under this scholarship.

Students' Prize Essay. No competition was held this year, but should the Council become aware that sufficient support would be obtained, they would welcome the opportunity to revive this feature.

Standard Table for Electric Lever Interlocking. The report of the Committee appointed to recommend a standard form of table for electric lever interlocking is being included in the Proceedings, together with the written comments received from members, and should form a valuable addition to our standardised practice.

Library. Owing to the great risk of fire and other damage from enemy action, the Council decided to remove the collection, which had been very little used since the outbreak of war, to a place of safety until the termination of hostilities.

Appointments Register. Only one enquiry for a post has been received during the year and that from an overseas member who subsequently withdrew it.

Council and Committee Meetings. Four Council meetings and various other committee meetings have been held during the session, dealing with papers, membership applications and other matters.

War Office and Members. Correspondence with the War Office has made it evident that membership of the Institution has, in at least one case, been recognised by the authorities as a qualification for promotion to commissioned rank.

British Standards Institution Committees. Our representation on the Committee and Sub-Committee was substantially the same as in the previous year and the following is a report received from B.S.I. of the work done during 1940 :—

Technical Committee EL/22—Railway Signalling Apparatus.

The only meeting held during the year has been a meeting of Sub-Committee EL/22/9, Track Circuit Insulation. This meeting was called to consider the report A/T 75 of the Electrical Research Association which dealt with the development of tests for railway track circuit insulation. The Committee were of the opinion that the report was a very valuable one, but that it did not provide a basis for a specification for an acceptance test for insulating materials. It was decided that the preparation of a specification should not be proceeded with at the present time, particularly in view of the development in insulating materials which might make it possible to abolish the insulating channel and substitute a fishplate made of insulating material.

Technical Committee EL/29—Leclanche Cells.

No meetings of this Committee have been held during the year, it having been decided that the revision of B.S. 397 should be held in abeyance until after the war.

A meeting of Sub-Committee EL/29/1, Air-Depolarised Type Primary Cells, has been held for the purpose of reviewing the comments that have been received as the result of the circulation of the draft specification for A.D. Cells. Since that meeting views have been exchanged by correspondence, as the result of which it appears that there is not sufficient support at the present time for the specification to be proceeded with under war-time conditions.

Technical Committee ELG/10—Colours for Signal Glasses.

B.S. 623, Colours for Signal Glasses for Railway Purposes, which was published in 1935, was revised during 1940 at the request of the railway companies as the existing limits no longer represented the ranges of colour which were considered most suitable by them, this state of affairs being particularly noticeable in the case of the yellows and greens.

The revision includes a slight re-grouping of the clauses and a modification of some of the references and includes a diagram showing the area within which the proposed limits fall.

The re-grouping takes the following form. Whereas in the original specification step lenses and colour filters for search-light signals were grouped together, they have been separated in the new specification. For the step lenses the limits of red, yellow and green have all been slightly modified. For colour filters for searchlights, red, green and white are the same as for step lenses, but the yellow lights are slightly different.

For the moulded semaphore lense, the red, green and white are the same as for step lenses, but the yellow again is slightly different.

For the cut semaphore lense no change has been made in the red; the yellow is the same as for moulded semaphore glasses but the green and lunar white remain as in the original specification.

Just after the commencement of the war it was suggested that an attempt should be made to correlate the colour specifications for railway, aircraft, road and marine purposes. A Joint Committee of representatives of all the Committees concerned had one meeting but as a considerably extensive research into the matter was in hand it was decided to await results of this before proceeding further with the matter. It is understood that this research work is making quite good progress.

Sub-Committee EL/25/4—Terms and Definitions.

This Committee has no work in hand.

Technical Committee ME/14—Mechanical Signalling Apparatus and Sub-Committee ME/14/1—Signals and Signal Fittings.

No meetings of these Committees have been held during the year, it being decided that the subjects coming within the reference of the Committees should be held in abeyance until after the war.

Sub-Committee ME/18/5—Steel Wire Strand for Signalling Purposes.

The Sub-Committee ME/18/5 has been engaged in the revision of B.S. 163A, Galvanised Steel Wire Strand for Signalling Purposes. This revision was undertaken in view of some doubts expressed as to whether a wire possessing a high elongation value and a relatively high twist value provided the most efficient wire to withstand the shocks to which railway signalling wire is subjected in service. A draft revision has been circulated for the technical comment of the interested organisations and firms. The principal amendments which have been made in this revision are as follows.

In place of four types of wires having tensile strengths ranging from 25 to 90 tons per square inch, provision is now made for three types only, with tensile strengths from 50 to 80 tons per square inch.

In the mechanical tests, the *maximum* elongation has been specified in place of the minimum formerly specified, and a reverse bend test has been substituted for the torsion test.

Some amendments have been made in the procedure laid down for taking samples for testing in order that such samples may be better representative of the bulk, and in addition it is now required that the manufacturer shall test each wire before stranding.

It is now provided that the core wire shall be of slightly larger diameter than the cover wires.

During this session the war has increased in severity, and home members particularly have been strenuously occupied in dealing with the emergency. In these circumstances the Council has deemed it expedient to abandon for the time being the ordinary meetings for the reading and discussion of papers. It is hoped that the Proceedings about to be published will be duly appreciated by members, having been contributed to largely by our overseas members and compiled by the Hon. Editor under very trying conditions, the circumstances of which are known to the majority of home members. Every endeavour will be made to maintain the Proceedings at their usual high standard, and an appeal is again made to those able to contribute to send in written communications for circulation and comment.

Several members whose names were on the Central Register have now been appointed to posts, and to these, and other of our members who are in the Forces, the best wishes of the Council are extended.

Conclusion. The Council has welcomed with great pleasure the return of our Hon. Secretary, Mr. M. G. Tweedie, after his illness, and is glad to learn that he has so far recovered as to be able to resume full participation in our activities. I am sure that it is the wish of all our members, to which I subscribe, that he may be spared many years to give us the benefit of his long experience as Hon. Secretary to this Institution.

My sincere thanks are extended to the Vice-President, Past Presidents and Members of Council for their loyal support during the past session. There have been excellent attendances at the Council meetings, often at personal inconvenience to its members.

My thanks are extended to the Hon. Treasurer and Librarian, Mr. T. S. Lascelles, who has rendered me great service during my Presidency.

The grateful thanks of the Institution are also due to the Hon. Auditors, Messrs. T. Austin and F. Edwards, for again consenting to continue in that capacity.

I would conclude with a personal note. During my second year of office the members have shown the utmost consideration and been ever ready with their assistance, which I appreciate very sincerely. It had been contemplated, after a previous similar emergency, that no member should remain President for more than one year. In the extreme crisis with which we were faced you signified your desire that I should remain in office for a further term. I was happy to do so, and on behalf of the Council and myself would express our appreciation of the unselfishness shown by the Vice-President, Mr. H. W. Moore, who not only acquiesced in your decision, but has given me valuable support during this exceptional period.

JAMES BOOT,
President.

February, 1941.

THE INSTITUTION OF RAILWAY SIGNAL ENGINEERS (*Incorporated*).

ACCOUNTS FOR THE YEAR ENDED 31st DECEMBER, 1940.

REVENUE ACCOUNT.

Dr. *Expenditure.*	£	s.	d.	£	s.	d.
To printing and distributing Proceedings 1939 (Part 1) ...				177	16	9
,, Editing Proceedings				7	2	0
,, Expenses of Meetings—						
Reporting, etc.	3	15	0			
Hire of Rooms	5	3	6			
Refreshments	1	2	6			
				10	1	0
,, Hon. Secretary's Office Expenses	115	0	0			
Rent of Office	10	0	0			
Petty Cash	20	0	0			
				145	0	0
,, Hon. Treasurer's Office Expenses	45	0	0			
Petty Cash	15	0	0			
				60	0	0
,, Rent of Room for Library ...				10	0	0
,, Miscellaneous Printing, Stationery, etc. ...				54	3	1
,, Income Tax and Corporation Duty ...				7	9	0
,, Annual Subscriptions—British Standards Inst. and Association of Special Libraries				7	7	0
,, Subscription to I.R.A.M. for South America Branch				5	16	0
,, Sundry Expenses				7	9	9
,, Purchase of £100—2½% War Bonds ...				100	0	0
,, Balance—Cash at Bank				101	18	4
				£694	2	11

Cr. *Income.*	£	s.	d.	£	s.	d.
By Balance as per 1939 accounts				65	13	8
,, Subscriptions—						
Arrears paid	91	1	0			
Year 1940	455	13	10			
In advance	7	19	6			
				554	14	4
,, Advertisements in Proceedings				45	0	0
,, Sale of Proceedings				2	9	6
,, Interest on Investments				26	5	5
				£694	2	11

THORROWGOOD SCHOLARSHIP BEQUEST ACCOUNT.

Dr.	£	s.	d.	*Cr.*	£	s.	d.
To Amount bequeathed by the late W. J. Thorrowgood (Past President) ...	1000	0	0	By Investment in 5% Conversion Loan of £1,000 at cost	992	9	8
				,, Rebate transferred to Deposit Account	7	10	4
	£1000	0	0		£1000	0	0

Expenditure.	£	s.	d.	*Income.*	£	s.	d.
To Grants for Fees, Instruments, Books, Expenses, to the following Student Members qualified for Scholarships:				By Balance as per 1939 accounts	82	17	5
,, R. G. Bates				,, Interest	50	3	8
,, A. N. McKillop							
,, R. C. Dale							
,, P. Lamb	22	1	6				
,, Balance—Cash at Bank	72	18	7				
On Deposit at Bank ...	38	1	0				
	£133	1	1		£133	1	1

There is a contingent liability for outstanding Scholarship awards to an amount of £61 0s. 0d.

BALANCE SHEET, AS AT 31st DECEMBER, 1940.

Liabilities.	£	s.	d.
To Thorrowgood Scholarship Bequest Fund	1103	9	3
,, Sundry Creditors	9	13	0
,, Balance, being excess of Assets over Liabilities	1227	5	2
	£2340	7	5

Assets.	£	s.	d.	£	s.	d.
By Library, valued at				20	0	0
,, Proceedings, not valued ...				—		
,, Office Requisites at 31st December, 1939	12	5	10			
Less written off	11	5	10			
				1	0	0
,, Outstanding Subscriptions not valued ...				—		
,, Thorrowgood Scholarship Bequest Fund				1103	9	3
,, Investments (Nominal value)				1100	0	0
(The market value at 31st December, 1940 was £1,112)						
,, Cash at Bank and in hand				115	18	2
				£2340	7	5

We hereby certify that the above accounts contain a full and true statement of the financial condition of the Institution as at 31st December, 1940.

F. EDWARDS, T. AUSTIN } *Hon. Auditors*

Signed on behalf of the Council { R. DELL, L. J. M. KNOTTS } *Members of Council.*

22nd *January*, 1941.

T. S. LASCELLES, *Hon. Treasurer.*

Annual General Meeting of the Institution

HELD AT

The Institution of Electrical Engineers,

Monday, 24th March, 1941.

The President (Mr. JAMES BOOT) in the chair.

The Hon. Treasurer (Mr. T. S. Lascelles) having read the notice convening the meeting and the minutes of the previous meeting having been read and approved

The President said it was his pleasure to submit the Annual Report for acceptance. He regretted to announce that they had lost by death since they last met Messrs. W. S. Every, E. W. Hallam, J. H. Nicholson, A. S. Hampton, R. Dormer, F. G. L. Knibbs and R. J. F. Harland. He invited those present to stand for a brief interval as a mark of respect to their memories. It was unfortunate that it had not proved possible to resume the holding of meetings, but the next issue of the journal would contain the papers by Messrs. H. E. Cox and A. C. Rose, the report of the electric locking table committee and the written discussions thereon. He invited Mr. Lomas to second the proposition, moved by himself, that the report and accompanying statement of accounts be accepted.

Mr. P. Lomas, seconding, thought that they had cause for satisfaction in the position revealed by the report, when they considered the great difficulties of the time. Membership had been well maintained, in spite of the fact that many members were serving with H.M. Forces and the restricted train services and black-out made it impossible to hold meetings. The Council had been able to invest £100 in War Bonds. (The proposition was carried).

The President said that it would simplify procedure if those present would consent to the election of all four officers being dealt with by one common vote and, there being no objection offered,

Mr. F. Downes proposed that Mr. J. Boot be re-elected President; Mr. H. W. Moore, Vice-President; Mr. T. S. Lascelles, Hon. Treasurer; and Mr. M. G. Tweedie, Hon. Secretary, and expressed the thanks of the members to them for the way in which they had continued to conduct the business of the Institution. He was very glad to think how it had proved possible in the course of the year just closed to render material assistance to a member who had been incapacitated from continuing his ordinary work by a severe affliction. He was also glad to see such a good attendance that day. Although they could not at present get ordinary papers offered for discussion they could, and should, do their best to continue the Institution's other activities to the best advantage.

Mr. F. L. Castle felt sure that all would be grateful to the officers for what they had done in such anxious times. They were especially indebted to Mr. Boot for continuing in the chair. The general activity of the Institution might not be so great as usual, but in some ways, he thought, the work involved was greater. He seconded the proposition with pleasure, and it was carried.

The President, expressing thanks for the vote, announced the result of the ballot for the election of Members of Council, as follows :—Messrs. F. L. Castle, R. Dell, F. J. Dutton, H. H. Dyer, F. Horler, W. R. Jones, R. F. Morkill, S. W. Spendlove, L. J. Boucher, J. H. Fraser, C. H. Hills, L. J. M. Knotts, P. Lomas, A. Moss, L. Preston, and A. W. Woodbridge. It was now necessary to elect two Auditors; the present Auditors, Messrs. F. Edwards and T. Austin were eligible for re-election and willing to serve again.

Mr. S. L. Glenn proposed and **Mr. V. Openshaw** seconded the re-election of those gentlemen, which was carried.

Mr. H. H. Dyer moved a vote of thanks to the Auditors for their services during the past year.

Mr. C. H. Hills seconded the proposition, which was carried.

Mr. B. Wagenrieder thought that the time had come, although it might possibly not be opportune to deal with the matter just at the moment, to endeavour to broaden the basis of the Institution. He thought that on a previous occasion another member had spoken on the point and referred to the position of the Associates. He felt that closer association with traffic officers was desirable, and that the status of that class of membership should be reconsidered. Signalling came very much under the influence of the Operating Superintendents of the railways ; the connection between signal and traffic officers was a very close one and there should be closer co-operation between them in the Institution. This would broaden the scope of the papers presented to it and possibly in that way the Associates would feel themselves to be more directly concerned with the Institution's work.

Mr. H. H. Dyer was much interested by what Mr. Wagenrieder had said. For himself, he would greatly welcome papers from the operating side, and the running side too. The latter had been rather neglected in their proceedings. If they did not include the running side, they excluded the very men who had to use the signalling, and he had always regretted that they had not been more in touch with them. The operating people were always in the picture with which signal engineers were concerned, but they had had far too few papers in which the point of view of operating and running men had found expression. As Mr. Wagenrieder had emphasised, they were governed by what the operating man wanted and the requirements he asked to have fulfilled. Undoubtedly if they could get more papers from the operating men the position of the Institution would be enhanced.

Mr. F. Downes asked whether Mr. Wagenrieder meant that gentlemen in the traffic departments should be admitted to membership before consenting to write a paper ?

Mr. B. Wagenrieder said his point was that the Associates should be permitted a more direct voice in the Institution's affairs ; at present, for example, they had no voting powers.

Mr. F. Downes believed that what Mr. Dyer had said was a matter for serious consideration. The Associates formed a valued section of the membership and he was sure the other members would welcome them to more active association in the work.

Mr. C. H. Hills expressed his full concurrence with what had been said on the matter. He believed that something was already being considered in connection with it.

The President said that the point raised by Mr. Wagenrieder would receive Council's careful attention. He thought he ought to point out that there was a difference between Associates and Associate Members that had to be carefully borne in mind. He then asked if those present wished to discuss any other business and, there being no reply, proceeded to deliver the following short address.

" I would first of all like to thank you on behalf of the Council for attending this afternoon and thereby showing your interest in the affairs of the Institution. We are very grateful for the support we are receiving and have no doubt that we shall emerge from our present trials with renewed energy, to help in the post-war rehabilitation of industry.

At the moment our energies are directed to facilitating rail transport under the prevailing war conditions, but arduous as these are, we should be among those who are planning for problems which will beset us upon the restoration of peace. It is clear that while much renewal work will have to be undertaken, we shall be confronted with the fact that, in consequence of the enormous burdens imposed by war expenditure, most careful consideration will have to be given to the economic aspect of the tasks to be undertaken. It would appear therefore that the time is not far distant when the signal and operating departments will be afforded an opportunity for giving consideration to schemes for the handling of traffic under the most economical conditions. The two main heads under which any scheme is usually considered are cost and savings, but there are other factors on which, while they admittedly bring advantages from an operating point of view, it is difficult to place a monetary value. This refers more particularly to economies produced by better use of engine power, rolling stock and their attendant personnel.

An efficient signal system should aim at increasing the track capacity and decreasing the cost of train operation. It should bring such improvement by eliminating or reducing delays, so affording a more intensive use of the existing track, power and other facilities.

Signalling designed to produce the minimum of delay to trains will allow a more intensive service to be operated, often without increased maintenance charges. This will result in a quick turn round, with consequent saving in the quantity of rolling stock in use. The resultant savings, where delays are avoided, are expressed in fewer locomotive and rolling stock repairs, less fuel and lower wages costs. The increase in average speed will result in saving of time between terminals, together with a more efficient use of motive power and rolling stock. The latter in turn should show a saving in interest and depreciation charges.

These savings are difficult to arrive at, and the advantages obtained cannot be estimated without a great deal of joint study by the signal and operating departments. To achieve the best results it would seem necessary to record those obtained with previous installations, which should be available when considering future ones. I have in mind more particularly proposals for the complete resignalling of considerable lengths of track. So far as isolated interlockings are concerned, the savings are generally effected only by a reduction of signal operating staff and do not as a rule show any in connection with rolling stock, etc. Where, however, an intensive service exists or is proposed, there is no doubt that economies can be effected, apart from any advantages gained by providing an improved public service.

The change in economic conditions resulting from the war will lead to the railway managements exploring every avenue to improve the present best operating ratio. Taking the long view, it is my opinion that real economy cannot be achieved by further reduction of expenses, such as by reduction of staff and the cutting out of betterment and wages, but that, as with the replacing of the social order, we must view the rail transport system as a whole, so as to provide the utmost facilities in the most economical manner. This will necessitate close collaboration between the various departments concerned, and speaking on behalf of contractors, I am certain they are ready to co-operate in any investigation thought desirable. I would suggest that this Institution could also play an important part in the task. A number of excellent papers on this subject have been read and discussed in the past, notably those by Mr. G. H. Crook, "Ethics and Economics of Speed Signalling,"* Mr. C. W. Prescott, "Railway Signalling Economies,"† and Mr. H. H. Dyer, "The Financial Side of Signalling Economies."‡ As signal engineers we are already in possession of material which should enable us to give approximate costs and maintenance figures for various types of equipment, but as I have mentioned before, any savings are mostly concerned with the operating departments.

* Proceedings, 1931, page 122.
† Proceedings, 1932, page 13.
‡ Proceedings, 1933-34, page 229.

To make a true balance sheet these items would have to be included, and I am wondering whether it would be too much to ask some of our operating friends to help us in this matter. I would like to suggest that either a small mixed committee be set up to deal with the subject, or a joint paper be read before the Institution. I am aware that at the moment all our energies are concentrated on the war effort, but my object in mentioning this subject at the present moment is that as the collecting of data will occupy a considerable time, a start could be made at an early date, so as to have the material ready at the opportune moment.

The foregoing is one of the subjects which I believe could be handled by this Institution, because of its close association with traffic operation. Other activities in the immediate future are uncertain and it is to be regretted that our ordinary meetings cannot be maintained, but I think this will be generally recognised as impossible under present conditions. In spite of these conditions there is still good progress being made in the art and new developments are being planned. We can therefore look forward to many interesting papers in the future and to the resumption of our meetings, which in the past have been of great benefit to the profession as a whole. In the meantime the Council will be happy to receive communications from members which could, if suitable, be circulated for written comment. In this way we shall be able to continue the publication of our proceedings, which provide a most useful link with our members overseas.

In conclusion may I express the hope that next year we shall have the pleasure of hearing a presidential address of the usual scope and length and that by then our normal life will have been resumed. This is the second great npheaval we have had during the lifetime of the Institution. In the nature of things conditions will have altered considerably when the present conflict ends, but I am confident that this Institution will take its place among those to be entrusted with the task of rehabilitation."

The President acknowledged the applause which followed his address and declared the meeting closed.

Signalling in Connection with Electrification:

Notes on work carried out on the Southern Railway, 1926-39.

By L. J. M. KNOTTS (Member of Council).

The chief purpose of what follows is to put on record some of the technical considerations and work involved in signalling carried out under electrification schemes on the Southern Railway, more particularly those completed immediately prior to the present war. The system of traction is throughout the d.c. with third rail charged at a nominal voltage of 600.

At the outset, however, it may be useful to list the principal schemes brought into service since the amalgamation of the three constituent companies into the Southern Railway in 1923, as follows:

1926. The first multiple-aspect colour light signals on the Southern Railway were installed at Holborn, St. Paul's and Elephant and Castle, in March of this year, those at Charing Cross and Cannon Street following in June.

1928. Colour light signals were installed at London Bridge and for some distance towards New Cross, with a new signal box of 311 levers, with mechanical interlocking, at the former place.

1929. A further extension of colour light signalling was made on the Eastern Section from the London Bridge area—including a new signal box at the North Kent Line East Junction—to New Cross, Lewisham, Hither Green, Blackheath, Nunhead and Ladywell. The new box at North Kent East Junction saw the adoption, for the first time on any railway in England, of the all-electric interlocking frame, by which is meant throughout these remarks a power frame with electric locking only, *i.e.* there was no mechanical locking of the tappet and dog type, hitherto considered essential to any interlocking frame.

1932. Electrification of the main line to Brighton and installation of colour light signalling, with new signal box at Brighton containing 225 lever all-electric interlocking frame.

1934. Extension of electrification from Bickley and Chislehurst Junction to Sevenoaks *via* Swanley and from Orpington to Sevenoaks *via* Chelsfield but incorporating no outstanding signalling installations.

1935. Extension of electrification to Eastbourne and Hastings lines, with a minimum of colour light signalling but a number of electrically operated semaphore intermediate section signals.

1936. Colour light signalling was introduced on May 17 on all lines between Waterloo " B " box and Clapham Junction and on to Marsh Lane—now Berrylands—and the new fly-over at Wimbledon, resulting in the through and local lines being thereafter arranged alternately, up and down, above that point, instead of in up and down pairs, the arrangement still in use below Wimbledon. On June 28 similar signalling was installed between Malden, Marsh Lane and Hampton Court Junction, and new signal boxes at Surbiton and Hampton Court Junction, which have mechanical frames, were brought into service. This section of line was finally completed on October 18, when colour light signalling was brought into use at Vauxhall and the new signal box at Waterloo, containing 309 levers in an all-electric interlocking frame.

1937. Colour light signalling was installed at Woking, Worplesdon and Guildford and an all-electric frame at Woking, together with additional 3-aspect sections between Woking and Guildford, on June 27.

1938. Colour light signalling was introduced at Horsham and Dorking in connection with the projected scheme of electrification to Portsmouth and Bognor Regis *via* Arundel and Barnham Junction.

1939. The extension of electrification from Hampton Court Junction to Portsmouth was opened after further colour light extensions had been brought into use at Havant, Fratton, Portsmouth, etc., the new electric service being also brought into operation at this time from Dorking to Bognor Regis and Portsmouth, *via* Barnham Junction. Another extension from Swanley to Gillingham and Maidstone was completed for the summer traffic, but this did not involve much colour light signalling, except between Sole Street and Rochester Bridge Junction (now controlled from Strood) where owing to the length of the section—over 6 miles—and the ruling gradient of 1 in 100, an interesting installation of two-aspect colour light signals was installed, with five sections on the up line and two on the down. The new signal box at Victoria Central, with 225 lever all-electric frame, with colour light signalling, was introduced on June 4, and on June 25 colour light signalling on the Eastern section side of the station completed the programme for colour light signalling in this area, which had previously been brought up to Victoria from Pouparts Junction in October 1938.

General Features. In all the above schemes where colour light signals were installed (except intermediate section signals, which were two-aspect), either three or four-aspect signals were adopted, depending upon the headway required, which in the main meant that four-aspect signals were required in the London area and three-aspect signals on the longer stretches, such as the Brighton main line. A number of two-aspect intermediate section colour light signals were installed on sections of line at places below Guildford, between Sole Street and Rochester, and in some other long sections. In the later schemes, in which electrification was being carried further out of London, very large reconstruction works were necessary at some of the largest stations, and so far as signalling was concerned, involved either a complete colour light installation, or an extensive mechanical installation, with all the electrical adjuncts to the latter which provide the additional safety and facility required to handle the increased traffic.

Among the most notable and interesting innovations introduced into Southern Railway practice throughout the period of intensive modern signalling have been :—

1. The all-electric power frame at North Kent East Junction in 1929.
2. The junction indicator, introduced for the first time between Waterloo and Hampton Court Junction in 1936.
3. The normally dark track diagrams, with two red lamps per section, lit only during track occupation, introduced for the first time at Waterloo in 1936.

4. The introduction of " P " signs and a signal post telephone system, concurrently with the new installation from Waterloo to Hampton Court Junction in 1936.
5. The magazine or storage train describer, introduced between Coulsdon and Brighton in 1932, and its adoption as a permanent feature in later schemes.

It is not possible within the scope of these remarks to cover many items of technical interest in the larger signalling installations, and it is not proposed to do more than refer to the following in connection with signals.

Colour Light Running Signals.

Four-aspect signals are spaced from 500 to 700 yd. apart and three-aspect about twice this distance. The standard track overlaps on these are about 200 yd. This spacing gives quite good headway for the mixed steam and electric traffic which operates over the sections concerned, and is of course dependent upon the usual factors of speed, the length of the longest train, gradient and the required braking distance. Drivers on sighting the double yellow in the case of the four-aspect, and the single yellow in the case of the three-aspect, have ample warning in which to bring their trains to a suitable speed in order to pull up. " Through " and " local " lines are of course signalled for the same headway, since the two signals must be located at the same position, or on the same bridge in case of gantries, and a 1¾ min. headway, running on the green, is easily possible on the " through " lines with fast traffic over certain sections. One technical feature which may be of particular interest is that it is the practice for each colour light signal to prove the signal ahead " on " or section ahead of that signal " clear ". This is done by proving in connection with the home relay or the stick relay, or by a special control of the feed to a track circuit, the method adopted depending upon whether both the inner and outer signals are controlled by the same signal box, or whether the outer signal is worked from a different signal box, or either signal is automatic.

Subsidiary Signals.

Ground or shunt signals and calling-on signals in the colour light area are of the disc type, solenoid operated and flood-lit.

The ground signals have the ordinary red arm and the calling-on signal a " C " superimposed on this. The shunt signals are of course not as a general rule track controlled, but the following is the arrangement employed with calling-on signals :—

(*a*) *Terminal and Bay Platform Lines.* When trains are required to be run to a partially occupied platform, its track circuiting is divided in such a position that the first portion of the train occupies the section nearest the buffer stops, leaving the second section track circuit unoccupied. When either of these track circuit sections is occupied the running signal in the rear is locked, or controlled at danger. When the forward track circuit section is occupied and the rear one is clear the running signal remains locked and the calling-on signal is released. Similar control is used to govern the control of the green, yellow and red aspects, where colour light signals are installed for calling-on purposes at the larger London termini where several trains may run to one platform.

(*b*) *Through Stations.* At through stations, in circumstances similar to the above, only one track circuit is provided as a rule, and the occupation of this locks or controls at danger the running signal and releases the calling-on signal.

Calling-on signals used as mentioned above are also controlled at the " on " position until a train has reached a pre-determined point on the approach side, this, as a general rule, being situated 150 yd. in rear of the signal.

WORK OUTSIDE THE SUBURBAN AREA.

On the lines involved in the extension of electrification beyond the London suburban area, except for certain colour light installations, semaphore signalling predominates, and the work to be carried out in such cases falls under the following broad headings, for each of which estimates are prepared, apart from the major station reconstructions and one-box signalling schemes, which are of course dealt with as separate items and for which separate estimates are prepared.

1. Provision of return wires ;
2. Signalling supply cables ;
3. Conversion of track circuits from d.c. to a.c. ;
4. Clearance of signal and telegraph line side apparatus for the conductor rail ;

5. Signalling alterations ;
6. Additional telephone circuits for traffic purposes, etc. ;
7. Additional telephone circuits connecting all sub-stations and main control rooms.

Provision of Return Wires.

The provision of metallic returns has been found necessary, particularly in country areas where the block instruments and associated apparatus have hitherto been operated with earth return, and the general plan is to provide one 200 lb. copper wire on the aerial route throughout the area to be electrified and for some distance beyond often depending upon the extent to which switching out of signal boxes is in force. It is considered a wise precaution in any case to take the return wires a few miles beyond the electrified area, but no hard and fast rules can be laid down for this, so much depending upon local conditions. At each station another 200 lb. copper wire is also erected, approximately between the distant signals in each direction, this latter wire providing the necessary return for such local circuits as treadles, fouling bars, signal repeaters and other local functions which can be operated on a common return. The block return is separated at each signal box and not run through the area as one common return, in order to make a separate test possible in any one section. Where there is a closing switch the return is of course taken through it, so that when the signal box is switched out of circuit the return is put through. This may require new closing switches, provided with additional contacts.

It will be appreciated that with some types of block where the line currents are comparatively heavy the provision of a metallic return increases the resistance, some increase in battery power being needed.

It may in some cases be an economical proposition to take out of service the older types of two-position block instrument and put in a more modern system of three-position block, which on the Southern Railway has sensitive high resistance coils. This will effect an economy in battery power where long lengths of line are switched out, at the same time adding to the efficiency of the block apparatus, which becomes ever more necessary under an intensified electric service. Moreover the modern block lends itself more readily to the addition of such features as the proving of signal arms, control by track circuit, and what may be termed lock-and-block features, involving for example, the control of the section signal from the box in advance. One system of block working on the Southern Railway which had to be dealt with had already two line wires through the section, one for the block signalling instrument and the other for the section locking, and it was found necessary in this case to provide a separate return for each of these functions, otherwise with a common return the difference of potential set up in it by the passage of current when the section lock was released would be sufficient to ring the bells and operate the block instruments irregularly. These instruments were of comparatively low resistance and generally speaking, with a common return system, it is of course necessary to have instruments of such a resistance as to be well above that of the block return.

It may also be noted that under this heading the provision of ironclad test cases containing fuse and lightning arrestors is also arranged at each signal box, so that all wires coming into the signal box are taken to terminals in this test case and efficiently fused with vacuum arrestors for protection against lightning, or accidental contact with high traction voltage in the event of a wire breaking and falling on the conductor rail. It may be interesting to record in connection with this that, throughout the many years of electrification on the Southern Railway, only one instance has ever been reported of a wire actually getting into contact with the traction voltage, so that there is no real danger from this cause.

Signalling Supply Cables.

In the earlier schemes of electrification on the Southern Railway, the signalling supply was provided by the Electrical Department at each point where it was required by means of a separate kiosk with a supply transformed from a 3,000 volts ring main to 220 volts 75 cycles single phase, and this was the case on the old London and South Western Railway and on the original electrification schemes on the Eastern Section of the Southern Railway. The more modern extensions have been dealt with differently, due to the advent of the grid system, and it is now the practice for the Electrical Engineer to provide the signalling supply at each of the mercury arc unattended substations at 440 volts 50 cycles single phase. It is now the responsibility of the Signal Department to run cables from these sub-stations to the points required, and this is the system in use on the Brighton line and on the extensions to Portsmouth, Alton, Reading and Gillingham. The two standard sizes of supply cable which are found suitable are the twin 7/16 and twin 19/16 impregnated paper insulated and lead covered. These cables carry the 440 volt supply to a suitable point from which it is transformed down to 110 volts for supply to track circuits and signals. In long lengths of line it may be that a number of transformers are used throughout the length of the cable to transform to the necessary 110 volts, on which all the track circuit and signalling apparatus is designed to work. The cables are fused at the sub-stations in a separate chamber fixed to the wall outside, the aero-flex type fuse box being used. The Electrical Engineer maintains the continuity of supply and, being on a 3,000 volt ring main, it is readily restored if damage or breakdown results at any point. The cables are run on concrete stumps with iron cable brackets having wood spreaders about 3-ft. in length at each stump, or in some places in shallow poilite troughing, which has holes in the bottom for draining away water. Capped wooden troughing has been abandoned owing to the risk of fire and also to the trouble due to rats running through it and damaging cables. All cable is therefore now exposed and is periodically treated with a suitable compound to preserve the covering. Where it is necessary to carry the cable through at occupation crossings or level crossings, it is put into underground ducts formed with fibre tube cased in cement and concrete. Surface concrete troughing is also used where stumps are impracticable in busy yards, etc. Cables are generally supplied in lengths of about 440 to 500 yd. to the drum, which, with this amount of cable, is not unduly heavy for running out. At each 500 yd. length a joint box is provided with substantial lugs to which the cable is sweated. This is found better than making wiped joints with lead sleeves, as it is quicker and also provides a means of making a test of the cable in reasonably short lengths, and thus narrows down the locating of any fault which arises.

Conversion of track circuits from D.C. to A.C.

Any existing d.c. track circuits must be replaced by the a.c. type when d.c. traction is introduced. The conversion may involve only an isolated track or two at one station, or it may mean that anything up to 20 or 30 track circuits, or even more, may have to be converted at an important place. Plans of the area to be dealt with are prepared in the drawing office to a scale of 40 ft. to the inch on which is shown the number of impedance bonds and insulated rail joints which will be necessary. The arrangements are agreed with the Electrical Engineer, the number of bonds depending upon the amount of return rail available for the traction return current. The traction bonding diagrams are prepared after the track circuiting has been shewn on the 40 ft. plans.

The length of a single rail track circuit *i.e.* one without impedance bonds, is frequently limited to 200 yd., so that it will be appreciated that impedance bonds are needed in most cases. Where the track circuiting runs through permanent way connections it is necessary for it to be divided up, as between double and single rail tracks, the single rail portion being run through the connections, otherwise unbalancing would result in the traction return, affecting the bond impedance from rail to rail and rendering track circuit operation impracticable. It will be seen therefore that whereas to the Operating Department one track circuit is indicated, in many cases it may in fact involve at least two and sometimes three separate track circuits which amount to cut sections, from the signalling point of view. The longest double rail track circuits are usually limited to about 1,200 to 1,500 yd., depending upon the amount of cross bonding required for the traction return. The number of intermediate resonating bonds may be anything up to three in such a length. It has been found possible to get efficient track circuit operation with two auto-bonds and three resonating bonds in the one track circuit, a shunt figure of between 0.3 and 0.5 of an ohm being obtained, which is quite sufficient. Track circuits in the latest electrification schemes are operated with 110 volts 50 cycles, fed to the track through condenser feeds and the relay " locals " being also of course energised at 110 volts a.c. ; 800 volt class condensers are employed.

In the case of single rail track circuits the bonding is usually carried out by the Signalling Department with two No. 8 S.W.G. copper wires at each joint, but for the double rail ones the bonding is automatically provided by the Electrical Engineer, since the substantial bonding required for the traction return current is available. " Protection boarding " is provided throughout single rail track circuits where the " track " rail is adjacent to the conductor rail, to minimise the risk of accidental contact with the traction voltage.

The track circuit relay, 440 to 110 volts transformer, or the track circuit feed case and transformer, are fixed beside the line on neat iron frames mounted on old rails or angle iron. In places where there is a large number, systematic grouping is the rule, in order to maintain an orderly line-side appearance. On long lengths of completely track circuited line, where there are only two roads of way, it has been usual for traction cross bonding to be arranged at not more than about every 600 yd., which necessitates the use of the resonating bonds previously referred to, and which are of course bonded from the neutral point of one to the neutral point of the other in the opposite road. It is found that by arranging a suitable disposition of track circuiting and bonds, where there are long lengths of line so to be dealt with in co-operation with the Electrical Department, economy can be achieved in the number of bonds required.

It is usual to carry the track circuit relay into the signal box if the relay end of the circuit is not above 500 yd. from the box. In that case No. 12 S.W.G. gauge wire is used, but if the distance is more than 500 yd. an a.c. line relay is used to repeat the track relay. Where there is a large number of track circuits at a place where there may also be a considerable amount of electrical detection and other features for which relays are used, it is usual to have a separate relay room built adjacent to the signal box. In this room a terminal panel with fuses forms the connecting link between the relays and the electric locking in the signal box. The relays are mounted on iron racking, all wires being carried round on suitable hooks and laced up, the whole forming a very neat job. In small installations the relays have been accommodated under the signal box, which is quite convenient, but in order to make a satisfactory job, it is desirable to have the floor concreted and suitable iron racks provided, together with a good terminal panel. The d.c. track circuits which remain beyond the electrified extension area are blocked back by the insertion of one or two insulated rail joints in series in the running rails. It is not usual to have d.c. track circuits within about one mile of the electrified area, although local conditions govern the decisions arrived at. A very efficient insulated rail joint, now being used for all block joints, is the compressed wood type, with substantial metal washers under the fish bolt heads.

Clearance between Signal and Telegraph Line-side Apparatus and the Conductor Rail.

Although the conductor rail is laid above the sleepers, insufficient clearance with respect to existing runs of rodding and signal wires usually results, so that it is necessary for such apparatus to be set back or altered in some way to give the necessary clearance, and a good deal of work may be entailed in this way. Along platform walls, where for any reason it is not possible to take the conductor rail in the 6 ft. way between the two running lines, or more usually to give clearance for the collector shoes, signal wires and pulleys have to be diverted, and in some cases cranks and compensators let into recesses in the walls, in order to maintain the clearance of 2 ft. 2½in. from the inside edge of the running rail up to rail level and 2 ft. 4¾ in. from the inside edge of the running rail for any apparatus encroaching above rail level. (The standard clearance of 5 ft. 1 in. is of course required over a height of 3 ft. above rail level). Similarly any treadles or bars which are fixed to the running rail adjacent to the conductor rail have to be taken off and refixed on the other running rail. Although it is not essential, it is considered desirable to eliminate signal wires through tunnels as far as possible, and electrical operation of signals, usually distant signals, is arranged for instead of the mechanical operation in force prior to electrification. It is convenient under this heading to refer to the fact that a certain amount of insulation from earth is required with signal rodding and wires, and it is the practice as far as possible to have signal wires run on wooden stumps, and cranks, compensators and segments of the rodding fixed down on precast concrete bases. In principle it is desirable that the signal and point connections shall be, as nearly as possible, at the same potential as the running rails, *i.e.* the traction return. It will be appreciated that if connections are carried on metallic supports there is a possibility in certain soils of there being a difference of potential between them and the traction return, which might produce electrolysis and possibly sparking. As the rodding etc., is connected to lever frames, it follows that they are also at the same potential, and these are therefore not " earthed ". Power frames, however, are always fully " earthed," as of course they are not connected in the same way with the mechanical apparatus outside the signal box.

Signalling Alterations.

The alterations referred to here are separate from those which result from the extensive reconstruction at large stations, but in the aggregate may amount to quite an appreciable amount of work. With the introduction of electrified lines some country stations are provided with foot-bridges, so that passengers do not pass from one platform to another across the tracks. It is often found that in such cases the sighting or position of signals is affected, particularly platform starting signals, and it is quite usual for a straight post to have to be replaced by a half bracket, or to be altered in some way to give better sight. In difficult situations it may be necessary to provide banner repeater signals on the approach side. Many of the high signals which were in vogue years ago, which were suitable for steam trains, are unsuitable for the view obtained from the motorman's cab, and many have to be sighted by a sighting committee, with a view to an alteration in height being made. In some cases where the signals are placed on the opposite—or "wrong"—side of the line owing to curve, they have to be taken over to the left of the road to which they apply. This also necessitates in some cases the provision of banner repeater signals on the approach side. Another instance of alteration is that brought about by the re-positioning of a crossover road, which under steam conditions may have been between the platforms. This is often moved out clear in order that the conductor rail may be laid between the two running roads throughout the platforms. It will be appreciated that when this is done it usually means that the home signal—and consequently the distant signal—has to be moved out, and in cases where such signal is re-positioned, it sometimes happens that it comes beyond mechanical working distance and electrical operation has to be resorted to.

Under electrified traffic conditions with a more frequent service the home or acceptance signal, particularly at junctions, may be moved out 440 yd. in order to permit a train being brought up to it while another is fouling the junction or station. As is well known, signals this distance from the box have to be covered with a " train waiting " track circuit and electrical repetition of the arm becomes necessary. The repositioning of the distant signal also becomes necessary, and if over about 1500 yd. from the box it may have to be electrically operated.

With the provision of a conductor rail the matter of " fogging " cannot escape attention, and fogging machines which are fixed to the sleepers are provided with what is known as a fogging ramp, which lifts the conductor shoe clear of the machine.

The up and down distant signals, in sections which permit of it, are usually brought as closely together as possible, as this saves a fogman, but it will be appreciated that although a man may be able to put the fog signals down by hand on one road, he has to work a machine to do it on the other. On the side which the man works the conductor rail is gapped for a rail length on the cess side and carried over to the 6-ft. side. The rodding between the fog lever frame and the machine is insulated by wooden strips (hard wood) so that the man operating the levers is protected from possible contact between the rodding and the conductor rail.

It has been the practice to eliminate signal wires as far as possible where complicated mechanical slotting exists in short sections, particularly on distant signals where there are inner and outer distants, and electrical operation has proved to bring a great saving in time spent in maintenance. It is of course better from the traffic point of view, since it eliminates the adjustment of wire which is necessary to meet changes of temperature and which has to be done by the signalman, but is sometimes insufficiently attended to.

Level crossing gates which are not wheel operated from the cabin have to be remodelled for such operation, and much work may be involved at a crossing when this is done, as usually new gates are necessary and a considerable amount of brick or concrete channelling through the highway is required. A great many level crossings have had to be dealt with in this way in the latest extension.

Additional Telephone Circuits for Traffic Purposes, etc.

With the increase in traffic density and the need for quick communication, it has been found necessary under most electrification extensions to provide extra telephone circuits, particularly between important centres. These circuits are usually of the omnibus type, with code ringing telephones having 3,000 ohm relays. In the latest colour light signalling installations telephones are provided at each signal location. These are of the central battery bakelite table type, enabling trainmen to call the signal box merely by removing the receiver, with hand microphone set. To facilitate communication between signal boxes direct circuits are provided between them. These and the signal telephone circuits are terminated on a cordless type switchboard, enabling the signalman to have access to all circuits from one point. At accommodation or occupation crossings, as a general rule, a magneto ringing telephone is provided on each side of the crossing on a separate circuit to the signal box, so that the owner of the property or his employees may get into touch with the signalman to ascertain if the line is clear and that no train is approaching.

Additional Telephone Circuits connecting All Sub-Stations and Main Control Rooms.

It becomes necessary on new extensions to provide a complete new telephone system for the Electrical Engineer's Department, including the necessary switchboards at the main control rooms. Every station, sub-station and main control room is connected to one or more circuits, in order that quick communication can be made from any station, particularly necessary in the case of any mishap or breakdown. The telephones on the stations are usually accommodated in a silence cabinet on the platform, and in the later extensions the instruments employed are of the selective ringing type. Copper wire, 200 lb., is used for the telephone circuits and star-quad dry core cable for cabled sections. Dry cells are used for ringing and speaking.

It will be appreciated that much detail has had to be omitted from these remarks, but it is hoped that they will nevertheless prove of interest to members.

Early Tube Railway Signalling.*

By T. S. LASCELLES (Hon. Treasurer).

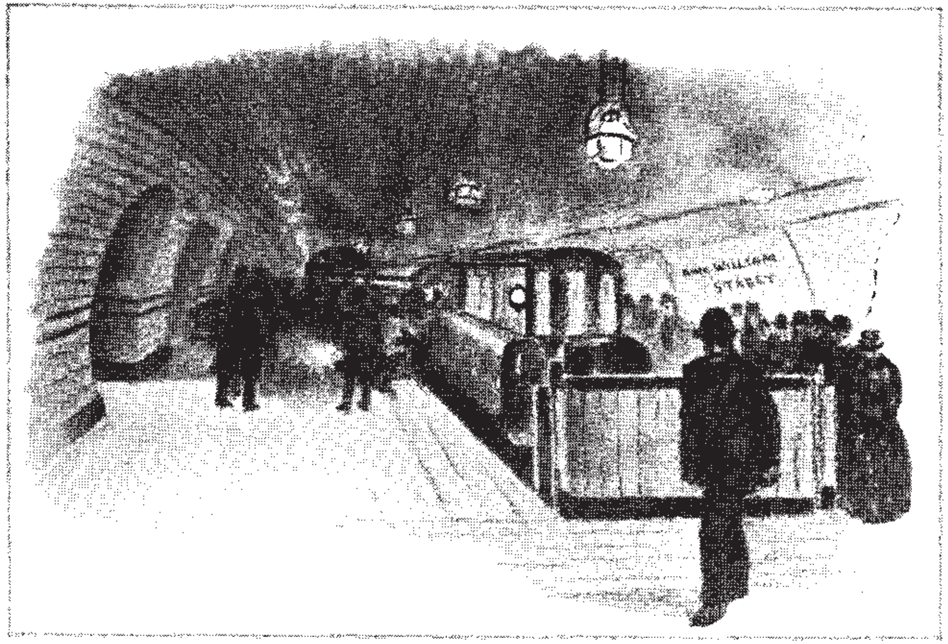
The rapid growth of London in the middle of last century, which seemed alarming to many even then, with the consequent increase and congestion of street traffic in the central districts, led to numerous proposals to relieve it by constructing underground railways, but the cost of building the Inner Circle and the connecting routes of the Metropolitan and District systems was so great that no general extension of such methods was undertaken. The total number of passengers carried by those two railways, the tramways and buses, rose from 54,370,000 in 1864 to 311,880,000 in 1884, an astonishing expansion. In 1867, P. W. Barlow, F.R.S., a well-known civil engineer, proposed a system of " omnibus subways," consisting of iron tunnels, 8-ft. diameter, in which single steel omnibuses—in reality tramcars—to seat 12 passengers, were to be propelled by man power aided by gravity, fares being collected in the vehicles. There were to be different levels of lines in different districts, carriages and passengers being conveyed by lifts from one to the other. In 1870 Barlow obtained an Act authorising the construction of a subway between the Monument, in the City, and St. George's Church, Southwark, passing under the river just west of London Bridge, to be 8-ft. diameter and 1,200 yd. long, and worked in the same way as the short Tower Subway, opened in that year near where the Tower Bridge now stands and in which a small tramcar was drawn to and fro by a wire rope and steam power. The failure of this arrangement there made it impossible to raise the money for Barlow's Southwark Subway scheme. In 1884, however, J. H. Greathead, who had carried out the construction work for the Tower Subway, in association with Barlow, joined with others to form the City of London and Southwark Subway Company, which obtained an Act to make a twin tube line, on the Greathead shield system, practically on the route proposed by Barlow, but extending to the Elephant and Castle. Greathead had been impressed by the success of cable tramways in America, where

*Certain information incorporated herein, together with some of the illustrations, has already appeared in various issues of *The Railway Gazette*, principally those for November 15 and December 13, 1940, and is reproduced by the kind permission of the Editor, Mr. J. A. Kay.

they had been introduced by Hallidie in San Francisco in 1873, and thought that cable traction offered a means of working tube railways simply and economically. (A cable tramway began working on Highgate Hill, London, in 1884). Work was begun under the river in 1886 and in the following year authority was obtained to continue the line to Stockwell, making it just over three miles long, with four intermediate stations, Borough, Elephant, Kennington and Oval. In 1890 an extension to Clapham was authorised and the name of the undertaking changed to City and South London Railway. Although arrangements had been made for the supply of the cable traction equipment, Mr. C. G. Mott, the chairman, a director of the Great Western Railway, induced his colleagues to investigate the possibility of using electricity, and finally the company accepted the proposals made by Mather & Platt, Ltd., of Salford, to equip the line for electric working, with ten 3-car trains, seating 96 persons, hauled by small four-wheeled locomotives, having their motor armatures direct on the axles and weighing some ten tons. The power house was to be at Stockwell. The public service began on December 18, 1890, and the new venture was a pronounced success from the first, over 10,000 persons having passed the turnstiles—no tickets were at first issued—at the City station by 7.0 p.m. Great difficulties soon arose from the sharp curves and steep gradients approaching that station and eventually a new line was built, leaving the old at the Borough and passing east of London Bridge to Moorgate Street. This was opened in February, 1900, after which the City station lay derelict until converted to an air-raid shelter in the present war. In June, 1900, the extension to Clapham was opened and in November, 1901, the line reached Islington. In 1907 it was extended to Euston. Large additions to the original rolling stock had by then, of course, been made. A new generating station was built in time for the extensions and the line changed to the 3-wire system, with 1,000 volts between the conductor rails of the up and down lines. Except for an experiment in 1894 with a motor coach train, locomotive working was used until the complete reconstruction of the line, completed in 1924. This was begun in 1922, under powers obtained in 1913 when the line passed to the London Underground Group ; the 1914 war, however, led to a long delay in commencing the work, but after the war the services were temporarily much improved by the installation of a.c. track circuit signalling and other alterations. No train stops were provided, however, while the old trains were running. The southern half of the line below Moorgate Street was kept in operation for some time while the tunnels were being enlarged, a remarkable engineering achievement. The accompanying illustration shows the interior of the old City station, as first constructed. The public entrance was at the corner of King William Street and Arthur Street East, by the Monument, the line commencing at right angles to London Bridge and curving round, with a fall of 1 in 14 on the down line, to meet the river at the end of Swan Lane.

The C. & S.L.R. Signalling.

The original signalling was supplied by Dutton & Co., of Worcester, and had to be specially designed to suit the restricted conditions of space. The tunnels between the City and the Elephant were only 10-ft. 2-in. in diameter, but were 4-in. larger on the rest of the line. The signals which had to be fixed in them were known as " box " signals, from their shape, and consisted of a narrow cast-iron box to hold the lamp with a stepped type lens and spectacle glasses arranged in two square frames at right angles to one another, turning on a horizontal spindle, the whole, with its balance lever, being carried by bolting to the tunnel segments. In the danger position a small green—later changed to violet—backlight was shown and in the clear position a white one. Semaphores with very short arms were used in the stations. The Stockwell terminus had an island platform with a line on each side, a scissors crossover, and a connection to the incline tunnel leading to the generating station and depot on the surface. The starting signal bridge, at the signal box, carried six semaphores, which were accommodated with difficulty in the top of the rather small station tunnel. At the City station both lines converged to a single terminal track with a platform on each side, an arrangement made under the plans for cable working, the signalling being very simple, but at the end of 1895 the layout was altered to resemble that at Stockwell, to facilitate the handling of the growing traffic. The intermediate stations presented some interesting features. Except at the Elephant, where there was a crossover siding, Greathead purposely arranged the up and down lines, although they were side by side in plan, at a difference of level of 9-ft. 6-in. so as to have the minimum of slopes and stairs to the lifts, which brought passengers to the mean level. This



The King William Street (City) station of the City & South London Railway, as arranged when opened in 1890. A drawing made by Mr. E. A. Lovejoy from one by Mr. W. Luker, jnr., in "London City," published in 1891.

necessitated separate up and down signal boxes. Each station had home and starting signals and no distants, the block sections extending from starting to starting, or to the buffers at a terminus. Backstroke locking was fitted, and at the termini the shunt signals controlling the locomotives following out were included in it, compelling all movements to be gone through before another train could be admitted to the platform. Owing to the way in which the tunnels had been driven between the City station and the river, the lines at the Borough station were right-handed, but crossed each other again below there. This arrangement had to be continued to a point north of Bank when making the extensions, so that to-day passengers are surprised to see the trains at that station and London Bridge apparently running on the wrong line. To keep the third rail, which was laid in the 4-ft. way about 1-ft. from one running rail, as far below the locomotive frames as possible, it was placed below running rail level, wooden slopes being used at the points to carry the collector slippers up and across. The scissors crossing at Stockwell was rather acute, and to enable the locomotives to negotiate it satisfactorily movable conducting bridges were fitted, operated from the signal box and appropriately interlocked, so providing a continuous path. This signal box had 24 levers, a few more being added later when extra siding tunnels were built, in a frame of peculiar type, illustrated in fig. 1. This was designed by W. Buck for Dutton & Co., Patent No. 11,741 of 1889, the novelty being that there was no separate catch handle. The lever handle acted as such, being pulled forward to release the catch in the normal position, retained in the hand throughout the movement, and finally pulled still further when the lever reached the reverse position. As the lever travelled over the handle moved back relatively to it, so as to remain vertical during the act of pulling. This frame was chosen for the Stockwell terminus, as it was considered to be very rapid in working, but the other frames on the line had ordinary catch handles. It remained in use until the re-construction of the railway over 30 years later. The design found its way to other railways, but did not become popular. When the City terminus was altered the new signalling was provided by Evans O'Donnell & Co. of Chippenham, as was the equipment for the extensions, and the tunnel signals were of a different type with vertical sliding spectacles. These became standard, but some of the original signals were still in service when automatic signalling was put in just after the last war. The locking frame and five semaphore signals were still standing in the derelict City station early in 1939.

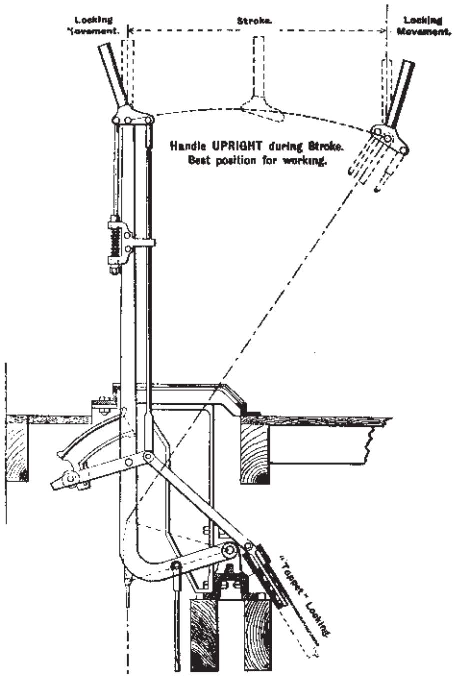


Fig. 1—Dutton's frame without separate catch-handle, designed by W. Buck in 1889 and used at Stockwell, C. & S.L.R.

The Block Apparatus.

The consulting electrician to the company was the inventor of the well-known induced needle, C. E. Spagnoletti, Telegraph Superintendent to the Great Western Railway. His electric locking between block instruments and levers was already in use on the Metropolitan Railway, in conjunction with his disc type block telegraph instruments, which he had introduced on the opening of the first section of that line in 1863. He did not put them forward for the C. & S.L.R., however, but designed entirely new apparatus requiring only two line wires between the stations, not counting the return circuit, whereas on the Metropolitan Railway three were required for the block and bell signalling additional wires being run for the control of the electric locks on the starting signals in rear, principally owing to the lock-and-block action having been added to apparatus already in service and to the peculiar way in which the block was worked at that date on the Metropolitan. Instead of the now familiar arrangement in which the instrument at the box in rear is keyless, both instruments were fitted with keys. The normal indication was " line clear ", the white key being pegged down at the box in rear, the lock on the starting signal being on. Except in the case of goods trains and a few trains on the St. John's Wood line, which ran through certain stations, no train was permitted to be rung forward until it had arrived in a station. The signalman then unpegged the white key, causing the discs of the instruments to swing, and gave the offering bell signal, the man in advance repeating it and pegging " train on line " with his red key. This released the lock for the train to proceed. (The distant signals were preceded by the home signals only, obviously essential with such a method of working, but the signalman was instructed to apply what is now Rule 39 (*a*) to goods and non-stop trains.) When the train operated the treadle at the box in advance the discs again swung to neutral. " Line clear," as it was called, was then rung back and acknowledged and the white key re-pegged at the box in rear, unless the signalman had another train to send forward at once, which in busy periods he usually had. Every stopping train therefore always found the starting signal at danger as it ran into a station.

The block apparatus supplied by Spagnoletti to the C. & S.L.R. was very different from this. The instruments were of two types, each with a circular dial opening, behind which the words " train arrived " on a green screen were normally visible. The instrument at the box in rear had three tapper keys, marked " train on line going," " bell," and " train arrived." They all rang the bell at the box in advance but if the first mentioned key was used a red disc lettered " train on line going " appeared in the dial opening, after which pressing the " train arrived " key would cause it to disappear. This action was purely mechanical and not connected with the electric lever locking in any way. The instrument at the box in advance had a plunger handle. When this was pressed and released it locked itself, sent the releasing current to the box in rear and caused a red disc marked " train on line coming " to appear behind the dial. This disc was made to disappear and the plunger to become free again when the approaching train operated the treadle. The service being so frequent, it became the practice to signal another train forward directly " train arrived " was received, so that the plunger instruments may be regarded as having stood normally at " train on line coming." A plain single stroke bell—the tappers being in the block instrument—was provided at the box in rear, but a tapper bell at the box in advance, the arrangement being duplicated for the opposite direction, so that an ordinary double line box had four bells, not two as in main line practice. This was necessary, however, in any case, owing to the intermediate stations except Elephant and Castle having, as already explained, up and down boxes, so that the signalman there was in communication with four others. When the extensions were opened the same arrangements were continued, although each station on them had one box controlling both lines and four bells were not essential. The line wire joining a pair of instruments transmitted a current of either polarity to the box in rear, according to whether the accepting plunger was used or the bell key pressed, a polarised relay selecting the circuit to the signal lever lock, which controlled the catch handle, or the bell. The line wire also served to convey the bell current the other way. The up and down circuits were thus completely independent. The treadles were at first of Spagnoletti's rail deflection type and proved a little difficult to keep in adjustment. Protected emergency contact boxes were installed for use if a treadle failed. The signal repeaters were at first of Spagnoletti's design. He read a paper on this equipment before the " Inventors' Institute " in January, 1891, according to a press announcement, but no other record of it has been traced.

Outer Home Signals and Last Vehicle Treadles.

It soon proved impossible to work the traffic with the block sections as originally arranged. This was especially the case at the City terminus, as no up train could be accepted unless the station was clear, while a down train could not start until the line was clear to the Borough starting signal, 1,330 yd. away. The section from Stockwell to Oval was also inconveniently long. The company applied to the Board of Trade for permission to instal a down outer home signal at Borough and an up outer home at Oval, 600 yd. in rear of the original platform home. Major-General Hutchinson inspected the arrangements and gave the desired sanction in February, 1892. As soon as an approaching train had reached the treadle in advance of the outer home and produced the indication " train arrived " on the rear section plunger instrument, the signalman could, after putting the signal to danger, use the instrument again to free the starting signal at the station in rear. This was found especially helpful, as it accelerated the working in the two termini. It is believed to be the first regular use of outer homes as block acceptance signals, at least for this class of service. The line between the outer home and starting signals then formed an additional section, as shown in fig. 2, an extra plunger instrument being provided and used

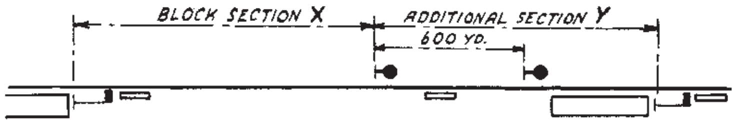


Fig. 2—Outer home signal working, C. & S.L.R.

to free the lock on the outer home after the starting signal treadle had restored it to " train arrived." In the following year Stockwell station was provided with a down outer home and by January, 1894, both tracks at all stations had been equipped, which greatly speeded up the working. At this time too a new form of treadle was introduced and eventually replaced the old rail deflection type throughout the railway. Although always known as a treadle it was not one, in the strict sense of the word, but rather a contact maker. It consisted of an insulated copper plate, a few feet long, attached to brackets at the side of the tunnel, a copper leaf brush being secured to the bogie of the last coach, on the right hand side in the direction of running—the leading brush being thus on the wrong side—the releasing circuit to the block instrument being completed when the brush passed over the plate. To enable a locomotive to run light a portable brush could be clamped to it, but whenever possible a locomotive was always sent coupled in front of an ordinary train and only run singly in an absolute emergency. As traffic increased the two home signals at two or three stations were moved further out still and a second additional section, with corresponding plunger instrument, was created between inner home and starting signals. The little 10 lever Elephant signal box became quite a curiosity, the signalman having instruments and bells on three sides of him, with Annett locking for the outer, or up end, points of the siding crossover. Switching out arrangements were eventually installed at two boxes, Clapham Road (now Clapham North) station and Weston Street, an intermediate box in the tubes between Angel (Islington) and King's Cross. Up and down switching out levers were provided, each direction of working being cut out at the most convenient moment. This was easily done, as the use of four block bells made the signalling on the two roads absolutely independent. The signalman did not put his signals to danger behind the last train he intended to deal with, but pulled over the additional lever for that line instead, backlocking them and lighting a white marker light on the starting signal in rear. He then extinguished the ordinary signal lights. The "train arrived" signal for that train was therefore transmitted from the box in advance. When he had dealt with the other line similarly he could leave by a staircase shaft. The switching in was also effected separately for each line, immediately after the passing of a train.

Signal Repeaters ; Tunnel Telephones and Lights.

As already stated, Spagnoletti provided his own type of signal repeater. The signals had oil lamps, but gas was later tried. There was no spare power for lighting at first, and gas lamps were provided to light the stations. Difficulty was experienced with the strong draughts in the tunnels extinguishing the signals and finally electric light was adopted, under Mott and McMahon's patent No. 9,034 of 1894. The signal repeater was a small box with red and green lamps, acting as pilots to the signal lamps, and a change over switch on the lever and at the signal were so connected that unless both were in agreement the lamps could not burn. This is believed to be the first instance of a luminous type signal repeater and it became standard on the line. With the opening of the first extensions the company introduced two improvements, later adopted generally with small modifications on all the London tube lines. Electric lights were fixed in the tunnels at intervals of 50-ft. and bare conducting wires along them, to which a driver could clip a portable telephone set and speak to the signalmen in advance and rear. It was a signalman's duty to turn on the lights when requested, or if a train should be an unusually long time in section. Storage batteries at the sub-stations, where the 2,000 volts pressure across the feeder outers was reduced to the 1,000 volts across the up and down lines, ensured the lights being available at all times.

The only train accident dealt with in an official report occurred on September 26, 1900, when an up train ran into another which had broken down between London Bridge and Bank. Evidence was, as it generally is, conflicting, but it was held that the driver had passed the Bank outer home at danger. Even if he did not he could have seen the lights of the other train in sufficient time to have stopped clear of it had he been keeping a proper look out, which the assistant driver was clearly also not doing.

One of the original carriages of this pioneer tube railway is to be seen in the Railway Museum at York. The second No. 1 locomotive—not the original one provided for experimental running in 1889—is in the Science Museum, South Kensington. No. 36 locomotive, built for the extensions, was placed on a pedestal at Moorgate Street (Metropolitan) station, and has been regrettably damaged in the fires caused by air raids.

Waterloo and City Railway.

In order to remedy the inconvenience of reaching the City from Waterloo terminus, powers were obtained in 1893 by an independent company, under the auspices of the London & South Western Railway, which absorbed the undertaking in 1907, to construct an electrically worked tube railway between that terminus and a point near the Mansion House. Construction was begun in the following year and the line opened to the public on August 8, 1898. There were no intermediate stations. The trains were composed of four cars, with motors on the end bogies, but in a short while the mid-day service was run by special single car trains. Fares were collected in the carriages. The line met a great want and was well patronised in the business hours. From each terminus the line fell gradually to the Thames, but no advantage could be taken of the down grades owing to some very sharp curves having to be introduced, presumably to avoid interference with certain property, at the foot of each bank, over which the Board of Trade imposed a severe speed restriction. Although the speed limit was afterwards raised, these curves have always remained an obstacle to the working of the traffic. There were only two short pieces of level track on each line. The City—now called Bank—station was of the now customary tube pattern, but the Waterloo station was built under the arches carrying the terminus and involved some difficult engineering work. The tubes were lighted throughout.

Advance Section Signalling.

The line was peculiar in having only two stations but being long enough to require an intermediate signalling point. Mr. J. P. Annett, Signal Superintendent of the L. & S.W.R., son of the inventor of Annett's key locking, President of the Association of Railway Companies' Signal Superintendents and Signal Engineers for the year 1894, assisted by Mr. W. R. Sykes, designed the signalling arrangements. In one fundamental respect these were the reverse of the methods adopted on the C. & S.L.R. It was decided to instal advanced starting signals instead of outer homes and put the additional section under the control of the signalman in rear, a method now very generally met with in main line work. Fig. 3 shows the principle of the W. & C.R. signalling.

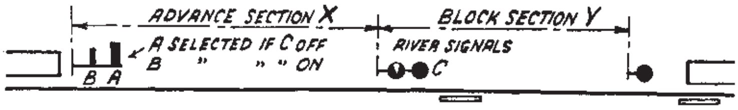
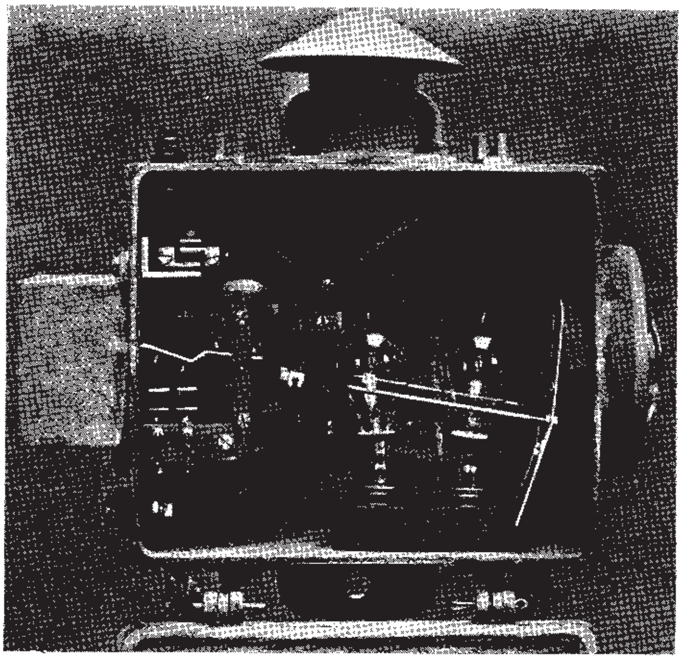


Fig. 3—Original form of advance section signalling. W. & C.R.

The starting signal at a terminus had a lower subsidiary arm of shunt pattern, both being worked by one lever through an electric selector, so circuited that if the advanced starting signal was at danger when the lever was pulled the subsidiary arm would be lowered, but if it was at clear the ordinary starting signal would be given. The positions at first chosen for the advanced starting—officially called the " river section "—signals were rather near the curves above mentioned and it was thought advisable that drivers should know whether those signals were against them or not before beginning to run down the inclines. The down river section signal had the Waterloo distant beneath, the up one the splitting distants for the City terminal roads. All points and the signals in the stations were mechanically operated, but the signals in the tunnels were electrically worked, consisting of a cast iron box with a single lens behind which were duplicate electric lamps and a light spectacle frame carrying coloured glasses, moved by a Z-armature mechanism. The working of the spectacles was indicated in the signal boxes by ordinary repeaters. These signals continued to give satisfactory service for over 40 years. Sykes's lock-and-block instruments were provided—the only instance of their use on a tube railway—without releasing key, the lineman having to be sent for to deal with any failure or other emergency, with electrical point detectors and fouling bars in the stations. These bars were also used as block release treadles.



Electric tunnel signal used on W. & C.R., 1898-1940.

As at first arranged a signalman had to pull off his platform home signal before he could plunge on Sykes's instrument to free the river signal in rear. In consequence of this, and the electric selector control shown in fig. 3, it followed that if the starting signal was lowered at the City it indicated that the line was clear right into the platform at Waterloo. This was soon found to be too restrictive. The home signals were moved out and a train allowed to approach when another was in the station or, in the case of the single car trains at Waterloo, was moving away to the depot lines beyond. During the whole time the manual signalling was used the block was worked on the " normally clear " principle adopted on the L. & S.W.R. The intermediate signals were also eventually re-fixed further out on the straight piece of line under the river, giving drivers a better view of them, and the subsidiary arms and selectors on the starting signals abolished. An interesting feature of the W. & C.R. signalling was the use of an early form of automatic train control. It had been intended to have dead third rail sections in the vicinity of each signal at danger, but the complication necessary to realise this idea effectively was considered too great. Short lengths of conductor rail were therefore fixed just in rear of each signal at the side of the track—the actual power rail was in the centre—a special contact shoe, or slipper, at the front of the train passing over them. When the signal was " on " this short rail was earthed, and on the shoe touching it current passed through a release coil in the driver's cab, tripping the main switch. Although there was no action on the brakes it was thought that the tripping would be enough to draw the driver's attention to his error. Apparently no train accident has ever occurred on the line, but a narrow escape from a collision is known to have taken place, providing an interesting example of jumping to a false conclusion and acting recklessly in consequence. It seldom happened, traffic being so very regular, that a train had to stop at one of the river signals. On one occasion, however, this took place, due to some slight interruption ahead. After a moment or so the signalman looked at his instruments and saw those controlling the starting and river signal levers both locked. He somehow imagined that he had duly worked the river signal and put it to danger behind the train, but that the act of replacing the lever had failed electrically to release the instrument on the starting signal. There being no releasing key, the proper course would have been to send for the lineman to investigate the matter, but instead the signalman committed the gross irregularity of pulling the starting signal wire by hand independently of the lever. The driver of the second train saw the glare from the lights of the first one in time and succeeded in pulling up short of it.

The apparatus above described continued in service until the re-habilitation of the line in 1940, when the Southern Railway relaid the track with welded joints, removed the power rail to its standard position outside the track, provided new rolling stock and signalling, with a.c. track circuits, colour light signals and train stops. The City signal box was abolished and a panel apparatus installed in a relay room, for the use of the station official when required. Normally, however, he has nothing to do, the scissors crossing and signal movements being effected automatically, the first instance of such a layout in London. The points and train stops are electro-pneumatic at the City, but mechanical working at Waterloo has been retained for the points, the old locking frame being fitted with electric lever locks and generally altered to suit. The number of signalling sections remains the same.

Central London Railway Signalling.

The Central London Railway which, from the excellence of its equipment and service exceeded anything before attempted in the Metropolis, was opened to the public on July 30, 1900, from Shepherds Bush to the Bank. The trains were much longer and more commodious than those on the two other tubes and drawn by double bogie electric locomotives, having four motors with armatures direct on the axles, the method of construction adopted on the older lines. The unsprung weight on these powerful engines was excessive, but this would probably not have been objectionable had the bridge type of rail, laid on longitudinals, not been adopted. The two combined led to serious vibrational disturbances being communicated to buildings along the route and the risk of residents securing an injunction to stop the service. After experiments with a geared locomotive and a multiple-unit train, the latter system was adopted and locomotive haulage abandoned in 1903. The line was later extended eastwards to Liverpool Street and westwards to Wood Lane, and eventually to Ealing. At Post Office (now St. Paul's), Chancery Lane and Notting Hill Gate stations, the two lines were one above the other, to bring the railway within the width of the street, and separate up and down signal boxes were provided.

In 1899, while the line was under construction, Mr. W. R. Sykes submitted a scheme for signalling it automatically, the plan of which is still in existence. Light signals were to be used, consisting of boxes containing electric lamps behind coloured lenses, the circuits to which were to be controlled by a heavy sticking polarised relay. Except for the main supply to the signal lamps, there was to be no source of signalling power along the line. Accumulators were to be carried at each end of the train and connected by the act of placing the tail signals in position to brushes on each side, making contact with treadle plates, similar to those used on the C. & S.L.R., the signalling controls being thus completely insulated from earth. The locomotive was to be similarly fitted, but the act of coupling up to the train was to disconnect its brushes so that it could not affect the signals, but would do so if running light. Each signal was to be proved at red before the one in rear could be restored to green. These proposals were not thought acceptable and the company decided to adopt the same apparatus as was fitted on the C. & S.L.R. extensions, including the four block bells in a double line box, the mechanical signalling being supplied by Evans O'Donnell & Co., with trifling improvements. This continued in use until replaced by a.c. track circuits and automatic signals just before the last war, but before this occurred train stops had been fitted to the mechanical signals. It seems that only one train accident on the C.L.R. formed the subject of an official report, the collision at Shepherds Bush on September 30, 1913, just before the last of the manual signalling was superseded. It is of interest as showing how an experienced man, a signalman from the day the line was opened, could commit a series of blunders. Fig. 4 will enable the facts to be understood. Each signal stands at the entrance to a block section and has a treadle in advance of it.

The Shepherds Bush Accident.

A train was on its way from Wood Lane and in due course operated the treadle beyond outer home signal *B*. The signalman put that signal to danger, in order to clear back to Wood Lane and release signal *A* again, but made the mistake, without at first

Fig. 4—Shepherds Bush accident, C.L.R., September 30, 1913.

noticing it, of putting the inner home *C* to danger as well, with the result that the train was tripped there and stopped with its front portion a little in advance of it, the driver being unable to pull up in time when it was thrown to danger. He duly accepted the following train and then perceived what he had done. Wrongly concluding that the train had been stopped in time in rear of the inner home and that it was necessary to clear that signal again to enable it to come forward, he resorted to the emergency release to free the front lock, but made a further mistake, releasing the outer home signal *B* instead and pulling that off behind the train. When he noticed that he had done this he released and cleared the inner home, but had by then become so flustered that he forgot to put back the outer home lever, so that both signals were now showing a false green light. Meanwhile the motorman had replaced his trip cock and drawn slowly forward. Finding the line unoccupied in the station he ran up to signal *D* and went into the box, which was just alongside, to tell the signalman what had happened. Realising at last the extraordinary blunders he had committed, the latter threw signals *B* and *C* to danger, but was just too late to trip the following train. Fortunately the collision was not serious as, of course, its motorman was preparing to stop. A curve somewhat obstructed his view, however.

J. E. Spagnoletti's Automatic Signalling.

Although traffic was handled fairly expeditiously on the line, as on the C. & S.L.R., by manual signalling, especially when a number of inner homes were made into section signals, the operation of signals by mechanical transmissions and the incessant manipulation of block instruments and bells were thought by many to be out of place under such conditions. Proposals for installing automatic signals were suggested from time to time, but there was then no known way of providing track circuits on a railway needing to use both rails for the traction return. The block instruments and other electrical signalling items on the C.L.R. had been provided by the firm of Spagnoletti and Crookes, of which the partners were J. E. Spagnoletti, son of C. E. Spagnoletti, and Joseph Crookes, son of Sir William Crookes, the eminent physicist. (On the death of Joseph Crookes in 1902 the business was continued for a time as Spagnoletti & Co.) J. E. Spagnoletti interested himself in automatic signalling and patented the arrangement shown in fig 5. (Patent No. 12,089 of 1901.)

Each signal, *S*, consisted of a box with red and green lenses and lamps in series with pilot lamps *P* in the nearest station, controlled by the armature of a solenoid relay *R* which was itself normally held up by a catch, the green signal lamp being illuminated. The catch could be withdrawn by a setting coil L, connected to a contact plate treadle in advance of the signal. A brush on the last bogie of the train was connected to the traction circuit when the guard inserted a fuse, as he changed ends at a terminus, and on passing a treadle the signal setting coil was energised, releasing the solenoid armature, which dropped and set the signal to red, closing at the same time the circuit to the clearing wire leading to the signal in rear. The brush being still on the

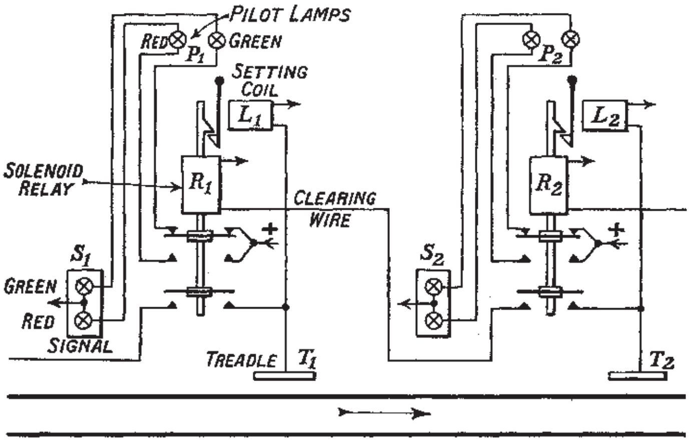
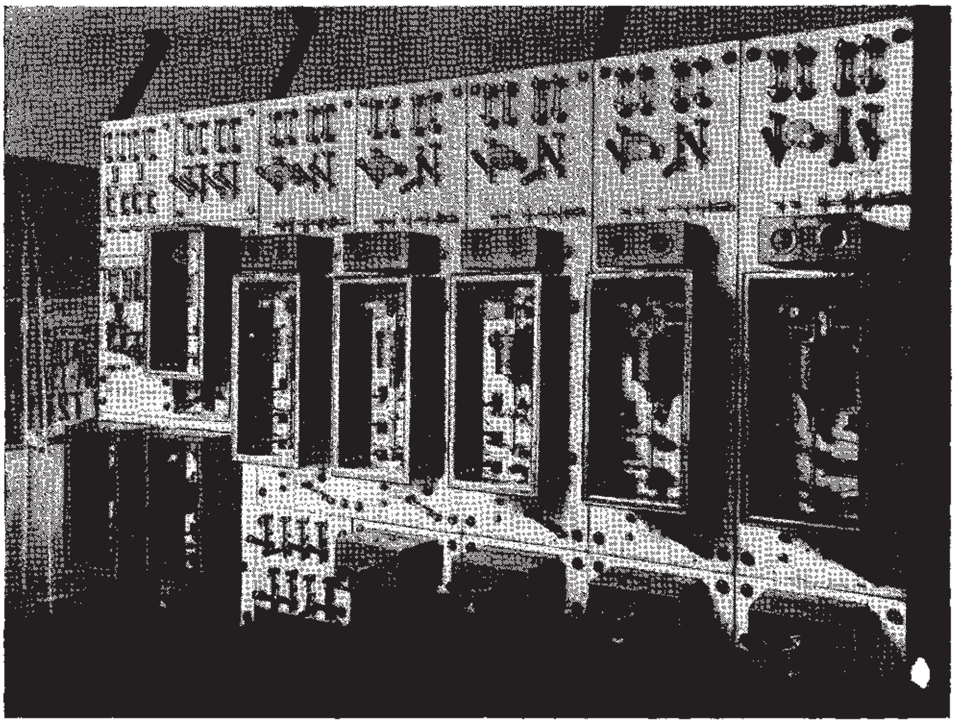


Fig. 5—J. E. Spagnoletti's Automatic Signalling System.

treadle, an impulse then passed to energise the solenoid relay there and restore that signal to green. The working was therefore extremely simple. This apparatus was tried experimentally on the C.L.R. between Tottenham Court Road and Bond Street stations, the manual signalling being put temporarily out of use, but a serious false clear failure, caused by a defect developing in the wiring, led the company to lose confidence in it and it was removed, nothing further being done until the adoption of the modern equipment already referred to.

Great Northern and City Railway Signalling.

Notwithstanding the failure of the Spagnoletti automatic signalling on the C.L.R. it was installed throughout the Great Northern & City Railway, opened between Finsbury Park and Moorgate Street on February 13, 1904. It had originally been intended that this line should serve for the running of Great Northern suburban trains through to the City for which purpose the tubes were made to the unusually large diameter of 16-ft. This enabled a very roomy and agreeable type of car to be put on and it is much to be regretted that the extensions recently undertaken have not been made to suit, the introduction of the ordinary



The original equipment for Finsbury Park signal box, G.N. & C.R., the first type of automatic signalling apparatus used on a London tube.

sized tube stock being a decided step backwards. An insulated traction return was adopted for the first time on a tube railway, the positive and negative rails being arranged one on each side of the track, an arrangement adopted on no other line. (It had, however, been used for the short lived experimental section between Earl's Court and High Street, Kensington, equipped jointly by the Metropolitan and District Companies, on which a compartment type train was run for a time in 1900.) Each station was provided with outer home, inner home and starting signals. On leaving a station a train put the starting signal to danger and cleared the two home signals simultaneously. The starting signal was cleared when the following outer home was put to danger. At the termini the points were manually worked and additional controls were added to the signals to make them semi-automatic and provide for the protection of the movements into and out of the terminal roads. The terminal home signals had a form of A.T.C. resembling that used on the W. & C.R., but with an overhead brush contact. The controlling apparatus was grouped on a board in a signal box at each station, but the signalmen at the intermediate stations had normally nothing to do but book the times of the trains, watch the pilot lights and exercise a general supervision over the working. Emergency switches enabled them to intervene to correct any irregularity. By the courtesy of Mr. J. R. Barden, of Great Baddon, Essex, who maintained this equipment, the accompanying photograph is reproduced showing the apparatus originally fitted in the Finsbury Park signal box. The solenoid relays, setting coils and pilot lamps are clearly seen. Below the relays are plunger handles used in connection with the bay terminal movements.

Brousson and Binyon's System.

When Sir Arthur Yorke came to inspect the railway he refused to allow this signal system to be used for a longer period than three months and insisted on radical modifications being effected by the expiration of that time. He pointed out that it was necessary to transmit a current in order to set a signal tc red, which was not good practice. If a brush broke off, or a guard failed to insert the fuse in the brush circuit, or if the fuse gave out, a train could proceed without putting any signal to danger, and the pilot lights would then give incorrect information to the station staffs regarding the position of the train, something which could very easily lead to serious consequences. Similar results would follow if the traction supply was interrupted for a few moments and a train passed a signal location while this obtained. (It was for this reason that W. R. Sykes's proposals for signalling the C.L.R. included accumulators on the trains.) If a train broke down with its brush on a treadle an extremely dangerous situation would be produced, the signal controlling the section in rear being held permanently green, something which ought to have been obvious at the outset. The signalling was therefore re-arranged on a plan (Patent No. 13,709 of 1904) devised by Mr. R. P. Brousson, Engineer and Traffic Manager of the line, and Mr. A. H. Binyon, an assistant to Spagnoletti, and shown in fig. 6.

The line was divided into d.c. track circuits fed through lamp resistances from mains supplied from motor generators at Highbury station. The solenoid relays in the signal boxes controlled the signals as before, but were made into *TP* relays, to repeat the

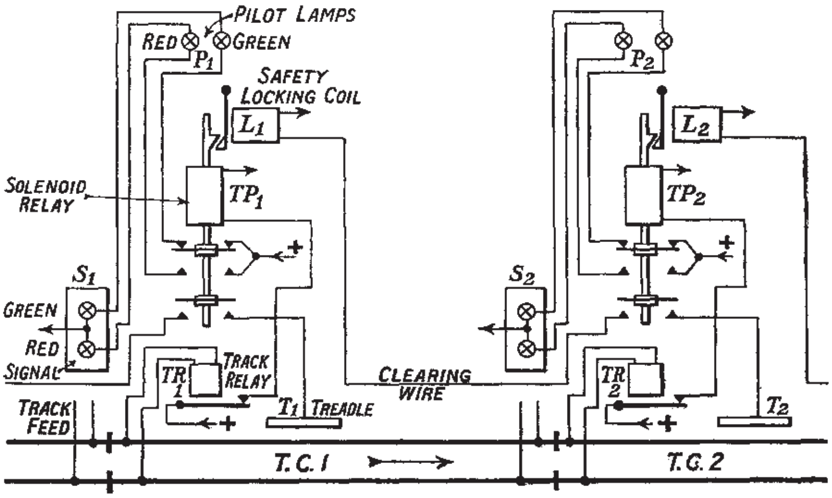


Fig. 6—Brousson & Binyon's Automatic Signalling System.

track relays, which were of a rather heavy pattern. The function of the additional coils was precisely reversed. Instead of holding the solenoid relay armature in the raised position they were arranged to lock it in the dropped position. Directly the track relay was shunted by the first bogie of a train the *TP* relay became absolutely locked and no subsequent failure of the shunt could cause a green signal to appear. The lock was not taken off until the brush on the rear bogie reached the treadle at the overlap point. This freed the *TP* armature and allowed it to rise. These improvements were accepted by the Board of Trade and the equipment continued to function until replaced by modern designs many years later. The signalmen at the intermediate stations were eventually withdrawn and the signal boxes then became apparatus rooms. A disadvantage of the system was that an interruption in the signal supply would lead to the *TP* relays becoming locked, necessitating the staff intervening to free them, unless one waited for a train to go through under caution and pass over the treadles, and safety catches, held clear by coils energised from the signal supply, were proposed, to stop the solenoid armatures falling far enough to lock under such conditions, but it is uncertain whether they were tried or not. The G.N. & C.R. was thus the first tube railway to have an insulated traction return, and to have automatic signalling throughout using light signals with no moving parts in them. (At the Drayton Park station, which was open to daylight and connected with the car sheds and shops, there were some electrically worked semaphores.)

The Glasgow District Subway.

The only other city in the British Isles to have a tube railway was Glasgow. In 1890 the Glasgow District Subway Company obtained powers to make a double line circular railway, 6½ miles long, making the circuit of the central and western areas of the city and passing under the Clyde, on the east near St. Enoch station and on the west at Govan, with 15 stations, to be worked by cable traction. The nature of the sub-soil gave rise to considerable difficulties in many places and six years elapsed before the line was finished. It ran fairly near the surface for a great part of its length and the stations were reached by short staircases, some even being open to daylight. A few were at a greater depth, one having a lift, and the line was 115-ft. below the surface at one part of the route. The steepest gradients were 1 in 18 and 1 in 20 at the river crossings. The tunnels were 11-ft. diameter. Only 3,349 yd. were lined with iron segments, however, the remainder being in brick or concrete. At the stations there was an island platform, in a tunnel of 28-ft. span in the case of the underground ones. Notwithstanding the success of electric traction on the C. & S.L.R. and Liverpool Overhead Railway, the promoters of the Glasgow Subway still favoured cable working, but before the matter was decided their consulting engineer, Mr. D. Home-Morton, visited the United States and inspected the principal cable and electric tramways. (His son, Mr. A. Home-Morton, Secretary of the Incorporated Association of Electric

Power Companies, has kindly confirmed the accompanying particulars.) He recommended the company to adhere to their original intentions, his principal reasons being that a lighter track could be used, and the concentrated weights kept down, desirable in the prevailing sub-soil conditions. Electric locomotives with sufficient adhesive weight to ascend the steep gradients met with he considered inadvisable and motor coaches impracticable in the small space available. Under his direction a very fine cable haulage plant was therefore put down in a power station in Scotland Street, Glasgow, and as it was unique in British railway annals a few details may be of interest.

The track was laid to a gauge of 4-ft. 0-in. and the up and down lines, known as the inner and outer circles, were entirely distinct, there being no crossover or pair of points anywhere on the line. The cars were lifted bodily off the tracks by a crane at the depot, which was built over a cutting. The trains on the two circles—generally about 10 on each—were hauled by separate cables, each about 36,300 ft. long, and 1½-in. diameter, formed of six strands on Lang's lay over a hemp core and weighing 58 tons. The splice was 75-ft. long. The hauling into position by a messenger rope of the first pair of cables was a difficult operation needing great care. The power plant was in two halves, each comprising a 1,500 b.h.p. non-condensing engine, driving by cotton ropes two countershafts carrying the cable driving drums for one of the tracks, provided with differential rings. Clutch mechanism, however, enabled the whole plant to be driven from one engine, if desired, and this in fact was usually done, the other engine being kept in reserve. An incoming cable passed to the farther drum and back to the nearer, to make four and three turns round, respectively, and returned to the track over an Upton tension regulator, designed to accommodate the cable to the rapid changes of load. Pulleys, to the number of 3,400, guided the two cables on their way. The maximum speed adopted in regular service was 13½ m.p.h. but higher speeds were tried. The trains at first consisted of one bogie car, but very soon a trailer was added. The gripping apparatus on the leading bogie consisted of a long steel jaw, the top half being lowered and raised by a handwheel. In addition, a special hand lever worked an ejection device, which would cause the cable to fall right out. This had to be done on each journey just before passing the so-called " cross-over " at the power house, where the cable passed in and emerged again, but if the driver failed in this duty a ramp in the track made the gripper open automatically and produced the discharge of the cable. On the other side of the " cross-over " the cable was guided by special pulleys in such a way as to allow the gripper to pick it up and the train to continue without stopping. The cars were not unlike those used on the C. & S.L.R., but more attractive, and were lighted electrically, current being picked up by sliding skids from conductors on the tunnel side.

The Glasgow District Subway was opened with a uniform 1d. fare on December 14, 1896, but so great were the crowds that it had to be closed again on the same day. It was re-opened on January 21, 1897, with graduated fares and for some years was financially successful. It was not long, however, before the company regretted that electric traction had not been adopted, but various proposals to make the change came to nothing. Gradually the line fell into difficulties and, after being closed for a time in 1922, passed into possession of the Glasgow Corporation in 1923, who electrified it in 1935. It was the only railway of its kind ever constructed, but several cities, such as Chicago, New York and Melbourne put down extensive cable tramway installations. Edinburgh, however, was the only city in the United Kingdom to have a complete tramway system worked by cable.

The Subway Signalling.

The signalling apparatus was supplied by Saxby & Farmer Ltd. and was called by them their semi-automatic block system, being derived from Charles Hodgson's " union of lock and block," then well-known. Each station had a semaphore starting signal, of the " somersault " pattern, the wire from which was brought to a chain round a pulley over the centre of the platform, where it hung down, but beyond the reach of the public. The station official had a stick terminating in a hook, with which he could pull down on the chain and clear the signal, which was then held off by a catch on the transmission, on the spring blind principle. The signal balance lever operated the arm through a Hodgson type electric slot, or reverser, which was energised when a block indicator arm, placed on a bracket across the station adjacent to the signal chain, showed " line clear." This was a polarised movement, similar to that used in Tyer's block instrument, and was connected to an electric treadle beyond the starting signal and to the treadle at the station in advance also. A trembling bell rang when current was received from the latter, to attract attention to the block indicator. There were no intermediate signals of any kind. A complete system of telephone communication was provided between all stations and with the power house, and any station could sound an alarm signal gong there, if an emergency arose necessitating the immediate stoppage of the cables. When a train arrived in a station and the block indicator showed the section in advance to be clear the platform official pulled the starting signal off in the manner described. When the train left it released the slot and placed the semaphore to danger by means of the treadle, the deflection of which set the block indicator to " train on line " and de-energised the slot, so that the signal could not be lowered again. When the same operation took place at the station in advance the block indicator was restored to " line clear " to the accompaniment of the trembling bell, which notified the station official that he could send another train forward. This apparatus remained in use until the line was electrified.

Only two train accidents appear to have been made the subject of official reports, a collision between Buchanan Street and Cowcaddens stations on June 6, 1912, and another between Hillhead and Partick Cross stations on April 26, 1917, both on the inner circle track and, by a coincidence, between trains Nos. 1 and 2. In both cases the first train had to stop in section, in one instance because the gripping apparatus failed, in the other because the electric lighting skids became defective. No " line clear " signal being received after the usual interval had elapsed, the stationmaster in rear telephoned ahead to enquire but, as so often occurs in these cases, the messages were not well worded, confusion resulted, and the second train was allowed to proceed under written order. The collisions were not serious, however.

The Signalling Installed on Electrification.

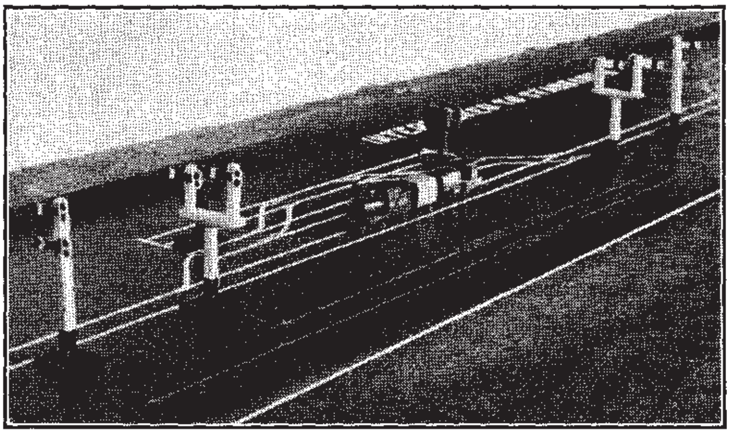
To convert the line to electric working, while maintaining the service running with cable traction, called for much thought and care. The restricted space available made it necessary to fix the conductor rail—which in any case had to be outside the track owing to the presence of the cable in the centre—at a much higher level than usual, the insulator brackets on the ends of the sleepers having a large overhang. To give them additional support steel sleepers were put in at those points, rendering track circuiting impossible. Some special system of signalling was therefore essential. The method of lighting the trains from independent conductors on the tunnel sides, adopted with the cable system, was continued and use made of the collector skids travelling along these conductors to act in place of a track circuit and effect part of the control over the signals, which were changed to colour lights and fitted with train stops. The putting to danger of a signal was positively effected by a short depression bar type of treadle, acted on directly by the wheels themselves, and the clearing action made dependent on the lighting skids passing over a short separate section in the conductors arranged at the overlap point. A special signal panel, with signal repeater and block section indications and certain auxiliary equipment was provided in each station. The adoption of automatic signalling and electric haulage considerably reduced the journey times and brought the working into line with that obtaining on the London tubes, although the trains were much lighter. The Glasgow Subway is not only unique in having been the only line of its kind to be worked for many years by the endless cable system, but even to-day possesses certain special features, including automatic signals controlled on a method peculiar to itself.

(The above remarks are primarily intended to give members some idea of the signalling arrangements originally used on the early tube railways. The apparatus adopted for the electrification of the Glasgow Subway will be found described in the technical press of the time, while the developments made in London from about 1905 onwards are dealt with in the inaugural address delivered by Mr. H. M. Proud, President for 1937, in the Proceedings for that year, page 20, and in the paper by the late Mr. W. S. Every, President for 1928, published in the Proceedings for 1924, page 154.)

Models for Training Railway Staff.*

By H. C. TOWERS (Member).

Many railways in various parts of the world have opened training schools and staff colleges, where instruction is given by means of lectures, diagrams, films, lantern slides, and demonstration and practice with models and with actual equipment. Typical examples are the signal schools of the London Passenger Transport Board and of the British main-line railways. For efficient railway operation, each member of the staff requires to be thoroughly trained in his duties and preferably also in the duties of the next grade above. Particular attention should be



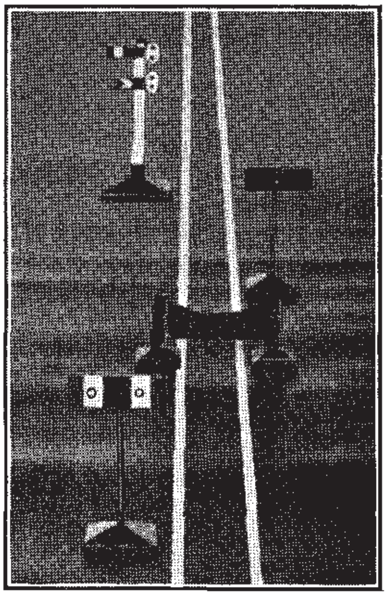
View of station with miniature train.

paid to the rules and regulations for dealing with emergencies; staff will assimilate this knowledge more readily by practical demonstration with models than by listening to rules, sometimes couched in varying and ambiguous phraseology. A well-equipped training school is, however, expensive, and, to run one well, permanent instructors must be employed.

Training schools exist on the Bombay, Baroda & Central India Railway at Parel and Bulsar, on the broad-gauge system, and at Ajmer, the metre-gauge headquarters, mainly for instruction in the operation of block instruments and Morse

* Reprinted with additional illustrations from *The Railway Gazette* for August 22, 1941, by kind permission of the editor, Mr. J. A. Kay.

telegraph working. The Ajmer school contains a number of dummy keys, working keys and sounders, and two Tyer No. 7 type tablet instruments. The course takes from 3 to 5 months, depending on the individual, the efficiency reached in Morse signalling being 25 and 16 words a minute. The usual strength of the class is from 45 to 65 pupils.



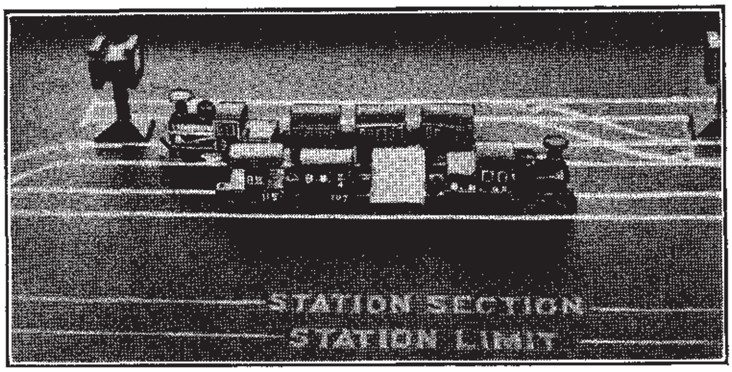
View of " dead stop " restriction outside station with banner flag and stop indicator.

Model Railway Provided.

Lately an attempt has been made to educate the men in other branches of signalling and the rules pertaining thereto. A spare room was provided with framed station diagrams, showing the various types of signalling in use on the metre-gauge system, caution order books, line clear tickets, etc. An enthusiast presented a small model railway with two typical single-line stations, having their signals correctly operated from platform lever frames, properly interlocked. One station has the outermost points operated from a ground frame interlocked with the station signals, the other is uninterlocked, using positive locks only.†

† See Mr. H. C. Towers' description of the signalling on the B.B. & C.I.R. (metre-gauge) in these proceedings for 1939, page 85.

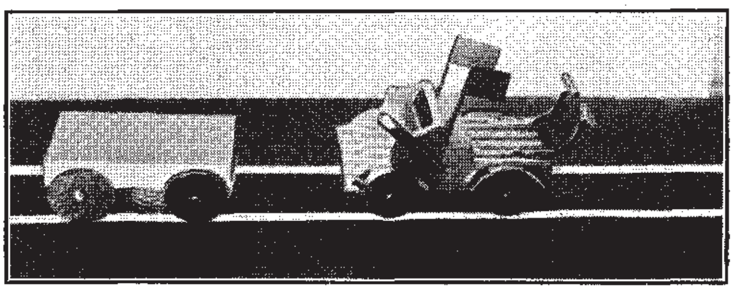
Loading gauges, scotch blocks, level crossings, etc., are provided. Although from a technical point of view the model is defective in parts, much can be taught with its aid.



View of miniature rolling stock.

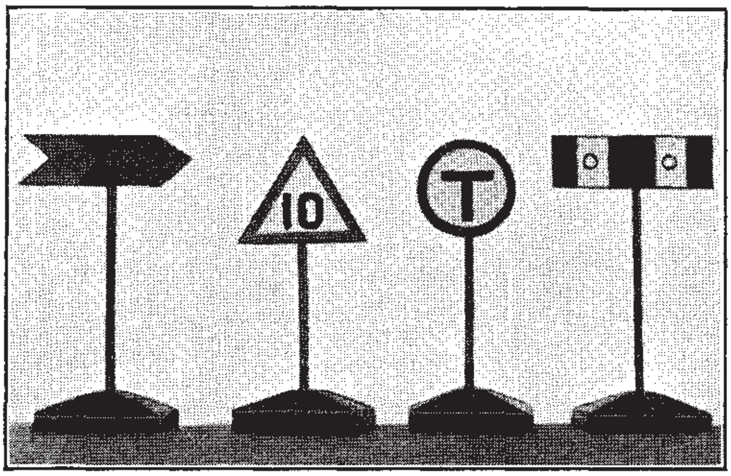
Advantages of Model.

Financial and other difficulties in constructing a perfect working model led the author to produce another kind having the advantage of cheapness, simplicity, and portability. The " track " in this case consists of lines painted on black oilcloth. Four or five station yards, of typical single-line design, are given,



Miniature material lorry and inspector's push trolley.

the distance between stations being about 5-ft. Miniature signals, with arms capable of being operated, outers, homes, starters, combined outers and warners, shunts, point indicators, etc., can be stood alongside the painted track in accordance with Indian signalling and interlocking standards. The extent of the block section, station sections and station limits is clearly indicated by arrows in different coloured paint. Miniature locomotives, trucks, brake vans, carriages, etc., can be pushed about as required, the whole being kept in a small fitted box, together with a diagram illustrating the various types of signalling installations in service. Various situations and emergencies, with explanations of the working rules, and of the general and subsidiary rules book, etc., can be easily demonstrated to students by the instructor with this model.



Engineering signals (left to right) : caution indicator (black and yellow) ; speed indicator ; terminating indicator ; stop indicator (red and white).

Engineering Department Model.

Another model of similar design is used in the Engineering Department for working out the positions of signals for temporary speed restrictions and for dead stops, such as would be imposed for repairs to bridges, culverts, etc. The signals are positioned according to standard orders and where these encroach on interlocked territory certain working signals have to be put out of use. This model can be used to illustrate such situations, and is found of advantage in sub-permanent way inspectors' examinations. The illustrations which accompany this article show the construction and manner in which the arrangements above described are used.

C. E. Spagnoletti.

By T. S. LASCELLES (Hon. Treasurer).

Although everyone in the Signal Departments of our British railways, at home and overseas, is familiar with the induced needle, or axle, practically universally employed in signal repeaters and many other types of electrical indicators required in signal boxes, probably not many know much about the life of its inventor. A few words on the subject may possibly therefore be of interest to members.

C. E. SPAGNOLETTI (1832-1915).

Charles Ernest Paolo Della Diana Spagnoletti was born in London on July 12, 1832, and was descended from the once well-known Neapolitan family of Della Diana, owners of extensive estates in Naples and Sicily. His grandfather, Paolo Ludovico Della Diana, was a precocious musical genius, and achieved such a reputation as a child when travelling in Spain, that on his return to Italy he became popularly known as "*Lo Spagnoletto,*" which may be approximately rendered as " the charming little one from Spain." He later obtained formal permission to adopt the plural form " Spagnoletti " as a family name. He left Milan and settled in London, becoming a well-known and highly talented orchestral leader and composer. His grandson, the subject of these remarks, left school at the age of 14 and entered the National Debt Office, but very soon after obtained work more to his taste with one of the pioneers of telegraphy, Alexander Bain, inventor of an early form of printing telegraph and an electro-chemical telegraph. In 1847 he joined the City offices of the Electric Telegraph Company and in 1855, when only 23 years of age, he was given charge of the telegraphs on the Great Western Railway, a post he retained until 1892. For some years this was evidently not an exclusive appointment, for Spagnoletti engaged in other business on his own account, as is evidenced by advertisements appearing in the press of the period. He naturally became much interested in the application of the telegraph to train signalling and in 1862 produced and patented the disc type block instrument, still standard on the G.W.R. and ever since known by his name. Instruments of this type were first used on the opening of the Metropolitan Railway in 1863, over which the trains were originally worked by the G.W.R., and remained ever after the standard on that line, until superseded by automatic signalling. The District Railway was also fitted with them, but later adopted Sykes's lock-and-block, and the Netherlands Rhine Railway. They also found some favour in South Australia. The great danger of false reversal by lightning effects, to which the early needle telegraphs were liable, led to various forms of induced needle being suggested, Spagnoletti patenting in 1869 the one still so widely used, and to all appearances in little danger of being superseded. He soon after became interested in working signals electrically and took out some patents for the purpose in 1873, principally with the object of doing what is now called intermediate signalling, but without track circuit had, of course, little chance of seeing his ideas adopted. He constructed some electrically worked semaphores, however, and from documents discovered a few years ago and kindly placed at the writer's disposal by Mr. R. Falshaw Morkill, Vice-President, it appears that they were tried for a time at Queen's Road and Praed Street stations, on the Inner Circle, in 1875, the year in which W. R. Sykes fixed his first electric signals at Sydenham Hill tunnel, on the London Chatham and Dover Railway. Spagnoletti also advocated electric locking as a substitute for mechanical locking in lever frames, and introduced his electric interlocking between block instruments and levers, which came into use generally on the Metropolitan Railway and to a small extent elsewhere. In 1888 he was appointed consultant to the City of London and Southwark Subway—later City and South London Railway—Company, as related elsewhere in this volume, then engaged in deciding whether to work their line by cable or electric traction, and in their report dated January 29, 1889, the Board said they had settled in favour of the latter system, aided by " the valuable assistance of Mr. C. E. Spagnoletti, an experienced electrical engineer." This announcement received some mild criticism in the technical press, on the grounds that Spagnoletti's experience had been confined to telegraphy. For this company he designed a special form of his block apparatus. Almost all his work was connected with railways, but he designed a fire alarm apparatus, adopted in some districts of London, and described at the time as being " as efficient as it was unsightly." Spagnoletti joined the Society of Telegraph Engineers—the Institution of Electrical Engineers from the end of 1888—in 1872 and was elected to the Council two years later. He became Vice-President in 1884, in which year he was President of the Conference of Railway Companies' Telegraph Superintendents and Engineers, and President in 1885. He never read a paper before that body, but constantly took part in discussions. In 1912 he was elected Honorary Member. He was a Member of the Institution of Civil Engineers, the Physical Society and several other scientific bodies, while he was selected as juror or adviser in connection with the Paris Exhibitions of 1878 and 1881, the Health and Inventions Exhibitions in London in 1884 and 1886, and the Chicago Exhibition of 1893. Inheriting the musical gifts of his family he wrote and composed songs, and at times wrote the words of songs for contemporary composers. In 1878, when Sir William Preece exhibited the first Edison phonograph in London, he sang a song and then " God Save the Queen," which were duly recorded, Sir William saying that it would be an excellent idea to preserve the records in order to play them again in 1978, but whether this has been done and, if so, who has them, the writer has as yet been unable to ascertain. Spagnoletti died at Hampstead on June 28, 1915.

Accumulators and their Ailments.

By T. C. ELLIOTT (Associate Member).

It would no doubt appear strange to the sectional officer who received a report from his lineman to read that a battery was "ailing," or that a cell was "sick." Nevertheless, such terms would be perfectly appropriate in the majority of instances, for the reason that the life of a battery is analogous to that of a human being, being harmfully affected by the same excesses, want of care, and improper attention. For instance, take such things as (1) over-feeding; (2) starvation; (3) overwork; (4) prolonged idleness; (5) uncleanliness; (6) strong drink, or none at all; (7) carelessness; (8) ignorance; (9) impurities; all these are dangerous to both human beings and secondary cells. Let us consider them in turn, as applied to batteries, bearing in mind that the dry battery and other forms of primary cell are not strictly included in these remarks, although to some extent the same comparisons apply to them as to accumulators.

Over-feeding.

It is unnecessary to dwell on the harmful effects of gluttonous habits on human beings. A battery can be overcharged in two ways, either (*a*) by the rate of charge being too high, or (*b*) charging being continued after a cell has reached its maximum voltage. The first is fortunately not often encountered, because the modern practice is to provide a charging plant which cannot exceed the appropriate rate fixed by the battery manufacturer. When a generator (or rectifier), intended possibly for other uses in addition to the battery charging, is employed the normal charge rate may sometimes be exceeded. The battery inspector should soon be made aware of the fault, however, by the violent gassing that will take place towards the end of the charge, some abnormal rise of temperature, loss of acid through spray, frequent topping up and rapid fall of active material. This is very harmful and may involve cleaning out the sediment in two to four years instead of the normal period of eight to twelve years. Such a condition would—or should—be immediately reported, and steps taken to reduce the charge rate by one of the well-known methods. The other cause of overcharging is, however, commonly met with. In this case the fault lies in failing to cut off the charge when the battery is "full," and allowing the plates to continue gassing sometimes for an hour or more every time the battery is charged. What are the consequences of such persistent overcharging? There are several. The plates are worn away prematurely, the positive plates become weaker, so that when called upon to take heavy discharges they become liable to buckle. There is the shedding of active material, so that cleaning out becomes necessary before the usual time. There is also excessive loss of acid through spray, involving frequent topping up. An actual and striking example of this fault, and the troubles that were accelerated by it, occurred in connection with a large station battery in a service establishment. The engineer gave half to one hour overcharge every day, either through having been wrongly informed on the subject at the start, or through misguided zeal in the endeavour to make sure that the battery was "full." After about 12 months the specific gravity was found to be falling away 10 to 15 points, caused by the loss of acid through spray being made up with water in abnormal quantities. This lower specific gravity only aggravated matters. The engineer, on referring to the instruction card, noticed that the specific gravity was much lower than the figure then given as to be expected under normal conditions, *i.e.* about 1215-1220. The final specific gravity at the end of charge, fell to about 1190. Thereupon the engineer attempted to bring it up by more thorough charging, to such an extent that gassing of from 2 to 3 hours was not uncommon. Then more acid was lost, more water was added to make up and specific gravity decreased almost day to day, with a crescendo of charging. Eventually the manufacturer was called in. The inspector was appalled, when entering the battery room, to find the stand, the floor and other parts of the equipment reeking with acid spray. The maximum specific gravity at end of charge was down to 1180, but most definitely the battery was fully charged. In fact it had had several gigantic "meals," and was nearly on the way to its end. The fault was just stopped in time to allow of the battery giving further useful service.

This is one of those rare instances in the life of a storage battery when strong acid (specific gravity 1300-1400) *might* be added to bring the strength nearer the normal figure. It is not always done, and there are occasions when it is wiser to allow the battery to work at a lower maximum specific gravity figure than the normal.

This incident, which readers are assured actually took place, has been described at some length as a warning of what may happen if a bad start is made in the upkeep of a battery, even when in the hands of a trained engineer.

There is one other aspect of this " over-feeding " fault which should not be overlooked, namely the waste of energy and the extra cost occasioned by the dissipation of wholly unwanted k.w. hours. Some of the larger installations are provided with watt-hour meters, or ampere-hour meters in the battery circuit. These instruments are very useful as a day-to-day guide, calculating on an efficiency of 75 per cent in watt-hours, or 85 to 90 per cent in ampere-hours, to allow for the extra charge required to make up for conversion losses in the battery. There is some need to be cautious, however, in the use of meters, for the reason that the discharge rate is sometimes so low, as to affect their accuracy, whereas the charge rate is reasonably constant. In one instance a complaint was received regarding the low working efficiency of a large country house battery. The charge was controlled by ampere-hour meters rated up to 100 amperes. It was soon discovered that the armatures of these meters failed to rotate, or to overcome the friction of the pawl, when a few lights only were on—a load of 3-4 amperes—which occurred for a period of 5-10 hours every day.

The foregoing remarks may lead the reader to enquire how a battery attendant is to know the *precise* moment for cutting off the charge. The precise or exact instant can no more be defined in ordinary industrial working than it can be for the completion of a man's meal, but there are certain indications which give sufficient guide to maintain a satisfactory control, and secure the highest possible efficiency in practical performance. These, for a fully charged cell with current passing into it, are as follows :

(1)—The colour of the positive plates. This is, however, only a *very* approximate guide, and by itself is in fact a somewhat unsafe one. A dark colour may indicate a fully charged condition and also an over-charge. On the other hand, *a very light* colour—like straw—is definitely a sign of an under-charge. If one or two cells among several in series alone show the straw colour it is an indication of a short circuit, or the presence of some impurity, such as iron.

(2)—Gassing, which should be fairly vigorous from positive and negative plates, its amount varying with the rate of charge. There is no difficulty in observing the gassing in an open type cell, particularly of the glass box type, but with the sealed-in type it requires close inspection to do so ; it is not easy to determine if both positive and negative plates are gassing. Great caution is necessary when using naked lights in a battery room and with cells of the sealed-in pattern, with ebonite lids and vent plugs, such lights should be rigorously prohibited. There have been several cases of serious explosions being caused in this way and as an example and a warning the following brief account of such an accident may be given. The battery, used for lighting a country house, was of the closed-in type in glass boxes of substantial thickness. It had been on charge for a few hours and the owner, wishing to check the specific gravity before shutting down the engine, struck a match in order to read the hydrometer floating in the end cell. The flame must have passed within the stream of oxygen and hydrogen gases issuing from the vent hole barely $\frac{1}{8}$-in. in diameter. The ignition reached the more or less concentrated gases underneath the lid of the cell, a violent explosion ensuing and breaking into pieces the glass box, the walls of which were $\frac{3}{8}$-in. thick. The unfortunate man was in hospital for two weeks with a seriously damaged face.

It should be noted, however, that this danger is only present with sealed-in cells, or open types housed in a very confined space. It is an interesting fact that in one of the early text books on accumulators, written by an eminent scientist, its author mentioned one method he used for detecting a fully charged battery, consisting in applying a lighted match to the bubbles of gas on the surface of the electrolyte. The effect was to give a sharp report, of a certain intensity of sound, which by experience could be used as an indication of complete charge. Such a test was applied of course only to open type cells in battery rooms of normal size. This method should preferably not be used in modern practice, for, as the foregoing story shows, it may be wrongly applied with disastrous results.

Another explosion incident which will be of interest to many readers occurred in Ireland on a railway coach many years ago. The heavy lids of the accumulator compartments, or containers, were actually burst off by the force of the explosion and in fact one or two of the 12 cells forming the set fell on the permanent way. The explanation of the mishap was that the train, having just completed a long journey of $3\frac{1}{2}$ hours with only 2 stops, in daylight with no lights on, the battery, on arrival at the terminal station, was more than fully charged, and a large amount of gas had collected under the lids of the lead-lined wood box cells. That condition, of itself, would not have caused an explosion; it obtains in fact as a daily occurrence hundreds of times. The essential detail wanting was a spark, and it is surmised that when the train was being shunted into its siding—where the explosion took place—a momentary rough movement of the vehicles must have displaced, or slightly disconnected one of the connecting bolts, causing a spark to pass. It may reasonably be argued, however, that for a spark to be created there must be a current flowing, and that during shunting the dynamo is not giving out any current. The only other alternative is that a discharge current must have been present. This was the case, for the reason that this particular coach was a dining car, the attendants being still inside with the lights on, thus creating the sequence of requirements necessary to produce an explosion, *viz* :—

(*a*) a fully charged cell ;
(*b*) a closed-in type of cell ;
(*c*) a spark within reach of the vent ;
(*d*) current flowing into or out of the battery.

All these must be present simultaneously to produce such an accident, reminding one of a railway swing bridge, somewhere on the east coast, which is so protected that 7 mistakes or errors must be made simultaneously for an accident to happen, and yet this did happen once.

(3)—The voltage per cell with the current on, which should be 2·6 to 2·7 volts at normal charging rate.

(4)—The specific gravity of the acid, which should have reached its maximum figure, or be within five points thereof. Taking, for example, a cell in which its value is expected to be 1210 when fully charged, upon its reaching 1205, with its plates gassing, the battery can be considered "full." As a check on this method it is useful to have what is called an observation charge once a month, or once in 3 months, when the charge is kept on, for this one occasion only, for 2 to 3 hours extra. If there is no rise in specific gravity during that extra time it can be safely assumed that the maximum fully charged condition has been reached. If, however, the specific gravity continues to rise during this additional charge, it must be continued until a level value is obtained, readings been taken from one or two pilot cells every half-hour. This method of control is undoubtedly the safest, and in fact cannot be wrong unless the hydrometer itself happens to be out of order.

There are nevertheless two conditions where slight adjustments or correction to the readings may have to be made. These are :—

(*a*)—The specific gravity reading, if taken on the same day as topping up water is added to the battery, is liable to be slightly low. For this reason it is recommended to top up a few days before any observation charges are made, to give the electrolyte sufficient time to mix up.

(*b*)—Under extreme ranges of temperature a correction should be made by allowing 1 point on the hydrometer scale for each 3°, Fahrenheit, above or below 60°. Thus a fully charged cell of 1200 maximum specific gravity at 60° should read 1190 at 90°, and with the electrolyte at 45° the hydrometer reading should be 1205. Normally, both in railway and general work, temperature corrections are not made, except under extreme ranges of temperature, as instanced above.

The specific gravity tester is an instrument deserving of more attention. There are too many in use of the miniature pattern, involving a short float with a crowded scale, difficult to read, and a large error allowance. The length of the glass tube should not be less than 9-in. and of the float scale 2½-in. In most cells there is sufficient free electrolyte above the top edges of the plates to fill the larger size tester. A misunderstanding often arises when requisitions are sent in calling merely for "hydrometers." The supplier is sometimes able to find out by enquiry whether the complete specific gravity tester is required comprising rubber suction ball, glass tube, hydrometer float and indiarubber cork, with leading in tube of the same material, or if the float only is wanted, that is to say the hydrometer itself. If it is the latter, then the requisition should state whether the float is to be for the large or the small size tester. There are only two sizes in common use for the enclosed type of cell. For the open type the *flat* hydrometer is used, its length varying from 6 to 18-in. according to the size of the cell.

Of the foregoing methods available for recognising a fully charged cell, it can be said that if two of them produce correct results the battery charge may certainly be discontinued. The most reliable are methods Nos. 3 and 4.

Under trickle charge working the full gassing condition does not apply and the voltage per cell is of course less. There may be very slight gassing—an occasional bubble—but any considerable amount, even only half as much as when the full charge rate obtains, would be detrimental if allowed to go on continuously. The easiest and most correct guide with trickle charged batteries is to obtain a working voltage of 2·15 to 2·25 volts per cell. It is recommended to make this test at least once a quarter, if not once a month. The actual input in milliamperes can be disregarded if this working voltage is maintained. Caution should be used, however, whilst obtaining the reading that no discharge is taking place at the same moment that the voltmeter is being held in position. The specific gravity of trickle charge batteries may be taken as a safe guide.

The observant engineer will learn from a year or two of practical experience to know the anticipated date of topping up, as well as the approximate quantity of water that will be required. If it begins to seem necessary to top up more frequently and an increased quantity of water is required, he should look for excess charging. It is difficult to state a fixed topping up period for all batteries, even of the same size. There are several factors which govern the matter, such as the relation between the charging and discharge currents, the ventilation of the room or space where the battery is installed, its position with respect to exposure to wind, sun, or currents of air, and the humidity of the atmosphere. An interesting example illustrative of this was provided by the owner of a country house battery of open type who complained that the acid was always slightly running or dripping over. Of course the first explanation he was offered was that he topped up too near to the top of the box. The astonishing reply was received that he never topped up at all and " had not done so for years." The battery house was found to be situated in a low-lying part of the estate, amid very humid surroundings, and to have no ventilation whatever. Suitable ventilation was then provided and the dripping stopped. It is well known, but not always kept in mind, that the absorption factor of sulphuric acid for atmospheric moisture is very high. Adequate ventilation of even the smallest battery container or cupboard is therefore of great importance.

Starvation.

This ailment requires little explanation, and indeed is not difficult to avoid. It is seldom met with in modern practice, whereas over-feeding is fairly common. The starved condition is produced by cutting off the charge too soon. The visible effects on the plates are not apparent for a long time—a year or two possibly—when expansion and buckling of the positive plates occurs. Long before this state is reached, however, a definite warning of what is taking place appears, which should be noticed and heeded by the battery attendant or inspector. This consists of a gradual falling off in specific gravity, from week to week, or month to month. It can be said to be an infallible warning, except in the case of some excessive overcharging, as already described, and which happily is rare. Ingress of impurities in a heavy degree can also lower the specific gravity as well as a high absorption of moisture in a very humid atmosphere, but such cases are very exceptional. If starvation is detected in its early stage no harm will result, provided the remedy—a long charge at a low rate—is promptly applied. The suggestions, already mentioned when dealing with overcharging on the method of controlling the charge, are sufficient to prevent undercharging if duly carried out.

Overwork.

Overwork is in many ways analogous in its effects on battery plates and human beings, and above all in its main effect of producing a prematurely worn out condition. Applied to accumulators the term overwork implies heavy and prolonged discharges to the point of exhaustion, and if this is coupled with persistent overcharging rapid wear and tear of the plates results. This is often due to selecting a size of battery too small for the requirements. It should be noted, however, that occasional discharges at high rates have no harmful results, provided that the battery is then fully charged. The comparison with putting a heavy load on a tired man's back is apt in this case and needs no amplification. An example of the ability of a battery to withstand a heavy load is provided by a 24-volt set, of about 160 ampere-hours capacity (normal discharge 16 amperes for 10 hours), used on a 6 ton lorry, run by an internal combustion engine, a current of 800 to 900 amperes, for 10 to 15 seconds being needed to start it. This battery performed its duties daily for six years, without anything being done to it, and it was then considered time to examine the plates. They were lifted and found in such good condition that the cells were put back into service. Other instances in railway operation are the small capacity batteries used for point machine working and other purposes, when the momentary discharge current is many times the 10 hours rate of discharge for a few seconds. Yet these batteries, if well made and properly maintained, will last for many years under trickle charge conditions.

A difficult problem is encountered when a lighting plant is, as usual, shut down in the late afternoon or evening, the battery thereafter providing the supply all night until the engine is re-started on the following morning. What happens in such circumstances is well exemplified in a recent report about a steam plant, which is closed down at 10.0 p.m. The 250 ampere-hour battery then takes over the supply, starting at a load of 30 amperes and continuing until midnight, the figure thereafter being 15 amperes until 6.0 a.m., after which the early morning load rises rapidly up to 50 amperes or more by 7.0 a.m. The engine generator is supposed to start up at 7.30 a.m. In winter time the load is then approaching 100 amperes, and the nominal capacity of the battery has been almost exhausted. Much then depends on the engineer, for if he is late in " getting away " the tired-out battery has to carry a load far in excess of its normal 10 hours rate. It is to be feared that this procedure is not uncommon in many installations of this kind. Provided that all possible steps have been taken to avoid this last hour of duress and that the owner is aware of the facts, nothing more can be done except to allow for a renewal of the plates sooner than would otherwise be expected. There is one obvious method of overcoming the difficulty, if the working hours cannot be extended, and that is to instal at the outset a battery of such ample capacity that not more than 75 per cent of the charge is taken nightly during the season of heavy demand.

Prolonged Idleness.

This is not considered so harmful as it used to be, provided that a battery is first fully charged. It may then be left on open circuit from one to six months, depending on its situation and other factors. In general it is recommended to charge an idle battery once a month. There are some who consider a periodical discharge is required. This is not essential, however, but is definitely useful as demonstrating that the required capacity is available when the need arises. The development of the rectifier and trickle charging arrangements has now overcome all troubles which may fairly be considered to come under this heading.

Uncleanliness.

We are here speaking of external uncleanliness and not to the removal of sludge or sediment, which is a regular part of the maintenance service once in 5 to 10 years. As a rule batteries are kept clean. In fact it is the general experience of inspectors that upon discovering a battery in a dirty condition, where for instance the plates in a glass cell are invisible on account of an external coating of grime, they may expect trouble. The greatest danger arises with sealed-in type cells, nested close together in a container of wood or metal. An actual case may be mentioned where the neglect had been really bad and allowed an accumulation of dirt, moisture and acid spray to remain for months, resulting in serious arcing when the battery was on charge and the breakdown of some of the cell boxes.

Strong Drink.

In the battery world strong drink means strong acid, something which of course, should never be met with. Even to this day, however, there are still some engineers or attendants who will add strong acid to a cell in low condition, in the belief that they are curing it, but slow and careful feeding is the right way to restore a sick cell—or a man—to health, if the true cause of the trouble is first removed.

Ignorance.

One would think that there was at the present day no excuse for ignorance about the care of accumulators, seeing that so many ready sources of information exist to refer to if a battery is in trouble. Nevertheless some astounding instances of it are met with at times, and not necessarily in the ranks, as it were, but also higher up. A certain power station chief once announced that he wanted his positive plates renewed, but thought that the *zinc* ones would carry on! There are unfortunately, now and then, instances of appalling ignorance displayed in the specifications issued by certain authorities, which in these times give one cause for sad and serious thought. As an instance of the other extreme, in its simplest form, the case may be mentioned of a gardener in charge of a country house battery, whose knowledge went no further than the taking of the hydrometer reading in a pilot cell every day. When the specific gravity dropped to 1175 he started up the engine. For at least 11 years he continued to do this, and even then no repairs had been done, nor were any necessary.

Impurities.

The effect of impurities on the working of storage batteries is a large question which could easily form the subject of a book in more than one volume, as it could also if applied to mankind. The engineer, however, makes no pretence of being either a chemist or a physician and there are ample instructions available in simple form covering the things which are harmful to accumulators and those which are not. In the first place, the manufacturer is responsible for the purity of the materials used in the construction of his products, even down to the sulphuric acid. Thereafter the user is responsible for the supply of water, and he cannot possibly do any harm as long as he uses distilled water from a reliable source. It is unwise to be satisfied with condensed steam, as proved to have been the case with a large power station battery, on being visited for the first time by a competent inspector. Noticing the pale colour of the positive plates and suspecting the presence of iron he enquired about the quality of the topping up water. He was informed that it was " distilled "—in other words, it was condensed steam, drawn from the outlet of a steam trap—and that no complaints regarding it had been received from other inspectors. It had been used for a number of years. The inspector then requested that the steam trap cover be removed, and it was found wholly covered inside with a mass of oxide of iron over ½-in. thick. It is needless to add that the steam trap was thereafter no longer used for the supply of " distilled " water ! Before a still is connected to a live steam main enquiries should be made if boiler fluids are used. The softening compositions are usually heavy in alkaline substances, and on condensation the resulting vapour contains much ammonia.

An impurity can be suspected if :—

(1)—All the positive plates have a brick red colour, probably due to iron (a very dark colour may however be due to ammonia) ;

(2)—There is corrosion of the lugs at the surface, which may be due to chlorine ;

(3)—Falling off in capacity shows itself ; this can be caused by the presence of iron and other metals, or arsenic.

In industrial practice the presence of some impurities in the acid is inevitable, and the object must be to keep their quantities within the limits prescribed in the standard specifications, and to take such steps as will prevent harmful impurities in excess thereof getting into the cells. This is not difficult if, as already mentioned, pure distilled water alone is used for topping up. In a few places tap water may be used, *but only after careful analysis,* failing which it is essential that it be rigidly prohibited.

Having taken this precaution, the only other means by which impurities can enter the acid is from the atmosphere, and this occurs here and there usually as the result of an accident or inexperience. An example of the former is provided by a large capacity open type battery, situated in a basement space adjoining another room in which a refrigerating plant was installed. Normally the dividing wall was securely closed, effectually preventing any passage of air between the one room and the other, but became partly broken one day in a dark corner. This passed unnoticed for a few months, when the battery connecting bars and lugs were discovered to be coated with a white pasty substance, which was found to be sulphate of ammonia. A considerable amount of ammonia had by then got into the battery room and the life of the cells was shortened. Another case, due to an oversight, only discovered after 2 to 3 years working, happened at a railway station. In one room a medium size open type battery was installed and used for power and lighting purposes. In the adjoining room were some hundreds of primary cells—Leclanché, etc.—for telegraph work. There was a direct air connection between the two rooms through a ventilator. Effects similar to those just described resulting, an investigation was made and the trouble was fortunately stopped before the accumulator cells had become seriously damaged.

Modern precautions being amply sufficient to avoid troubles due to impurities, there is no necessity to enlarge further on them here. As in all other matters, the application of common sense and thoughtfulness by an engineer will suffice to carry him right on satisfactorily to the end of the normal life of a battery. An actual instance of thoughtlessness and its effects may be mentioned, however. At a power station provided with a battery of considerable size carboys of sulphuric acid and water were standing in the yard. This station also used hydrochloric acid for metal cleaning, etc., supplied in similar shaped carboys. Going to refill with acid a cell just fitted with new plates, the attendant drew from the wrong carboy and the plates were ruined. The smell of the hydrochloric acid ought, however, to have been sufficient to warn him of his mistake.

Rainwater, carefully collected from a roof that is reasonably clean, where the gutters are not rusty and the receptacle itself is also free from rust, may often be used. The presence of dead leaves in the gutters is, however, difficult to prevent. Moreover, containers are often left uncovered, with the result that the water collecting in them becomes infected with vegetable and animal matter. In some large towns the percentage of ammonia or its compounds in the atmosphere is heavy, such that rainwater collected in the area might not be safe to use in storage batteries.

Conclusion.

The foregoing remarks relate mainly to batteries as a whole. There is, as a rule, little or no difficulty in diagnosing the complaint in the case of ailments affecting a single cell among a group in series. The ordinary cases of short circuits arising from buckled plates, from " growth " on the negative plate accumulating until it touches the positive one, or from sediment mounting up between the plates, are too well known to need any description. Here again, however, the human analogy applies. The cause of the trouble should first be removed by one of the well-known methods, and the cell afterwards coaxed back into a healthy condition by a long charge at a low rate. Above all the use of " dopes," such as are put on the market from time to time, should be as strictly avoided as the taking of quack medicines.

Special Catch Point Interlocking.*

By A. C. ROSE (Member).

Outlying catch points, particularly on certain single lines, are expensive but necessary evils. On double lines automatic operation is simple and cheap, but on single lines the efficient working of catch points outside the station section to ensure that they are only set for the main line when required for the passage of trains in a facing direction, is a problem that cannot be solved without ingenuity and expense.

Take for example the layout shown in the figure. The station is built on the edge of a ghaut and it is all important to ensure that trains, in whole or in part, should not escape down the ghaut. The neighbourhood is such that it would be difficult and costly to remodel the stations suitable for "A" class working, therefore outer signals are provided. Trains are not ordinarily stopped at the up grade outer, but as the signal exists and emergencies occur, a possible breakaway has to be guarded against, hence the catch siding in rear of the outer. But this protection serves another purpose ; non-vacuum down trains leaving the station must be heavily braked by weighted brake handles in addition to brake-vans. The procedure is for the train to start with 2/3rds of the brake handles down and then to stop on the grade for the remainder to be let down, as it would be difficult to start the train on the level with the full number down.

It will be realised that until the train has been fully braked and it is evident that it is under the control of the driver and guards, there is a risk of dangerous speed being attained. Therefore until all the brakes have been let down and the driver and guards have demonstrated their ability to control the train, the facing catch points should be set for the siding. For this purpose, the rules prescribe a dead stop in front of the points which should be set as stated. Unfortunately such rules are liable to breakage and as the consequences on a long steep ghaut with sharp curves would probably be calamitous, it is advisable

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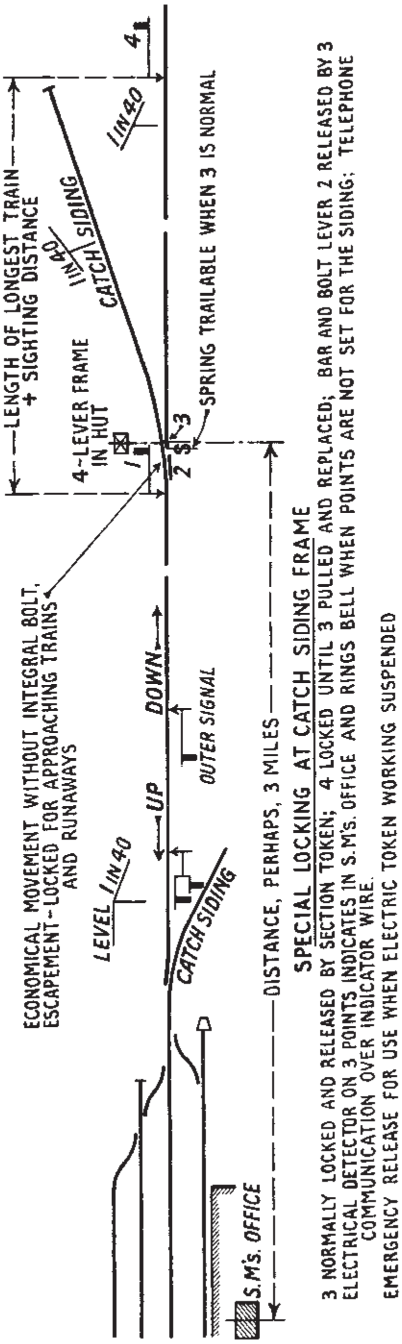
SPECIAL CATCH POINT INTERLOCKING.



to ensure that the points are set for the catch siding and that the dead stop is made by down grade trains. Also that no stop is made by an up grade train until the last vehicle has passed beyond the catch points.

The interlocking essentials for such protection are as follows :—

(1) Trailable spring catch points normally set for the catch siding but capable of being set and locked for the main line.

(2) The lever working the points to be released by the section token, the arrangements being such that the token can be extracted immediately the release has been effected.

(3) A stop signal for the down grade direction in rear of the catch points, and interlocked with them so that it cannot be lowered until they are set for the main line.

(4) A stop signal, the longest train length, plus adequate sighting distance, in advance of the catch points, so interlocked with them that the signal lever cannot be pulled until the catch point lever has been restored to normal, thus setting the points for the catch siding, when the lever becomes locked and can ordinarily only be released by the token of the section.

(5) An emergency release to take the place of the token should token working be suspended.

(6) An electrical indicator in the stationmaster's office showing the position of the catch points as the stationmaster is responsible not to grant or receive "line is clear" unless the indicator shows that they are set for the catch siding.

Points No. 3 are fitted with a trailable spring apparatus, so designed that when set for the catch siding the points can be trailed through by each pair of wheels. The points can also be moved from their normal position to the straight, by No. 3 lever, without compressing the spring provided for trailable operation. The points are fitted with a switch and lock movement, without integral bolt mechanism, so that they are escapement locked for approaching trains, and for breakaway movements into the catch siding. The points are also fitted with an electrical detector which indicates their position in the stationmaster's office. Should they not be set for the catch siding a warning bell rings. A telephone is superimposed on the indicator wires to enable the stationmaster to communicate with the pointsman in the event of an emergency. The standard lock bar and bolt apparatus is worked by No. 2 lever, which locks No. 3 reversed only. Lever No. 3 is normally controlled by a special token release apparatus arranged so that the lever can only be moved from the normal position by the insertion of the token, which is not then locked in the apparatus.

Lever No. 4, working the advanced starting signal, is released by point lever No. 3 pulled and restored. This locking also ensures that lever No. 4 must be restored before the point lever can be pulled, thus ensuring that No. 4 is not left over.

The operating procedure is as follows—

(a) *Down trains.*—Before obtaining " line is clear " the stationmaster observes that the point indicator shows the points to be set for the catch siding. The driver whistles as he approaches signal No. 1 at danger and comes to a stand as near it as possible. The fireman alights with the token and inserts it in the release on No. 3 point lever which is then pulled by the pointsman, who also locks the points and lowers No. 1 signal. Meanwhile the fireman has extracted the token and returned to the engine with it, thus enabling the driver to proceed. As soon as the last vehicle has cleared the points the pointsman restores them to their normal position, set for the catch siding, when the lever becomes token locked and releases advanced signal No. 4, which is lowered and the driver proceeds.

Should the point indicator show that the points are not set for the catch siding, the stationmaster issues a caution order to the driver of the train and goes to the points to investigate, and ensure safe working.

(b) *Up trains.*—The stationmaster assures himself that the points are correctly set for the catch siding before granting line clear. No action at the catch points is necessary other than to ensure that signal No. 4 has been restored to danger. As the train trails through the catch points, the electrical detector is operated and the bell in the stationmaster's office rings, thus warning him of the approach of the train and reminding him that unless his up outer has been lowered, the train will be irregularly stopped on the steep grade.

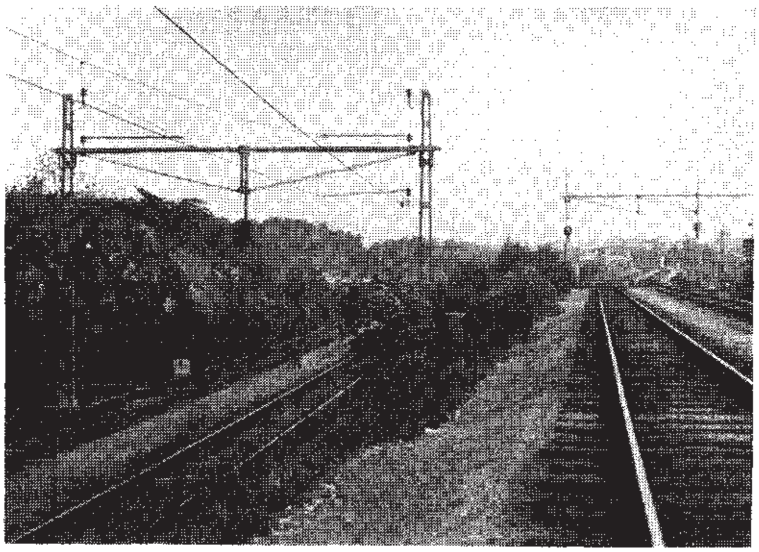
Signalling on the Swedish Railways.*

By T. S. LASCELLES (Hon. Treasurer).

Although railways made their appearance in several European countries within a few years of their introduction for public service in Great Britain, it is of some interest to note that such refinements of working as signalling and interlocking—especially the latter—were much slower in securing adoption there, even where English influence was active. To some degree, no doubt, this was due to the fact that traffic did not grow to anything like the remarkable extent it did during the first half of the last century in England, with the accompanying great increase in industrial activity. These considerations apply to Sweden, where the first railway was opened in 1856, about the period when the earliest practical experiments in interlocking were engaging the attention of Saxby and Chambers in England and Vignier in France. Within 25 years interlocking apparatus was being extensively used in both those countries but was not seen in Sweden until 1888, when the State Railways made an installation. Signals, both disc and semaphore, had made their appearance, the latter being frequently of the type having an arm for each direction at the same level, like the old " main " signal at one time prevalent in India, and constructed on the English model, with left-hand lower quadrant movement. (Both rail and road traffic works left-handed in Sweden ; towards the end of 1940, however, the authorities decided to adopt the right-hand rule of the road on the highway in June, 1943). Such signals were, however, used at important places only, for the most part, and the points long continued to be worked locally on the ground. After 1888 progress with the installation of modern safety devices, but leaning much on German ideas, was gradually made, although much prejudice had to be overcome, and the larger stations were equipped with well-constructed apparatus as opportunity offered. A very serious collision, due to the lack of efficient appliances,

* Reprinted, with additions, from *The Railway Gazette* for November 1, 1940, by kind permission of the Editor, Mr. J. A. Kay.

occurred at Malmslätt on June 16, 1912, and the Government appointed a commission to investigate and report on the whole subject of safe working. The commission reported in August, 1913. More than half the State railway stations then still needed proper interlocking. Most of them had bolting of the points, especially facing points, by the signal transmissions, but the traffic imperatively demanded more than this. The commission made a series of recommendations covering the whole of signalling, traffic working, rules, etc., but the 1914 war and the economic difficulties it created in Sweden prevented improvements being

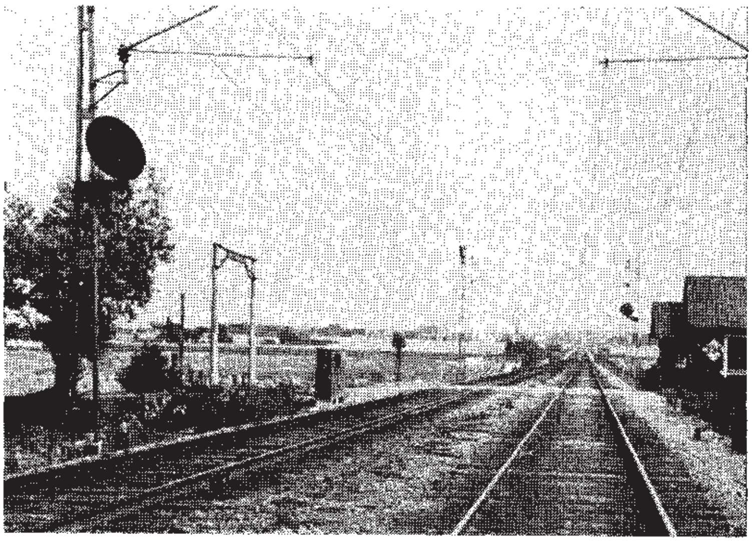


Colour light signals carried on contact wire standards.

carried out. In later years this actually had the effect of securing the adoption of more progressive measures than had been intended, the absolute necessity of considering economy as much as safety leading to a radical change in principles of operation and a breakaway from Central European ideas.

Signal Aspects.

The running signals long consisted of the usual Central European distant, home and starting, the advanced starting not being seen, with circular disc, rotating on a horizontal axis for the distant signal and the ball ended semaphore arm for the others. The first interlocking apparatus was of German make and the details of signals were German also, with lattice or steel section posts, metalwork arms and other fittings. The German junction signal, with concealed lower arm, was also adopted, but it is worthy of note that lower quadrant working did not give place to upper quadrant until 1915. Signals with two concealed arms were also used at certain places. The danger that could arise from a light going out caused the Malmslätt commission to recommend the working of the junction signal being reversed—a step actually taken in Norway—but the general adoption of acetylene signal lighting in 1918 was held to make such a radical change unnecessary. Light signals for day and night use first appeared at Södertalje in 1923 and are now the standard. The night aspects adopted were red and green for semaphores and green and white for distant discs, the practice at the time in Germany, the distinction between the green light in a distant " on " and a semaphore " off " being derived from the height above rail level, distant signals all being on very short posts. The Malmslätt report recommended the use of yellow for " caution," but the idea was not favourably received, although a trial was made with it in some special distant signals of semaphore type, having pointed arms, used to indicate at the home signal whether a train might run right through, first put in between Stockholm and Saltskog in 1914. The yellow light was not retained, however, partly from a desire to avoid the difficulties which any transitional period must occasion and because the use of red, green and white did not necessitate such close colour specifications for the signal glasses, especially with acetylene lights, in which the white light is quite distinctive. By making the distant signal lights flashing all difficulty in distinguishing them from others was abolished. The danger of a green glass breaking was considered sufficiently met by using a very strong wired glass, installed everywhere by 1930. The subsequent standardisation of colour light signals has, of course, eliminated the question of broken spectacle glasses altogether. Thus it comes about that the yellow light is not seen in running signals in Sweden. It is seen, however, in a special signal indicating a " flag station " stop. A flashing green light indicates " caution " and a flashing white that the signal ahead is " off." This latter indication is said to be very distinctive, being exceptionally visible in the daytime. Up to 1914 the distant signals had been two-indication and worked simultaneously with the home signal for all routes, as in Germany. In that year, on the Saltskog line, experiments were made with a three-aspect signal, having a fishtailed arm mounted below the disc, and normally in line with the post, but the signal was not adopted. Its construction was a little complicated. About the same time home signals were all moved 200 m. (219 yd.) from the fouling point and distant signals placed much further out than had usually been the case. In 1923 a beginning was made with



Colour light distant signal. Just beyond the crossing is seen a position light signal for reversible line working.

installing colour light distants, the first being put in at Gnesta station. This consisted of an acetylene light with special lens combination and internal spectacle worked by a gas mechanism governed by an electrically controlled valve. It proved highly satisfactory and by 1930 some 25 per cent of all distant signals were colour lights, the gas mechanism being used where no power supply was readily available, and ordinary colour light units elsewhere.

With the older semaphore system route aspects were given, as far as the 2 and 3-arm system would allow, supplemented by " directing signals " in advance, as in the then German practice.

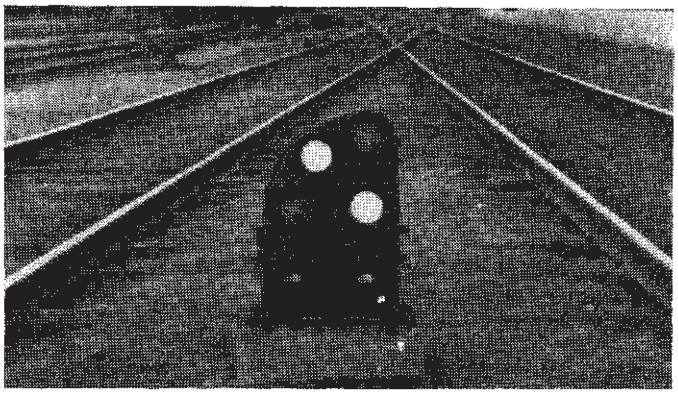
This was followed (except for the "directing" signals) with colour lights, but later practice has been to attach a speed meaning to the signals and restrict the triple green aspect to controlling the entrance to goods and subsidiary lines. All home signal units carry a distant unit, showing flashing green or flashing white when the direct route is signalled, to repeat the starting signal in advance.

Signals for Shunting.

For many years all points had point indicators, on the Central European system, and a few semaphores were used as "stop shunting" signals, but eventually a special signal was introduced for this purpose. After a study had been made of the signalling practice in other countries, especially Great Britain and America, it was decided to adopt the principle of signalling all shunt movements and the position light dwarf signal was selected for the purpose, with 3-aspect working. The dwarf signals are now used for governing all movements within station limits, being shown in the third position for a running train. Colour light starting signals are not provided for each converging outlet road, the dwarf signals sufficing, a single colour light advanced starting or block section signal being placed beyond the last pair of points, restricting colour lights to the absolute minimum. Certain dwarf signals have a fourth aspect called "neutral," which authorises movements under the orders of a shunter on the ground. Point indicators remain in use, however, at many places, double slips having one indicator displaying four distinct signs.

Mechanical Signalling.

This has for very many years been exclusively of the double wire type, using German designs and often in earlier years purchased from German firms. At the smaller stations the frames are worked by the station supervisors who, even when this is not the case, control any signal boxes in their station limits. Points located at some distance from the supervisor frequently have a "dual" mechanism, enabling them to be worked locally with his permission. The peculiar "crank handle" type of frame has found much favour, being very suitable for working out of doors. Its original disadvantage of not allowing such long transmissions to be used as the ordinary double wire lever has been overcome by installing closer pulleys and ball bearing fittings. Standardisation of mechanical signal equipment was begun in 1912 and completed in four years. Signals are invariably operated by cam plate mechanisms. On many single line sections there is little traffic at night and stations are closed, special locking arrangements being used to enable signals to be cleared for opposite



Position light signal with additional green fixed and flashing light units below repeating advanced starting (block) signal.

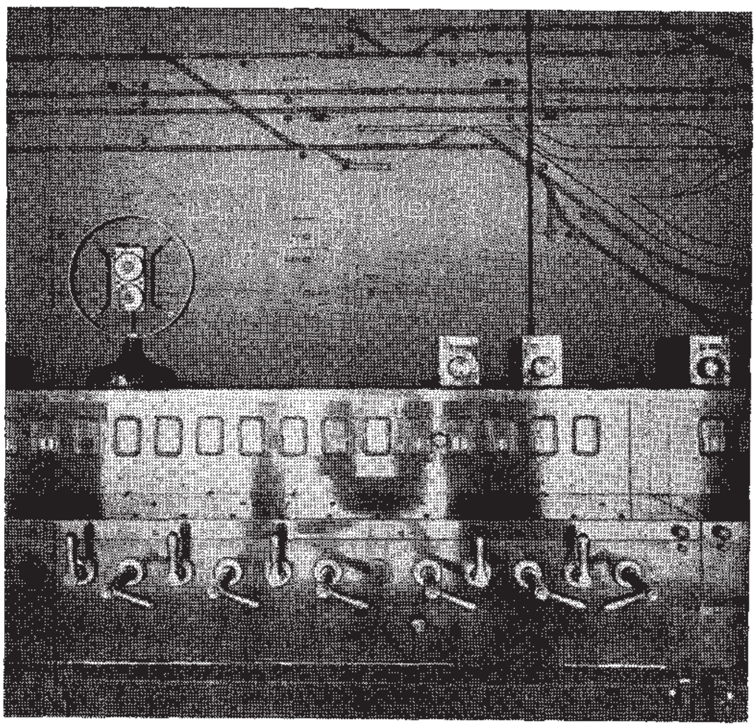
directions simultaneously. Some stations have key locking. There is the usual route holding locking, so general in Central Europe, and much use is made of track locking sections in place of lock-bars. In course of time the manufacture of mechanical signalling was taken up in the country, but general principles remained unchanged.

Block Working and Track Circuits.

In the beginning trains were worked by time table rule and later by the telegraph message system, which was in effect block working. In 1906 the Siemens a.c. lock-and-block apparatus was introduced between Malmö and Arlöv and subsequently was much extended to both double and single lines, it being decided in 1912 to work all important routes in this manner. It was found however that the apparatus did not lend itself readily to the switching out of stations during hours of light traffic, rendered increasingly necessary by the economic position, especially on single lines, while to put the equipment temporarily out of use and work by telegraph, as was sometimes done, was decidedly unsatisfactory. Automatic signalling was therefore resorted to and two short double line sections between Norsholm and Kimstad and Gothenburg and Olskroken equipped in 1925. The former section had ordinary type signals, the latter light signals of the acetylene type. Soon afterwards the Malmö-Arlöv line was converted to automatic working. Track circuiting—except for short rail lengths acting in conjunction with electric treadles—was late in finding favour in Sweden, but experiments were begun with the intermittent feed type at Tomteboda in 1918, and gradually track circuits were applied on the ordinary principles, at a number of signal boxes. Both a.c. and d.c. apparatus was used, depending on local circumstances. It is found that, with suitable arrangements, d.c. track circuits can be efficiently worked where the single-phase a.c. traction is in service. The first illuminated diagram was installed at Flen in 1925. In recent years there has been a large increase in track circuiting and automatic signalling and in many installations both tracks of the double lines have been fitted for both way operation, movements in the right direction being controlled by colour lights and in the wrong direction by position lights. These improvements have been applied to most of the new work undertaken in recent years. The Siemens block was also applied to enable the station supervisor to control the signalmen in the area under his orders, this method of working having been recommended by the commission, but other apparatus has also been used for the same purpose.

Power Interlocking.

Power signalling first made its appearance in 1910, when an all-electric installation was provided at Nyboda. (The all-electric system has ever since been used exclusively). This equipment was of German make, with mechanical locking and circuits on the Central European style. There was no track circuiting and several signal boxes were therefore required in some layouts, of which Hagalund, Uppsala, Järna and Luleå-Svartön were typical. Further work was interrupted by the 1914 war and in 1916 installations of similar type, but made in Sweden, were put in at Eslöv and Åby, followed by several more during the next 6 or 7 years. There was little or no saving in staff costs with this system. The difficulties of working mechanical signalling in the severe weather conditions obtaining on the Lapland line led to electric working, using a.c. point motors, being substituted, the frames being in the stationmasters' offices. (The Norwegian Railways fitted the Narvik terminus with power working in 1930). In 1925 a decisive step forward was taken when the important station at Malmö was power signalled. A great deal of shunting took place there and the three mechanical signal boxes were supplemented by



Part of a modern power frame with all-electric locking.

observation posts for the better supervision of the movements. The disadvantage of the point indicator system was apparent and it was decided to break away from it and adopt a complete equipment of independent shunt signals of the position light type, with one central signal box and automatic signalling on the adjacent block sections, resulting in a saving of 22 men and greatly speeding up the working. The locking frame in this instance was of a well known English type with indication locking and signal selection. Trailable points were retained and are still standard, with practically no locking between point levers, as in previous work. This is considered better for Swedish conditions, as otherwise the inability to operate one pair of points, due to frost or snow, may unduly interfere with the emergency use of others. Internal locking mechanism has superseded the hook and other outside forms of point lock. The platform starting signals were colour lights at Malmö: the use of ground signals for all movements inside station limits came later. The excellent results obtained soon led to other installations being made, but of Swedish design. At Hässleholm in 1927 mechanical locking was given up in favour of electric, and this has been done in most of the work since. Further work followed at Lund in 1929, Gothenburg in 1930 and then Stockholm Central. Electric locking was later adopted for a number of small installations, such as Abisko, Kiruna, Bodens and Jönköping, while the point indicator system gave way to the ground signal system at a number of places where the older type of power working was in use, such as Luleå. Track circuits became more and more general. In recent years C.T.C. apparatus has made its appearance.

Power Supply.

In all the early power work accumulators were invariably provided for point operation. The costs were not low and trickle charging was introduced to enable the reserve cell equipment to be reduced. Where two sources of power were available direct working through rectifiers was used, with the accumulators as final standby, but later they were dispensed with at many places. Where, however, much of the equipment was a.c. operated accumulators could not, of course, serve as standby, when one was considered essential, and reserve petrol generator sets, were used, but at many small stations no standby was thought necessary.

Swing Bridges and Level Crossings.

Both swing and lift bridges—the latter type now the usual—are worked electrically, with electrically operated safety siding points, light signals and approach locking control by track circuit. Many flashlight warning signals have been installed at level crossings, principally at the unattended ones, and where barrier gates exist these have been adapted for power operation, hand working being kept as a reserve. At some places, such as Halmstad, there is a number of crossings in a short distance and by concentrating the working in the hands of the station supervisor the gatemen originally employed have been dispensed with. The barriers are set across the road from the station when a train is about to approach but clear up automatically in turn as it passes them, reducing delay to road traffic to a minimum. Power control of barriers has been included in the recent resignalling at Uppsala.

Although what has been said above chiefly relates to the State Railway system some of the most up-to-date equipment, including C.T.C., is to be seen on the privately owned lines. The progress made in signalling in Sweden during the last 15 years or so has been due in great measure to the ability and foresight of Mr. T. Hård, Member, Signal Engineer of the State Railways, who contributed a most comprehensive study of the question to the railway commemorative volume issued by the Swedish Government in 1931, from which the above particulars are chiefly taken.

Summer Evening Meeting at Watford : August 1st, 1941.

The prevailing conditions making it impossible to hold the usual summer meeting the Council, in response to a wish expressed by a number of members, arranged to hold a special evening meeting with supper at the Spider's Webb Restaurant, Watford By-pass, on Friday, August 1st, 1941, which was attended by over 100 members and ladies. The President, Mr. James Boot presided, supported by Mr. R. Falshaw Morkill, Vice-President, Messrs. J. Punter, R. S. Griffiths and H. M. Proud, Past Presidents ; Messrs. A. Moss, L. J. M. Knotts, F. L. Castle, L. J. Boucher, F. Horler, and C. H. Hills, Members of Council, and the Hon. Treasurer, Mr. T. S. Lascelles. Messages regretting inability to be present were received from Mr. W. C. Acfield, Past President, Mr. G. H. Crook, Past President, and Mr. M. G. Tweedie, Hon. Secretary. The evening proved most enjoyable to all.

At supper, after the Loyal Toast, Mr. J. Boot expressed the pleasure the Council felt at the support given to the meeting. The ordinary meetings still had to be suspended and it was thought members would welcome the opportunity to attend an informal gathering before the days became shorter and difficulties of travelling increased. To the Council's great regret, Mr. H. W. Moore had felt obliged to relinquish the office of Vice-President, which he had held since February 22, 1939, and Mr. Morkill had kindly consented to accept it ; this change had just recently taken place. They were under an obligation to the General Purposes Committee for arranging the present meeting and especially to Mr. and Mrs. F. L. Castle, who had given particular assistance in the matter.

Supper was followed by dancing, Mr. C. H. Hills, Member of Council, acting as M.C.

OBITUARY.

ROBERT JOHN FRANCIS HARLAND.

Mr. Robert John Francis Harland, who died at Streatham, London ,on February 2, 1940, at the early age of 44, was born and educated at Rochester, Kent, and entered the service of the Signal Department of the South Eastern and Chatham Railway in 1914, after being employed by W. R. Sykes Interlocking Signal Co., Ltd., of Clapham, on the installation and maintenance of track circuit equipment at signal boxes in the Chatham and Gillingham area. In 1915 he joined H.M. Forces and saw service in France with the Signal Corps, Royal Engineers, returning to the railway in 1919. For about six years he was then engaged as Lineman on the maintenance of the Sykes lock-and-block apparatus and track circuit work. In 1925 the Southern Railway, in which the South Eastern and Chatham had by then become merged, commenced the installation of its first multiple-aspect colour light signalling between Holborn and Elephant and Castle, Mr. Harland being among the first men selected to assist in the work and being promoted to be Chief Lineman in 1928. He was made Sub-Inspector in 1931 in connection with the colour light signalling on the main line between Coulsdon and Brighton, being retained for district maintenance work on completion until 1936, when he was appointed Inspector at Clapham Junction, his district including such important stations as Waterloo and Victoria. During the time he held this post the important installation of power signalling at Waterloo, with colour light signals to Hampton Court Junction, and the substitution of electric for the old pneumatic type power frames at West London and Clapham Junction was successfully carried out. In January, 1940, he received the rank of first-class Inspector. Mr. Harland, who was ever most keenly interested in his professional work and studied every detail of it with much thoroughness, became an Associate Member of this Institution in 1933.

RICHARD DORMER.

Mr. Richard Dormer, who died at Norbury, London, on October 5, 1940, after a short illness, was born at Newtownbarry, Co. Wexford, Ireland, on June 26, 1875, and was first employed at the Great Western Railway's Poplar goods station. He made an excellent model of one of the vans used there, which brought him to the notice of Mr. L. M. G. Ferreira, then Telegraph Superintendent of the North London Railway, who offered him a situation on that line, which he accepted and in due course became engaged on the maintenance of the Ferreira type block telegraph instruments used by the N.L.R. The lock-and-block system introduced by Mr. Ferreira in conjunction with the late Mr. H. J. Pryce, the Locomotive Superintendent, President of the Association of Railway Companies' Signal Superintendents and Signal Engineers and of the companion Association of Telegraph Superintendents and Engineers for 1895, was adopted by the East Indian Railway, whose Signal Engineer was then Mr. S. T. Dutton, and Mr. Dormer, with the late Mr. F. E. Leversedge, of the Great Northern Railway, was selected for the post of Maintenance Inspector, in connection with the original 126 mile section between Calcutta and Asansol, sailing for India in November, 1900. An instructional room was fitted up by him with a complete set of apparatus and every signalman had to have a certificate of competency before being allowed to take charge of a signal box. Mr. Dormer, who was one of the ablest Inspectors the E.I.R. ever had in its service, returned home in 1916 to join the Royal Engineers and attained the rank of Captain, eventually having command of the No. 4 Section of the 200th Railway Signal and Interlocking Company, operating in France and Belgium, under Major R. Falshaw Morkill, in whose company he entered Lille immediately after the retirement of the Germans, they being the first two British officers to do so, proceeding later to Cologne with the Army of Occupation. Returning to India in May, 1920, Mr. Dormer was selected to take charge of the first fully equipped railway training school established in that country at Asansol, of which he made a conspicuous success, and after the E.I.R. became a State Railway he was appointed Superintendent of the State Railways Staff College at Chandausi, later transferred to Dehra Dun. The fine model room which he designed and equipped at the latter place became known after his retirement as the Dormer

Hall. He threw himself into this educational work with much enthusiasm and his varied gifts, which made him a born and highly capable instructor, will cause him to be long remembered in India, where there must be large numbers of staff who were trained by him. Mr. Dormer retired on June 26, 1931. He was elected an Associate Member of this Institution in 1917 and a Member in 1924.

ERNEST FÉLIX WAGNER.

Monsieur Ernest Félix Wagner, who died in France in the course of the year 1940, is believed to have been born in 1876 and became a prominent figure in brake and signal engineering circles on the Continent. He was a student of the École Centrale in Paris and began work at the brake manufacturing town of Freinville in the Department of Seine-et-Oise, France, about 1903-1904, and was employed chiefly in dealing with Westinghouse brake interests among railway officials in that country and elsewhere in Europe. He was an excellent linguist and spoke English well. He eventually became General Manager of the Compagnie des Freins Westinghouse and was for the last eight or nine years of his life its Managing Director. Well-known to some signal and brake engineers in this country, he often visited England on business. On the occasion of the summer visit of this Institution, of which he became a Member in 1921, to the Northern Railway of France in 1927, under the Presidency of the late Mr. E. F. Fleet, he joined the company in Paris and showed much courtesy and assistance to those who attended the meeting. It is to be regretted that the continuance of hostilities makes it impossible to do more than give the above brief particulars of his career. The deceased was a Member of the Legion of Honour and was awarded the Croix de Guerre in the last war.

ALFRED SMITH HAMPTON.

Mr. Alfred Smith Hampton, who died on February 4, 1941, was born at Brechin, Scotland, on May 31, 1873, and was educated at Dundee Academy and the Royal Technical College, Glasgow, and served an apprenticeship to the Woodside Electrical Company in the latter city, on the completion of which he joined the Caledonian Railway's Telegraph and Electrical Department as a draughtsman, rising eventually to become Assistant Electrical Engineer and Telegraph and Electrical Engineer. He carried out the design and installation of the 33,000 volt transmission line from Bridge of Allan to Gleneagles, the wiring for light, power, telephones and bells of the Gleneagles hotel, the electrical engineering work for the Grangemouth docks extension, and the coal conveyor plants at Stranraer and General Terminus. He was also responsible for the supervision of the installation of the large power signalling installation at St. Enoch station, Glasgow, in replacement of the old electro-mechanical signalling. Mr. Hampton was a Member of the Institution of Electrical Engineers and Chairman of its Scottish section in 1922, as well as of the Institute of Transport. He was elected a Member of this Institution in 1913 and served as a Member of Council during 1924.

HERBERT CHARLES WAY.

Mr. Herbert Charles Way, who died unexpectedly in India on May 31, 1941, at the age of 51, was born in Dorsetshire in 1890 and educated at Taunton School and Hartley University, Southampton. In 1908 he joined the London and South Western Railway's Signal and Telegraph Department, in which his father, Mr. W. J. Way, was an Inspector and later an Indoor Technical Assistant, and remained with that line until 1917 when he joined the Army and served as an officer in the Royal Engineers. In December 1920, Mr. Way was appointed Temporary Signal Engineer to the Bombay, Baroda and Central India Railway, his position being confirmed in the following July with the rank of Junior Signal Engineer. He was promoted to the rank of Senior Signal Engineer in 1924 and was appointed Deputy Chief Engineer, Signals, in succession to Mr. W. H. Hayles, in December, 1935. He was stationed at first in Bombay, but moved for a time, first to Bulsar, on the broad gauge lines, and then to Ajmer, to take charge of the work on the company's metre gauge system, returning in due course to the Bombay Headquarters. During his years of service with the railway numerous important improvements were effected in its signalling equipment, especially on the heavily worked routes in the vicinity of Bombay, where the latest power and colour light signalling was installed and greatly facilitated the operation of the electric train services in the suburban area. Descriptions of the apparatus used on both the broad and metre gauge lines of the Bombay, Baroda and Central India Railway have appeared in previous issues of these Proceedings. Mr. Way's untimely end is a matter for keen regret among his colleagues, both in India and Great Britain, who had come to feel much respect for his character and professional abilities. He was elected a Member of this Institution in 1920.

PETER ASHCROFT ARNOTT.

Mr. Peter Ashcroft Arnott, who died at Helen's Bay, Co. Down, Northern Ireland, on September 25, 1941, was born at Perth and educated at George Watson's College, graduating finally as Civil Engineer at Edinburgh University. He then obtained a post in the service of the North British Railway and was with that line for some years. In 1906 he was appointed Assistant Engineer to the Belfast and County Down Railway and served many years in that capacity under the late Mr. G. P. Culverwell, during which time he was directly responsible for the works in connection with the new terminus at Queen's Quay, Belfast, and the re-signalling of the Belfast yard, which involved the erection of one of the largest signal boxes in Ireland. Mr. Arnott had always taken considerable interest in signalling and was well acquainted with its theory and practice although he was a civil engineer by profession. He joined this Institution in the second year of its existence and was elected a Member. In 1919, on the death of Mr. Culverwell, he became Chief Engineer to his railway and controlled the whole of the Engineering Department with conspicuous success. He relaid the greater portion of the line with bull-head rails in place of the flat-bottomed type previously employed and carried out the renewal of the largest bridges on the system, such as those at Holywood Arches, Connswater and Dundonald, the Carstand Bridge at Comber, Quoile Bridge at Downpatrick, and others. Faced with the insistent demand for greater economy in operating costs and the running of the most efficient service to meet road competition, which was severely felt by the B. & C.D.R., Mr. Arnott introduced numerous signalling improvements, many of which were specially adapted to the rather difficult conditions obtaining on the railway. He installed track circuiting throughout the Belfast yard and automatic signalling over the entire line between Belfast and Bangor, eliminating the intermediate signal boxes. These installations were worked on the normal danger system, the only other instance of which in the United Kingdom is believed to have been that originally put in between Alne and Thirsk on the North Eastern Railway. The later work carried out under Mr. Arnott's direction involved a special design of banner signal, in which the day indications were given in the customary manner, but the night indications were given by coloured lights, approach lighted, produced by a special spectacle mechanism and electric lamp unit. Some of the signals also had "A" signs, for use at signal boxes open only at intervals. On other parts of the line Mr. Arnott introduced outer home and intermediate advanced starting signals, to reduce the length of the block sections and expedite traffic, together with several installations of single line token switching apparatus, the results of which were highly successful. At Ballynahinch Junction he introduced a specially designed attachment to an existing mechanical frame, making it into an electro-mechanical one, in order to enable ground shunt signals to be added without extending the length of the original signal box, which it would have been very inconvenient and costly to do. His constant and successful efforts to reduce working expenses were much appreciated by his company. In the spring of 1941 he had an illness, from which he made a good recovery, so that his end came as a painful surprise to his colleagues, by whom he was highly esteemed.

HEDLEY JAMES ALLEN DYER.

Pilot Officer Hedley James Allen Dyer, who gave his life while serving with the Royal Air Force, was born at Derby in September, 1915, the elder son of Mr. H. H. Dyer, Member of Council, and on leaving Loughborough Junior College joined the London Midland and Scottish Railway's Signal and Telegraph Department in January, 1933, as an Engineering Apprentice. After training in the Signal and Telegraph Workshops at Crewe, with maintenance staff on the line and in the Drawing Office at Derby, he was posted to maintenance work at Willesden Junction and later at Barking. On the outbreak of war in September, 1939, he was mobilised, having joined the Royal Air Force Volunteer Reserve some time before, and after a further period of training was posted to a Squadron of Bomber Command as Sergeant Pilot. He made many operational flights, and early in 1941 he was awarded the Distinguished Flying Medal for "gallantry and devotion to duty in the execution of air operations." Shortly after this he received his commission. In September, 1941, he was reported missing in the course of an operational flight and news was eventually received that he had lost his life, with the other members of the crew. He was elected a Student Member of this Institution in 1935.

ANDREW VERDIE.

Mr. Andrew Verdie, who lost his life by enemy action during 1941, was born in 1870 and entered the service of The Craigpark Electric Cable Co. Ltd. in 1897 in Scotland. He left Glasgow in 1904 to become its agent in London, in which capacity he became widely known in railway electrical engineering circles. Together with Dr. A. B. McLean, a Director and one of the promoters of the company, Mr. Verdie had had considerable experience with the India Rubber, Gutta Percha and Telegraph Works Co., Ltd., of Silvertown, North Woolwich. His professional attainments and experience as a cable maker earned him much esteem and his able representation of his company's interests brought him into close association with many signal engineers, who had occasion to use material furnished by his firm, of which he was made a Director in 1926. One of his principal recreational interests was the game of golf, in which he had acquired much skill. He had a bright, genial disposition which earned him many friends, to whom his tragic end came as a most painful shock. Mr. Verdie was elected an Associate of this Institution in 1929.

List of Names and Addresses of Members, 1941.

Corrected to March 1, 1942.

NOTE.—A new name is not included until the first subscription is received. Members are requested to inform the Hon. Secretary of changes of address and designation.

Overseas Members, when in England, are asked to forward their address to the Hon. Secretary together with an intimation as to how long their temporary address holds good.

Certain members are stationed at temporary addresses during the continuation of the national emergency. In addition to those shown as on active service a certain number have served for a period and returned to civil life.

FOUNDATION MEMBERS.

Name.

1912 Acfield, Wilfred Cosens, O.B.E. (Past President)
1912 Blackall, Alfred Thomas (Past President) (*deceased*)
1912 Firth, Harold William
1912 Insell, Robert James Singer (Past President) (*deceased*)
1912 Johnson, Arthur Henry (*deceased*)
1912 Sayers, Josiah, O.B.E. (Past President)
1912 Dutton, Charles

HONORARY MEMBERS.

	Name.	*Address.*
M. 1913 *H.M.* 1936	Brown, H. G.	Melrose, Ashburton, Devon
M. 1913 *H.M.* 1922	Cotterill, William Howard	" The Downs," Brading, I.O.W.
1913	Denney, C. E. ...	President, Northern Pacific Railway, St. Paul, Minn., U.S.A.
M. 1913 *H.M.* 1932	Ferreira, L. M. G.	26, Regency Square, Brighton, 1
1929	Mount, Lieut.-Col. Sir Alan H. L.	Ministry of War Transport, Berkeley Square House, Berkeley Square, W.1
1913	Rudd, A. H.	Upper Farm, Lakeville, Conn., U.S.A.
1919	Terrell, George ...	Managing Director, Tyer & Co., Ltd., 16, Ashwin Street, Dalston, London, E.8

Name.	*Address.*
1929 G. J. de Vos van Nederveen Cappel	Directeur, Alkmaarsche Ijzer en Metaalgieterij, Voorduinstraat, Alkmaar, Holland
A.M. 1913 *M.* 1920 *H.M.* 1935 Wallis, A. B. ...	40, Fairfield Road, Derby
1925 Willaert, Germain ...	Belgian National Railways, Engineer-in-Chief, Permanent Way Department, Brussels

MEMBERS.

1928 Ablett, James Samuel	22, Tillett Road, Catton, Norwich
1913 Acfield, Wilfred Cosens O.B.E. (Past President)	
S.M. 1925 *A.M.* 1928 *M.* 1936 Aldridge, T. J.	Continental Engineer, Westinghouse Brake & Signal Co., 82, York Way, King's Cross, N.1
1927 Alexander, Albert Cecil	Assistant to Signal and Telegraph Engineer, The Engineer's (Scotland) Dept., L. & N.E.R., 47, Leith Street, Edinburgh
1915 Ames, Azel, Col. ...	30, Church Street, New York, U.S.A.
1928 Anderson, Burt Thompson	General Sales Manager, Union Switch & Signal Co., Swissvale, Pa., U.S.A.
A.M. 1938 *M.* 1938 Anketell, C. A. R.	Assistant Engineer, Ceylon Government, Colombo, Ceylon
1923 Atkins, F.	"Ashview," Crowle, near Scunthorpe, Lincs.
1930 Atterbury, William Albert ...	Telegraph Engineer, Posts and Telegraphs, Tanganyika, G.P.O., Dar-es-Salaam, East Africa
A.M. 1922 *M.* 1931 Ault, A. J. ...	District Signal and Telegraph Assistant, L.M. & S.R., Watford Junction Station, Watford
A.M. 1920 *M.* 1922 Austin, Tom ... (Hon. Auditor)	Chief Engineer, Siemens & General Electric Railway Signal Co., Ltd., East Lane, Wembley
A.M. 1923 *M.* 1927 Baker, E. W. ...	Railway Buildings, P.O. Chittagong, Bengal, India

Name.	*Address.*
1931 Ballard, Thomas William	Messrs. Tyer & Co., Ltd., 16, Ashwin Street, Dalston, E.8
S.M. 1923 *A.M.* 1930 *M.* 1934 Barfoot, R. M.	S.R., Signal and Telegraph Dept., Wimbledon, S.W.19
A.M. 1921 *M.* 1926 Barker, Ernest Arthur	Signalling Assistant, L. & N.E.R., Signal and Telegraph Engineer's Office, N.E. Section, York
A.M. 1915 *M.* 1925 Barnes, W. ...	L.M. & S. Rly., Divisional Signal and Telegraph Engineer's Office, Hunt's Bank, Manchester
A.M. 1923 *M.* 1934 Bartlett, G. A.	Assistant Signal Engineer, East Indian Railway, Dinapore, India
S.M. 1930 *A.M.* 1934 *M.* 1940 Battams, Eric Charles	Assistant Signal Engineer, B.B. & C.I. Railway, Ajmer, India
1937 Beall, C. R.	Chief Engineer, Union Switch & Signal Co., Swissvale, Pa., U.S.A.
1932 Beath, George Christian	Kenya and Uganda Railways and Harbours, Box 79, Nairobi, Kenya
1922 Beavan, R.	Sales Engineer, Railway Signal Co., Ltd., 40, Broadway, Westminster, S.W.1.
A.M. 1922 *M.* 1941 Beighton, S. ...	Area Technical Assistant, L.M. & S.R., Signal and Telegraph Dept, Glasgow (St. Enoch)
S.M. 1932 *A.M.* 1937 *M.* 1940 Bennett, Peter Scott	Assistant Signal Engineer, Bengal North Western Railway, Gorakhpur, U.P., India
1914 Boot, James ... ... (President)	Signal Engineer, General Railway Signal Co., Ltd., Hillcrest, Frith Hill, Great Missenden, Bucks
A.M. 1921 *M.* 1934 Boucher, Lewis James (Member of Council)	S.R., Signal and Telegraph Dept., Wimbledon, S.W.19
1913 Bould, Reginald Perry	St. Patrick's, 15, New Road, Northbourne, Bournemouth
1913 Bound, Arthur Frank (Past President)	Signal and Telegraph Engineer, L.M. & S.R., Watford
1936 Brentnall, E. G. ...	Chief Technical Assistant, L. & N.E.R. (S. Area) Signal and Telegraph Engineer's Office, Hadley Wood, Herts.
A.M. 1913 *M.* 1930 Brearley, Sam Ernest	"Ashover," Nantwich Road, Wistaston, Crewe, Cheshire
1923 Brittain, F. C.	40, Marshfield Road, Chippenham, Wilts
1921 Brookes, Frederick Henry	7, St. Anne's Road, Caversham, Reading

Name.	*Address.*
A.M. 1936 *M.* 1938 Brown, A. ...	40, Walfield Avenue, Whetstone, N.20
A.M. 1930 *M.* 1934 Brown, T. E. ...	Area Technical Assistant, L.M. & S.R., Signal and Telegraph Dept., Fishponds, Bristol
A.M. 1927 *M.* 1934 Brown, William	Assistant (Telegraphs), L.M. & S.R., Signal and Telegraph Engineer's Office, 302, Buchanan Street, Glasgow
S.M. 1924 *A.M.* 1927 *M.* 1937 Bruce, F. C. ...	General Railway Signal Co., Ltd., Hillcrest, Frith Hill, Great Missenden, Bucks
1927 Bryson, William, Jnr.	Divisional Signal and Telegraph Engineer, L.M. & S.R., 302, Buchanan Street, Glasgow
S.M. 1924 *A.M.* 1930 *M.* 1936 Buckingham, Wm.	" Signals," c/o. Chief Engineer, Nigerian Railway, Ebute Metta, Nigeria, W. Africa
A.M. 1931 *M.* 1934 Burton, Frank ...	Divisional Assistant (Telegraphs), L.M. & S.R., Divisional Signal and Telegraph Engineer's Office, Crewe
A.M. 1921 *M.* 1926 Burton, Joseph Hallam	Engineer, Development and Designs, Railway Signal Co., Fazakerly, Liverpool, 9
1913 Byles, Cyril Beuzeville	20, Welham Street, Beecroft, N.S.W., Australia
1933 Candler, John Edward	21, Becmead Avenue, Kenton, Middlesex
1925 Canguçu, Arthur ...	Paulista Railway, Traffic Manager, Campinas, E de S. Paulo, Brazil
1925 Canguçù, O. G. ...	Paulista Railway, Telegraph and Signal Engineer, Estação Comp., Paulista, Campinas, E. de S. Paulo, Brazil
1941 Cant, R. L.	Technical Assistant to Signal and Telegraph Superintendent, Great Southern Railways, Broadstone, Dublin
1913 Carslake, Charles (Past-President) ...	Signal and Telegraph Engineer, L. & N.E.R. (North Eastern Area), York
A.M. 1921 *M.* 1922 Carter, Horace L.	District Signal Engineer, East Indian Railway, Howrah, India

Name.	Address.
S.M. 1913 *A.M.* 1918 *M.* 1919 Castle, F. L. ... (Member of Council)	General Manager, Siemens & General Electric Railway Signal Co., Ltd., East Lane, Wembley
S.M. 1926 *A.M.* 1930 *M.* 1938 Challis, E. W. ...	Westinghouse Brake & Signal Co., Ltd., Chippenham, Wilts
1933 Challis, W. H. ...	Indoor Assistant to the Signal Engineer, L.P.T.B., Signal Engineer's Office, Earl's Court Station, S.W.5
A.M. 1925 *M.* 1934 Cogger, Robert	S.R., Signal and Telegraph Dept., Wimbledon, S.W.19
1937 Comber, C. T. T. ...	Signal and Telegraph Supt., B.A.G.S. Railway, Plaza Constitucion, Buenos Aires
A.M. 1913 *M.* 1924 Constable, R. A.	Warnes, 1044, Florida, F.C.C.A., Prov: Buenos Aires, Argentina
1914 Cooke, Charles Joseph	66, Henty Close, Worthing, Sussex
1919 Cortez-Leigh, F. A. ... Lieut.-Col. R.E. (*retired*)	L.M. & S.R., 27, Euston Square, N.W.1
1927 Cosserat, Edward Wilford	Signal Engineer, Signals, Bengal Nagpur Railway, Calcutta, India
1938 Cox, G. C.	Divisional Assistant Signal Engineer, N.W. Railway Headquarters, Karachi City, India
1913 Cox, H. E.	Deputy Chief Engineer, Signals, G.I.P. Railway, 81, Victoria Terminus, Bombay
S.M. 1930 *M.* 1932 Cox, N. L. ...	Signal Engineer, P.W. Dept., Leopoldina Railway, Caixa 291, Rio de Janeiro, Brazil
1925 Crathorne, J. L. ...	Westinghouse Brake & Signal Co., Ltd., Chippenham, Wilts
1913 Crook, George Herbert (Past President)	Chief Assistant to the Signal Engineer, G.W.R. Signal Engineer's Office, 80, Caversham Road, Reading
1931 Cruse, Herbert Arthur	Works Manager, Westinghouse Brake & Signal Co., Ltd., Chippenham, Wilts
1925 Cullis, W. H.	Westinghouse Brake & Signal Co., Ltd., Chippenham, Wilts

Name.	*Address.*
S.M. 1923 *A.M.* 1927 *M.* 1941 Currey, John Heylyn	L.M. & S.R., Signal and Telegraph Engineer's Office, Watford
1936 D'Abren, Eustace L. ...	G.I.P. Railway, Administrative Offices, Jhansi, India, W.P.
1921 Davidson, A. W. ...	29, Wilton Grove, Wimbledon, S.W.19
A.M. 1922 *M.* 1934 Dean, Francis ...	District Signal and Telegraph Assistant, L.M. & S.R., Stoke-on-Trent
S.M. 1921 *A.M.* 1925 *M.* 1928 Dell, R. ... (Member of Council)	Signal Engineer, L.P.T.B., Signal Engineer's Office, Earl's Court Station, S.W.5
1922 Dickens, C. E.	District Signal Engineer, East Indian Railway, Calcutta, India
A.M. 1921 *M.* 1934 Dickin, Horace Croxall	Area Technical Assistant, Signal and Telegraph Dept., L.M. & S.R., Bedford
A.M. 1921 *M.* 1925 Dillon, T. F. ...	Electrical Signal Engineer, E.S. Railways, Cairo, Egypt
A.M. 1924 *M.* 1933 Dixon, F. ...	Technical Assistant, L.M. & S.R. Signal and Telegraph Dept., Crewe
A.M. 1930 *M.* 1934 Dobie, John ...	39, Stamperland Gardens, Clarkston, Glasgow
1913 Downes, Fredk. ... (Past President)	Arlow House, Arlow Road, Winchmore Hill, N.21
A.M. 1927 *M.* 1928 Downing, C. J.	Asst. Telegraph Supt., Burma Rlys., P.O. Box 118, Rangoon, Burma
1924 Dunn, John Howard ...	Editor, *Railway Signaling*, 105, West Adams Street, Chicago, U.S.A.
A.M. 1923 *M.* 1926 Durham, Lindsay F.	Kotam Jct., B.B. and C.I.Rly., Rajputana, India
1926 Dutton, Frederick James (Member of Council)	Divisional Signal and Telegraph Engineer, L.M. & S.R., Derby
A.M. 1913 *M.* 1923 Dyer, H. H. ... (Member of Council)	Electrical Assistant, L.M. & S.R. Signal and Telegraph Engineer's Office, Watford
1920 Eades, G. J.	Corner House, The Riding, Woking, Surrey
1921 Edey, Reginald Muirhead	Pound Farm, Herd's Hill, Langport, Somerset
A.M. 1920 *M.* 1924 Edwards, Frank (Hon. Auditor)	Siemens & General Electric Railway Signal Co., Ltd., East Lane, Wembley

Name.	*Address.*
S.M. 1922 *A.M.* 1923 *M.* 1931 Edwards, John R.	Assistant (Communications) L.M. & S.R., Signal and Telegraph Engineer's' Office, Watford
A.M. 1932 *M.* 1936 Egginton, Frank Bartram	L. & N.E.R., Signal and Telegraph Engineer's Office (S. Area), Hadley Wood, Herts
1913 Ellison, Charles Hustwick (Past President)	"Kibworth," Clifton Dale, York
1936 English, J.	L. & N.E.R., Signal and Telegraph Engineer's Office (N.E. Area), York
A.M. 1917 *M.* 1922 Ensor, E. L. ...	Deputy Transportation Supt., G.I.P. Railway, Victoria Terminus, Bombay, India
1930 Fahmy, Ahmed ...	Signal Supt., Egyptian State Railways, Signalling Dept., Cairo
A.M. 1927 *M.* 1938 Fiddes, John Stuart	Assistant Signal Engineer, M. & S.M.R., Park Town, Madras, S. India
S.M. 1923 *A.M.* 1930 Firminger, Henry *M.* 1938 William	Signal Engineer's Office, L.P.T.B., Earl's Court Station, S.W.5
1919 Ford, G. Woolaway ...	c/o Mercantile Bank of India Ltd., 15, Gracechurch, St., London E.C.
1924 Forrest, W.	Signal and Telegraph Maintenance Engineer, Victoria Govt. Railways, Melbourne, Australia
A.M. 1922 *M.* 1934 Fossey, Arthur James	Technical Assistant (Works), L.M. & S.R. Signal and Telegraph Engineer's Office, Crewe
A.M. 1919 *M.* 1921 Foulsham, F. C.	Assistant Signal and Telegraph Engineer, B.A.P. Railway, Calle Florida, 783, Buenos Aires, Argentina
A.M. 1921 *M.* 1924 Fraser, J. H. (Member of Council)	L. & N.E.R., Assistant Signal and Telegraph Engineer (N.E. Area), York
1933 Friend, Bernard William	Post Office, Tabora, Tanganyika
1919 Gaby, C. O.	c/o Standard Bank of South Africa, East London Branch, Cape Province
A.M. 1922 *M.* 1927 Gardiner, L. V.	Westinghouse Brake & Signal Co., Ltd., Chippenham, Wilts
1920 Gardner, Mostyn R. ...	"Parkside," Hadley Common, Barnet, Herts
1939 Gentles, T. A. ...	L. & N.E.R. District Engineer's Office, Newcastle-on-Tyne

Name.	*Address.*
1938 Gillespie, S. E. ...	Vice-President, Western Railroad Supply Co., 2360, South Ashland Avenue, Chicago, Illinois, U.S.A.
1913 Glenn, Samuel Lear ...	Hillcrest, Frith Hill, Great Missenden, Bucks
S.M. 1922 *A.M.* 1925 *M.* 1938 Glisbey, James Edward	c/o. Station Master, L.M.S. Railway, Central Station, Liverpool
S.M. 1925 *A.M.* 1929 *M.* 1932 Golding, A. J. ...	L.M. & S.R. Divisional Signal and Telegraph Engineer's Office, Crewe
A.M. 1928 *M.* 1931 Goss, Frederick Edward (Hon Secretary and Hon. Treasurer South American Branch)	Senior Signal Assistant (Power), B.A.G.S. & B.A.W. Railways, Senales y Telegrafos, Estacion Plaza Constitucion, Buenos Aires, Argentina
1927 Graham, Joshua Heap	Edificio Est. Retiro F.C.C.A., 2do Piso Escretorio 24, Calle Maipú 1358, Buenos Aires
1933 Gray, John	Caerketton, The Avenue, Sale, Cheshire
1934 Greenall, John T. ...	Signal and Telegraph Dept., L.M. & S.R., Leeds (City)
S.M. 1921 *A.M.* 1926 *M.* 1929 Griffith, L. J. P. **(H.M. Forces)**	
1922 Griffiths, C. H. ...	48, Hill Street, Richmond, Surrey
1931 Griffiths, John Balmain	Standard Telephone & Cables, Ltd., Oakleigh Road, New Southgate, N11
1913 Griffiths, Ralph Stanley (Past President)	Engineer, Signal Dept., Westinghouse Brake & Signal Co., Ltd., 82, York Way, King's Cross, N.1
1937 Grœnback, Gunnar ...	Signal Engineer, The Danish State Railways, 40, Solvgade, Copenhagen
A.M. 1915 *M.* 1925 Guest, Thomas	Assistant (Signals), L.M. & S.R., Signal and Telegraph Engineer's Office, Crewe
S.M. 1923 *A.M.* 1928 *M.* 1930 Guthrie, H. J.	Signal and Telegraph Superintendent, Great Southern Railways, Broadstone, Dublin
S.M. 1923 *A.M.* 1926 *M.* 1937 Hall, Clifford M.	Saxby & Farmer (India), Ltd., Entally, Calcutta, India

Name.	*Address.*
1933 Hall, George Leslie Lieut.-Col.	Assistant Engineer (Signals and Telegraphs), Southern Railway, Deepdene Hotel, Dorking, Surrey
1936 Hamdy, G.	Deputy Signal Supt., Egyptian State Railway, 84, Road No. 9, Maadi, Egypt
1924 Hard, Ture Alfred Teodor	Chief Engineer for Signals, Swedish State Railway, Stockholm, Sweden
A.M. 1913 *M.* 1925 Hardman, P. W.	L.M. & S. Rly., Signal and Telegraph Dept., Crewe
1929 Harris, Reginald John	Asst. Tel. Supt., G.I.P. Railway, Victoria Terminus Annexe, Bombay, India
1915 Harte, John Joseph ...	Anchoreena 510, Barrior Saenz Pena, Rosario de Sante Fé, F.C.C.A., Argentina
S.M. 1930 *A.M.* 1935 Hathaway, Francis *M.* 1939 George	Westinghouse Brake & Signal Co., Ltd., Chippenham, Wilts
A.M. 1915 *M.* 1916 Haywood, T. E.	Managing Director, Thomas Haywood & Sons, Falcon Works, Coulsdon, Surrey
A.M. 1927 *M.* 1932 Hewitt, Geoffrey Irwin	Assistant Signal Engineer, East Indian Railway, Calcutta, India
1928 Hickman, Ernest ...	L.M. & S.R. Divisional Signal and Telegraph Engineer's Office, Crewe
1913 Hills, Charles Herman (Member of Council)	L. & N.E.R. Signal and Telegraph Dept., Hadley Wood, Herts
A.M. 1913 *M.* 1927 Hitchcock, C. M.	Chief Draughtsman, L.M. & S.R., Signal and Telegraph Engineer's Office, Watford
A.M. 1913 *M.* 1937 Hodges, Rupert	Assistant, G.W.R., Signal Engineer's Office, Reading
A.M. 1928 *M.* 1930 Hodgson, C. P. B.	Deputy Chief of Signal Section, Sao Paulo Railway, Sao Paulo, Brazil
1924 Hodgson, H. C. ...	Acting Signal and Telegraph Engineer, South Indian Railway, Trichinopoly, India
1914 Hodgson, P. F. ...	Dyer's Leaze, Lacock, Wilts
S.M. 1922 *A.M.* 1923 *M.* 1931 Holmes, W. H.	Assistant Signal and Telegraph Superintendent, B.A.G.S. & B.A.W. Rlys., Señales y Telégrafos, Oficina G26-6° Piso, Plaza Constitucion F.C.S., Buenos Aires, Argentina

Name.	*Address.*
1913 Holt, George	Assistant (Signals), L.M. & S.R. Divisional Signal and Telegraph Dept., Derby
1930 Holt, Horace William	Area Technical Assistant, L.M. & S.R. Signal and Telegraph Dept., Sheffield
1920 Horler, F. ... ... (Member of Council)	Signal Engineer, Siemens & General Electric Railway Signal Co., East Lane, Wembley
A.M. 1921 *M.* 1937 Hornblower, Thomas Jos.	17, Convent Road, Entally, Calcutta, India
1928 Howard, Lemuel Frederic ...	Union Switch & Signal Co., Swissvale, Pennsylvania, U.S.A.
A.M. 1925 *M.* 1934 Howarth, James	"Stanmore," 23, Glebelands Road, Prestwich, Lancs.
1922 Howe, W. K. ...	Chief Engineer, General Railway Signal Co., Rochester, N.Y., U.S.A.
1941 Hunter, J. P.	Chief Draughtsman, Signal Engineers' Office, L.P.T.B., Earl's Court Station, S.W.5
1914 Hutt, Geoffrey Granger	Signal Engineer, Sao Paulo Railway, Sao Paulo, Brazil
1920 Jacobson, J. B. ...	Managing Director, McKenzie & Holland (Australia), Ltd., Newport, Melbourne, Australia
1940 Jones, F. E.	Assistant Engineer, c/o. Signal and Telegraph Engineer, Queensland Government Railways, Brisbane, Queensland, Australia
1928 Jones, Harry	Area Technical Assistant, Signal and Telegraph Dept., L.M. & S.R., Victoria Station, Manchester
1922 Jones, W. R. ... ... (Member of Council)	31, Crosby Road, Birkdale, Southport
1920 Kellenberger, K. E. ...	c/o. Union Switch & Signal Co., Swissvale, Pa., U.S.A.
1939 Kendall, C. L.	Signal Engineer, Burma Railways, Rangoon, Burma
1916 Kershaw, A. G. ...	Chief Mechanical Engineer, Westinghouse Brake & Signal Co., Ltd., Chippenham, Wilts

Grade	Year	Name.	Address.
S.M.	1931		
A.M.	1935		
M.	1939	Kershaw, Norman Greenwood	Westinghouse Brake & Signal Co., Ltd., Chippenham, Wilts
A.M.	1930		
M.	1930	Kidd, D. J. ...	Chief Draughtsman, The Railway Signal Co., Ltd., Fazakerley, Liverpool
S.M.	1921		
A.M.	1927		
M.	1942	King, V. S. ...	6, Bede Close, Pinnerwood Park Estate, Pinner, Middlesex
S.M.	1921		
A.M.	1925		
M.	1932	Knotts, L. J. M. (Member of Council)	S.R., Signal and Telegraph Dept., Wimbledon, S.W.19
A.M.	1931		
M.	1938	Kubale, John Charles **(H.M. Forces)**	
	1925	Lamb, D. R.	5, York Road, Colwyn Bay, North Wales
S.M.	1914		
A.M.	1915		
M.	1920	Lascelles, T. S. (Hon. Treasurer) (Hon. Librarian)	W. R. Sykes Interlocking Signal Co., 26, Voltaire Road, Clapham, S.W.4
A.M.	1930		
M.	1932	Leech, Thomas Dominic	Posts and Telegraphs, Saltpond, Gold Coast, W.C. Africa
A.M.	1921		
M.	1925	Leversedge, Geo. H.	L. & N.E.R. (Southern Area) Signal and Telegraph Engineer's Office, Hadley Wood, Herts
	1913	Liley, Walter Hemming	114, London Road, St. Leonards-on-Sea, Sussex
	1913	Lomas, P. ... ... (Member of Council)	Outdoor Assistant, L.M. & S.R., Signal and Telegraph Engineer's Office, Watford
	1928	Loomis, H. S.	Assistant General Manager, Union Switch & Signal Co., Swissvale, Pennsylvania, U.S.A.
A.M.	1930		
M.	1932	Lowther, L.W. H.	Assistant Telegraph & Signal Supt., F.C.E.R., Concordia, Argentine
A.M.	1937		
M.	1939	Majid, M. A. ...	Offctg Dvl. Asst. Signal Engineer, N.W. Rly., Rawalpindi, India

Name.	*Address.*
A.M. 1930 *M.* 1936 Marshall, W. ...	Signalling & Electrical Assistant, L.M. & S.R., Northern Counties Committee, York Road Station, Belfast
1920 Martin, R. H. ...	"Lovedale," Exmouth, Devon
1935 McMellon, Edward ...	L. & N.E.R. Signal & Telegraph Engineer's Office (Southern Area), Hadley Wood, Herts.
1919 Meggitt, Harry ...	Outdoor Assistant, L. & N.E.R. Signal and Telegraph Engineer's Office (Southern Area), Hadley Wood, Herts.
1935 Meneze, John Arthur ...	District Signal Engineer, East Indian Railway, Howrah, India
1926 Millie, Arthur Thomas	L. & N. E. R., Signal and Telegraph Engineer's Office (Southern Area), Hadley Wood, Herts.
A.M. 1936 *M.* 1938 Mohindra, L. C.	Divisional Assistant Signal Engineer, N.W. Railway, Delhi, India
1932 Montgomery, David ...	L. & N.E.R. Assistant Engineer's Dept., Signal and Telegraph Section, 47, Leith Street, Edinburgh
1919 Moore, Harry William (Past Vice-President)	57, Fotheringay Road, Glasgow, S.1
A.M. 1913 *M.* 1922 Moore, James S.	"Dunromin," Congresbury, Bristol
A.M. 1913 *M.* 1914 Morgan, Herbert E. (Past President)	Divisional Signal and Telegraph Engineer, L.M. & S.R., Crewe
1925 Morkill, R. Falshaw (Vice-President)	Ministry of War Transport, Berkeley Square House, Berkeley Square, W.1
S.M. 1923 *A.M.* 1926 *M.* 1938 Moseley, Ernest G.	Assistant to the Signal and Telegraph Engineer, B.A.P. Railway, Florida 783, Buenos Aires, Argentina
A.M. 1913 *M.* 1923 Moss, A. ... (Member of Council)	Signal and Telegraph Engineer (Scottish Area), Office of the Engineer (Scotland), L. & N.E.R., 47, Leith Street, Edinburgh
A.M. 1933 *M.* 1936 Mott, John Edward	19, Crutfield Crescent, Harrow

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1926 Mottram, John Edward	Area Technical Assistant, L.M. & S.R., Signal and Telegraph Dept., Rugby
1938 Muggeridge, H. C. ...	Engineer, Rendel, Palmer & Tritton, 55, Broadway, Westminster, S.W.1
A.M. 1926 *M.* 1930 Murray, W. A.	Signal Engineer, Bengal N.W. Railway, Gorakhpur, U.P. India
S.M. 1926 *A.M.* 1929 *M.* 1936 Nock, O.S. ...	Westinghouse Brake & Signal Co., Ltd., Chippenham, Wilts
1913 Oldham, Alfred ...	" Outspan," Crewe Road, Wistaston, Crewe
1921 Ollerenshaw, Leigh ...	Works Manager, Railway Signal Co., Fazakerley, Liverpool , 1
1913 Openshaw, Vincent H.	Indoor Assistant, L.M. & S.R., Signal and Telegraph Dept., Watford
A.M. 1921 *M.* 1926 Padmore, B. R.	The Poplars, Fernhill, Horley, Surrey
1932 Page, F. H. D. ...	Signal Engineer, Great Western Railway, 80, Caversham Road, Reading
1914 Painter, Percy William	General Railway Signal Co., Ltd., Hill-crest, Frith Hill, Great Missenden, Bucks
A.M. 1923 *M.* 1938 Paranjape, V. N.	Divisional Engineer, B.B. & C.I. Railway, Bulsar, India
1932 Palmer, T.	Signal and Telegraph Inspector, Cheshire Lines Railway, Central Station, Warrington
1919 Partington, J. L. ...	Signal Engineer, c/o. Evans Thornton & Co., Calle Defensa 465, Buenos Aires, Argentina
A.M. 1929 *M.* 1937 Pearce, Harry Felix ...	General Railway Signal Co., Ltd., Hill-crest, Frith Hill, Great Missenden, Bucks
1913 Peter, Bernard H. ...	Managing Director, Westinghouse Brake & Signal Co., Ltd., 82, York Way, King's Cross, N.1
1920 Peter, L. H.	Chief Electrical Engineer, Westinghouse Brake & Signal Co., Ltd., 82, York Way, King's Cross, N.1
1937 Pethick, J.	District Engineer (Signals), c/o. System Manager, South African Railways and Harbours, Durban

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S.M. 1922 *A.M.* 1923 *M.* 1927 Phillips, C. G. R.	Divisional Engineer, Posts and Telegraphs Dept., Ipoh, Perak, F.M.S.
1928 Pickard, Alan	Assistant Signal and Interlocking Engineer, G.I.P. Railway, Bombay, India
A.M. 1925 *M.* 1934 Pierce, Ernest E.	L.M. & S.R. Signal & Telegraph Engineer's Office, Watford
1927 Plogsted, W. J. ...	Managing Director, General Railway Signal Co., Ltd., Hillcrest, Frith Hill, Great Missenden, Bucks
1923 Pont, Leon Victor ...	c/o. Thos. Cook & Son, Berkeley Street, London, W.1
1938 Pott, N. H.	Telephone Engineer, Ferro Carril Central Argentino, Calle Maipu 1358, Buenos Aires, Argentina
1913 Potter, John	Signal Superintendent, G.N. (I.) Railway, Amiens Street Station, Dublin
1913 Powell, William Howard	Director and General Manager, Westinghouse Brake & Signal Co., Ltd., Chippenham, Wilts
1934 Poynton, Brian Osborne	c/o. System Manager, South African Railways and Harbours, Capetown, S. Africa
1931 Prache, Paul	Directeur de la Cie. Gle. de Signalisation, 23, Rue D'Athènes, Paris
A.M. 1921 *M.* 1924 Preston, Leo (Member of Council)	Assistant Signal and Telegraph Engineer, L. & N.E.R. (Southern Area), Kirklands, Park Road, New Barnet, Herts
A.M. 1915 *M.* 1918 Proud, H. M. ... (Past President)	Chief Commercial Engineer, Westinghouse Brake & Signal Co., Ltd., 82, York Way, King's Cross, N.1
1913 Punter, James William (Past President)	Director, Messrs. Tyer & Co., Ltd., 16, Ashwin Street, Dalston, London, E.8
A.M. 1926 *M.* 1936 Purves, R. J. ...	L. & N.E.R. Signal & Telegraph Dept., (N.E. Area), York
1932 Redman, Christopher	Telegraph and Signal Engineer, F.C.C.C., Depto. V y O, Retiro. F.C.C.C., Buenos Aires
1938 Rendle, P. R.	Telegraph Assistant, Suptcia Senales y Telegrafos F. C. Sud, Plaza Constitución, Buenos Aires, Argentina
1920 Richards, T. D. ...	L.M. & S.R. Divisional Signal and Telegraph Engineers Office, Crewe

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A.M. 1931 *M.* 1938 Rickett, Thomas William	Area Technical Assistant, L.M. & S.R., Signal and Telegraph Dept., Arpley Station, Warrington
A.M. 1923 *M.* 1925 Roberts, H. R.	Railway Signal Co., Ltd., Fazakerley, Liverpool, 9
1913 Roberts, Walter Sydney (Past President)	Managing Director, Railway Signal Co. Ltd., Fazakerley, Liverpool, 9
S.M. 1923 *A.M.* 1928 *M.* 1938 Robinson, M. H.	Westinghouse Brake and Signal Co., Ltd., Chippenham, Wilts
A.M. 1914 *M.* 1917 Rose, A. C. ...	Deputy General Manager, M. & S.M.R., Park Town, Madras, India
1928 Rose, Frank	Maintenance Assistant, L.P.T.B., Signal Engineer's Office, Earl's Court Station S.W.5
S.M. 1913 *M.* 1914 Routh, C. I. ...	Assistant Signal and Interlocking Engineer, G.I.P. Railway, Jubbulpore Division, Jubbulpore, Central Provinces, India
A.M. 1917 *M.* 1923 Royal, J. W. ...	Engineer, Westinghouse Brake & Signal Co., Ltd., 82, York Way, King's Cross, N.1
A.M. 1925 *M.* 1928 Runnett, John (Vice-Chairman: South American Branch)	Divisional Signal and Telegraph Engineer, F.C.B.A.P., Calle Florida 783, Buenos Aires, Argentina
A.M. 1925 *M.* 1937 Russell, Norman Way	L. & N.E.R., Signal and Telegraph Engineer's Office (Southern Area), Hadley Wood, Herts.
A.M. 1919 *M.* 1926 Sadler, W. J. ...	Technical Assistant (Signals) L.M. & S.R., Signal and Telegraph Engineer's Office, Watford
1933 Sen. Saradindu ...	Assistant Signal Engineer, M. & S.M.R., Park Town, Madras, India
1913 Sayers, Josiah, O.B.E. (Past President)	Calder Bank, Avenue Road, Duffield, Derbyshire
A.M. 1929 *M.* 1936 Scarff, C. ...	Assistant Signal Engineer, G.I.P. Rly., Signal Engineer's Office, Victoria Terminus, Bombay
A.M. 1921 *M.* 1931 Scott, T. E. ...	L.M. & S.R., Signal Sighting Committee, Weston Lane Offices, Crewe
1937 Seth, R. B.	Government Inspector of Railways, Indian State Railways, 2's, Office, Sealdah, Calcutta

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1936, Severn, Albert E. ...	Divisional Signal and Telegraph Engineer's Office, L.M.S.R., Hunt's Bank, Manchester
A.M. 1930 *M.* 1942 Sharp, R. K. ...	Chief Assistant to Signal Superintendent, Chief Civil Engineer's Office, G.N. Railway (Ireland), Amiens Street Station, Dublin
A.M. 1924 *M.* 1928 Shorter, Mervyn W.	Westinghouse Brake & Signal Co., Ltd., Chippenham, Wilts
1923 Sinha, R.	Deputy Chief Engineer, Signals, East Indian Railway, Calcutta, India
S.M. 1926 *A.M.* 1929 *M.* 1939 Slater, G. A. ...	Signal Engineer, M. & S.M. Rly., Park Town, Madras, India
A.M. 1913 *M.* 1930 Spendlove, Sebert Walter (Member of Council)	Divisional Signal & Telegraph Engineer, L.M. & S.R., Hunt's Bank, Manchester
1913 Starkey, S.	6, Griswold Road, Saxonwold, Johannesburg, South Africa
1926 Stone, T. H., M.B.E.	P.O. Box 1479, Nairobi, Kenya Colony
1917 Sykes, F. J.	Managing Director, W. R. Sykes Interlocking Signal Co., 26, Voltaire Road, Clapham, London, S.W.4
1927 Taff, Arthur William ...	Organisation Officer, Eastern Bengal Railway, Koilaghat Street, Calcutta, India
A.M. 1923 *M.* 1938 Targett, E. H. ...	Signal Engineer, Ceylon Government Railway, Way & Works Dept., Colombo, Ceylon
A.M. 1936 *M.* 1939 Tervet, E. J. ...	Standard Telephones & Cables, Ltd., Oakleigh Road, London, N.11
S.M. 1923 *A.M.* 1927 *M.* 1929 Towers, Herbert	Signal Engineer, B.B. & C.I. Railway, Ajmer, India
1928 Tremain, William Ewart	Assistant Signal & Telegraph Engineer, B.A.P., Calle Florida 783, Buenos Aires, Argentina
1933 Trench, Arthur Chenevix, Colonel, (R.E. *retired*)	Ministry of War Transport, Berkeley House Square, Berkeley Square, W.1
A.M. 1936 *M.* 1938 Tubbs, John F. G.	Westinghouse Brake & Signal Co., Chippenham, Wilts
1926 Tuck, H. A.	Dep. Chief Engineer, Signals, N.W. Rly., Lahore, India
1918 Tweedie, M. G. ... (Hon. Secretary)	29, Conisboro Avenue, Caversham, Reading

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S.M. 1923 *A.M.* 1928 *M.* 1932 Valentine, B. J.	Outdoor Assistant, Signal and Telegraph Dept., Buenos Aires Great Southern Railway, Oficina 630, 6° Piso, Edificio Nuevo, Plaza Constitucion, Buenos Aires, Argentina
A.M. 1926 *M.* 1931 Veale, Roland ...	Works Manager, East Indian Railway Signal Workshops, Howrah, Calcutta, India
S.M. 1924 *A.M.* 1926 *M.* 1930 Venning, Chas. F. D.	Westinghouse Brake & Signal Co., Ltd., Chippenham, Wilts
S.M. 1925 *A.M.* 1928 *M.* 1931 Webb, W. H. R.	General Railway Signal Co., Hillcrest, Frith Hill, Great Missenden, Bucks
1928 Webster, J. A. ...	Telegraph and Signal Superintendent, E.R. & N.E.A. Rlys., Estacion Concordia, F.C.E.R., Argentina
1913 Wheatley, William George	Meadowcroft, Balcombe Road, Horley, Surrey
A.M. 1927 *M.* 1930 White, Cyril Arthur	Assistant Signal and Telegraph Engineer, South Indian Railway, Trichinopoly, S. India
1920 Whitney, Albert ...	Assistant Signal and Interlocking Engineer, G.I.P. Railway, c/o. National Provincial Bank, York
1913 Whysall, Philip ...	Westinghouse Brake & Signal Co., Ltd., 82, York Way, King's Cross, London, N.1
S.M. 1928 *M.* 1932 Wilkins, G. R. E.	Signal Engineer, F.M.S. Railways, Kuala Lumpur, F.M.S.
1925 Williams, C. S. ...	Westinghouse Brake & Signal Co., Ltd., Chippenham, Wilts
1913 Williams, David Dennis	Engineer, Railway Appliances Works, Darlington
A.M. 1930 *M.* 1940 Williams, John William Milner	c/o. Chief Telegraph Engineer, P.O. Box 581, Nairobi, Kenya Colony
1913 Williams, Owen Richard	Engineer, Railway Appliances Works, Darlington
A.M. 1920 *M.* 1928 Williams, Sidney	Development Assistant (Outdoor), L.M. & S.R. Signal and Telegraph Engineer's Office, Watford
1924 Windahl, Eric G. ...	Director, Signalbolaget, Stockholm, Sweden

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	1937 Wittrup, R.	Chief Draughtsman, Signal & Telegraph Dept., Central Argentine Railway, Calle Maipu 1358, Officina 24, 2° Piso, Retiro, Buenos Aires, Argentina
	1913 Wood, William ... (Past-President)	Assistant Signal and Telegraph Engineer, L.M. & S.R., Watford
S.M. 1926 *A.M.* 1931 *M.*	1937 Woodbridge, A.W. (Member of Council)	Assistant, G.W.R., Signal Engineer's Office, 80, Caversham Road, Reading
	1923 Woodhouse, Ernesf Lt.-Col., (R.E., *retired*)	Ministry of War Transport, Berkeley Square House, Berkeley Square, W.1
	1923 Woods, R. C. ...	Research Dept., Ericsson Telephones Ltd., Beeston, Notts.
	1922 Worrall, Stanley ...	L. & N.E.R., District Electrical Engineer Guide Bridge, Manchester
A.M. 1929 *M.*	1934 Wright, W. J. ...	S.R. Signal and Telegraph Dept., Wimbledon, S.W.19
	1913 Wyles, Guy Wilfred ...	Signal and Electrical Engineer, N.Z. Government Railways, Wellington, New Zealand
	1913 Wynn-Williams, Llewelyn	Haughton Bridge Works, Darlington
	1913 Wynne, Henry J. ...	10, Woodward Street, Wellington, New Zealand
	1935 Yates, Virgil	Technical Assistant, Signal and Telegraph Engineer's Dept., L.M. & S.R., Hunt's Bank, Manchester

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	1939 Abel, C.	Sub-Inspector, Signal Dept., G.W.R., West Ealing
S.M. 1933 *A.M.*	1936 Adams, C. W. H.	20, Woodside Road, New Malden.
	1924 Alger, William James	L. & N.E.R. Signal & Telegraph Dept., Stratford, E.15
	1926 Allen, Jack	Inspector, G.W.R. Signal Dept., Reading
	1937 Allen, P. R.	Inspector, Signal Engineer's Office, G.W. Railway, Reading
	1933 Allen, Walter James ...	L.M. & S.R., Signal and Telegraph Dept., Gresty Road, Crewe
S.M. 1934 *A.M.*	1937 Allison, Alexander B.	L.M. & S.R. Signal and Telegraph Dept., Derby
	1935 Allsop, John Henry ...	Inspector, L.M. & S.R., Signal and Telegraph Dept, Carlisle

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1929 Anderson, I. C. ...	Inspector, Signal and Telegraph, L. & N.E.R., Holbeck, Leeds
1930 Andrews, R. A. ...	Inspector, G.W.R. Signal Dept., Plymouth
1921 Andrews, W.	5, Campbell Road, Hanwell, W.7
1939 Athavale, V. L. ...	Assistant Signal Inspector, B.B. & C.I. Rly., Bandikui, India
1926 Awde, Herbert ...	L. & N.E.R., Signal and Telegraph Engineer's Office (Southern Area), Hadley Wood, Herts.
1928 Baker, Francis Frederick	L.P.T.B. Signal Engineer's Office, Earl's Court Station, S.W.5
1938 Baker, H. J.	G.W.R. Signal Department, Frome
S.M. 1933 *A.M.* 1939 Baldwin, H. ...	Signal and Telegraph Inspector, L.M. & S.R., Perth
1933 Bannister, William John	Assistant Signal Engineer, Madras & Southern Mahratta Railway, Park Town, Madras, India
1938 Barlow, Frederick ...	Signal Inspector, L.M. & S.R., Signal and Telegraph Dept., Islington, Blackburn
S.M. 1933 *A.M.* 1938 Barnes, Albert ...	L.M. & S.R., Signal and Telegraph Engineer's Office, 302, Buchanan Street, Glasgow
1938 Bass, G. W.	Technical Assistant, L.P.T.B., Earl's Court Station, London, S.W.5
S.M. 1936 *A.M.* 1942 Bates, R. G. ...	L.M. & S.R., Signal and Telegraph Dept., Crewe
S.M. 1928 *A.M.* 1935 Batter, Raymond Charles	Westinghouse Brake & Signal Co., Ltd., Chippenham, Wilts
S.M. 1934 *A.M.* 1937 Beavan, Edward James	The Railway Signal Co., Ltd., Fazakerley, Liverpool, 9
1928 Bell, Percy	L.M. & S.R. Divisional Signal and Telegraph Engineer's Office, Crewe
1923 Bennett, Albert V. E.	Signal and Telegraph Inspector, S.R., Eastleigh, Hants
S.M. 1934 *A.M.* 1940 Bennett, Charles Chapman	L.M. & S.R. Signal and Telegraph Dept., Watford, Herts.
1936 Benneworth, Frank ...	Signal & Telegraphs Inspector, L.N.E.R., Engineer's Office, York

Name.	*Address.*
1934 Berry, Reginald ...	Signal Inspector, London Passenger Transport Board, Signal Engineer's Office, Earl's Court, S.W.
S.M. 1927 *A.M.* 1932 Birchenhough, H. **(H.M. Forces)**	
1938 Bird, O. V.	c/o Signal Engineer, M. & S.M. Rly., Park Town, S. Madras
1924 Bishop, Charles ...	69, Church Lane, Kingsbury, N.W.9
1924 Blackwell, G. H. ...	G.W.R. Signal Dept., Newport, (Mon.)
1929 Blackwell, Victor Alexander ...	L.M. & S.R., Signal and Telegraph Dept., Walsall
1935 Blakemore, Harry ...	L.M. & S.R. Divisional Signal and Telegraph Engineer's Office, Gresty Road, Crewe
1937 Blignant, P. L. ...	South African Railways, Signal Engineer's Office, Johannesburg
1931 Blundell, William ...	L.M. & S.R., Signal and Telegraph Dept., Barrow-in-Furness
1936 Bowdler, S. E. ...	L.M. & S.R. Signal and Telegraph Dept., Rhyl
1923 Bowers, B. **(H.M. Forces)**	
S.M. 1930 *A.M.* 1932 Box, C. E. ...	L.M. & S.R., Signal and Telegraph Dept., Hunt's Bank, Manchester
S.M. 1933 *A.M.* 1939 Brearley, H. ...	Divisional Signal & Telegraph Engineer's Office, L.M. & S.R., Crewe
1927 Brettell, Benjamin Orme	Westinghouse Brake & Signal Co., Ltd., Chippenham, Wilts
1927 Brettell, Cecil Ernest ...	Westinghouse Brake & Signal Co., Ltd., Chippenham, Wilts
S.M. 1927 *A.M.* 1932 Bridge, Alfred T.	Siemens & General Electric Railway Signal Co., East Lane, Wembley, Middlesex
1937 Bridges, W.	L.M. & S.R., Signal and Telegraph Dept., Barking
1936 Britland, H. L. ...	23, Broadfields, Headstone Lane, Harrow, Middlesex
S.M. 1928 *A.M.* 1933 Brittain, L. F. C.	L.M. & S.R. Divisional Signal and Telegraph Engineer's Office, Derby
1923 Brown, T. J. ...	Inspector, G.W.R. Signal Dept., Neath

Name.	*Address.*
1923 Browning, T. W. ...	Inspector, G.W.R. Signal Dept., Wolverhampton
1926 Bruxby, John Howard	19, Park Crescent, Romford, Essex
1922 Buckland, Harry ...	L. & N.E.R., Signal and Telegraph Dept., Nottingham (Low Level Station)
1926 Bumstead, W. R. ...	21, Mayo Gardens, Lahore, N. India
1932 Burnet, James ...	L. & N.E.R. Engineer's Dept. (Signal and Telegraph Section), 47, Leith Street, Edinburgh
1922 Burridge, Arthur ...	L. & N.E.R., Signal and Telegraph Engineer's Office (Southern Area), Hadley Wood, Herts.
1936 Butler, E. G.	B.A.W. Railway, Señales y Telégrafos, Plaza Constitucion, Buenos Aires, Argentina
1939 Bygate, R. A. ...	St. Codd, Lastingham, York
S.M. 1929 *A.M.* 1932 Carr, Archie Edward ...	L.P.T.B. Signal Engineer's Office, Earl's Court Station, S.W.5
1934 Carter, Herbert ...	L.M. & S.R. Signal and Telegraph Dept., Lancaster (Castle)
1935 Cartwright, John P. ...	Inspector, G.W.R., Signal Dept., Gloucester
S.M. 1939 *A.M.* 1942 Cartwright, W. L.	Signal and Telegraph Section, Engineer's Office, L.N.E. Rly., York
1937 Carty, C.	c/o. Westminster Bank, Ltd., Berners Street Branch, London, W.1
1924 Challis, Albert	38, Roxburgh Road, Harrow, Middlesex
1930 Chande, N. K. ...	Assistant Signal Engineer, B.B. & C.I. Railway, Ajmer, India
1925 Charge, George Charles	General Railway Signal Co., Ltd., Hillcrest, Frith Hill, Great Missenden, Bucks
1940 Chatterji, S. K. ...	Assistant Block Inspector, East Indian Railway, Aligarh, India
1927 Cheal, Albert Edward...	Sub-Engineer, c/o. Engineer-in-Chief, & Telegraph Dept., Lagos, Nigeria, W. Africa
1938 Cheetham, W. E. ...	"Lyndhurst," 14, Verdun Avenue, Salford, 6, Lancs.

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1938 Chessell, R. C.	Electrical and Signal Branch, W.A.G.R., Wellington Street, Perth, Western Australia
1930 Chir, Lawrence ...	Callenders Cable & Construction Co., 2, Pollock Street, Calcutta, India
1937 Chopra, D. R. ...	Signal and Telegraph Dept., North Western Rly., Ghagrahad, U.P., India
1932 Clarke, Donald Metford	G.W.R. Signal Engineer's Office, Reading
S.M. 1926 *A.M.* 1931 Claridge, W. J.	G.W.R. Signal Engineer's Office, Reading
1939 Cleary, E. J.	Signal Inspector, L.P.T.B., Earls Court Station, S.W.5
1938 Coates, H.	21, Beechwood Avenue, Neath
S.M. 1936 *A.M.* 1940 Coley, J. P. ...	Westinghouse Brake & Signal Co., Chippenham, Wilts
1921 Colley, Samuel John ...	L.M. & S.R., Signal and Telegraph Dept., Sheffield
1928 Collins, Edward ...	32, Kingsway, Ashton-on-Ribble, near Preston, Lancs.
1930 Constable, George ...	Sub-Inspector, S.R. Signal and Telegraph Dept., Clapham Junction, London
1942 Constable, George ...	29, Sandycove Road, Dun Laoghaire, Eire
S.M. 1924 *A.M.* 1931 Cook, Clifford Baden	L.M. & S.R. Signal and Telegraph Dept., Tyldesley, Lancs.
S.M. 1920 *A.M.* 1922 Coope, H. W.	L.M. & S.R., Divisional Signal and Telegraph Dept, Derby
1923 Cooper, J. E.	Engineering Assistant, c/o. Chief Civil Engineer, Railways, Wellington Street, Perth, Western Australia
1938 Cooper, W. A. R. ...	98, Park Road, Regent's Park, London, N.W.1
1930 Copley, V. C.	L. & N.E.R., Signal and Telegraph Engineer's Office (Southern Area), Hadley Wood, Herts.
S.M. 1930 *A.M.* 1935 Cox, Stephen Leon	General Railway Signal Co., Hillcrest, Frith Hill, Great Missenden, Bucks

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1938 Crosbie, S.	Engineer, Metro-Vickers Co., Ltd., Trafford Park, Manchester 17
1939 Cruse, E. J.	Engineering Assistant, Westinghouse Brake & Signal Co., Ltd., Chippenham, Wilts
S.M. 1937 *A.M.* 1941 Cunliffe, J.P. **(H.M. Forces)**	
S.M. 1928 *A.M.* 1933 Damon, Allan W. **(H.M. Forces)**	
1936 Daniels, Abraham ...	S. & T. Inspector, Flat No. B2 Victoria Terminus Annex, Bombay, India
1938 Das, S. N.	10, Dinendra Street, Calcutta, India
1936 Davenport, John ...	135-8th Avenue, Maylands, W. Australia
1938 David, D.	c/o. Signal Engineer, M. & S.M. Railway, Madras, India
S.M. 1931 *A.M.* 1934 Davis, John S.	Signal and Telegraph Dept., L.M. & S.R., Miles Platting Station, Manchester
S.M. 1934 *A.M.* 1937 Daum, Edward Oliphant	Westinghouse Brake & Signal Co., Ltd., Chippenham, Wilts
1934 Dean, Walter	L.M. & S.R., Divisional Signal and Telegraph Engineer's Office, Hunt's Bank, Manchester
1938 De la Motte, G. W. ...	c/o Signal Engineer, Park Town, Madras, S. India
S.M. 1926 *A.M.* 1929 Dennison, H. F.	Assistant Signal and Telegraph Engineer, Assam Bengal Railway, Chittagong, India
1924 Derbyshire, C. G. ...	Technical Assistant, L.M. & S.R., Signal and Telegraph Engineer's Office, Watford
1936 Dharwar, T. F. ...	248, Petits Bungalow, Tardeo Road, Bombay
S.M. 1932 *A.M.* 1940 Dickins, Lancelot A.	Westinghouse Brake & Signal Co., Ltd., Chippenham, Wilts
1928 Donkar, Jivaji Ramachandra	Telegraph Inspector, Ramprasad, Ponmalai Patti, Golden Rock, S. India
1937 Dolman, R.	14, Merton Road, Heaton Park, Manchester

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S.M. 1927 *A.M.* 1933 Downes, David Gordon **(H.M. Forces)**	
1938 Doraisami, T. S. I. ...	Assistant Signal Inspector, M.S.M. Rly. Co., Ltd., Satara Road, S. India
1919 Drew, A. W.	Technical Assistant (Works), L.M. & S.R. Signal and Telegraph Dept., Hunt's Bank, Manchester
1930 Dudley, F. B.	L.M. & S.R. Signal and Telegraph Engineer's Office, Watford
1921 Dyke, A. W. M. ...	Inspector, G.W.R. Signal Dept., Cogan, nr. Cardiff
1940 Eastham, W. J. ...	L.M. & S.R. Divisional Signal and Telegraph Engineer's Office, Hunt's Bank, Manchester
1929 Edmonds, Albert Victor	General Railway Signal Co., Ltd, Hillcrest, Frith Hill, Great Missenden, Bucks
1929 Edwards, John ...	Southern Railway, Signal Dept., Tonbridge
1931 Eggleston, Charles Henry	L. & N.E.R., Signal & Telegraph Dept., London Road Station, Nottingham
1928 Eldridge, Tilden Theodore **(H.M. Forces)**	
1919 Elliott, T. C.	D.P. Battery Co., 50, Grosvenor Gardens, S.W.1
1920 Ellis, S. H.	Assistant to the Signal and Telegraph Engineer, B.A.P. Railway, Florida 783, Buenos Aires, Argentina
913 Ellison, C. C.	L. & N.E.R., Signal and Telegraph Dept. (N.E. Section), York
1925 Ellston, Benjamin H.	L.M. & S.R. Signal and Telegraph Dept., Hunt's Bank, Manchester
1933 Evans, F.	S.R., Signal Dept., Waterloo Junction, S.E.1
1934 Evans, Stanley Dale ...	L.M. & S.R. Signal and Telegraph Engineer's Dept., Gresty Road, Crewe
S.M. 1926 *A.M.* 1931 Evans, Thomas William	L. & N.E.R. Signal and Telegraph Engineer's Office (Southern Area), Hadley Wood, Herts.

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1923 Farenden, Edwin A. ...	Inspector S.R. Signal Dept., Woking, Surrey
1939 Felstead, H. J. ...	Signal Inspector, L.P.T.B., Earls Court Station, London, S.W.5
1938 Fishenden, H. A. ...	Signal and Telegraph Dept., L.M. & S.R., Barking
1932 Fisher, Harry	L.M. & S.R., Signal and Telegraph Dept., Chester
1940 Fisher, H. D.	Signal Engineer's Office, L.P.T.B., Earl's Court Station, S.W.5
1922 Fisher, J.	L.M. & S.R., Signal and Telegraph Dept., Heaton Norris, Stockport, Manchester
1941 Fleming, G. T. ...	Westinghouse Brake & Signal Co., Ltd., Chippenham, Wilts
1931 Fleming, William Hamilton Dalrymple	The Croft, Gatley Road, Gatley, Cheshire
1928 Flint, Frederick John	Westinghouse Brake & Signal Co., Ltd., Chippenham, Wilts
S.M. 1929 *A.M.* 1935 Fordham, Kenneth N.	L.M. & S.R., Signal and Telegraph Engineer's Office, Watford
1938 Fox, G. P.	Assistant Signal Inspector, Railway Quarters, Rajahmundry, S. India
1936 Fotherby, Henry D.	L.M. & S.R., Divisional Signal and Telegraph Dept., Hunt's Bank, Manchester
1924 Frost, Frederick ...	L.M. & S.R., Signal and Telegraph Dept., Walsall
1939 Gandevia, R. N. ...	Chief Signal Inspector, B.B.C.I. Rly., Rajputana, Ajmer, India
1928 Gee, Donald William	
S.M. 1926 *A.M.* 1932 Gheury-de-Bray, Roy	30, Elmsleigh Road, Weston-super-Mare
1932 Ghosh, Birendra Nath.	Signal Inspector, Power, Eastern Bengal Railway, 11, Convent Lane, Entally, Calcutta, India

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1936 Gibson, E. M.	B.A.G.S. Railway, Suptcia de Señales y Telégrafos, F.C.A. Plaza Constitucion, Buenos Aires, Argentina
1939 Gibson, F.	Signal Dept., L.M. & S.R., Bank Hall Station, Liverpool
1939 Giles, B.	Sub. Inspector, G.W.R. Signal Dept., Wolverhampton
S.M. 1933 *A.M.* 1938 Gillies, Gerald Edmund ...	Westinghouse Brake & Signal Co., Ltd., Chippenham, Wilts
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1934 Glossop, Roy Fairfax	Materials Assistant's Office, L.M. & S.R., Signal and Telegraph Engineer's Laboratory, Gresty Road, Crewe
S.M. 1932 *A.M.* 1936 Godfrey, Lionel John	Signal and Telegraph Inspector, Sudan Government Railways, Atbara, Sudan
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1939 Goodchild, B. F. ...	Engineer, Saxby & Farmer (India), Ltd., 17, Convent Road, Entally, Calcutta, India
1923 Gough, W.	36, Malvern Road, Gloucester
1938 Greenshields, H. ...	c/o. System Manager, South African Rlys. and Harbours, Capetown
S.M. 1930 *A.M.* 1941 Gregory, George Arthur	Westinghouse Brake & Signal Co., Ltd., Chippenham, Wilts
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1936 Halliwell, G. G. F.	35, North Parade, Bootham, York
1936 Hammill, John B. ...	G.I.P. Rly., Station Road, Ahmednagar, India
1928 Hammond, William ...	L.M. & S.R., Signal and Telegraph Engineer's Office (Materials), Crewe
1939 Handa, J. R.	Assistant Block Inspector, N.W. Rly., Delhi, India
S.M. 1929 *A.M.* 1936 Hardman, W. A.	Signal Dept., L.M. & S.R., Birmingham
1931 Hardman, W. F. ...	L.M. & S.R., Divisional Signal and Telegraph Engineer's Office, Crewe
S.M. 1923 *A.M.* 1929 Hardy, Cyril ...	L.M. & S.R., Signal and Telegraph Engineer's Office, Watford
1923 Harley, F.	Inspector, G.W.R., Signal Dept., Shrewsbury
1923 Harris, George S. ...	Westinghouse Brake & Signal Co., Ltd., Chippenham, Wilts
1928 Harris, William John Gray	L.P.T.B., Signal Engineer's Office, Earl's Court Station, S.W.5
1939 Hastings, A.	Assistant Divisional Engineer, Signals and Telegraphs, B.A.P. Rly., Buenos Aires, Argentina
1926 Hawkings, Reginald	c/o. The General Elec. Co. (India) Ltd., P.O. Box 2329, Calcutta, India
1931 Head, Alfred	Telegraph Inspector, L.M. & S.R., Signal and Telegraph Dept., Leicester
1927 Heatly, John Fade ...	c/o. Messrs. Henry Williams, 7, Church Lane, Calcutta, India
1937 Heaton, J. D.	Inspector, Signal and Telegraph Dept., L.M.S.R., Barrow-in-Furness
1924 Hellier, William Thomas	Flat 3, 57, Sinclair Road, Kensington Park, W.14
1940 Henderson, E. G. ...	Siemens & G.E.R.S. Co., East Lane, Wembley, Middlesex
S.M. 1937 *A.M.* 1942 Hennessey, N. P.	L.M. & S.Rly., Signal and Telegraph Engineer's Office, Watford
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1931 Higgins, Arthur William	Inspector, L.M. & S.R. Dist. Assistant's Office, Signal and Telegraph Dept., Sowerby Bridge, Yorks
1938 Hiley, S. G.	Engineer, Metropolitan-Vickers Electrical Co., Ltd., Trafford Park, Manchester, 17
1939 Hill, R. J.	Signal Inspector, Engineer's Dept., L.N.E. Rly., 56, George Square, Glasgow, C.2
1939 Hoare, F. J. E. ...	Inspector, L.P.T.B., Signal Dept., Earls Court, S.W.5
1938 Hobley, F. G.	Signal Inspector, L.M. & S.R., Rugby
S.M. 1928 *A.M.* 1934 Hogben, Ronald James	Westinghouse Brake & Signal Co., Chippenham, Wilts
S.M. 1934 *A.M.* 1939 Holland, Reginald B. **(H.M. Forces)**	
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1938 Hopkins, R. W. ...	12, Byron Road, North Wembley, Middlesex
1923 Howes, William J. ...	Inspector, G.W.R., Signal Dept., Bristol
1925 Hoy, William	L.M. & S.R., Signal and Telegraph Dept., Crewe
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1941 Jhaveri, N. J. ...	Engineering Student, Apprentice, L.N.E. Rly., Signal and Telegraph Dept., York
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1937 Khanna, H. D. ...	Chief Signal Inspector, B.B. & C.I. Rly., Muttra (Cantonment), India
1939 Kill, R. C.	Technical Assistant, L.P.T.B., Earls Court, S.W.5
S.M. 1936 *A.M.* 1939 Kirk, K. ...	L.M. & S.R., Divisional Signal and Telegraph Engineer's Office, Crewe
1938 Koilpillai, D. M. ...	Assistant Signal Inspector, M. & S.M.R., Bitragunta, S. India
1939 Krasse, S. L.	Office of the District Inspector of Telegraphs, Ceylon Govt. Railways, Maradana, Ceylon
1930 Krishnaswami, K. T. ...	Acting Electric Signal Inspector, South Indian Railway, T46, Railway Quarters, Madras Egmore, S. India
1932 Lamb, Peter	L. & N.E.R., Engineer's Dept. (Signal and Telegraph Section), 47, Leith Street, Edinburgh
1923 Lane, E.	106, Wallbrook Road, Derby
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1932 Lewis, James ...	District Signal Inspector, L.M. & S.R., Signal and Telegraph Dept., Bank Hall Station, Liverpool
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S.M. 1932 *A.M.* 1935 Liebenhals, Walter	Assistant Signal Engineer, Bombay, Baroda & Central India Rly., Bombay, India
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1935 Loosemore, Jack Percival	Westinghouse Brake & Signal Co., Ltd., Chippenham, Wilts
1929 Lovatt, Cyrus Roy ...	Assistant Engineer, Head Office, New Zealand Govt. Rlys., Wellington, N.Z.
1930 Lowe, D. V.	Divisional Signal and Telegraph Engineer, B.A.P. Railway, 783 Florida, Buenos Aires, Argentina
S.M. 1933 *A.M.* 1941 Mackean, L. G.	Westinghouse Brake & Signal Co., Ltd., Chippenham, Wilts
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1938 Mackrell, T. E. ...	Inspector, L. M. & S.Rly., Signal & Tel. Dept., Bolton (Trinity Street)
1939 Mahon, R. W. S. ...	Signal Inspector, B.B. & C.I. Railway, Pholera, Rajputana, India
1927 Macmillan, John Nivan	District Signal Engineer, East Indian Railway, Asansol, India
1936 Makin, P.	L.M. & S.R. Signal and Telegraph Dept., Arpley, Warrington
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1931 Matthews, Albert Edward	L.M. & S.R., Signal and Telegraph Dept., Rugby
1937 McAdam, A. E. ...	Signal and Telegraph Engineer's Office, S.A.R. & H., Capetown, South Africa
1932 McClean, Harold **(H.M. Forces)**	
1938 McCorry, W. J. ...	Signal Inspector, East Indian Railway, Sahit Gunj, S.P., India
S.M. 1925 *A.M.* 1928 McLaren, W. D.	G.P.O. Post Office (London), Rly., Mount Pleasant, London, E.C.1
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1923 Mead, W.	c/o. G.W.R., Signal Dept., Newport
1938 Mehta, R. S.	Probationary Assistant Signal and Interlocking Engineer, Gt. Indian Peninsular Railway, c/o. Deputy Chief Engineer, Signals, Victoria Terminus, Bombay
1938 Michael, E. J. ...	c/o. Signal Engineer, M.S.M. Railway, Madras, S. India
1930 Melhuish, E. B. ...	Siemens & General Electric Railway Signal Co., Ltd., East Lane, Wembley
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1927 Milner, Reginald George	"Caerhayes," Hardenhuish, Chippenham, Wilts
1937 Milsom, Horace ...	Acting Telegraph Inspector, L.M. & S.R. District Assistants Office, Signal and Telegraph Dept., Sowerby Bridge, Yorks
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1930 Mitchell, Denys Lindley	Technical Assistant, L.M. & S.R., Signal and Telegraph Engineer's Office, Watford
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1937 Mottram, A. A. ...	L.M. & S.Rly., Signal and Telegraph Dept., Bedford
1938 Mugford, A.	Technical Assistant, Signal Engineer's Office, L.P.T.B., Earl's Court Station, S.W.5
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1923 Munn, William Joseph	64, Bramfield Road, London, S.W.11
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1938 Natall, J. T.	Signal and Interlocking Inspector, M. & S.M.R., Railway Quarters, Rajahmundry, S. India
1927 Newman, Geoffrey ...	Metropolitan-Vickers Electrical Co., Ltd., Trafford Park, Manchester, 17
S.M. 1924 *A.M.* 1930 Newman, H. ...	S.R. Signal and Telegraph Dept., Wimbledon, S.W.19
1937 Nicholls, H. F. ...	L.M. & S.Rly., Swansea St. Thomas, Swansea
1926 Norris, Herbert William	Sub-Inspector, G.W.R. Signal Dept., Treforest
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1936 Packer, B.	L.M. & S. Railway, Signal and Telegraph Dept., Junction Station, Watford
1938 Palmer, L.	Engineer, Metropolitan-Vickers Electrical Co., Ltd., Trafford Park, Manchester, 17
1932 Parkinson, Robert Reginald ...	Technical Assistant, Materials, L.M. & S.R. Divisional Signal & Telegraph Engineer's Office, Derby
1937 Pathak, G. R. ...	B.B. & C.I. Rly., c/o. Deputy Chief Signals, Churchgate, Bombay, India
1935 Payne, Henry S. ...	S.R., Signal and Telegraph Dept., Wimbledon, S.W.19
1941 Pearch, A. C. ...	179, Chamberlayne Road, Willesden, N.W. 10
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S.M. 1922 *A.M.* 1925 Philp, John Thurston	L. & N.E.R., Electrical Engineer's Dept. (Scotland), Edinburgh
S.M. 1933 *A.M.* 1934 Pointon, E. F. ...	L.M. & S.R., Signal and Telegraph Engineer's Office, Crewe
1933 Powell, Reginald Alfred	Southern Railway, Signal and Telegraph Dept., Hither Green Station, S.E.13
S.M. 1926 *A.M.* 1930 Porter, Cecil Edward ...	L. & N.E.R., Signal and Telegraph Engineer's Office (Southern Area), Hadley Wood, Herts.
1939 Porter, J. W. **(H.M. Forces)**	
1934 Protasiewicz, Waclaw	
1922 Quelch, R. P.	Assistant, G.W.R. Signal Engineer's Office, 80, Caversham Rd., Reading
1926 Ramaswami, Kuppaswami ...	Technical Assistant, Signal & Telegraph Engineer's Office, S.I.R., Trichinopoly, India
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S.M. 1924 *A.M.* 1929 Riddle, Hubert J.	Siemens & G.E.R.S. Co., East Lane, Wembley
1932 Roberts, John Francis	10, Warners Road, Cantonment, Trichinopoly, S. India
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1938 Robinson, T. G. ...	L. & N.E.R. Signal and Telegraph Engineer's Office (N.E. Area) York
1929 Robson, F. G. ...	New Zealand Govt. Rlys., Wellington, New Zealand
S.M. 1922 *A.M.* 1926 Rock, A. S. ...	"Penstone," 18, Marlfield Road, Grappenhall, nr. Warrington
1937 Rodgers, A.	Inspector, Signal and Telegraph Dept., L.M. & S. Rly., Conway, N. Wales
1935 Rogers, Ernest Reginald	c/o. J. E. Robson & Co., 11, Bothwell Street, Glasgow
1929 Rutherford, H. G. ...	Southern Railway, Signal and Telegraph Dept., Brighton
S.M. 1939 *A.M.* 1942 Sadler, M. B. ...	Westinghouse Brake & Signal Co., Signal Works, Chippenham
1930 Salt, J.	L.M. & S. Rly., Signal and Telegraph Engineer's Office, Watford
1939 Sambrook, A. G. ...	Telegraph Inspector, Signal Dept., L.M. & S.R., Rotherham
S.M. 1927 *A.M.* 1928 Scott, Bernard Arthur	Westinghouse Brake & Signal Co., Ltd., Chippenham, Wilts
1936 Scroggs, G. W. ...	Westinghouse Brake & Signal Co., Ltd., Chippenham, Wilts
1938 Seymour, R. W. H. ...	Signal and Telegraph Inspector, Sudan Govt. Rlys., Atbara, Sudan
1929 Shalaby, A. E. ...	Chief of Technical Office, Signal Dept., Egyptian State Railways, Cairo, Egypt

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1936 Sherrett, H. J. ...	29, Salisbury Road, Harrow, Middlesex
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1926 Siret, E. C.	c/o. T. Cook & Sons, Dalhousie Square, Calcutta, India
1927 Slatter, Arthur Thomas	Signal and Telegraph Dept., L. & N.E.R., Cambridge
1937 Slogrove, C. V. C. ...	Signal Engineer's Office, South African Railways and Harbours, Johannesburg
1922 Smith, Albert	"Anglezarke," 51, Boroughbridge Rd., Poppleton, York
1940 Smith, C. R.	101, Grange Crescent, Grange Hill, Chigwell, Essex
1935 Smith, Thomas Metcalfe	L.M. & S.R., Signal and Telegraph Dept., New Street Station, Birmingham
1941 Smithies, A. L. P. ...	Materials Assistant's Office, Signal and Telegraph Dept., L.M.S. Rly., Crewe
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1920 Somers, W. H. ...	L.M. & S.R., Divisional Signal and Telegraph Engineer's Office, Derby
S.M. 1938 *A.M.* 1942 Sowerby, G. V.	L.M. & S.R., Signal and Telegraph Engineer's Office, Watford, Herts.
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1931 Stevens, Claude Alexander	L.M. & S. Rly., Signal and Telegraph Dept., Skipton, Yorks
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1931 Stoddart, Stuart Douglas	Signal Inspector, 164, North Sealdah Road, P.O. Amherst Street, Calcutta
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1940 Stokes, T. H. ...	B.B. & C.I. Railway, Signal Dept., Churchgate, Bombay, India
1929 Stone, Adolphus ...	Telegraph and Signal Inspector, Central Uruguay Rly. of Montevideo, Reparticion Telégrafos y Señales F.C.C., Montevideo, Uruguay, S. America
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1931 Syer, Alan F. **(H.M. Forces)**	
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1923 Thatcher, W. J.	...	Sub-Inspector, G.W.R. Signal Dept., Shrewsbury
1936 Thew, G. C. ...	...	L. & N.E. Railway, Signal and Telegraph Engineer's Office (N.E. Area), York
1936 Thomson, L. P.	...	Calle Mitre, Ducilo S.A., Berazatequi, F.C.S., Argentina
1938 Thompson, M. A.	...	Signal Inspector, c/o. Signal Engineer, M.S.M. Rly., Madras, S. India
1935 Thompson, K. H.	...	Inspector, Signals, Telegraphs, Telephones and Tablet, Sudan Govt. Rlys., Engineering Dept., Atbara, Sudan
1938 Thompson, J. L.	...	Assistant Engineer, Westinghouse Brake & Signal Co., Ltd., Chippenham, Wilts
1938 Thorne, W. L. ...	...	G.W.R. Signal Engineer's Office, 80, Caversham Road, Reading
1936 Thorngate, A. W.		Sub-Inspector, G.W.R. Signal Dept., Bristol
1938 Timmins, S. O. L.	...	Assistant Signal Inspector, M. & S.M.R., Railway Quarters, Rajahmundry, S. India
S.M. 1938 *A.M.* 1941 Todd, W. N.	...	Signal Engineer's Office, L.P.T.B., Earl's Court Station, S.W.5
1938 Tomlin, D. A. **(H.M. Forces)**		
1923 Towell, Frank	...	Siemens Bros. & Co., Ltd., 38 & 39, Upper Thames Street, E.C.4
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1935 Trezise, Trevor	...	Westinghouse Brake & Signal Co., Ltd., Chippenham, Wilts
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1938 Viswanathan, S. ...	Head Draughtsman, M. & S.M.R., Signal Engineer, Park Town, Madras, S. India
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1927 Walker, Albert Edward	L.M. & S.R., Signal and Telegraph Engineer's Office, Watford
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S.M. 1937 *A.M.* 1940 White, A. P. R.	L.M. & S.R., Signal and Telegraph Dept., Rhyl, N. Wales
S.M. 1936 *A.M.* 1939 White, K. B. ...	L.M. & S.R., Telegraph Inspector, Chester
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1933 Challis, C. F.	58, Montague Gardens, Wallington, Surrey
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1938 Cox, R. A.	L.M. & S.R. Divisional Signal and Telegraph Engineer's Office, Crewe
1939 Dale, R. C.	General Railway Signal Co., Hillcrest, Frith Hill, Great Missenden, Bucks
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1937 Guyatt, Peter R. G. **(H.M. Forces)**	
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1935 Wheeler, Roland Hugh		106, Valley Road, Ipswich, Suffolk
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GENERAL INDEX

of

ANNUAL REPORTS, MEETINGS, DINNERS, SUMMER MEETINGS, STATEMENT OF ACCOUNTS, PAPERS, OBITUARY NOTICES.

The Honorary Secretary has a considerable number of back numbers of papers and proceedings for sale to members and non-members.

GENERAL INDEX.

ANNUAL REPORTS.

	Year.	Proceedings.	Page.
Annual Report—First	1913	1913	5
,, ,, Second	1914	1914	5
,, ,, Third	1915	1915	5
,, ,, Fourth	1916	1916	5
,, ,, Fifth	1917	1917	5
,, ,, Sixth	1918	1918	5
,, ,, Seventh ...	1919	1919	5
,, ,, Eighth ...	1920	1920	5
,, ,, Ninth	1921	1921	5
,, ,, Tenth ...	1922	1922	5
,, ,, Eleventh ...	1923	1923-4	200
,, ,, Twelfth... ...	1924	1924-5	249
,, ,, Thirteenth ...	1925	1925-26	319
,, ,, Fourteenth ...	1926	1926-7	257
,, ,, Fifteenth ...	1927	1927-8	286
,, ,, Sixteenth ...	1928	1928-9	244
,, ,, Seventeenth ...	1929	1929-30	249
,, ,, Eighteenth ...	1930	1930-31	219
,, ,, Ninteeenth ...	1931	1931-32	331
,, ,, Twentieth ...	1932	1932-33	401
,, ,, Twenty-First ...	1933	1933-34	270
,, ,, Twenty-Second ...	1934	1934-35	345
,, ,, Twenty-Third ...	1935	1935-36	295
,, ,, Twenty-Fourth ...	1936	1936-37	322
,, ,, Twenty-Fifth ...	1937	1937-38	291
,, ,, Twenty-Sixth ...	1938	1938-39	322
,, ,, Twenty-Seventh ...	1939	1940	35
,, ,, Twenty-Eighth ...	1940	1941	10

ANNUAL GENERAL MEETINGS.

	President.	Proceedings.	Page.
Annual General Meeting (*Inaugural Session*)	A. T. Blackall	1913	9
Annual General Meeting	J. Sayers	1914	9
,, ,, ,,	A. Hurst	1915	9
,, ,, ,,	A. Hurst	1916	9
,, ,, ,,	A. Hurst	1917	9
,, ,, ,,	A. Hurst	1918	9
,, ,, ,,	A. Hurst	1919	9
,, ,, ,,	A. Hurst	1920	40
,, ,, ,,	C. H. Ellison	1921	23
,, ,, ,,	W. C. Acfield	1922	12
,, ,, ,,	R. J. Insell	1923	5
,, ,, ,,	W. J. Thorrowgood	1924	5
,, ,, ,,	A. F. Bound	1925	5
,, ,, ,,	F. Downes	1926	5
,, ,, ,,	E. F. Fleet	1927	5
,, ,, ,,	*S. American Branch*	1927-8	217
,, ,, ,,	W. S. Every	1928	7
,, ,, ,,	R. G. Berry	1929	7
,, ,, ,,	W. Wood	1930	7
,, ,, ,,	J. W. Punter	1931	67
,, ,, ,,	C. Carslake	1932	42
,, ,, ,,	W. Challis	1933	13
,, ,, ,,	R. S. Griffiths	1934	49
,, ,, ,,	H. E. Morgan	1935	12
,, ,, ,,	W. S. Roberts	1936	13
,, ,, ,,	H. M. Proud	1937	16
,, ,, ,,	G. H. Crook	1938	16
,, ,, ,,	J. Boot	1939	14
,, ,, ,,	J. Boot	1940	48
,, ,, ,,	J. Boot	1941	20

GENERAL INDEX.

ANNUAL DINNERS.

ANNUAL SUMMER MEETINGS.

GENERAL INDEX—*continued.*

GENERAL INDEX.

GENERAL INDEX—*continued.*

GENERAL INDEX.

GENERAL INDEX.

GENERAL INDEX.

GENERAL INDEX.

GENERAL INDEX—*continued.*

GENERAL INDEX.

GENERAL INDEX—*continued.*

GENERAL INDEX.

PAPERS READ AT GENERAL MEETINGS *(In Date order)*.

Title.	*Author.*	*Proceedings.*	*Page.*
Signalling and its Connection with Construction and Management of Railways ...	R. J. Insell	1913	14
Colour and Colour Blindness	A. Hurst	1913	32
Sympathetic Numbering of Levers	J. Parsons	1913	57
Characteristics and Efficiency Factors of some Typical Electrical Signalling Circuits	G. H. Crook	1914	19
American Signal Practice as compared with British Practice	A. H. Rudd	1914	69, 99
A Review of the Art of Signalling and Some Suggestions	A. F. Bound	1915	14, 38, 49, 68 95
Relative Merits of Track Circuits and Bars for Fouling Point Protection ...	Open Discussion	1916	12
Faults on Telegraph and Telephone Circuits	G. Edmonson	1916	25
Economical Signalling of a Colonial Railway	A. C. Rose	1916	45
Automatic Signalling	C. H. Ellison	1917	9, 36, 51, 63
Some Impressions of Continental Signalling Practice	R. S. Griffiths	1917	79, 101
Maximum Regulating Resistance and Maximum Shunt Resistance of Track Circuits	W. J. Thorrowgood	1918	9, 51, 76
Graphical Method of Solving D.C. Track Circuit Problems	H. M. Proud	1918	94, 129, 139, 157
Renovation of Leclanché Porous Pots and the Re-use of the Interior of Spent Dry Cells	W. J. Thorrowgood	1919	15
British Railway Telegraphs France	M. G. Tweedie	1920	9
Some Problems of Track Circuit Lay-out	W. C. Acfield	1920	66, 99
Do. do do. do. do.	W. C. Acfield	1921	10, 98
Some Fundamental Calculations of A.C. Track Circuit (*Awarded 2nd Prize*, 1921)	D. C. Gall	1921	39
Magnetic Storms	W. J. Thorrowgood	1921	105
Some Problems of Automatic Train Control	W. J. Thorrowgood	1921	165, 195
Some Recent Problems of Token Working on Single Lines	W. S. Roberts	1921	214
Do. do do. do. do.	W. S. Roberts	1922	108
Do. do. (Northern Section) (*Awarded 1st Prize*, 1921)	W. S. Roberts	1921	299
Three-Position Signalling	A. E. Tattersall	1921	247, 284, 320
Light Signals	W. J. Sadler	1921	272
Signal Repeaters and Light Indicators	H. H. Dyer	1922	26
Compensation of Point Rodding ... ... (Northern Section)	T. Guest	1922	34
Signal Replacers	B. W. Cooke	1922	44

PAPERS READ AT GENERAL MEETINGS—(*In Date order*).

Title.	*Author.*	*Proceedings.*	*Page.*
Intermediate Block Signalling	C. Carslake	1922	59
Do. do. (Northern Section)	C. Carslake		
Location of Signals as an Aid to Traffic Working	R. S. Proud	1922	85
(*Awarded 2nd Prize*, 1922)			
Rotary Interlocking Block (Midland Section	A. B. Wallis	1922	117
Do. do. do. (London Meeting)	A. B. Wallis	1923	19
Training of Maintenance Staff	J. H. Tonge	1922	136
(Northern, Midland and York Section)			
Weissenbruch's Signal System on the Belgian State Railway	T. S. Lascelles	1922	149
(Also Northern and Midland Section)			
(*Awarded 1st Prize*, 1922)			
Light Signals	H. E. Fawkes	1922	184
Do. do.	W. J. Sadler	1922	184
Railway Accidents	G. Holt	1923	40
Signalling Apparatus in Foggy Weather and Snow on Metropolitan Railway	W. Challis	1923	132
Theory of Interlocking (*Awarded 1st Prize*, 1923)	J. S. Moore	1923	148, 191
Automatic Telephone Switchboard, Waterloo, Eastleigh and Southampton ...	W J. Thorrowgood	1923	200
(Also at Midland Section)			
Signalling Colours	F. R. Lankshear and A. F. Bound	1923	226
Transient Track Circuits	A. E. Hudd	1923	245, 267
Electric Signal Machine	J. Boot	1924	33
A Survey of Indian Signalling (*Awarded 2nd Prize*, 1924)	A. C. Rose	1924	50
Mechanical and Electrical Detection	Open Discussion	1924	75
Mechanical Interlocking	F. R. Addis	1924	92
Possibilities of Railway Signalling from an Economic Point of View	Open Discussion	1924	137
Signalling on the London Underground Railways (*Awarded 1st Prize*, 1924) ...	W. S. Every	1924	154, 174
Report on Three-Position Signalling	Sub-Committee	1924	200, 231
Double-Wire System of Mechanical Signalling (*Awarded 1st Prize*, 1925) ...	R. S. Griffiths	1925	33

PAPERS READ AT GENERAL MEETINGS—(*In Date order*).

Title.	*Author.*	*Proceedings.*	*Page*
Some Recent Developments in A.C. Track Circuits	R. Dell	1925	78
Lock and Block	T. S. Lascelles	1925	102
Ministry of Transport Requirements and their Application to Signalling Practice	G. Holt	1925-6	165
Continental Practice in the Working of Points and Signals by the Compressed Double-Wire Transmission System	W. J. Sadler	1925-6	196
Long Burning Lamps (*Awarded 2nd Prize*, 1925)	H. E. Morgan	1925-6	257
The Construction of Aerial, Covered and Underground Lines as applied to Railways	W. Wood	1925-6	287
Four-Aspect Colour Light Signals	W. J. Thorrowgood	1926	29
Selection, Inspection and Control of Materials used in Railway Signalling ...	R. C. Woods	1926	50
Comparative Survey of American and British Signalling	J. Parsons	1926-7	117
Fundamentals of Automatic Telephone Switching (*Awarded 2nd Prize*, 1926) ...	H. H. Harrison	1926-7	148
Electrical Power for Railway Signalling and Communications (*Awarded 1st Prize*, 1926)	M. G. Tweedie	1926-7	176
Railway Signalling in Germany	T. S. Lascelles	1926-7	222
Railway Level Crossings (*Awarded 1st Prize*, 1927)	F. Horler	1927	31
Some Signalling Overseas	H. M. Proud	1927	68
Four-Aspect Colour Light Signals and Power Signalling Practice	W. J. Thorrowgood	1927	89
Route Signalling (*Awarded 2nd Prize*, 1927)	J. Boot	1927-8	178
Automatic and Power Signalling Economics	G. H. Crook	1927-8	220
Methods of Holding the Road by Electrical or Mechanical Means or Both during the Passage of Trains	Open Discussion	1927-8	260
Speed and Route Signal Aspects Compared (*Awarded 1st Prize*, 1928) ...	C. W. Prescott	1928	26
A Short Account of the Siemens & Halske Lock-and-Block Systems	T. S. Lascelles	1928	54
Square Sheet Locking Table (*Awarded 2nd Prize*, 1928)	A. C. Rose	1928	92
Short Papers on Some Recent Signalling Developments and Problems	W. Challis, G. H. Crook Geo. Guyatt	1928-9	167
Token Instruments and their Use in Securing Safety in Single Line Working ...	F. W. Leake	1928-9	213
Early History of Railway Signalling (*Awarded 2nd Prize*, 1929)	W. H. Deakin	1929	22
Electric Locking Releases—Their Use and Possible Abuse	A. F. Bound	1929	44
Inter-Communication Telegraph Working	J. A. Webster	1929	75
Specification, Installation and Maintenance of Power Signalling System ...	H. W. Moore	1929-30	163
Some Notes on A.C. Rectifiers (*Awarded 1st Prize*, 1929)	F. A. Downes	1929-30	184

PAPERS READ AT GENERAL MEETINGS—(*In Date order*).

Title.	*Author.*	*Proceedings.*	*page*
Some Further Electrical Details of The Bow Road-Barking Signalling ...	H. H. Dyer	1929-30	219
Reminiscences of an Early Signal Engineer	W. H. Deakin	1930	25
Problem of Signal Aspects: What must we tell the Man on the Footplate? ...	R. S. Griffiths and T. S. Lascelles	1930	47
Training of the Railway Signal Engineer	F. Raynar Wilson	1930	85
Railway Signalling in Holland	G. J. de Vos	1930-1	154
Street Traffic Signals (*Awarded 1st Prize*, 1930)	F. L. Castle and F. Horler	1930-1	179
Installation of Double-Wire Interlocking on Assam-Bengal Railway ... ... (*Awarded 2nd Prize*, 1930)	E. W. Baker	1931	11
Contribution to the Question of Route Lever Working	T. S. Lascelles	1931	79
Ethics and Economics of Speed Signalling	G. H. Crook	1931	122
Electric Lever Interlocking and Intermittent Fed Track Circuits	W. Challis	1931	168
Indicators and Repeaters (*Awarded 2nd Prize*, 1931)...	W. Buckingham and A. Weir	1931-2	242
Discs and Miniature Signals for Shunting and Setback Movements ... ... (*Awarded 1st Prize*, 1931)	B. F. Wagenrieder	1931-2	267
Automatic Train Control (Students Prize Essay, 1931)	H. Myers	1931-2	292
An Unusual Signal Mechanism	F. L. Castle	1931-2	307
Developments in Signalling on the B.B. & C.I. Railway	C. E. Davies	1931-2	308
Railway Signalling Economies	C. W. Prescott	1932	13
Railway Colour Light Signalling in Relation to Manual Block and Multiple Aspect Signals	A. F. Bound	1932	57
Reform of the Signal Aspects on the French Railways	T. S. Lascelles	1932	150
Discs and Miniature Signals for Shunting and Setback Movements	B. F. Wagenrieder	1932	172
Signal Lamps and Kerosene Oils	F. W. Baker	1932-3	241
Signal and Sand Drags	A. C. Rose	1932-3	318
Lightning Protection and Interference from High Voltage	W. Wood	1932-3	342
Token Exchange Apparatus in Scotland	W. Bryson	1932-3	378
Uses of Electricity for Signalling Purposes (Students Prize Essay, 1932) ...	L. C. Lang	1932-3	390
Running of Electric Wires and Cables and the Class of Cable and Wire Used ...	Open Disscusion	1933	28

PAPERS READ AT GENERAL MEETINGS—(*In Date order*).

Title.	*Author.*	*Proceedings.*	*Page.*
Automatic Train Control	G. H. Crook	1933	53
Railway Telephony (*Awarded 1st Prize*, 1932/33)	J. R. Edwards	1933	116
The Problem of Overcoming Wrong-Side Failures of Track Circuits caused by Sand, Rust, Grease, etc.	Open Discussion	1933-4	209
The Financial Side of Signalling Economies (*Awarded 2nd Prize*, 1932/33) ...	H. H. Dyer	1933-4	229
The Component Parts of a Mechanical Signalling Installation and their Functions (Students Prize Essay 1933)	J. S. Davis	1933-4	259
Railway Signalling in Australia	C. W. Prescott	1934	14
Some Notes on Centralised Traffic Control (*Awarded 2nd Prize*, 1934) ...	L. H. Peter	1934	65
Single Line Switching-Out Problems	W. S. Roberts	1934	92
The Rule Book and its Relation to Signalling	A. G. Rickett and B. F. Wagenrieder	1934	119
The Distant Signal Problem	Open Discussion	1934-5	219
Electrically Controlled Gravity Marshalling Yards	F. S. Jackson	1934-5	237
Some Developments in Intermediate Block Signalling (*Awarded 1st Prize*, 1934)...	S. W. Spendlove	1934-5	270
Some Applications of Rectifiers to Railway Signalling	L. H. Peter	1934-5	321
Nomenclature of Interlocking Signals (*Awarded 2nd Prize*, 1935)	F. B. Egginton	1935	34
Economic Aspects of Railway Signalling	A. J. Pearson	1935	62
Road Signals, Traffic Actuated (*Awarded 1st Prize*, 1935)	F. Edwards	1935	87
Interlocking, The Comparison between Mechanical and Electrical Open Discussion	T. D. Richards	1935-6	187
Standardisation of Methods and Practice ... ... Open Discussion	R. F. Morkill	1935-6	206
Switching of Block Sections	F. Burton	1935-6	225
Design, Manufacture and Examination of Mechanical Signalling Apparatus ...	P. W. Hardman	1935-6	256
General Characteristics of Colour and Position Light Signals (Student's Prize Essay 1935)	F. W. Young	1935-6	284
Remote Control and Operation of Outlying Points (*Awarded Joint 1st Prize*, 1936)	P. A. Langley	1936	34
Some Notes on Electric Interlocking	W. H. R. Webb	1936	73
Electro-Pneumatic Operation for Signalling Apparatus (*Awarded Joint 1st Prize*, 1936)	R. S. Proud	1936	103
Signalling Developments in the Irish Free State	H. J. Guthrie	1936-7	200
How Telephones Help to Work Railways	W. E. Green	1936-7	223
A Chronological Record of the Protection of Facing Points	R. S. Griffiths	1936-7	252

PAPERS READ AT GENERAL MEETINGS—(*In Date order*).

PAPERS READ AT GENERAL MEETINGS—(*In Date order*).

ADVERTISEMENT SECTION.

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Issue	Photos	Title	Pages	Author	Keywords
1941		Signalling in Connection with Electrification	26 - 39	L.J.M. Knotts	Southern Railway, colour light, subsidiary signals, supply cables, track circuits, conductor rail, telephone
1941		Early Tube Railway Signalling	40 - 65	T.S. Lascelles	London, underground, Dutton, Spagnoletti, treadles, repeaters, telephones, accident, Glasgow, Saxby & Farmer, electrification
1941		Models for Training Railway Staff	66 - 69	H.C. Towers	model railway, engineering, training
1941		C.E. Spagnoletti	70 - 72	T.S. Lascelles	spagnoletti, telegraph, block
1941		Accumulators and their Ailments	73 - 85	T.C. Elliott	accumulators, over fed, battery, cells, maintenance, faults
1941		Special Catch Point Interlocking	86 - 89	A.C. Rose	catch point, brakes, trailable, signal, indicator, interlocking
1941		Signalling on the Swedish Railways	90 - 99	T.S. Lascelles	Sweden, Saxby, signal aspects, semaphore, colour light signals, distant signals, shunting signals, block, track circuits, power interlocking, power supply, level crossing
1941		R.J.Harland - obituary	101		obituary
1941		R. Dormer - obituary	102 - 103		obituary
1941		E.F. Wagner - obituary	103		obituary
1941		A.S. Hampton - obituary	104		obituary

1941	H.C. Way - obituary	104 - 105	obituary
1941	P.A. Arnott - obituary	105 - 106	obituary
1941	H.J.A. Dyer - obituary	106 - 107	obituary
1941	A. Verdie - obituary	107	obituary