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Government of India
Railway Department
(Railway Board)

Control of Railway Traffic Operations *by* Telephone and Teleprinter

with 18 illustrations

by

Major H. L. CARTER, I.E., M.I.R.S.E.
anning Officer, Telecommunications, Railway Board

Technical Paper No. 317

Delhi
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New Delhi,
20th April 1945.

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This Technical Paper, which issues from the office of the Railway Board, India, is not an official publication. Neither the Government of India nor the Railway Board are responsible for statements made or opinions expressed in the paper.

New Delhi,
20th April 1945.

W. S. BENTON,
Director, Civil Engineering,
Railway Board.

Control of Railway Traffic Operation by Telephone and Teleprinter

INDEX

PREFACE

The writer has prepared the following text with some degree of trepidation. In the first place he has attempted to deal somewhat exhaustively with a subject of primary and vital importance to modern railway operation which, however, has achieved little recognition in printed form. Indeed, a student of railway operation would probably search in vain for text-books on the subject of Train Control.

In the second place he is fully conscious of the temerity of attempting to write on a railway operating subject without due credentials. However, a railway signal engineer, as an onlooker to many facets of railway development and operation, can hardly fail in the course of a lengthy experience, to assimilate some of the inner mysteries of transportation. In any event the writer can justifiably claim to be steeped in railway lore and tradition by family associations which go back, in unbroken succession, to the earliest days of the Great Western Railway. In this work, therefore, he has attempted to use this inborn native intuition to the full rather than to trade on the professional knowledge of a railway signal engineer.

Earlier work of the writer has been criticized on the reasonable grounds that he too frequently used abstruse illusions and words that necessitated constant reference to a compendious dictionary. While this work cannot be covered by the limited vocabulary of Basic English, the text has been prepared with care to avoid technicalities to the greatest possible extent and with the most simple English compatible with the subject.

It has been necessary, in certain instances, to quote specific examples from ordinary practice on Indian Railways to illustrate points in the text. The writer craves the indulgence of the Administrations of these Railways and would hasten to add that any inferences to be drawn from these illustrations are certainly not intended to be long-range criticism of existing practice.

The writer's grateful acknowledgements are extended to the Managements and Officers of the British Railways who facilitated his short tour in 1944, by giving him exceptional opportunities of an intensive study of modern Train/Traffic Control practice in Great Britain.

He also expresses his thanks to the Drawing Office Staff of the Additional Chief Engineer, Posts and Telegrahps Department, for the preparation of Illustrations and to his colleagues who have given him generous assistance in the preparation of this work for the press and he particularly acknowledges his indebtedness to P. Scott Bennett, Esq., Signal Enginer, Oudh and Tirhut Railway, for much helpful criticism, and to Colonel C. M. Scott, O.B.E., Chief Engineer, Posts and Telegraphs Department, Burma, for the period of happy collaboration which greatly helped to lay the original foundations for this work and for the preparation of much of the text and data included in Part III.

New Delhi. H. L. C.

March 1945.

CONTROL OF RAILWAY TRAFFIC OPERATIONS BY TELEPHONE AND TELEPRINTER

By

MAJOR H. L. CARTER, I.E., M.I.R.S.E., Planning Officer, Telecommunications, Railway Board.

PART I

Train and Traffic Control Systems

CHAPTER I

Introductory

1. In the year 1837, Cooke and Wheatstone obtained an agreement with the far-sighted engineers of the Great Western Railway to provide an experimental telegraph circuit between Paddington and Slough, a distance of about 18 miles. A short section was actually working by April 1839. Soon after the circuit was completed to Slough a message sent through to Paddington led to the arrest of a murderer named Tawell. He had sought to make an escape from the scene of his crime by boarding a train leaving Slough for London. Police vigilance rapidly traced the fugitive's movement and the message sent over the Cooke-Wheatstone telegraph enabled a force of police to meet the train on its arrival in London and make an effective arrest. It must be remembered that at that time there were no telephones[1] or other means of electrical communication between the various towns of Great Britain and this somewhat dramatic demonstration of the possibilities of the Cooke-Wheatstone telegraph caught the popular imagination: the first experiment towards the provision of a system of railway telecommunication had been successful.

2. It was not long before other telegraph circuits were brought into use[2] and in the hundred years interval, great developments have taken place in the provision of telegraphs, telephones and teleprinters (commonly associated in the single general term, telecommunications), to assist in dealing with the many problems connected with the transportation of passengers and freight over the railway systems. With these developments came inevitable improvements in the design and efficiency of the equipment, and in more recent times marked progress has been made in the improvement of telephonic speech transmission, testing equipment for the effective maintenance of equipment, and lines and in automatic telegraphy.

3. During the last century these developments were mainly confined to the erection of numbers of telegraph circuits which linked the more important centres of the numerous railway systems which had been built in this era and many of these circuits are still in every day use. Some of the original stone posts which carried the Calcutta-Delhi telegraph brought into use in 1853, are still standing on the East Indian Railway embankment.

4. Simple telegraphy did not meet all telecommunication requirements of the rapidly developing railways and telephone systems were gradually introduced. More important centres were linked by through telephone connexions and later it was found useful to link adjacent stations and signal cabins by local telephone circuits. In many instances a number of adjacent stations and cabins were linked by means of a common circuit, called an omnibus circuit, and code ringing was devised to enable individual points to be called. By this means many points in a given railway system gradually became linked to an intricate network of communication channels by telephone or telegraph.

[1] Inventor of the telephone, Alex Graham Bell, born 3rd March 1848.

[2] Telegraph between Baltimore and Washington opened 27th May 1844.

5. As the majority of these circuits were purely local in character, it followed that instructions issued by the railway management, either by telegram or by oral telephone message, often had to undergo a number of re-transmissions or verbal repetition from station to station before reaching the required point of the system to which the orders applied. It will be readily understood that this system left much to be desired as the constant repetition of messages from point to point meant much loss of time and frequent mutilation of the original text.

6. A further difficulty occurred in connexion with the omnibus circuits referred to above and that was the practical limitations of code ringing. With a few stations on the circuit it was feasible to arrange that one ring meant station 'A', two rings meant Cabin "B", &c. Attempts were made to provide "long" and "short" bell signals to enable additional stations to be added to the omnibus, but, with varying opinions on the duration of time that constituted a "short" signal, there was frequent confusion and a number of stations would answer a call intended for one individual station on the omnibus circuit.

7. The early years of the present century formed a period of great progress in the development of railways. Improved locomotive design enabled longer and heavier loads to be carried at higher speed. Permanent way was strengthened and rolling-stock improved to carry the constantly increasing volume of traffic, both passenger and freight, which the railways were called upon to handle. New railway systems were opened for public traffic, extensions and branches were added to existing railway systems and in order to increase traffic capacity between important centres some railways found it essential to convert lengthy sections of single line to double and sometimes multiple line. In brief, this era witnessed a great expansion of the railway systems and in the volume of traffic carried by the railways.

8. Although there is practically no recorded information from which to draw conclusive evidence, there is not the least doubt that with this general expansion in traffic volume with its attendant operating problems, railways became more and more dependent on the provision of telegraph and telephone facilities for the quick exchange of information and the passing of executive instructions in connexion with traffic operations. This is confirmed by an examination of the very extensive net-work of telegraph and telephone circuits which were built up by the railways of Great Britain during this period. It is no distortion of fact to suggest that telecommunications became the "Nerve System" of railways and that efficient railway operation is absolutely dependent on the "Nerve System" being adequate and functioning properly.

9. Increasing complications in the handling of traffic made it necessary to provide means for more centralized and incisive methods of control of various operational factors than could be satisfactorily given by means of local telegraph and omnibus telephone circuits. As previously explained in paragraphs 4 and 5 such circuits had serious limitations and some method of overcoming these inherent difficulties had to be devised. The solution was forthcoming by the introduction of special telephone circuits known variously as "Train Control", "Traffic Control", or "Train Dispatching Circuits".

10. In bare essentials each of these circuits consisted of an omnibus telephone circuit linking an operating supervisor with a number of stations and signal cabins. In lieu of the code-ringing previously employed, electrical equipment was devised which enabled individual stations or cabins to be called by the operating supervisor, later termed Train or Traffic Controller, by means of an electrical selection switch or key. At the same time means were provided to enable individual stations or cabins to call the Train or Traffic Controller. With these facilities it was possible to exercise a much more detailed supervision or control of traffic operation over a given section than had previously been practicable and executive orders given by the officer responsible for traffic operation could be carried out with greater precision and speed.

11. Many writers have devoted attention to the production of a host of practical volumes on Telegraphy and Telephony and the modern student has the advantage of a most extensive bibliography on which to draw for exhaustive information on either of these subjects. While Telephone Traffic Control is based fundamentally on normal telephone practice, the use of a common circuit to link a number of individual stations or cabins introduces certain technical phenomena and idiosyncracies not encountered in ordinary telephone practice. With the sole exceptions of a comprehensive article describing the Midland Railway Train Control System which appeared in the Railway Gazette of July 8th, 1921, and a technical paper entitled "Recent Developments in Telephone Equipment for Train Dispatching Circuits" by William H. Capen which was presented to the Annual Convention of the Telegraph and Telephone Section of the American Railroad Association on 19th September 1923, the writer is unable to trace the publication of any literature dealing specifically with Train/Traffic Control either from the technical aspect or from the railway operating standpoint.

12. It is not unlikely that this somewhat marked absence of literature or summarized information on a subject of vital interest to efficient railway operation may account, in part, for the widely varied methods of Train/Traffic Control practice on various railways at the present time. Though earlier systems of Train/Traffic Control were instituted about 35 years ago, the passing of time has not brought about any general uniformity of practice and during a short visit to the United Kingdom in 1944, the writer found that even on individual railway systems, actual methods employed in connexion with Train/Traffic Control were not uniform, each Division or Area, in certain cases, using its own particular system. This was possibly a partial legacy of earlier amalgamations of smaller railway systems into the larger systems of the present day, (e.g., London, Midland and Scottish Railway; London and North Eastern Railway, &c.) the smaller railway which had formed component units of the larger combinations, still retaining some of their individual characteristics. These may include some original systems of train control which are held sacrosanct and jealously preserved. In brief, it is clear that this most valuable asset to modern railway operation has developed somewhat fortuitously within boundaries of expediency which have not been critically defined

13. It is necessary to amplify the foregoing paragraph with the comment that in the very wide field of railway operation there are inevitable cases where circumstances necessitate special methods and to which adapted systems of Train/Traffic Control are a vital adjunct. These special cases however are exceptional and do not entirely explain the necessity for the divergent methods of Train/Traffic Control in use at the present time for general operating conditions which are common in greater or less degree to all railways.

14. On Indian Railways a far greater uniformity has been achieved, mainly on account of the fact that graphical Train Control was adopted initially when train control systems were first introduced on Indian Railways about 25 years ago. Indian Railways were faced with the problem of increasing track capacity over lengthy single line sections and speedily found that the graphical method of train plotting (to be described in detail later) met operating requirements to the greatest advantage. Despite this desirable degree of uniformity however, other methods of control have been copied from various examples of British practice and introduced on some Indian Railways. An example may be found in the use of a section diagram associated with the movement of pegs to represent trains in course of movement through the section. As will be explained later this is a common and sound form of Traffic Control which is not at all synonymous with graphical Train Control. The systems differ basically and it is not surprising that attempts made at various times on Indian Railways of maintaining both graph and "Pegging-Board" systems simultaneously have not met with success. Here again the absence of text-books on the subject or at least an available pool of common knowledge has led to costly experimentation and frustrated endeavour.

15. If a given subject has been included in an official military text-book it is a sound plan to give it the most careful consideration if only on account of the clarity which normally characterises such issues. A reference to "Notes on Military Railway Engineering" Part IV, Operating 1942, reveals a well-written chapter on operating control with a clear and concise differentiation between "Traffic Control" and "Train Control". The applicable uses of the respective systems is very effectively developed. It is unfortunate that this most useful volume is not available for general reference.

16. From this rather unpromising background the writer seeks in the following text to differentiate clearly between Traffic Control and Train Control, to describe the methods associated with each and to show how both are closely interconnected with the general operating efficiency of Railways.

CHAPTER II

Traffic and Train Control

17. It is desirable to open this chapter with practical and concise definitions of "Traffic Control" and "Train Control" in order that the distinction between the two systems may be clearly understood at the outset—

"**Traffic Control**" is an overriding supervision of railway operations involving the movement of rolling-stock, passenger or freight, from one point on a given railway system to a destination on the same system or a contiguous railway, **without** a detailed check on the actual movement of trains between given points.

"**Train Control**" is an arbitrary supervision of the actual movement of trains between given points in order that the train carrying capacity of the section may be utilized to the greatest advantage.

18. Traffic or Train Control over a section of railway is generally exercised by a railway employee known as a Traffic or Train Controller. He is located in a suitable office, generally termed Control Office, and his table or "position" is linked by one or more telephone circuits to all the stations, signal cabins and other traffic points in the section in order that he may give instructions to the stations, cabins or other points and receive from these "Way-Stations" information in regard to traffic operation which is required to make the supervision effective. If this operating supervision is Traffic Control, the Traffic Controller will probably require certain equipment to enable him to have a visual reminder of the current position. This equipment takes various forms and will be described in detail in a subsequent chapter. If the supervision necessitates the use of Train Control, the Train Controller will require a graphical chart to enable him to plot the actual progress of trains moving from point to point and plan anticipated crossing or overtaking points to facilitate train operation to the greatest advantage.

19. In very general terms, Traffic Control is suitable for the effective control of operations over—

(a) Single-line sections where traffic is limited to not more than 5/6 trains per day in each direction.

(b) Double and multiple-line sections, except in exceptional circumstances.

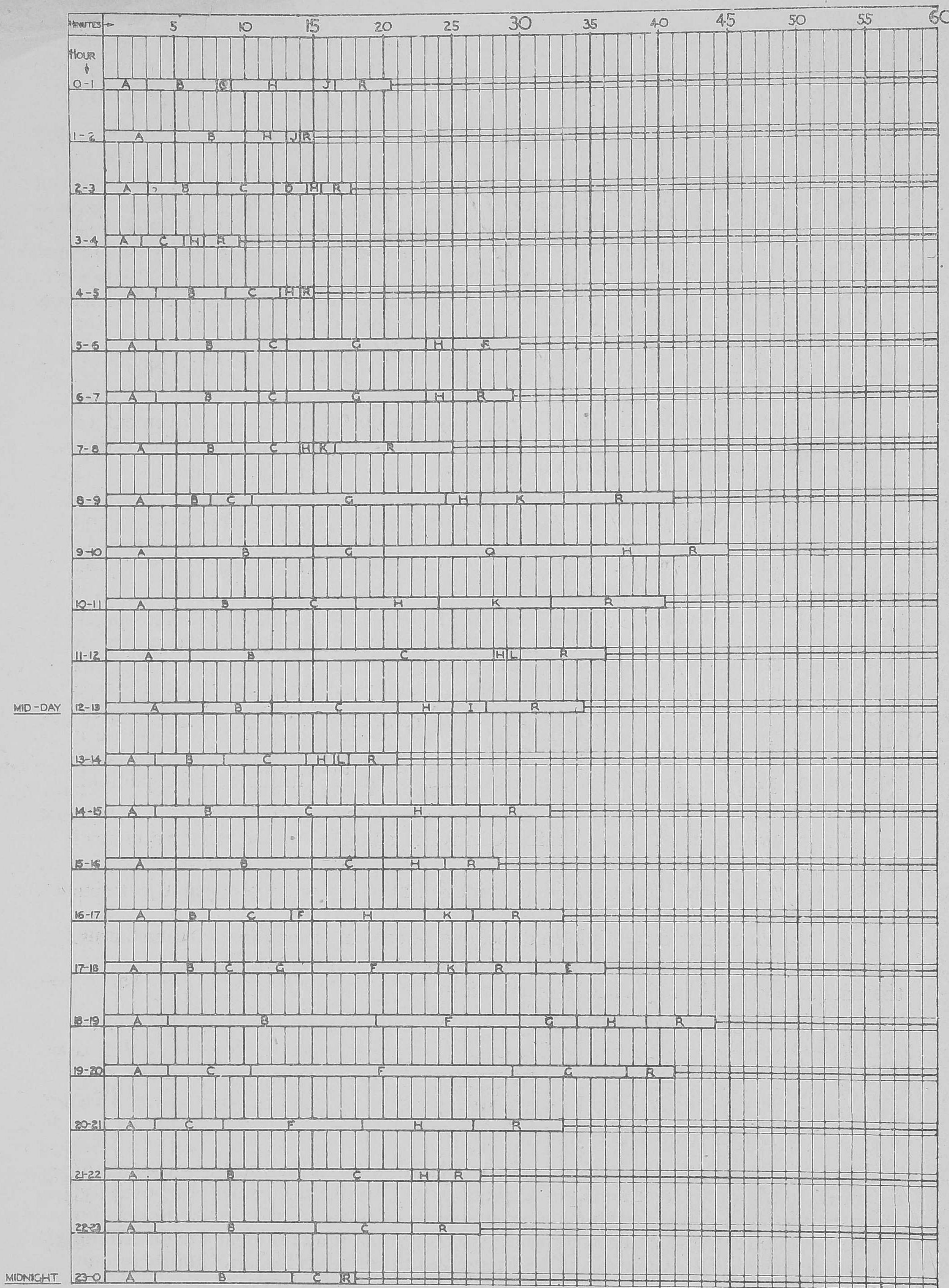
On the other hand Train Control (with graphical plotting) is recommended for the adequate control of operations over or in—

(a) Single line sections where traffic density exceeds 5/6 trains per day in each direction.

(b) Certain double and multiple-line sections where there may be a lack of adequate operating facilities such as running or passing loops, or other considerations tending to make arbitrary Train Control a necessity.

(c) Larger marshalling yards.

20. Whereas Traffic Control can be exercised without an arbitrary control of the movement of traffic from one point to another, Train Control must, of necessity, carry with it some of the functions attributable to Traffic Control. It would depend on the volume of traffic and the complication of operating requirements to determine to what degree a Train Controller could maintain his graphical Train Control and at the same time exercise the functions of a Traffic Controller. Obviously, on a very busy section, not only will the frequency of messages in regard to actual train running be so continuous that the Train Controller will have no time to spare for any other work than maintaining the graph to accord with the actual position, and issuing necessary instructions to way-stations based on the graph, but the actual control circuit is likely to be so fully employed that very few opportunities will occur for the transmission of messages dealing with other traffic matters. When such a position is reached, two alternative courses are open. Either the circuit may be divided into two separate circuits, each with its respective Train Controller, or it becomes necessary to supplement the Train Controller with a Traffic Controller and to provide an additional circuit linked to the more important stations on the section in order that information in regard to traffic operation, other than the actual movement of trains, may be obtained by the Traffic, Engine, or Deputy Chief Controller, as the case may be, without interfering with the work of the Train Controller or attempting to overload an already busy circuit.



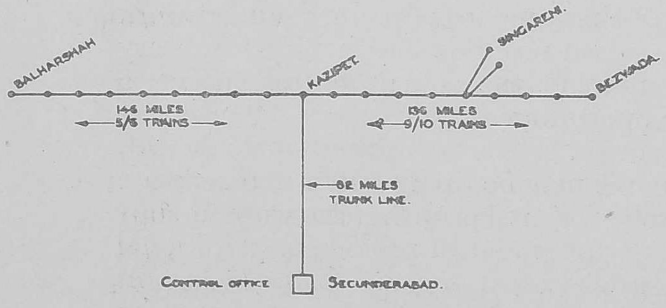


DIAGRAM OF CIRCUIT.

KEY:—

- A — IN/OUT REPORTS WAY-SIDE STATIONS.
- B — IN/OUT REPORTS TERMINAL STATIONS.
- C — RECORDING LOADING, UNLOADING AND SHUNTING DETAILS/DETENTIONS/TIME LOST OR MADE UP
- D — RECORDING DETAILS OF MINOR ACCIDENTS.
- E — DAILY TIME SIGNAL (1800 HOURS)
- F — RECORDING STOCK REPORTS OF WAY-SIDE STATIONS.
- G — RECORDING STOCK REPORTS OF TERMINAL STATIONS.
- H — RECEIVING/DISPACHING MESSAGES RE: TRAIN NOTICES/MOVEMENT OF STOCK.
- I — RECORDING ENGINE POSITION.
- J — RECEIVING JUNCTION INTERCHANGE MESSAGES.
- K — RECORDING RELIEF POSITION AT STATIONS
- L — SENDING RELIEF MESSAGES.
- Q — RECORDING 0900 HOURS COACHING STOCK REPORT.
- R — OTHER ENQUIRIES FROM STATIONS.

FIG. I. 24-HOUR CHART SHEWING TRAIN CONTROL CIRCUIT UTILIZATION.

21. Fig. 1, on the preceding page, gives a useful example of the utilization of the Balarshah-Bezwada Train Control Circuit of H.E.H. The Nizam's State Railway under a monitored test made during the year 1942. It will be seen that at that time the circuit was only in operation for an aggregate period of 11-44 hours per day and that both Train and Traffic Control requirements were being catered for with a reasonable margin. It will be noted, however, that at certain peak hours the circuit loading was approaching saturation point.

22. Quite apart from the fact that the particular circuit illustrated was fundamentally unsound from the technical standpoint, increasing traffic in the interim has necessitated the circuit being divided into two separate Train Controllers' sections each with its own circuit, the position mentioned in paragraph 20 having been reached. The method of monitoring a control circuit as practiced on the H.E.H. The Nizam's State Railway is worthy of emulation and it is advisable to make a detailed analysis of individual circuit utilization, on similar lines, in all cases where control circuits appear to be overloaded. If an individual circuit is continually operated to the extent of full-time utilization, either throughout the day or in peak periods, it is almost certain that some degree of efficiency is being sacrificed. The remedy is one of the alternatives mentioned in paragraph 20.

23. It will now be convenient to consider the actual functions performed by Train, Traffic, Engine and Wagon control with some degree of detail. The more important functions attributable to these varied forms of control are as follows—

(A) **Train Control.**—(i) Arranging the movement of trains from point to point as expeditiously as possible and recording on time/mileage graphs the progress of these movements.

(ii) To anticipate from the graph likely points where trains moving in opposite directions may be conveniently crossed, or fast trains may overtake and pass slow trains, and to give necessary executive orders for these operations before they occur.

N.B.—This is of primary importance in the operation of single line sections. A competent Train Controller can effectively reduce operating costs by intelligent anticipation of crossings and other operating contingencies.

(iii) Arranging the operation of engineering ballast and material trains to the best advantage in co-relation to the normal train schedule.

(iv) Adopting special working arrangements required by blocks or restrictions imposed by Engineering Department.

(v) Controlling the operation of banking engines.

(vi) Controlling emergency single-line operation in the event of obstructions.

(vii) Giving daily time signals at specified hours to all way-stations.

(B) **Traffic Control.**—(i) Obtaining from all stations information in regard to the precise position of traffic offering,i.e. wagons loaded and awaiting dispatch, number of empty wagons on hand available for loading, number of additional empty wagons required to load with goods awaiting dispatch, number of empty wagons on hand which are superfluous to immediate requirements and which may be moved to another point where empty wagons are in short supply.

(ii) Arranging for the running of additional trains to clear exceptional traffic or the cancellation of booked trains if the traffic offering does not warrant the train being run.

(iii) Securing the maximum workable load for each train compatible with the type of engine utilized and special characteristics of the section through which the train is to be worked.

(iv) Obtaining at pre-determined fixed times, stock/position reports from sorting sidings, goods yards and marshalling yards.

(v) Distribution of brake-vans.

(vi) Controlling the hours of duty of enginemen and guards so that they may return to their home station or reach their out-station within the working day.

N.B.—On heavy traffic sections it may be advisable to employ a special staff controller whose duties would be confined to this particular work. Considerable economy in operating costs can be effected by the systematic regulation of hours of duty of enginemen and guards to avoid overtime bonus payments, irregular turns of duty, &c.

(C) **Engine Control.**—(i) Requisitioning locomotive power, i.e. engines, direct from locomotive Running Sheds for all operating requirements, i.e.—train working, shunting and banking.

(ii) Arranging for a minimum light-engine milage

(iii) To ensure the most economic use of engine power available by close supervision of engine working, both in traffic and when passing through running sheds.

(iv) to effect an even balance of engine power between running sheds within each district or division of the railway based on the traffic forecast for an ensuing period.

(v) To ensure the return of engines to "Home" running sheds at regular intervals for wash-outs and other maintenance requirements.

(D) **Wagon Control.**—(i) Arranging for the distribution of stock to meet all traffic requirements based on the returns obtained from the line, vide (B) (i) and (iv).

N.B.—Wagon control may be an overriding control for the whole railway and may operate under direct orders of a centralized wagon interchange.

24. In dealing with a subject of such wide and varied application to railway operations, it is not suggested that the foregoing lists are either exhaustive or complete. Other functions may be, and frequently are assigned to Train/Traffic Control to meet the exigencies and specialized requirements of railway working. To quote but one example, the preparation of a revised time table may require a considerable amount of preliminary research and the co-operation of Train/Traffic Control may be sought to watch and report upon the performance of certain selected trains being worked against an experimental time schedule, the result of such experiments being used as the basis for the new time table.

25. Having considered the various functions undertaken by Train and Traffic Control respectively it is possible to state as an axiom that Train Control (i.e. graphical plotting) should **not** be introduced as a permanent measure, if Traffic Control will meet the **ordinary** operational requirements over any given section.

26. As this axiom goes rather against long-cherished tradition established on some railways and may give the more conservatively minded among operating staff considerable cause for thought, it is necessary to analyze this point in some detail. The basis is the fundamental question of economics. Train Control in its simplest form envisages the employment on each section, of **three** Train Controllers working through the twenty-four hours in three shifts of eight hours duration. Obviously, in the twenty-four hours the density of traffic will fluctuate considerably. There are likely to be periods of heavy traffic and there may be lighter periods when little traffic is passing. The work of the Train Controllers will vary proportionately with the traffic, but the point to be emphasized is that there will be a Train Controller on duty at all times even if the volume of traffic being dealt with is insufficient to provide adequate work for him. It would be possible in many instances, for sections with comparatively light traffic to be adequately controlled, for all purposes, by **one** Traffic Controller working say, between the hours of 08-00 and 16-00 during which period all necessary information and orders will be received from and given to the way-stations controlled; ensuring by this means a sufficient degree of control to meet normal operating requirements for the day. It is in such cases that the economic factor is important and before orders are given for the permanent employment of Train Control the question must be asked—"is the traffic sufficiently dense to justify graphical Train Control or would operating requirements be fully met by Traffic Control?"

27. The foregoing point has been purposely stressed on account of the fact that a number of newly erected control circuits will shortly be made available to Indian Railways and that some of the sections to be provided with control circuits carry only very light traffic, in some cases only two or three trains in each direction per day. It seems clear that in these cases there would not be sufficient justification to initiate full Train Control. However, this will be given a more detailed examination in Chapter VII, wherein a form of economic Traffic Control will be considered.

28. On sections where Traffic Control is normally exercised it would be quite sound practice to introduce graphical train control for short periods and particularly after the introduction of a new time table or where consistently bad time-keeping has been observed. The introduction of the temporary check by graphical methods should only be retained for a sufficient time to enable the operational difficulties to be brought to light and rectified.

29. While the actual structure of the control organization must be adapted to suit the particular operating requirements of an individual railway some assistance in regard to the form this organization might take is afforded by the examples given as Figs. 2, 3 and 4 herewith which show the Main, Area and District Control Systems in operation on the London and North Eastern Railway.

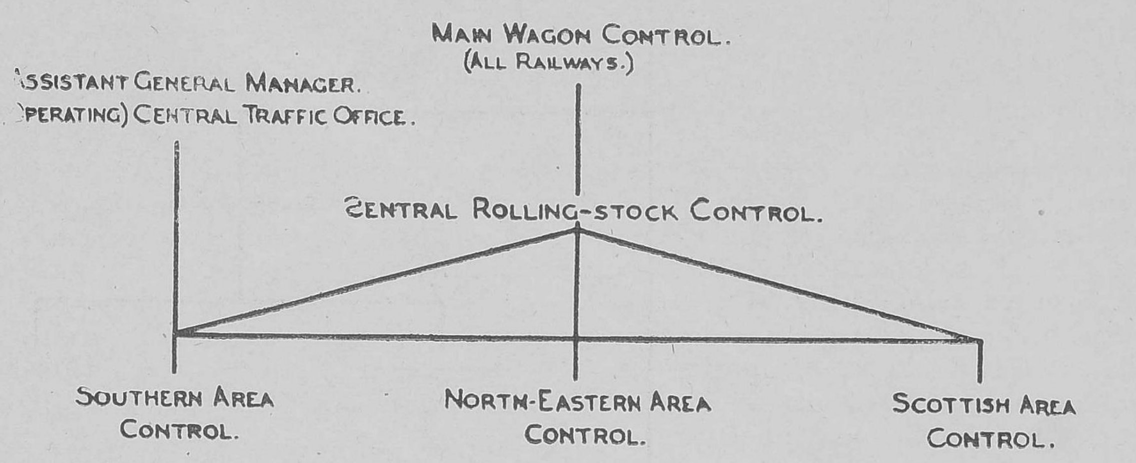


FIG. 2 MAIN CONTROLS.

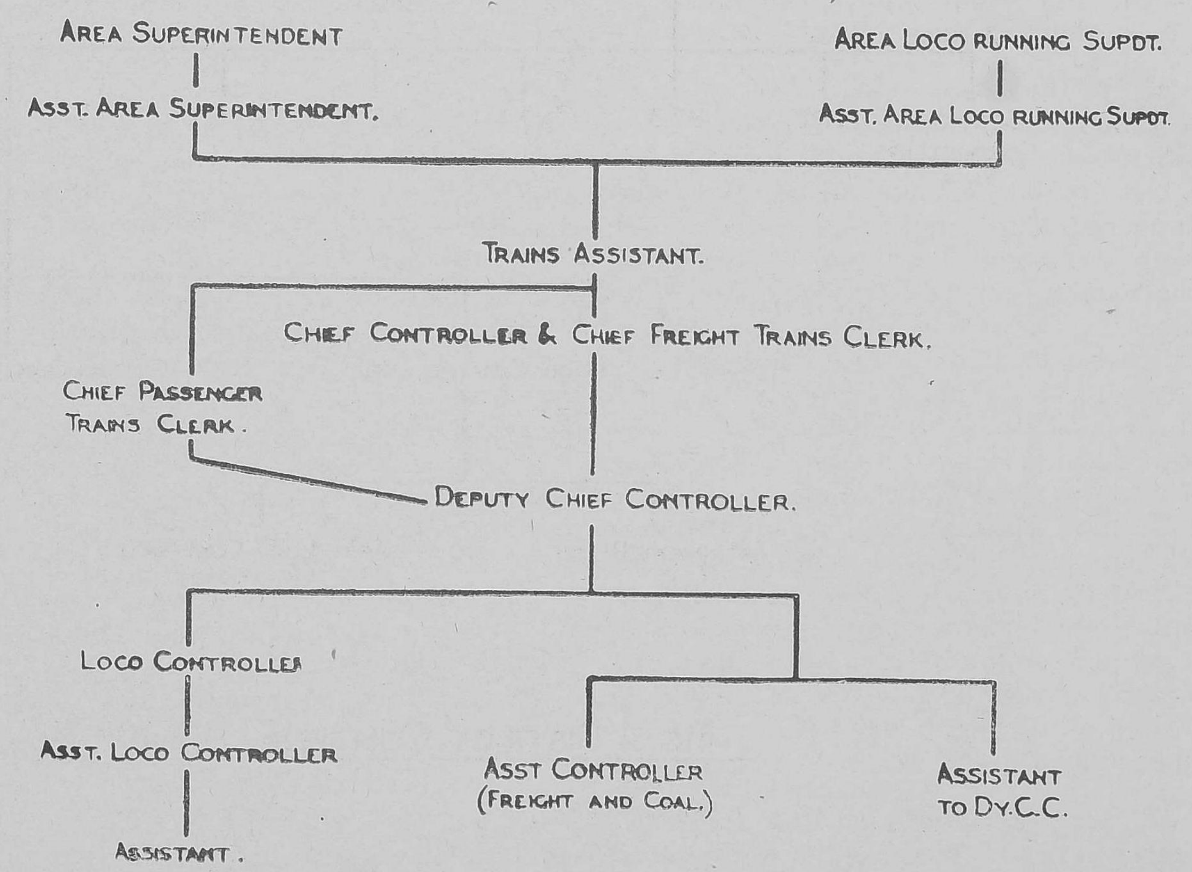


FIG. 3 AREA CONTROL.

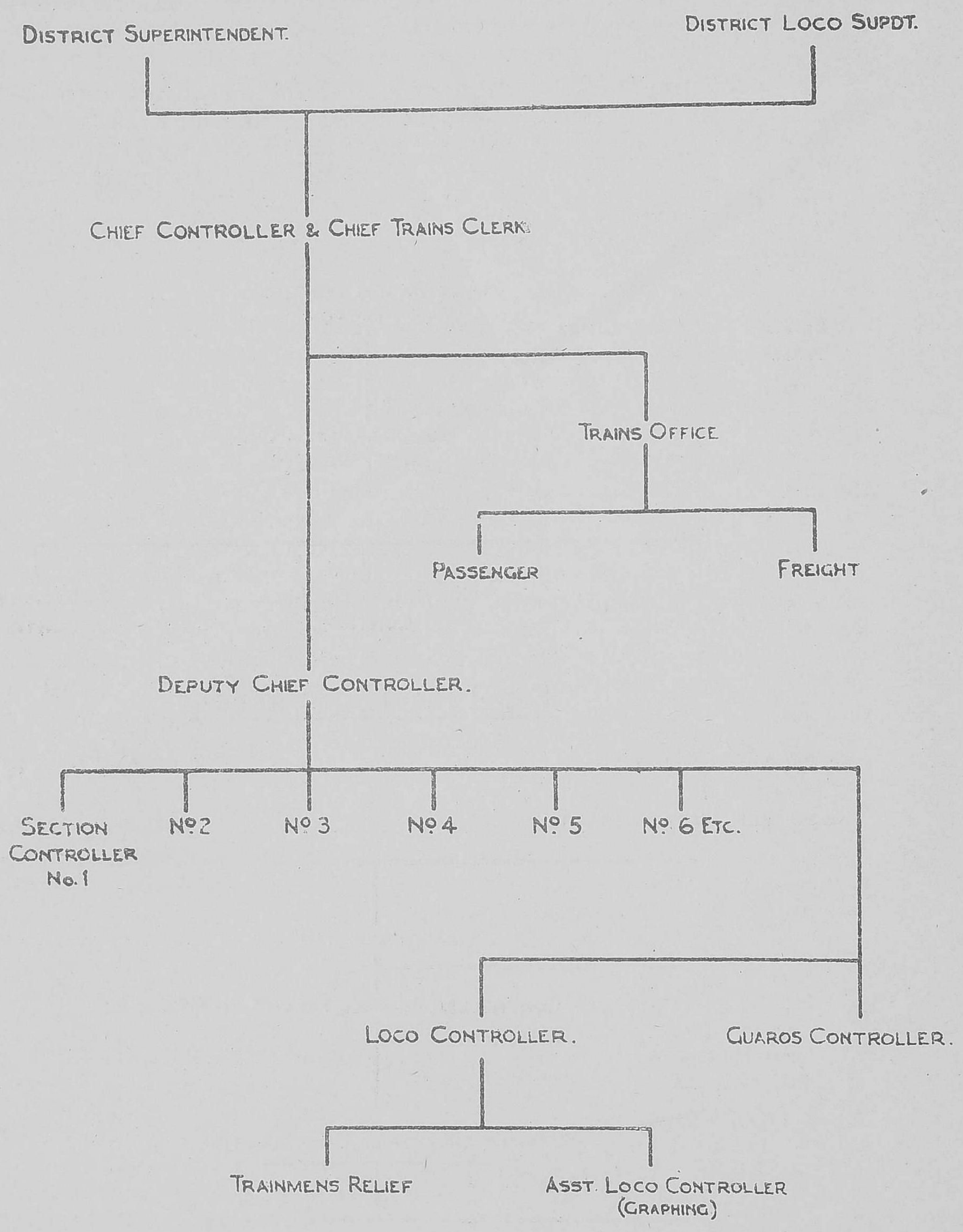


Fig. 4 District Control.

30. The comprehensive control organization depicted in Figs. 2, 3 and 4 has been built up with the advantage of being able to utilize a large number of individual telephone circuits. Indian Railways, unfortunately, have no counterpart to the circuit availability of British Railways though action is now being taken to provide many additional circuits. When the new trunk telephone network is completed it is advocated that all the larger Indian Railways should consider the institution of a centralized or main control, the primary function of which should be the allotment of wagons, for all purposes, from a single controlling authority at the headquarters of the Railway concerned, who, in turn, would be in direct communication with the Director of Wagon Interchange at New Delhi, for the settlement of all questions of interchange balances and other contingencies affecting the inter-railway movement of wagons. It is conceded that this desirable arrangement has not been possible in the past, and that may be mainly attributed to the lack of a suitable trunk telephone network.

31. Indian Railways are not infrequently criticized for maladministration on the grounds of the alleged practice of "selling" wagons by the less scrupulous members of their staffs who may be in a position to withhold or delay the supply of empty wagons. The methods employed were simple and as long as merchants could be found who were willing to make an illegal gratification for the allotment of a wagon, or wagons, for the dispatch of a particular commodity, and adequate centralized control of wagon allotment on a whole-line basis was impracticable, due to the meagre telecommunications, this alleged abuse might be expected to continue.

32. The writer has made this reference to a sordid matter solely on account of the fact that the mere possibility of this abuse being given an opportunity to develop has made the administration of at least one Indian Railway doubtful of the wisdom of improving its control circuits by decentralizing a few of its control offices, though, admittedly, this was the most satisfactory method open to give the technical improvement desired. It was suggested that the decentralization of control offices might lead to an increase in the practice of wagon "selling", on the grounds that the staff operating in the decentralized offices would be less subject to centralized supervision. Here, then, is a case where the prospects of providing much needed improvement to a Railway's telecommunication system are hindered by an incipient cancer. It is to be observed, however, that that cancer may develop with the same malignancy if telecommunications are insufficient or inefficient and a vicious circle is thus created.

33. There is only one solution to this impasse. That lies in the creation of a central authority or main control responsible for the allotment of wagons on an all-line basis and for a Railway's telecommunications system to be sufficiently extensive and efficient to make this practicable.

CHAPTER III

Train/Traffic Control Staff

34. Train/Traffic Control has been previously referred to as the "Nerve System" of a railway. As its functions cover almost every phase of railway operation, the control organization is almost invariably placed under the jurisdiction of the Operating Department of a railway. Various appellations are given to this branch, e.g., "Movement", "Transportation", "Traffic" or "Operating"; all of which are similar terms in this sense, that they denote that branch of the railway responsible for the operation, or movement of traffic, passenger or freight, from one point of a railway system to a destination on the same system or another. On many of the larger railways the actual utilization of engine power is also under the jurisdiction of the Operating Department and in these circumstances some measure of control is usually applied to engine movement and operation.

35. The operation of a railway's control organization devolves upon certain well-defined categories of staff who are selected for these duties by virtue of considerable experience in actual traffic operations at stations and marshalling yards or who have been specially trained for this particular work. It is necessary to observe that efficient control staff are "made and not born". Indeed, the whole efficiency of a railway's control system depends on adequate selection and training of the most promising men, or women, available.

36. The various categories of staff normally associated with control operation and the general scope of their duties are as follows—

(i) **Chief Controller.**—As implied by the designation, the Chief Controller is the senior operating and administrative supervisor of an area, divisional or district control system. In British Railway practice the Chief Controller generally functions also as Chief Freight Trains Clerk or Chief Trains Clerk (where Passenger and Freight Operations are combined). The work of a Chief Trains Clerk is virtually synonymous with that of a Chief Controller and it avoids a considerable amount of overlapping if these two posts are combined.

It is the principal function and duty of the Chief Controller and Chief Trains Clerk to be the "right hand man" of the Area, Divisional or District Operating Superintendent, and on him devolves the general responsibility for the correct normal functioning of all train and traffic operation in his area. He should be capable of, and permitted to use wide executive power in the execution of his duties. Apart from making normal periodic reports of the traffic position, the criterion of a good Chief Controller is an inherent ability to carry the responsibility for the general efficiency of train and traffic operation in his area without constant recourse to his Operating Superintendent.

It is not necessary that the Chief Controller and Chief Trains Clerk should be regarded as an integral member of the actual control office staff. On the contrary, it is desirable that he should have greater personal freedom in carrying out his duties than could be derived from a room or partitioned cubicle in the control office itself. In actual practice it should be seldom necessary for the Chief Controller and Chief Trains Clerk to visit Control Offices except, perhaps, for periodical administrative inspections. Instead, the traffic summaries, yard and stock positions and other information obtained by the control office, should reach the Chief Controller at the hands of one or other of the Deputy Chief Controllers.

(ii) **Deputy Chief Controller.**—The Deputy or Deputy Chief Controller, one being normally required for each working shift, is in general administrative charge of the working of the control office during his period of duty, and is responsible to the Chief Controller and Chief Trains Clerk for providing, at regular pre-determined intervals, all relevant figures covering the precise traffic position at all points in the controlled area.

His work will include the supervision of the work being carried out by Train, Traffic, Staff and Engine Controllers on duty and the collation of information received from way-stations in order that the current traffic position obtaining on all the controlled sections may be available at all times.

He must also be responsible, normally, for all decisions referred to him by Section Controllers. It must be noted that Chief Controllers are usually only available during the day shift.

All the operating graphs, together with the information regarding the traffic position collected from way-stations should be frequently scrutinized by the Deputy Chief Controller with the object of assisting the railway administration by every avenue of economy in operation that may be available, compatible with the volume of traffic. In other words he should consistently watch all operations to ensure the maximum movement of traffic with the minimum expenditure of engine power.

Apart from having a thorough and intimate knowledge of the general layout of stations, yards and sidings in the controlled area, a Deputy Chief Controller should also be conversant with the categories of normal and seasonal traffic originating in the area under his jurisdiction. Weather conditions may influence requirements or necessitate immediate executive action, as, for example, when continuous heavy rain has led to flooding or breaching of the line and alternative routing has to be arranged.

A highly important side of a Deputy Chief Controller's work lies in the discipline he must at all times maintain. The key to successful control operation is found in effective discipline in the control office. It is essential that there must be the greatest possible degree of quietness and this is most important if a number of controllers are located in the same room. In the interests of efficient working on the part of the staff there are also aesthetic considerations, including orderly routine, office cleanliness, ventilation, &c. all of which are covered by effective office discipline and to which the Deputy Chief Controller must give unremitting attention.

(iii) **Section Controllers (Train Control or Traffic Control).**—A divisional or district control system is usually divided into sections, each section being allotted to a section controller who will be responsible for the control of traffic operation on that section. The work of a Section Controller is generally summarized in Chapter II, Paragraph 23 (A) and (B). Normally three Section Controllers will be required for each section, working in eight hour turns of duty.

(iv) **Staff Controllers.**—In divisions or districts where traffic is exceptionally heavy, either continuously or at certain peak periods, it is desirable to relieve the Train or Traffic Controllers of all matters affecting the booking, hours of duty, relief arrangements, &c. of engine crews and guards. In such cases it is recommended that Staff Controllers should be employed to carry out the work of co-ordinating the working to prevent engine crews and guards incurring excessive hours on duty and, when necessary, to make arrangements for their relief.

For each working shift, one Staff Controller would normally be in a position to co-ordinate all work affecting staff arrangements for the entire divisional or district control system. It would be necessary for his table, or "Position", to have means of connexion to the various main and section control circuits.

(v) **Engine Controllers.**—On those railways where engine running is delegated to the Operating Department, the direct control of all engine movement and operation may be conveniently supervised by the control organization of the railway. If this supervision entails more work than can be readily dealt with by Train or Traffic Controllers it becomes necessary to employ Engine Controllers to carry out the duties summarized in Chapter II, Paragraph 23(C).

Certain railways use the designation "Power Controller" or "Loco Power Controller" instead of Engine Controller. On railways where electric traction is provided a "Power Controller" may have an entirely different function and for this reason it is suggested that the term "Engine", rather than "Power" is more applicable to all duties in connexion with locomotive running.

The scope of this work does not permit consideration of the various factors, for and against, bearing on the question of train running, including the utilization of locomotive power, being vested in one authority, the Operating Superintendent. It is, however advocated that on railways where responsibility for train running is still divided between two separate departments, the Engine Controller should be transferred from the Locomotive Department to the Operating Department and function as an integral member of the control staff under the orders and jurisdiction of the Deputy Chief Controller.

The foregoing paragraph touches on a somewhat intricate problem.

A problem which is almost as old as the railways. With some experience of what goes on "behind the scenes" it may be observed that departmental rivalry is all too frequently taken to a stage of regrettable animosity. While inter-departmental rivalry, at the proper level, is perhaps a pre-requisite to efficient over-all railway operation it is expedient that this friendly competitive spirit should be restricted to the administrative officers who are in a position to visualise the general picture of railway working as a whole. If "Departmentalism" is allowed to creep in at lower levels, and more particularly between members of the staff who are not in a position to appraise the whole picture, the effect may often be greatly to the detriment of efficient operation. If Train/Traffic Control is to function as a reasonable asset to the effective operation of a railway these tendencies must be curbed. It seems essential that the full and complete administration of a control office must lie with the Deputy Chief Controller and if the suggested method, outlined above, or some similar adjustment cannot be achieved, as between Locomotive and Operating Departments, the appointment of Engine Controllers is likely to be premature to developed requirements and ineffective in its outcome.

(vi) **Clerical and Junior Control Staff.**—Depending upon the volume of recorded work prepared by the Control Organization it may be necessary to employ clerical staff to assist the Deputy Chief Controller in the preparation of traffic summaries, statistical records, &c. Other clerical staff may be necessary to deal with staff duty rosters, booking guards for duty and similar work.

On some railways it is customary to train future Traffic Controllers by a form of apprenticeship and the junior hands spend much of their period of training in the control office. These can be usefully employed in preparing train cards and in maintaining pegging-boards in the correct current position under orders of the Traffic Controllers.

37. The training of suitable staff to fill positions in the control organization is a matter of considerable importance. It will be obvious that candidates with the specialized knowledge required cannot be recruited from the open market and the problem has hitherto been solved by some railways with one or other of the following methods.—(a) Recruiting juniors with sound educational qualifications and training them to be potential Traffic Controllers by a lengthy apprenticeship which is almost wholly spent in control offices or (b) transferring promising members of the staff from stations, goods or marshalling yards and giving them a short period of training in control offices before promotion to the status of Train Controller. Both these systems have inherent disadvantages. Those recruited as juniors and who receive practically all their training by under-studying regular Traffic Controllers, ultimately acquire ability to take over duties as Traffic Controllers themselves. On the other hand, because their open line experience in the actual operation of traffic has been negligible, staff trained in this way cannot readily appraise the practical difficulties which occur in everyday operation, and, from lack of familiarity with station and yard operation are not in a position to pass executive orders based on practical experience. The other method of recruitment; combing the ranks of station and yard staff, would certainly tend to produce a type of Traffic Controller well-versed in outdoor operating experience but such recruitment can only be secured at the expense of the open line operational organization. It is merely a case of "robbing Peter to pay Paul".

38. On British Railways the general method of recruitment of Traffic Controllers is by the means described in paragraph 37(a) and only one of the larger systems has resorted to the provision of a special school for training suitable candidates for the duty of Traffic Controllers.

In India, if full advantage is to be taken of the constantly increasing utilization of the control organization; bringing in its train the construction of many additional control circuits, it would seem essential that a sound system for the recruitment and training of suitable candidates must be established. This does not seek to suggest that some of the principal Indian Railways may not have already arrived at a via media to deal with this problem, though there may be considerable lack of uniformity in the methods employed as between the various Indian Railways.

39. In the case of the administrations of other Indian Railways who have had difficulty in this matter or are considering schemes for the recruitment and training of Traffic Controllers the following scheme of training recommended by the Train Control Committee of the London and North Eastern Railway in February 1943, may be of interest and assistance.

Scheme for Training Control Staff

The training to be spread over one year. 38 weeks being occupied in a course of practical training in all aspects of the working associated with train, traffic and engine control, and 12 weeks' attendance at a school of training for instruction in the basic principles of control working, &c. The division of time in each section to be as follows, but the Training Scheme Committee may, at their discretion, vary the practical training course in individual cases if they consider this warranted

(A) Practical Training. (38 weeks)—	Period
(i) Main Line and Junction Signal Boxes studying train working.	4 weeks.
(ii) Marshalling Yards; with the object of acquiring a knowledge of problems associated with the marshalling dispatch and disposal of trains. A short period to be spent in a Yard Master's Office.	8 weeks.
(iii) Large Passenger Stations; to acquire a knowledge of the problems of platform working, maintenance of connexions, making up carriage sets, the loading and unloading of parcels traffic, &c.	4 weeks
(iv) Locomotive Depot; general working of, including disposal, preparation and listing of engines. Rostering of enginemen.	6 weeks.
(v) District Superintendent's and District Loco. Running Superintendent's Offices; Freight and Passenger Trains Sections, including periods with Train Inspectors; in Control Offices and Rolling-stock Section.	12 weeks
(vi) Superintendents and Loco. Running Superintendent Offices; Freight and Passenger Trains Sections and Central Control.	3 weeks.
(vii) Rolling-stock Controller's Office; distribution arrangements, freight and coaching stock.	1 week.
Total ..	38 weeks.

(B) Instruction at Training School (12 weeks)—

1st Week. Railway Organization.—(i) L.N.E.R. Operating and Locomotive Departments in detail, and other Departments, general. Division into areas and districts.

(ii) Organization, general, of other Main Line Companies.

(iii) Inter-Company contacts.

(iv) Operating and Locomotive Departments. Staff Agreements with particular reference to methods of compiling rosters and main principles arising out of guaranteed day and week; rest clauses; and a general outline of disciplinary procedure.

2nd Week Railway Geography and Industries.—(i) Of the country as a whole, and

(ii) the areas served by the L.N.E.R. in greater detail; their industries and main flows of traffic.

(iii) Exchange points, and junctions with other Railway Companies and main flows of traffic.

(iv) Location of principal Marshalling Yards and Locomotive Depots.

(v) Ports owned or served by L.N.E.R.

3rd and 4th Weeks. Operating and Locomotive Departments. – (i) The detailed organization and functions of the various sections in the Headquarters and District Offices; also the organization at stations, marshalling yards and locomotive depots.

(ii) Preparation of public and working time tables and special train and traffic circulars.

(iii) Passenger train working; carriage working rosters and parcels and luggage loading instructions.

(iv) Freight train working; classification of trains, speeds and point to point running times; marshalling lists; out-of-gauge loads, &c.

(v) Engines; description of the various types; maximum load tables for passenger and freight trains; restrictions on running over certain sections of the line; engine working diagrams.

(vi) Rolling-stock Controller's organization; types of rolling-stock and distribution arrangements, freight and coaching.

(vii) Train and Marshalling Yard statistics.

5th and 6th Weeks. Miscellaneous.—(i) Rules.

(ii) Regulations for Train Signalling. (To include instruction in the Signalling School at York).

(iii) Appendix Instructions.

(iv) Permanent way operations.

(v) Conditions of conveyance of out-of-gauge loads.

7th Week. History of Control, Organization, Functions and Methods.—(i) On British Railways, general.

(ii) On L.N.E.R. in detail.

8th, 9th and 10th Weeks. Train, Traffic and Engine Control.—Lectures, practical demonstration and instruction.

11th Week. Relations of Operating and Locomotive Departments to other Departments.—A series of talks by representatives of other Departments, (Civil Engineer, Signal and Telegraph Engineer, Mechanical Engineer, Goods Manager, Passenger Manager and Rolling-stock Controller) explaining the functions of these Departments in relation to the Operating and Locomotive Departments.

12th Week. Examinations. –(i) Written.

(ii) Oral.

40. This comprehensive scheme was drawn up to cover the training of suitable men, aged 24-26 years.

It was laid down that it was a condition of appointment that a candidate, after training, should be prepared to accept any Controller's post for which he might be selected by the Company and the right was reserved to terminate the training of any candidate at any stage of the training if satisfactory development was not being achieved.

41. In India, it is thought that recent improvements in the pay and prospects of Train/Traffic Controllers should make posts in the control organization more attractive and it should be possible to recruit young men of reasonably high educational qualifications, who would profit by a course of training on lines similar to those described in paragraph 39. In the view of the writer, a course such as described, blending experience of actual operations in stations and marshalling yards with theoretical and practical training in actual control operations, if reasonably intensive, should ensure the production of a good type of Train/Traffic Controller for the future.

42. Under the stress of war conditions British Railways have found it necessary to employ a number of women in various duties in the control organization, e.g. maintenance of statistical records and compilation of traffic returns. In one busy control office, the writer observed that a complicated engine running graph was being competently maintained by feminine hands.

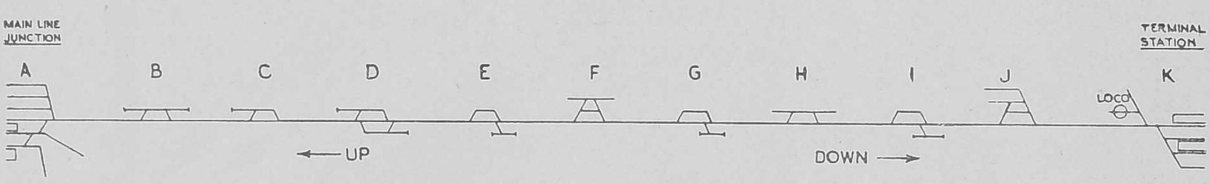
CHAPTER IV

Traffic Control Methods

43. As explained in Chapter II, Traffic Control does not involve a detailed and sustained check on the actual movement of trains from station to station in the Section controlled and for this reason the maintenance of a time/mileage graph is not necessary and the Traffic Controller is relieved of the duty of graphical plotting. As an alternative, the Traffic Controller will almost certainly require some means of indicating the current location of trains together with particulars of the loads, engine numbers and names of engine crew and guard. These devices or aids to a Traffic Controller's memory, will vary considerably with the volume of traffic normally controlled. With very light traffic, the only equipment required may be a pencil and a pad of foolscap paper; with heavier traffic the Traffic Controller will require additional equipment. This chapter considers some of the methods available.

44. Before analysing these methods it is desirable to interpose the comment that Traffic Control of a section of railway will almost invariably cover all aspects of freight train operation, but the Traffic Control of passenger train working is not always necessary. In cases where passenger trains are operating to reasonable time schedules, the composition of the trains is practically constant from day to day (i.e. the "sets" or "rakes" are made up to a pre-determined schedule), and the engines hauling these trains are operating to a regular schedule or link, the time table is the controlling factor and Traffic Control is virtually redundant, except at those times when the normal time table has been considerably upset due to some abnormal circumstance.

45. As an introduction to normal Traffic Control methods some features of the work involved in the Traffic Control of a branch line, carrying very light traffic, as illustrated in the diagram below may be examined.



46. (The booked time table traffic on this section is three passenger trains daily in each direction. These are operated to a time table giving adequate time margins for crossings and station requirements, and the actual running of these trains is not normally controlled. Freight trains are not scheduled and are only operated as and when the volume of traffic offering on the section justifies a train being ordered.)

(i) On taking over duty, the Traffic Controller would call for the current "position" in the yard at "A" and note the number of loaded wagons on hand for distribution to the branch stations 'B' to 'K'. He would note these as follows—

Loaded on hand at 'A' for—'B'—4; 'C'—1; 'D'—2; 'E'—1; 'F'—4: 'G'—5; 'H'—2; 'I'—2; 'J'—1 and 'K'—10 Total 32.

(ii) The next procedure would be to ascertain the current traffic position at each of his stations 'B' to 'K' and, calling each station in order, the following information would be obtained and tabulated—

Station	Outwards				Inwards	
	Loaded on hand for stations		Surplus empties on hand		Additional empties required	
	Up	Down	Covered	Open	Covered	Open
B	4A	2E 2K	2	2	....	....
C	2A	1K	....	....	....	....
D	....	1K	....	....	....	....
E	5A	....	....	2	....	....
F	4A	1H 1K	2	....	....	....
G	....	....	4	2	....	....
H	5A	1K	....	....	3	3
I	2A	....	....	....	....	....
J	....	1K	....	....	2	....
K	24A	....	....	....	3	3

(iii) From the information obtained vide (i) and (ii) the Traffic Controller will know that for the down direction he has 32 loaded wagons on hand for distribution to stations 'B' to 'K' and an additional 10 loaded wagons to be collected from intermediate stations and worked towards 'K'. Further, Stations 'B' to 'G' have surplus wagons available which will meet demands for additional wagons made by stations 'H' to 'K.'

(iv) A brief analysis of these tabulations will indicate to the Traffic Controller that he has a downward load which may be started from 'A' as 32 loaded plus brake, and that the load, after working each station by picking up and setting-off wagons, will never exceed 36 wagons (32 loaded plus 4 empty) plus brake. The train will finally arrive at 'K' as a terminating load of 23 wagons (17 loaded plus 6 empty) plus brake.

(v) The Traffic Controller will also observe that he has a return up load available which will leave 'K' as a train of 24 loaded plus brake and arrive at 'A' after picking up additional loaded wagons at intermediate stations as a train of 46 loaded plus brake.

(vi) From this analysis the Traffic Controller will decide that there is sufficient traffic justification for running a "work" or "pick-up" freight train from 'A' to 'K' and to work a return load from 'K' to 'A.'

(vii) Having acquainted the Deputy Chief Controller with the position and obtained approval, the Traffic Controller will make arrangements with the Yard Master at 'A' for the train to be marshalled in correct station order (to facilitate attaching and detaching at intermediate stations), and mutually arrange a convenient starting-time. It is then necessary to advise the Loco Foreman and request that an engine may be made available to work the load from 'A' to 'K' and be in readiness to leave 'A' at the arranged starting time. The Traffic Controller will give the Loco Foreman particulars of the approximate maximum load to be drawn (in this instance 46 loaded plus brake) in order that the Loco Foreman may decide the most economical type of engine to employ for the purpose.

(viii) Arrangements for the engine crew will normally be made by the Loco. Foreman but the Traffic Controller must arrange for a Guard. Normally the next-for-duty on the guards' roster will be advised by call-book giving him particulars of the train he is being called to work and the arranged starting time.

(ix) Having completed the arrangements in connexion with the formation, starting time, engine power and guard for the train, it may be necessary for the Traffic Controller to work out an approximate time table for the passage of the train through the section, making due time allowances for shunting operations, crossings, &c., and advise intermediate stations accordingly.

(x) The Traffic Controller will advise station 'K' that the return load should be marshalled and in readiness to start at a given time. Assuming the downward journey to require approximately 7 to 8 hours a fresh engine crew and guard will be required to work the return journey from 'K' to 'A' and necessary arrangements must be made. If a fresh engine crew and guard are not normally available at 'K' it would be necessary to send the relieving staff to 'K' by passenger train.

(xi) After the train has left 'A' en route to 'K', the Traffic Controller will keep a watching brief on the running of the train by making periodical inquiries from way-stations. (Way-stations would not normally call the Traffic Controller).

(xii) The Traffic Controller's work will end with the completion of the necessary traffic records.

This short description of the operation of Traffic Control on a section carrying very light traffic is not exhaustive but is illustrative of basic principles involved. In such a case the Train Controller would only require a working time table, a pencil and pad of foolscap paper to complete his essential working equipment.

47. Where heavier traffic is involved it is usual to introduce the use of some system of cards, separate cards being used for each train involved. Each card is entered with the following particulars—

> Train number, date, names and home station of engine crew and guard, (with time of booking-on duty), engine number and type at the head of the card, the body of the card being utilized for subsequent noting of alteration to load, station arrival times, and other relevant details. It is useful to be able to distinguish different types of traffic, e.g. "Fast Freight", "Coal", "Empties", "Perishables", &c. by the use of cards printed in differing colours or by means of a bar of colour at the top of the card. Facsimiles of typical cards used in traffic control systems on British Railways are reproduced as Figs. 5, 6 and 7 on pages 20 and 21.

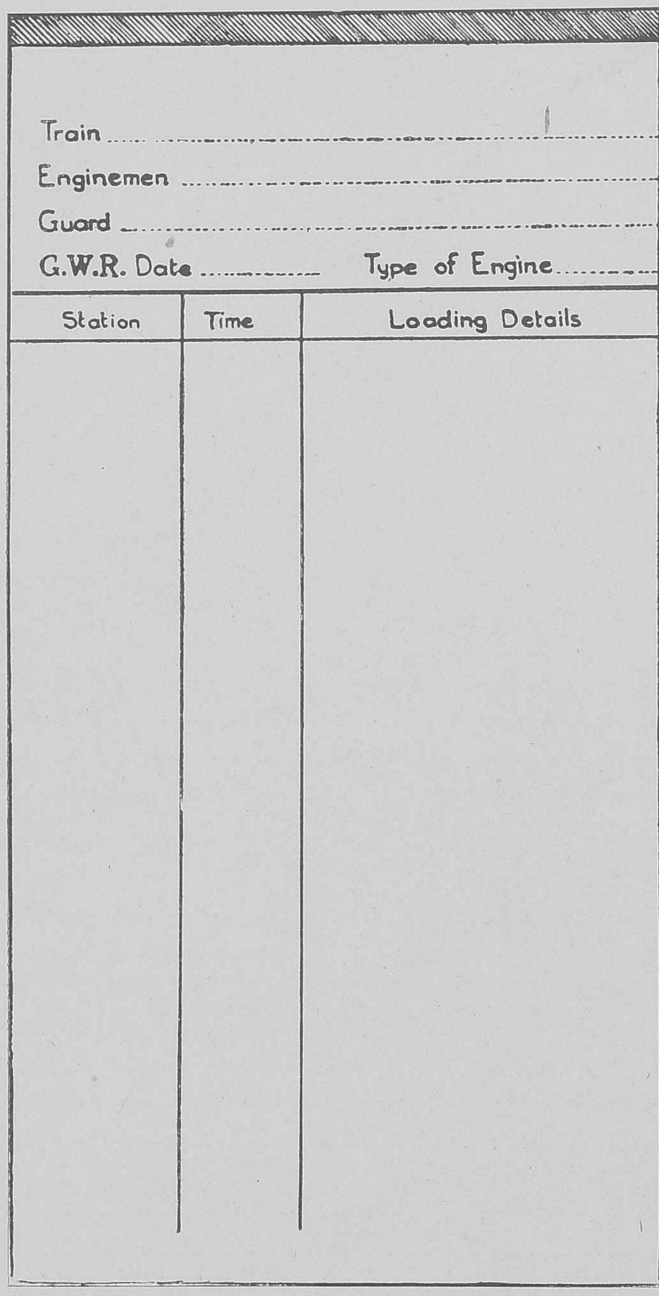


Fig. 5. Standard $3\frac{1}{4}'' \times 6\frac{1}{4}''$ Traffic Control Card in use on Great Western Railway. A bar of colour $\frac{3}{16}''$ wide is printed across the top of the card in cases where it is required to differentiate between various classes of freight traffic; different colours being used as necessary. These cards are reversible being printed identically on each side.

L.N.E.R. Number_______ ________________ 19 __

TRAIN	CLASS	ENGINE No.	CLASS	SHED

STATIONS, &c	TIME			LOAD			REMARKS
	Booked	Actual	Late	Booked	Actual	Under	
							Hrs. Mins.
							Time Train Out __________

Fig. 6. Standard 5″×8″ Traffic Control Card in use on London and North Eastern Railway for the operation of non-regular trains running to a scheduled time table if justified by traffic requirements; Sunday trains, &c.

TRAIN L.N.E.R.

DATE										
ENGINE No. CLASS AND DEPOT										
STATION, &c.	BOOKED TIME	ACTUAL TIME	LATE	LOAD	ACTUAL TIME	LATE	LOAD	ACTUAL TIME	LATE	LOAD
Dalmeny										
Queensferry Jct.										
Edinburgh (arr)										
do. (dep)										
Longniddry										
Drem										
Dunbar										
Grantshouse										
M. Meadows										
Berwick										

	LOAD:-	REMARKS:-
THURSDAY		
FRIDAY		
SATURDAY		

Fig. 7. Shows a 6″×8″ Traffic Control Card in use on the London and North Eastern Railway for the operation of regular daily freight trains, one card being used for the same train throughout the working week, Monday to Saturday. The cards are similarly printed on both sides with the exception of the days of the week. In cases where there is a heavy regular freight trains service between given points, the preparation of special cards with the names of stations printed (as shown in the illustration), would assist the Traffic Controllers and reduce clerical labour in the Control Office. If required these cards may be printed in various colours to enable different classes of traffic to be readily identified. When many cards are involved this colour differentiation is xtremely useful to the Traffic Controller.

48. To facilitate the use of train cards the Traffic Controller is generally provided with a partitioned box, each partition being used for a separate station. As reports are obtained from way-stations the "train cards" are moved from one partition to the next as the train proceeds through the section. By a glance at the box a Traffic Controller has a good approximation of the current traffic position at any given time; the last reported location of any given train and a particularly good indication of "bunching of traffic" should this tendency occur. Obviously if a number of cards tend to accumulate in one partition, the Traffic Controller will at once ascertain the cause from the way-station concerned.

49. As a train completes movement through a Traffic Controller's section, the corresponding "train card" is handed over to the Traffic Controller responsible for the control of the contiguous section. When a train reaches its final destination or passes beyond the boundary of the railway district or division the "train card" is passed to the statistical section of the Control Office, where necessary detailed information is extracted and collated and the cards are then filed, in date order, for further reference in case inquiries are made subsequently in regard to running, load or other particulars of a given train on a certain date.

50. On sections of railway carrying heavy traffic a constant visual indication of the traffic position may be given by means of a "pegging board". This consists of a diagrammatic map of the section, showing all stations, yards, running lines and sidings. This diagram is painted on a firm background of ply-wood, metal or composition. Holes are drilled at appropriate places for the insertion of pegs to represent trains, the pegs being moved as train movement reports are obtained from way-stations. Pegs may be painted in various colours to represent different classes of traffic and usually carry small cards which are frequently miniature reproductions of the cards described in paragraph 47. The photograph reproduced on the next page gives a clear view of pegging boards fitted above the Traffic Controllers' "positions".

51. In the opinion of the writer, the "pegging board", if conscientiously maintained in up-to-the-minute order, is the most advantageous method of assisting a Traffic Controller to maintain a constant visual indication of the traffic position in his section. It facilitates supervision by the Deputy Chief Controller and enables an inspecting officer to appreciate the traffic position at a glance.

52. As a footnote to this chapter it is desirable to comment that the various mechanical aids to Traffic Control are all transient in character and have the marked disadvantage that, while the current position is clearly indicated at all times, reconstruction of a position that obtained at some earlier time, required occasionally in case of inquiry into an accident or other circumstance, may involve considerable research in obtaining the requisite information from the cards.

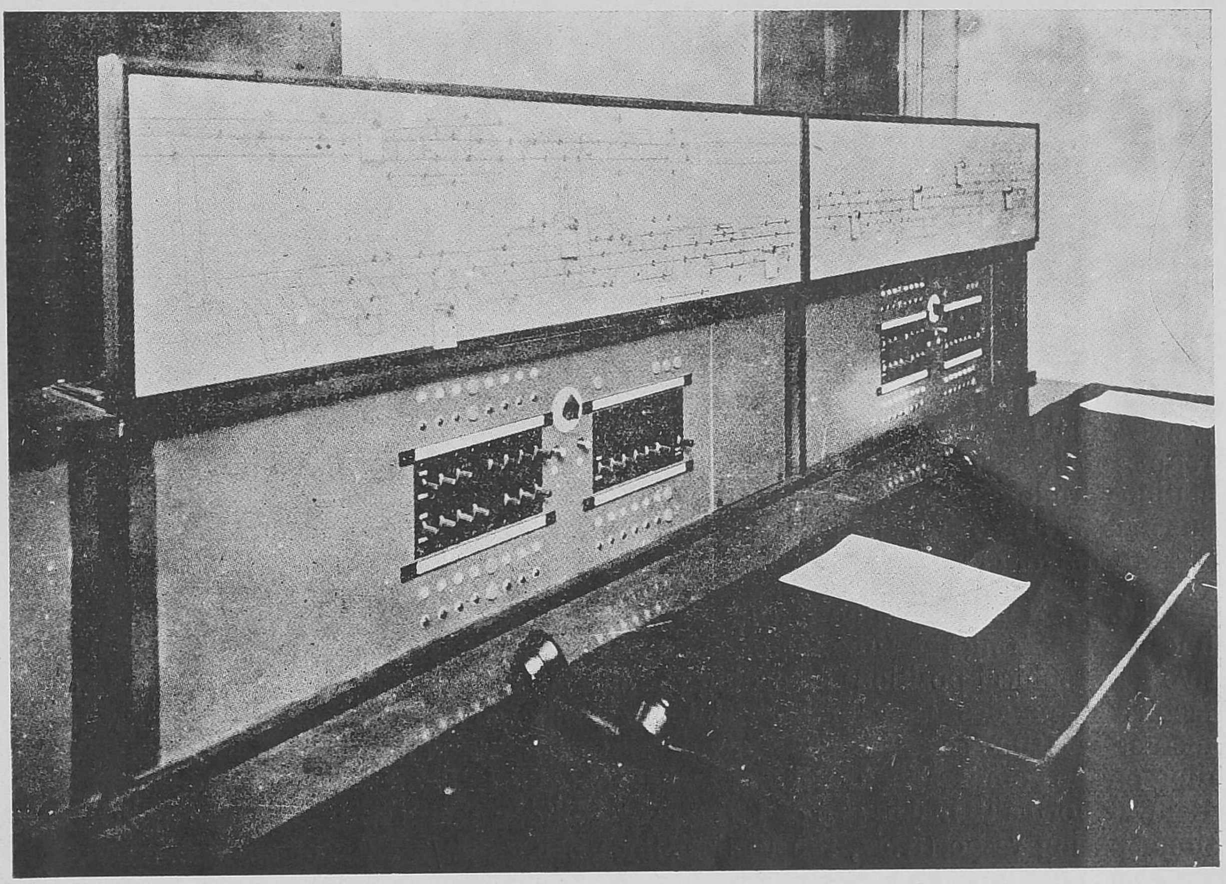


Fig. 8. Controllers' positions with Pegging Boards

CHAPTER V

Graphic System of Train Control

53. As mentioned in Chapter II, Train Control, as distinct from Traffic Control, is primarily the arbitrary supervision of the actual movement of trains between various points in the controlled section to ensure the train carrying capacity of the section being utilized to the greatest advantage. This implies the necessity of clearing traffic by the minimum number of trains carrying the maximum possible loads traversing the controlled section in the shortest possible time. In certain special cases on double and multiple line sections of railway, and almost invariably on single line sections carrying medium or heavy traffic, these requirements can only be attained by Train Control by graphical means, supplemented by a certain degree of Traffic Control.

54. It cannot be too highly stressed that Train Control, to be carried to the highest peak of efficiency, is essentially dependent upon a well-constructed time table and the normal running of trains in strict accordance with that time table. Provided a "workable" time table is formulated it should be the constant ambition of all concerned with train operation to keep trains running exactly in accordance with the time table schedule. It is to be regretted that this most important principle which applies with equal force to both passenger and freight train working has not always received the attention required. Indeed, on some Indian Railways there is still a regrettable tendency to permit freight trains to operate to open timings. While making due allowance for difficult operating factors it is essential to enforce all train movements being carried out in strict accordance with pre-arranged time tables or running schedules. Otherwise Train Control is unlikely to achieve any marked degree of efficiency or value to the Railway concerned.

55. Train Control by graphical methods is based on a graph or square chart previously printed in blank form for the particular section to be controlled. The graph combines two elements, time and distance. In usual practice vertical lines represent divisions of time and horizontal lines represent mileage or the point where stations are located in accordance with the mileage scale adopted. This may be more conveniently explained by a reference to Fig. 9, which illustrates a section of a typical Train Control graph.

56. In this illustration it will be noticed that the chart is printed with vertical lines representing the time factor. The horizontal lines indicate stations in the relative geographical position according to mileage, representing the mileage or distance factor. The scales used for both time and mileage may vary according to requirements. The time scale is usually divided into 1-minute or 2-minute divisions depending on the comparative density of traffic controlled. The London and North Eastern Railway normally makes use of 12-hour or 24-hour charts with 1-minute or 2-minute time spacing respectively, the vertical lines being one/twelfth of an inch apart.

57. It is desirable to emphasise that the preparation and printing of blank control graphs is worthy of meticulous care. The paper employed should be of fairly heavy texture and of reasonably good quality. A slightly glazed surface is an advantage. It is most desirable that the vertical and horizontal lines of the graph should **not** be printed in black, but in some light-toned shade of green or yellowish-grey. It may be mentioned that graphically-squared paper, prepared commercially, is invariably printed in some subdued colour, enabling all work carried out on the prepared ground to stand out boldly. A blank graph of black lines on a white ground is extremely tiring to the eyes, particularly if sustained work is necessary. When it is considered that a Train Controller is normally on duty for a period of eight hours, attention to this small but important psychological detail will result in the Train Controller being less mentally fatigued towards the end of his turn of duty with a corresponding increase in his overall efficiency.

58. To illustrate the work involved in the graphical control of train movement Fig. 9 will be considered. It may be assumed that a Train Controller has just taken over duty at 08·00 hours. Having studied his predecessor's chart and handing-over position he is in readiness to commence his period of duty as Train Controller. His work may be expected to develop in the following manner.

Time	Caller	Conversation	Answer	Notes
H. M. 08 07	Colne ..	101 Up passed 5 (a)	Right ..	(a) i.e. passed at 08-05.

(A) Controller makes a mental calculation to decide at which station 101 Up will be shunted to give precedence to 11 Up. He decides if he allows 101 Up to reach Etah, there may be a risk of delay in the line being cleared for 11 Up between Daws and Etah. To avoid this contingency he decides that 11 Up will precede 101 Up at Daws.

08 08	Irma ..	102 Down in 8	Right ..	
08 09	Alne ..	11 Up ready	Right Start ..	
08 10	T.C. to Daws(b)	11 Up to take precedence 101 Up at yours ..	Right ..	(b) Giving Daws timely information to make arrangements.
08 16	Alne ..	11 Up out 15 (c)	Right ..	(c) Right time.
08 21	Daws ..	101 Up in 18 1st Loop Line (d)	Right ..	(d) i.e. side tracked to allow 11 Up to pass through on Main Line.
08 22	Irma ..	102 Down out 21	Right ..	

(B) Controller considers the running of 102 Down and has to decide where it will cross 11 Up. 102 Down has been running slowly from Maner (see footnote E) and though there appears to be a reasonable margin at Ghond, he decided not to risk detention to 11 Up and decides to cross the trains at Hay.

08 23	Barr ..	11 Up passed 23	Right ..	
08 24	T.C. to Hay	Hold 102 Down at yours to cross 11 Up.	Right ..	(e) Station Master may point out long detention likely to be given to 102 Down for this crossing. Train Controller has good reason and his instruction is final.
08 32	Colne ..	11 Up passed 32	Right ..	
08 33	Hay ..	102 Down in 32 1st Loop Line ..	Right ..	
08 36	Maner ..	12 Down ready	Right Start ..	
08 43	Daws ..	11 Up passed 42	Right ..	
08 45	Maner ..	12 Down out 44 .. .. 2 minutes late start. Loco ..	Right ..	Controller makes footnote (F).
08 51	Etah ..	11 Up passed 50	Right ..	
08 55	Daws ..	101 Up out 54	Right ..	
08 56	Lokh ..	12 Down passed 54	Right ..	
09 01	Filghat ..	11 Up passed 00	Right ..	
09 05	Kais ..	12 Down passed 4	Right ..	
09 08	Etah ..	101 Up in 6 Water	Right ..	
09 11	Ghond ..	11 Up passed 10	Right ..	
09 16	Jaur ..	12 Down passed 15	Right ..	

Time	Caller	Conversation	Answer	Notes
H. M. 09 20	Etah ..	101 Up out 17	Right ..	

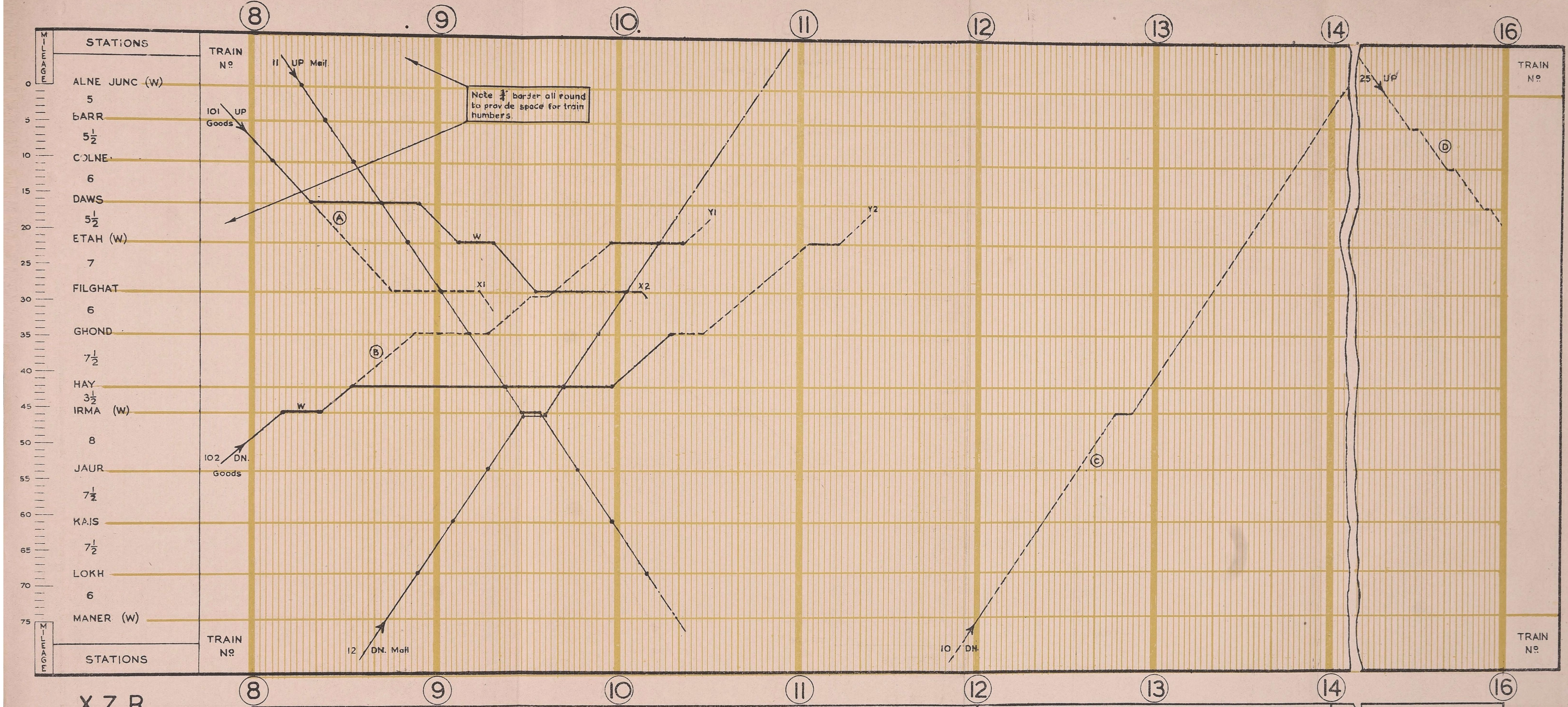
Here, again, the Controller must consider the most suitable point for crossing 101 Up with 12 Down. If he allows 101 Up to proceed to Ghond he should have 6″ margin. However, he again elects not to risk detention to 12 Down Mail and decided to cross the trains at Filghat.

09 21	T.C. to Filghat.	Hold 101 Up at yours to cross 12 Down.	Right ..	
09 22	Hay ..	11 Up passed 21	Right ..	
09 30	Irma ..	11 Up in 1st Loop 27 .. 12 Down in Main Line 28 (f) .	Right ..	(f) Booked crossing point Both trains running "right time".
09 34	Filghat ..	101 Up in 1st Loop 32 ..	Right ..	
09 36	Irma ..	11 Up out 33 .. .. 12 Down out 35 .. .	Right ..	
09 42	Hay ..	12 Down passed 41 .. .. May I start 102 Down on "back-"report."	Right. Yes, start 102 Down	
09 48	Jaur ..	11 Up passed 47	Right ..	
09 54	Ghond ..	12 Down passed 53	Right ..	
09 59	Hay ..	102 Down out 57	Right ..	
10 00	Kais ..	11 Up passed 58	Right ..	
10 03	Filghat ..	12 Down passed 2 .. .. May I start 101 Up? ..	Right. Yes, start 101 Up.	
10 10	Filghat ..	101 Up out 8	Right ..	
10 11	Lokh ..	11 Up passed 9	Right ..	
10 14	Etah ..	12 Down passed 13	Right ..	

Note.—As successive reports are received from way-side stations the Train Controller makes a dot at the appropriate time/distance point in the graph and subsequently connects up the dots (or ordinates) by firm lines in black or coloured pencil to indicate the actual time-paths of the trains controlled.

59. The form in which the preceding chronological resume of a Train Controller's work has been shown was specially framed to bring out the important consideration of telephone discipline. For efficient working, a proper telephone discipline is absolutely essential and all reports or inquiries should be made in proper form; brief and to the point. The answer to all reports is "Right" followed by any order that the Train Controller may have to give. It should be noted that a Train Controller's orders to way-side stations are definite and final and must be acted upon to the letter. At the same time a Train Controller cannot issue instructions which would involve dangerous working or the breaking of any General or Subsidiary Rule.

60. In handling the movement of the four trains shown in Fig. 9, the Train Controller on duty was involved in several errors of judgement which resulted in unnecessary delay to the transit of both 101 Up and 102 Down Goods. It is true that he had to contend with the running of 11 Up and 12 Down Mails; trains of considerable importance and running to a rigid time-schedule. He elected not to take the slightest risk of detaining either of these trains. As 101 Up Goods was approaching Daws, quick plotting would have shown the Train Controller that he could except



XZR

ALNE DISTRICT CONTROL

ALNE – MANER LINE
(SINGLE LINE SECTION)

DATE. 12 / 12 / 44.

PERIOD. (8) TO (16)

102 Down ex Maner 0640. Slow running. (E)

12 Down 2" ex Maner (Loco.) (F) Right time at Irma.

FIG. 9. TYPICAL CONTROL GRAPH.

FOLD

that this train would arrive at Filghat (and clear the Etah-Filghat Section), 6/7 minutes before 11 Up Mail was due to pass Etah. Quite sufficient time margin for the chance to "steal a run". Had he allowed 101 Up Goods to proceed onwards to Filghat [dotted path (A)], a detention of approximately 55 minutes to 101 Up Goods would have been avoided. (The detention is shown by the comparative points X1—X2). Similarly 102 Down Goods need not have been held at Hay. The crossing with 11 Up Mail could easily have been arranged at Ghond with ample time margins. See dotted path (B). These examples may be slightly exaggerated but they are typical of daily occurrences in single-line traffic operation. The real value of Train Control is most clearly demonstrated by the extent that Train Controllers are able to anticipate likely developments and on this anticipation arranging operations to involve the least possible delay to the forward movement of traffic.

61. In the example of a Train Controller's work given in paragraph 58, all the conversations recorded were in connexion with Train Control, i.e., actual train running. Assuming that a separate Traffic Controller was not employed, the Train Controller would have to undertake a certain amount of work applicable to Traffic Control on the lines described in Chapter IV, paragraph 45. It will be clear, however, from the simple example given in Fig. 9 a case where only four trains are involved, that a Train Controller has little time to devote to any work other than the maintenance of his graph and planning (i.e. controlling) ensuing crossings and other contingencies affecting train-movement. In short, immediately the density of traffic reaches a certain level, not only will the Train Controller be **fully** employed in the control of train running but the circuit he is operating will be in such constant use that it will not be available for other requirements. This position has been described in Chapter II, paragraph 20, but is worthy of re-iteration in order to draw attention to existing cases of this nature on some Indian Railways. It is to be feared that there are many instances where attempts are made to combine Train and Traffic Control by means of circuits operated to the fullest extent of availability. There must inevitably be a corresponding loss of efficiency.

62. In completing a graph, the Train Controller makes use of pencils or crayons of various colours to give a clear distinction between differing classes of traffic. The colour code to be followed is decided by the Operating Superintendent and should be uniform throughout the Railway. In addition to the preparation of the graph showing the actual train running it will be the duty of a Train Controller to supplement the graph by adding a written report on any unusual occurrences, operating delay or other information likely to be of assistance to the Deputy Controller or other senior official in subsequent perusal of the graph. It is desirable that space should be provided for this purpose on every blank control graph.

63. At the close of the 8-hour; 12-hour or 24-hour period, as the case may be, the completed graph or control chart forms a most convenient record of all train movements in or through the controlled section during the period. It will indicate points where delays have occurred, congestion has been noted or other unusual circumstances have taken place. Such instances are normally supplemented with a short written report made by the Train Controller at the bottom of the graph. The careful perusal of a series of graphs for the same controlled section over a period of weeks will quickly reveal any time-table difficulties. For example, if a train, normally running to time through most of the section, is consistently detained at a certain point, day after day, investigation will probably suggest that some additional operating facility is necessary. In case an accident occurs the control chart forms a most comprehensive record of the position of all trains at the time of the occurrence and frequently furnishes valuable data for the information of a subsequent committee of inquiry.

Simplified Methods of Graphic Train Control

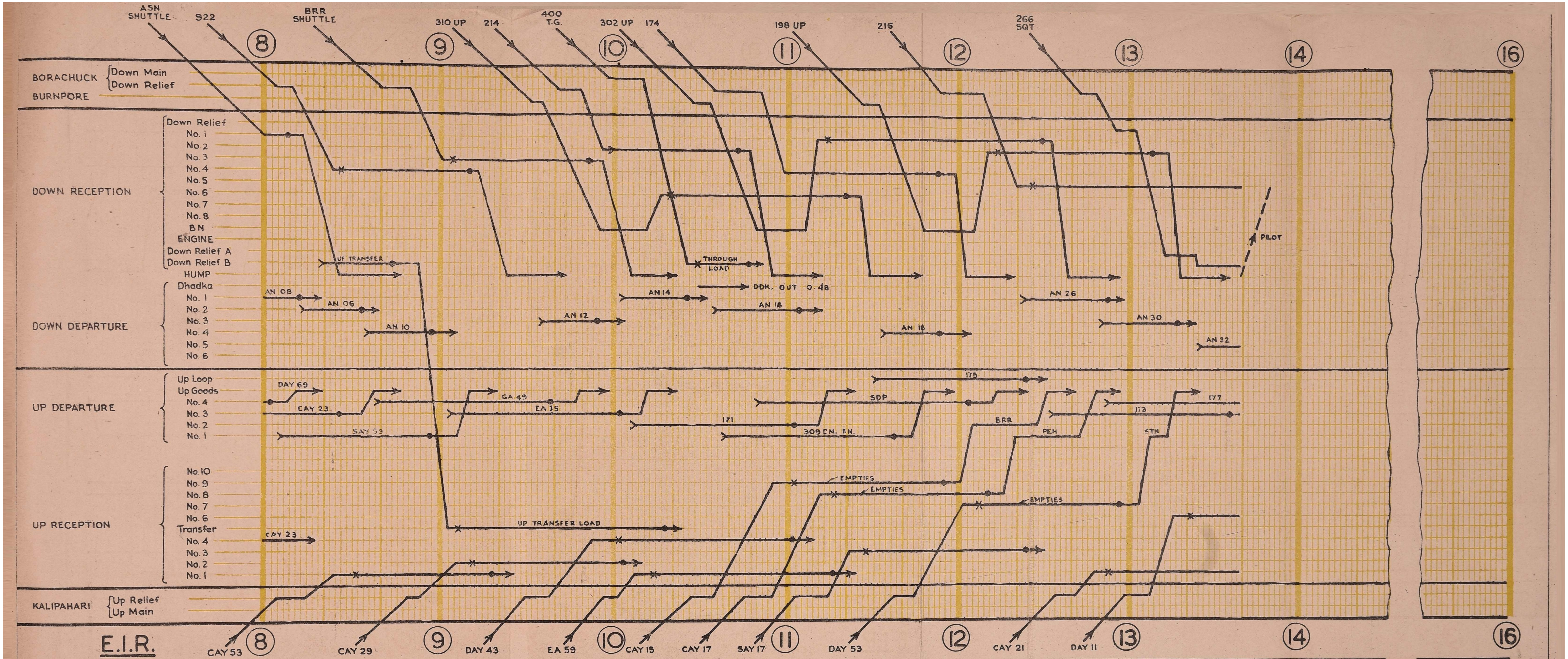
64. The impact of vastly increased transportation requirements occasioned by war contingencies has, of necessity, enforced the utilization of many of the existing Train Control Circuits of the Indian Railways to the utmost capacity,

Fortunately, further consideration of the example of a Train Controller's work, as summarized in paragraph 58, would serve to suggest that if any sound expedients were available which would have the effect of reducing the number of reports made to a Train Controller, he would be given more freedom to undertake other work (e.g. Traffic Control) and at the same time the availability of the Control circuit would be increased. Two such expedients are commonly employed on British Railways which could be followed by Indian Railways with advantage. These methods are briefly—(a) Reduction in reporting "in," "out" or "passing" times of passenger trains running to regular time-table schedule and (b) classification of certain stations as "non-reporting" points.

65. Considering the first of these methods, a good illustration is given by the running of 11 Up and 12 Down Mails shown in Fig. 9. In this instance both trains are running to time to a regular and strict time schedule. Provided the Train Controller is given "out" reports by the dispatching stations, in this case Alne in respect of 11 Up Mail and Maner for 12 Down Mail, and the trains are running to time, the Train Controller knows precisely where these two trains are at any given time during their passage through the section he is controlling. On British Railways the "paths" of these trains would be **printed** in the blank graph sheet. (See similar dotted paths (C) 10 Down Express and (D) 25 Up Passenger shown in Fig. 9). As the Controller knows automatically where these trains are at any given time it is absolutely unnecessary for the intermediate way-side stations to report the passing time of these trains provided they are running in accordance with the time-table schedule, or within a few minutes of that schedule. *It will be understood that it is the first duty of any way-side station to report to Train Controller every instance where a booked train is running late, stopped "out-of-course," or detained for any reason whatsoever.* If this elementary rule is strictly enforced the reporting of passenger train running by way-side stations can be greatly minimized. The operating slogan might be—"Normal Running—No Report."

66. The advantage to be gained by the adoption of this "Normal Running—No Report" system is so considerable that it is desirable to analyse a concrete example. The case of the Allahabad—Cawnpore Section of the East Indian Railway is an excellent case in point. On this single-line section there are 5 Up and 5 Down daily passenger, express and mail trains running to a strict time schedule. Between Allahabad and Cawnpore Central there are 23 intermediate crossing stations. Now, assuming that all these trains are running approximately to time, the adoption of the "Normal—Running—No Report" system would save 10×23, or 230 reports in 24 hours. It is true that each individual call may be only a matter of a few seconds duration; collectively however it is another matter. Obviously with such a large reduction of redundant calls to the Train Controller there will be a greatly increased availability of the actual circuit for handling other work. There are also important psychological factors in reducing this volume of redundant calls. With greater freedom from constant attention to way-station reports, the Train Controller can devote far more attention to his forward planning of crossings, &c., and at the same time, the fewer calls that are made from way-stations will receive more considered and detailed attention than would otherwise be possible.

67. The second method of reducing the number of incoming train running reports from way-stations is to classify certain stations as "non-reporting," i.e. stations which do not make train running reports to Train Controller in the course of normal working. In special circumstances, e.g. in case of accidents or delay to a train, a "non-reporting" station would immediately call the Train Controller and explain the position, otherwise a "non-reporting station" would normally not initiate calls. In certain circumstances it might be feasible to classify certain single-line station as "non-reporting," but this system is more readily applicable to double-line working. In an average double-line section over which Train Control is in operation there are usually a number of road-side stations which either have not the requisite facilities or do not, in the ordinary routine course, alter the sequence of trains passing through. Such stations may be conveniently classified as "non-reporting."



E.I.R.

ASANSOL YARD CONTROL

DATE 4/2/45.

PERIOD (8) TO (16)

PILOTS

C	No.	Time on	Driver	To
CT	1192	04.02	Hafiz	E.Y
CT	1200	08.10	Nazimuddin	E.Y
Y1	1694	22.05	Rosario(06·00)	W.Y
Y1	1698	03.55	Shaffi	W.Y
Y2	1680	10.00	Smith	W.Y

TRANSHIPMENTS

Ex.	R	No.	Ex.	R	No.
214	NW	23961			
174	BB	11336			
SAY 17	BA	20011			

214. Acid BN 21037. MSM 9641. non-hump.

R.T.O. booking EI 65655 EI 3912 by SDP Pilot. Mil. stores.

Transfer load ready 08,45. EY advised.

DDK. 4 open 18 covered.

SDP. 6 loaded 10open 10 covered.

X = TRAIN ENGINE TO SHED.

—●— = PILOT OR TRAIN ENGINE ON.

>— = LINE OCCUPIED.

—> = LINE CLEARED.

Note:- Incoming UP BNR loads are received in BNR Siding and then shunted to Reception Lines.

FIG. 10. GRAPHICAL YARD CONTROL

FOLD

FOLD

68. As an illustration of the extent by which train reporting can be reduced by the classification of certain intermediate way-side stations as "non-reporting" another example will be taken from the East Indian Railway. On the double-line section between Moghal Sarai and Allahabad (93 miles) there are 6 Up and 6 Down scheduled passenger, express and mail trains daily. Of the 19 intermediate stations the watering stations—Chunar, Mirzapur and Mandah Road might be selected as reporting stations and the others classified as "non-reporting" stations except in special circumstances. The elimination of reports from 16 stations in respect of 12 trains daily would mean a saving of 212 virtually superfluous calls every day in respect of passenger train running alone, without the least detriment to traffic operation. It should perhaps be emphasized that while the Train Controller is thus relieved of a constant succession of calls from way-stations, he is in a position at all times to assert his true function as a Train Controller and can give instructions to "non-reporting" stations in regard to trains being shunted to give preference to faster trains. When given orders to shunt a train a "non-reporting" station becomes temporarily "live," i.e. a temporary reporting point in respect of the shunted train until it has been dispatched.

69. Variations of this system may be necessary to meet individual requirements. In certain cases it may be necessary to classify a station as "non-reporting" in the case of passenger train running only or vice versa. Unquestionably there is a very rich field for experimentation in this direction on Indian Railways. It may be suggested that the elimination of a large percentage of reports from way-stations, would in a sense, open up the question of the basic necessity of Train Control. There is a twofold reply. Firstly the preparation of an elaborate control graph (particularly in the case of double-line operation) is not the only achievement to be desired. The extent to which a Train Controller can effectively carry out Traffic Control simultaneously is perhaps the more important consideration from the economic standpoint. Secondly, however, successfully trains are run to rigid time-table schedules there are inevitably certain occasions when incidents occur which upset the schedule. It is at such a time the Train Controller steps in to rectify the position by timely action.

Graphic Train Control of Large Yards

70. In certain cases, British Railways extend Train Control to cover the operation of traffic through larger goods receiving, marshalling and departure yards. As for as the writer is aware, there is only one example of this practice at present extant on Indian Railways. It is possible that considerable operating economies might be achieved by applying Train Control methods to the operation of larger yards. It is reasonable to suggest that a constant graphical representation of the current position of all traffic in the various reception and departure lines of a large yard would be of invaluable assistance to the Yard Master in the general supervision of operations.

71. A blank graph sheet for the control of a large yard is similar to a standard control graph, the time element, represented by vertical lines, is retained but instead of the horizontal distance or station scale, individual lines ruled equidistantly are provided for each reception line, departure line, brake-van siding, &c. The occupation of any of the "controlled" lines by various classes of traffic is indicated by black or coloured pencil markings from the time of occupation to the time of departure. Any consequential delay in yard operation is immediately noticeable and the Yard Controller, who would be connected to all relevant points in the yard by a local Control circuit, would be in a position to ascertain the cause of delay. Here again completed graphs in respect of operations in a yard during a given period would furnish valuable information to the Operating Superintendent in bringing to light any major operational difficulties or weak spots in the organization.

72. Fig. 10, on the preceding page will serve to convey some idea of the control of a large yard by means of graphic Train Control.

CHAPTER VI

Engine Control

73. The application of telephonic control to engine operation offers broad scope for considerable economy and may have a direct bearing on financial returns. Engines are one of the major items of capital expenditure and in order to avoid loss on unremunerative expenditure it is necessary that engines should be operated to the maximum limit compatible with regular routine maintenance and periodical overhauls. If control methods are applied it is possible to ensure a more constant supervision of the actual and sustained employment of every available engine. At periods when abnormal traffic has to be carried, engine control may be especialy valuable as the most satisfactory means of regulating the employment of available engines to the greatest advantage. It is probably on this account that an increasing number of railways have developed some measure of engine control as an ancillary to the Traffic Control system in operation.

74. The fundamental considerations underlying engine control have been given in chapter II, paragraph 23(c) and the means employed are closely analogous to Traffic or Train Control methods already described in preceding chapters. It will be necessary for the Engine Controller to be in communication with every engine running shed and other points which may concern engine running and he will require some mechanical means of indicating the current position of all engines. This may take the form of an engine control board on which discs or squares bearing engine number and types may be moved from point to point to accord with movements actually made. This is a modification of the pegging board described in Chapter IV and has the same disadvantage, viz. the current position is ascertainable at a glance but reconstruction of a position that obtained at some given time previously may be very difficult.

75. After studying a number of variants of the engine control board as employed by various railways and noting this salient drawback which is common to all, the writer was greatly impressed with a semi-graphical method of engine control used on the London and North Eastern Railway (North-Eastern and Scottish Areas). In this system printed 14-day charts are employed, the vertical lines providing hourly divisions (¼″ spacing) while individual engine numbers, with their type and "home" running shed are shown serially on horizontal lines (¼″ spacing). The actual employment of each engine is shown by lining in with various coloured pencils, the colour scheme indicating the type of traffic working on which the engine was being employed, periods in shed for boiler wash-out or minor repairs or periods when the engine was receiving major overhaul or repairs. In short, the chart at the completion of each 14-day period, formed a permanent record of the detailed operation of every engine during the period. At the same time the chart assisted the respective Engine Controllers to maintain close watch on the due return of engines worked through from other Districts and the return of engines to "home" running sheds for periodical boiler wash-outs and routine maintenance.

76. Fig. 11 illustrates a section of a 14-day engine control graph adapted to meet the requirements of a typical division of an Indian Railway.

Note.—The writer, in checking the proof copies of this work, is disconcerted to realize that this particular illustration quite unconsciously portrays a somewhat catholic utilization of engine power ! He desires to emphasise that, while his choice of Running Sheds was entirely fortuitous, there is little doubt that the engine running diagrams or "links", on which the graphs was constructed, must have dated back to a more halcyon age and do not, in the least, reflect the current engine power utilization of the present day !! Nevertheless, it is of the utmost value to observe how very clearly a graph of this type can bring an uneconomical utilization of engine power into practical perspective. Herein the normal engine running or "link" diagram frequently fails !

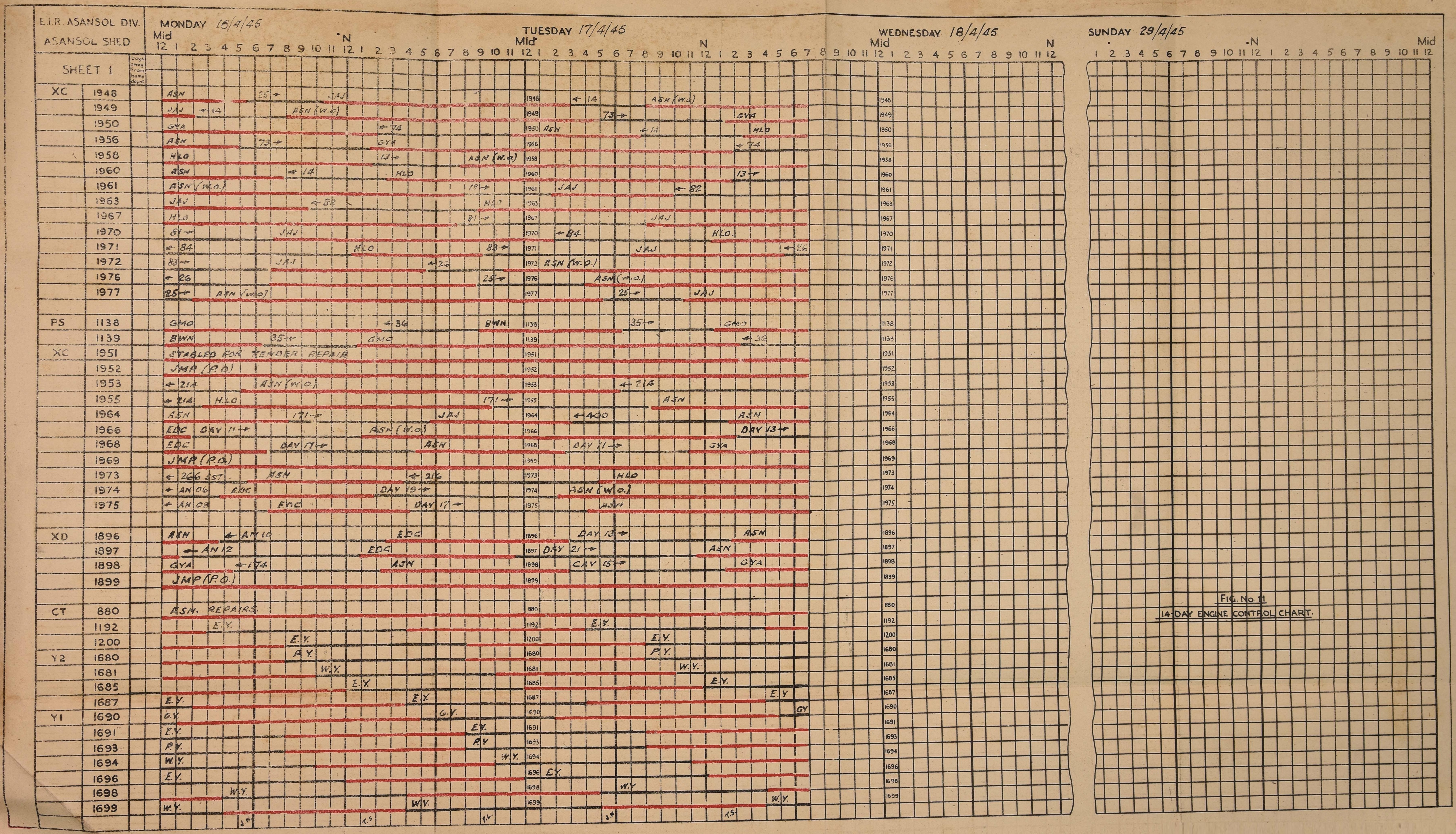


FIG. No. 11
14-DAY ENGINE CONTROL CHART.

CHAPTER VII

Economic Control for Light Traffic Operation

77. Indian Railways, in general, are not served by a generous telecommunication network. Indeed, many sections, some of considerable length, are entirely dependent on telegraph circuits for communication between way-side stations and the controlling District/Divisional Headquarters. It would obviously facilitate work and expedite train operation if a control circuit could be provided to link the way-side stations even if the average daily traffic handled is comparatively light. This desirability has been noted and a number of sections will shortly be equipped with control circuits. In several cases, however, the light traffic operating on the sections concerned, perhaps one, two or three trains daily in each direction, would be insufficient to justify the employment of Train or Traffic Controllers throughout the day. This point has been previously touched upon in chapter II, paragraph 27.

78. It has been suggested to the writer that one of the most important reasons for providing a control circuit on a lightly operated section, is the influence it would tend to have on the general working of the staff at way-side stations. It was inferred that if Station Masters knew that a Train Controller was constantly on the alert and checking up on orders given to way-side stations, there would be an immediate and noticeable improvement in train running and traffic operation generally. There may be some degree of truth in this argument though it is to be regretted that it should be so. If Train Control has to be employed as a means for coercive discipline it would seem apparent that the morale and discipline of the operating staff posted to work certain way-side stations have been permitted to deteriorate. If this is the case, a Train Controller is likely to be faced with overwhelming difficulties, and rather than leaving him the task of attempting to re-create order from prevailing chaos it would be essential that more drastic and direct disciplinary action should be applied. A preliminary step in this direction would be the thorough inculcation into the minds of Station Masters that they are entirely responsible for all traffic detentions to trains within the limits of their stations, and that it must be an essential part of their duty to report to the Train/Traffic Controller *all* cases where trains have been stopped out of course, detained beyond the scheduled starting time for any reason whatsoever, or any other feature or irregular operation. Such report must be made at the earliest opportunity.

79. The previous paragraph covers a point which was urged as a valid reason for the employment of full-time Train Control, irrespective of the volume of traffic obtaining. In the writer's view, this is not likely to be an entirely satisfactory solution and he considers the economic aspect of the case to be far more important. The yard-stick must be—will operating requirements be adequately met by part-time Traffic Control? If the answer is in the affirmative, what is the best means of ensuring a reasonably satisfactory measure of control?

80. The North Western Railway have the present unique distinction of being the only Railway in India to control the operation of ten branch lines, carrying comparatively light traffic, by intermittent Traffic Control. There are instances, on other Railways, where similarly light traffic is the rule although full-time Train Control is in force. With the provision of a number of additional circuits there will be an increase of controlled sections where the daily traffic handled rarely exceeds two/three trains per day in each direction. Full-time Train Control on such lightly operated sections is definitely not justified except on rare occasions at certain periods of the year, when a peak of seasonal traffic may have to be covered.

81. In the normal routine, it is suggested that one Traffic Controller, working one daily shift, say from 08-00 to 16-00 hours daily should be capable of effectively controlling the traffic operation of the majority of these light traffic sections for all practical purposes. In some instances, the Traffic Controller would probably require an assistant as an understudy and to assist in the preparation of reports and returns based on the information obtained from way-stations.

82. The general outline of work to be performed by a Traffic Controller has been previously considered in chapter IV, paragraph 45. For the purposes of record and to facilitate the Traffic Controller's work, it is suggested that printed charts should be available for each controlled section; these charts being in the form of a questionnaire to be completed by Traffic Controllers in respect of each station. Every station would be called in turn and asked for the following information—

(a) Station............................

(b) Passenger Train running..........?(Traffic Controller would enter particulars of late-running, detentions, out-of-course stoppages &c.)

(c) Goods Train running..............? Ditto.

(d) Loaded wagons on hand for clearance.

Up......? Down......?

(e) Empty wagons required.

Open ......? Covered......?

(f) Empty wagons on hand surplus.

Open......? Covered......?

(g) Weather report..............?

(h) Any other information............?

Completed charts would be handed to District Superintendent at a regular time each morning for perusal and any special operating orders which the Traffic Controller would then proceed to put into effect during the remainder of his period of duty.

83. It is suggested that economic Traffic Control based on the foregoing principles should constitute all the degree of "control" necessary for the satisfactory operation of sections carrying comparatively light traffic. If the duties of a Traffic Controller includes the completion of a "traffic chart" on the lines suggested above, a permanent record would be available for immediate inspection or subsequent reference.

84. With projected development, there are several instances where two or three separate control circuits are to be provided to control light traffic sections which will be operated from the same Control Office. It is probable that the one Traffic Controller will suffice for the adequate Traffic Control of two, or even three such sections simultaneously. This factor is worthy of consideration in deciding the dimensions of Control offices and the range of equipment to be provided. It would, for instance, only be necessary to instal one set of Controller's equipment and a single bank of calling keys could be arranged to call way-stations on the respective circuits with the same code-setting, depending on a switch linking the particular circuit required.

CHAPTER VIII

Multi-position Control for heavy Traffic Operation

85. Although parallel circumstances do not obtain on Indian Railways, and for this reason there seems little likelihood of any general adoption of the principle in the immediate future, it is of interest to refer to a development in control practice on British Railways which has been accelerated to meet the vastly increased commitments borne by these Railways in connexion with the war.

86. Unlike control systems on Indian Railways, the control net-work of British Railways is usually built up from a number of short individual circuits and a consequential feature is that it is frequently necessary for several Controllers (Section, Engine or Staff) to have means of access to the same circuits. To meet this exigency special equipment has been devised which permit the circuits used in common to be connected to the tables, or "Positions" of all the Controllers concerned. The arrangement is usually associated with some form of indication system to show when a circuit is being used, generally by the lighting of a red "busy" indication lamp. In addition, means are provided for the way-stations to "call" the controller by "loop-calling" or other means which operates a white "calling" lamp on the panel of each Controller's "position". The incoming calls are normally accepted by the particular Section Controller responsible but can be "transferred" to another Controller's "position" by internal inter-communication arrangements linking individual Controllers

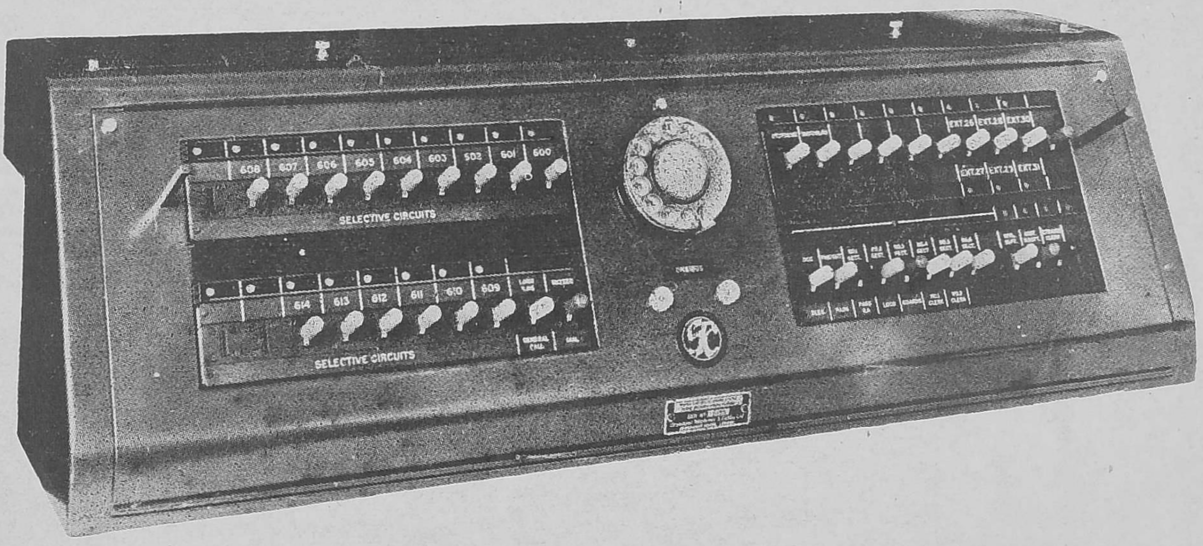


Fig. 12. Typical Multi-Position Controller's Panel

87. The illustration above shows a typical Controller's panel as used in connexion with multi-position control on the Southern Railway. On the left of the panel, a series of keys with their respective "calling" (white) and "busy" (red) lamps are provided to connect any one of fifteen separate control circuits while space is left for future extension. This side of the panel is completed with a general call/long ring key and buzzer/dial key used to link the central auto dial or press buttons to the required circuit. In the centre, a standard auto dial is fitted to provide two-figure code ringing, the Controller merely dialling two figures to obtain any desired way-station. (The two-figure code is converted electrically in the sending equipment to the standard three groups of impulses required to operate way-station selectors). On the Southern Railway, a few omnibus circuits are still retained and the push buttons enable the Controller to call by code ringing or to clear the line after speaking. The right hand panel provides a series of switches for external connexion to administrative telephone circuits and internal intercommunication to the other Controllers. A special group of switches enables Divisional Superintendent, Assistant Superintendent or Chief Controller to be linked through to any way-station.

88. There is little doubt that with its successful operation and maximum flexibility this system represents the current "high water mark" in the development of traffic control equipment. It is not surprising, therefore, that some of the more progressive technical officers of the Indian Railways would desire to mould their

control systems on similar lines. The writer is in full sympathy with such aspirations but has to comment that this system has been developed primarily to meet involved and intricate operation of extremely heavy traffic over an extensive network of alternative routes to which all classes of traffic could be rapidly diverted in case of accidents, weather conditions, or war incidence on the British Railways.

89. On Indian Railways there is virtually no counterpart to the intricate network of alternative routes which exist on some sections of the British Railways. Moreover, in India, the Control circuits consist mainly of lengthy individual circuits which would not readily yield to multi-position conversion and finally, with the exception of an infinitely small percentage, way-stations are not provided with electrical equipment to call the Controller. While, therefore, there may be some justification in the future development of Indian Railways, to keep in view the possibility of introducing multi-position control, it may be suggested that neither the time nor the necessity has yet arrived for the extension of this system to Indian Railways.

CHAPTER IX

Stock and yard position reporting by Teleprinter

90. It has been previously mentioned in foregoing chapters, that Indian Railways are not over-generously provided with train control circuits and as a direct consequence, available circuits are frequently employed to the maximum capacity. There is little doubt that a considerable amount of the availability of some control circuits, and this applies more particularly in areas where traffic is heavy, is occupied in the transmission of lengthy reports to Divisional /District Headquarters of the precise traffic position obtaining in certain yards and the wagon and rolling stock position at stations, as collated by the various Control offices. Such information is essential for the effective control of traffic operation on a Divisional/District basis and, in turn, much of this information has to be re-transmitted to Central Headquarters for the collation of all-line statistics and, if in being, for the information and action of the Main Control.

91. In cases where a sufficient volume of traffic is being handled it would be very advantageous, and greatly to the relief of the overworked control circuits, if the greater proportion of this yard and stock position reporting could be passed over alternative telecommunication channels at the first opportunity and it is suggested that there is a wide field for the employment of teleprinters in this connexion.

92. Teleprinter operation may be briefly described as the inter-connexion of two typewriters at distant points by electrical means whereby any information typewritten on one machine is simultaneously reproduced on the distant machine.

93. Modern teleprinters are manufactured in two distinct types. The "tape" machine reproduces messages in a continuous strip of paper tape, while the "page" machine reproduces messages on a foolscap page or sheet as a virtual facsimile of the message as transmitted. The "page" machine is probably the more advantageous for use in general railway work and is particularly useful for the reproduction of statistical work. The standard No. 7-B page teleprinter prints on to a continuous roll of paper $8\frac{1}{2}''$ in width; messages being torn off, as received, by means of the knife-edge on the carriage. For statistical work or other cases where carbon copies are required it is necessary to interchange the standard carriage with a "sprocket feed carriage".

94. To meet the case of yard and stock position reporting, it would be possible to utilize "blanks" consisting of a block of pre-printed forms, interleaved with carbons to give the requisite number of copies. These "blanks" would be printed with all the data required, leaving only spaces to be filled in by the teleprinter. Utilizing this method, the precise statistical position obtaining in a large yard, could, for instance, be transmitted from the Yard Master's office to the Divisional/District Headquarters, and, if required, simultaneously to Central Headquarters, at certain pre-arranged daily timings, the receiving teleprinters being already "set-up" with the necessary "blanks" in readiness.

95. When it is considered that yard and stock position reports are frequently complicated and lengthy and, moreover, are usually reported thrice daily, it will be apparent that the use of direct teleprinter reporting, in the manner described, would not only greatly relieve circuits at present employed for the verbal transmission of these reports but would, at the same time, largely avoid the possibility of errors inherent with verbal transmission. In addition, the advantage of having instant facsimile reports at Divisional/District Headquarters as they are transmitted from the various main yards, eliminating all delay occasioned by oral transmissions, should be of considerable value and materially facilitate general traffic operation

96. At least one firm of manufacturers in India, Messrs. Bharat Carbon & Ribbon Mfg. Co., Ltd., Lahore, are in a position to supply printed "blanks" with interleaved carbons, for the purposes described in the foregoing paragraphs

CHAPTER X

General Instructions for Train/Traffic Control Operation

97. It is desirable to close the first section of this work with a reference to another facet of British Railway practice which might be profitably emulated by Indian Railways. In order to ensure a full and complete understanding of every phase of the work involved, printed booklets of General and Local Instructions for Train/Traffic Control Operation are issued by British Railways to every member of their respective staffs who are connected with the operating Control Organization.

98. As an indication of the scope of these booklets the following tabulation gives the items covered, seriatim, in the London, Midland and Scottish Railway handbook, "Operating Control Organization, General and Local Instructions"—

(i) Description of the Traffic Organization of the Railway, limits of operating Divisions and Districts, and location of Control offices.

(ii) General Instructions.

(iii) Responsibilities of Station and Traffic Yard Staff.

(iv) District Control Office Procedure.

(v) Train Reports and Records.

(vi) Planning and Organizing of Trains in Running.

(vii) Working of Ballast, Material Trains, &c.

(viii) Inclement Weather Conditions.

(ix) Accidents and Fires.

(x) Relief of Trainmen.

(xi) Utilization of Engine Power.

(xii) Workings and Diagrams.

(xiii) Traffic on Hand.

(xiv) Regulation of Traffic by Stops and Restrictions.

(xv) Distribution of Freight Rolling Stock.

(xvi) Responsibilities of Engine Depot Staff.

(xvii) Local Instructions.

99. While some of the items contained in the above tabulation may not be applicable to normal operations on Indian Railways, the majority of these headings may be a useful guide for the preparation of similar books for use on Indian Railways.

PART II

Control Offices

CHAPTER XI

General Considerations

100. On most of the Indian Railways, the provision of modern buildings for use as Control offices has not kept pace with the greatly extended development of Train/Traffic Control which has taken place during the past twenty-five years. In many cases, the buildings set apart for the original Control Organization, often a convenient wing or annex of the Divisional/District Headquarters office and frequently quite unsuitable for the intended purpose, have become cramped and congested with the constant increases in staff required to handle the growing volume of work.

101. Sections of Part I of this work will have indicated the large contribution provided by Train/Traffic Control to the operating efficiency of a Railway and it is reasonable to suggest that the greater the degree of internal efficiency of the Control Organization, the greater will be the over-all efficiency of the Railway. The internal efficiency of the Control Organization depends upon numerous factors; some psychological, not readily apparent and not always taken into account. Undoubtedly the most important contribution to the internal efficiency of the Control Organization lies in the provision of well-designed Control offices built expressly for the purpose intended, and incorporating in the design the requisite psychological and aesthetic features so necessary if the highest degree of internal efficiency is to be attained and maintained.

102. With few exceptions, Control offices are always open: day and night, with the staff working in a continuous rotation of shifts, normally of eight hours duration. The sustained controlling of an average section for a period of eight hours must be recognized as an onerous task; more particularly so if the incidence of heavy traffic involves the preparation of an intricate graphical record associated with traffic planning. There is little doubt that such work can only be performed with the maximum personal efficiency, throughout the periods of duty, if the working and general psychological conditions are reasonably favourable.

103. It is not always desirable to draw comparisons: more particularly when relative conditions are far from equal. Nevertheless, in order to emphasize the point made in the previous paragraph, the writer feels impelled to depict the sharp contrast between the condition of absolute quietness which characterises the working of a Control office on a British Railway, (quietness in which the proverbial "drop of a pin" may be heard despite the fact that many controllers may be working together in a comparatively small room) and the noisy antithesis which, regrettably and quite unnecessarily, characterises the working of an average Control office on Indian Railways. Unfortunately, the same invidious comparison can be made in respect of practically every other facet of control operation. Unquestionably, there is wide scope for the general improvement of control on Indian Railways and the foundations for this improvement would appear to rest on the fundamental principles suggested in paragraph 101.

104. The main requirements in this connexion are—

(a) Control offices should invariably be bright and airy rooms with special attention being given to cooling or air-conditioning equipment in all locations where climatic conditions are likely to reduce the personal efficiency of the staff.

(b) Control offices should be acoustically treated in order to reduce room echoes and local noise to the minimum degree possible. With acoustically treated rooms it would be possible for Controllers to give instructions to line stations without having to raise their voices to the distraction of other Controllers working in the same room. At the same time, the automatic reduction of room echoes and the noise of other conversations, would enable incoming messages from line stations to be heard with far more clarity by the receiving Controllers.

(c) Coupled with the acoustic treatment of Control offices is the need to provide efficient and noise-free control circuits with the lowest practicable speech transmission losses. This brings technical considerations to bear and will be dealt with in Part III.

(d) Control tables and other furnishings of Control offices should be specially designed to give the maximum facilities to Controllers in the execution of their duty.

(e) Control offices should be absolutely private and admission should be **strictly** limited to duly authorized officials and the control staff.

(Note.—(i) In the past, it has been commonplace for meals to be eaten at the control tables. This practice involves numerous private servants entering the precincts of the Control office. On aesthetic grounds alone it is desirable that a special room should be set apart as a meal room for the control staff.

(ii) Guards and other running staff should **never** be permitted to enter the Control office. All inquiries from running staff in regard to their next booked turn of duty, &c. should be made at an inquiry counter in an office specially set apart for this purpose.)

(f) The interior treatment of Control offices should be deliberately calculated to provide the requisite "atmosphere". Dull and drab surroundings gravely mitigate against personal efficiency. It should be the aim to induce control staff to live "up to their surroundings" rather than the reverse.

(g) It is desirable from the point of view of efficient supervision that the entire control staff should be accommodated in the same room and it is advantageous, in the case of larger offices, for the Deputy Chief Controller or other official in charge of the Control office, to be seated on a raised dais from which a commanding view of the whole room may be obtained. The practice of subdividing Control offices into a number of separate partitioned cubicles is to be greatly deprecated. This practice has undoubtedly originated in an attempt to combat the prevailing noisy conditions mentioned in paragraph 103 whereas the better remedy would have been to consider the acoustic problems involved and to have redesigned the Control office accordingly

(h) The adequate lighting of Control offices merits special consideration. Indifferent lighting must inevitably contribute to loss of personal efficiency.

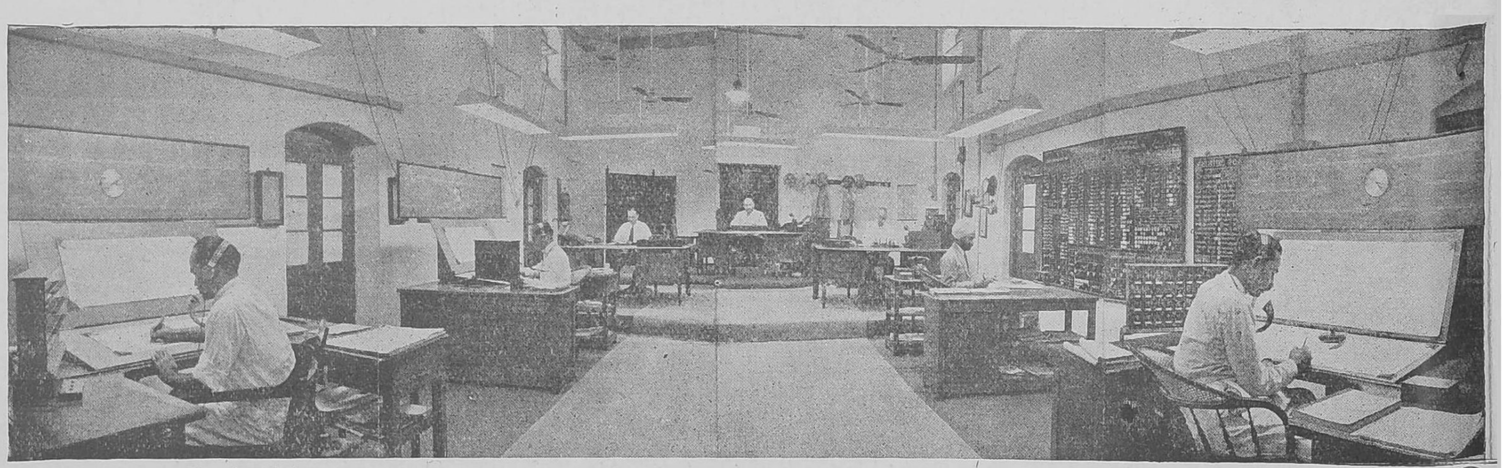


Fig. 13. Interior view of Lahore Control Office, N.W.R.

CHAPTER XII

ACOUSTIC TREATMENT—VENTILATION AND COOLING—LIGHTING

Acoustic Treatment of Control Offices

105. In order to reduce speech echoes and other noises and to create the conditions of comparative quietness requisite for the sustained efficiency of Control office personnel some degree of acoustic treatment is probably required in every Control office. The degree of acoustic treatment required must necessarily vary considerably as internal dimensions, height of roof, type of construction and the materials used in the construction of the building are variable factors to be taken into consideration.

106. To some extent, therefore, the precise degree of acoustic treatment to be rendered to a Control office must be a matter of experimentation, though some of the methods adopted in modern cinemas, telephone exchanges, broadcasting studios, &c. may be introduced as standard practice. The acoustic treatment of floor, ceiling and walls may be briefly considered as follows—

(a) **Floors.**—In order to maintain the timbre of speech transmission a highly polished floor of Bengal Patent Stone or some similar material has been found to give effective results. A floor acoustically "deadened" by a rough uneven surface or carpets should be avoided. Apart from maintaining the quality of speech, a polished stone floor improves the office from purely aesthetic considerations, more particularly in regard to the freedom from dust given by the polished surface. A weekly dressing of wax polish and daily mopping with a damp cloth would assist in maintaining the "pin-point" characteristics of the floor.

(b) **Ceiling.**—It is important that the ceiling should be acoustically "deadened", either partially or wholly, by the use of a false ceiling of absorbent material. This may be of acoustic "Celotex", "Heroclith" or other commercial sound-absorbent material. An alternative and equally effective method of damping may be attained by the use of perforated plywood or "Masonite" backed with a loose padding of glass-wool or similar absorbent material. Apart from acoustic considerations, the false ceiling with an air space above it may assist in reducing room temperature.

(c) **Walls.**—If the ceiling has been acoustically "deadened" it is unlikely that the walls will require special treatment. Damping effects should not be overdone. If a room is made acoustically "dead" unnatural conditions are created which impose a strain on the voice, and on hearing, in an effort to overcome the complete lack of echo. For this reason, ordinary plaster walls finished with a coarse granular surface should meet acoustic requirements by giving the minimum echo desirable.

107. Associated with the acoustic treatment of Control offices is the necessity for the initial training of Controllers in elementary telephone discipline and in the ability to give instructions to way-stations in clearly enunciated diction delivered in low and quiet tones. This becomes of major importance if a number of Controllers are working in close proximity in an office of small dimensions.

Ventilation and Cooling

108. The importance of adequate ventilation and cooling facilities in a Control office cannot be too highly stressed. As previously mentioned, these offices are almost invariably open continuously and unless adequate ventilation is provided and the room temperature kept at a reasonably low level the atmosphere rapidly becomes vitiated to the detriment of the physical well-being and the personal efficiency of the staff.

109. While electric fans are a necessity in most locations in India during the hot-weather months, thereare other areas where the climatic conditions are both hot and humid throughout thegreater part of the year. In such locations the installation of standard air-conditioning equipment is worthy of consideration. In the view of tne writer the cost of installing and maintaining air-conditioning equipment would be amply repaid in the resultant over-all increase in personal efficiency of the operating staff.

110. It is perhaps advisable to suggest that the dimensions of a projected Control office would be affected by the question of providing air-conditioning. If such equipment is to be installed, an office of minimum dimensions with a comparatively low acoustically treated ceiling will be indicated. The capacity of the air-conditioning plant required would depend on the cubical contents of the building to be treated.

Lighting

111. With modern improvements in interior lighting little difficulty is presented with the problem of efficiently lighting Control offices. There may be variations in the most suitable type of lighting to suit individual offices and where possible it would be advantageous to seek the recommendations of technical experts on the subject. Many railways have adopted the fluorescent quartz-arc tubular type of lighting as standard for Control offices as being restful to the eyes and almost shadowless. The effect of this type of lighting, which simulates daylight, is well demonstrated in the photograph of the Lahore Control Office, North Western Railway on page 44.

PART III

Design and Operation of Train/Traffic Control Circuits

CHAPTER XIII

Control Circuit Transmission Problems

112. The following technical information is intended to assist all who are concerned with the maintenance of Train/Traffic Control circuits. To many, much of this information may not be new, but having regard to the fact that the basic design of one of the principal systems of telephone train control was carried out in the year 1917 and subsequent experience has necessitated few alterations to the original design, it is thought that a brief recapitulation of the design problems which had then to be overcome, may give the younger generation of engineers a more complete appreciation of their problems in maintaining Control circuits.

113. The telephone was first used for "Train Controlling" about the year 1907. Very little technical information has been published on Train Control Systems. It will be found that the Manufacturers' Descriptive Bulletins while giving much information on the selective ringing equipment associated with the system, offer little information on the telephone transmission problems overcome in the design of the equipment. These transmission problems are described fully in a paper by Wm. H. Capen of the Engineering Department, Western Electric Company, which he presented at the Annual Convention of the Telegraph and Telephone Section of the American Railway Association on September 19, 1923. The title of the paper was "Recent Developments in Telephone Equipment for Train Dispatching Circuits", and it describes the design work which led to the successful installation in America of the new type of train control system in October 1917. The help obtained from this paper in compiling these notes is gratefully acknowledged.

114. A satisfactory train control system must provide—

(a) A circuit with a maximum transmission equivalent to the most distant station of about 20 decibels. (See explanation of transmission equivalent at the end of paragraph 115).

(b) A fool-proof selective ringing device from a control centre.

(c) Satisfactory telephone communication between the Controller and any one way-station, any group of way-stations or all way-stations on the section controlled.

(d) Facilities for any way-station to call the Controller or to call any other way-station on the section through the Controller.

115. In regard to (a) above the original designers of the control system surveyed a number of controls then existing in the United States of America from a purely operational point of view and it was considered that a circuit with a grade of transmission of about 19 decibels gave satisfactory operating conditions which imposed no strain on the operating staff. Allowing for the greater efficiency of present day transmitters and receivers it is considered that it would be reasonable to permit a degrading of control circuits to 22 decibels, without affecting operating conditions in India.

(Transmission equivalent or level is a measure of the ratio of the power at any point in a transmission line to the transmitted power. This measure is expressed in decibels. The decibel ratio is expressed by the relation—

$$\text{Decibels} = 10 \log_{10} \times \frac{\text{Power Transmitted}}{\text{Power Received}}$$

The decrease in magnitude of the transmitted power, due to line or apparatus losses is known as attenuation and is expressed in decibels.)

116. In regard to condition (b) one of the Manufacturers' Descriptive Bulletins gives all the information required and up-to-date copies of these Bulletins are available from the Manager, Standard Telephones and Cables, Ltd., Calcutta. From the telephone transmission point of view it is to be noted that the ringing selector must always remain bridged across the line, ready to receive the code ring from the Controller. However, it will be noted from the Bulletins that "the coils of the selector are wound to 21,000 ohms resistance and are tuned to $3\frac{1}{2}$ cycles per second by a condenser in the selector set." (The frequency of the ringing impulses is $3\frac{1}{2}$ cycles per second). The impedance of the selector at $3\frac{1}{2}$ cycles per second is 35,000 ohms, and *the impedance at 800 cycles per second (i.e. the basic or mean speech frequency) is over 1 megohm. The loss to speech due to the selectors is, therefore, invariably considerably less than the loss due to line leakage.*

117. From the telephone transmission point of view this is important. It can be assumed that for all practical purposes the losses to speech transmission caused by the selectors bridging the line may be neglected. This was done by the designers in 1917 who assumed "that the loss introduced by the selectors was negligible". It will be appreciated, however, that if any component of a selector is allowed to deteriorate or is replaced by one which alters the overall impedance characteristics of the selector, *a definite defect has been introduced in the circuit*, which will affect its whole operation.

118. To satisfy condition 3(c) was more difficult. Under actual working conditions there is no way of limiting the number of way-stations which may be listening on the section control at any time. The designers, therefore, assumed the worst condition *with all stations listening*. They also chose a section control of No. 9 American Wire Gauge, Copper Wire, 250 miles long with 40 way-stations as a typical control circuit *of that period*. (No. 9 AWG with the American type of line construction is roughly equivalent to 200 lbs. per mile copper wire with 12 inch wire spacing as used by the Indian Posts and Telegraphs Department). The problem to be solved was to find a bridging impedence for the way-station telephone, which with forty of them *evenly spaced* along the 250 miles control circuit, would produce the minimum loss at 800 cycles through the circuit up to the fortieth impedance and still leave sufficient power available at the end of the circuit to be converted to sound in a receiver. By calculation and experiment this was found to be approximately an impedance of $7500\angle 70°$. (This represents an impedance with a small resistance component and a large inductive component). This impedance included a $\frac{1}{2}$ m.f. condenser in series with the bridging induction coil in order to keep down the loss of the low frequency ringing selector currents.

119. Having arrived at a suitable impedance for the way-station instrument and constructed a telephone set with these characteristics, it was found by test that unequally spaced way-stations *did* affect the transmission loss along the line but not to an extent which made any alteration in the impedance design necessary. It was also confirmed that transmission from the most distant way-station to the Controller was satisfactory, and also that communication between the Controller and intermediate way-stations was efficient.

120. It was found that for a circuit longer than 200 miles the number of way-station telephones with an impedance of $7500\angle 70°$ at 800 cycles bridged across the line had little effect on the overall transmission loss on the circuit. In fact, an increase in the number of way-stations from ten to fifty evenly spaced on a 200 miles long circuit gives an average loss per way-station of only 0·08 decibels for fifty way-stations in circuit. For lines shorter than 200 miles the decibel loss per way-station is very variable. It depends on the length of the line and on the number of way-stations and on the spacing of the way-stations. The worst conditions occur on a line about 100 miles long when the average loss per way-station is about 0·5 decibels. Figs. 14 and 15 graphically illustrate these transmission conditions.

121. In general terms, the decibel loss per way-station is so low that the factor limiting the number of way-stations on a control circuit of average length, say 180 loop miles of 200 lb. per mile copper in India, is not the transmission loss introduced by these way-stations, but the traffic operating load imposed on the Controller by this number of way-stations.

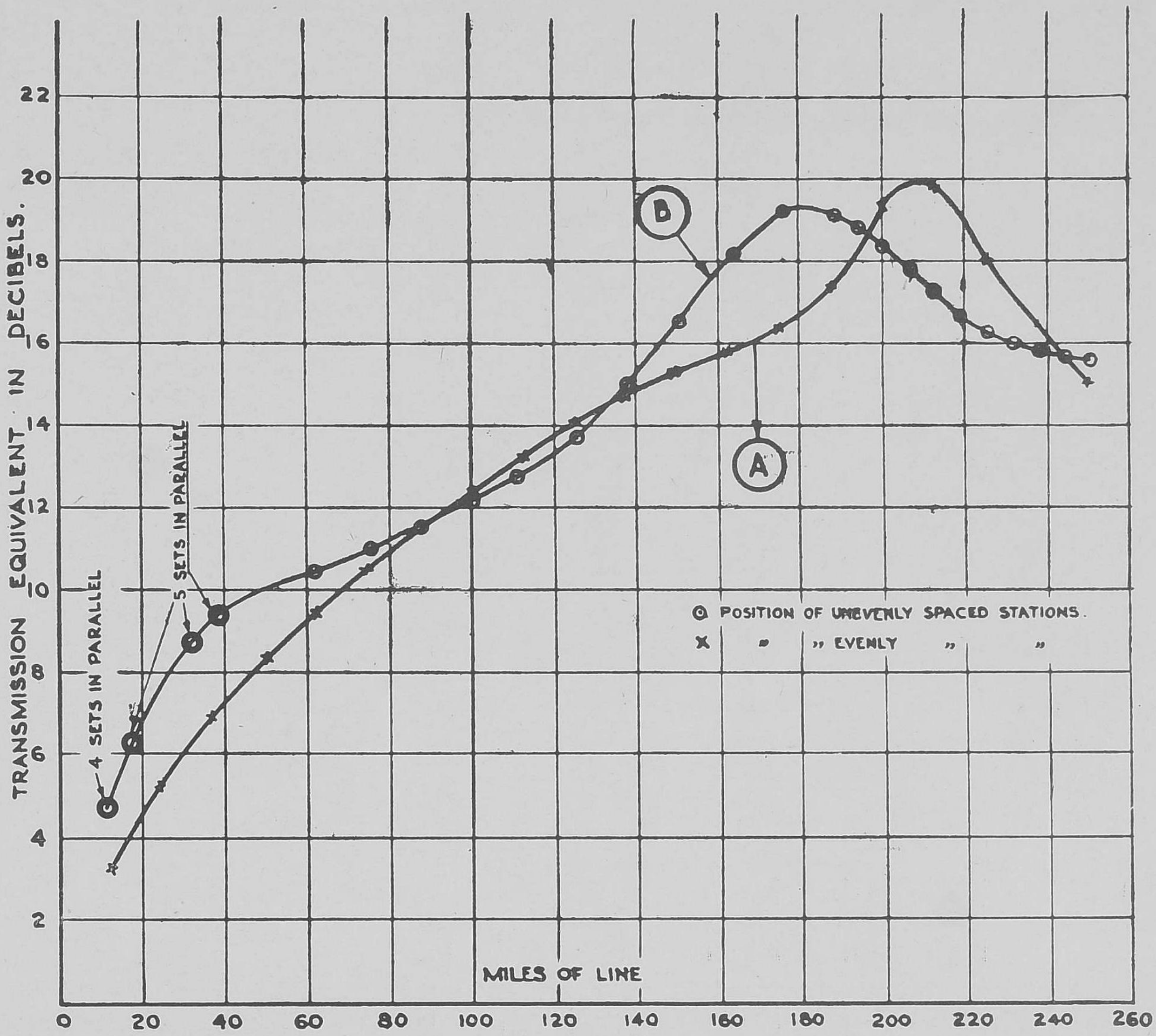


Fig. 14. Transmission Equivalents of Typical Control Circuits

Curve A shows variations of transmission equivalent for 40 way-stations evenly spaced along the line.

Curve B shows variations of transmission equivalent for 40 way-stations unevenly spaced along the line.

Line under test—250 miles. No. 9 A.W.G. Copper. Test frequency 800 cycles.

122. Figure 15 on page 50 shows theoretical circuit loss curves for evenly spaced way-stations on a No. 9 A.W.G. copper line. It is of technical interest to note that, for a particular length of line, a certain critical number of way-stations of the designed impedances when evenly spaced, produced minimum overall loss in the circuit. For example, 40 way-stations involved a loss of about 9·5 decibels over 160 miles of No. 9 A.W.G., while the same number of way-stations caused a loss of 13·5 decibels over a similar circuit 65 miles long, and a loss of 13 decibels over a circuit 250 miles long. Similarly 30 way-stations evenly spaced produced minimum loss on a line 120 miles long, and 50 way-stations minimum loss on a line 200 miles long.

123. From these results it will be noted that if the way-stations happen to be evenly spaced at 4 miles intervals throughout a control circuit the best transmission conditions are obtained. This is explained by the fact that the telephone bridging impedances load the aerial line and, theoretically, it can be shown that spacing of 4 miles produces the maximum loading effect on a No. 9 A.W.G. open wire copper line.

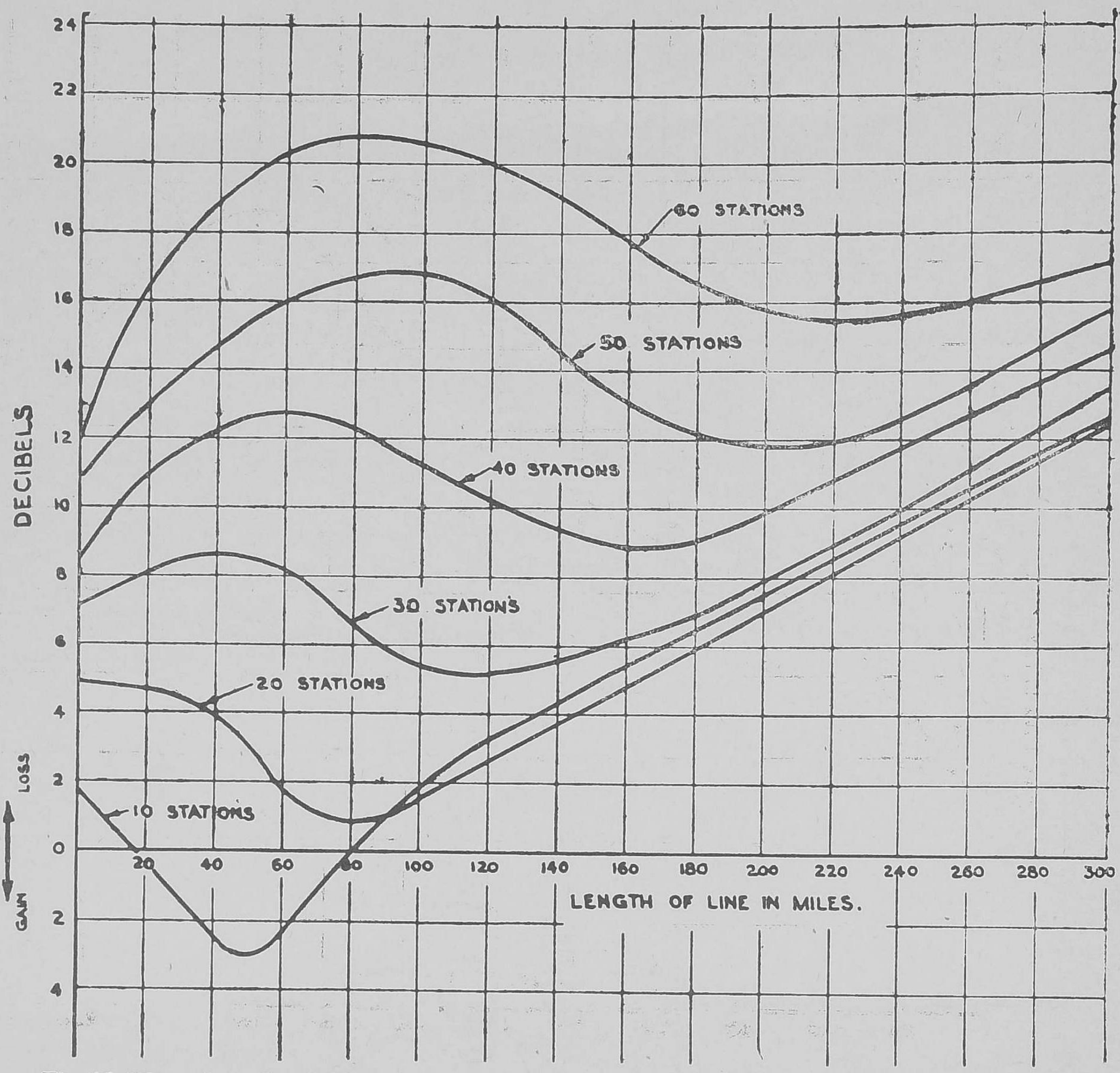


Fig. 15. Theoretical Circuit Loss Curves. Evenly spaced way-stations on a 9 A.W.G. Copper line (Non-loaded)

124. The foregoing explains why it is observed sometimes in practice that when efforts are made to improve a control circuit by shortening the length controlled without materially reducing the number of way-stations, the anticipated improvement in transmission may not be obtained; in fact the overall transmission loss may increase,

125. Reverting to Fig. 14 it will be noticed that the transmission equivalent in each curve rises to a peak at a point about 180 to 200 miles from the controlling point and the transmission equivalent beyond this actually decreases. This apparently abnormal result is due to reflection from the end of the circuit. It has been noted previously that both the selector and the telephone bridging impedances have a high value at 800 cycles per second. They are also high in comparison with the characteristic impedance of the open wire line which is approximately 650 ohms. At the last way-station on the line, therefore, the line is practically open-circuited notwithstanding the impedance bridged across it.

126. It is suggested that on circuits longer than 200 miles where this reflection is marked, the open wire line should be terminated with its characteristic impedance of 650w so that the transmission loss curve is smoothed out at the distant end. An improvement of two or three decibels in the transmission loss up to the way-stations near the distant end may be obtained in this way. To avoid losses to ringing selector currents it would be necessary to connect a 1 m.f. condenser in series with the resistance of 650 ohms.

CHAPTER XIV

Control Telephone Design

127. The principal operating and technical requirements affecting the design of a way-station control telephone are as follows—

(a) There should be a 'Listen and Speak' key. In the 'Listen' position the transmitter should be disconnected.

(b) The circuit should have good 'Break-in' efficiency.—That is, the side tone in the way-station receiver should not drown incoming spech from the controller, who can therefore cut in.

(c) When the 'Speak' key is operated, the transmitting circuit should be arranged for maximum efficiency.

(d) The receiver and the transmitter must be insulated from the line by an induction coil.

(e) The impedance in the 'Receive' or 'Listen' position of the key must be as close as practicable to the desired theoretical value of $7500\angle 70°$.

128. The way-station control telephone circuit is shown in Fig. 16 below. When the receiver is hung up the primary of the induction coil remains bridged across the line in series with the 0·25 m.f. condenser. In this condition the secondary of the induction coil is not in circuit and the bridging impedance is slightly higher than $7500\angle 70°$. This produces less loss at a way-station not "listening" and improves transmission to way-stations which may be listening. When the receiver is removed to listen, the listen circuit is arranged for maximum efficiency, and this combined circuit most nearly simulates the theoretical impedance of $7500\angle 70°$.

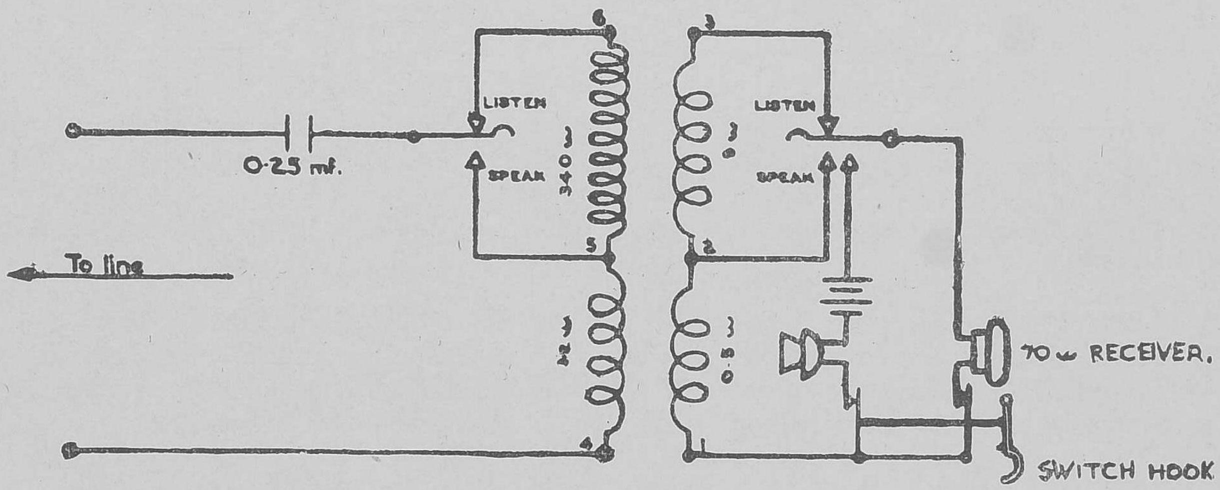


Fig. 16. Way-station Control Telephone Circuit

129. It is necessary to impress on all traffic staff who use the control circuit, that, when listening the circuit should be in the "listen" condition, i.e. the 'Speak' key should not be operated. It is realized that in an ordinary conversation it causes a certain inconvenience to keep on releasing the 'Speak' key when the controller is talking to the way-station, but practice should make the operation instinctive.

130. When the operator at the way-station wishes to speak to the Controller; the 'Speak' key alters the circuit to provide a high transmission efficiency into the line. It will be seen that the ratio of the turns in the induction coil is changed. At the same time the transmitter battery circuit is closed. Maintenance engineers do not have to be reminded to impress on the traffic staff using the control equipment, that unnecessary operation of the 'Speak' key, e.g. when the Controller is dictating a message, not only reduces the listening efficiency of the circuit, but drains the transmitter battery unnecessarily.

131. When the circuit is arranged for "Speaking" the receiver is bridged directly across the transmitter winding of the induction coil (Secondary). This is necessary to give the 'break-in' efficiency mentioned in paragraph 127(b). The impedance of the receiver is relatively high compared to that of the transmitter coil winding so that no serious loss of transmission occurs, but the side-tone is unavoidably greater than is to be found in telephones fitted with anti-side-tone circuits. This side-tone imposes little strain on the operator at the way-station as he is not using the telephone continuously.

131. The Controller's telephone set differs from the way-station control telephone and is designed to give both the maximum practicable transmission and receiving efficiency. The "break-in" efficiency must be as high as possible in order that when a Controller is talking to a way-station, the side-tone in his receiver will not drown speech from a distant station who may require to impart urgent information. While the side-tone must be sufficient to enable the Controller's own speech to sound natural, it should be sufficiently low to prevent amplification of extraneous room noises or otherwise impose a strain on the Controller.

132. The circuit employed for the Controller's telephone set is shown in Fig. 17 below. It incorporates an anti-side tone device. This circuit has a transmitting efficiency approximately 2 decibels less than the way-station control telephone, but the receiving efficiency is approximately 6 decibels better than the way-station control telephone in the "Speak" condition.

133. Maintenance engineers will appreciate that since way-station sets and Controllers' sets have been specially designed for the service required of them, no alterations to their circuits or components can be made without the risk of causing serious deterioration in the operation of the control system. It is realized that during the war, when it has been difficult to obtain spare components for maintenance purposes, temporary expedients may have been made, pending replacement by standard components when this becomes possible.

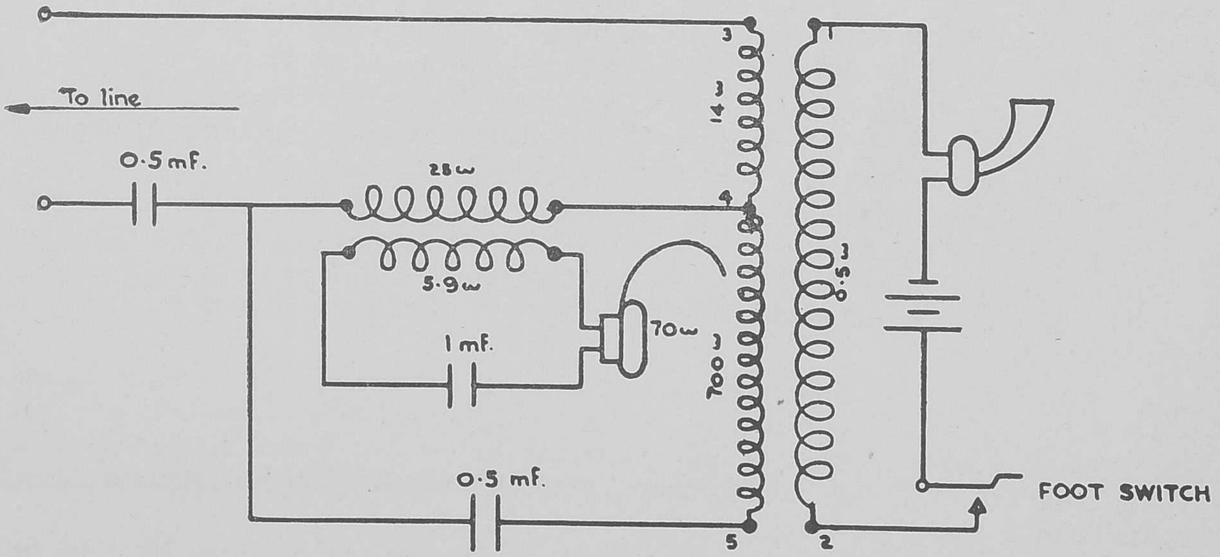


Fig. 17. Controller's Telephone Circuit

CHAPTER XV

Train/Traffic Control Circuits

134. The planning of individual Train/Traffic Control circuits requires careful consideration. From some of the data given in Chapter XIII it has been shown that it is not easy to predict the effect on overall transmission of a required number of way-stations on a certain length of line, more particularly if these way-stations are at irregular spacing. It is equally difficult to predict the effect which abnormal grouping or bunching of way-stations will produce on a line. Additional complications may accrue if branches, several miles in length, are combined with the main circuit (particularly if these branches are 'T' connected) or if sections of cable are inserted in the circuit without due regard to loading.

135. From its fundamental design, it is desirable that a control circuit should be controlled from one end. Attempts to control circuits from intermediate points or to incorporate long branches to the main circuit may meet with little success. In India, a number of cases of abnormal but comparatively short Control circuits do operate with fairly satisfactory results but it may be remarked that there are other abnormally arranged Control circuits which do not operate satisfactorily.

136. Unless adventitious assistance in the form of a terminal repeater or amplifier is provided the total permissible overall length of a Control circuit, if the transmission loss is limited to 22 decibels, will be governed by the decibel loss due to (a) line resistance and capacitance between the two conductors and (b) way-stations.

137. Taking an average number of way-stations as 40 and the average loss per way station as 0·1 decibels, the permissible length of a Control circuit would be as follows—

Circuit	Attenuation Decibel/Mile.	Way-Station losses.	Permissible length.
200 lb. per mile copper ..	·064	4 db.	281 miles.
300 ,, ,, ,, ..	·044	4 db.	409 miles.

138. On Indian Railways it has not always been found possible to limit the overall length of Control circuits to the permissible lengths suggested in the previous paragraph. As an operating facility it was found convenient to centralize the control circuits of a District/Division for operation from a main Control office. In many instances this involved the practice of linking an outlying control circuit to the central control office by trunk lines, frequently of considerable length.

139. There are technical objections to the use of trunk connections to an outlying circuit which may be briefly stated as follows—

(a) Transmission losses which occur on the trunk portion of the circuit added to the losses of the outlying "controlled" section of the circuit frequently cause the overall transmission loss to exceed 22 decibels.

(b) Trunk lines necessarily increase risk of interruption and if failure occurs at any point in the trunk line section the entire section control circuit in automatically suspended. In such a case there is no opportunity of cutting out the faulty section and continuing control working with a portion of the circuit suspended.

(c) Unlike a section control where switches are provided at each station and the localisation of failure is a precise and simple operation, trunk lines are only provided with testing points at long intervals, say of 25 miles, making localisation of a failure only very approximate, inevitably resulting in longer duration of failures.

(d) Signalling (i.e. ringing and selector operation) batteries have to be increased to cover the increased resistance added by trunk lines.

140. In order to overcome these marked disadvantages several of the Indian Railways have adopted the policy of Control decentralisation where this has been found necessary. Detached Control offices are provided at suitable locations from which radiate compact and comparatively short Control circuits covering only the actual routes controlled, and in order to maintain administrative control between the outlying Control office and the District/Divisional Headquarters Office, a separate telephone circuit is provided.

141. In certain cases, where decentralisation is found to be impracticable for special reasons, an improvement in the operation of a long trunk-linked Control circuit can be effected by the provision of a standard telephone repeater installed at the Controller's end of the circuit as a 2 wire/4 wire terminal repeater, the arrangement being shown diagrammatically in Fig. 18 below.—

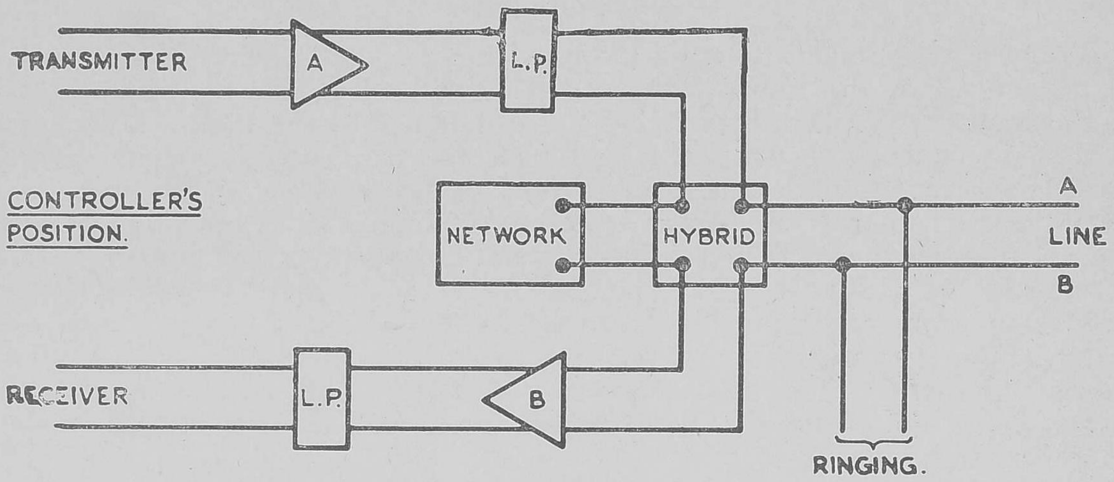


Fig. 18. 2 wire/4 wire Terminal Repeater

142. It may be emphasized that a correctly designed and installed Control circuit of reasonable length should not normally require the installation of a repeater to overcome line transmission losses. Abnormal transmission losses may be due to defective way-station equipment which should be eliminated by careful testing with suitable transmission loss measuring equipment.

143. The introduction of intermediate telephone repeaters to Control circuit operation is a new departure which is still in an experimental stage. Until further data is available the writer is chary of advancing an opinion on the successful practicability of the development though it would seem, from analogous telephone practice, that there should be no insurmountable difficulty in linking two adjacent Control circuits by an intermediate 2-wire repeater for end-to-end speech.

Train Control Circuits in large yards

144 In large station yards with a complicated line network of telephone, telegraph, block and Control circuits linking various cabins and offices there is a risk of frequent line faults particularly in the nesting season when odd pieces of wire, &c. found too frequently in larger yards, are picked up and dropped on the open wire lines by birds. Much can be done to eliminate those faults by simplifying the line networks. It is clear that the greater the length of a circuit in a railway yard the greater is the risk of faults developing and vice versa.

145. In the case of a control office situated at a large headquarters, the outgoing line wires are generally looped into several cabins and offices before reaching the "open line". In the other words the circuit has to run the gauntlet of the "vulnerable area" and any fault occurring within that area will automatically involve suspension of working of the entire circuit.

146. Where practicable, it is desirable that a control circuit should proceed direct from the control office to the "open line", the local offices and cabins being connected to the control office by a subsidiary loop. In this case should a fault occur in the complicated network of the subsidiary loop, only work on this loop will be

suspended, the main control circuit being unaffected. It is realised that this means an increase in the total milage of control line for which rent is paid but this increase will generally be small. The length of wire in the main circuit where it passes through the vulnerable area is reduced.

147. A control circuit entering a large station area should invariably be led direct into the cabin or office of most importance from the point of view of train controlling. The circuit should then proceed to cabins and offices of lesser importance which can be cut off if a fault develops beyond the main cabin or office, thus keeping the main circuit working between the control office and the most important cabin or office.

Conclusion

148. On most Indian Railways the line wires for Control circuits are provided and maintained by the Indian Posts and Telegraphs Department, while the office and way-station equipment is provided and maintained by the Railways. Experience has all too frequently shown that if line wires and office equipment are treated as two separate responsibilities, there has been a constant tendency, in the past, on the part of the two authorities, to blame each other for unsatisfactory operation. It is quite certain that unless the staff of each Department, i.e., Railways and Indian Posts and Telegraphs, can regard a control circuit as an entity; a complete electrical device in the efficient operation of which they are as keenly interested as their colleagues in the other Department, really efficient maintenance of Control circuits cannot be attained. The writer urges the utmost degree of liaison and collaboration between the officials of the Railways and the Indian Posts and Telegraphs Department to this worthy end.

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