

**BRITISH RAILWAY  
OPERATION**

**T. BERNARD HARE**

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BY

T. BERNARD HARE, M.Inst.T.

*Principal, L.N.E.R. All-Line Operating School, Darlington*

*Written in 1927, whilst Asst. District Superintendent, London and  
North Eastern Railway, Hull*

WITH FOREWORD BY

Sir RALPH L. WEDGWOOD, C.B., C.M.G.

*Chief General Manager, London and North Eastern Railway*

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## FOREWORD

**I**T is often said that Railway Operating, like Politics, is not a Science ; and the statement is true. That, however, is no reason why it should not be the object of systematic study, and this book is intended as a contribution towards such a study.

The publication in book form of Mr. Hare's articles on Railway Operation which have appeared in *MODERN TRANSPORT* is an encouraging sign, and for two reasons. It indicates the increasing desire on the part of the rising generation of railwaymen to prepare themselves by reading and study for the operating problems which they will later be called upon to face in practice, and it indicates also an increasing readiness on the part of the present generation of practising railwaymen to rationalise and generalise their operations and to substitute, so far as may be, a statement of principles for mere rule of thumb. Both these tendencies are to be welcomed.

Mr. Hare's book is not by any means the first text-book on Railway Operation ; it is none the less a useful contribution to our educational material. We may study Railway Operation from many points of view, but the material is too diverse and too changing to lend itself to any final treatment. The most that can be hoped for is that in limited fields certain general rules and principles may be outlined.

Since there can be no such thing as an orthodox creed in Railway Operation, the field is clear for a variety

of text-books, each of which will throw its own light on the subject according to the writer's method or practical experience, and, so far as I know, Mr. Hare's is the first book published in this country which comes from the hand of a practising railwayman. This is a feature which gives special value to the publication. I believe that it will be found to be of real use to the Railway Student, and that not only for the information it imparts but also for the varied lines of thought which it suggests.

R. L. WEDGWOOD.

King's Cross Station, N.1.

*16th March, 1927.*

## PREFACE

**T**HE very kind reception which the contents of this volume received when published in the form of weekly articles in *MODERN TRANSPORT*, and the many enquiries which have been made as to the intention to republish them in book form, have led to a decision to do so.

Limitations of space and the necessity for avoiding the use of diagrams and illustrations, if the cost is to be such that the selling price may be within the reach of the average student, have resulted in a good deal of matter being omitted which, from other points of view, it might have been regarded as desirable to include. Within these limits, the aim has been to provide a general outline on which the study of the subject may be based. It is for this reason that an endeavour has been made to discover and discuss the principles underlying the various practices which together may be described as *Railway Operation*, rather than to describe the practices of individual companies.

After rather more than twenty years' service with the same company, it is not easy to avoid a tendency to be prejudiced either for or against the methods employed by that company, though an effort has been made to overcome this. The reader is, therefore, recommended to examine any statement which may appear to be tinged with such prejudice even more critically than the others.

In conclusion, I must express my thanks to Sir Ralph L. Wedgwood, C.B., C.M.G., for the honour he



has conferred upon the writer by contributing the Foreword to this book, and to Messrs. G. Davidson, C.B.E., and C. M. Jenkin Jones, Divisional General Manager and Superintendent respectively of the North Eastern area of the London and North Eastern Railway, for their kind permission to write it. I am also indebted to Professor Hallsworth, M.A., of Durham University, on whose suggestion the work was undertaken, and to Mr. R. H. Nicholls, C.B.E., Superintendent of the Line, Great Western Railway, and Mr. J. Thornton, Superintendent of the London Underground Railways, for their kindness in granting facilities for obtaining a knowledge of certain phases of the work on their respective lines, whilst I acknowledge the help of my railway colleagues of all ranks and grades, from whom, consciously or unconsciously, I have accumulated that knowledge which is summed up in the word "experience," on which the statements in the book are based. My grateful thanks must also be tendered to Miss C. E. Taylor, who, by devoting her hours for leisure or recreation to the somewhat uninteresting business of typing the MS. and the notes of the lectures on which the MS. is based, made possible a task which would otherwise have been impossible in the amount of time available for their preparation.

T. B. H.

## INTRODUCTION

**I**T is very difficult to say exactly what should be the logical order of the different subjects which come under the general heading of railway operation. The whole thing is so interwoven that a knowledge of certain subjects which, from some points of view, should come late in the syllabus is desirable when discussing points which naturally have to be dealt with earlier. In other instances, the converse is the case. The sequence followed has, therefore, been adopted as one which is, on the whole, judged to be the most convenient for a thorough appreciation of all the points involved.

The business of working a railway is, in many respects, unique. This is unfortunate from the point of view of the student, since it is probably true that the easiest way of grasping a new subject is to compare it with something with which one is already familiar. In some degree, certain aspects of railway work may be compared with the business of the manufacturer, others with that of the wholesaler, and still others with that of the retailer of commodities. One essential difference is that transport is rather a service than an article! Turning to those concerns which provide a service, we can, to some extent, compare the service the railway gives with that given by a doctor, a barrister, or a banker. In no case, however, can we carry any such comparison very far. This point will be developed when dealing with the question of "Organisation." Confining ourselves to operating, it may be helpful, as an ideal to keep

before us, to regard a railway as one complete machine, so arranged that, while the different parts work at differing speeds, the processes are, in turn, completed at such a rate that the whole works in complete harmony and the desired results are obtained in the most economical way.

CHAPTER I  
SIGNALLING

THE financial difficulties which the railway companies are passing through has led to a tremendous effort to ensure economy in working, and this at a time when working has become more than ordinarily difficult owing to the altered directions the main streams of traffic have taken as a result of the grouping enforced by the Railways Act, 1921. In many cases, accommodation provided under the old régime has gone partially out of use. In others, pressure upon the existing accommodation has become so great that the necessity for expensive widenings and other new works is indicated at a time more than usually inconvenient for the raising of the necessary capital. Enquiries which have been made in all directions as to possible means of economy have indicated considerable possibilities in the desired direction by a thorough revision of signalling arrangements. When railways first came into use there were no signalling systems. The driver was responsible for keeping his train under sufficient control to enable it to stop short of any obstruction he might see on the line, just as the road driver is to-day. It is significant that on one of the most congested suburban lines in the United States this state of things has been reverted to, the only signal the driver has to guide him being the tail lamp of the train in advance. It is more than significant that a commission appointed to inquire into the substitution of this system by some modern system of automatic, or other, form of signalling reported in favour of the continuance of the present arrangement.

Evolution of  
Signalling.

In the cycle represented by the events mentioned has come the birth and development of a most wonderful and complicated system of signalling, first devised to ensure safety, but later developed

so as to enable a maximum density of trains to be dealt with. To put it another way, the original idea underlying the introduction of signalling was that the signals were to be used to stop trains. This has now developed, and signals, though still used to stop trains where this is absolutely necessary, are, or should be, arranged so as to enable the maximum necessary number of trains to be kept moving.

The Time-Interval System.

The first stage in the evolution of our signalling systems was the introduction of what was equivalent to our present-day policeman on point duty. This gradually developed into the fixed signal, with the lever for working it carried to some central point, the signal box, for convenience of working. With increasing traffic, it became necessary to extend this protection, originally provided at the more difficult places, to the whole line. Signalling, in itself, not being sufficient protection, the time interval system of train working was brought into operation, so that a sufficient distance might be kept between the tail of one train and the head of the next. Headway is the term we should use to describe this interval to-day. The variation in the speeds at which trains were run, and the extent to which they were controllable with the brakes then in existence, made it necessary to improve this method. This led to the introduction of the block telegraph system, which substituted the fixed time interval for a varying one depending upon the time occupied by the particular trains concerned.

The Block Telegraph System.

A further change of importance in connection with the block system was that, before its introduction, the line was normally assumed to be clear, and the signals were only put to the "danger" position when it was definitely known that the line ahead was blocked. The block system reversed this, the line being assumed to be blocked until the reverse was established by definite inquiry. The block system necessitated the division of the running lines into sections, the boundaries of which were marked by a signal called the starting or advance (or sometimes the advanced starting) signal. It is in its capacity as the boundary of the block section that we must first consider this signal.

The Arrangement of Block Sections.

It is not unfair to say that, until a comparatively recent date, the position of most signal boxes, and to a large extent of the starting signals worked from them, was settled by some local consideration (*e.g.*, the necessity for communication to station yards, private sidings, etc., or the controlling of road traffic over some level crossing) rather than by such considerations as the relation of one block section to the others on that line. Even where some attention was paid to this, the construction of branches converging with such lines was rarely, if ever, followed by the desirable revision of the section lengths on the parent lines. This was inevitable, in view of the way railways developed.

The experience of those immediately concerned in dealing with the rapid increase of suburban traffic to and from London termini has drawn attention to the importance of the scientific arrangement of block sections. The further examination of the question, from the point of view of what may be called the ordinary main and branch line working, has indicated that in this direction lies a very promising field for inquiry.

A moment's thought will suffice to show that if all trains are to run at the same speed, sections of unequal length\* must be wasteful (*a*) in so far as they involve unnecessary signal boxes, signalling apparatus, and signalmen without enabling any greater train density, and (*b*) because additional stops to trains will result, thus actually reducing the possible train density as well as causing additional expense on the engine. Such questions then arise as: Does the same apply when, as in practice, trains run at differing speeds?

The student is recommended to work out by means of simple tables or graphs some simple theoretical cases. We have not space to do so here. As a beginning, only very simple examples need be taken, dealing first with the effect of unequal sections on trains of the same speed; then with equal sections on trains

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\* In referring to length of sections, we must think of it in terms of time, not distance. For our purposes, the *length* of a section is the time the standard train takes to pass from one starting signal to the next. By so doing, we eliminate the variation caused by gradients, curves, and the effect of stops for working purposes, etc.

of differing speeds. These can then be combined and a table showing the effect of unequal sections and differing speeds prepared. In preparing them, it should be assumed that maximum line occupation consistent with freedom from signal delay is required, and it is simpler either to omit the time taken in exchanging block signals, or add an allowance for this to the section length.

From the consideration of such simple tables, the principles underlying the best arrangement of block sections, will emerge. We shall discover, for example, that, speaking broadly but sufficiently accurately for practical railway purposes, on any line between two consecutive junctions with unequal sections and with trains at differing speeds it is the time distance of the slowest train on the longest section that settles the capacity of the line.

Effect of  
varying sec-  
tion lengths  
and differing  
train speeds  
on line  
capacity.

We shall further see that apparent gains over that portion of the line where sections are shorter ultimately result in greater losses and reduce the possible line occupation.

Other interesting facts will come to light. For example, few students will care to accept, without careful check, the statement that the number of trains which can pass over a simple up or down line will be less if alternate trains are running at 60 and 30 miles per hour respectively than if all are running at 30 miles per hour. It is, however, quite true; for a reduction in line occupation as a result of the trains of higher speeds only begins when two or more such trains are consecutive. Even then, the reduction is not great, the loss resulting from even one slower train being very considerable. In general, we shall discover that, if greater train density is required, our aim must be to shorten the length of the ruling section and raise the speed of the slowest trains. Our consideration of this phase of the subject is necessarily far from complete. What, for example, should be the effect on the arrangements of our time-distance intervals of two or more converging lines, of the provision of running independents or relief sidings, and so on?

Signals.

We have seen the importance of having the minimum necessary number of signal boxes. It is almost

equally important to see that the number of signals themselves is kept to a minimum. The average cost of erecting a semaphore signal and connecting it to a signal box may be taken as something like £50. To this must be added about £7 a year as the cost of maintenance, exclusive of the cost of oil and labour for trimming and lighting the lamps. Nor does this direct waste represent the whole case against unnecessary signals. They are liable—in fact, almost certain—to cause unnecessary stops, with the consequent expense of starting, and additional line occupation. Further, the work of the signalman, and the risk of the driver or signalman making a mistake, is increased. Rules as to what is necessary cannot be made to meet all circumstances, though many cases where conditions are exactly, or almost exactly, parallel can be grouped. It is no exaggeration to say that there are hundreds of unnecessary signals in existence in various parts of the country to-day.

The distant and starting signals are the two essential for block working purposes. The function of the distant signal under absolute block working conditions is to give a preliminary warning to the driver of the position of the starting signal. If the distant is at caution, then the driver must expect the starting signal to be at danger. The home signal is the name very appropriately given to the signal which is used normally to protect the points leading to and from the station yard. (The other obstructions which a signal designated a "home" signal may legitimately be used to protect are such as junction points, crossover roads, level crossings, etc.) Since the signal box is usually placed near to these points it follows that the home signal is usually near the signal box. This, and the fact that it is the first stop signal worked from the signal box in whose block section it is, has tended to create a general impression that the home signal is a more important signal than the starting signal, which is unfortunate. Further, it has led to the application of the descriptions of "inner home" and "outer home" to signals used for quite a different purpose than the home signal. We may say, then, that starting signals are used to protect obstructions in advance, but on the same

The Distant  
Signal.

The Home  
Signal.



running line, whilst home signals are used to protect obstructions which may foul the line by a converging or crossing movement. The home signal, however, where provided, has two additional uses; first as an additional safety device, because, unless the block section ahead is clear, the home signal is kept at "danger" until the train is brought nearly to a stand before it is lowered to enable the train to proceed to the starting signal, i.e., to the end of the section that is clear. The other use, confined, as a rule, to freight trains on favourable gradients only, is to allow it to be regarded temporarily as a division of the block section into two block sections.

Outer Home  
Signals.

Where the section is sufficiently long, a similar effect is obtained for all trains, including passenger trains, by the provision of an additional stop signal either within or without the home signal. Where such signal is provided, a train may be accepted at "line clear" to the outer home signal if the line is clear up to the inner home signal, the distance between the two being sufficient margin of safety in the event of the driver failing to stop at the outer home signal. In other words, the inner home signal temporarily assumes the function of a starting signal.

Regulation 5.

The use of Regulation 5, as the regulation which permits of the temporary division of the normal section into two sections is called, and of outer home signals, is undoubtedly valuable when approaching a diverging junction. They are certainly not of equal value under other circumstances, except in block sections of exceptional length in relation to those on the same section of line. Whether their value is worth the extra expense of the additional stop and start may well be tested by working out the effect on similar lines to those indicated earlier.

Position of  
Signals.

Where other considerations allow, the starting signal should be sufficiently beyond the farthest points worked from the signal box to allow a shunting movement to take place without its being necessary to enter the next block section, or, at junctions, to enable a train which cannot be accepted by the block section in advance to go sufficiently far forward to stand clear of the junction points. It must be at

least 440 yards ahead of the home signal, this being the minimum overrun allowance for safety purposes.

The position of the distant signal in relation to the first stop signal it repeats depends upon the momentum to overcome and the braking power available for the most difficult train likely to pass over it. On normal lines it is usually from 800 to 1,200 yards in the rear, whilst on the electrified lines of the London Underground railways, where there is, strictly speaking, no distant signal but a repeater signal performing the same functions, the distance is sometimes as short as 100 feet.

We must just touch upon the question in its relation to lines worked on the recording block regulations. Under these regulations, any number of freight trains may be in a block section, provided the drivers of all trains but the first are warned that the section is not clear when they enter it. A moment's consideration will bring us to the conclusion that the only limit to the length of the sections on such lines is the necessity for protection at junctions where lines converge or diverge, or where connections to the main line, busy level crossing gates, etc., require to be worked and protected. We reach conditions very nearly approaching those on lines equipped with automatic signals, and even nearer to those in operation on the suburban line near New York already referred to, where the only signals in use are the tail lights of the trains themselves.

Recent developments in signalling indicate that the need for getting an increased number of trains over the existing lines of British railways will inevitably lead to the abolition of the standard method of equipping each section with distant, home and starting signals, there being substituted for it some system under which each signal can perform at least two functions, namely those of a caution and those of a danger signal, any two of which working in conjunction will form a section.

The value of the three-position (i.e., *danger, caution or clear*) and three-colour aspect signal, with its further development of four-position signals to lines where there is a great contrast in the speeds of trains,

Recording  
Block.

Three-Position  
Signal.

can be regarded as definitely established.\* Their effect from the operating point of view is that the number of sections is increased, and, consequently, a greater number of trains can be got over the lines, providing the increasing of the sections is done in such a way as to preserve something like equality in the time distances between their boundaries.

**Power Signalling.**

By power signalling is meant the substitution of the present man power mechanism used for working signals, points, etc., by some other form of power, usually electricity, air under pressure, or a combination of both. The advantages of power signalling are :—

(1) The movement of signals, points and other appliances is much quicker than is possible with hand-worked mechanism.

(2) Points and signals can be worked at a greater distance from the signal boxes. The maximum distance allowed by the Ministry of Transport for the working of points by hand levers is 350 yards; with other than man power and suitable safeguards this may be extended almost indefinitely.

(3) Fewer signalmen are required, and the work of those who remain is made much less laborious.

(4) A very much smaller box and frame is required; often quite a valuable consideration at busy centres.

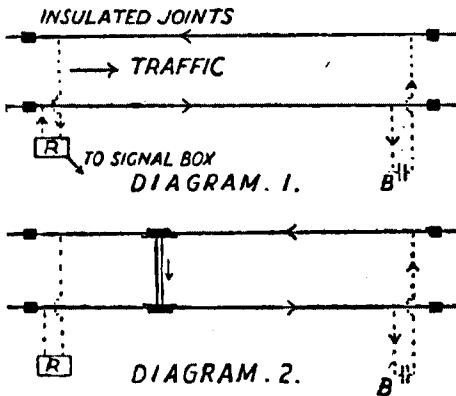
**Automatic Signalling.**

Automatic and semi-automatic signalling is rendered possible by the application of the principle of the track circuit. Originally introduced as an electrical method of indicating in the signal box when a portion of track was occupied, the simple principle underlying it has been extended into the wonderful systems of automatic and semi-automatic signalling which exist to-day. Diagram 1 illustrates the arrangement. The rails in the section over which an indication of occupation is required are connected by wires, and insulated from the remaining rails; the power is supplied through the battery (B) and normally flows in the direction indicated by the arrows through the relay (R). The introduction of a pair of wheels

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\* The student should read the report of the Committee on three-position signalling issued by the Institution of Railway Signal Engineers, March 29, 1922.

with the axle connecting them causes a short circuit, as indicated by the arrows in Diagram 2, and the current, being diverted from the relay, gives the necessary indication to the signal box that the line is occupied. In the ordinary way, the indication is given by the moving of an indicator in the signal box. Where the working is very complicated, as at a large station or important junction, it is usual to have a small scale diagram of the lines, the sections of which become illuminated as the track circuits operate. Put briefly and simply, automatic signalling is an



arrangement whereby, by the use of the track circuit at appropriate points, the signals are put to "danger" behind a train, and kept there to protect it until it has made such progress that there is no longer the need for protection.

Semi-automatic signalling is very similar, except that the movement of the signals is also controlled by a signal box either in the rear or in advance; it is normally applied on automatic sections where, for some reason, it is desirable occasionally to work connections with the main line, the working reverting to automatic for the remainder of the time. Failures, though not unknown, are exceedingly rare, and can

be provided for in systems of automatic or semi-automatic signalling by arranging matters in such a way that failures cannot result in accidents, but, at the worst, lead to delay and inconvenience. The principal advantages of automatic signalling may be summarised as follows :

(1) The wages of the signalmen necessary to work other than automatic signals are saved.

(2) The possible line occupation is increased, because the signals are released the moment the clearance point is passed.

(3) The saving in construction and maintenance of the signal boxes and the necessary apparatus leading from them to the signals.

(4) The possibility of increasing the line occupation by increasing the number of sections at a much less cost both in capital and wage expense than would be necessary if manual signalling was used.

It is not difficult to visualise, in the comparatively near future, important branches on which the whole of the signalling is controlled from one signal box, or control office, semi-automatic arrangements being applied at wayside stations during such periods as may be necessary for the station working.

## CHAPTER II

### TERMINALS

THE word terminal, like quite a number of other words, has acquired a special meaning for railway purposes. It is used to refer to both ends of any journey. At the initial terminal, the passengers or goods are assembled into sufficiently large units to carry them with a reasonable degree of economy by rail. At the terminal proper, such passengers or goods are dispersed, apart from accidents, into the units in which they were originally received.

For practical purposes, we may say that all stations are terminals in both senses of the term. Stations, Situation of Stations. whether passenger or goods, must be situated in the centre of the areas they serve if they are to be of such convenience to the public as to attract the necessary traffic. In towns of any importance, this necessarily involves occupying sites of extremely high value not only for the stations, but for the approaches thereto. Further, the difficulty of expansion, apart from the extra cost due to the high price of land in the vicinity and the fact that it is probably already occupied by some other sort of premises, is exceptional, because a railway station is a special type of property.

These features all emphasise the desirability of increasing the capacity of a station or its approaches by improved methods of working, rather than by the provision of extra accommodation.

Apart from a reminder of the possibilities arising Passenger Stations. out of the use of "halts" in lieu of small stations, we need not spend much time upon the consideration of small stations. On single lines one platform with the simplest office and waiting-room accommodation will serve in both directions. Where the lines are double we have a choice between two platforms, one on each side of the main line, and an island platform between, and serving, both lines. The island is more economical, in so far as one set of buildings will serve

both platforms. Against this, it necessitates a series of curves in the running lines which interfere with the running of expresses. At junctions, where there is exchange between trains of luggage, parcels or passengers, the value of the island platform increases, since it facilitates the transfer between up and down direction traffic.

We can divide the types of bigger stations into two, though obviously the different conditions applying vary considerably in degree, namely, the large intermediate, or through station, which is also a terminal station for some trains, e.g., York, Crewe, Nottingham, etc., and the purely terminal station, such as the large London stations, where every train entering must leave in the reverse direction. At the latter type, the platforms must, of necessity, be dead-ended. For the former—and especially if, as is often the case, the station is also a junction station—the island principle is, by general consent, the best.

The Island Platform.

What might be called the first stage is the simple island, often sufficiently long to take two, or even three, trains on each platform line at once. The next stage adds bay platforms at one or both ends for use of terminating, or starting, trains. In addition to the advantages for transfer purposes already mentioned the island type enables some duplication of such buildings as booking offices, refreshment rooms, waiting rooms, etc., to be avoided, thus reducing expenditure both in construction and subsequent maintenance and staffing. Further, it enables trains in reverse directions to exchange vehicles without fouling other than the lines on which the trains are standing: a by no means inconsiderable advantage. The disadvantage of this type is that, unless the station level is well above or below street level, and the neighbourhood otherwise suitable, all passengers, luggage, parcels, etc., must go both up and down to reach the platforms, by subway, stairs or lift.

By the time we reach the stage when more than two through platform lines are required, the island principle is forced upon us. Whether the further development takes the shape of conversion of existing bays into through platforms, or a duplication of the existing island with or without bays, depends upon

such local considerations as the extent and directions of the traffic to be catered for, etc.

Speaking broadly, however, we may say that any inconvenience arising from a duplication of islands will be more than compensated for by the working advantages obtained by doing so.

The position and extent of the different sorts of accommodation required for passengers at a large station, such, for example, as the booking offices, waiting rooms, refreshment rooms, and so on, are worthy of careful consideration, the final choice depending to a large extent upon the space available, and the lay-out of the approaches to the station. Lack of space prevents any detailed discussion of the conditions affecting the final choice, and we must content ourselves by saying that they should, as far as possible, be arranged in such order that the passenger will find them conveniently placed, both in relation to each other and to the entrances to the station and platforms.

Design of  
Passenger  
Stations.

If a station is to be what is called a "closed" one, i.e., one at which the general public are not admitted to the platforms without payment, suitable barriers must be placed at the entrances to the platforms. The advantages of this system are that congestion on the platforms is reduced, a check is provided against certain types of ticket irregularity, and a revenue is obtained from the sale of platform tickets.

The points we have just considered refer more particularly to those which are more apparent to, and, therefore, appreciated by, the travelling public. Even more important are those which are not so apparent. The two principal ones, which, indeed, may be said to settle the maximum capacity of the station, are the length and number of platform lines and the lay-out of them and the lines communicating with them. The platform accommodation at any station must depend on the traffic to be dealt with and other local circumstances, but whatever the number of lines, they should be so arranged as to give the maximum inter-communication with a minimum of fouling of the other lines. Any limitation of the amount of platform accommodation available reacts on the train service, both at the stations where

Platform  
Lines.



the platform accommodation is inadequate and at stations greatly distant from that place, owing to its effect upon the train timing.

The difficulty may be minimised by arranging that, as far as possible, an incoming set shall form an outward train at the shortest possible interval after arrival, and that sets which, from force of circumstances, must be starting sets are not brought to the platforms until just sufficient time to meet the convenience of the intending passengers and any luggage or parcels traffic there may be.

A quite important minor point at terminal platforms is the provision of suitable means to enable an engine to get round the carriage set it has worked into the platform in readiness for the next journey. Where the platform lines are in pairs, the usual way is to provide a crossover as near to the buffer stop as possible. The effect of this is to waste approximately 30 yards of each platform. The alternative of a third line for the express purpose of releasing engines would reduce this to very little more than the length of engine and tender, but is a somewhat expensive remedy. In future, we may well hear more of an arrangement which has been adopted at one of the large stations in South America, where a traverser is used to carry an engine from one line to the other, thus limiting the waste of platform to the length of the engine.

It goes without saying that the platforms should be sufficiently wide to cater for both the inward and outward traffic expected to pass over them, and they should, as far as possible, be free from such obstructions as roof-supporting pillars, etc.

The Parcels  
Office.

The position of the parcels office, with its necessary equipment of loading lines, docks, etc., needs careful consideration. The entrance from the street both to the office itself, where the smalls are dealt with, and to the loading lines and docks, must be convenient to road vehicles but clear of the stream of passenger traffic proper. The approach from the platform must be such that the parcels traffic is kept as clear as possible of the streams of passengers and their luggage; while the approach by rail should be such that the necessary working between the loading lines and

the platform lines can be carried on with as little interruption as possible to the working of trains into and out of the station. These three different considerations are often difficult to harmonise. At the terminal station, with the circulating area beyond the buffer stops, a position to one side of the station is generally accepted as the most convenient. In all cases, however, a good deal depends upon such local circumstances as the level of the approaches to the station by road as compared with those by rail, the nature and extent of the different traffics and so on.

The position of the engine shed and carriage standing and cleaning sidings should also be considered in relation to their convenience of access to the various lines in the station and the fouling of the running lines thereto. No general rules can be laid down, but the guiding principle to apply is to make all rail approaches to the station in such a way as will keep the fouling of other approaches to the lowest possible limit.

Engine Shed  
and Carriage  
Sidings.

In addition to what is provided at the shed, water columns, preferably with overhead supply, should be provided in such positions about the station that water may be obtained by engines without their having to make special movements for that purpose.

The size of the carriage sidings will naturally depend upon the extent of cleaning, storing or marshalling required. As a general rule, it is not possible for such sidings to be sufficiently near the platforms to enable additional carriages to be provided expeditiously to meet unexpected demands. Special accommodation for such strengthening stock should be provided as near as possible to the platforms. With bay platforms, a line between each pair of platform lines is ideal. At through platforms, a line adjacent, or nearly adjacent, is equivalent.

The signalling arrangements for both the station itself and the approaches thereto are important. The whole area should be controlled from one signal box so as to save the time otherwise taken in, and possible confusion caused by, consultation between men controlling parts of the area. With the same object, namely, that of saving time, the signals, points, etc., should be power worked and the whole

Station  
Signalling.

of the lines track circuited with connections to an illuminated diagram.

Passenger  
Station  
Working.

At many large stations there is a document, usually in pamphlet form, showing from where, at what time, and at which platform each incoming train will arrive, what happens next to the engine, carriage set and guard respectively, and from what platform and at what time each outgoing train will depart.

The planning of the arrangements shown in this pamphlet, and the adjustments made in the working from hour to hour to meet the constantly changing conditions due to minor or major accidents or other circumstances, represents a much greater proportion of the work included under the heading of station working than is often appreciated.

Nor is it made easier by the fact that of the items we have summarised in this way, viz., engine working, guards' working, carriage working, platform working and station shunting, the first three must necessarily be settled to a large extent by considerations other than those affecting the working of any one station. We shall deal with these three items later.

For our present purpose it will be sufficiently correct to say that, after they are settled, the station-master and his staff must proceed with the allocation of the platforms to the different trains and the shunting arrangements so far as the latter are constant. The chief considerations affecting the platform working are :—

Platform  
Working.

(1) Trains should be booked to and from such platforms as will give a minimum of fouling movements outside the station ;

(2) The occupation of the platforms should be approximately equal so as to minimise the risk of the late running of one train reacting on others ;

(3) Regard should be given to the relative position of trains between which "connections" are made ;

(4) Trains which frequently have extra vehicles (horse boxes, fruit and fish vans, etc.), to attach or detach should be dealt with at platforms most convenient for this purpose ;

(5) At bay platforms the necessity for releasing the engines of arriving trains must be considered ;

(6) Trains for the same destinations should, as far as possible, depart from the same platform.

Where, as they quite often do, these considerations clash, either with each other or with the carriage working, the course which appears to give the balance of advantage must be taken. For the normal working, there is sufficient time for the necessary thought to be given. The adjustments necessary to meet the booking of excursions and other types of additional trains can also be made in advance. The last-minute alterations, which are naturally greatest on the days when most trains are running, demand not only a thorough training, but a high degree of efficiency from the station staff concerned.

The shunting work cannot be prearranged to any- <sup>Shunting.</sup> thing like the same extent as the platform working, but all regular shunting should be. It is the custom at most large stations to employ special shunting engines. At some stations it is more economical to use up what otherwise would be the non-effective time of the train engines, either before or after finishing their train working or in any long interval there may be between their arrival with one train and their departure with the next. The disadvantages of this, which must be taken into account when deciding which method to use, are (a) that a train engine is slower in its movements than a shunting engine; (b) that the drivers do not become so familiar with the work and therefore tend to work more slowly; (c) that when some special occurrence, such as an accident, tends to make trains run late, and it is therefore desirable that any shunting necessary should be done as expeditiously as possible, there is less power than usual to do it; and (d) that working cost of a train engine is higher than that of a shunting engine.

The work involved in dealing with passengers is <sup>Passengers and Luggage.</sup> comparatively simple. Apart from ticket examination and collection, which are dealt with later, all that is necessary is a good supply of clear indicators, and a good deal of tact on the part of the station staff.

Passengers' luggage is rather a bigger problem.

It is really a little difficult to know just what would have happened in regard to luggage at holiday times if someone had not invented the "Advance Luggage" or "Carted Luggage" system. Its advantages both to the passenger and the train working are too obvious to need enlarging upon here. It sometimes involves the employment of some additional staff, but, taken as a whole, the receipts should rather more than cover the extra cost.

The probable alternative which would have been forced upon us in the absence of the "Advance Luggage" system would have been some system of registration on the lines of those in operation on the Continent and in America. The advantage of registration, to the passenger, is that he is relieved from the worry and trouble of looking after it at stations where he and it have to change trains. The disadvantages, from his point of view, are that the luggage must be at the station considerably earlier than is necessary under the British system, and there is usually a longer wait at destination whilst it is taken to the distributing office and handed over to the passengers in exchange for their vouchers. From the operating point of view, the advantages of the registration system are that the luggage, being concentrated at the registration office, can be conveyed to and from the trains in greater bulk; and it can be loaded to greater advantage in the vans; and that it gives greater opportunities for observing excess luggage and collecting the charges on same. Most of these, however, can be obtained to a considerable extent under the British system, if proper arrangements are made for concentrating passengers' luggage at the station entrance and distributing it from there in bulk to its appropriate trains. For this purpose considerable scope exists for the employment of electric barrows or haulers.

The principal methods of collecting tickets are :—

- (1) At a special ticket platform before reaching the destination station ;
- (2) At the last stopping station before the destination of the ticket holder ;
- (3) At a barrier erected at the exit to a platform ;

- (4) At the train's side before departure of the train ;
- (5) In the case of corridor trains, on the train itself as it is travelling.

The considerations to keep in mind when deciding which method to adopt are the efficiency of collection, the cost of collecting staff, the effect on the transit time of the train, and the effect on line occupation. The ideal way from all points of view, except that of staff cost, is to collect on the train, though this is necessarily confined to trains composed of corridor and vestibuled stock.

Collection at the special ticket platform is efficient, but costly for staff, adds time to the train journey, and has an adverse effect on line occupation even though special loops may be provided at the ticket platforms. It was in common use some thirty years ago, but is now almost extinct. The collection at the last stopping station is slightly less expensive in staff, but has the other disadvantages of the special platform. The train-side collection before departure is rather costly in staff and is liable to annoy the passengers, since it necessitates the locking of all the carriage doors once collection is started.

The collection at a barrier leaving the platform is economical in staff, and is efficient, except for detecting passengers out of class ; nor does it lengthen the journey time or adversely affect the line occupation.

The operating advantages are generally considered to outweigh the risk of loss, and at large stations the barrier collection is becoming more and more the standard method, with a check against "out of class" by train-side examination before starting or at the principal intermediate stations. Of course, ticket collection is only rather more than half the story. Frequent examination of tickets is required to insure against longer journeys being taken than have been paid for. A complete barrier examination, which at large stations fits in very well with the platform collection since very few additional staff are required, is the best check against this type of fraud. At small stations, however, the necessary staff to make a complete examination cannot be justified. On this account the check made at the larger stations is

usually supplemented by the employment of travelling inspectors. If the excess such inspectors collect is equivalent to their wages, one may be sure that the moral effect is worth a good deal more.

Parcels  
Traffic.

The work of a parcels office may, in many respects, be compared with the work of a goods station. The essential differences are that there is a higher percentage of "smalls" and that the vehicles into which most of the "goods" have to be loaded are in a position on the train before loading takes place instead of after. The effect of the first difference is to emphasise the importance of the axioms for working at goods stations, viz., handle as few times and carry for as short a distance as possible, whilst the usual effect of the second is to prevent direct loading of smalls between the rail and road vehicle and to lengthen the distance to be carried. The detailed methods to be adopted at any station must depend upon the lay-out of and circumstances prevailing at that station. The combined effect of the two features referred to usually offers considerable scope for the use of mechanical apparatus of the conveyor type or of mechanically propelled barrows or haulers and demountable trays. The principles of loading also follow those for smalls goods traffic, e.g., load in such a way as will result in a minimum number of times to be handled on the journey.

Parcels should, as far as possible, be kept out of the more important trains, and advantage is often obtained by restricting parcels traffic to definite services. For example, on lines where there is a frequent service of slow trains, the first train of each series of three might be booked to convey parcels to one-third of the stations, the second train of the series to another third, and the last to the remaining stations. By this means, the work in the van is simplified, and the parcels work divided fairly equally over the whole of the trains. For long-distance traffic the advantage of such an arrangement is that the allocation of the staff required at the different stations can be made in advance with less risk of waste. The running of special parcels trains requires rather careful consideration. At first sight, the idea of keeping the parcels vans off the ordinary trains seems

very attractive. The extra time taken to attach or detach one or more vans may mean an extra minute or two to the passenger train. If, however, as is frequently the case, the additional vans spread over a number of passenger trains are within the capacity of the engines hauling them, then the employment of an additional engine is somewhat of a luxury, and can only be justified where the interference with the passenger trains would be considerable, or the service given by them would be unsatisfactory.

This must complete our section on passenger station working. The student who is not already familiar with the detailed organisation of the staff at a large passenger station, from the stationmaster to the junior lad porter, should take the necessary steps to become so. All we have space to do here in this connection is to emphasise the importance of allocating the maximum amount of the numerous and various duties in advance. It is true that the considerably varying conditions will necessitate a good deal of adjustment to whatever arrangements are made. Such adjustment, however, represents only a small proportion of the total work. The fact that the remainder is settled in advance enables the supervisory staff to concentrate on adjustments to the original plan rather than the larger task of making the plan whilst the work is actually proceeding.

In certain parts of this country it is customary to describe the covered portion of a goods station as a goods warehouse. Since, however, a warehouse is a place where "wares" are "housed," or, to use more modern English, "goods" are "stored," this use of the term is an unfortunate one. Perhaps the most essential thing about the working of a goods station is that anything that comes into it shall be taken out again as quickly as possible. "Transit shed" or "shed," which are also in fairly common use, are much more appropriate names. It is true that at some large stations warehouses are provided by the railway company, who are willing to act as warehousemen in addition to fulfilling their normal functions as carriers, but that side of the work is rather outside our subject.

The variety, both in kind and size, of traffic

Station Staff  
Organisation.



necessitates a good deal of manual labour: one consignment may be a piano, and the next a bag of nails. This and other conditions existing at most goods stations makes it almost impossible to utilise mechanical devices for the general run of work to any considerable extent. This does not mean that there is no scope for mechanical devices. At many large stations there are fairly regular flows of certain special traffics which render possible the use of some of the numerous mechanical appliances now on the market. Where such appliances can be used in such a way as to reduce the cost or expedite the rate of handling, every advantage should be taken of them. There will, however, always remain a large proportion of traffic which—apart from the use of cranes and, under certain conditions, mechanically propelled barrows—must be manhandled. It is fairly clear, therefore, that the cost of working will depend very largely upon the number of times the different packages are handled and the distance they have to be carried.

Most large sheds are used for two quite distinct and separate functions, namely the forwarding of traffic and the receiving of traffic. The conditions applying generally make it advantageous to use the same accommodation for both functions. To meet present day business conditions, received traffic requires to be unloaded in the early hours of the day, so that it can be delivered early that day; whilst, speaking broadly, forwarded traffic is not ready for forwarding in any appreciable quantities before noon, and mostly later than that time.

On the whole, it is sound to say that the lay-out which is ideal for forwarded traffic is not ideal for received traffic. It would, however, in most cases, be uneconomical to provide separate accommodation for the two, so that the lay-out must eventually be a compromise between the requirements of both traffics. There are cases in which sheds are divided into forwarding and receiving sections, and there are a few cases in which separate sheds are provided for each kind of traffic. It is improbable that the interest on the additional capital cost, and the maintenance cost of the additional building and equipment, will

be counterbalanced by the saving in working cost which may be expected from such specialisation. Such cases, therefore, would appear to indicate that the time has not yet arrived when it is necessary to work such sheds to their maximum capacity, i.e., the receiving side is used effectively for one portion of the day only, and the forwarding side for another; or that traffic is not being dealt with as expeditiously as it might.

Though differing in many details, the larger goods sheds can be divided into two principal types. Design of  
Goods Sheds. In one, the benches or decks—as the raised floors are called—and the roadways, run parallel for the full length of the shed with the lines on which the wagons stand. There does not appear to be a generally accepted name for this type, though it is sometimes known as the longitudinal type. In the other, which is known fairly generally as the gridiron type, the bench is indented to receive a series of lines in pairs, the effect of which is to give a number of short benches parallel to the lines, the main bench and road being at the end of, and at right angles to them.

Let us consider the comparative advantages of these two types. The gridiron type gives a greater average length of carry between the wagon and the ralley in both directions. It is true that this disability can, to some extent, be overcome by the employment of electric barrows. These, however, involve expense both in first cost, power, and maintenance.

The longitudinal type enables a higher portion of ralleys to wagons to stand in position. For received traffic this allows a greater number of gangs to be employed economically, and for forwarded traffic reduces the risk of ralley congestion during the rush periods. This type also lends itself to the provision of standage lines on which wagons can stand for direct loading from ralley as an alternative to loading over a bench—a very considerable advantage.

The chief advantages of the gridiron type are that, assuming the same area of ground is occupied, a greater number of wagons can be placed in position at one time, and that replacements can be made with less interruption of the work in the shed. On the

whole, it will be seen that the balance of advantage appears to rest with the longitudinal type. A good deal, however, depends upon the nature of the traffic and other local conditions, and in most cases the site available has probably been the deciding factor when the decision to build either type was made.

Let us now consider briefly certain points common to both types of shed :—

*Benches or Decks* : The calculation of the ideal width for the benches of any station is a matter demanding considerable judgment. If too narrow, congestion and consequent delay is caused. If too wide, not only is valuable space wasted, but the length which packages must be carried is increased. Theoretically, for received traffic, all that is necessary is a bench sufficiently wide to handle conveniently the goods as they come out of the wagon, with a barrow-way for two loaded barrows to pass, and a small space to allow room for transferring goods from barrows to rulleys without blocking the barrow-way. The width necessary for this, however, would not be sufficient for forwarded traffic, a certain proportion of which must be placed on the bench until a decision can be made as to the point at which it shall be loaded. The actual width of at least part of the benches, therefore, will normally be settled by the forwarding requirements. Even at stations, where, when first designed and brought into use, there is sufficient accommodation to allow forwarded and received traffic to be dealt with in separate sections or sheds, it is probably sound to settle the width of all benches on this basis, in anticipation of the time when it will be necessary to get full use out of the accommodation.

*Roadways* : The general tendency is to make all shed roadways too narrow. They should always be wide enough for a rulleys to work end on at any adjacent bench or wagon, and leave room for passing vehicles between. Where this width of road is quite impossible, and there is more than one road through the shed, it is generally possible to do something to assist by regulating the traffic so that one or more roads are used in one direction only, and others in the reverse. This, however, has some disadvantages.

One is that it necessitates the rulleys passing over the lines leading to the shed, with consequent risk of accident, which risk, in many places, is so considerable that it is considered necessary to station men to warn crossing vehicles, and another that it forces all rulleys to cover the full circuit though they may have disposed of their loads at some point quite near to the beginning of it.

*Standage Lines*: These are the lines on which wagons can stand for loading or unloading direct from rulleys, without the traffic being carried over a bench. Such lines should invariably be used for full wagon load traffic, both received and forwarded, even though the traffic is of such a nature that it is necessary to handle it under cover.

Received smalls traffic cannot, as a rule, be conveniently loaded direct, but must pass over a bench to enable the necessary sorting to be done, but a large proportion of the forwarded smalls traffic can be. It is possible by experience, or by compilation and examination of records of traffic passing to different destinations over a fair period, to decide in advance the majority of the destinations to which wagons of smalls will be loaded each day. A brief consideration of the conditions under which such traffic is handled if dealt with over a bench, as compared with direct from rulleys, is bound to lead to the conclusion that direct loading is distinctly the more economical method.

*Rulleys Park*: A rulleys park is a paved space of suitable dimensions—preferably covered—in which loaded rulleys may stand whilst waiting their turn to be dealt with, clear of the roads leading to the shed or yard. To get the maximum value out of the heavy capital expenditure of providing a large goods station, and to deal efficiently with traffic up to its maximum capacity, it is necessary to work for twenty-four hours each day. There are not many traders who are prepared to receive from or deliver to a railway company for more than eight hours, and frequently much less. From this it follows that at certain parts of the day the delivery or collection must be at a much faster rate than the loading or unloading. There will, therefore, be an accumulation of loaded rulleys

waiting delivery to the trader in the morning, and an accumulation of loaded rulleys waiting to be dealt with in the late afternoon. The rullely park is the reservoir which receives these irregular streams of traffic, and enables them to be regulated to meet the requirements of the trader or shed respectively. It is true that the private rulleys still continue to come direct to the shed, but the railway rulleys as a rule form such a proportion of the total offering that the relief afforded by the regulation of the latter is very substantial.

Goods Station  
Yards.

The design of the goods station yard is usually dependent upon the shape of the available site. The yard is used for the loading and unloading of full wagon loads of traffic which do not require to be dealt with under cover.

The normal lay-out, which is quite simple and efficient, is to have a series of pairs of standage lines with reasonably wide roadways between them. If the land available allows of reasonably long standage lines, some economy of staff can be made as compared with those required if the lines are shorter, but their number proportionately greater. The roads between the standage lines should be sufficiently wide to allow of the free passage of a road vehicle whilst rulleys are standing at two opposite wagons, and the lighting arrangements should, if possible, be suspended in such a way as to prevent the posts carrying them obstructing the roadways. Near the entrance, a cart weighing machine is necessary, and if the building forming the weigh office is not sufficiently near the standage sidings, a further building for the checkers and other yard staff should be at a central point near the end of such sidings.

Cranes.

The different types of crane available for use at a goods station—whether inside the shed or outside in the yard—may be classified as (1) fixed cranes; (2) overhead cranes; (3) travelling cranes on rails; and (4) travelling cranes on roads. Considered broadly—for there may always be special circumstances at a particular place to justify a type generally unsuitable being provided—the operating considerations in reference to each type are as follows:—

*Fixed Cranes:* The space occupied on the benches

or roadways, and the very limited area which a fixed crane will serve, make them generally unsuitable. The possible exception is the station at which there are only occasional heavy lifts. In such a case, the cost of the mechanical power required to bring the wagon to the crane may not be equal to the interest and maintenance and working cost of an improved type of crane. In the shed, the constant interruption of work which would be caused by placing the appropriate wagon under the plumb of the lifting hook necessitates a whole series of cranes being provided, thus making very serious inroads into the bench space. Whether inside or outside the shed, additional mechanical power is required to place the wagons in position.

*Overhead Cranes:* At points where there is sufficient lifting work to justify the additional expense of erecting, this type of crane is undoubtedly the most useful, both for inside and for outside work. In the shed, such cranes should normally cover the widest possible span, consistent with reasonable construction costs and the possibility of frequently requiring two or more journeys in conflicting directions at the same time.

The principal scope for the employment of crane power in the shed is usually for the purpose of transferring goods from bench to bench for reloading purposes, or goods which for any reason must wait orders, to the appropriate storage point. It is a considerable advantage if the latter can be stored at some place away from the ordinary receiving and/or forwarding benches, these being kept free for their normal uses. In this way the congestion which an increase in the amount of stored traffic otherwise would be liable to cause is prevented, the risk of the goods being despatched in error is minimised, whilst the eventual delivery of the goods does not interfere with the normal bench working. At stations where the nature of the traffic is such that the packages are small, trays on which loads of traffic for the cranes to lift can be accommodated are an advantage. Inside the shed overhead cranes should be considered from the point of view of their potentialities as savers of man power rather than as mechanical means of lifting packages

too heavy to lift by man power, though they are required to some extent in the latter capacity.

In the yard, the position is rather different. The traffic is loaded direct from wagon to rullely or vice versa at the wagon side, and much of it is not suitable for handling by crane at all. The cost of providing an overhead crane to cover even a considerable portion of a yard could not, therefore, be justified. Generally speaking, an overhead crane of considerable lifting capacity arranged to cover a short length of siding, the length varying according to the number of heavy lifts to be dealt with, is sufficient to meet requirements. The site chosen should be one which gives good access to the public street, so that the special road vehicles required for articles of exceptional weight or bulk may manoeuvre freely. It is a distinct advantage if, within the span of the crane, there is sufficient ground on which to unload articles of which prompt delivery is not taken, thus releasing the wagons, usually of the special type.

**Travelling  
Cranes.**

The travelling crane on rails has the advantage over the fixed type in that it can, within the limits of its rails, travel to the wagons at which it is required to work, instead of each wagon having to be specially placed within its reach. Its disadvantages are that the rails on which it travels occupy space which would otherwise be available for other purposes, and that the necessity for a special track limits the extent to which it can be used. Both these disabilities are overcome by the use of road cranes.

In the last few years, most of the large manufacturers have put on the market electric, or petrol-electric, road cranes, usually to lift up to about 30 cwt., which will travel over any ordinary road and lift from the far side of a wagon to a rullely or vice versa. Such cranes may be regarded primarily as labour-saving machines rather than machines for lifting weights which cannot be handled by man power. Their use is extending rapidly, but there is still considerable scope for extended use. The principal check to the more rapid extension is the difficulty of getting sufficiently continuous service out of them to give the necessary return on capital expenditure, after deducting the maintenance and working costs.

A full discussion of the detailed operations of a Goods Station Working. goods station would in itself fill a large volume. It will be sufficient for our purposes, however, to mention and discuss briefly some of the principal considerations underlying it. The importance of the allocation of the bench space and standage lines in the shed is chiefly due to considerations outside the goods station. If the interest of the goods station staff could be said to have ceased when the goods passed out of the shed door, then all that would be necessary would be to divide the available space evenly over the total amount of traffic to be dealt with—keeping the traffic for the same destination to approximately the same position from day to day, so that all concerned would become familiar with the location of the wagons for particular destinations. Such, however, is not the case. The staff at the goods station must do all they can to ensure that the traffic handed to them is delivered at its destination at the earliest possible time. The most important factor, therefore, affecting the allocation of the bench and standage lines for forwarded traffic is the need for arranging the loading of the wagons in such a way as will enable them to be despatched either as complete train loads or as sections of other trains, with a minimum of shunting. In this way the cost of shunting is avoided, and the traffic ready for despatch on its journey at the earliest possible time.

The considerations are naturally quite different in connection with received traffic. Here the wagons should be placed into the shed as they arrive. The allocation of the bench space is largely settled by considerations outside the shed, since it must to some extent be arranged to suit the rulleys delivering the traffic. In some cases, however, shed considerations enter into the question. If the number of rulley sections can be duplicated or triplicated, the average length of wheel from the wagon to the rulley is reduced by half or two-thirds, as the case may be. If, therefore, duplication is possible by some extension of the size of the rulley areas, the question of the balance of advantage as between the rulley working and the shed working becomes one requiring very careful consideration. Advantage can sometimes be gained by



duplicating only heavier sections, and placing the lighter ones between the two series, so that they may be common to both. Whatever arrangement is decided upon, both for forwarded and received traffic, it is important that clear indicator boards should be hung in prominent positions at frequent intervals, so that even a stranger may, without difficulty, know where to go without having to make special inquiry. It is recognised that both the railway staff and private carters who regularly use the goods station will quickly become familiar with the arrangements, but there is always a certain proportion of new comers both to the railway staff and from outside, to whom such indicators will be of value. For both traffics, also, it is important to remember that it is much cheaper to load direct from rullely to wagon or vice versa than across a bench.

Organisation  
of Labour,

The principal operating cost at goods stations is that represented by the wages paid to the manual labour employed. This being the case, the organisation of the labour is worth a little thought. Considered as a whole, the principal problem is the balancing of the requirements of the forwarded and received traffics so that both traffics may be handled promptly without any waste. At most sheds the proportions of the two traffics fluctuate from day to day, and any system based on the change-over from one sort of traffic to the other of a certain number of men at certain fixed times is almost bound to be wasteful.

The second phase of the question relates to the composition of the individual gangs. The requirements of a particular class of work may vary from a gang consisting of a single checker who does his own loading or unloading work, to one consisting of a checker, a loader, and a number of porters, sometimes reaching as many as five or six. Between these two, there is room for considerable variation, depending upon the nature of the work, the weight of the traffic to be handled, and the distance it has to be carried. The principle to keep in mind is that any gang must be balanced: that is to say, the strength of the different types of unit forming the gang should be such that all are fully employed. In many sheds the tendency is to regard a certain composition of gang

as the standard, and to employ a gang of this size on all work. This may be convenient in so far as it makes it easier to transfer men from one sort of work to another, but it is liable to be distinctly wasteful.

The traffic dealt with at a goods station can conveniently be classified under two heads—consignments of sufficient size and weight to be loaded in a separate wagon, that is wagon-load traffic, and those which are not of sufficient size and weight, that is less-than-wagon-load traffic, commonly known as "smalls." A certain proportion of less-than-wagon-load traffic can be combined with other traffic for the same destination and loaded direct. The balance must be treated differently, since it is obvious that there must be a minimum in weight or bulk to justify the provision of a wagon and the cost of hauling it to destination. Such goods must be sent to some intermediate point, and are called tranships.

In certain cases, tranships are dealt with at special tranship sheds, but the advantage of making a large town goods station into the tranship station for an area is such that, in practice, this is nearly always done. By combining the originating traffic with the tranship traffic, it is possible to load many more direct wagons than would otherwise be the case, and thus the two traffics mutually help to improve the service of both. Against this advantage must be weighed the disadvantage that the cost of handling tranships at a town goods station is rather higher than at a station specially designed for tranship work.

We have said that there must be some minimum to justify the provision of a wagon. The question of what that minimum shall be is a very burning one. Some companies say two tons, others one ton, and in both cases certain exceptions are made. The average tare weight of the normal type of goods wagon may be taken as about six tons, so that, whatever load the wagon may have, the engine has six tons of non-paying weight to haul in addition to the contents of the wagon, and in many cases for double the distance. The question is, what is a fair minimum proportion of paying weight to expect? A proportion of two tons paying weight to six tons non-paying weight certainly does not appear to be unreasonable.

Tranships.

The Minimum  
Wagon Load.

If each case could be settled on its merits, the purely operating considerations would be the comparative cost of the provision and hauling of the wagon or wagons and the cost of an additional handling of the traffic in a shed. All these, however, would be liable to vary from day to day, and could not even be estimated before the event. Nor, of course, would it be practicable to treat each case on its merits. Some general rule must be laid down. Like many other matters connected with railway operating, it has not yet been found possible to arrive at any scientific method of settling what the minimum load shall be, and, up to now, it is expediency, rather than principle, which has settled it.

An Outline of  
a Tranship  
System.

Whatever minimum is adopted, we shall always have some tranships left, and we must, therefore, consider how to deal with them. The principle on which our instructions must be based is to make an arrangement in such a way as will give the quickest delivery with the fewest handlings. We may, therefore, say that a company with a well arranged tranship scheme can afford to insist on a higher minimum wagon load than a company with a badly arranged one, because the better transit in the former case will make less urgent the need for direct loading.

The first step necessary is to select certain stations as tranship centres, and define the boundaries of the tranship areas, or zones, as they are sometimes called, round those centres. In defining these boundaries, regard must be paid to the service from the tranship station to the stations within its area, and the almost invariable rule should be that there is a daily direct service from the tranship station to every station in the area, either by through wagon or road van. In many cases other stations within the tranship areas are selected and ear-marked as subsidiary tranship stations. If the condition laid down in regard to service from the tranship station is fulfilled, there does not at first sight appear to be much necessity for such an arrangement. The advantage lies in the fact that they increase the possibility of direct loading to and from the smaller towns in the area.

Whilst the detailed instructions will vary somewhat according to local circumstances, the following

guiding rules for the loading of smalls may be laid down, to be followed in the order given. (1) Combine with other smalls for the same destination and load a direct wagon. (2) Load in a road wagon which will give either a direct or connecting service to destination. (3) Load to the main tranship station of the zone in which the destination station is situated, unless equal service can be given by loading to a subsidiary tranship station in the zone with traffic for that subsidiary station. (4) Combine the traffic to two or more zones and load to the most convenient tranship station in one of the zones.

It may be assumed that by transhipment the journey time will be extended by a day. When, therefore, there is a reasonable prospect of loading direct by holding the traffic for a day at the departure station it is sound to do so. When alternative methods of loading are available, an important point to remember is that it is normally advantageous to get the majority of the journey over during the first night, after the traffic has been loaded if the train service will give an arrival at the tranship point which will enable the wagon to be dealt with there during the following day.

Obviously there is a limit to which goods can be Road Wagons. combined with others for some intermediate destination. The final stage of the journey is then taken in what are called road wagons. A road wagon normally conveys traffic to or from all the stations between two junctions. Instead of the road wagon being permanently detached from the train conveying it, the goods are taken out or put in either whilst the train is standing at the platform or at some other convenient time. The arrangement is not a good one. The few extra minutes occupied in handling the road goods will often result in the train "missing its margin," the ultimate extra cost of the engine and train crew amounting to more than the whole charges on the goods concerned. Many alternative schemes have been considered, but none has been so successful as to replace the road wagon system. Experiments in the direction of working the road wagon direct to the largest or most conveniently situated station of the group it serves and distributing the contents from

there by road, either to the actual destination of the goods, or, where this is too much out of the way, to the destination station, have been sufficiently successful to warrant further investigation.

**Journey Time  
Slips.**

Whatever instructions as to the working of transships are issued, it is desirable that they should be tested from time to time so as to discover whether changing circumstances have made revision necessary or desirable.

One way to discover weaknesses is to wait for complaints of delay in transit, but this is a little like locking the stable door after the steed has been stolen. Another way is to make periodical examinations of large batches of invoices, but this is laborious, and leaves out a good deal of desirable information. Perhaps the most efficient, and at the same time easiest, method, is by use of what are called "journey time slips." A journey time slip may be described as a tie-on label, printed and ruled in such a way as to facilitate a history of the journey of the package being entered upon it. As the package proceeds on its journey, each member of the staff through whose hands it passes makes the appropriate entry. The receiving station, having completed the slip, removes it from the package and forwards it to the collecting point to enable the particulars of the different journeys to be tabulated and a summary prepared.

**Goods Station  
Supervision.**

It will have been gathered from what has been said on the subject that the success or otherwise of a goods station depends upon careful attention to a considerable number of different details, and it follows from this that effective supervision and detailed organisation are essential to get the best results.

Some reference must be made to the statistics necessary to enable one to judge whether the work is carried on as efficiently as it might be. The first question to settle is what unit of work shall be taken. The alternatives are wagon loads, or tons: neither is perfect: one wagon load may be, say, a 12-ton wagon with twelve tons of flour, and another a small wagon full of returned empty cases. Whilst it may be argued that, since in the long run similar average types of wagons will, on the whole, pass through the same station, a figure based on wagons will be sufficiently

accurate for comparison with the work of the same station in a different period, such figure would not be of much value for the daily check which is essential. The tonnage figure has many similar drawbacks, but, on the whole, is more reliable than the wagon, and is the best figure that can easily be obtained.

It is desirable that the work performed by each gang, expressed in tons per gang or per porter hour, should be available, and, where the station is divided into sections under different foremen, the work per gang or man hour in the different sections should be obtained. Sometimes the figure of cost expressed in pence per ton handled is used, but, since this fluctuates with changes in the rates of pay, it is not such a useful figure for comparative purposes. Figures to indicate the work waiting to be done, as distinct from those showing how the work has been done, are also necessary. Normally, very little definite information can be obtained in regard to the forwarded traffic. The carting staff can form some idea from their orders for carting, and large firms who regularly use the station should be encouraged to give early advice when the traffic is expected to be substantially greater or less than normal. On the received side, however, the number of wagons on hand waiting unloading will give a fairly accurate idea of the work waiting to be done. This figure should be available at frequent intervals throughout the day, the actual times depending upon the circumstances prevailing at the particular station.

The so-called control system, as applied to goods stations, is really—apart from the more efficient supervision of the rulle working which the system of reporting gives—very little more than the provision and recording of the essential statistics to enable the supervisors to see how the work is progressing.

## CHAPTER III

### MARSHALLING YARDS

WE have seen that one of the chief functions of a goods station is to convert consignments into what we may call the first travelling unit—the wagon load. We must now consider how this first unit is converted into a second—the train load. This work of sorting and combining wagon loads into train loads is done in marshalling yards.

Ignoring for the moment the question of cost, the test of efficiency at a marshalling yard is the rate at which wagons can be sorted into and worked out of it. Any tendency to use it as a storage yard is certain to react unfavourably, not only on the work at that yard but in many other ways.

It will be remembered that when considering the rules to be followed with less-than-wagon-load consignments, the first rule was to combine a number of small consignments for the same destination and make a through wagon for that destination. It may also be remembered that the reason for this was two-fold, namely, that the time that would otherwise be spent, and the cost of handling, at the tranship station would be saved. If we substitute the wagon for the consignment and the possible intermediate marshalling yard for the tranship station, our rule applies in a similar way.

Indeed, the similarity between the rules which should guide the treatment of less-than-wagon-load consignments at goods stations, and wagons in marshalling yards, are so similar that the student is recommended to work out the latter by a comparison with the former.

The location of the different marshalling yards of any railway system is a matter of some importance. Theoretically, the most important feature is their arrangement in relation to each other. In practice, however, local considerations have usually to be given

Location of  
Marshalling  
Yards.

precedence, the whole line position having a greater influence upon the relative importance, than upon the relative positions, of the different yards. Each extra stage results in an extended journey time both to the wagon and the traffic in it, as well as the cost of an additional handling.

Under present-day British conditions, each town of any size must have its marshalling yard so as to make through working possible for, at any rate, a portion of its traffic. In so far as wagons from other yards which must be staged are sent to that yard, the chances of a higher proportion of through working are increased. In other words, the case against the purely intermediate marshalling yard is the same as that against the purely tranship station. There may be special cases where either is justified, but they will be the exception rather than the rule.

When the general directions of the flow of traffic leave a choice, the considerations affecting such choice are the gradients and the density of the traffic already passing on the lines connecting the respective yards and the desirability of train runs occupying such time as shall just fill the standard hours of the train men.

The requirements of a marshalling yard may be briefly summarised as follows :—

Requirements  
of Marshalling  
Yards.

*Reception Sidings* : These are sidings upon which the loads of incoming trains may stand clear of the running lines, whilst waiting their turn to be dealt with. For terminating trains such sidings give an additional advantage in that they enable the engine to be released immediately on arrival. The number of reception sidings required will depend upon the maximum rate at which trains may be expected to arrive faster than they can be sorted in the yard. Their position depends upon the type of yard. With a flat yard, the reception sidings are better alongside the sorting sidings : with a gravitation yard, they are better in tandem with them.

*Sorting Sidings* : These are the lines into which the wagons for the different destinations are sorted. Their number depends almost entirely upon the number of destinations to which through trains can be accumulated, and the extent to which it is desirable that such trains should be marshalled in section order.



If there is very much of this sectioning it is sometimes better to do it in a subsidiary yard, usually called second-sorting sidings. The transference to such subsidiary yard must, however, take up additional time, and under British conditions it is usually better to do any second sorting at the outgoing end of the sorting sidings, lengthening the sidings a little to enable this to be done. Normally the length of the sorting sidings will depend upon the lengths of the trains which engines of the classes available can haul from them, plus a small margin for safety. The gradients should so be arranged as to encourage the wagons to run quickly over the first portion and then gradually come to a stand. The layout of the points leading from the shunting neck to the sidings should be such as will enable a wagon to clear a following one in a minimum of time, and, especially in hump yards where the rate of propelling over the hump must be governed by the longest clearance time, as will make all clearance times as equal as possible. The levers for working the points should be grouped for convenience of working, and there is scope for the extension of the arrangement, already applied in some modern yards, of concentrating the whole of them at some central point and working by power.

*Shunting Neck* : This is a line leading to sorting sidings on which the actual shunting of the train may be done clear of any running lines. Where the reception lines are tandem to the sorting sidings, these, and a short connecting line between them and the sorting sidings, serve as shunting necks.

*Departure Sidings* : These may be described as reception sidings for departing trains. They are rarely necessary, since it is usually found possible for trains to depart sufficiently soon after they are ready to make their use unnecessary. It may, indeed, be said that conditions indicating the need for the provision of such sidings also indicate the desirability for an inquiry into the methods of working, with a view to eliminating the delay to traffic and wagons which would be represented by the time trains spent after they were ready to leave for their destinations.

Other features which must be mentioned, but which we have not space to enlarge upon, are the provision

of van sidings, facilities for coaling, watering, and turning engines, and office and mess-room accommodation, the former fitted with telephones giving communication with the different parts of the yard, the signal boxes in the vicinity, and the other yards in conjunction with which they work. At large yards, facilities should also be provided for watering, feeding or transshipping cattle, and for rectifying displaced loads or transshipping loads of wagons which have developed defects in transit. Lastly, though by no means of least importance, mention must be made of the need for good artificial lighting.

Marshalling yards can be divided into two general types—flat and gravitation yards. Considering flat yards first: these can be sub-divided into dead-ended and double-ended yards. Where the ground available admits, the latter is much to be preferred, since it enables shunting or other operations to proceed simultaneously at both ends, thus doubling the rate at which wagons can be shunted into and worked out of the yard. It also reduces the risk of wagons for the same destination being despatched out of turn.

Gravitation yards can be subdivided into three types: those in which the whole operation of shunting is done by gravity; those in which the shunting is done by gravity assisted by some form of engine power, either applied directly or through a "pole"; and the hump type, in which the wagons are propelled up one side of a hump, to run by gravity down the other into the appropriate sidings. It would not be economical to construct a purely gravitation yard, except at a place where the natural gradients lend themselves to this. Quite apart from the cost of making an artificial bank, the additional cost of hauling or propelling the wagons up to the high level from the normal level of the railway would be at least as much as the cost of propelling over a hump. The gravitation yards save power, in so far as no power is required to start the wagons, but they are a little uncertain in their action, because the rate at which the wagons will run depends on weather conditions; the different type of axle box with which the wagons are fitted; the weight of the loads of the wagons, etc. It was probably this difficulty which led to the adop-

Types of  
Marshalling  
Yards.

tion of yards called poleing yards, where the wagons are given a start by means of an engine. Tests held in America have shown, however, that even when an engine is employed in this way, the gravity yard does not work so quickly as a hump yard, though a less powerful engine can be used.

The hump yard, admitting, as it does, of a steeper fall because of the shorter distance, and greater control, enables shunting to be carried on more quickly. Even in hump yards, however, adverse wind and frosty weather are very liable to reduce the working speed. This can be counteracted to some extent by the provision of a second hump with a steeper fall, for use when weather conditions would otherwise have a retarding effect on the wagons.

According to some figures made in an American test, mentioned by Dewsnup, the hump yard will deal with wagons at four times the rate of a flat yard, the poleing yard at rather less than twice the rate, and the gravity yard at one and three quarter times the rate. No details, are, however, given of the conditions under which the tests were made. The ratio of four to one for the hump as compared with the flat yard is hardly confirmed by British practice. Many hump yards have difficulty in dealing with an average of 100 wagons per hour, whilst many flat yards can deal with rather over 50. We must, moreover, remember that the hump yards are, on the whole, up-to-date yards, with the point levers concentrated and often worked by power. The flat yards are often old-fashioned, with the points worked by hand levers. On the other hand, the hump yards are usually larger, i.e., have a greater number of sorting sidings. Probably a ratio of three to one in favour of the hump yard more nearly represents the position under comparative conditions in Britain. To achieve this superiority of speed, the hump yard requires a bigger staff, usually at least double. This is a serious handicap to the hump yard in these days of high wages, and it is not surprising that efforts are being made to introduce mechanical means of braking wagons to replace the brakemen at present employed. Perhaps the best known apparatus of the kind is the Frolich rail brake, an ingenious contrivance so arranged as to apply a

hydraulic rim brake with a force which can be varied according to the weight of the wagon passing over it. The essential weakness of this appliance is that a man is required to work it, with the result that it can only be applied economically on the common line leading from the top of the hump to the sorting sidings. Since the speed at which wagons can be propelled over the hump depends upon the rate at which they run clear of this line into the sorting sidings, a check made whilst the wagons are still upon it must reduce the working speed. Experiments are now being made with electrically-controlled skids, or brake shoes, applied in the sidings, which, if successful, would appear to go a long way towards overcoming this disability.

From what has been said, it will be clear that at yards where there is a sufficient flow of traffic to keep the staff constantly employed the superior rate of shunting makes the provision of the hump desirable. Where, however, the flow of traffic is intermittent, the choice of type requires careful consideration. In some cases the increased labour cost in the hump yard is at least counterbalanced by the advantage of quicker handling, and consequent earlier departure, thus made possible.

A detailed analysis of the work done in a hump yard is both interesting and instructive. Figures for a number of yards indicate that something less—often considerably less—than 50 per cent. of the total engine time used is spent in actually propelling loads over the hump. To this may be added 10 per cent. for running round loads on the reception lines preparatory to pushing them over. The remainder, though not waste in the ordinary sense of the word, is non-effective so far as the business of getting on with sorting wagons is concerned. Pushing down roads occupied about 15 per cent., locomotive duties rather less than 10 per cent. (most of this could be saved if electric locomotives were used), something under 5 per cent. rectifying wrong shunts, and the balance is due to miscellaneous causes, such as waiting traffic, providing under-runner wagons, guards vans, and so on.

## CHAPTER IV

### ROLLING STOCK

Design of  
Vehicles.

THE very considerable differences in the design of coaching and freight rolling stock do not prevent the principles underlying the design and the methods of control being sufficiently similar to make it advantageous to consider them together. Dealing with design, we may say that the first, though by no means the most important, consideration is cheapness of construction, including, within this term, first cost, length of life, and cost of maintenance. These three points must be considered together. It would obviously be the reverse of cheap to save money in first cost of construction only to spend a greater sum in replacement or maintenance. To any cost of repairing must be added the cost of specially separating the damaged vehicle and working it to the repair point and the inconvenience caused to other traffic during this process; also the costs of any further damage which may arise as a result of one vehicle developing a flaw in transit.

The next consideration is the tare weight of the vehicle in proportion to its capacity. If we say that for every passenger carried a railway company hauls on an average 1 ton, and for every ton of goods traffic 2 tons, of vehicle, we are probably understating the case, but we are at least putting it sufficiently high to emphasise the importance of this consideration. The point is of greater importance in relation to goods than to passenger vehicles. In the latter the saving would in many cases be confined to the saving of coal, etc., on the engine. This is by no means inconsiderable, but is rather overshadowed by the much greater potential savings on the goods side. Here, in addition to the saving on the engine, saving in train mileage, leading, in turn, to improved service both to traffic and wagon, which again would give a quicker turn round to the vehicles, could be expected

in nearly—though not quite—the ratio of the reduction in the tare weight.

Perhaps the most definite step in the direction of reduction on the passenger vehicle recently has been the development of the articulated principle, whereby one bogie is made to carry a portion of the weight of two vehicles. On the goods side something has been done by the substitution of steel for wood in the construction of both the underframe and the body. Whether we have reached the limit is a question for the mechanical engineer, but it cannot be too strongly emphasised that even a considerable increase in cost of construction could be justified if it gave an appreciable reduction in tare weight.

Capacity, in the case of passenger vehicles naturally refers to the amount of seating accommodation, but with goods vehicles capacity can be measured in at least two ways, viz., in relation to the weight and in relation to the bulk of the load a vehicle can carry. The bulk capacity depends more on length than anything else, because of the gauge restrictions in regard to width and height. It may, therefore, be said that the two considerations of weight and bulk capacity rather counteract upon each other, because the longer the wagon the more difficult it is to give a high weight capacity without increasing the tare. The final result, therefore, must be a compromise between these two, and, theoretically, should be largely settled by the nature of the traffic requiring to be handled, e.g., if, on the whole, traffic is light and bulky, then low weight capacity with large bulk capacity is the desired feature, and vice versa.

In practice, however, British railway companies, at their present size, have to handle all sorts of traffic on the different parts of their systems, and, apart from exceptional cases, the convenience of having wagons which can be used for all sorts of traffic outweigh any advantage which might be derived from building separate types for the heavy and light traffics respectively. This is even more the case since common user of wagons between the different companies, which will be referred to later, was introduced.

Indeed, we may say that the most important consideration of all is that the design shall be such that

the vehicles are suitable for as many different kinds of traffic as possible. The reduction in the number of types made possible by this means will ensure a greater chance of loading in both directions, and thus reduce the total number of vehicles required.

The case for  
Special Types  
of Vehicle.

There are, of course, cases in which the advantages of specially designed vehicles to meet the need of special traffics can be justified if the special traffic may be relied upon to pass in sufficiently regular quantities to keep the special vehicles in constant use. If, for example, either ten wagons of a common type with a total tare weight of 60 tons, or one wagon of special type with a tare of 18 tons, will carry a given load from A to B, and, on the return journey, traffic is offering which could be carried on either the ten common wagons or the special wagon plus five common wagons, and that to obtain their next load these five common wagons had to return to B, then we must compare  $60+60$ , a total of 120 tons tare in the first case, with  $18+18+30+30$ , a total of 96 tons tare in the other. In this example the case for the special type of vehicles is clearly established. With a considerably less margin of advantage, the lack of mobility of the special type when owing to trade depression in the particular trade for which it was provided, its usual load may not be available for it, and the extra shunting which any special type necessitates, would probably be sufficient to deter us.

Standardisa-  
tion.

Space does not permit of any discussion on the advantages and disadvantages of the different types of vehicles from the point of view of their convenience for loading or unloading, or even for us to enumerate and compare the different types of vehicles. We must, however, make reference to the efforts that are being made in the direction of standardisation of design by the Railway Clearing House, as representing the whole of the British companies. In these days it is hardly necessary to emphasise the advantages of standardisation in cheapening construction and maintenance. It is, perhaps, more necessary to point out its danger in the direction of tending to delay the introduction of new and improved designs once a standard design has been agreed upon. It is not suggested that this is sufficient to outweigh the

advantages, which, indeed, are many, but it is important that steps should be taken to guard against it.

It has already been agreed that the standard capacity of both the open and covered goods wagon shall be 12 tons, and a common standard underframe of the following dimensions, and suitable for both types of wagon, has been agreed to. Length (outside), 17 ft. 6 in. ; width (outside), 8 ft. 6 in. ; wheelbase, 9 ft. Subject to slight variations in detail, the principal dimensions of wagon bodies to fit these frames have been agreed upon, and there can be little doubt that wagons of such dimensions are a considerable improvement upon those—still in general circulation—which were built before these standards were suggested.

Incidentally, we may remark that the fixing of the standard capacity at 12 tons seems to indicate fairly definitely that British conditions do not allow of economical use being made of goods wagons of such high capacity as are used in America and other places where traffic conditions are quite different.

The term "Control," as applied to the rolling stock usually regarded as belonging to the traffic department—i.e., the vehicles used for carrying as distinct from those used for hauling traffic, is frequently applied either to the work of distributing the vehicles the supervision of such distribution, or to a combination of both these functions. To prevent misunderstanding we will use the term in its fullest meaning.

Rolling Stock  
Control.

The total number of vehicles owned by British railway companies is well over one million. We shall be well within the mark if we say the capital value of these is over £200,000,000. If, therefore, by more effective methods of distribution and working even a very small percentage of reduction in the total number required can be made, the saving in capital will be very considerable. Nor will any loss due to inefficient control be confined to the unnecessary expenditure on the provision and maintenance of a large number of vehicles. Additional vehicles necessitate additional siding accommodation upon which to stand them. Moreover, although, in theory, under certain favourable circumstances, an increase in the total number of vehicles



should result in a decrease in empty vehicle mileage, in practice it is very liable to increase it. To the possible loss from such causes as these must be added that arising from the loss of traffic if vehicles are not at the point required at the time required for loading.

At first sight it would appear that the effect of an increased number of vehicles should be to reduce the amount of empty mileage necessary to meet a given demand at the loading points. This is true in cases in which, within a reasonable period, the number of loaded journeys in both directions between any two points or districts balances, because the possibility of holding a surplus at both ends may postpone the necessity for transferring empties sufficiently long for the movement of loaded wagons to make it unnecessary. Such conditions, however, rarely exist. In the much more frequent cases in which there is not a balance of loaded traffic, the effect of a larger supply of vehicles than is really essential is merely to postpone the empty movement. This may occasionally enable a certain amount of train mileage to be saved, since it gives a greater choice of time for moving the empty vehicles.

Speaking generally, however, any advantage which may be obtained in the two directions indicated will be very much more than counterbalanced by the additional cost of providing and storing the additional vehicles. These considerations, therefore, only become of practical value when, owing to the demand being below normal, there is a surplus of vehicles. They should then be taken into account when deciding the points at which the surplus vehicles shall be held.

We may say then that the object of any system of control is to ensure that the traffic offered is carried in a minimum number of vehicles.

We have still, however, to settle what is perhaps the most difficult problem of all in connection with the supply of vehicles. Upon what basis shall the total number of each of the different classes be fixed? The demand naturally varies at different times of the year, and although the demands of the different seasonal trades do, to some extent, counteract upon each other, there are certain periods of the year when

—with fair regularity—the demand figure reaches its peak. What is a railway company to do? Is it to have such a number of vehicles that on the day when the demand is heaviest it shall be met in full, or shall it be able to meet its average demand, or somewhere between these figures? If it is sound to meet the maximum demand, then, theoretically, a certain vehicle or number of vehicles representing the difference between the maximum and the next lowest demand will only work one loaded trip per year, or even longer if one or two years of bad trade come. It may be argued that unless there is a very wide difference between the normal and the maximum demand, the effect of the surplus is only to reduce slightly the average use of each vehicle, and ought, therefore, to be put up with. Usually, however, the margin is too great and the very wide difference between the lowest and highest demand such that it would not be sound business to provide for the highest.

The usual practice, therefore, is to provide for well above the average demand, and endeavour to ease the position about the times of maximum demand by:—  
 (1) Expediting repairs, and postponing the repair of minor damages; (2) incurring additional train mileage by running special trains with small loads of empty vehicles; (3) hiring either from other companies or from private owners; (4) making special efforts for quicker release of vehicles which are unloaded by the company, and urging traders to do the same; (5) using types of vehicles which are not normally considered suitable for the traffics which are causing the heavy demand.

In principle, the different methods of distributing rolling stock vary, only in so far as they differ in the degree to which the vehicles are treated as individual units, and to which the work of distribution is centralised. Thus, on the one hand, we may have a system—if we may call it that—under which the vehicles are allowed to take their course, and adjustments are only made by, and at the instance of, any centre which may be embarrassed by either a shortage or excess of vehicles.

On the other hand, we may have a system under which every journey of each vehicle is directed by

Methods of  
Distribution.

some central authority, developed, in certain cases, up to the point of quasi permanent arrangements, for certain vehicles or sets of vehicles to work a succession of journeys between certain pre-arranged points. Between these two extremes there is scope for a great variety of methods. Let us consider examples representing a system at each end of the scale, and one which may be said to represent a position about midway between them.

It is not so very long since the common system of distribution of much of the rolling stock on British lines was that of allowing the vehicles to take their natural course, usually supplemented by more or less complete instructions to points which habitually had surplus vehicles as to the direction in which they should send them. Stations which were short of vehicles made appeals to stations they thought might be able to help them, stations with a large surplus made appeals for assistance in the reverse direction.

The only advantage of this system was that no special staff was required to work it. Its disadvantages were many, the chief of which may be enumerated as follows:— (1) A greater stock of vehicles was necessary. Each place in a position to do so quite naturally took care to see that it kept rather more than plenty for its own use. The net result was that a large number of vehicles were standing idle when the general position appeared to indicate the need for more vehicles to be built.

(2) Stations which did not "make" empties were often unable to supply their customers, even though there was a surplus on the system as a whole.

(3) The absence of intelligent regulation at times of a general surplus caused congestion in goods stations and marshalling yards, resulting in additional shunting cost and delay to loaded vehicles.

(4) In times of exceptional demand the effect of any shortage was confined to the places which did not "make" empties, instead of being distributed equally over the whole system. Thus, a shortage which, divided equally over the whole of the industries served by the system, might have been almost negligible, seriously handicapped those which happened to be situated at such places.

(5) It did not lend itself to efficient supervision over the distribution arrangements.

If we now go to the other extreme and consider the system of individual distribution, we find that all the disadvantages thus referred to are avoided. What we may call its highest form, viz., that in which a repetition of pre-arranged journeys is made by vehicles or sets of vehicles, is only possible in those cases in which a regular flow of similar traffic can be anticipated between certain stations. It is, therefore, confined to the working of carriages for regular passenger trains and certain special freight services. In its more general form it is applicable to all classes of vehicles. We must, however, consider how far its cost, using the word in its broadest sense, makes its application desirable. A moment's consideration will tell us that such a system will necessitate careful records being taken of the movements of all vehicles and the compilation from such records at a central point of some form of record showing the position of every vehicle at any given time. Considered as a total, the cost of such a record would be considerable, but the cost per vehicle would not in itself be out of proportion to the benefits which might be obtained. The disadvantages of such a system, if applied to types of vehicles of which there are a considerable number in use, are (1) that the time that would elapse between the completion of the record of the movements necessary to the distributor and his instructions reaching the point at which the vehicle was in the meantime resting, would be such that considerable loss of user would occur, and (2) that the additional shunting necessary to despatch or place the individual vehicle ordered, instead of being able to take the most conveniently placed vehicle of similar type, would both be costly and waste additional time.

We see, therefore, that, in spite of its advantages, such a system can only be applied with advantage to exceptional types of vehicles, and that as the number of units in each type increases the case for individual distribution gets weaker. For the more common types, therefore, some *vis media* must be found which, whilst retaining as many of the advantages of individual distribution as possible, will be sufficiently

elastic to avoid its disadvantages. This is achieved by transferring the responsibility for individual distribution to the station, and sharing the responsibility for the general distribution between intermediate district officials and headquarters.

Under such a system each station, having supplied its own needs as far as it is able sends a daily report to its district official (normally the district superintendent or district controller) showing the number of vehicles it has of each type and the number it requires. The district in turn adjusts the supplies within its district and reports to the central authority, which, in turn, makes adjustments between the different districts and arranges for the division of the empty vehicles expected from other railways between the different districts according to their needs.

A possible weakness of this system is that during the time taken to pass the detailed position from station to district and district to headquarters valuable opportunities for moving surplus empty vehicles may be lost. This can, however, be minimised by (a) keeping the number of districts as low as possible, (b) giving standing instructions for the disposal of surplus empties to stations where the train service is so arranged that delay would take place if they waited for the disposal instructions despatched at the usual time to reach them. In addition to the advantages already referred to, the centralisation should ensure that the surplus empties shall be got to the points requiring them with a minimum of light mileage.

#### Supervision of Distribution

Having considered the comparative advantages of the different methods of distribution, it is desirable to look at them from the point of view of the extent to which they lend themselves to an efficient system of supervision, and we can conveniently combine this question with that of the extent to which a high degree of supervision can be justified. The records necessary for a system of individual distribution can so be made as to give a complete history of the movement—or lack of movement—of each vehicle, whether loaded or empty, except that it omits the time spent at intermediate marshalling yards through which a vehicle may pass in transit, whether loaded or empty.

It is true that this is a very important omission. In many cases, however, the terminal records would be sufficient to draw attention to bad cases of delay between terminals, though they would not actually locate them. If records of wagons entering and leaving marshalling yards were provided in addition—which many people consider desirable for other purposes—a complete history could be compiled.

The records necessary for the distribution of wagons under a method of centralised bulk distribution can so be arranged as to give an indication of the average turnround of vehicles at terminal points, whilst the system of complete decentralisation would necessitate special and independent records being made. We may, therefore, say that the higher the degree in which the distribution arrangements are based upon the principle of individual distribution, the more completely does the system lend itself to easy supervision. In Britain it appears to be generally accepted that such a degree of supervision is sufficient, though it may be that the ease of giving it has had some bearing on the matter.

Outside Britain, for example in America and India, a much higher degree is considered to be necessary. Records of the movements of individual vehicles in such common use that individual distribution is not desirable are kept for supervision purposes.

In passing we may say that this has frequently given rise to the mistaken impression that such vehicles are distributed by units. In India and similar places the employment of a number of native staff whose powers of initiative are not yet highly developed strengthens the case for a high degree of supervision, and on at least some of the lines there supervision is carried so far that fines are inflicted on the local staff if the records show that vehicles have been delayed without good cause. In America, the larger size, and, consequently, greater value of the vehicles must be remembered when considering the question.

It is sometimes argued that a considerable expenditure in this direction cannot be justified because any results obtained are only of value when the demand for vehicles is high, say when it is above the average. If the demand is low a little delay does not appear to

matter because the demand can still be met in full. The argument is not a sound one. If good, supervision will increase the user of vehicles, not only can the peak demand be met with less but there will be fewer vehicles out of use when the demand falls. Further, experience proves that good habits of dealing with vehicles as in other directions, can only be acquired and retained by constant practice.

So far as is known to the writer, the limit to which any British company has gone in the direction of individual supervision of vehicles distributed in bulk is to compile records of the individual movements of a few types of vehicles for which there may be a special demand, for example, the more modern types of covered wagons. The results obtained were invariably sufficient to justify the expense of the special record.

It does not follow from this, however, that an extension of the arrangement to all types would be equally successful. It is at least possible that the vehicles within the arrangement were given preference at the expense of those outside it. On the other hand, the benefits were limited by the fact that the records were confined to the terminal points only. As previously stated, the cost of the staff necessary to take the records would probably work out at a very low sum per vehicle. A very small improvement in the average user would, therefore, justify the additional expense. In addition, the records would give much valuable data for other purposes.

Although there are sufficient points in common to both passenger and goods rolling stock to have made it convenient to have considered them together, there are certain important differences to which reference should be made. The first and most important is that the railway company can influence the time at which passenger vehicles are required for loading, and, indeed, the demand for the vehicles also, to a much greater extent than is the case with goods vehicles.

When arranging many of the passenger train services, the company can take into consideration, as one of the factors in deciding the time at which a train shall run, its convenience in relation to the supply of the necessary vehicles. Again, by reason of

its freedom to make temporary reductions in fares as compared with goods rates, a company can create a demand for the use of passenger vehicles which would otherwise be standing idle by running special trains at cheaper fares.

Another difference which makes the control of the passenger vehicle easier is that there is no risk of it being used as a warehouse for the traffic it has carried for an indefinite and variable period after its arrival at destination.

The chief factor tending to reduce these advantages is that whereas goods wagons are ordered with some fairly definite idea of the amount of traffic to be conveyed, passenger vehicle requirements must be based on estimates and actual requirements are certain to vary considerably from day to day. Whilst the original estimate can be adjusted in the light of experience, considerable waste is likely to occur before this is practicable, and even further time must elapse before the necessary arrangements can be made to utilise the spare vehicles in other directions and bring such arrangements to the notice of the public. The time the vehicles must be out of use at regular intervals for cleaning and washing is also a feature which affects only passenger vehicles and the vehicles used for the conveyance of live animals.

These differences make it desirable that we should devote a little space to one or two of the special problems of the distribution of passenger vehicles. The general consideration of the question can be divided under two heads, viz., the provision of carriages for the ordinary service of trains, and the use of the balance of the vehicles for extra trains such as excursions.

Distribution  
of Passenger  
Vehicles.

Taking them in this order, we may say that the theoretical ideal would be so to arrange the regular working that, apart from suitable intervals for cleaning and washing, the vehicles are continually in use, each compartment being occupied up to its maximum seating capacity. There are many causes which prevent this ideal being reached. There is rarely an even flow of passengers for two successive stages of the same train, much less for two successive journeys of the same train set. The number of passengers



between any two given points varies according to the time of day, to the industries carried on at such points, to the habits of the people, to the weather, and the many other influences which may bear upon potential passengers. There is a distinct limit to the number of passengers who are willing to travel during the night hours, even though reduced fares may be offered. Further, not only does the majority of the traffic tend at certain times of the day to flow in one direction only but at the other times, when the number of passengers in each direction tends to become more even the reduction in number is such that fewer vehicles are required to accommodate them.

This provides an interesting problem in what we may call the economics of operating. Will it pay better to go on running the larger sets of vehicles or to reduce the sets and let the spare stock stand in the most convenient place until it is required again? On the one side we have the expense of the wear and tear to the carriage caused by the additional running and of the additional coal, oil, etc., consumed on the engine as a result of the heavier load. On the other, the cost of taking the vehicle to and from the storage sidings and the cost of the construction and maintenance of the storage sidings. Whilst it is impossible to lay down a rule, and each case must be considered on its merits, the general opinion appears to be that it is not usually worth while to get rid of odd vehicles. What should be aimed at is that whole trains should be put out of use, others being divided to provide the stock for two trains. This not only reduces shunting operations to a minimum but increases the possibilities of utilising the periods when the stock is out of use for cleaning purposes. Where, however, other conditions allow the majority of the stock to be in effective use for most of the day, the night period can be utilised for cleaning.

The different types of vehicle required for the different sorts of journey also increase the difficulty of arranging an economical carriage working. For the long-distance through trains, corridor or "open" vehicles with lavatory accommodation accessible for every passenger are essential; for the long-distance trains which stop at the principal intermediate stations

a proportion of compartments with access to lavatory accommodation will suffice; whilst for the short-distance trains no lavatory accommodation is necessary. The general standard of comfort desirable also increases as the length of the journey increases.

Again, the proportion of first to third class accommodation required is liable to vary not only on successive trains but even on different portions of the journey of the same train. In their endeavour to meet the varying requirements as economically as possible, most companies have a greater number of varieties of what may be called ordinary carriages than is generally appreciated. Any attempt to increase the average use by reducing the number of varieties must, if complaints are to be avoided, result in higher types being used for certain journeys than is really necessary. These, in addition to being more expensive to build, usually have less seating accommodation.

The arrangement of the carriage roster consists of fitting in the requirements of the different trains in such a way that the whole may be provided for with a minimum amount of stock. These requirements will vary from day to day. Some trains only run on certain days of the week, some regularly need additional vehicles on certain days, e.g., market days, etc. All this can be provided for in the roster, though it normally results in a certain amount of spare stock on those days on which the rostered demand is below the highest demand for the week.

The Carriage  
Roster.

Additional spare stock is, moreover, required to meet such contingencies as additional trains, or last-minute strengthening, both of which are most likely to occur on the day of the peak rostered demand, and to provide replacements for vehicles which may have to be sent to "shops" for repairs.

The efficient control of this spare stock presents considerable difficulty. The casual demands upon it cannot be foreseen. The demand made for the purpose of running special and excursion trains at low fares must be settled so far in advance that it must be based upon an estimate of the stock which is likely to be available. The usual method is to apportion the spare stock between conveniently placed stations

with authority to use it to meet their casual demands if it has not previously been earmarked for some other purpose, daily returns being sent to some central point on similar lines to those used for the distribution of goods wagons in bulk from some central point, so that adjustments between centres may be made as necessary. On days of exceptional demand these returns are frequently supplemented by returns arranged to show how far the estimates of stock expected to be available have proved to be correct.

**Common User.**

No consideration of rolling stock control would be complete without reference to the system of "Common User" now in operation so far as the majority of the railway-owned goods wagons in this country are concerned. It may be said to have been forced upon the British railway companies by the war conditions, but the system remains in operation, and affords a striking example of the advantages of co-operation between railway companies.

Prior to the war, wagons loaded from one company's line to another were only allowed to be loaded in the reverse direction if their contents were consigned in the direction of, to, or beyond, but via the owning company's line, and that within a certain limited period which varied according to the length of the journey. A company which disobeyed the regulations had to pay the owning company a penalty charge which was usually sufficient to act as a deterrent. Common user is an arrangement under which wagons of the types included in the arrangement may be treated for loading purposes as though they were owned by the company on whose line they happen to be, subject to periodical adjustment of the total number of wagons of each type on each company's line, to correspond with the number of that type owned by each company. It does not involve—as many people still appear to think—common ownership of wagons, or the placing of wagons into a common pool out of which any company can draw to meet their demands so long as there are any wagons left in the pool. Its advantages are due to the fact that it saves the unnecessary haulage of empty wagons.

It has been calculated that, prior to common

user, the exchange of wagons between companies was in the ratio of 10 loaded to 6 empty. After common user the ratio became 10 to 3. Had it remained the same, approximately 3,000,000 additional empty wagons would have been exchanged per year. In saving the haulage, the non-effective time which would otherwise have been spent in making the empty journey is saved. If this is calculated at the rate of one day saving on each of the 3,000,000 wagons, it will give some idea of the saving under this head.

Further advantages are the relief given in the marshalling yards at the exchange points as the result of fewer wagons having to pass through them and the saving in engine time which was previously spent in shunting out the empty wagons for return home, or of specially placing those that could under the regulations be loaded, at the points where loads were available. The principal disadvantage of the arrangement is that the companies whose stock is, on the whole, of better design than that of the others are placed at a disadvantage. This will disappear in course of time as the older wagons go out of use and are replaced by others built to the standard designs previously referred to.

## CHAPTER V

### PASSENGER SERVICES

Relative Im-  
portance of  
Passenger  
Traffic.

WE get some idea of the importance of passenger, as compared with freight, traffic from the following ratios of passenger to total receipts which were recently given in evidence before the Railway Rates Tribunal. On the Southern Railway no less than 72 per cent. of the total receipts are derived from passenger traffic, whilst the corresponding figures for the Great Western, London Midland and Scottish, and the London and North Eastern are, respectively, 43 per cent., 39 per cent. and 37 per cent. The difficulty of apportioning many of the items of expense between the two services makes it impossible to quote conclusive figures, but an examination of two or three of the principal ones will indicate that passenger traffic is by no means negligible from a profit-making point of view.

The average receipts per ton mile for freight traffic may be taken as under 2d., whilst the receipts per passenger mile are rather over 1d. The superior speed of the passenger train and the very much less shunting work necessitated by passenger traffic, will, however, result in the receipts per engine hour—a much more accurate indication of working cost than the ton or passenger mile—being at least equal, and probably leave a balance of advantage in favour of the passenger traffic. The vehicle cost per passenger or ton mile, in spite of the higher cost of the passenger vehicle, will be less because of the quicker turn round, as also will be the labour cost of “handling” the traffic at termini or intermediate points.

Requirements  
of Passengers.

The considerations affecting the arrangement of a passenger service may be divided into those which more directly concern the travelling public and those which have to do with the operation of the railway. Of the former, probably the most important is that services shall be given at reasonable intervals. The

length of such intervals varies with the length of the journey. For very short distances such a frequent service is desired that a railway company can hardly hope fully to satisfy public requirements in this respect unless lines can be specially set apart for the short distance traffic. As the distance increases to, say, 50 miles, an hourly service will normally meet the case, while for journeys of 100 miles or more three or four services per day at well arranged intervals are generally ample.

The possibility of the railway company providing such services must, of course, depend upon the number of passengers who wish to travel. However desirable the standard indicated by the examples quoted may be from the point of view of individual members of the public, it would not be sound business to provide it unless, directly or indirectly, the additional revenue from each train was equal to the additional cost of running it.

As the intervals between the trains get longer, the selection of the times at which they shall run so as to meet the requirements of the travelling public becomes of increasing importance, but increasingly difficult. The requirements for the shorter distances, are comparatively easy to gauge. Besides, suburban and other types of regular passengers are not, as a rule, slow in making their requirements known. It is the occasional travellers, who in the aggregate make up a considerable portion of the long-distance traffic, whose requirements are difficult to discover. To many of them, indeed, the actual time of the train does not matter a great deal providing its departure and arrival times fit in reasonably well with the normal times for taking meals, etc., and they may be said to approach the question with an attitude of "At what time is there a train?" rather than one of "I want a train at such and such a time." A railway company would, however, be neglecting its own as well as its customers' interests if on that account it relaxed its efforts to choose the most convenient times.

Speaking generally, British companies are content to rely upon the experimental introduction of new services for which it is considered there may be a demand, though from time to time at least one

company—the Great Western—has made direct appeals to its passengers on the subject.

Perhaps the next most important point to the passenger is that he shall complete his journey without having to change. In so far as this may be possible by the running of through trains, the interest of the passenger and the operating department are usually identical. As we shall see later, the essence of economical passenger train working, assuming there is a sufficient number of passengers to justify it, is to keep an engine and train set moving in the same direction. Moreover, the saving in trouble, and, perhaps, expense to the passenger who avoids a change is accompanied by a saving to the company, since they save the cost of transferring the luggage, parcels, etc.

Through  
Carriages.

The latter advantage is retained where the through service is given by means of through carriages, though this, from the operating point of view, is often accompanied by more than corresponding disadvantages. Even if the cost of transferring a through carriage from one train to another could be said exactly to equal the cost which would otherwise be incurred on the platform—and it would usually be greater—there would still remain the great disadvantage of the effect of through carriages on punctuality.

Initially, every passenger may be said to desire punctuality, but if the question becomes one of whether a second train should be kept waiting to enable a connection to be made with a train which, for some reason, is running late, the view is liable to be coloured according to what train the person expressing it is travelling in. The usual practice, apart from abnormal conditions, is to keep all connections with through carriages. For other trains, margins are laid down, varying according to such circumstances as the interval before the next service in the same direction, beyond which trains normally making connections do not wait.

Through carriages are, therefore, liable to affect the general standard of punctuality, and this not only directly but indirectly. The occupation of the platform line by the waiting train may often result in other trains, due in turn to occupy that platform, being delayed awaiting admission. At other than

island stations also, the movements across the running lines necessary for transferring through carriages frequently lead to a choice between delaying other trains or taking a longer time to make the transfer, thus increasing the delays to the original trains.

The general aim must be to provide the maximum of convenience to the majority of passengers, giving rather special consideration to those who are making the longer journeys. In this connection we may mention the necessity for an efficient system for the "reporting" of passenger trains. If connecting trains are running late, it is essential that this should be known to the staff at the connecting station sufficiently early to avoid the risk of trains being held up to the limit allowed in the "margins" list unnecessarily. For example, if the connecting train is, say, fifteen minutes late at the last stopping station, and the margin is five minutes, a report of the late running of the train will enable the departing train to be started at its booked time.

Reporting of  
Passenger  
Trains.

Train reports are, of course, required for other purposes than this. Late running may upset platform, engine or guards' working, and it is, therefore, desirable that the staff concerned should have due notice of this. On the other hand, too many reports are apt to lead to confusion. A sound rule to follow when settling how far to go is that reports should only be sent when the normal or booked working of a train is in any way departed from.

Punctuality, and a reasonable degree of speed on the journey, are both desirable from the passengers' point of view, but these two considerations are to some extent antagonistic. The modern locomotive, though a wonderful machine, has not yet reached the stage when it can give exactly the same results under all conditions of weather. Traffic also is liable to fluctuate, and the time taken by a given train in station duties may vary between, say, one and five minutes according to the traffic passing on different days. If the train is timed on the average time necessary, then, under favourable circumstances, it will reach its destination a few minutes before time. In unfavourable circumstances it will be a few minutes late. Thus, by decreasing the booked throughout

Punctuality  
and Speed.



speed an improved standard of punctuality may be obtained. Providing the increase in total journey time is not too great, the normal passenger would probably prefer punctuality. There is, however, a very definite limit to which this is desirable. Again, to the extent that time is wasted when conditions are favourable, unnecessarily increased line occupation takes place, a matter of considerable importance on busy lines. The common demand from the travelling public for speed on passenger trains takes the form of a demand for trains without intermediate stops rather than for an increase in the speed of travel.

Even when full allowance has been made for the varying requirements of the different passengers, it is probable that had the routes followed by British railways been planned as a whole, instead of their being merely a collection of lines originally planned for local use but later joined into large systems for greater convenience, some general principles might have been laid down on which passenger train services should be arranged.

It is, at any rate, certain that should the day ever arrive when a wholesale replanning of routes takes place, and that passengers are at that date still carried by rail, one of the most important considerations in settling the new routes will be the extent to which they lend themselves to a passenger train service based on the principle of the "interval" service. Such a service would probably take the form of a series of trains over the principal lines, arranged to leave the terminal stations—or, perhaps, we should say the "key" stations since it is extremely doubtful whether an ideal layout would have any termini—at regular intervals, and the secondary lines so arranged that the trains over them could arrive at and depart from the principal line stations at such regular intervals as would give connections in all directions. Students are recommended to take the time-table of any railway company running out of London, and, with the data available therein, see how soon—and what kind of—difficulties are encountered if they attempt to arrange such a service. To some extent, however, interval services are possible under present conditions. They are in common use for

The "Interval" Service.

suburban traffic, and in comparatively recent years have been extended to certain main line services. They are greatly appreciated by the public because they are easy to remember.

We must now consider the operating considerations concerned in the arrangement of a passenger train service. We may say there are five principal ones. In addition to the working out of a path over the line affected, usually called the "timing," provision must be made for the necessary accommodation of the train at the larger stations it is to serve, whilst arrangements must be made to provide, with due regard to economy, the necessary engine, carriage set and guard.

Passenger  
Train Timing.

Though these considerations vary in importance, no one of them can be said to be predominant, and in practice all must be given equal consideration so that the service which gives the balance of advantage may be taken. If one were to consider a complete revision of the passenger train service for a large system, it would be necessary first to settle what trains should be run, and then to make any necessary adjustment to fit in the operating considerations to the best advantage, where this could be done without spoiling the service. For additions or adjustments to the service, it is advantageous for the public requirements to be considered along with the operating requirements.

The possibility of providing any additional services must depend upon both the anticipated additional revenue to be derived and the cost of providing them. It follows from this that if a maximum net revenue from passenger traffic is to be obtained, inquiries as to possible new services ought to arise in two ways—the first by the discovery of an anticipated demand for a new service followed by an inquiry as to the cost of providing it, and the second the discovery of the possibility of providing additional services at a very small additional cost, followed by an inquiry as to the potential revenue from such a service. It is, perhaps, unnecessary to add that if under any system of organisation the two types of inquiry indicated are made by representatives of different departments, the very closest co-operation must be

maintained between them if the highest results are to be obtained.

The engine, carriage and guards working are all arranged on the principle of getting a maximum proportion of effective to ineffective time: that is, time during which they are earning revenue by carrying passengers from place to place. The degree of success will be limited to some extent by the requirements of the travelling public and by certain inherent characteristics of the means used, which we will now consider; but, if these are ignored, very little consideration is required to arrive at the conclusion that the longer the engine, carriages and guard work as an effective unit in the same direction (i.e., without having to detach the engine) the more likely is the desired end to be attained.

The Carriage  
Set.

The carriage set possesses the advantage of greater mobility than the other items. Apart from the provision of suitable intervals for cleaning and washing, there is no limit to the hours it can be worked, nor is there any reason why it should return to its home station at the end of each day's work. The necessary examination, lubrication, and recharging of the gas and water tanks, where necessary, can be done whilst the set is standing in a station for loading and unloading purposes.

The Loco-  
motive.

The effective use to be obtained from the locomotive is limited in many other directions. There is a very definite limit to the time it can be kept in use, the maximum period usually being regarded as sixteen hours, though even this would not be possible for a number of successive days nor, indeed, for one day for engines working important main line passenger trains. This time, moreover, must be so divided as to give opportunities for oiling the engine and cleaning the fire about once every four hours, and for a fresh supply of water to be obtained at more frequent intervals. To some extent the latter can be fitted in with the times the engine is at a station for traffic purposes, whilst, at places where conditions are favourable for their use, water troughs, from which engines fitted with a scoop may take a supply of water whilst travelling, are provided.

An engine must start and end its day at an engine

shed, so that the necessary conveniences for overhauling, repairing if necessary, and generally preparing for the next day's work may be available. Since there are considerable advantages to be gained by this being its "home" shed, its starting and finishing points are confined to that particular place.

As progress is made in the standardisation of the wearing parts of locomotives, the case for the daily return to the home shed will weaken. Any departure from this practice must, however, always be accompanied by a balancing arrangement to prevent one shed receiving a surplus while another is short of its necessary number of engines for the following day's working.

The balancing of trips so that an engine may, without light running, return home at the end of its day is, therefore, one of the most important features in connection with the engine working arrangements. Where the passenger service is not, and cannot with advantage be, arranged so as to avoid a light trip, a freight trip can often be inserted with advantage. The crew of the train, the driver, fireman and guard, must commence work at their home station and return to that point within their standard day of eight hours, except where lodging turns are in operation, in which case the choice of an alternative destination is offered every second day, though the time limit still applies. All these considerations make the arrangement of a passenger train service a complicated affair, and it is perhaps a good thing that the comparative permanence of the passenger train services enables very full consideration to be given to the arrangements.

The Train  
Crew.

It is a fairly common practice to make use of graphs for preparing or reviewing the different workings. Such graphs should so be arranged as to show ineffective time in distinctive colours and otherwise in such a way as readily to indicate the possibilities of rearranging the different trips which go to make up the "turns."

Use of Graphs.

The increasing necessity for economical operation during late years has drawn attention to the fact that the ordinary train set hauled by a locomotive is too expensive a unit for services on branch lines, or even for giving a sufficiently frequent service on fairly

Branch Line  
Services.

busy lines, to compete successfully against road competition. The vehicles with which experiments have been made may be divided into two classes, namely, those in which the engine is an independent unit, and those in which the engine is part of the carriage, though sometimes capable of hauling one or two trailers.

In the first class are the so-called autocars, in which a small locomotive of normal type is connected to an ordinary carriage in such a way that the engine may be driven from a compartment at the opposite end of the carriage from that to which the engine is attached, the fireman remaining on the engine. This unit can thus be used in either direction without the engine changing ends, and the time which would otherwise be occupied by the engine running round at terminals is saved. This, the principal advantage, disappears if trailers are attached, because either the engine or the proper end of the fitted carriage must be in front, and, in effect, the autocar then becomes an ordinary train.

Recently, a considerable advance has been made in the desired direction by an adaptation of steam engines of similar type to those used on road vehicles to this class of work. The best known example of this is the Sentinel-Cammell Steam Rail Coach, which will provide accommodation for eighty passengers and can be worked at a cost of approximately one-third that of a small carriage set hauled by a small tank passenger locomotive of normal type. Its low working costs are chiefly due to its low fuel consumption and the fact that since one man can both fire and drive the engine the train crew can be reduced from three to two. Many types have already been evolved to meet the varying needs of different railways, and while to some extent the adoption of this type of engine for railway purposes may be said still to be in the experimental stage, it has already achieved sufficient success to show that it will go a good way towards solving the problem.

The drawbacks of such vehicles are that they must be confined to the special class of work for which they are provided—and it is often difficult to find continuous use for them—and that, since they tend to

run rather more slowly than an ordinary passenger train, especially under bad weather conditions, because of their not possessing the same reserve of power, they occupy the block section rather longer than the ordinary train, thus lengthening the margins required to run freight trains in front of them.

The special difficulties in connection with suburban services, with their heavy streams of traffic for a short time three times a day, are well known. Summarised, we may say that the problem consists of working a maximum number of trains during the rush periods and disposing of the otherwise surplus engine power and stock as economically as possible between the rush periods. Let us consider these two aspects in turn. To deal with the maximum number of trains they must all run at the same speed, and the line must be so equipped as to reduce the intervals between successive trains to the lowest limit consistent with safety. This, as we saw when dealing with signalling demands the arrangement of the block sections on a strictly "time-distance" interval, the use of automatic signalling for intermediate sections, and semi-automatic and power signalling at all junctions. If this is done the feature which will limit the line capacity is the time spent at stations, especially terminal stations. The latter are to be avoided, if possible, the so-called circular working having special advantages for this type of traffic. Where, as is usually the case under British conditions, the terminal station cannot be avoided, the number of platforms should, if possible, be such that the station can receive and re-forward trains at the same rate as they can pass over the lines between stations. This number is kept to the minimum if the platform lines and lines leading thereto are so arranged as to reduce the necessity for crossing the tracks of trains in diverging directions, and if facilities are provided in convenient positions on which engines to work outgoing trains may stand, and, in the intervals of waiting, take water or perform any other necessary locomotive duties. Probably the best arrangement for this purpose is the provision of short spur lines leading off the platform lines near the entrance to the platform. From these an engine may back on to an incoming set as soon as it comes to rest,

Suburban  
Services.

be attached, and be ready to work the outward trip by the time the incoming passengers have detrained or outgoing entrained, whilst the engine which worked the incoming train, having been detached, can follow the set out of the platform, proceed to the spur line, and there prepare to repeat the arrangement for the next train.

Short of electrification, it is generally agreed that the more powerful types of tank passenger engines are the best fitted for this sort of work, because of their advantage over tender engines from the point of view of rapid acceleration; this, of course, being due to their greater adhesive force as a result of the weight of the water in the tanks being over the driving wheels. The possibility of using up the engines, train crews and carriage sets during the slacker periods depends very largely upon local circumstances. Frequently some can be used to work the more normal services and some to work short trips with freight traffic. If the opportunities in these directions are comparatively few, and unless the number of freight trains requiring to use the lines between the rush periods is heavy, it is sound to provide frequent passenger services between the rush periods.

## CHAPTER VI

### FREIGHT SERVICES

CONSIDERED in relation to the arrangement of train services, the fundamental difference between passenger and freight traffic is in what we may call the conveyance unit. Passengers can and will join or leave a train at any stopping place, joining another train where necessary to complete the journey, without in any way affecting the composition of the vehicles forming the train. With freight, the traffic cannot be loaded into or unloaded from the carrying vehicles sufficiently quickly to enable this to be done, and consequently the vehicle, together with its contents, if any, becomes the conveyance unit. This characteristic of freight traffic makes it necessary—as we have seen in an earlier article—to provide marshalling yards in which the operations of combining wagons into trains at the commencement of the journey, re-sorting them at intermediate yards where necessary, and finally dispersing them into wagons at the completion of the journey may be performed.\* It soon becomes apparent, therefore, that one of the important considerations in connection with the arrangement of a goods train service is the load which will be required before a train is arranged.

Freight Train  
Loads.

One of the first questions to arise is that of the terms in which the load shall be expressed. The only alternatives are to define it in terms of either "wagons" or "tons." "Wagons" is undoubtedly the more convenient term, since the vehicles are easy to count. The difficulty is that one is almost bound to work on average wagons, and there is such a variation that

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\* It may be objected that this statement is only partially correct so far as wagons for or from stations not sufficiently large to receive or forward a train load of goods at one time are concerned, because at such stations the wagons are attached to or detached from the "pick-up" train serving the station direct from or to the station sidings. It must, however, be remembered that to this extent every small station yard may be said to be a marshalling yard.



this will almost certainly lead to under-loading the engines when the wagons and loads are lighter than the average, and over-loading when they are heavier. It is very difficult to say which of these evils is the more expensive in the long run. Both are avoided if the loads are expressed in tons. The tonnage is much more difficult to calculate, and to obtain it exactly would necessitate the appointment of quite a number of special staff to make the necessary calculations. Experience has, however, shown that an approximately correct figure may be obtained by the guards or yard staff.

The tonnage basis, though a good deal more exact than the wagon basis, is still imperfect. The amount of friction set up by the load which must be overcome by the engine that is to haul it, depends to some extent upon the number of points at which the friction is applied, the friction increasing as the number of points increases. Strictly speaking, therefore, we should have a tonnage load which is varied according to the number of wagons which comprise the load, or, more correctly, the number of axles carrying those wagons. In practice, however, this would result in such a variation of load as would be impracticable.

Those companies which have adopted the tonnage method of loading cover the point in some degree by making three classes : namely, concentrated loads, which are higher than normal tonnage loads, which in turn are higher than empty wagon loads, the concentrated loads being those which are carried on the smallest number of axles, such as loaded wagons of coal, iron ore, pig iron and other heavy traffics ; normal loads, those of the more normal goods traffic ; and empty loads, those consisting of empty wagons only.

Which ever system of loading is adopted, it must be based upon normal weather conditions, and reduced when heavy side winds, greasy roads, or other bad weather conditions make this desirable.

It is also important that particulars of the loads arranged according to the different classes of engines in use shall be published either in the appendix to the working time-table or as a separate pamphlet.

In endeavouring to settle what the train loads shall be, we immediately raise another important con-

sideration—that of the speed at which the trains shall run. The two considerations are directly antagonistic. Given the same engine, the load may be increased as the speed is decreased, and vice versa, up to the limits, on the one hand, of the capability of the engine to start the load, and, on the other, of the maximum speed which the construction of the engine will allow. We can only reconcile these conflicting considerations by using them in conjunction in such a way as will give us the maximum number of units of work for a given cost. The work is to move wagons or tons through distance. The nearest cost figure which can readily be obtained is that of the time spent by the engine and train crew. The ton-miles or wagon-miles per engine-hour figure will, therefore, tell us what the ideal load will be, considered from the point of view of economy of engine power.

For example, if a given engine can haul 40, 50 or 60 wagons respectively, at 30, 25 or 20 miles per hour, the wagon-miles per engine-hour would be 1,200, 1,250 and 1,200 respectively. To get the maximum capacity out of the engine, the 25 miles per hour speed would, at least in theory, be the best to select because it would give us 50 more units of work per hour than either of the other speeds. This economical speed figure naturally varies according to the extent to which the types of engines available for goods train work tend to follow the passenger or the heavy mineral types. With the latter, the economical speed is frequently as low as 20 miles per hour, and many of this type are in any case restricted to a maximum speed of 25 miles per hour because their reciprocating parts will not bear the strain of a higher rate. In practise moreover, the economic speed is affected by the fact that when train speeds are mixed, the slower trains require longer margins in front of the faster ones.

If, however, the economical speed greatly exceeded 30 miles per hour, we should soon be limited by the maximum rate at which it is considered safe to run wagons fitted with the types of axle box and the loose couplings in common use on goods wagons in Great Britain. These two considerations of speed and load, though important, are by no means predominant ones, though it is to be feared that the comparative

ease with which they can be calculated in the first place, and later used for supervision purposes, has resulted in their being given an exaggerated importance. There are two others of at least equal importance which are liable to affect the latter and so react upon the former.

Marshalling  
Yard Costs.

The maximum figure of ton-miles or wagon-miles per engine-hour can be obtained by choosing such speed as will give this for each train, and then insisting upon each engine hauling the maximum load at that speed. To do this, however, we must not only increase our marshalling yard working costs but be content with a lesser use from our goods wagons and a poorer service for the traffic. Very little consideration is necessary to show us that the smaller the train load the greater will be our chance of arranging "through" trains, if not always to destination at any rate to points farther in the direction of the destination of the traffic, thus reducing the number of marshalling yards into which a given number of wagons must be handled.

To arrive at the cost of handling a few extra wagons in any yard is a difficult problem. It may be that the cost will not be increased at all. It may be that they represent just that margin of additional work that necessitates an extension to the yard or the employment of an additional engine, or the extra train which brought them may be sufficient to cause a succession of delays to following trains which may, in total, amount to several engine-hours. From what figures are available we may say that the average cost of handling a wagon in a marshalling yard is rather over 6d.

Effect of  
Transit Time  
on Wagon  
User.

The value of the loss in wagon user is equally difficult to estimate. On the average at least an additional six hours and often more will be added to the throughout transit time for each additional yard a wagon enters. The degree to which this additional time affects the wagon user depends upon the comparative arrival time at its ultimate destination. If, without it, the wagon would have arrived there at say, midnight, then the effect on wagon user is negligible, since an arrival at 6 a.m. is equally valuable from the point of view of the possibility of delivery

being taken and the wagon thus released. If, on the other hand, the comparative arrivals were 10 a.m. and 4 p.m., then the chances are that an additional day will be spent at the arrival point before the wagon is unloaded.

Let us now endeavour to arrive at some idea of the money value of a wagon-mile. If, with a view to making our figure comparable with those already quoted, we exclude interest and maintenance costs, the cost of working a goods engine, including the cost of the train crew, will not be likely to exceed 7s. 6d. per hour. Suppose it averages a speed (including delays and time at terminals) of 5 miles per hour with a load of 60 wagons, we get 300 wagon-miles for 7s. 6d., rather over 3 for 1d. If the figures quoted represent anything like an approximately correct indication of the relative values—and they do not pretend to do more—it will be seen that the quick throughout transit which modern trading conditions demand is essential in the interest of economical working.

Each case must necessarily be judged on its merits, and to some extent the question of line occupation may become an important factor, but for practical purposes it is probably safe to say that, where necessary, a reduction of up to one-third of what has been fixed as the maximum load of the engine available at the speed which has been selected as most suitable is justified, if by so doing the wagons composing the train thereby avoid entering one intermediate marshalling yard. The margin becomes distinctly less, and our problem more difficult, when we consider what we may call the semi-through train. In this case, the whole of the train does not enter the yard—thereby avoiding a second handling—but simply exchanges one portion, possibly even ready marshalled for attachment to another train, and lifts a corresponding portion for its own destination. In such a case, the loss on wagon user would probably be negligible, the principal costs to set against the increased wagon-miles being the additional time occupied by the engine concerned. This would be directly reflected in the wagon-miles per engine-hour for that train, whilst possible delay to following trains

or to other work in the marshalling yard, whilst the exchange portions was being made, must be taken into consideration.

Operating  
Considerations affecting  
Goods Train  
Services.

We have seen that four of the principal considerations, when arranging a goods train service, are the speed of the trains, the load they shall carry, the marshalling yard costs, and the effect upon the wagon user, and that each of these is liable to react upon all the others in regard to both operating cost and the time taken to get the goods to their destination. In so far, for example, as the load may be reduced to avoid the cost, both in money and time, of an additional handling in a marshalling yard, not only may there be a gain in wagon user and a reduced journey time, but the fact that a smaller load is carried will enable the train to run at a higher speed. This will not only increase these advantages, but will often more than counter-balance the original loss in wagon-miles per engine-hour caused by the load reduction. An indirect advantage may also be gained in the effect of the higher speed on the number of trains which may be passed over the line.

On a purely freight line, where the advantages of a uniform rate of speed are so great as to be likely to override all other considerations, the speed which gives the maximum wagon-miles per engine-hour result is also the best from the point of view of line capacity. On lines which are used for passenger as well as freight trains, the degree of gain will depend upon the extent to which it is possible to group together the trains at the same speeds.

Theoretically, therefore, there may be said to be a case for considering each train and determining its speed in accordance with the economical load of the class of engine it is proposed to use for it, adjusted, of course, to meet the other circumstances already referred to. In practice, however, the inconvenience of having such a variety of speeds and loads—which, moreover, would be liable to vary whenever, for any reason, the usual class of engine employed was not available—is such that most companies are content to have two or three standard speeds for goods trains.

Having settled, on broad lines, the points between which trains shall run, together with their speeds

and loads, there are still a number of minor, though still important, considerations to be taken into account before the actual booking of the train can be done. It will be appreciated, for instance, that the load of any engine between two points must, assuming the speed is constant, be determined to a considerable extent by the worst gradient to be negotiated on the journey.

If the standard speed is adhered to throughout, it necessarily results in a surplus of power being available but not in use over the easier portions of the line. It is desirable, therefore, to express the standard speeds in terms of average, rather than constant, speeds, timings being prepared for each section of line where a sufficiently substantial change of gradient occurs in such a way that whilst, on the average, the complete journey is performed at the standard speed, the easier sections of the journey are at higher and the more difficult ones at lower speeds than that. Where an exceptionally difficult gradient occurs further means are adopted to minimise the disadvantage which would otherwise be felt for the remainder of the journey. The simplest, and within the limits possible, the most economical means, is to adopt a lower standard speed for the section on which the gradient occurs, either used alone, or accompanied by the pinning down of a number of wagon brakes to assist the engine and van brakes when travelling down the hill, and by special arrangements to prevent the necessity for stopping and, consequently, having to restart when travelling up hill. When this is done the block sections of the line over which the trains are running more slowly should be adjusted so that the "time lengths" are not greater than those on the remaining portions.

Where the gradient is too difficult for the method described above to be adopted with advantage, two other methods are in use. The first of these, "banking," as it is called, is to provide an additional engine or engines to assist the train over the heavy gradient. There are cases where the gradient is so severe as to make banking almost essential. It has, however, many drawbacks. Unless there is a very regular succession of trains a good deal of waste takes place,

Effect of  
Gradients.

because the banking engines—often of a special type—must wait about in the intervals which elapse between the arrival of trains which need assistance. On the other hand, a succession of trains at short intervals may cause delay to trains which are forced to await the return of the banking engine. Further, since assistance is only required in one direction, the banking engine only performs effective work on half its mileage, and is, moreover, occupying the running line at the risk of delaying other trains. Where circumstances permit, the latter risk can be avoided by providing a separate line on which the engine can return.

An alternative to banking is to provide suitable sidings at the foot and head of the gradient so that the train engine may divide its load at the bottom of the hill, work it up in two or three journeys, and then work it forward as a whole. At first sight this method looks very attractive, and in certain special cases where the difference between the gradient and the rest of the line is such that an engine can work just half its load up the gradient, and so take forward the full load after completing the second trip, there is a good deal to be said in its favour. Its principal advantage is that the ineffective waiting time of the banking engine is avoided, but against this the drawback of passing double the number of trains over a section of line which is already at some disadvantage because of the gradient is often sufficient to make it inadvisable.

Loads are liable to be limited by the length of relief sidings, reception sidings, etc., but apart from exceptional cases there should be no difficulty in justifying the cost of such alterations as will remove such restrictions.

It is not possible to say what the limit of a train load may be. It is not so many years since a load of sixty wagons was looked upon as a load of exceptional length, and with some suspicion. To-day it is comparatively common to find trains of a hundred and even more wagons. The general tendency, however, appears to be rather in the direction of reducing than increasing the loads.

The Maximum  
Train Load.

Braked  
Freight Trains.

As has previously been stated, the speed of British goods trains is limited by the type of axle box, the

loose couplings and the lack of continuous brakes. It is, therefore, desirable we should consider briefly the desirability of building and equipping the goods wagons as coaching vehicles so that speeds approximating to those of passenger trains might be attained. In many cases, the increased speed could thus be obtained without a corresponding reduction in load. The load of an engine is limited either by the amount it can start, usually called a "starting" load, or stop, a "braking" load. It is a little more difficult to start a tight-coupled train than a loose-coupled one. A small reduction in the "starting" loads would therefore be necessary. The improved braking power would in some cases enable the "braking" loads to be increased. The throughout journey time, and consequently the engine and wagon user, and the service the traffic would obtain should be better, though perhaps not to the extent that would at first sight appear to be probable. For short journeys the additional time taken to couple or uncouple the wagons, adjust the screw couplings, and connect the brake pipes, might counterbalance the saving in time due to the higher speed, but this in itself would not be a serious matter.

Two other aspects of this work present a much more formidable obstacle, and, indeed, if the difficulty of the cost of initial conversion is ignored, may be said to present the principal arguments against it. The first is that the extra time would be occupied in the station and marshalling yards which, in many cases, are "key" positions at which any additional time taken will, even in those cases in which it does not reduce the capacity of the line considered as a whole, at any rate slow down the rate at which the work of marshalling and despatching of trains can be done.

The increased risk of accident to the train and shunting staff because of their having to go between the wagons is also a strong argument against any change from present practice. The latter could be overcome and the former reduced by the provision of automatic couplings. If the automatic coupling gear could be made to embody an automatic coupling of the brake pipes, then both disadvantages would entirely disappear. The question would then become



the comparatively simple one of balancing the cost of equipping and maintaining the necessary additional gear and of hauling the additional dead-weight against the saving in the directions previously indicated.

Most British companies have a small proportion of their goods wagons fitted with the vacuum brake and screw couplings, and use them principally for the conveyance of long distance perishable or other urgent traffics. On the whole, the advantages indicated above are fully realised, especially in those cases in which there is a regular flow of suitable traffic in both directions. The general experience of their use, however, coupled with an experience of the North Eastern Railway gained during an experimental introduction of braked wagons into the iron stone trade, indicates that the flexible brake pipe connections are not suitable for use in connection with goods traffic, being too liable to damage with the rougher use that this entails. This feature, however, is doubtless one that could be remedied.

The general principles of the arrangement of the working of the engine and train crew follow those which have already been referred to in connection with passenger train working.

Generally speaking, however, it is more difficult to obtain so high a proportion of effective to non-effective engine time with goods traffic. The wider choice of time at which the less important goods trains may be run tends to ease the situation in this respect, though any apparent gain in engine cost must be carefully balanced against possible loss in other directions. The variation in the amount of goods traffic passing to the different destinations makes it impossible to provide a definite booked service for the whole of it. It is generally agreed that trains for the conveyance of goods traffic should, as far as possible, be booked, so that the advantages this gives in the economical arrangement of engine power and train crew working, in the organisation of the work at station and marshalling yards and in the working of trains over the running lines, may be obtained.

## CHAPTER VII

### THE WORKING OF SHIPMENT MINERAL TRAFFIC

FOR operating purposes mineral traffic may be <sup>Classification</sup> divided into three classes, viz., that consigned in <sup>of Coal Traffic.</sup> small quantities and usually disposed of by retail merchants, commonly known as "Landsale"; that consigned in large quantities for use in such places as iron and steel works and other large works and factories, usually known as "Industrial"; and that consigned to the different coal shipping ports for shipment either to some other British port or abroad, called "Shipment." By far the greater proportion of such traffic is coal, and the traffic will, therefore, so be described throughout this and the following chapter. To the extent that coke, limestone, or other minerals are concerned, all that is necessary is that the reader shall substitute for the colliery the coke-oven, the quarry, or other point of origin. The principles underlying the conditions of working remain the same. Similarly, the principles underlying the working of industrial coal compare with those of shipment coal, except in so far as the latter is more liable to be affected by unforeseen changes of conditions at the receiving point than the former.

The degree to which the working of landsale traffic can be compared with either of these on the one hand, or with goods traffic on the other, varies. It is usually lifted from the colliery either along with, or in a similar manner to, that of the other classes, but except in those cases in which the merchants work on a very large scale, frequently receives similar treatment to wagon load goods traffic from the first marshalling yard. Space does not permit of a detailed consideration of the different classes of traffic separately and that available will, therefore, be used in the consideration of the working of shipment coal traffic.

So far as conditions which affect train working are

concerned, the principal points of difference as compared with goods traffic, are that shipment coal traffic is normally consigned in much greater quantities nominally at any rate in train loads, that there is usually a regular balanced working in the reverse direction with the empty wagons, and that since, generally speaking, shipment coal is carried in other than railway-owned wagons, the consignor of the traffic has an interest in the transit of the wagon as well as of its contents. The two former make a good deal of direct working possible without risk of counterbalancing losses in other directions, and the wagon or ton-mile per train-engine hour figure becomes a truer index of efficient train working. There are, however, certain conditions other than train working, ones which need careful consideration.

Terminal  
Difficulties.

There can be little doubt that it is in the general interest that a minimum time shall be taken from the coal leaving the screens at the colliery to its arrival at the ship's side. It only needs a little thought to see that the expense of every part of the operation is thereby reduced.

However efficient the selling organisation of a colliery may be, there are times when the state of the market is such that it is not desirable to dispose of the whole output of the colliery currently. The high standing charges which must be borne by a colliery whether coal is produced or not make it desirable that coal shall continue to be produced even when there is no immediate market for it. Being a comparatively bulky article, the provision of storage accommodation is a matter of some difficulty, and in any case the ultimate loading to wagon from store is liable to involve considerable expense. It is, therefore, usual to store in wagons, and since many collieries have not sufficient siding room to stand the wagons on their own premises, a fairly general custom has grown up of allowing a considerable proportion of such wagons, with their contents, to be stored on railway companies' sidings. It is true that such wagons must be consigned to some destination before this is done, but since it is known there is no immediate outlet for the coal so consigned, it is equivalent to sending to store.

Again, most collieries "make" several qualities of

coal, but in varying quantities. To the extent that a colliery cannot fill sufficient of the right quality of coal to meet an order in one day, it is necessary to accumulate that quality for two or three days until the full quantity is available.

At the port end, the difficulty is that however carefully the journeys of ships may be planned, weather and other conditions which cannot be foreseen or avoided upset the plans, with the result that a ship may arrive at the port for its coal cargo later than the expected time, without sufficient notice of the change being available to prevent the coal reaching the port in time to be shipped on the original date.

The terminal conditions are also liable to be affected by certain geographical considerations. The chief of these are the distance to the port from the coalfield, and the choice of markets which the position of the coalfield in relation to the port, on the one hand, and industrial districts which, as consumers of coal, may be regarded as being in competition with the demand at the port, on the other, afford. In both cases the Durham and the Notts and Derby fields present the most striking contrast. In Durham many of the collieries are within a few miles of the port, and the average haul thereto is probably under, rather than over, twenty miles. Moreover, the industries which make large demands upon the coal supply are grouped around the ports, and are such that only a small proportion of the total output is required by them.

Location of  
Coalfield in  
relation to  
Markets.

The principal shipment ports for the collieries in the Notts and Derby fields are the Humber ports on the east, and the Mersey ports on the west, with an average haul of about 70 miles. This coalfield also supplies a very heavy industrial demand in the Midlands, as well as a considerable landsale demand for London and its suburbs. It is, to a certain extent, true to say that the effect of the longer haul is to necessitate an increased standage at the port to meet the contingencies of the longer journey. Such contingencies, however, are almost entirely confined to those inherent to staging, and may be considerably reduced by through train working. After all, the difference in the time taken on the journey, even for

an additional 50 miles, is not great when compared with the time necessary to ship an average cargo of coal.

The effect of the other geographical consideration mentioned is liable to vary. Where the choice of market is restricted the steady flow of traffic to its usual destinations makes it easier to arrange regular train services so long as conditions at the consumption point remain normal. Should, however, adverse weather or other conditions arise at the terminal, congestion, eventually leading to the stoppage of the collieries, soon follows.

The  
"Release"  
System.

In detail, the arrangements made between the collieries, or their port representatives, and the railway companies in regard to the movement of shipment coal vary at the different ports, but in relation to one important principle they may be divided into two groups, viz., those in which traffic intended for export may be sent without the permission of the railway representative, and those in which a definite permission, usually called a "release", must be obtained for each consignment before forwarding.

The release system demands the appointment of a special railway staff to collect and record the data on which the releases are based, but enables considerable economies in siding accommodation and shunting costs to be made. There are times when—if strictly applied—it appears to be to the disadvantage of the colliery, because it limits the extent to which the railway company's sidings may be used as storage sidings. It must, however, be remembered that even with a release system it is necessary to order coal forward some little time before it is actually required to cover the risk of possible contingencies on the journey, and that this also provides a margin to the colliery whose output is rather in advance of its orders.

It has, moreover, certain direct advantages even from the colliery point of view. The more definite information which the release system gives enables the colliery whose sales are in line with or in advance of its output to postpone the filling of coal to meet a particular order to the last minute, thus giving a better wagon user and quicker return on the money represented by the coal.

On the other hand, the open system does appear rather to encourage slack salesmanship and give opportunities for an undesirable type of speculation in coal, both of which are against the interest of the colliery, both as coal and wagon owners, as well as that of the railway.

Apart from such considerations as these, a very serious disadvantage of the "open" system is that at busy times—since there must obviously be a limit to the amount of standage accommodation at any port—a system of regulation must be introduced. Speaking generally, in the desire to postpone what is regarded as the evil day as long as possible, the port becomes badly congested before the attempt to regulate is made. Besides this, the difficulty of introducing an efficient regulation system at short notice and at an especially busy time is very considerable.

There is really no reason why equally efficient train working arrangements should not be applied with an "open" as with a "release" system, but in practice they usually can be conducted more economically and efficiently under the "release" system. This system necessitates a clear understanding being arrived at daily between colliery and railway officials as to what traffic will be lifted the following day, and it is a very short step further to add to it a mutual arrangement as to the time at which the necessary trains shall be run, to the advantage of both colliery and railway company.

A unique form of what is, in effect, a "release" system is in operation in the Durham and Northumberland coalfields. Here, the whole of the wagons are, contrary to the usual practice, supplied by the railway company. Briefly, the system is as follows:—Each colliery is supplied with sufficient empty wagons to hold rather more than one day's output of coal. Theoretically, it does not matter whether these are loaded or empty, though actually a colliery which regularly had a surplus of empty wagons would have its allotment reduced. As loaded wagons are lifted, equivalent empty wagons are supplied. Coal for shipment is not, however, lifted until a few hours before it is required at the port, so that to obtain empty wagons a colliery must sell its coal for immediate

shipment. To those accustomed to the greater freedom of action which the colliery ownership of the wagon appears to give, the system seems to be a somewhat arbitrary one, but it has many advantages, and complaints of wagon difficulties are probably not greater than in those coalfields where the majority of the wagons are privately owned.

The  
"Private"  
Wagon.

The whole question of the advantages or otherwise of the private as compared with the railway ownership of wagons for coal traffic has recently attracted renewed attention as a result of the evidence presented before the Coal Commission.\* The most conservative estimate placed before that Commission of saving in railway operating costs by the elimination of the privately owned wagon was somewhere between £600,000 and £1,000,000 per year.

To this must be added the saving in operating cost in the colliery yards. The latter would be avoided if the wagon ownership was restricted to the colliery company; at present, however, there is a growing tendency for the receivers of coal to provide their own wagons. The increased cost of shunting necessary to get the appropriate wagon under the screens at the appropriate time, and of providing sidings at the colliery in which to store the empty wagons which for the moment are not required—all of which must be borne by the colliery—is, to some extent, comparable with the expense caused to the railway companies as a result of the colliery ownership of wagons. The railway costs are, of course, also increased to the extent that the number of private owners is increased.

The principal advantages claimed by the advocates of railway ownership, amongst whom are many who have no direct interest in either railway or colliery management, are :

(1) The saving in the cost of the shunting necessary for sorting. With common ownership wagons may be worked direct in train loads from the empty roads adjoining the shipping appliances to the collieries, while private ownership necessitates at least one, usually two, and often three or more sorting

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\* Students are recommended to read the chapters entitled "Conveyance of Coal" in the *Report of the Royal Commission on the Coal Industry (1925)*, Vol. I. Price 3d. H.M. Stationery Office.

operations between the shipping point and the colliery.

(2) The saving in journey time of the empty wagons by the avoidance of this staging. This would enable an equal amount of coal to be carried in a considerably reduced number of wagons with an equivalent saving in capital expenditure and some saving in maintenance cost.

(3) The siding accommodation at present used for sorting the empty wagons would be unnecessary, and, since such sidings could, as a rule, be employed usefully for other purposes, a saving in capital as well as maintenance cost may be claimed.

(4) A further reduction in wagon stock would be possible because of the equalisation of the shortages and surpluses over the whole of the collieries on a railway system. At present one colliery is often short of wagons whilst an adjacent one has a surplus. Under private ownership each colliery must have a surplus to meet emergencies. Since it is most unlikely the emergency will arise at all the collieries at the same time, a common ownership of wagons would enable business to be carried on at least as efficiently with a smaller total surplus.

The principal arguments advanced against railway ownership—they could not be applied with the same force against common ownership—are :

(1) That private owners obtain supplies of wagons and maintain the same more cheaply than railway companies.

(2) That the railway companies would refuse to supply a sufficient surplus to enable the wagons to be used for storing coal when the state of the coal market made this desirable.

(3) That the supply of wagons for coal would not be sufficiently reliable to meet the special requirements of particular industries to whom a regular supply of coal is a vital requirement.

Dealing with the third point first, it may be stated that the experience of those areas where the railway company own practically all the mineral wagons rather shows that there is no need to be apprehensive on this ground. Against this, however, the adherents of private ownership point out that the railway



companies themselves retain a special type of wagon for carrying locomotive coal. Apparently, therefore, they are willing to incur the additional expense of sorting a special type of wagon to ensure the regular supply of coal which is essential to their own industry. This, however, is only partly true.

The principal reason for the supply of a different type of wagon for locomotive coal in those areas where the railway company own the wagons used for shipment coal is that the type of wagon used for the latter is not suitable for locomotive coal. In the areas where the railway company only supply a small proportion of the wagons, the fear is that, unless a certain number were specially ear-marked "for locomotive purposes," wagons supplied for the purpose of loading locomotive coal would be used by the collieries for other purposes in times of wagon shortage. It is generally admitted that there is some force in the first two arguments.

Much more powerful factors in maintaining the present position, however, appear to be the facts that the railway companies do not wish to embark on the capital expenditure which the provision of wagons for coal traffic would involve, and that the present difference in the rates for carrying coal in owners' as compared with railway, wagons, is such that the private wagon owner can show a sufficiently substantial profit on the business to make him anxious to retain it.

Influenced by such considerations as these, the Coal Commission recommended that, as an alternative to private ownership, some of the advantages of common ownership should be reaped by the pooling of the private wagons owned by a number of collieries in the same district. This recommendation appeared to be based on the evidence of certain colliery companies who had already done this. The advantages of pooling in this way are :

(1) If done on a sufficiently big scale a smaller total number of wagons is necessary because the reserve of wagons would be available for use at any of the collieries which, owing to exceptional circumstances, needed it, instead of a separate reserve having to be kept for each colliery.

(2) Less time is taken to return the empty wagons to

the collieries. This is achieved in three ways. Certain marshalling yards at or near which coal wagons are unloaded do not get sufficient empty wagons belonging to any one colliery to make a train load, and consequently must stage them to another marshalling yard. If, from the whole pool, as would often be the case, a train load was available, this staging and consequent additional transit time would be saved. Again, even the second marshalling yard might not be able to make up a through train to all the different collieries, but only to some of them. To that extent a further staging would be saved. Even, however, where a marshalling yard obtained a sufficient number of the wagons of each colliery in the pool in, say, twenty-four hours to make a train to each colliery without a pooling scheme, considerable time would be saved in regard to most of the wagons by pooling.

If, to take a simple illustration, we say that there are four collieries in a pooling scheme, one load could be despatched at the end of each six hours, so that the last load only, representing a quarter of the wagons, would take the full twenty-four hours.

The proportionate saving in wagon user which may be expected from a pooling scheme will necessarily depend upon local circumstances and the kind of trade in which the wagons are employed. The writer has had an opportunity of examining a scheme which was already partially in operation, and in which, therefore, there was a fair amount of reliable data available. A most conservative estimate of the saving in wagon user to be made from the complete scheme was one of 10 per cent., no inconsiderable sum when the capital value of the wagons this represents is considered. The saving in operating expense which such schemes would bring would depend upon the size of the pools and the extent to which the merchant wagon owner, as distinct from the colliery wagon owner, was concerned in them. To the extent to which a higher degree of direct working was made possible, the shunting costs at what would otherwise be the staging points would be avoided, while the reduced number of destinations would tend to reduce costs at the yards it was still necessary to enter. Where, however, one or more merchant owners con-

tinued to send their wagons to special collieries in the pool in any considerable quantities, the savings under the latter head would be considerably reduced. It will be seen, therefore, that pooling gives the same sort of advantages as common ownership, but restricts them to the degree to which the pooling goes in that direction.

High Capacity  
Mineral  
Wagons.

Whilst dealing with the wagon question, reference must be made to the desirability of an increase in carrying capacity of the wagons used for mineral traffic. The capacity of the standard mineral wagon in use up to a comparatively few years ago was approximately  $2\frac{1}{2}$  tons, and there are people alive to-day who can well remember the objections which were raised when wagons to carry as much as 8 tons were introduced. This capacity has gradually increased, until to-day—with the exception of the Durham and Northumberland coalfield, where the standard may be regarded as 20 tons—the 12-ton capacity wagon is recognised as the standard. The subject is dealt with fairly fully in the report of the Royal Commission on the Coal Industry, previously referred to, from which the following summary of advantages, given in evidence by Mr. W. T. Stephenson, is quoted:— “The 20-ton wagon, as compared with the 10-ton wagon, gives an increase in carrying capacity of 100 per cent., with (a) an increase in tare, i.e., non-paying weight of between 33 to 50 per cent. ; (b) an increase in length, and, therefore, of siding accommodation required at every point at which the wagons are liable to stand, of from 16 to 30 per cent. ; (c) an increase in the gross load of the locomotive of at least 10 per cent. ; (d) a reduction in shunting work owing to the fewer wagons employed ; and (e) a saving in total wagon capital cost of 25 per cent.” To these might have been added the advantage that the rate at which shipment can be carried on is dependent to a much greater extent upon the number of wagons than upon their capacity, and that at a moderate estimate the speed of shipping from 20-ton wagons is 50 per cent. higher than from 10-ton wagons.

Desirable though the gradual adoption of the 20-ton wagon as the standard may be, its adoption

will probably be seriously delayed because of the expense it will be necessary to incur at loading or unloading points which are not at present equipped to deal with wagons of such high capacity. That such an expenditure would, in the long run, show a return can hardly be doubted, but so long as wagons are, on the whole, privately owned, the risk of the expenditure being to a certain extent wasted, because it is undertaken too soon, will probably lead to the postponement of the necessary alterations, especially at the docks, where the greater part of the expense will be incurred. This, in turn, will discourage the wagon owners from adopting the higher capacity as the standard, so that until some sort of an agreement can be made between the private wagon owners and the railway and dock companies, there seems to be little prospect of much progress being made.

We have already referred to the difficulties at the port terminal when circumstances at the colliery make it desirable—or irregular arrivals of vessels make it unavoidable—that considerable stocks of loaded wagons should accumulate there. These are liable to be increased almost *pro rata* according to the number of merchants or exporters operating at the port, the number of collieries from which the coal is drawn and the number of qualities of coal made by each of them.

Whatever there may be to say from the consumer's point of view, of the advantages of buying coal by class, based on analysis, as compared with buying it by name, a good many of the operating difficulties which the present method causes would be reduced very considerably if we followed the example of our American friends in this respect. If, in addition, we could copy another example set by America, and pool the ownership of the same class of coal after it has reached the port, very far-reaching advantages to all concerned would be obtained. Until something on these lines can be done, the problem of how to handle the coal after its arrival at the port storage sidings waiting its turn for shipment will continue.

The two principal considerations are (1) that the wagons of coal to be stored shall so be arranged that a minimum of time shall be necessary to get them into appropriate loads for shipping after the advice is

received from the dock that the ship is about to obtain a berth and the coal for it is required on the appliance lines, and (2) that the cost of necessary sorting shall be as low as possible.

With a strict release system in operation, probably the soundest way from both points of view is to allocate in the storage yards sufficient siding accommodation to store the complete cargo for a ship immediately the release is issued for it, and to arrange for the coal to be sorted into the appropriate sidings immediately on arrival. In this way the wagons are only handled once, and, except when there is more than one quality of coal for the same ship, no further sorting is required. Without a release system, however, much traffic is liable, and indeed certain, to come forward so long in advance as to make it impracticable to allocate the sidings in this way. Even if this difficulty could be overcome, the chances of the coal being transferred to other owners and/or ships after arrival at the storage sidings would be such that considerable further shunting would be required.

The alternative remaining ways appear to be to sort on arrival according to the merchants, or according to the colliery and quality—or not sort at all. The last of these is probably the most expensive in the long run, although, without an allocation system, it is the method which is almost invariably forced into operation. The additional shunting costs involved in the second and third handlings, which either of these alternative methods involves varies according to circumstances at the different ports, as does also the time taken to collect the necessary loads for the docks when required there. The sorting to ship on arrival method has such considerable advantages over any of the others, from both points of view, that it can almost be claimed as one of the additional advantages of the "release" as compared with the "open" system.

## CHAPTER VIII

### TRAIN AND TRAFFIC CONTROLS

**I**N recent years the term "Control" has been applied <sup>Meaning of "Control."</sup> to many different aspects of railway work. It is desirable, therefore, to define its use in general before dealing with the two particular applications of it used in the heading given above. On broad lines we may say that the term "Control" has been applied to any system in which the current information necessary to enable instructions to be given in regard to the movement of vehicles, trains or staff in a specified area is concentrated at a central point, from which such instructions are given, or previous instructions modified, as may be necessary from time to time to meet the constantly changing conditions inherent to certain phases of railway working.

The size of the area may differ from, say, the different groups of sidings and lines connecting them, which together form the railways of a moderately large town, to the whole of a large railway system; but wherever we get such concentration of information and decision it would appear to be sound to say that the principle of control is in operation. The usual means employed for transmitting the messages which must pass between the controllers and the staff in the control area are the telephone or telegraph, because the sections of railway business to which controls usually are applied require quick decision, but we cannot say that the principle of control is affected thereby. We can only say that without the quick means of communication which these media provide certain controls would not function efficiently.

Similarly, most existing forms of control use some special apparatus, which we will discuss in detail later, to enable the controllers more easily to visualise the position indicated by the received messages. Here again, the absence or presence of such apparatus does not affect the control principle.

Train or  
Traffic Control.

Having thus attempted to make clear the general idea underlying the term "Control," it is equally important to arrive at a clear understanding of the meaning of the qualifying terms "Train" and "Traffic" as applied to controls.

Originally, they were used synonymously, and to a considerable extent are still so used. Recently, however, there has seemed to be a growing tendency to use them in a way which appropriately describes the two fairly clearly defined functions which experience has shown can be applied with most advantage to controls as we now understand them.

On those lines where controls have not been introduced, the work of making adjustments to the booked working, and arrangements for the unbooked working, of traffic over the railway is divided between two groups of staff. To the extent that they involve decisions as to what time trains should leave the termini, what traffic they should convey, what the engine and guards working should be, and so on, they are in the hands of the station or yard masters (or similar officials of other names responsible for the work of the termini).

When the trains have left the termini and are on the running lines, the responsibility for settling which train shall have preference at a junction, the stage at which a slower train shall be shunted or diverted to enable a faster one to pass it, and so on, is in the hands of the signalman. There may be, and occasionally are, cases in which it is desirable, even while trains are on the running lines, that what we may call traffic conditions—say, the urgency of a particular consignment—should override train conditions—that is, the getting of the trains over the line with due reference to their normal importance with a minimum of delay.

Generally speaking, however, the two functions we have described are quite separate. The application of the term "Traffic Control" to one whose functions are comparable to those just described as belonging to the station or yardmaster, and "Train Control" to those belonging to the signalman, enables a fairly clear and simple line of demarcation to be made. Whilst there are controls in existence which come

within the limits of either of our definitions, the majority of the better known systems combine the two functions described, though in widely varying proportions. In some, the train control function predominates, the traffic arrangements being left almost entirely in the hands of the staff in charge of the termini. In others, the traffic side is predominant, the signalman retaining his duty of deciding which train shall have precedence over the running line. In others again, both functions are completely transferred to the control.

There is also a considerable degree of difference in the extent to which passenger trains are brought within the scope of either traffic or train controls. The *raison d'être* of traffic controls may be said to be the fact that the constantly changing conditions make it impossible to book accurately the whole of the working. This applies with very much greater force to the freight than to the passenger working.

Similarly, on the train side, the general rule is that the passenger train adheres to its booked working, and there is far greater scope for the controller in connection with the freight trains. It is, of course, true that a high degree of train control is not possible unless reports are received in regard to all trains. In most of the cases, however, in which a complete control of passenger trains was introduced, there has been a tendency to modify it, in some cases even to the extent of only receiving information in regard to the running of passenger trains when they are sufficiently out of course to be likely to affect the running of freight trains, or in other exceptional circumstances. On the other hand, many control systems which, at the outset, had no concern with passenger trains, have later extended their functions to about the same degree.

The principal advantages, common to either train or traffic controls, arise from the fact that the information available to the controller covers a greater area, and thereby enables him to give a sounder decision than one whose view is restricted to a portion of the area only. A less obvious advantage is the scope they afford for the prompt collection of information considered necessary for supervision purposes.

There is a wide difference of opinion amongst rail-

Control of  
Passenger  
Trains.

Advantages  
Controls.



way officials as to the extent to which it is desirable to collect data on which to criticise the train and traffic working arrangements after the event. All, however, are unanimous in agreeing that whatever information is collected for this purpose should be available promptly, so that any question raised may be dealt with whilst the incidents are fresh in the minds of those concerned. The data which must be available in a control if proper decisions are to be given is exactly that required for criticising the results following from such decisions. With little, if any additional work, therefore, records suitable for supervision purposes can be compiled in a control, and thus be available for immediate use.

Train  
Controls.

To take train control first: the controllers, receiving as they do full reports from all the points in their area, and, where desirable, beyond it, are in a better position than the signalmen to see more accurately what the position is and, therefore, to judge what is the best way to act. Against this, the control view, though wider, is apt to be a little less exact, and there are cases in which the short time spent in receiving a report from a signalman and giving a decision back to him may make the difference between a train getting a run in front of a following train or the former having to be shunted if delay to the second train is to be avoided.

Further, a train control is apt to take away the initiative of the signalman, and thus make his work almost purely mechanical, except in emergencies. Both these features point to the desirability of encouraging the signalmen to continue to take an interest in the business of regulating trains, even where train controls are in operation. They also appear to indicate that whilst a purely train control system would be of some value in an area consisting of a number of short lines connected by junctions in varying directions at frequent intervals, it is doubtful whether its expense could be justified on more normal British lines. On the busier of these, however, it probably would be of value in those cases where, a traffic control having been established, a certain amount of train controlling could be carried on without materially adding to the expense of installing and working the control.

There appears to be a much stronger case in favour of traffic control. The more comprehensive view gained by centralising the information in regard to the traffic to be moved and the engines and train crews which are, or may be, available to move it, makes it possible to see the most economical way of working the traffic as a whole. Traffic Controls.

Without a control, it is only natural, however much consultation there may be between those responsible for the working at the different termini, that the tendency will be for each to look after the interests of his particular terminal. Moreover, none can get a sufficiently clear view of the whole situation to give the best decision. Thus a controller can make the following savings :

(1) In engine power, both by getting the fullest use out of the engines which are already working, and by ordering any additional engines which may be required in such a way as will cater best for the traffic as a whole. Both these tend to eliminate light running and, incidentally, to reduce the number of trains over the line, which, in turn, decreases the possibility of delay to the remaining trains.

(2) In staff, both by using the train crew available to the best advantage and by making the best arrangements for relief where, either because of the long journey, or delays, the trips cannot be completed within the recognised standard day.

(3) In the quicker movement of loaded or empty wagons. Theoretically, it ought, perhaps, to be possible to get equivalent speed of movement of traffic without control. In practice, however, the small proportion of time which the yard staffs can devote to this portion of their duty prevents their doing so. They are liable to be so busy with the shunting work on hand that they have not time to think of the movement of traffic from the yard. Moreover, the controller, with the advantage of additional information at his disposal, can often make arrangements for the removal of traffic from a yard before the train conveying it arrives there. Generally speaking, the yard staff must wait for its arrival before they can begin to act. The last, though by no means the least important, of the advantages is that

derived from the superior position of a control when accidents or other circumstances, such as fogs, snowstorms, etc., make it desirable to stop or divert certain trains or traffics.

It may be argued that this advantage should be claimed for the train, as well as the traffic control. If, however, the clear distinction is kept between these two, it will be seen that this is only true in so far as the train control, under such circumstances, temporarily becomes a traffic control. The extent to which these advantages may be gained will be limited by the extent to which the density of traffic in the area and other local conditions indicate the need for some co-ordinating power.

Dangers of  
Controls.

The possible disadvantages of control systems, which should, perhaps, be referred to as dangers rather than disadvantages, since they are not inherent, are that in lieu of exercising their proper functions the control either rely entirely upon the outside staff, and merely act as recorders of what has happened after the event, or, on the other hand, that they ignore the outside staff so completely that the latter lose all interest in work in regard to which their local and exact knowledge may be of the utmost value.

We frequently hear that the argument against the adoption of an automatic method of bringing a train to a stand if a driver should happen to pass a signal at danger is that it would tend to create a type of driver who relied upon the safety device so much that he became less careful. The removal of responsibility for train and traffic movements from the staff most closely in touch with them is liable to react in a similar way. However carefully a control system is planned, and however skilfully it is operated, some loss in this direction is almost certain. It may be minimised in so far as the system still leaves with the outside staff the responsibility of advising the control, and the skill with which the control staff take advantage of such advice and only overrule it on those occasions when their wider view enables them to see that the line of action suggested is not the best. In such cases, the reason why the advice given was not acted upon should be explained.

As already indicated, it is customary to equip a

control with telephones to expedite the collection of information and distribution of instructions, and with some form of diagram board to assist the controllers to visualise the position indicated by the various received messages. Little need be said in regard to the former. The circuits and the terminals at the control end should be arranged in the way that is most convenient for the controller who requires to use them. The means of calling attention in the control should be visual and not aural, and the arrangement for obtaining attention from points outside the control such that it may be obtained with a minimum of movement on the part of the controller.

Whether a diagram board shall be used, and, if so, what type it shall be, is a more difficult question. There are few controls where boards of some type are not provided. Nevertheless, many experienced railwaymen are of opinion that they are of more value to the casual visitor to the control than to the controller. To use the old army term, they are "eyewash." The belief is strengthened when it is discovered as it is frequently possible to do, that the diagrams are by no means always kept up to date, and that in some cases where this is done under normal conditions, it is the first work to be neglected when any special emergency increases the pressure on the control staff. The correctness or otherwise of this view can hardly be other than a matter of opinion. The writer's view is that, in the cases in which it is to some degree true, this is due to one of two causes. Either the type of board is not suitable for the conditions of the area, or the traffic is so light or the area so small that the controller is not being occupied to the limit of his capacity. With the assistance rendered by a board, if properly used, he could deal efficiently with a greater area. If we agree that a board does help by enabling the controller to visualise the position more quickly and accurately, we may say that it follows that, in selecting the type of board to be used, we shall be guided chiefly by this consideration. A secondary, though quite important, consideration in so far as it may affect the number of staff required in the control is that of the ease with which the board may be kept up to date.

The Value of  
Diagram  
Boards.

While there are many variations in detail, the majority of the diagram boards in use in this country fall into one of two classes. In one class the lines are either painted or modelled upon the board, so as to give a more or less correct geographical representation on a small scale of the actual railway lines in the area. In most, the lines are, as a matter of convenience, diverted from the natural course to some extent, varying from the flattening of a curve to avoid an undue extension of the board to an absolute straightening out of all lines. The names of the stations and signal-boxes are shown in their respective positions, whilst such features as marshalling yards, standage sidings, relief sidings and so on are more or less completely indicated, figures being added to show the lengths of the different lines or the number of wagons each line will accommodate.

The other type follows very closely the form used for the now familiar train timing diagrams. The names of the stations and signal-boxes are arranged in order down the left-hand side of the board. Most of the remainder of the board is divided by vertical lines into spaces representing time intervals, provision being made for 12 hours. In details, the methods used in different controls vary considerably. In general, we may say that in most of them provision is made whereby particulars of traffic to be lifted are reported to the control. The controllers record this either on a small ticket, which is placed in a clip near the point concerned, or on some suitable form. As the engines which have been ordered come from the engine-shed, small models or tickets are used to represent them, on which is put the information necessary (usually the engine number, destination, load, if any, and time the engemen signed on duty). As the reports of their movements are received, the models or tickets are moved to the appropriate point, thus enabling the controller to obtain a comprehensive view of the position as a whole.

The "geographical" boards, if made to represent anything like a really correct view, give rather a better picture. On the other hand, the other type, which we may call the "time" board, can usually be made to occupy less space and has the advantage of

drawing attention to any slackness in reporting on the part of the outside staff, because the train concerned will be behind the general line of tickets representing the trains which have been correctly reported. Probably the former type has a little advantage from the traffic and the latter from the train control point of view. In neither case, however, is the advantage considerable. Controllers who have used both systems appear to have difficulty in deciding which is the better. It is more a question of use.

Both types, however, possess the serious disadvantage that, apart from the taking of special records for the purpose, they afford no permanent record of the working. We not infrequently hear the view expressed that this is not necessary, and occasionally that it is undesirable. When we remember, however, that the controller is normally working under high pressure and giving a series of important decisions with very little time in which to consider them, constructive criticism of his work would appear to be even more desirable than in many other cases. Far from destroying the confidence of the controller, it should, applied intelligently, strengthen it.

Comparatively recently, experiments have been made to cater for this weakness by the substitution of a paper diagram for the diagram board. The form used is prepared on similar lines to that of the "time" diagram board. Down the left-hand side of each day's sheet are shown particulars of the stations and signal-boxes, the intervals between them representing to scale, the time-distances of a standard train as previously described. Along the top and bottom margins of the form are a succession of rectangular spaces, suitably ruled, in which the information corresponding to that placed on the tickets may be entered. The body of the form is covered with a series of perpendicular lines. These represent, to a suitable scale selected according to the density of the trains, time intervals, the lines representing the hours, half-hours and quarter-hours being printed in slightly heavier type for convenience of reference. Under the names of the stations and signal-boxes already referred to as being on the left-hand side of the form are horizontal lines, which are continued for the full

The Daily  
Diagram.

distance across the form. Normally, the forms are sufficiently wide to cover a day's working. The paths of the passenger trains are printed on the forms, being indicated by a series of thin dotted lines. In principle, the forms are used in an almost exactly similar way to the boards. In place of recording particulars of train movements on small tickets, the particulars are filled in on the appropriate rectangle. In place of the ticket being moved when a report is received of the movement of the train it represents, a point is made at the appropriate place on the graph, the different points being connected by pencil lines.

It will be appreciated, therefore, that if the trains were all through trains, the controller would be gradually completing a series of oblique lines. In so far as the trains stop for any purpose, the arrival and departure times are indicated by horizontal lines. Some of these horizontal lines represent stops for traffic or locomotive purposes, and, to the extent they do, the normal colouring of the lines is adhered to and a small letter placed over the line to indicate the reason for the stop. Where, however, the lines indicate that delay has taken place, a red pencil is used, so that all delays stand out clearly from the rest of the graph. Should exceptional delays take place, the controller ascertains the reason and makes an appropriate note, either alongside the train or in the margins at the top or bottom of the form.

Where duplicate running lines exist, the running of the train on the duplicate line is indicated by a different colour. Separate diagrams are kept for up and down lines, but if a train passes from one line to the other, a suitable reference is made to the appropriate diagram. For convenience of handling, the diagrams are carried in suitable holders, so arranged that sufficient of the graph to represent three or four hours' working is in sight, while a quick reference can be made in either direction if any longer period than this is concerned.

The diagrams are considered to have numerous advantages over the more usual diagram boards. If anything, they take rather less time to compile than is necessary to keep the board up-to-date, and are a greater help to the controller in visualising the general

position than either the "time" or "geographical" form of board. Further, they bring vividly before the notice of the controller the result of any action he may have taken. The experience thus obtained is often a valuable guide to him as to the action he should take in similar circumstances in future.

Considerable as these advantages may be, and indeed are, advantages to be obtained outside the control must be added to them. Each day's diagram, when completed, gives a complete picture of the running of the trains over the lines concerned for that day in relation to each other. The reasons for the delays can be seen, and the extent to which adjustments must be made to avoid them on future days can be calculated.

The Value of  
a Daily  
Record.

There is considerable difference of opinion as to whether the cost represented by inquiries into train delays as reported on guards' journals or from signal-box records of the running of individual trains, is worth while. There can, however, hardly be two opinions as to the value of a record such as that described. It must be remembered, also, that this use is only a secondary one, and, if it is agreed it is desirable for controlling purposes, entails no additional cost. The diagrams also direct attention to the density of trains over the line during the different hours of the day, and indicate the possibilities in the direction of lengthening block sections by closing signal-boxes on the one hand, or the desirability of shortening the existing block sections on the other, either for portions or the whole of the day.

In so far as the advantages of the control system arise from the fact that the concentration of information in regard to a wider area enables a wider view to be taken before the instructions are given, it would appear to be true to say that the bigger the area controlled from any one centre the greater the chance would be of reaping the maximum advantage. No unbiased observer of the effect of the control system, however, can help but admit that some loss occurs by reason of the lack of the personal touch which results. To the extent that the control area is increased, this loss is increased.

Size of  
Control Areas.

Apart from this, the cost of extending the tele-



phone circuits tends to be prohibitive if the area is too large. On the other hand, a small control area is not in a position to reap anything like the full advantage of the control system. The desirable size can hardly be settled in terms of mileage, but must rather depend upon the general layout of the lines concerned, the traffic density, the positions of the marshalling yards, and other similar considerations. The general aim should be so to plan the boundaries that the working in the area is as far as possible self-contained. The division of the control area into sub-areas should follow the same general lines, and be such that each controller may, as far as possible, control his trains for the whole of their journeys, and not have to hand them over to another controller.

Organisation  
of Control Staff.

The division of duties within the control is also a matter of some importance. The receiving of the messages and the correction of the diagram to correspond is more or less mechanical work. The really important work is that of deciding what instructions shall be given. At first sight, therefore, it would almost appear to be sound to employ low grade assistants for the former work, and thus, by relieving the controller of it, enable him to look after a larger area. There are, however, one or two rather strong reasons against this. In the first place, the person who has actually received the messages and recorded them is more likely to have a full appreciation of the position they represent than can be obtained from a glance at a diagram.

Besides this, the position represented by some of the messages demands that immediate instructions shall be given. The passing of the message through a third party wastes valuable time. Further, if the point previously made as to the outside staff assisting the control is accepted, much of the information conveyed rather takes the form of conversation than definite messages. Their real meaning is liable to be lost if translated into the simple movement of a ticket, even though supplemented by a brief remark. For these reasons, it would appear that the better way is to make the sub-areas of such size that the controller in charge can receive and record all messages, and issue all instructions direct.

We have confined our consideration of controls to the functions we have described as train and traffic respectively. Space does not allow us to do more than suggest the possibilities of further concentration in the direction of combining with these such functions as that of the control and distribution of rolling stock, the regulation of shipment mineral traffic and other similar functions, which, in many controls, have already been combined with considerable advantage.

An indirect advantage of the extended use of the control principle in these ways is that it makes it possible to bring within the system, lines which would otherwise be excluded, because the advantages to be gained by doing so would not justify the cost of the necessary equipment.

## ELECTRIFICATION

**I**GNORING certain distinctions which we may regard as belonging to the engineering rather than the operating side, we may say that the essential difference between steam and electricity, considered as motive powers in connection with the hauling of trains, is that the former must be manufactured on the engine which is used to haul the train, while the latter can be generated elsewhere and transmitted to the engine as required. Because of this difference, the use of electricity gives many advantages. As indicated in a previous article, the design of a steam engine must be in the nature of a compromise between speed and load capacity. The former is limited by the power to haul—the tractive force—which, in turn, depends upon the amount of effective steam available, and by the strain which the reciprocating portions of the engine will stand: the latter by the friction existing between the driving wheels and the rails—the adhesive force—and is dependent upon the weight carried over the driving wheels.

The necessity for carrying the part of the engine which we may describe as the steam-raising machinery within the limits of the loading gauge and of applying the motive force through cylinders, piston rods, etc., imposes very much greater limitations upon the steam locomotive in these respects. An electric train can, therefore, be started, or where already started, accelerated, much more quickly than a steam train. On the other hand the electric power may be applied with a retarding effect and so supplement the braking power of the air brakes. Consequently, the electric train can also be stopped more quickly.

These two features have special value on lines over which a very frequent service of trains is desired. The quicker movement has the effect of shortening the lengths of the block sections, whilst the more

Special Value  
of Electricity  
for Suburban  
Traffic.

rapid deceleration makes it possible actually to shorten them. This increases the number of trains it is possible to pass over the lines in a given time, whilst the quicker movements to and from the platforms increase the platform accommodation.

As indicated in previous articles, much can be done to improve terminal accommodation by careful layout, improved signalling methods, etc., but even greater advantages can be gained by combining these with electrification.

The reduction in the time taken to get an engine into service may be mentioned as the next advantage which electricity gives. Assuming the necessary overhaul was made on the completion of the previous trip, it is available for use at a moment's notice. All that is necessary is that the switch shall be turned to the "on" position. With steam, even under favourable circumstances, two or three hours are required to get the fire to the necessary condition and sufficient steam generated.

Again, the steam locomotive demands a fresh supply of water at frequent intervals, whilst opportunities for other "locomotive duties" such as cleaning out the fire and so on, must be given about once every four hours. Similarly, at the other end of the day, valuable time is occupied in the process of cooling down, drawing the fire, etc. Regarding a steam engine as available for use for 24 hours, it is not over-stating the case to say that 25 per cent. of this will be non-effective time for these reasons. With an electric engine the necessary attention is confined almost entirely to oiling and general examination. To the extent, therefore, that the different services render continuous use possible, the whole of these can be worked with a fewer total number of engines.

Further, special advantages are derived on those classes of work which it is important should be continuous; for example, such work as the propelling of wagons over the "hump" at a marshalling yard. On the other hand, however well the operating work of a system may be organised, there will always be a number of periods when for service or other reasons, continuous use of locomotives cannot be arranged. The waste, in total a very considerable one, which

Continuous  
Service.

must ensue with the steam locomotive, because steam must be maintained during such intervals, is avoided if electricity is used.

Staying  
Power.

The ease with which the power can be reduced or increased to meet changing conditions, and what we may call the superior "staying power," i.e., the power of keeping up the maximum effort for a considerable period, are two further important advantages of the electric locomotive. A steam engine, designed to supply a given number of units of hauling power, requiring the generation of a given amount of steam, soon entails considerable waste of fuel if the demand upon it falls much below the amount it was designed to give. Consequently, on lines with varying gradients waste is likely to occur on the easier portions of the journey. With electricity, the regulation of the power is such that there is no waste of current on the easier grades, whilst the maximum power the engine is capable of transmitting is readily available.

Again, the steam engine, labouring under the disadvantage of having to manufacture its power under most difficult conditions, has great difficulty in sustaining any special effort it may make. By use of good judgment in both firing and driving, an experienced crew can get a little power in reserve to meet the demands of a rising gradient, but this is soon exhausted if the gradient continues. The power station can continue to supply the necessary current to meet the maximum demand without regard to the length of time for which it may be required to continue.

The Human  
Aspect.

All these increases in the efficiency of the engine, regarded as a hauling machine, are accompanied by a reduction in the strain, both physical and mental, on the train crew. This reduction is such that it is possible to reduce the engine crew to one man, and still leave the driver in a better position to concentrate his attention on the condition of the track ahead. Moreover, where circumstances make it desirable, two or more engines may be coupled together and driven by one man without increasing his work to any greater extent than the extra judgment demanded to handle the heavier load.

The greater protection from weather given to the

driver as a result of its being possible to enclose, apart from the necessary provision for ventilation, the electric engine makes his position more comfortable and reduces the risk to his health which the alternate exposure to extremes of heat and cold of the steam locomotive involves.

It also enables the engine to be run with equally satisfactory results in either direction. Thus the cost of the provision and upkeep of turn-tables, and the time taken in turning to avoid tender-first running, is avoided. Many other small advantages of electricity may be mentioned, such as the greater cleanliness and consequent saving in painting costs, etc., especially at terminal stations, while there is also the reduced risk of fires along the line, and so on. Minor Advantages.

Nor are the advantages seriously offset by the disadvantages. The latter are almost entirely confined to the greater risks that any failures which occur may affect a larger area than is normally the case with steam failures, and the risks arising from the possibility of workmen or others coming in contact with "live" rails or wires. The very considerable balance of advantages has, of course, the effect of reducing the costs of working. The comparative cost of the production of a given number of effective power units of steam or electricity is primarily a question for the engineer, the actual cost of producing the power must be cheaper at the power station than on the engine. When as is necessary, the cost of conveying the electric power to the point where it is to be applied is taken into consideration, the question becomes a much more difficult one. Dis-advantages.

To the saving made at the power station must be added the saving of the cost of providing the necessary wagons and hauling them and the locomotive coal between the colliery and the engine sheds: also the cost of handling and other shed work which the use of coal necessitates. Some advantage also will be derived from the relief given on the running lines and in the yards. Cost of Production.

Against these must be set the cost of the provision and maintenance of the necessary cables and overhead wires, or third rails, through which to conduct the electricity, and any loss which may occur through

leakages en route. Judging, however, from expressions of opinion during recent years, the majority of experts appear to be satisfied that, with anything like reasonable conditions in regard to the supply of the electric power, the cost per effective unit of hauling power is, at any rate, not greater for electricity than steam, and probably rather less.

Cost of Equip-  
ment.

Whether the return on capital cost of the initial equipment for electric working would be sufficient to justify the expenditure, will depend upon the degree to which the advantages mentioned above will be derived in the particular case under consideration. The use of electricity on British lines has hardly developed sufficiently for us to appreciate fully the advantages to be obtained by its application to main line working conditions.

That it would, in many cases, postpone the necessity for expensive widenings and other increases in accommodation cannot be doubted. It would also go a long way towards making it possible to give the quicker service both for passenger and freight traffic which modern conditions demand.

The difficulty of testing this by a practical example may be attributed to the exceptionally stringent financial position of the British railway companies at the present time, rather than to any lack of enterprise. There is a very marked tendency to extend the use of electricity for all power purposes. The possibility of a cheap supply depends almost entirely upon the size of the demand. One of the incidental advantages, therefore, which the pioneer company in main line electrification will reap, is that many of the industries served by that company will thereby be placed in a position to obtain electric power at cheaper rates than would otherwise be possible. The advantage should be mutual.

## CHAPTER X

### THE UNDERGROUND RAILWAYS

THE consideration of the methods of working on underground railways is not only interesting in itself, but also because it enables a comparison to be made with those in operation on what we may call normal lines. Each has its special difficulties, and, by comparison, advantages, but the lessons to be learnt from the experiences of the one may often prove of value to the other.

Apart from the special difficulty of constructing the necessary "tubes" in which to lay the underground railways, a consideration which lies rather outside the scope of our subject, probably the greatest difference between the London Underground system and the normal railways is the fact that traffic on the former consists solely of short-distance passenger traffic. It is true that over certain sections freight trains are run, and also that a certain proportion of the passenger traffic is carried for distances that, by comparison with the average haul, may be described as long, but in neither case is the proportion of such traffic so great as substantially to affect the operating results following on the general statement just made.

The greater choice of direction and level can also be utilised to simplify the operating work. For example, many gradients may be entirely avoided, or so arranged as to assist a starting train and help to check a stopping one. The up and down lines, being laid in separate tubes, enable junctions to be arranged on the "flying," or "burrowing," principle, thus avoiding any crossing of paths. Further, the comparative freedom of occupation underground enables loops to be constructed at what would otherwise be terminal stations.

All these inherent advantages of underground railways would be of value on ordinary lines. They are, as we shall see later, of special value in meeting the



special conditions of the London Underground lines.

Special  
Difficulties.

The operating disadvantages of the London Underground lines may be summarised under three heads :-

(1) The fact that special arrangements for handling the passengers must begin at ground level, some distance from the station platforms.

(2) The extremely heavy and, to some extent, irregular traffic to be carried; and

(3) Risk of more serious consequences arising from accidents underground.

Of these, the first and last only are due to the railways being, for the most part, beneath the ground surface. The second would apply equally whether the lines were on the level or overhead. The first problem demands expeditious booking and ticket examination, and the provision of mechanical means of conveying passengers between the different levels. The former are provided by the use of automatic ticket-issuing machines, other ingenious machines which enable a booking clerk to issue tickets and give change where necessary at the rate of well over 1,000 passengers per hour, and, finally by the Passimeter, which combines these two actions with that of snipping the ticket, releasing the barrier, and counting the passengers. For changing levels, the lifts, with their wonderfully simple but effective safety arrangements still cater for the majority of the traffic. At a number of the busier stations, however, these have been and are being, replaced by the escalators, or moving stairways, which, though occupying a little longer time "on the journey," save time, and give a greater capacity, because they avoid the delays of loading or unloading.

Passing, now to our second heading, that of the density of the traffic, we may say that through a day starting approximately at 6 a.m. and terminating soon after midnight, there is a sufficient flow of traffic to necessitate services every few minutes. This is supplemented by the regular thrice daily flow of suburban business traffic and the later theatre traffic. To these must be added the occasional traffic created by special events, such as football or cricket matches, shows, etc., and lastly, the unexpected influx of passengers due to such causes as a sudden change of

weather conditions on the surface. The problem is so to equip the line and arrange the trains that the maximum amount of traffic may be handled. The lines are, for the most part, simple up and down lines, laid, as has already been mentioned, in separate "tubes," usually connected at the stations.

For signalling purposes, the lines have been divided into the shortest possible sections consistent with safety, the sections being as far as possible equal in the sense that a train will spend an equal amount of time in passing over them. The standard arrangement of distant, home and starting signals in use on normal lines is substituted by a succession of stop signals, each of which is repeated below the stop signal on the post next in rear. In effect, therefore, there is a succession of caution and stop signals, the over-run for safety purposes which the distance between the home and starting signal usually gives being provided for by keeping the stop signal at danger until the preceding train has passed the next stop signal ahead. Between junctions automatic signalling is applied throughout, arrangements being made, where necessary, for this to be replaced temporarily by semi-automatic, where occasional movements from line to line, or from adjacent sidings, make this desirable.

Movements of points and signals at junctions are controlled and operated by power, usually electro-pneumatic. Illuminated diagrams are provided in the junction signal-boxes, on which the movements of all trains on the lines within the control of the box are indicated by the darkening or lighting up—according to the system in operation—of the appropriate section of track. In this way, and with the assistance of an ingenious instrument called a train describer, block signalling, as normally understood, is entirely dispensed with. The maximum advantages of automatic and power signalling and of the scientific arrangement of block sections, as described in previous articles, are thereby gained. In the absence of the exchange of signals used in normal block signalling, some method of advising the junction signalman of the destination of the approaching train is necessary.

The train describer combines this function with that of illuminating the appropriate portions of the indica-

Signalling  
Arrangements.

The Train  
Describer.

tor boards fixed above the station platforms for the convenience of the public and platform staff. As a train leaves one junction, the signalman operates the train describer. If there is no other train on the line between his and the next junction, the indicator boards and the corresponding apparatus in the next junction signal-box repeat the information. If, however, there are one or more trains between the train described and the next junction, the apparatus stores up the messages and only releases them one by one, in their proper order, as each succeeding train is cleared by the signalman at the advance junction.

Electrification.

It is, perhaps, unnecessary to add that the whole of the lines are electrified. The maximum benefit of the advantages which the use of electricity gives is obtained under the conditions which prevail on the London Underground, and at least one of the risks, that of the electrocution of trespassers, is almost eliminated. The combined advantages of the layout of the track, the scientific signalling arrangements, and the use of electricity as motive power are such that the capacity of the lines is limited by the time spent at stations. To put it another way, the longest section length, in terms of time, is the section which includes the station platform. This time is, of course, settled by the length of time taken by passengers in detraining or entraining.

The Limiting Factor.

We must now, therefore, consider some of the steps taken to reduce this, keeping in mind that on a system which is operated as intensely as the London Underground, a very few seconds saved per train, will, in the course of a day, enable an appreciable addition to be made to the service. The design of the carriages is, perhaps, the most important feature in this connection. Confining ourselves to this aspect of carriage design, we may say that what are required are free gangways between the seats inside the carriage, and wide doors so placed that the passengers in any carriage shall, no matter in what portion of the carriage they may be, have only a short distance to walk to reach a door. After most careful experiments, it is generally agreed that two sets of double doors, placed at a distance of one quarter of the full length of the carriage from each end, is the best arrangement.

Design of Carriages.

It ensures that no passenger need walk more than one-quarter the length of the carriage. Further, to ensure that no time shall be lost after the passengers have entrained, mechanical arrangements, controlled by the driver for opening and closing the doors are fitted.

With the same end in view, i.e., that of shortening the average time spent at stations, it is now the established practice, the degree differing on different sections of lines, and to some extent according to the density of traffic at different times of the day, to select a certain number of stations which are passed by alternate trains. It will be seen, therefore, that apart from some at present unknown development of the idea of the moving platform, or the provision of double platforms to enable the doors at both sides of the carriage to be used simultaneously, everything possible seems to have been done to shorten the time occupied on what is at present the limiting feature to the capacity of the system.

The whole of the train working arrangements are carefully planned and published in the working time-table. This is issued in sections, and shows separately the train services for Saturdays excepted, Saturdays only, and Sundays. In addition to the train timings, particulars are given of the number of each train, the number of the crew working it, the number of cars, and the departure time of the next train worked by the same set. Each section also includes a summary of the set working, showing under each station, in time order, particulars of any sets starting or terminating, or being strengthened or reduced, at that station. Particulars of any speed restrictions in operation and certain other detailed information are also included.

The Working  
Time-Table.

The working time-table is supplemented by pamphlets, described as "traffic notices," containing details of any additional trains arranged to meet the requirements of special events, a list of special events whether specially catered for or not, details of permanent way operations, and any other special occurrences which may temporarily affect the working of trains over the section. The notices contain information of special interest to the staff in other ways. For example, comparative particulars of the consumption

of electric current over the different sections of the London Underground system are given periodically in graph form, mention is made of any cases in which employees act with special promptitude, comparative punctuality figures are quoted, and so on.

Headway  
Clocks.

The consumption of current, being one of the largest of the varying costs, is naturally watched very closely. To assist the drivers to conserve it, devices known as headway clocks are provided. These indicate to an approaching driver how many minutes have elapsed since the last train passed. The driver, knowing the normal interval for the particular line, can thus judge whether it is desirable to increase or decrease his speed.

Incidentally these clocks automatically record on a clock face diagram the trains which pass them. An examination of the day's diagram will show the period of heaviest density, and indicate the times during which, on that day, the number of trains over the line might have been increased. It is interesting to note, in passing, that the maximum number of trains past one point on a single line is rather over 40 per hour, an average interval between trains of something less than  $1\frac{1}{2}$  minutes.

How the Rush-  
Hour Traffic is  
Catered for.

Records are automatically compiled on the engines, of the distance covered with the current entirely cut off, and the percentage of "coasting" to total mileage is published periodically in the traffic notices. Speaking broadly, we may say that the booked service for the normal daily traffic represents the maximum number of trains which it is considered can be worked over the line. How then are the regular or irregular rushes of traffic catered for?

If the number of trains cannot be increased it is clear that the only way is to increase the number of passengers carried by each train. The carriage set for the normal traffic consists of units comprised of three or four vehicles. To meet expected rushes the trains are increased to two units, thus doubling the seating accommodation. The balance of accommodation required must be provided by strap-hanging, which more than doubles the capacity of each vehicle. The spare units required for such strengthening purposes, are, as far as possible, distributed amongst the

outlying depots so as to reduce the risk of delay or congestion being caused by attaching, though a certain number of sets, primarily intended as replacements in case of breakdowns, are kept on specially constructed spur lines within easy reach of the city stations, so that such replacements may be made with as little interruption to the service as possible.

The irregular rushes, except in so far as they may be catered for by strap hanging, are dealt with by the controller on duty. The method of applying the "control" principle is unique. As in other control systems, all points where traffic may arise, or where trains may be diverted from one track to another, are in telephonic connection with the control. Here, however, the parallel ends. All conditions which it is possible to foresee are provided for in advance. It is only when quite unforeseen conditions arise, or something however small, goes wrong with the booked working, that the control comes into action. An ideal day's working would be one during which the controller had nothing to do but make a nil return to the superintendent of the line. Any departure from expected conditions, such, for example, as an unexpected rush of traffic, or from booked working, whether arising from the extremely rare serious accident or any delay which makes a train two or more minutes late on any part of its journey, is promptly reported. The controller's first duty is to take such steps as are possible to minimise the consequences of the untoward occurrence. His next duty, if he has not already done so, is to find out the cause and report the facts and the steps he has taken on his daily report. The immunity of the London Underground from exceptional events sufficiently serious to be described as accidents is partly due to the completeness of the signalling arrangements already referred to.

The Under-ground Control.

Safety Appliances.

There are, however, two additional safety devices which must be mentioned. Both have reference to the human element as represented by the driver. To apply power to the train, the driver must depress a knob on what on a steam engine would be called the regulator handle. Should his pressure relax the current is automatically cut off. Should he become

ill, or even die at his post, the train would thus be brought to a stand. It is named, not inappropriately, the "Dead Man's Handle."

Automatic train controllers are also provided. Should a driver from any cause pass a signal at danger, a "trip-cock," set in position just outside the rail and worked in conjunction with the signal, engages a lever on the engine, which, in turn, opens the air locks on the brakes and thus brings the train to a stand.

If, in spite of all these precautions, it becomes necessary for the driver, between stations, to stop his train and communicate with the power station, or even to abandon the train and conduct the passengers on a walking tour to the nearest station, arrangements are provided to enable this to be done with perfect safety and a minimum of discomfort. Along the walls of the tunnels are a pair or parallel wires. By connecting these to the portable telephone instrument he carries, the driver can send any desired message. By pressing them together he not only cuts off the power from the "live" rail, but brings into operation an emergency lighting arrangement in the tunnel in place of that which, dependent upon the current through the "live" rail, he has extinguished.

In concluding this portion of the subject we must mention the careful training given to the staff at the company's training schools, where both the lantern and cinematograph are freely used for instruction purposes, and the skill and keenness with which the staff combine their efforts with those of the many ingenious devices described, to serve the public by providing an efficient service.

## CHAPTER XI

### STATISTICS OF OPERATION

USING the term in its widest sense, all figures compiled by or for a railway company may be regarded as statistics of operation. Considerations of space make it necessary that we must restrict its application to figures prepared to show (1) the cost of the various operations directly connected with the carrying of traffic, and (2) the results obtained from the arrangements which are made. This distinction between the cost of the operation and the quality of the service should be carefully noted.

Such figures may be compared with the compilation of the costs of the different processes necessary in the manufacture of, say, steel, and the analysis and tests of the finished steel to determine its quality. The comparison must not be carried too far. A railway company is not manufacturing an article: it is supplying services. Moreover, not only do the size, quantity and quality of the thousands of different services required simultaneously vary very widely, but the conditions are such that the different items are combined for part of the journey, the combinations varying according to the conditions which happen to exist at the time.

Because of this, it would be impossible, without keeping such records as would necessitate a greater cost than the total receipts obtained for the carriage of the traffic, to compile costs of the provision of each individual service. Nor, indeed, would such figures be of great value. The costs for similar services would vary so greatly according to the circumstances prevailing that they would be of little value as an indication of the possibility of effecting economies in working costs. It is necessary, therefore, to confine the preparation of any statistics to what we may call the operating units; the wagon-load, the engine, the train and so on.



Standards of  
Comparison.

Three alternatives present themselves. The cost or result of any operation may be compared with similar ones conducted on different parts of the same system. In most cases, however, local conditions differ so much that such a comparison would be more than likely to be misleading. A comparison of results or costs of similar operations in the same place or area for some preceding period or periods is less likely to be misleading.

Conditions affecting most operations, however, change so rapidly that such figures, at the best, can be said to indicate a possible case for inquiry into the cause of the difference, rather than to be any indication that there has been a change either for better or worse in the conduct of the operations. A third way is to prepare a "possible" figure, calculated in relation to such local conditions as are comparatively fixed, with which to compare the "actual" results obtained. The value of this method depends upon the degree of correctness it is possible to reach in deciding and revising the standard figure. This varies according to the particular operation under consideration. It is, for example, easy in connection with the punctuality test as applied to a passenger service. It would be much more difficult, though not impossible, to apply it to the cost of sorting wagons in a marshalling yard.

The difficulty of making comparisons is liable to lead the superficial observer to the conclusion that statistics, as applied to railway operating, are of no value, or at least of such small value as not to justify the expenditure necessary to prepare them. Very little reflection, however, must bring the conclusion that statistics of some sort are essential. Otherwise there can be no supervision other than that exercised by those who can actually see, and examine the records that may be made of, the individual operations. Moreover, the varying circumstances which make it exceedingly difficult to compile comparable statistics are really an argument in favour of an attempt being made to do so.

The Choice  
of Unit.

The choice of the unit in which we shall express the cost, the work, or the result, is a matter of considerable importance. Many of us are accustomed to think of

cost in terms of money. Assuming the money cost always bears the same relation to the work done, there is no better unit. It has two advantages. It is the unit in which the final results of railway operating must be expressed, and the denominator to which other units of cost must be reduced if a comparison is to be made between them. Where, however, the money cost is liable to be affected by considerations bearing no real relation to the operation concerned, some other form of unit may be desirable.

For example, the substitution of the money unit by units of man-hours and engine-hours eliminates the effect of variations in wages and the price of coal respectively, neither of which bears any direct relation to the work done by the man or the engine. The vehicle-day provides a convenient alternative to the money unit in which to represent the cost of providing the vehicle, having the advantage that it is not affected by the varying demand for vehicles.

The work to be done, which may be divided into the two operations of handling the traffic at termini and carrying it between them cannot be expressed in terms of money. Such units as wagons or tons loaded and unloaded, and wagon-miles or ton-miles, for the work at the terminal and on the journey respectively, may be used for goods traffic, and passenger-engines dealt with, and passenger-miles for passenger traffic. Neither the ton nor wagon unit is by any means a perfect one. One ton may be composed of a number of small parcels, another of two or three packages of convenient size for handling. The use of the wagon as an alternative to the ton increases the chances of error. To the variations of size and weight of the packages are added the variations in the capacity of the wagons and the varying extents to which they are fully loaded. Many companies, however, consider that the extra cost of compilation if the ton unit is used is more than sufficient to outweigh the advantage of a higher degree of accuracy in a figure which, in any case, is a very imperfect one.

To be of value to the operating official, statistics must be compiled in such a way as to render themselves easy of analysis, right down to the actual

The Need for  
Careful  
Analysis.

operations they represent. We may, indeed, say that statistics can be described as useful or merely interesting according to the degree to which they are or are not capable of such analysis. No correct explanation of apparent rises or falls in operating cost or efficiency as recorded by statistics can properly be made unless such an analysis is possible.

The possible economy in first cost by concentrating the compilation of statistics in some central office must, therefore, be compared carefully with the possible increase in the cost of any analysis which may be necessary in connection with their use, a cost which might be avoided if they were compiled in successive stages in the offices of the officials using them. The latter method has the additional advantage that the statistics are available for use earlier than is otherwise the case.

The Moral  
Effect.

Before passing to the very brief discussion of one or two of the statistics commonly used on British railways we must mention what many people regard as one of the greatest advantages of the use of statistics: what we may call their moral effect. However keen he may be, any normal man receives an additional stimulus if he knows the results will be reflected in certain figures which his superior will examine with interest. The advantage brings in its train a danger. He may yield to the temptation to improve the figures at the cost of inefficiency in other directions. This emphasises the necessity of the system of statistics being a complete one.

It is not possible, within the limits of this volume to discuss the qualities or merits of the principal statistics in use on British railways or to compare the values of the older forms with the newer form of "ton-mile" statistics. All that is possible is to examine a certain number of those in common use as examples on which the student may base his own investigations of the remaining figures.

Prior to the compulsory preparation of what are comprehensively termed "ton-mile" statistics, authorised by the Ministry of Transport Act, 1919, and confirmed by the Railways Act, 1921, the figures chiefly used by British railways for the purpose of supervising the freight train working, apart from the

examination of the daily results made from the guards' journals, control records, etc., were records of the average late start and arrival compared with the booked times—the punctuality statement—and the average load expressed in wagons. To a considerable extent they are still in use for similar purposes to-day. let us examine them in the light of what is stated above.

Punctuality in itself is not a test of the quality of the service for freight traffic. Its value in this direction must depend upon the efficiency of the booked arrangements. A low figure may merely be an indication that the booking is badly done, while, on the other hand, a high degree of punctuality may be obtained by allowing more booked time than is really necessary on normal days so as to allow "recovery" time when delay takes place. It cannot be a test of economical working, since the figure contains no factor of either cost or work.

The "Punctuality" Statement.

The average load figure does introduce the work factor. It is useful in that it directs attention to the desirability of varying the train arrangements as alterations in the flow of traffic make this desirable. Since, however, it only contains one part of the work unit, and no cost unit, it also cannot be regarded as a test of economical working. It would appear, therefore, that those who rely chiefly on the use of these figures start with the assumption that the booked working represents a sufficiently high degree of economy and efficiency.

The Train Load Figure.

Though by no means strictly comparable, the nearest figure to the combination of these two which the "ton-mile" form of statistics gives is that of the "wagon-miles per train engine-hour." It contains the units of work (the wagon-miles) and the units of cost (the engine-hours). Admittedly, these are somewhat imperfect units, but they are probably the soundest that can be obtained, and, given similar conditions in regard to gradients, weather, density of traffic, etc., they will give a fairly comparable result. Within these limitations, they would appear to give a fair test of the use made of the engines in steam. Their weakness as a test of economical freight train working lies in the fact that only one of the cost factors, that of the

"Wagon-Miles per Train Engine-Hour."

engine, is taken into account. Unless, therefore, such a figure is balanced by corresponding figures of the effect of the same service on wagon user and marshalling yard costs, it is liable to present a distorted view. The figure is, of course, of no value as a test of the quality of the service.

## ORGANISATION

GOING back to the beginning of railways, it is not difficult to imagine a railway company sufficiently small to admit of the whole of what may be called the management being within the capacity of one man. As the railway developed in size and in the amount of traffic carried upon it, the time would come when this was no longer possible. At least another member would have to be added. On that stage being reached, the question would immediately arise as to how the total work should be divided. Should the area be divided and each member be in complete, and more or less independent control of a portion; or should the division be between the different functions but extend over the whole area?

In those days there could only be one answer to such a question. A railway was essentially a business to be worked as a whole. Moreover, as railways developed, there soon emerged what appeared to be quite clearly defined groups of functions into which the work of the railway could be divided without impeding its growth or impairing its efficiency. It is the aspects of organisation represented by these divisions and their relationship to each other that must be considered.

Omitting many intermediate steps, and confining ourselves solely to those functions which are concerned with the actual working of the railway, it is significant to find that the organisation in existence some 25 or 30 years ago was, in all essentials, the same on practically every British railway of any size.

It is difficult to think that this was mere coincidence, or due to the lack of originality of thought on the part of those whose enterprise led to such rapid development as that of British railways.

Under the general manager, who was responsible to the directors for the whole of the work of the railway

(except in one or two cases in which the mechanical engineer still reported direct to the directors—a relic of the special importance attached to the locomotive in the early days of railways), came the heads of four separate departments, two engineering and two traffic.

The civil engineer, usually called the engineer, was responsible for the construction and maintenance of the permanent way, the signalling, the station and other buildings, and so on.

The design, construction and maintenance of locomotives, carriages, and other rolling stock, and the supervision of the work at the engine and carriage sheds and of the shed staffs and engine crews, were under the mechanical engineer.

On the traffic side, the division was made partly according to the nature of the traffic, though not to such a degree as the title of the heads of the respective departments appeared to signify. What was called the passenger department, under an official usually called a passenger superintendent, or a superintendent of the line, was responsible for all arrangements relating to passenger traffic and also for all matters in connection with the running of trains, whether passenger or freight. A goods manager, in charge of the goods department, dealt with all traffic questions pertaining to freight up to the time when it was ready to leave the goods station at the originating point and after it had arrived at the destination goods station. Some companies, with a heavy mineral traffic, divided the work of this department between a goods and a mineral manager.

In all cases, the area covered by the principal railways was so great that it was considered necessary to divide it into districts, each department having district officers looking after its departmental interests in their respective districts and reporting to the chief departmental officer.

This type of organisation is known as the "Departmental" type. It should be mentioned, in passing, that some of the districts were then, and some have since been, called divisions, but this did not in any way alter the nature of the organisation.

The type of organisation just outlined is in operation

on one of our large companies to-day. On the others, quite a number of alterations have been made. These can conveniently be divided into three groups, namely, those affecting the division of work between the traffic departments, those affecting the division of work between the mechanical engineering and traffic departments, and that of quite a different character, affecting the delegation of responsibility to district officers as compared with the centralisation of all responsibility in the headquarters officer.

The Division  
of the Traffic  
Functions.

The increasing importance of freight traffic, coupled with a desire to introduce a form of organisation which appeared to be more theoretically sound, gave rise to a strong opinion that it was not wise to commit the freight traffic for carrying purposes into the hands of a department whose primary interest, as its title indicated, lay in another direction, especially as the two interests were liable to clash. It was commonly stated, for example that no matter how important the service given by a goods train was, it was ruthlessly upset if the slightest advantage could thereby accrue to the passenger service. On the other hand, it was stated that the real difficulty in regard to the goods service was the lack of co-operation between the goods station and marshalling yard staffs, who, of course, belonged to different departments.

Probably the difficulties on both sides were exaggerated, but they were sufficient to result in a good many attempts being made to remove them by a change of organisation. It was clearly undesirable to transfer to the goods department the function of running the goods trains. This would involve a division of responsibility on the running lines. An attempt was therefore made to solve the problem by adopting a somewhat similar division of the traffic department functions to that which is made in America.

In place of a division of functions according to the kind of traffic, the division was made between the functions antecedent and subsequent to the actual carrying of the traffic and those involved in the actual carrying of the traffic itself. These new groups of functions are commonly spoken of as commercial and operating, respectively. The line of demarcation between the two groups varied a little, but in no case



went so far as the usual practice in America, where the principal function of the commercial department appears to be that of the development of new business.

Speaking broadly, however, we may say that in Great Britain the commercial department deals with such matters as the fixing and collection of rates and fares, booking and invoicing, and the collection and delivery of the traffic so far as it is done by the railway company. On the other hand, the operating department deals with the traffic from its arrival at the passenger or goods station to its arrival at destination station.

In most cases the commercial functions have been further sub-divided according to the kind of traffic, sometimes into passenger and freight, and sometimes into passenger, goods and mineral.

At first sight the change appears to be a very radical one, but this view is liable to modification if we examine the position as it affects the different departments. Prior to the change, the whole of the work in connection with passenger traffic was concentrated in one department. After it, processes up to and including the work at the booking office, along with any which might arise after the termination of the journey, were transferred to the passenger commercial department. In most cases the change, as it affected the work in connection with goods traffic, was that the entrance to the goods station by rail was substituted by the entrance by road, as the boundary between the two departments. Very little change was made in regard to the function of the mineral department, where such existed, but a tendency was displayed to combine the goods and mineral commercial functions to a greater extent than before.

It is, indeed, remarkable that such apparently small changes should have had the effect of creating such an entirely different atmosphere. The essential difference is that, whereas before the change both departments were interested in both revenue and working expenses, after it each department is concerned in only one of these.

The general idea underlying the division of functions in this way is that a railway company can be compared with a manufacturing industry, and that, just

as a manufacturer normally divides his organisation into production and selling departments, a railway company should do the same. This illustration, which has been used so frequently as to become almost a standard one, is not a very happy one.

As has been mentioned previously, transport cannot be described as, or likened to, an ordinary article of commerce. It is that very much more abstract thing called a "service." It is difficult to compare it with any other form of business. Even, however, if we assume that in a very broad sense a service can, for selling purposes, be compared with the more tangible article, the comparison with the manufacturer of commercial commodities is not a sound one as a guide to the type of organisation to be adopted.

If we admit the different transactions performed by a railway company to be equivalent to the manufacture of articles, we find that a railway company manufactures an almost infinitely greater number of separate kinds of articles than any manufacturer of goods. One article may be the conveyance of, say, 600 tons of coal to be carried perhaps 20 miles and put into a ship; another, the carriage of a returned empty box weighing a few pounds for a distance of 100 or more miles; and every possible variety both between these two examples and outside them.

Moreover a railway company cannot manufacture its articles in advance but must make them on demand and deliver them immediately. They are, so to speak made at short notice to the order of the customer.

An even more important difference in its effect upon the question of organisation is the fact that while a manufacturer can, with a very fair degree of accuracy, calculate the cost of the articles he is putting on the market, it is not possible for a railway company to do so. Whatever, therefore, are the merits or demerits of the new form of organisation, they must be established on some more substantial ground. It certainly removed the cause of the dissension which appeared to indicate the need for a change of some sort.

Moreover, if some other than the original division of traffic department functions has to be made, it is difficult to see where a clearer line of demarcation could be drawn, if anything like an even balance of

responsibility is to be given. Any division of responsibility as regards occurrences during the actual transit is unthinkable, whilst to move the line in the other direction would reduce the commercial departments to little more than development agencies. The question, therefore, would appear rather to be one of whether there should be any division at all.

Should the  
Traffic  
Functions be  
Divided?

It must be remembered that in recent years all railway questions have become more complicated. The trader is, for various reasons, more exacting in his demands, rates questions are much more complicated as a result of recent legislation, the increasing costs in all directions have emphasised the need for careful planning and supervision, whilst staff problems have developed to a size undreamt of, say, 25 years ago. All these may be said to indicate the need for a division, whilst a tendency toward the centralisation of at least two of them as a result of their being dealt with on national lines may be said to emphasise the need for some division at headquarters.

On the other hand, there can be no doubt that the functions we have described as operating and commercial are closely related; so closely, indeed, that any division is almost certain to lead to some loss of efficiency, a good deal of additional correspondence, and a rather serious risk of friction.

As the department which is in touch with the trader, the commercial department is inclined to regard itself as the one whose duty it is to look after his interests. An organisation that rather encourages than otherwise one department to take the view that unless it keeps an extremely careful watch on the other, the other will act against the interests of the trader, is extremely likely to result in the other department taking the narrow departmental view that the only thing that matters is the cost to its own department. There is the danger, therefore, that certain members of the staff may act as though they are wholly indifferent to the interests of the trader, and others as though operating costs are of no consequence.

The effect of the division upon the stationmasters and staffs at the smaller stations is rather serious. Except at those stations which are sufficiently large

to justify separate local officials representing each department, the stationmaster is responsible to no less than four different officials for the different sections of his work. This number is reduced to three where there is no separate mineral commercial department, and to two if all commercial interests are combined. There is no need to enlarge upon the effects of this upon the station staffs. It can hardly be likely to lead to a maximum of efficiency.

At headquarters, where the work is largely administrative, there is a good deal to be said for the division. The loss of time caused by the necessary consultations on questions in which the two departments are jointly interested, which is the case in a very considerable proportion of the total number of matters dealt with, may be outbalanced by the chances of sounder decisions being arrived at because of the consultation.

As we get nearer the actual executive work as done by the district, and eventually the local officials, the disadvantages appear to become greater and the advantages less. It is fairly clear that the need for some co-ordination of the functions of the different departments was felt, because in many cases the introduction of the new form of division was succeeded by the appointment of what were called traffic managers, whose function it was to effect this co-ordination.

It may have been the fact that these were headquarters officials, and that the principal weakness of the new form does not lie at headquarters, that led first to their becoming but another link in the chain and eventually to their withdrawal. A much more promising remedy was attempted by one company who adopted the new form of division at headquarters, but combined the whole of the traffic functions in the district officers.

The adjustments made in the division of work between the mechanical engineering and traffic departments are of rather a different nature. The development of railways largely depended upon the invention and perfection of the locomotive. It was essential, therefore, that if the maximum progress was to be made the men to whom the working of the locomotive was entrusted should be on the staff of

The Running  
Superinten-  
dent.

the mechanical engineer, so that, on the one hand, he could give them the necessary training, and, on the other, obtain the benefit of their experience in the practical use of the machine under working conditions.

The normal arrangement, therefore, was that the traffic department responsible for the working of the trains ordered the necessary engines from the mechanical engineer's department, the latter being responsible for supplying them as required. Such an arrangement, though inevitable during the development stage was far from satisfactory.

It was liable to result in the engine crew regarding themselves as independent of the traffic department staff, whose work they were performing. A more important weakness, however, was the fact that it resulted in a tendency on the part of the staff of the traffic department, to regard the engine shed as a sort of reservoir from which unlimited engine power could be expected on demand, no interest being taken in the effect of the demand upon the cost of working the shed or on the total stock of engines required.

Furthermore, there is a wide difference between the types of ability required in connection with the design and construction of locomotives, and that required on what we may describe as the traffic side of locomotive work, viz., the organisation of the shed work, arrangements for the supply of engines to meet traffic requirements, and the administrative staff work in connection with the men employed.

The first signs of the need for some change being recognised were the attempts made at closer co-operation between the two departments, frequently resulting in the setting up of what were called engine working committees, who jointly agreed any alterations necessary to the booked service as far as they affected the engine supply.

This was followed in many cases by the separation of the functions previously grouped under the mechanical engineer into the separate functions of the mechanical engineer and running superintendent. The former retained the responsibility for the design, construction and maintenance of the locomotives and other vehicles, whilst the latter took over the engine sheds and the work we have described as the traffic

side of locomotive work. In some cases, the running superintendent was subordinate to the mechanical engineer; in others he became an independent officer reporting direct to the general manager, and in still other instances he became subordinate to the mechanical engineer on questions of construction and maintenance and to the operating department on train working and running questions.

The weakness of the two former divisions, though modified somewhat by the influence of the engine working committees already referred to, lies in the fact that they only remove one of the three disadvantages of the older type of organisation. The remaining variation from the type of organisation which appeared to have naturally developed on British railways, though confined to one company only, was a very striking one. As has already been explained, the principal English railways had reached such dimensions that the common practice was to divide their areas amongst district departmental officials. The degree of authority given to these officials was originally very considerable. As the administrative and other work in connection with the building and amalgamation of the smaller lines into the railways as they substantially existed before the Railways Act, 1921, was completed, a tendency to centralise certain matters which had previously been left largely in the hands of the district officials appeared.

Centralisation  
of Operating  
Functions.

The degree of centralisation varied in different companies and in different departments of the same company. In the traffic departments it is probably true to say that it was the staff and other administrative questions which tended to be centralised, questions of working continuing to be dealt with very largely by the district officials.

It was all the more remarkable, therefore, that the late Midland Railway Company, simultaneously with the introduction of the train and traffic control principle as we know it to-day, should have centralised these particular functions. The district operating officers entirely disappeared, the operating work other than that at the large passenger and goods stations, which remained in the hands of the passenger

or goods manager, being placed under the district controllers. The district controllers, therefore, in addition to the duties already described in the articles dealing with train and traffic control, became responsible for the supervision of the work of the marshalling yards, the smaller passenger and goods stations, the signalmen, and the other operating work in their areas, though with very much less power to act than that previously possessed by the district officers, whom, to some small extent, they can be said to have replaced.

On general principles, it is clearly better to avoid a division of territory unless the size of the concern makes this necessary, and the Midland Railway was probably more fortunately situated in this respect than the other companies. The lack of such division would, as a rule, appear to carry with it the following disadvantages. The placing of a fair proportion of administrative work upon the district controllers may, and actually did, make it necessary to reduce the size of the district, until each contained very little more than one large marshalling yard and the lines radiating from it. It may be remembered that one of the great advantages of the control system was that the more comprehensive view of the position enabled the controller to give a decision unbiased by special local considerations.

Whilst it is true that in these days of national negotiations and agreements on staff questions certain of this work must be centralised at headquarters, there still remain a great many staff questions which can with great advantage be dealt with by a district official. If a man can talk about his troubles to someone other than his immediate chief, who is in a position to understand his local references, and has a fair amount of authority to remedy real grievances, the value is almost incalculable.

Perhaps the greatest weakness, however, lies in the fact that there is no district planning department. The controller is, as a rule, too busy conducting the current operations, whilst the headquarters staff is liable to be too remote from the details of the local working to be in a position to see the possibilities of improvement.

The conditions on American railways are so widely different from those existing here that it is not surprising to find a different type of organisation in use. The initial division of the principal functions performed by a railway company shows a remarkable degree of similarity. At headquarters we find the division into mechanical engineering, civil engineering and traffic, just as we do here. It is after headquarters is left that the essential feature of what is called the "Divisional" system of organisation is seen. The greater area covered by the American railways makes it even more necessary than here to divide it.

The  
Divisional  
System.

The functions just referred to as separated at headquarters are concentrated in the officers in charge of the different divisions, and tend, in varying degrees, to remain so. In a purely divisional system, therefore, once headquarters is left, there is never more than one official in charge of the whole of the railway operations at the same place, no matter whether the operation is a traffic, a mechanical engineering, or a civil engineering one.

The use of the term "Divisional" doubtless arose as a result of the sub-areas into which the American areas are divided being called divisions, whereas in Great Britain they are usually, though not invariably, called districts. In some quarters this seems to have created the impression that the appointment of a departmental officer described as a divisional officer, with the object of co-ordinating the work of two or more districts on its way to headquarters, represented a change from a "Departmental" to a "Divisional" form of organisation. This impression is, of course, erroneous. The division officer would be placed in control of all the departments in his division if the divisional type of organisation was in operation.

A very strong theoretical case can be made for the divisional type of organisation. Its quickness in action, the development of the team in place of the departmental spirit, the saving in correspondence and duplication of effort, the wider training of and opportunities of promotion for its staff, all combine to make it attractive.

Against these advantages it may be argued that the advantages of the degree of specialisation which



the departmental system gives are lost. Moreover, if, in an attempt to overcome this defect, specialised assistants to the divisional officer are employed, he will, unless a fair degree of decentralisation is both possible and considered desirable, tend to become a figure-head in whose name what are really the district departmental officers communicate with their respective heads of departments at headquarters.

The general tendency of the present day is in the direction of centralisation, the concentration of staff questions on national lines having been quickly followed by similar centralisation of effort on the part of the traders and travelling public in connection with such matters as rates, fares, etc. It would, therefore, appear that in many matters a high degree of decentralisation is not possible. The losses of the advantages of specialisation would tend to become greater as the less clearly related functions were combined, whilst the advantages to be derived from their being pooled would tend to decrease.

The natural line of evolution of the British railway organisation towards the divisional type—if considered desirable—would, therefore, appear to be through the combination of the whole of the traffic functions on the one hand and of the engineering functions on the other.

Prior to grouping, there appeared to be a steadily growing opinion in favour of the former. The amalgamations under the Railways Act, 1921, have altered the problem in so far as it is liable to be affected by the size of the undertaking. The necessity for bringing the organisations of the different companies which together form the new companies into line will require certain changes to be made. Up to the present many of the companies, realising that considerable experience of the working under the new conditions is desirable before making any final decision in the subject, have so far been content to adapt their older forms of organisation to the new conditions as a temporary arrangement. Where changes have been made, they appear to be rather of an experimental nature than otherwise. In any case, too little time has elapsed since they were made to enable the effect to be seen.

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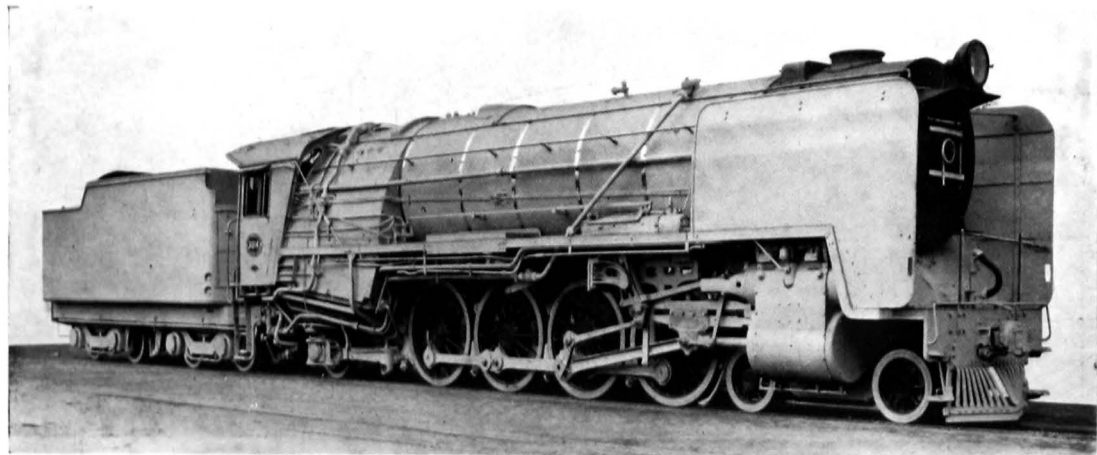
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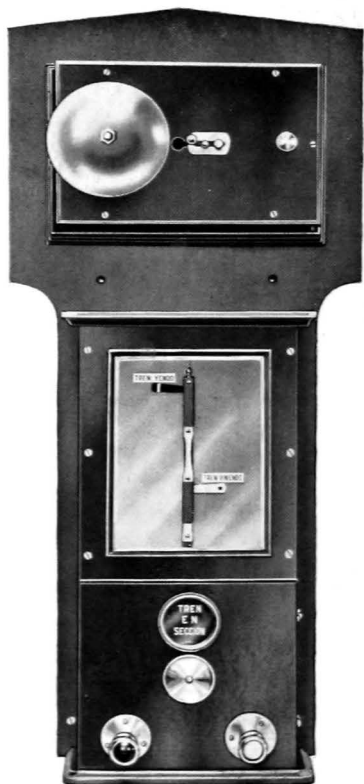
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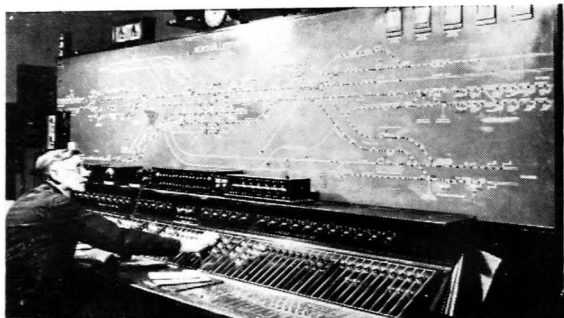
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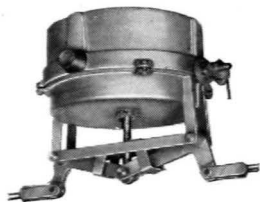
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