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JOSEPH LOCKE, M.P., President,
in the Chair.

No. 985.—“On the Arrangement and Construction of Railway Stations.”¹ By ROBERT JACOMB HOOD, M. Inst. C.E.

It is probably no exaggeration to affirm, that there is scarcely any branch of the Railway Engineer's practice which is of more importance, than the correct and judicious arrangement of the terminal and other stations, wharves, and depôts. It is equally true, that this subject is one which has received the least special attention, and on which the profession, generally, have the fewest means of acquiring information. With the exception of Dr. Lardner's "Railway Economy" (which, however, treats rather on management than construction), and a few published drawings of stations, there is no work, in the English language, which even professes to give to the engineering student any information of the kind. The only useful collection of plans and drawings on the subject, with which the Author is acquainted, are those included in Perdonnet and Polonceau's "Portefeuille," &c. That there should be this dearth of information cannot be a matter of surprise, when it is considered, how limited is the number of stations which can fall to the share of any but a few leading members of the profession, and how much this class of work is usually divided with directors, managers, and architects.

The superiority, as to convenience and effect, of the stations upon the continental lines of railway, is generally admitted; but whether such superiority is due to the greater liberality of the Companies, or to the higher talent of their Engineers, is a question

¹ This Paper was partly read at the previous Meeting, but it is printed consecutively.

The accompanying Figures are not to scale, and are only intended to illustrate a principle in each case. The initial letters used are to be understood thus:—

B. O. Offices, Waiting Rooms, &c.	G. Y. Goods Yard.
P. Platforms.	T. H. Tank House.
C. P. Coke Platform.	G. W. Goods Warehouse.
W. H. Warehouse.	L. Lodge.
C. S. Carriage Shed.	W. R. Waiting Room.
E. S. Engine Shed.	M. R. Mess Rooms.
C. W. Cattle Wharf.	S. B. Signal Box.
C. D. Carriage Dock.	

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upon which there may be some difference of opinion. Great advantages, however, must be derived from the architectural training enjoyed by the members of the profession abroad, as well as from the extent to which they are usually concerned in the working and traffic arrangements. It is, therefore, hoped, that it may not prove either useless, or presumptuous, to offer a short statement of the points which have, from time to time, appeared worthy of notice; with a view, rather to excite discussion, and to elicit opinions, than in the expectation of being able to afford any novel information to the profession generally. In dealing with a subject which embraces such an infinite variety of details, all of more or less importance, it is obviously impossible to comprise, within the limits of a single Paper, anything more than a systematic analysis of those details, combined with a few remarks on such as are most deserving of attention.

The judicious selection of sites for terminal and other stations will form the most appropriate introduction to the subject. Much will depend on the individual views of the controlling authorities, where circumstances admit of choice. The majority will look to ultimate convenience and efficiency, to guide them in so essential a particular, though a few, it is to be feared, will limit themselves to the narrow views of present economy. Some general rules, however, may be propounded for the consideration of either class. Every effort should be made to secure for a terminus, or important station, a position upon the surface, rather than on an embankment, on a viaduct, or in a cutting. Facility of access, in all directions, from the surrounding district, in the case of passenger-traffic, and of good water and railway communication, for goods-depôts, are obviously indispensable. In order to secure safety and regularity, it is equally desirable to aim at obtaining uninterrupted sight along the line of railway, by avoiding sharp curves, and a complication of over bridges, in the immediate vicinity of a large station. The question of gradients, in connection with a station, is also an important one. For a terminus, a slightly-ascending incline is convenient, as affording auxiliary means of readily controlling the ingress and assisting the egress of trains; but such inclination should never exceed 1 in 300, on account of the extra labour involved in moving carriages by hand. Intermediate, and junction-stations are best situated upon a dead level, and where a good length of this can be obtained, with gradients falling from it both ways, the greatest possible facility is given for working the traffic to advantage. Falling gradients into a station of any description are so obviously objectionable, as to require no comment.

Abundant supplies of good water for locomotive and other purposes, and ample means of drainage, are points not to be lost sight of; and, it is notorious, that, in some cases, it has been

found necessary to abandon stations, after completion, from neglect in these particulars. Nor can too great stress be laid on the necessity for providing, in the first instance, an ample area of land, to admit of the greatest possible extension of accommodation; and it is desirable to discourage, as far as is practicable, the erection of buildings on land immediately adjacent to that devoted to station purposes. Instances are but too numerous, of cases where Companies have been compelled to re-purchase, at a great sacrifice, land originally disposed of as 'surplus,' and generally with a special view to building operations. Where such a course is adopted, prudent managers will take care to secure in the conveyance, power to re-purchase the freehold at original prices, with allowance for outlay in building, or otherwise, to be settled by valuation.

The expediency of providing new lines of railway, before they are opened for traffic, with all the station appliances necessary for working them, in a complete form, is a question of some moment, which has given rise to much difference of opinion. Many good authorities have preferred opening with mere temporary accommodation, whilst others have gone to the opposite extreme, in constructing works adapted for the greatest possible extension of public requirement. Of late years, the general feeling would seem rather to have been in favour of the latter course; but it is not clear, whether this is so much the result of sound policy, as of a desire to meet the modern demand for the early closing of capital expenditure. It may also be due, in some measure, to the recently-adopted system of guaranteed contracts for the construction of railway works, which necessitates the consecutive completion of all their adjuncts. The main objections seem to lie in the impossibility of deciding, in all cases, beforehand, both as to the proper sites, and as to the requirements of the traffic to be developed. Any error on these points causes inconvenience in working, and ultimately leads to a great waste of money, either in subsequent abandonment, or in extensive alterations and amendments. It is suggested that the prudent course is, in every case, to devise a comprehensive plan, and to commence upon such portions, only, as are absolutely indispensable, for present purposes; proceeding with the remainder as circumstances may dictate. By this plan, unnecessary pressure on the funds, when they are generally at a low ebb, and the risk of loss from errors, are avoided; and, at the same time, credit is obtained for attention to public wants, by appearing gradually to yield to the public demand.

It may not be out of place to remark, that the Engineer is sometimes undeservedly blamed for alleged errors and oversights, which are due entirely to his inability to make those, upon whom

rests the responsibility of conducting the traffic, comprehend all the bearings of an extensive scheme, when presented to them upon paper. For this reason, it is to be regretted, that railway officers, in general, are not required to possess, at least so much of engineering and architectural knowledge, as will enable them to judge of the merits, or defects, of plans, or drawings of works, affecting their several departments; and, on the other hand, it follows, that he will be the most efficient engineering adviser of a Railway Company, who has acquired the greatest amount of practical experience in all branches of the business. Many difficulties, again, arise from the practice of employing architects to design and execute the station works. Few members of that profession have had any opportunity of obtaining the special kind of knowledge, which such works involve; and hence, it not unfrequently becomes the duty of the Resident Engineer, to correct the errors made by the original designer. If, therefore, the Engineer desires to do full credit to his employers, and to himself, he should in all cases design the station works, either engaging assistants, or working conjointly with an architect, to furnish the necessary amount of architectural decoration, a talent for which is not always combined with constructive ability, or the faculty of judicious arrangement.

In order to deal with the subject under consideration, in the most convenient form, it is proposed to classify every description of railway station under three heads; viz.:—

1. Passenger stations.
2. Goods-yards, wharves, and dépôts.
3. Locomotive- and carriage-sheds, manufactories, and workshops.

The passenger station admits of subdivision into the two simple types of the 'terminal' and the 'intermediate.'

The terminal station, in its most complete form, whether it be metropolitan, or provincial, comprises a great variety of details, each of importance, taken in connection with the other. The following is the order in which it is proposed to treat them; viz.:—approaches, roads, and yards; waiting-rooms; offices for booking passengers, for the luggage and parcels, and for the telegraph; cloak-room and lost-property office; platforms, platform-sheds; horse- and carriage-docks; lines of rails for trains, spare carriages, and locomotives; turn-tables, traversers, points, and crossings, and moving platforms; curves, ballasting, and paving; engine-stable, and pits; water-tanks, cranes, hydrants, and coke-stage; ticket-platforms, carriages-in-waiting, and means of egress; mess-rooms, and conveniences for drivers, guards, porters, and police; workshops for local repairs; stabling for post-horses, with coach-houses; provisions for lighting, watering, cleansing, and watching.

In laying out the approaches and station-yard, ample width and

space are the main desiderata. Arrangements should be made, by means of barriers, and well-defined means of ingress and exit, to secure a continuous circulation of vehicles, without confusion ; and the setting-down pavement should be as long as possible, to admit of several carriages discharging their passengers and luggage at the same time. The pavement itself should not be less than 20 feet in width, and should be raised from 1 foot to 2 feet above the roadway ; it should be sheltered from the weather, by a roof projecting considerably beyond the line of the kerb. Columns for the support of such roofs are specially to be deprecated, as entirely destroying the utility of a spacious pavement. When there are several entrances to the booking-offices from the pavement, all upon one line of frontage, it is necessary to distinguish them, as clearly as possible, and not to place them too near to each other. Buildings with sundry wings, recesses, and returns, though perhaps architecturally more effective, conduce greatly to confusion and delay.

The position of the main buildings, relative to the direction of the lines of rails, is the distinguishing feature in every variety of terminal station. Where space permits, the usual course is to place them on the departure side, parallel to the platform, as indicated in Fig. 1, page 454. It is frequently, however, found desirable to construct them at the end of the station, at right angles, or nearly so, to the platforms, Fig. 2, page 455. Another variety is formed by a combination of both systems, the offices being situated in a fork, between two, or more series of lines and platforms, Fig. 3, page 456.

The advantages in favour of the first plan obviously consist in the facilities for giving the greatest length of setting-down pavement, the most ample space for building offices, waiting-rooms, &c., and the least average distance for passengers and luggage to traverse in reaching the outgoing train.

Where, however, the traffic is of a mixed character, involving the despatch of trains to different points, in quick succession, and with perfect regularity, it is submitted that the second system is by far the best of the three. It admits of increase, to any extent, in the number of arrival- and departure-platforms,—with ready means of access to both ;—the rapid sorting, or selection of the several classes of carriages required to compose each description of train ;—the best general control over the method of conducting the entire business of the station ;—and the greatest facilities for the despatch and reception of trains without delay, or confusion. The main objections will be found in the necessarily contracted length of frontage ;—the increased average distance between the outside and the departing-trains ;—and the difficulty of providing more than one arrival-platform, with a coach road alongside ;—the last, however, being common to any system.

Fig. 1.

Fig. 2.

Fig. 3.

The third plan is probably one which is never adopted, except under circumstances of uncontrollable necessity;—and is open to all the objections which can be raised against the other two, whilst it combines but few of the advantages of either.

Several arrangements have been adopted to obviate the main objection to what may be distinguished as the 'parallel,' or side-

station, system,—with a view to increase the number of departure-platforms. That most in use is to place each train on separate lines; as will be readily understood by Fig. 1. The remedy, however, is very imperfect, as it involves a great waste in useless lengths of railway—a limited length of platform,—considerable embarrassment to the bewildered traveller;—and much difficulty in communicating with the spare carriage-lines at any moment.

On the other hand, the 'transverse,' or end-station system, offers every facility for working any number of platforms independently of each other, with the greatest economy of labour, affording a ready access to spare carriage-lines, and the means of complete supervision over the whole business. By reference to Fig. 2, it will be seen that trains can, without trouble, be made up, at one time, to depart from three separate platforms, with spare lines, available for each; and, if required, distinct booking-offices and waiting-rooms;—whilst the number of porters, and other attendants is not necessarily increased in proportion to the accommodation given. One of the greatest difficulties met with in working on this plan, when adopted for 'long' traffic, is to avoid the annoyance which arises from wheeling luggage along a crowded platform. Where width is no object, this might be met by railing off a passage down the centre, or at the back, of the platform, to be exclusively used by the luggage-barrows, but it is doubtful whether the gain would be balanced by the extra outlay involved in platform and roofing. A raised gangway, or passage overhead, for luggage, might perhaps be found preferable; particularly when it is to be loaded on the roofs of carriages, as is still practised by some Companies.

The most convenient arrangement of the several offices and waiting-rooms, with all their accessories, is very important. A large exterior vestibule, or hall, for those waiting for tickets, with ready communication from thence, for luggage, to the platform, clear of the stream of passengers, and a spacious, well-lighted, booking-office, with the greatest available length of ticket-counter, will give the greatest amount of comfort and convenience to the travelling public. The ticket-counter should be so constructed as to concentrate the business, and to reduce the number of clerks, as much as possible; it should be provided with an inner glazed office, raised above the floor-level, to enable the head-clerk to keep his eye upon his subordinates. The counter must be provided with numerous drawers for cash, spare tickets, and books; and with a large number of ticket-tubes, arranged in series, according to the traffic requirements; each series having the means of being closed, when not in use. These tubes should occupy the depth between the clerk's counter, and the cash-shelf, to which alone the public have access, the cash-shelf being placed breast-

high, or about 4 feet from the ground. The ticket-windows ought not to be too numerous, or too large, and should be legibly marked with their several distinctions. High barriers have usually been placed before each window, to avoid crowding, and to secure the pocket; but the recent substitution of wide tables is a decided improvement, as they permit the retention of parcels in the hand, and more effectually expose the pickpocket to detection. The separation of classes, before reaching the ticket-counter, is desirable under some circumstances; but offers many difficulties in arrangement, and increases the labour within the counter. Where the proportion of second- and third-class traffic is large, there can be no doubt as to the propriety of keeping it distinct, even at the risk of some additional outlay in duplicate conveniences of all kinds. After booking, it is the custom in this country to allow the passengers and their friends to wander almost indiscriminately over the Company's premises,—much to the detriment of the convenient working of the traffic. It is a question whether it might not be desirable to adopt the continental system, and to provide large halls, or saloons for each class, communicating with the booking-office and platforms; with a view to confine the passengers until a few minutes before the time of starting each train. Restricted space in building area seems to be the obstacle to the adoption of so great an improvement, added to which, the inherent restlessness of the English traveller, in the matter of luggage and its safety, might present some difficulty. This, however, could be easily met, and with advantage in many respects, by altering the luggage system, and compelling the public to book and pay for the whole of it, at an office distinct from the ticket-counter, and attached to the outer vestibule. All railway-managers know, but too well, how much the irregularity of trains is due to the want of punctuality on the part of the public; and in no small degree, to their requirements in the way of luggage. Much of this might be avoided, if Railway Companies had the power of converting a portion of the fare into a toll upon luggage, combined with facilities for disposing of it upon the trains, before the platforms are crowded with the owners.

In connection with the luggage question, reference must be made to the necessity for providing a spacious cloak, or left-property room, which should be accessible from the outside of the station, be conveniently situated with respect to the arrival-platforms, and be furnished with every requisite for ready stowage and sorting. If built fire-proof, with an upper floor, to serve as a lost-property store, additional safety and economy of space would be obtained.

The system of dividing the parcels-office into two, distinguishing them as, 'in' and 'out,' or 'up' and 'down,' does not seem desirable; as requiring more clerks and attendants than is other-

wise necessary. One large, lofty, and well-lighted office, to combine the whole business, is preferable, if it can be placed centrally, so as to be readily approached from both platforms;—but it is essential, that there should be equally good access from the outside, with ample space for the vans and town-carts to stand under cover, without impeding other traffic.

The same remarks apply, to a certain extent, to the position and arrangement of the telegraph-offices; the main object being to give every facility to the public, without actually admitting them within the station-premises, securing, at the same time, free communication with the platforms and offices for traffic purposes.

Next in importance to the arrangement and construction of the offices, are those of the platforms. The practice, with regard to the height above the rails, has varied considerably; the recent tendency being to raise them much higher than was usual at first. Three feet may be stated as the limit in this respect, but that height has probably been adopted as a necessary consequence of the increased width of the carriages, which prevents the use of a second step. Where there is no such impediment, a mean of about 2 feet has seemed advantageous, as being sufficiently convenient for entering, or leaving the carriages, and being safer for the station people, who frequently have to cross from one platform to another. Too much attention cannot be given, to the necessity for obtaining the greatest possible width of platform. Where the platform is used on one side only, the width ought never to be less than 20 feet; and when both sides are required, 30 feet, or even 40 feet, should be allowed. The best mode of constructing the platform is, undoubtedly, with stone-slabs, laid hollow, upon longitudinal walls; so as to admit of carrying beneath it the water- and gas-pipes, telegraph, or signal-wires, and the general drainage: with free access to each. Slabs of sawn slate have been used largely, and are found to be clean and quiet; but they are not to be depended upon for safety, as it is nearly impossible to obtain them thoroughly sound. There is also always a risk of lamination on the under side, which may proceed without discovery, until the slab gives way suddenly under a weight of luggage, or passengers. Hard Yorkshire landings are preferable; but they require rubbing on the upper surface, to avoid the accumulation of dust and dirt. Cutting out for turn-tables, and openings for cross-lines of rails, are frequently inevitable difficulties, which have given rise to various ingenious contrivances, as shifting-stages, draw-bridges, &c. The substitution of 'traversers' for turn-tables goes far to remove one class of impediment, and the other is best met by the use of easy inclines, with crossings on the rail-level. Where the platforms do not exceed 2 feet in height, and the surface is smooth, gradients of 1 in 10 are not too steep for luggage-

barrows,—nor are they dangerous in a crowd. The sorting of the different classes of passengers, preparatory to entering the carriages, is sometimes attempted, by means of barrier enclosures on the platform, but this is practicable only in cases where the trains are always uniform in length and arrangement. When the nature of the traffic renders it necessary, and time can be spared, the examination of the tickets before admission to the carriages, or before the starting of the train, is a more effective and simple precaution. Many serious accidents having arisen from carelessness in getting in and out of the trains, while in motion, at the platforms, attempts have been made by the Companies, urged by the Board of Trade, to reduce the chance of casualty, by some kind of barricade along the edge of the platforms. The danger of placing fixtures so near the sides of the carriages, as would be necessary to obtain the desired result, seems to have hitherto prevented the adoption of any plan calculated to meet the case; but it may be worth consideration, whether a system of rising barriers, counterpoised and guided from below, might not be contrived, so as to secure safety, and to some extent, to answer the same purpose as would be gained by separate waiting-saloons on the continental plan.

The greatest advance in station-works during the last few years, has been the roofing over, in one span, of the lines and platforms; the main object being to do away with intermediate supports of every kind. That columns, or pillars in a station are objectionable, seems to be agreed on all sides; but where two, or more, spans can be so arranged as to bring the columns in the centre of wide platforms, the great extra expense of large spans may be saved, and with some attendant advantages. Whatever may be the spans adopted, every effort should be made to obtain height, light, and ventilation. Too large a proportion of glass, in the shape of sky-lights, is to be avoided, as it is apt to render the heat, in summer time, so great as to endanger the health of the men employed, and to injure the rolling stock beneath; to say nothing of the expense of continual repairs, and the difficulty of preventing leakage and condensation. Durability is, of course, the great desideratum; hence iron and slate will naturally form the chief materials of the structure. It is impossible, however, to avoid the use of timber to a large extent, particularly for the sash-bars for the sky-lights, and the boarding for the slates. Iron sash-bars, though largely used, are not satisfactory in practice; as the effect upon them of changes in temperature is so great, as to render it impossible to keep the glass water-tight. The slating is sometimes attempted on iron battens, without the intervention of boarding, but the unfinished effect below is so bad, and the deterioration of the battens so rapid, that there is nothing to recommend

such a mode of construction. When boards are used to carry the slates, they should be laid horizontally, and not diagonally, or vertically, with a view to discover readily, through the droppings from the joints, the position of any leaks in the slating. Louvre ventilators, from their exposed position on the summit of the roofs, should be made moveable; with the means of closing them at pleasure, as has been done with those at the Crystal Palace. Without such a precaution, there will either be defective ventilation, or continual annoyance from the driving in of rain, or snow. The use of galvanised sheet-iron, whether corrugated, or flat, is not to be recommended as a covering material, in, or near a large town; as it will be found to perish rapidly, either through the galvanic action of the metallic compound, or from the chemical effect of the sulphurous fumes of coke and coal, when largely consumed in the immediate vicinity. That material may, however, be advantageously used in the country.

The best position for the horse- and carriage-docks is a question not easily decided. Experience would lead to the conclusion, that two sets, one for arrival and one for departure, are not absolutely essential; but if concentrated at one point, it is doubtful at which end of the platforms they will work the most satisfactorily. Looking to the greater importance of time in the despatch of trains, as compared with a certain amount of delay, attendant upon unloading, on arrival, the balance of advantage points in favour of placing the docks at the extremity of the station lines, where they may be so arranged as to communicate equally well with both series of rails, securing, at the same time, ample length of siding space for spare stock. This system has been in use at the London terminus of the Brighton Railway for some years, and answers the purpose, even in times of the greatest pressure; whilst at Brighton, where the plan is unavoidably reversed, out-going trains are necessarily stopped, after starting from the platform, to allow of carriage- and horse-boxes being attached—an arrangement which is obviously defective. Despatch and regularity will be found to depend, not so much on the number of each kind of dock, as in the perfection of the means provided for securing a constant succession of trucks, by passing off the loaded ones, and bringing in those that are empty, without allowing them to impede each other. The details of construction require attention; particularly as to the surface, which should be wood pavement, for the sake of cleanliness, and to prepare horses for the floors of their boxes; also as to the means of admitting the buffers and draw-hooks, without injury either to them, or to the structure; the difficulty being to provide for variation in the heights of vehicles when loaded, or empty, or when not uniform in build.

The correct arrangement and appropriation of the several lines

of railway in a terminal station materially affect the economical and efficient working of the traffic. Circumstances will necessarily indicate a particular principle to be followed in each case, but there are a few general rules which cannot be overlooked. It is essential, that every traffic line, both in and out, should be provided with one, or more spare sidings, in addition to those set apart for the break-vans, horse-boxes, and carriage-trucks, and for the locomotive department. All these lines should communicate with each other, by means of points and crossings, to allow of shunting with engine-power; and to reduce to the lowest limits the number of turn-tables, or their substitutes. Sharp curves are of course objectionable, and they ought never to have a radius of less than 800 feet. The use of self-acting points, or switches, may be assumed to be now universal, though it is believed, that some managers still prefer the old eccentric, or lever switch; because they involve more constant attention on the part of the pointsmen, and fix responsibility, with greater certainty, in case of casualty. The incessant introduction of novelties, or, as the inventors consider them, 'improvements,' in all matters of detail connected with the permanent-way and its fittings, is a source of much perplexity to the Engineer, in laying out station-works. His best course will probably be to select, in each case, whatever appears to be most simple, and best suited to his purpose, and then to adhere firmly to such selection, regardless of the pertinacity of patentees, so as to secure uniformity in details, the essence of true economy in repairs and maintenance. In the construction of points and crossings, the quality of rail out of which they are to be made, is the most important consideration; for which reason, all Companies should make their own points, &c., and should spare no expense to obtain the best metal that can be supplied. The extensive use of three-throw, and four-way points, is sometimes objected to, as being more complicated and costly; but if they are well made, and properly fixed, there is no real difficulty in working them, and siding space can frequently be so gained, with much advantage. Turn-tables, in a passenger-station, and especially when placed on the traffic-lines, can only be viewed as necessary evils. The wear and tear both to the rolling and to the fixed stock, the intolerable noise when passing over them, the interference with the line of platform, and the waste of space between the lines of rails, are objections sufficiently obvious to condemn turn-tables, where they can be dispensed with. The late Mr. C. H. Wild secured some economy in width, by the introduction of his three-way tables, fixed diagonally; but his plan of using inclines at the intersection of the cross-rails, to save the hammering of the passing wheels, is not approved, as it has been found injurious to the flanges of heavily-laden vehicles, locomotives, and tenders. By far the best substitute for the turn-table yet introduced is the

'traverser,' as invented, or improved by Mr. Dunn, Mr. Ormerod, and others. If they are well made, and carefully worked and attended to, the shifting of carriages, from line to line, can be performed without extra manual labour, or interference either with the rails, or the platforms. In cases where the edge of the platform is unavoidably indented, by the position of a turn-table in the line adjoining, there is a choice of contrivances for preserving the line, when the table is not in use; such as, leaves folding back on hinges, circular trollies on low wheels, stages to slide, or roll back above, or below, the platform, and sundry other plans, all of which are but so many additional sources of obstruction and expense; hence if the turn-tables can be so placed as to fall at the ends of waiting-trains, the least evil seems to be, to leave the platform open, with barriers to prevent accidents.

The whole area of every large station ought to be paved with stone, or with Staffordshire blue bricks, laid in mortar; great attention being paid to the surface drainage. Having regard to conveniences for washing carriages, and general cleansing purposes, it will be found best to form the rise in the intermediate space; and the channels and gratings within, or between, the rails. A longitudinal-timber road, with bridge rails, will be found to give the greatest facilities for effective paving, or pitching.

It is assumed, that every terminus will be provided with one, or more engine turn-tables, according to the nature of the traffic, but it does not appear to be the general practice to construct engine-sheds, as a part of the station, probably because most lines have suburban depôts, which offer greater facilities for the purpose. If, however, space can be afforded, economy and convenience are obtained, by placing a shed in communication with the turn-table and coke-lines, large enough to contain as many engines as usually stand about, during the day, or come out for working the morning trains. The lines leading to such a shed should connect directly with those of arrival and departure, and be distinct from those appropriated to the turn-table and the coke-waggons; but the best arrangement of all, is to place the shed on a loop-siding, connected at both ends with the main lines, so as to obtain the easiest means of access, at all times. Good light and ventilation are essential points in a well-constructed engine-shed, with ample height to the roof, and width between, and outside, the rails. The gas-fittings should be such as to admit of examining any portion of the machinery with accuracy, and the water should be laid on with sufficient pressure to thoroughly wash out the boilers, from time to time. It is not unusual to make the large water-tank, for station use, do duty as a roof to the engine-shed. To this there can be no objection, provided the tank is fixed at a sufficient height to secure perfect ventilation, and this will

also improve the pressure at the points of delivery. Such tanks cannot be too large, and should never hold less than one week's average consumption, to meet the chance of failure in the means of supply. Each line of rails, within the shed, should have engine-pits, properly drained, and contrived to admit of examining and repairing all parts of the machinery from below; similar pits should be constructed on each line outside the shed, to admit of raking out the fires, or removing the clinkers, operations which are best done in the open air. The arrangements for coking and watering are naturally connected with the turn-table and engine-shed. Large coke-sheds, or stores, are now generally considered unnecessary; it being found more economical to bring up the supply from the ovens, or *depôt*, as wanted, delivering direct from the waggon into the tender. For this purpose coke-sidings should be laid alongside those leading from the turn-table, with a platform intervening, on which the coke can be weighed, or measured in transit. Much time is lost in watering, if the cranes are not fixed in proper numbers, or position; nor is sufficient attention generally paid to having them, and the service-mains leading to them, of large diameter. The gain of a few minutes, in filling a tender, is frequently of vital importance in working the traffic to advantage.

The collection of tickets is a branch of railway business, which generally involves special provision in the arrangement of a terminus. The practice of stopping the trains, for this purpose, at the entrance to the station, is objected to by the public, but it cannot be avoided, unless there is some station immediately preceding the terminus, of sufficient importance to combine traffic purposes with collecting the tickets. When such is not the case, the next best course will be to utilize the time spent in collection, by running the engine round from the head to the end of the train, by a loop-siding behind the ticket-platform, and pushing the train, instead of drawing it, up to the platform. Every ticket-platform is usually furnished with convenient offices and mess-rooms for the head collector and his men, fitted up for sorting and arranging the tickets, keeping the books, and taking their meals; attention of this kind to the comforts of the men is always highly appreciated by them.

The road for carriages-in-waiting, which adjoins the arrival-platform, should be wide enough to permit, at least, two ranks to stand, with passing-room clear of them; and it is essential, that the means of access should be distinct from that of exit, to secure a continuous stream of vehicles, and to avoid delay in turning, or meeting others in an opposite direction. Protection from the weather, and from cold draughts, by means of roofing and side walls, is important, where there is a good first-class traffic; because attention in a particular, so apparently trivial, will not unfre-

quently bias the owner of valuable horses in favour of one line as compared with another. The pavement should be of wood, creosoted, if the ventilation is good, and constant attention is paid to sweeping and cleansing, without which the ammoniacal exhalations will prove injurious to the health of the men employed at the station. At the entrance to the cab-road there should be a large area, sufficient to hold at least one hundred cabs, as a reserve to meet the requirements of the heaviest trains, with proper conveniences of every kind, both for the men and the horses; and at the exit should be placed the Cab Inspector's Office, for registering the departures.

Attention to the material comforts of the men employed, and particularly of those much exposed to the weather, in the execution of their duties, being an important element of success, in securing good and cheerful service, it is obviously politic to furnish every large station with distinct mess, or waiting-rooms for the engine-drivers, guards, porters, switchmen, &c. These should be spacious, well ventilated, lighted and warmed, and be fitted with good cooking apparatus, cupboards, lockers, and tables, and be so placed as to be near the work of each class of men. Connected with the mess-rooms may be combined, with advantage, offices and store-rooms for the superintendents of the different departments, such as the permanent-way, locomotive and carriage superintendents, police, &c.; thus giving each an opportunity of keeping an eye upon his men, and of readily communicating with one another.

Experience will dictate the necessity for constructing sundry other buildings, as accessories to the effective working of a busy terminus. The lamp-room should, if possible, be detached, and be fire-proof; with warm store-rooms for oil, tallow, and waste. The dressers for cleaning and trimming should be covered with polished zinc, in preference to slate. The shelves, or brackets for the lamps, should be sufficiently extensive to hold the largest number in use, and there should be ready means for disposing of the waste and rubbish, as they accumulate, to avoid all risk of fire. It is frequently found good economy to have a few small shops, for the different classes of mechanics required for repairs and for odd jobs, such as smiths, gas-fitters, joiners, plumbers, &c., much time being wasted in sending men and materials to and from the general workshops of the line. Unless a large hotel is attached to the station, it will be found necessary to construct stabling for post-horses, and coach-houses for private carriages on arrival, or when waiting to go by the trains. The construction and arrangement of the closets and urinals are too important to be dismissed without brief notice. Comfort and decency will be best consulted by distributing the conveniences amongst separate buildings, in

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various parts of the station area, and appropriating some of them to the different classes of employes, distinct from those for public use. Urinals should not have any roofs, or be very freely ventilated, and be paved with slate, or some other non-absorbent material: the walls should be lined with glazed tiles for 7 feet, or 8 feet in height, and the divisions and backs be of enamelled slate. Risers are objectionable, and quite unnecessary, if the floor have a sharp incline towards the channel. Closets, whether for the passengers, or for the company's men, cannot be too simple in their construction. All brass-work should be avoided, or it will soon be stolen. The walls should be lined with glazed tiles, or be grained and varnished, to prevent the surface being defaced: a shelf should be provided in each closet for depositing parcels; and water should be turned on by the action of the door in opening and closing. In fact, a constant and abundant supply of water, both to closets and urinals, offers the only chance of confining, within tolerable limits, the annoyances necessarily connected with such structures. The importance of keeping a large station constantly swept and cleansed is too often overlooked, in consequence of the difficulty of disposing of the dirt and rubbish, which so rapidly accumulate. To meet this, proper receptacles should be distributed at various points, with shoots, or traps to receive from above, and means of access below for the scavengers' carts.

The details given thus far are obviously intended to apply, in the main, to metropolitan termini, or to those of equal importance and extent. The leading principles, however, will be found available, more or less, according to circumstances, for the arrangement and construction of terminal stations of every description. For the purposes of illustration, attention will now be drawn to the general features of small terminal stations, on branch lines of railway, with the peculiarities of each, and the advantages, and defects which have been met with in working them.

The first (Fig. 4) is at the extremity of a double line of railway, in an important town on the coast; and accommodates the traffic and trains of two separate companies. The peculiar shape of the land originally purchased, its position with relation to that part of the town from which the bulk of the traffic is derived, the necessity for providing means of extension, and the existence of a public street, crossing on the level, at the very entrance to the station, were the chief controlling elements in the original design. It will be observed, that by placing the offices and both platforms on one side, with the spare carriage-lines adjoining, the frontage to the main street is economized, and left free for carrying one, or more of the lines forward, as has since been done. The arrival and departure-platforms are both accessible from the main lines, at the same time, and are made long enough to allow one train,

Fig. 4.

belonging to each company, to arrive and depart, or to stand, one after the other : whilst an extra line, with its platform, is provided for special occasions. The great length of the station offers every facility for abundance of spare lines, which can be roofed over to any extent that may be desired, at a moderate cost. The horse- and carriage-loading arrangements are combined with the goods- and cattle-lines and docks, and with the spare carriage-sidings ; and the whole of this department of the business is worked with great success. The approach and the yard in front of the offices are convenient, as regards length, for setting down and taking up, but are much too confined and narrow. The road should have been 50 feet wide at the least, including the footway, and the yard not less than 80 feet in width, with roofing over some part of it. The position of the goods-department is satisfactory, being sufficiently near to the town, without any objectionable interference with the passenger-station. The arrangements are not, however, so good as could be wished, having been devised under the impression that the goods-traffic of two companies could be worked under joint management as easily as that of passengers. Experience has proved, that separate warehouses, yards, and sidings, ought to have been constructed, and that the whole accommodation should have been on a more extensive scale. The engine-sheds in duplicate, turn-table, offices, mess-rooms, shops, tank, &c., are as well placed as the shape of the land would permit ; but the table is too far from the platforms, and involves some loss of time, and the employment of extra police, to secure safety, with so much crossing of the main lines. A second engine-table will be seen adjoining the goods-yard, which was found convenient both to save time in turning, and to bring into use, with additional sidings, sundry corners of land which would otherwise have been wasted. The great defect in this station is the existence of a level crossing and a foot-bridge close to the entrance ; the thoroughfare being now a street, though originally but a narrow lane. Attempts have been made, both by the public, and by the Board of Trade, to compel the companies to build a bridge ; but neither being able to confer permissive, or compulsory powers of purchase, nothing has been done in the matter.

Fig. 5 shows the outline of a station forming the terminus of a small, single-line branch, the nature of the traffic on which necessarily admits of much simplification in all its arrangements. The trains being light, and only moving in one direction, a single platform suffices for passengers ; but as goods are frequently attached to such trains, it becomes necessary to combine the goods-yard as intimately as possible with the passenger-lines, so as to avoid loss of time on the arrival of the trains, and to clear the trucks and leave the carriages ready for going out

again, when the engine has been turned and brought round. On short branches, to which alone the single-line system ought to be confined, it is generally an object to despatch the incoming train back again, as soon after its arrival as the engine can be connected for the purpose. It is, therefore, convenient to place the engine-table at the end of the station, beyond the platform, instead of connecting it with the engine-shed, as heretofore recommended; so that the engine may be turned, run round the train, by means of the middle spare line, and be hooked on ready for starting, with the least possible delay; the coke and water being taken after these operations, and while the out-going train is being loaded. A station of this character should always be so arranged, that a second line of way, as well as spare lines, may be added, without involving the removal of any permanent works, or buildings; in fact it should combine in one, the character both of a terminal and of an intermediate station. This rule will determine the position of the warehouse, goods- and coal-yards, engine-shed, &c., and regulate the number of sidings. Reference to Fig. 5 will show, that such a course can be adopted by the simple removal of the carriage- and cattle-docks, to the goods-yard, and of the engine-table entirely, the latter being no longer requisite. The position of the engine-table is convenient for working the goods-traffic, and obviates the necessity for using any smaller ones. Attention may also be drawn to placing the warehouse directly opposite the offices, as affording facility for throwing a light roof from one to the other, to serve as shelter to the platform and as cover for the spare carriages. Every such station should be provided with gas-works, large enough not only to supply its own lights, but the town also; as in most cases, it will be found, that the inhabitants are desirous of such a con-

Fig. 5.

venience. The proceeds from the sale of the gas, and the carriage

of coals, will secure a handsome profit to the company; and the introduction of gas-lighting will encourage improvements in the town, tending to increase traffic. The same course may be recommended, with regard to water-works, when the station stands high, and good water can be obtained on the spot; added to which, there is economy in combining the gas-retorts with the boiler-furnace. Too much stress cannot be laid on the importance of providing, at first, abundant space for goods-traffic, with large yards for coal, lime, timber, &c., and plenty of siding space. Such traffic is generally by far the most remunerative, for some time after the opening of a line of the nature indicated, and can only be secured, by offering great facilities. It should also be noted, that it is desirable, for reasons previously urged, to combine with the station, comfortable residences for the station-master, porters, engine-drivers, and guards.

Before leaving the subject of terminal stations, attention may be directed to one of a class indicated in Fig. 6, the arrangements of which are peculiarly adapted for the working of unusually heavy passenger-traffic, on particular occasions, such as races, or fairs. These consist mainly in placing a large number and considerable length of spare sidings, at each end of the platforms, to admit of trains arriving, discharging, and drawing out of the way, in rapid succession; and *vice versá*, on the return journeys. The system

shown in Fig. 6 has worked very satisfactorily for the last ten

Fig. 6.

years, and enables an almost unlimited amount of traffic to be conducted with perfect ease and safety. It may be objected, that with two platforms there will be some danger in crossing to the one opposite the offices, but in practice, it is found, that one platform only is necessary, as the traffic will always be in one direction, at the same time. The second platform is convenient for special, or foreign trains; and all danger can be avoided, by connecting the two by a bridge over, or under, though such an expedient is objectionable for this class of traffic. The small extent of carriage- and horse-docks may also be thought a defect, when race traffic is in question. As, however, horses and carriages cannot be carried with the passenger-trains, or during the height of the passenger-traffic, their transit ought to be limited to previous days, and early hours, by which plan they can be unloaded, or loaded with sufficient despatch, provided the siding-room is convenient and ample for working off the empty trucks without confusion. The large extent of spare sidings at the end of the station, not being required during the greater part of the year, may be utilized to much advantage, by roofing them over and devoting them to the purpose of stowing spare carriages, during the slack seasons.

In dealing with the class of stations distinguished as 'intermediate,' it will not be necessary to go into so much detail as heretofore. They will be found to vary, in their leading principles, to a greater extent than those previously treated of, though the general accommodation and requisites may be much the same throughout, but modified according to circumstances. The area to be occupied will naturally depend on the importance of the town, village, or district to be served; the character of the works, on that of the railway where the station is to be placed; and the position of the offices, warehouses, and other buildings, on the special requirements of the traffic in each case. As respects extent of space and accommodation, in the way of works, it has already been suggested, that it is best to err, if at all, on the side of extravagance; but the situation of the offices, waiting-rooms, &c., relative to the platforms and lines of rails, when there are more than one, is a point of considerable importance. When the station is situated midway between towns of such extent as to cause an equal flow of traffic in each direction, offices may be requisite on both sides of the line; but where the bulk of the traffic tends one way only, it will be desirable to concentrate them on that side which involves the larger number of passengers, and the greater extent of waiting-space. This rule again will be modified by the position of the town, or the district from whence the traffic is to be derived; especially if the railway lies on the natural surface, and adjoins a public road, whether crossing on the level, or otherwise. This last condition is the most frequent one;

Fig. 7.

and as some portion, at least, of the traffic must be expected to depart from the platform opposite to the offices, provision must be made for crossing with the least amount of danger to the public. When the passengers are numerous in both directions, over-bridges, as before stated, are objectionable, and in a surface station, an archway under the line is frequently impracticable. Some good authorities have adopted the plan of making the trains cross to the passengers, with one platform only, as indicated in Fig. 7, in which it will be seen, that the platform is made rather more than double the length of a single train, having crossings in the centre to communicate with both lines of rails, thus placing the trains, when standing at the platform, upon a loop-siding, distinct from those lines. This system is only admissible when the traffic is of such importance as to warrant the increased risk of so much crossing, and the extra cost of maintaining the additional staff of men, necessary to insure safety; in fact, it should never be adopted, except where all the trains are likely to stop, as the number of facing-points increases the elements of danger, and of delay to the through traffic. Much will also depend upon the probable uniformity in the length of all the trains; as it is obvious, that special provision must be made for the longest possible train to approach and to leave each platform, without interfering with the other; so that if there is much variation in the general length, unnecessary expense may be incurred without commensurate advantage. At the same time, it must be admitted, that this system offers great convenience to the public, when there is much first-class traffic, and a large quantity of luggage, and it is especially applicable when the station partakes of the character of a terminal one, or is used as a receiver from branch, or neighbouring lines; offering, as it does, great facilities for making up and receiving trains, which may run over a portion only of the main lines; as well as for attaching and detaching the carriages intended, or used, for branch-traffic.

An example is given, in Fig. 8, page 474, of a large station, where, from the position of a level crossing, combined with other circumstances, the system last explained could not be adopted, owing to the want of sufficient length for a double platform on one side. The traffic is large in both directions; and therefore, although the offices and main buildings are placed on that side from which the greater proportion departs, the opposite platform is provided with waiting-rooms and other conveniences, for general accommodation. In this case passengers cross the rails on the level, and have done so for some years without casualty, owing probably to the proximity of the public road crossing, where policemen are always in attendance. The placing of the platform wall opposite to the main buildings, affords facilities for throwing a roof over, in one span,

which shelters both platforms most effectually, at the least cost; and hence a satisfactory result is obtained. As there is a consider-

Fig. 8.

Fig. 9.

able amount of luggage to be conveyed across from one platform to the other, the extremities of both are furnished with easy inclines,

paved with smooth stone, and a paved crossing is formed from one to the other, between the rails, so as to allow hand-barrows to traverse with ease. Important intermediate stations, such as the two last described, will be found to require most, if not all, of the conveniences and adjuncts previously recommended for adoption, in the case of second, or third-rate termini. This particularly applies to the houses for clerks and porters, gas- and water-works, complete booking and other offices, with comfortable waiting-rooms, well-arranged and spacious warehouses for goods, and coal- and timber-yards, with as much length of siding as can be obtained. Relative to the construction of houses for the company's servants, in connection with the general business premises, it may not be out of place to observe, that there should be no door to communicate between the residence and any of the offices, both because such facilities frequently lead either to robberies, or to neglect of duty, and especially, because the whole block of buildings will be rendered liable to rates and taxes as an inhabited house.

The leading defect in the arrangement of the platforms, in Fig. 8, where no footbridge over, or under is provided, lies in the difficulty of crossing, when two trains arrive at the same time. This is sometimes met, by arranging the platforms as shown in Fig. 9, when the end of one is placed nearly opposite to that of the other, with a paved crossing between them; so that a clear space can always be maintained between the ends of the two trains, when standing at the platforms. Such a plan offers many facilities for connecting sidings with the main lines, and with one another; but is open to the objection of increased cost, in consequence of the extra length, and is not popular with the public, on account of the greater distance to be traversed both by passengers and luggage.

It has already been urged, that when a station is necessarily situated on an embankment, or in a cutting, it is true economy, in the first instance, to raise, or to excavate a sufficient area to allow of conducting the whole of the business at the platform level; with easy inclined approaches to and from the public road. This applies particularly to cases where there is much 'long' passenger-traffic with heavy luggage, besides the ordinary horses, carriage, cattle, and goods business. Steps, up or down, ought, as a general rule, to be avoided at any cost; but when the station is situated near London, or any large town, so that the traffic is chiefly confined to passengers, they may be adopted with some advantage, particularly if the line is in a cutting and the offices can be placed over it, and adjoining the public-road bridge, as shown in Fig. 10, page 476. Peculiar facilities are offered by this plan, when communication is desired with a middle platform, as must be the case when three, or four lines of rails are used. It will then, however, be found necessary to build waiting-rooms on each platform, as the public will not

Fig. 10.

be content to remain on the upper level until the trains arrive. There may also be some objection to the separation of the station-master from his platform duties, if he is confined to the booking-office; but this is partially met, by the facilities given for general supervision over the subordinates below, as well as for an economical and simple concentration of the entire business of the station. A somewhat similar system is available when the station is on an embankment, and the offices can be constructed in connection with a bridge over the public road. But the advantages are by no means the same, as there is no power of supervision from the office, whilst the public will always object to the inevitable darkness, damp, and noise. Nor are there the same reasons for adopting the plan, as it is easy upon an embankment to place the offices on one side and to connect them with the opposite, or intermediate platforms, by means of archways under the rails, which are not objectionable if well lighted and ventilated.

The junction-station is a special variety of the intermediate, or local class, which presents questions of too much importance and interest to be dismissed without distinct notice, however brief. Where two double lines of railway converge, it is frequently open to the Engineer, either to place the buildings and yards in the fork, between the two, Fig. 11 (page 477), or beyond the point of junction, Fig. 12 (page 478).

When the means of access for the public, and of communication between the platforms, are equally

convenient, in either case, he will be guided in his decision by the peculiarities of the traffic. If the branch, or secondary line is

Fig. 11.

simply a feeder to the main trunk, and the trains on both are worked in connection with each other, whether by attaching, or detaching special carriages, or by transferring the passengers, the balance of convenience will lie with the second system, provided the sidings are so arranged as to enable the branch, or subsidiary trains to clear the main lines, before the others are due. If, on the other hand, the two lines joining belong to distinct companies, or are worked independently of each other, it will be far more convenient to adopt the first system; because two trains in both directions can draw up at the same time, without interference with each other, and special conveniences for accom-

modating subsidiary traffic, or varying the size of the several trains, can be arranged with the greatest facility. Judging from

the general practice throughout the country, the latter seems to have become the more popular course.

Junction-stations, for single-line branches, may be arranged with

greater simplicity, as the traffic upon them is generally of less magnitude ; so that passengers and luggage can be transferred over a platform, without the necessity of attaching, or detaching carriages

to, or from the main-line train. Fig. 13 supplies instances to meet either case, being the plan of a junction with two single-line branches, one of which connects directly with the main line, and

the other only through the medium of an intervening platform ; facing-points in both cases being avoided. On such a system, the offices will be placed on the side opposite to the through line, the several platforms being connected by means of an archway under them and the rails, wherever it is practicable. Waiting-rooms and their adjuncts must necessarily be placed on the further platform, and a roof, in one or more spans, should cover the platforms and sidings—such roofs being enclosed on both sides, and as far as practicable at the ends, to protect the passengers from the weather, to which their exposed position will render them peculiarly liable. Engine- and tank-houses, gas-works, engine-tables, and rooms for the men employed, will also prove as essential a portion of the general arrangements as in the case of terminal stations.

As the limits of a Paper, for this Institution, do not admit of considering, in sufficient detail to be of any value, the two other classes of railway stations, distinguished as ‘the goods-depôt’ and the ‘locomotive and carriage depôt and shops,’ it is proposed to conclude with a few remarks on the position and construction of signals, on the efficient working of which, the safety of every description of traffic mainly depends.

The want of uniformity throughout this country, both in the description of signals used, and in the method of working them, is much to be regretted. The majority of the companies use the ‘semaphore,’ but all do not work it on the same principle : one manager uses it to give two signals, and another to give three ; a third manager will have an auxiliary to act as a repeating signal, his neighbours preferring to treat it only as cautionary. Those companies, again, which reject the semaphore system, adopt sundry varieties of ‘disc’ signals, which are, for the most part, limited in their application, though they may possess the advantages of simplicity and cheapness. The railways of this country having become gradually more intimately connected with each other, it would seem as essential to adopt an universal code of signalling, for the guidance of the executive of each company, as it has been found necessary to do in the case of ships at sea. Next to the question of uniformity is that of simplicity. The attention which has recently been paid to the subject, with a view to reduce the chances of fatal accident, has tended rather to introduce complication, and to substitute mechanical appliances for individual responsibility. Every point which requires protection, whether it is a station, junction, level crossing, or otherwise, should have one, or more semaphore signals of the simplest construction, to which should be attached as many men as may be requisite, whose duties must be strictly defined, and enforced with the rigidity of military discipline ; the same discipline being, of course, administered to those whose duty it may be to obey signals, when

given. With the Engineer will rest the responsibility of fixing such signals to the best advantage, in regard to the proper height and position, to secure the greatest possible length of view in both directions, clear of every obstruction, that can be foreseen, or anticipated. Whether, or not all such main signals should be assisted by others, worked at a distance, but in connection with them, is a question on which there is some difference of opinion. Too much caution, in the way of mechanical assistance, is apt to engender individual carelessness, unless there is some unfailing check on the vigilance and intelligence of the men employed. For this reason, it may be most prudent to limit the use of auxiliary signals to those places only which require peculiar caution, as where fogs are prevalent, or the sight is obstructed by curves, bridges, &c., and invariably to adopt some self-acting signal, like that of Whitworth's, which not only gives warning of the approaching object, but necessarily acts protectively, under any circumstances, unless it is wilfully and deliberately reversed. Such a contrivance tends to keep up constant attention on the part of the men, and renders it easy to fix responsibility when any one is in fault. The recent introduction of the electric telegraph, in connection with the ordinary system of signalling, offers some prospect of increased security, but it has not yet arrived at such a point of perfection, as to supersede the necessity of further efforts to improve either the one, or the other. Next in importance to the selection of the best men to take charge of the signals, is the duty of making them as comfortable as the nature of their work will admit, by providing them with convenient, warm, and well-fitted lodges, within which they can keep a constant watch over the line, without exposure to the weather. Economy in such respects is extremely impolitic, as trusty signal-men are too valuable to be neglected. At junctions, where the signal-man works the points in connection with the signals, his lodge, or box should always be raised some height above the surface, so as to give him perfect supervision in every direction. He will, at the same time, be rendered less liable to interruption from strangers, and be more likely himself to remain at his post. A similar precaution will be found to be of much service at all crowded stations, and other important signal-boxes, whether the points be worked from them, or not.

The Paper is illustrated by a large series of diagrams, plans of stations, &c., from which the woodcuts, Figs. 1 to 13, have been compiled.

[Mr. LOCKE, M.P.,
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