SECT. II.—OTHER SELECTED PAPERS.

(Paper No. 3671.)

**“The Design of Wayside Stations for Single Lines
of Railway.”**

By FREDERICK GEORGE ROYAL-DAWSON, M. Inst. C.E.

IN the early days of railway-construction in India the location and design of station-yards were based more or less on English ideas, which were themselves then in a comparatively undeveloped state. As traffic increased, the stations were extended from time to time in a haphazard manner in the attempt to keep pace with the growth of traffic. But this process could not go on indefinitely, and when the point was reached at which a yard could no longer be adapted to the increased traffic, it had to be entirely remodelled at considerable expense, with complete dislocation of traffic for the time being.

In many engine-changing stations, where the engine-shed had originally been built too close to the main platform, thus preventing the proper expansion of the yard, the press of traffic has at length compelled the removal of the entire locomotive-yard to a more remote site. In other stations, again, where insufficient space had originally been left between the goods-shed and the main line, expansions of the goods-yard have had in consequence to be made on the opposite side of the main line, till the constant shunting of all goods-trains across the main line, which this arrangement necessitated, has become such an intolerable nuisance that an entire remodelling has been inevitable. Such remodellings are going on at the present time in all parts of India, and absorb funds which might otherwise have been available for other purposes. The growth of local traffic, however, is not the only factor which has necessitated the remodelling of station-yards. Another factor which has reacted on the design of many minor wayside stations is the modern demand for through trains at high speeds. This demand on the part of the public has synchronized with a growing recognition, on the part of railway-managers, of the economic importance of getting the maximum use out of their rolling stock. The public and the managers are thus agreed as to the desirability of a certain per-

centage of fast trains and the expeditious transportation of goods; and as safety is of the first importance under these new conditions, the principles of safe working have become a special science, the main fruits of which have been (i) interlocking and (ii) automatic block-working. These two mechanical factors of safe working are being introduced gradually throughout the principal lines of India; and although their use is not compulsory, their omission entails the imposition, in the one case, of speed-limits over facing-points, and in the other case, of irksome rules in connection with "line clear" messages. Another factor which threatened to influence the design of station-yards a few years ago was the effect of quick-acting brakes on trains entering turnouts. It was considered that with the use of such brakes there was a tendency to enter turnouts at dangerously high speeds, and that the use of split turnouts, by easing the curvature, would mitigate the evil. But other considerations, to which reference will be made later, prevailed, so that the split turnout has never found favour, except perhaps on a few unimportant lines where fast non-stopping trains are not scheduled.

Types of Stations.—Omitting large termini and junction-stations, which obviously require special treatment, different localities present such a variety of traffic-conditions that wayside station-yards must necessarily be of many different types. Thus, comparing a busy double-line suburban railway, on which the stations are not more than about a mile apart, with a busy double-line section of a trunk-line up-country, having stations, say, 6 or 7 miles apart, it will be seen that, whereas a wayside station on the former consists of little more than an up line and a down line, each with its own substantial platform, and perhaps a trailing cross-over road, the trunk-line station requires in addition an up and a down lie-by siding, and a more or less developed goods-yard on one side, to which access is obtained trailing from both the near and the off track, involving in the latter case a diamond-crossing over the near line. Again, in single-line working the traffic-conditions may be such that (a) all trains stop as a matter of course at every station, as in small branch-lines, or (b) there is a large percentage of fast trains which do not stop at every station, as on important trunk-lines having a fluctuating local traffic. In the former case there may or may not be an up and a down platform, and the station may be approached either by means of a split turnout or otherwise. The number of signals may also be reduced to a minimum, and interlocking is not necessary. But in case (b) the station must be designed primarily for the safety of fast through trains, and secondarily for the development of local traffic; and as this class of station plays the most important rôle in the

transportation problem throughout India, the question of a suitable design has been the subject of much discussion from time to time, and is even now far from being settled. In this Paper, therefore, the Author proposes to confine himself to a consideration of this problem alone, and will begin by reviewing some of the discussions on the subject which have taken place in India during the last few years, and the conclusions arrived at.

Double-line principle applied to single-line stations.—In 1895, Mr. W. H. Cole, M. Inst. C.E., then Deputy Manager of the Eastern Bengal State Railway, having been on special duty in England for

Fig. 1.

the purpose of studying the question, embodied his conclusions in a Note¹ on the design of yards for single lines in India. Briefly, the type which he advocated was that shown in *Fig. 1*, which involves an up and a down line, with corresponding platforms, trains from both sides entering the facing-points on the straight and running through the trailing-points on the turnout. This design was circulated, with others by Mr. J. R. Bell, M. Inst. C.E., then Consulting Engineer for State Railways, in 1896, amongst various railway officers, for the purpose of obtaining their opinions.² On the assumption that the up and down line principle was desirable,

Fig. 2.

the relative merits of this type as compared with the symmetrical or split-turnout type (*Fig. 2*) were discussed. The general verdict was that for ordinary trains there was little to choose between the two types, except that the symmetrical type tended to minimize the length of the station. But for fast through trains it was held that the split turnout was a source of danger, and that the Cole type was preferable in that respect. Thus the split turnout became eliminated

¹ Technical Papers of the Indian Public Works Department, No. 54, p. 15.

² *Ibid.*, No. 161, p. 6.

for the time being from the discussion, as unsuitable for lines having fast through traffic. It was revived by Mr. F. J. E. Spring,¹ C.I.E., M. Inst. C.E., when Officiating Director of Railway Construction, in 1902, on the ground that with the introduction of quick-acting brakes, trains were liable to enter ordinary turnouts at excessive speeds, the effects of which would be mitigated by the use of split turnouts having easier curves. But in the discussion which followed, the verdict of 1896 was confirmed, inasmuch as the split turnout, although favourable to stopping-trains, was a source of danger to fast through trains; for, however easy the curve might be, the real point of danger was at the switch, when that was set to divert a fast train from the straight. The danger, it was pointed out, lay in the tendency of the leading outer wheel of an express engine to mount the switch, especially if the wheel-flange were somewhat worn; and as the safety of fast through trains was of paramount importance, it was held to be essential that at stations subject to fast through traffic the facing points at least must be on the straight.

It still remained to be considered whether the Cole type (*Fig. 1*) satisfied all requirements, or whether any other type would be preferable. This raised the preliminary inquiry as to whether it was necessary or desirable to preserve the double-line principle. No very clear reason could be given for compelling all trains, whether fast or slow, to take the left-hand road in entering a station beyond the vague plea that it was "English practice." It was thought to simplify matters for the driver, to diminish the risk of collision, and to simplify the signalling, as a train could be admitted by a one-armed home-signal at the facing-points, interlocked so as to be capable of being lowered only when the points were set for the straight. The single-line principle, however, by which all lines would be equally available for up and down traffic, presented no difficulties; for two-armed routing-signals at the points, the higher for the straight and the lower for the turnout, would give the driver all the information he wanted, whilst the List and Morse system of interlocking,¹ as used on the North Western State Railway, illustrated how, at small cost, it could be made impossible for two trains from opposite directions to be admitted simultaneously on to the same line. Thus it was clearly established that the double-line principle was not necessary for safe working. It only remained to be seen whether it was desirable. The system, it was pointed out,

¹ Technical Papers of the Indian Public Works Department, No. 160, p. 4.

² *Ibid.*, No. 63.

necessitated two platforms, so that passengers entering or leaving trains on the opposite side to the station-building would have to cross the line, which they would usually do on the level, even if an overbridge were provided. And even although the platform on the off-side might be merely a surface dressing at rail-level, so that the first cost need not be an obstacle, the difficulty of dealing effectively with an up and a down train at the same time without duplicating the staff was another permanent objection. It might be argued that these drawbacks exist at every station on a double line, but on a double line two platforms are a necessity, whereas on a single line, the necessity for two platforms disappears, and the question is reduced to one of expediency. Regarded in this light it is at once apparent that, (i) with a given staff, trains can be far more economically and effectively dealt with from one platform than from two; and (ii) with a single platform passengers are not exposed to the danger and inconvenience of having to cross the line.

There remains another side of the question to be considered, namely, the facilities for passing trains of different descriptions. The contingency of a slow train being side-tracked for a fast one in one direction, while another train was admitted from the other direction, necessitated the provision of a lie-by siding available for trains from either direction, in addition to the two lines for crossing-purposes. With the double-line principle of working, a lie-by siding would have to take off (preferably in a trailing direction) from each through line; that is, two lie-byes would have to be provided, although not more than one would ever be used at one time. On the other hand, it was seen to be possible, by abandoning the double-line principle of working, and by making either line available for trains in both directions, to do with one lie-by siding only, which would be "trailing" for one direction and "facing" for the other.

Single-line principle.—Thus, the advantages of what may be called the "single-line principle" as opposed to the "double-line principle" in working ordinary wayside stations on a single line were established, and may be summed up as follows: (i) the double-line principle requires two platforms, the single-line principle only one platform; (ii) the double platform involves a larger and more responsible staff than the single platform; (iii) the double platform is more dangerous and more inconvenient to passengers than the single platform, and accidents can be prevented only by the erection of an overbridge and by the provision of extra supervision to enforce its use; the cost of the overbridge and the extra supervision are saved in single-platform working; and (iv) the double-line system involves the construction

of at least two lie-by sidings, whilst the single line requires only one.

The issue is thus narrowed down to a question of the suitability, or otherwise, of the Cole type (*Fig. 1*) for single-platform working. From this standpoint it is at once evident that trains would be more favoured in one direction than in the other. For, supposing the platform to be placed as shown at A in *Fig. 1*, trains from the right would always have a straight run to the platform, whilst trains from the left would either have to take the first turnout facing, or shoot past on the straight and, after passing the second turnout trailing, shunt back to the platform. The latter procedure would be appropriate enough in the case of crossing trains, but in the majority of cases when the train from the left had a clear platform it would approach by the turnout as a matter of course. The defects of the design, however, are most apparent when a slow passenger-train from the left and a non-stopping express from the right are approaching the station at the same time. The station-master is confronted with the following dilemma: (A) if the slow train is admitted directly to the platform-line, the fast train would have to be put on to the other line by a facing turnout; (B) if, on the other hand, the slow train is put on to the off-line, there would be difficulty in preventing passengers from attempting to cross the intervening track in the face of the fast train. Thus, in the handling of the two trains two alternatives are open, both of which are dangerous. But the danger arises from different sources in the two cases. In case (A) the danger lies in the alignment of the off-line, and would disappear if that were made straight, while in case (B) the danger lies, not in the alignment, but solely in the relative position of the two trains, and is inherent in any system which allows a fast train to pass between a halted passenger-train and a platform. These considerations simplify the issues, for case (A) clearly indicates that the run-through line should be straight from end to end, the other line thus becoming a loop, and case (B) equally clearly indicates that the run-through line should not be between the loop and the platform.

Platform-on-straight versus Platform-on-loop.—The principle of the straight run-through, deduced from case (A), has now been generally accepted by railway-authorities, in supersession of the Cole type. But the principle of the platform-on-loop, deduced from case (B), has not by any means found general acceptance. In fact, when in 1896 and again in 1902 the various Indian railway-officers were asked to choose between the two types shown in *Figs. 3* and *4*, which may be described as “platform-on-straight” and “platform-on-loop,” respectively, and both of which satisfy the condition of a straight

run-through, a surprisingly large number voted in favour of the former, *Fig. 3*. The reason given for this preference was to avoid the lurch at the turnout to which all stopping trains were subject when the platform was placed on the loop as in *Fig. 4*. The danger of allowing a fast train to pass between the platform and a side-tracked passenger-train which the former type involved was lightly considered, and in some cases ignored altogether, by the adherents of this type. It was held that the undoubted comfort of the many should outweigh the problematical danger of the few. On the North Western State Railway, however, where the ratio of non-stopping to

Fig. 3.

stopping trains, including goods-trains, was comparatively large, namely, about 1 to 7, the verdict was strongly in favour of the platform on the loop, *Fig. 4*. It would thus appear that there were objections to both types, and that the factor which determined the choice for any particular railway was the ratio of fast to slow trains on that railway. This would imply that, as fast traffic increased, the stations of a given railway should be changed from the first to the second type, and vice versa when the fast traffic decreased, a manifestly absurd proposition. Moreover, there is a general tendency on most railways to increase the number of fast trains. It therefore becomes necessary to weigh the objections of each type *seriatim*.

Fig. 4.

Taking first the platform-on-straight type, the reality of the danger of allowing a fast train to dash between a halted passenger-train and the platform has been proved over and over again. As an argument it might not carry much weight in a civilized country such as England, where passengers and employees are well able to look after themselves. But in India, no amount of supervision is sufficient to keep foolish and careless passengers and employees from attempting to cross the intervening track in the face of an approaching express. Time, also, is lost in side-tracking a stopping train to allow a through train to cross, and if time is limited the probability is that the stopping train will be allowed to remain at the platform

while the fast train is diverted over the loop—a dangerous alternative. Moreover, the long stoppage of a train on a siding facilitates evasion of the ticket-collector, a drawback which, although not serious, must be considered as inherent in the type. There are thus three permanent objections to this type, while the sole feature in its favour is the straight run for all but crossing trains.

Considering next the platform-on-loop type, the sole objection to it is the lurch to which stopping trains are subjected on taking the turnout. This lurch, it is contended, is a three-fold evil. It is dangerous when turnouts are taken at excessive speeds, as often occurs when quick-acting brakes are used; it is always unpleasant; and it increases the wear and tear of the permanent way as well as of the rolling stock. The risk of taking turnouts at excessive speeds is, however, a relative rather than a positive danger. As interlocking prevents the risk of splitting the points, the danger is confined to two sources, namely, the risk of the outer leading wheel of the engine mounting the switch, when the flange is unduly worn, and the overturning tendency due to the necessarily limited superelevation. In either case the risk depends on controllable factors, namely, the condition of the tires, the speed of the train, and the curvature, etc., of the turnout. A practical limit to the speed is derived from the fact that the driver has to bring his train to a standstill at the platform. This in itself is a safeguard, whatever arbitrary restrictions of speed over turnouts may be imposed, for experience shows that however prone a driver may be to ignore speed-restrictions, stopping trains do not in practice enter turnouts at a greater speed than about 30 miles per hour. Accepting this limit, there would be no excuse for an engine mounting the switch if the wheel-flanges and the points were kept in reasonably good order, as they should be; in fact, even with flanges worn to a sharp edge, mounting is extremely unlikely to take place in ordinary practice. With regard to the danger of overturning, or of broken springs, it ought not to be impossible to design a turnout capable of taking a train with safety at 30 miles per hour. On the Indian standard gauge (5 feet 6 inches), with tracks 15 feet apart, centre to centre, curves of about 1,600 feet radius, with crossings 1 in 12 and switches 15 feet in length, are frequently traversed by trains at 30 miles per hour (against rules, it is true) with impunity. If this is held to be dangerous the remedy would appear to lie in easier curves and longer switches, rather than in speed-restrictions, for as long as the latter are imposed, much of the advantage of quick-acting brakes is lost, and train-movements are unnecessarily hampered. But the Author is inclined to believe that the standard 1 in 12 turnouts, if

scientifically laid out and fitted with 18-foot or 21-foot switches, and properly maintained, could be made available for much faster traffic than is at present allowed. In this connection the question of whether a certain amount of superelevation could be given at the points without detriment to the running-qualities of the straight road is worthy of investigation. But these are technical details which need not be discussed here. They are alluded to merely for the purpose of indicating the possibility of improving the design of turnouts, so as to take trains comfortably at 30 miles per hour, without materially increasing the length of a station-yard. The foregoing remedies would also have the effect of mitigating, to a large extent, the discomfort of the lurch. The increased wear and tear of rolling stock and permanent way on the turnout is confined in the present case to the extra amount caused by fast trains; but as the majority of the trains using the turnout would not be fast trains, the objection under this head is hardly worth considering.

A simpler remedy than any of the foregoing for the evils of the platform-on-loop type is suggested by certain existing practices. The first practice to which reference will be made is that on certain railways, when two passenger-trains cross at a wayside station, the first train draws up at the platform as a matter of course (whether the platform is on the loop or on the straight), and the second train draws up on the second line, clear of the rear of the first train where it is at once dealt with. The second train thus does not get the benefit of the platform at all, but, as far as the Author has observed, no inconvenience is caused thereby, either to the passengers or to the staff, provided the space between the rails is levelled up and dressed with fine metal, and provided the platform is not inconveniently high. Where, as at many wayside stations, the platforms are of the "flush" or rail-level type, the second train suffers practically no disadvantages whatever over the first. Moreover there is no danger in crossing the track in this case, because the crossing is done in rear of a train that has just arrived, so that no one can get run over unless the first train is backed. Even in the latter contingency the danger is very remote, for at worst the backing could only be due to shunting movements in front, the effects of which would not reach the rear of the train without timely and audible warning. The second practice to which it is desired to draw attention is the use of "flush" or rail-level platforms at many wayside stations. To the average third-class passenger of India a high-level platform is an unnecessary luxury. The carriage foot-boards afford all the facilities necessary for egress

and ingress; in fact, on occasions when goods-wagons have to be employed for the conveyance of passengers (as frequently occurs when there is a shortage of carriage-stock), it is found that passengers, whether male or female, have no difficulty in getting into them from any platform-level. The Author does not defend the practice of using goods-wagons for passenger-traffic, but the fact is cited in support of the contention that, with proper coaching-stock, raised platforms are not indispensable for wayside passenger-traffic, either on the 5-foot 6-inch or the metre gauge. This point being established, and considering that trains are occasionally dealt with on the second line without inconvenience, the Author ventures to suggest that if flush platforms were generally adopted at wayside stations, and extended up to the second track (as they might easily be) there would be no need to bring stopping trains on to the loop at all, except for crossing-purposes. If this principle were accepted, the main objection to the platform-on-loop type of station would disappear altogether, as the loop would then be used only on special occasions, *e.g.*, by the first of two passenger-trains which have to cross, or by a passenger-train crossing a goods-train. It would then only be necessary for the station-staff to see that passengers waiting for a train did not spread themselves beyond the limits of what may be called the permanent or "waiting" platform, which might be slightly raised or otherwise demarcated to emphasize its functions. In short, if the three objections to the platform-on-straight type be set against the three objections to the platform-on-loop type, it is found that the former outweigh the latter at every point, for the former contain unpreventable elements of danger, whereas in the latter the danger element is reducible to one of discomfort only, and this can be mitigated or eliminated entirely by the method just suggested.

Position of Platform in Relation to Traffic.—Assuming that the platform-on-loop type is adopted, the next question is whether it matters from which side of the main line the platform takes off. This question has also been ventilated, and the general consensus of opinion is thus summed up by Mr. C. W. Hodson,¹ C.S.I., M. Inst. C.E. :—

(i) Fast or heavy traffic calls for continuous brakes, and the adoption of continuous brakes with fast traffic necessitates interlocked routing-signals, which render it unimportant which side of the main line the turnout takes off.

(ii) Consequently there is no need to put either the loops or the

¹ Technical Papers of the Indian Public Works Department, No. 160.

platform uniformly on any particular side of the line, but in the absence of any special reasons to the contrary the loop may preferably be put on the side on which the line will eventually be doubled.

As regards the latter portion of the second paragraph, the Author has seen the principle of uniformity carried to extremes. One side of the line is selected for future doubling (a contingency usually more or less remote), and all platform-loops are placed on that side whether it suits the local traffic or not, with the result that in many cases a fairly important town, which has been keenly interested in the construction of the line, finds itself finally on the wrong side of its station, to which access can be gained only by means of a remote level crossing at the extreme end of the yard. In the opinion of the Author, the more elastic principle of locating a platform on whichever side is more convenient to local traffic is preferable, in that it tends to foster better relations with the public, and simplifies the work of the traffic-department, while it need not prejudice the question of future doubling; for supposing a loop to occur on the opposite side of the line to that selected for doubling, matters could easily be put right, when the need for doubling arose, by a local realignment involving a lateral deviation of 15 feet one way or the other from the original main line. In the absence of any special reason to the contrary, it would of course be proper, as pointed out by Mr. Hodson, to put the loop on the doubling side. This would occur, for instance, when a crossing-station serves half-a-dozen unimportant villages equally on both sides of the line.

Lie-byes.—The location of a lie-bye, to meet the contingency of a slow train being side-tracked for a fast one in one direction, while another train is being admitted from the opposite direction will next be considered. From a traffic point of view the simplest device would be a second loop on the off-side of the main line, as shown in *Fig. 5*; but the paramount importance of safeguarding fast trains necessitates the use of some form of interlocking, so as to secure the isolation of the run-through line. Traffic conveniences must therefore be governed by the price which the Administration is prepared to pay for their safety. Regarded in this light, it is evident that the fewer facing-points there are on the main line, the cheaper the interlocking will be, and consequently the simpler the working, whatever system may be adopted. In fact, it may be taken as a general rule that it does not pay to have more than one set of interlocked facing-points each way in an ordinary wayside station. This being the case, the type illustrated in *Fig. 5*, which has two sets each way, must be rejected as too expensive, although undoubtedly convenient, and it

is therefore necessary to take the lie-bye off the platform-loop. But as the platform prevents the lie-bye from taking the form of a second loop, the form eventually adopted is necessarily that of a long dead siding, as shown in *Fig. 6*. This is the type now generally adopted on State Railways, and is the cheapest form from the point of view of first cost. The shunting of a train into the lie-bye and its subsequent extrication are tedious and troublesome operations, and in some cases a certain amount of manœuvring is required, as for instance when a stopping passenger-train from the left and a slow goods-train from the right arrive in succession, and the latter

Fig. 5.

has then to be side-tracked for a fast through train from the right; in fact, in this case, if pressed for time, the goods-train could not be got into the lie-bye without great delay, and the probability is that, in order to save time, the passenger-train would have to go there while the goods-train occupied the loop. Such cases, however, are usually rare, and the temporary inconvenience involved has hitherto been accepted as inevitable. The inconvenience would still exist even if the lie-bye were placed in the alternative position shown by the dotted line in *Fig. 6*, or in both positions. On this point the Author will have something more to say later on.

Goods-Yards.—On the question of the development of a local goods-

Fig. 6.

traffic various opinions have been held, some officers being in favour of having the goods-shed opposite the passenger-platform, so as to be under the eye of the station-master, rather than on the same side, where it would necessarily be some distance off, imposing on the station-master a certain amount of trouble and loss of time in walking backwards and forwards, with the alternative of neglecting either the goods-work or the station-work. On most wayside stations of this class the superior staff consists only of a station-master and his assistant, who work by reliefs, only one being on duty at a time; and the man on duty has to combine the duties of train-signaller and goods-clerk. Two or three menials complete the establishment.

There is thus no doubt that a goods-shed opposite the station-building would be more convenient from the station-master's point of view. This arrangement, however, means a reversion to the type shown in *Fig. 5*, which has been shown to be too expensive by reason of the extra interlocking involved. Moreover, from the point of view of the public, if the passenger-platform is on the natural passenger-traffic side of the line, as it ought to be, the natural goods-traffic will almost invariably be on the same side. Therefore, the type shown in *Fig. 5* would be not only too expensive, but unsuitable to the public. Hence the predilections of the station-master have to give way to the combined exigencies of economical working and public convenience; and if it is found in a rush of traffic that one man cannot efficiently attend to both the station and the goods-work, the proper remedy would be to engage an extra man temporarily. Thus at every turn the design of a station-yard of this class involves a choice of evils; and having arrived at the conclusion that the goods-yard must usually be on the same side as the passenger-platform, the next step is to consider how it should be laid out. In many cases the steps taken for creating

Fig. 7.

a goods-traffic are tentative in the first instance, and very often an extensive traffic is developed from very small beginnings. It is therefore very desirable that the first sidings laid down, however modest, should form part of the future design of a fully developed yard. The goods-shed has to deal with both outward and inward traffic; therefore the sidings should be so arranged that a goods-train from either direction can readily detach and pick up wagons, whether loaded or empty, from suitable sidings in the neighbourhood of the goods-shed. Let B (*Fig. 7*) be a point on the train-siding A B C opposite the goods-shed G G'. An engine arriving from A with wagons to be detached would draw up in B C, clear of B, then shunt back over a cross-over B D, giving direct access to two sidings D E, D d F, one of which would be kept clear to receive the "inward" wagons, whilst the other would contain the "outward" wagons, previously assembled in readiness to be attached. Thus, with a minimum of shunting and in the shortest possible time, the engine would have detached its inward and attached its outward load, and returned to B C ready to rejoin its train in A B, and thence proceed on its journey. Similarly, a train arriving from the direction of C

would require a corresponding cross-over B D' and sidings D' E', and D'd'F'. It only remains to provide access from both sets of sidings to the goods-shed. This can be done most compactly by providing a platform-line d G G'd' and inserting scissors cross-overs Dd, Gg, D'd, and G'g'. The movements of individual wagons between the platform and the various sidings would of course be effected by hand shunting. On the North Western State Railway, where this type of goods-yard is in vogue, the sidings are long enough to hold, say, fifteen wagons each, and the platform-line a similar number. If further platform-accommodation is required, one of the scissors cross-overs is simply moved further out, say to double the distance, and the platform-line is extended to hold thirty wagons. Ordinarily, not more than fifteen wagons are ever likely to be received or despatched in one direction at a time, so that dead sidings long enough to hold fifteen wagons each are found to suffice, but a platform of double that capacity may be necessary in case of up and down traffic being equal in bulk at any time, as sometimes happens. Further accommodation may be given by joining up D D', as shown by the dotted line. For stations in embryo the portions F G and F' G' and the cross-overs Dd and

Fig. 8.

D'd' are omitted. In the earliest stages, when the traffic prospects do not amount to more than one or two wagons a day in either direction, no platform is provided, and the "yard" consists of a single cross-over B D or B D', leading from the train-line to a short siding E E' on which all traffic is dealt with. If a shed is required, it is made portable, so as not to prejudice future extensions.

Accepting *Fig. 7* as the normal type of goods-yard, based on common-sense principles, the next step is to fit it into the station-plan, *Fig. 6*. It has already been shown that it must be on the platform side. The first device that suggests itself is to merge the approach-siding A B C of *Fig. 7* into the lie-bye in *Fig. 6*. This is, in fact, what is usually done, the only objection to it being that, in a certain contingency, already alluded to, a goods-train on arrival might find the lie-bye occupied by a passenger-train, the main line being cleared for an expected through train. If such a contingency is likely to be of frequent occurrence, a second lie-bye can easily be put in as shown by the dotted line in *Fig. 6*, and one of these lie-byes,

say the right-hand one, reserved as the base of the goods-yard. Usually the second lie-by is not necessary, a short dead siding being sufficient there as a trap. The yard will then finally take the form shown in *Fig. 8*. The minimum distance between the station-platform and the near end of the goods-platform is fixed by the length of the sidings *D E* and *G F*, which must be at least equal to the length of fifteen wagons plus the length of the scissors cross-over. The station-platform being 600 feet in length, the distance from the station-building *H* to the nearest point of the goods-platform *G*, amounts to about 850 feet, on the standard gauge. Hence if the goods-platform is 720 feet in length (sufficient for thirty wagons) the station-master's average walk from the station-building to the centre of the goods-platform is 1,210 feet, or say 400 yards, which in the hot weather might be traversed in 5 minutes.

Interlocking.—The means by which such a yard can be interlocked have still to be considered. On the North Western State Railway, where the List and Morse key-locking system¹ is in use, the goods-yard is trapped at *K*, between *A'* and *B* (*Fig. 9*) and the points *A* and *A'* are kept normally locked off the loop, and cannot be unlocked

Fig. 9.

and set for their respective dead sidings when a loop-signal is lowered at the facing-points *X* or *Y* of the main line. The result is that no train can be admitted directly into a dead siding from the main line. It has to be brought first on to the loop, where it then has to wait till the desired road is made. This is done in the following manner. The points *A'* and the trap *K* are set and locked normally as shown in *Fig. 9*, by means of a Hepper double-key lock at *K* and a single-key lock at *A'*. To set the points for the siding, a key, called the "station-key," is obtained from the station-master, the issue of which locks the loop-keys, thus preventing loop-signals from being lowered while the "station-key" is in use. This station-key is taken to the double lock at the trap *K* and inserted in its proper hole and turned. This releases the switch, which must next be reversed and set for the siding. This releases a key, called the

¹ Technical Papers of the Indian Public Works Department, No. 63.

² *Ibid.*, No. 181, Plates *xx* and *xxi*.

“points-key,” from the other compartment of the double lock. The extraction of the points-key prevents the trap from being again reversed, and so locks up the station-key for the time being. The points-key is then inserted and turned in the lock at A', thus unlocking the points, which can then be reversed and set for the siding. This reversal locks up the points-key, so that when the siding is in use neither the points-key nor the station-key can be extracted and no loop-signal can be lowered. Consequently, if it is desired to admit a running train on the loop, the siding must first be restored to its normal setting and locked off the loop and the station-key returned to the station-master before the key for the loop-signal can be issued. It will be understood from the foregoing that any key locking-system, although securing at small cost the absolute safety of the running lines, entails a certain amount of delay in bringing the siding into use, and again in restoring it to its normal setting. A rodding system would be more expeditious, but the cost would usually be prohibitive for wayside stations. These drawbacks are beginning to be realized more and more every day. The more complete the interlocking, the more paralysing is its effect on ordinary traffic-operations. The safety of through trains is secured at the expense of station-to-station traffic. If the interlocking is only partial, ordinary traffic may be expedited, but the security of through trains is no longer guaranteed. On a certain Indian railway, where platforms are almost invariably on the main line, and a second loop takes off the first, the interlocking is confined to the facing-points on the main line. Sidings are not trapped, and the only protection is that afforded by the use of Scotch blocks which may or may not be left open. This cannot be considered a satisfactory state of affairs, but there are only two fast trains a day each way on this line, and as long as these suffer no mishap there is a tendency to be satisfied with existing arrangements, especially as they facilitate the handling of ordinary traffic.

Suggested Modifications.—Whilst it is illogical to approve of partial interlocking, it must be admitted that excessive interlocking sometimes constitutes a serious inconvenience in a rush of traffic. It raises the question whether, after all, a little elasticity should not be permitted in applying to wayside stations some of the tenets of interlocking, which in their entirety constitute a “counsel of perfection” difficult to attain in practice. For instance, the first golden rule of interlocking is the complete isolation of running-roads, and the second is the trapping of all lines leading from goods-lines and sidings to the running-roads. Both these conditions are fulfilled in the North Western State Railway type of wayside

station, the running-roads being the main line and the loop. But the isolation of the loop as well as the main line throws difficulties in the way of handling ordinary traffic. Reference to *Fig. 9* will show that a train on the lie-bye must be completely locked in before another train can be admitted into the loop. The Author contends that as long as the lie-bye is used only by *bona fide* trains, *i.e.*, trains consisting of vehicles coupled to one another and attached to an engine in steam, it is not necessary to lock it off from the loop, as with such trains there would always be a responsible man at the near end. If this point is conceded, it is possible to introduce the simple arrangement shown in *Fig. 10*, where the erstwhile loop becomes a disconnected line, to which access from the main line is gained by cross-overs XA, YA' from the facing-points X and Y. Each cross-over would be rodded and worked by a single lever in the same way as simple facing-points, whatever system of interlocking were used, the only difference being that the moving of a cross-over would involve a slightly greater effort than the moving of a single set of points. The only extra rodding necessary would be that required

Fig. 10.

to connect X with A and Y with A'. The safety of fast through trains is secured as before. It only remains to consider what risks may be incurred by a stopping train entering the loop. The first risk is that the cross-over may be reversed too soon after the train has cleared the facing end, which may be unlocked immediately after its passage, and before it has cleared the trailing end, which it would not be practicable to lock. But no more serious accident than burst trailing points would ensue from that remote contingency; and even if these burst trailing-points were not detected before the next loop-train from the opposite direction entered them facing, the ensuing derailment would not be serious nor likely to foul the main-line. Point-indicators would of course be used. The only other risk is that of runaway wagons fouling the loop. As regards this contingency, there would never be any occasion, nor any inducement (even if there were no orders on the subject) to stable wagons on the lie-bye siding A' B C; and the short dead siding A Z is merely intended as a trap, although possibly a short siding for spare carriages might be connected with it by a cross-

over, as shown by the dotted lines. Hence, if any loose wagons escaped from the goods-yard they could only get on to the lie-bye when the cross-overs B D, B D' were set for that line. It would then require a wind blowing in the direction C to A or a falling gradient in that direction to cause these wagons to foul the loop. The gravitation factor of the problem could be met by making the cross-overs B D, B D' fall, say, 1 in 50 towards the goods-shed sidings, putting the latter at a lower level. As a further precaution the lie-bye might be given a slight fall from A' to C, but this is not altogether desirable, as trains using it would have difficulty in getting out again. It is better that it should be level. Runaways can then be caused only by a sufficiently strong wind blowing from C to A. Wind in this direction would not affect the wagons on the sidings E and F, but it might start those in the sidings E' and F'. The conditions for a runaway then would be (i) the cross-over D' B must be set for the sidings, (ii) there must be loose wagons in one of the sidings E' and F', (iii) the Scotch blocks must be open, (iv) the wind must be in the direction C to A, and must be sufficiently strong to blow wagons up the 1-in-50 gradient over D' B. Hence if any one of the foregoing factors can be circumvented the problem is solved, and there can be no runaways. To circumvent the first three factors, by interlocking or otherwise, would be costly; but the fourth can be nullified by the simple device of erecting a wind-screen to protect the sidings E' and F', if they are not already sheltered by existing local features.

It will be seen that the station is now so interlocked that the safety of the through line is absolutely, and of the loop practically secured, whilst access to the lie-bye and goods-yard can be obtained at all times without the delay entailed under the systems previously described, where the lie-bye and goods-yard are normally locked off from the loop as shown in *Fig. 9*. Moreover, it will be seen that as long as the loop is not required for a running train (which would be the normal state of affairs) the lines B A and B C (*Fig. 10*) form perfect isolated shunting-necks for goods-trains in both directions. It is true that when a passenger-train is halted on the main line opposite the platform the portion of neck B A available for shunting purposes would be temporarily curtailed, so as not to screen the passenger-train. But as shunting operations could be suspended at any instant at a sign from the station-master this arrangement would present no traffic difficulties. The great advantage is that there are no interlocked traps or points to prevent the siding from being available for use at any moment, and thus a great saving of time is effected when there is any shunting to be

done. This type (*Fig. 10*) involves a quasi-infringement of the interlocking rules, which prescribe generally for the protection of running-roads without reference to their individual importance. But, as in wayside stations the main line alone is used by fast through traffic, the protection of which is the *raison d'être* for interlocking, whilst the loop is used only by stopping trains, for which the protection afforded by interlocked traps would not ordinarily be considered necessary, it appears to be a reasonable compromise, in this class of station (assuming that the exigencies of shunting preclude the general adoption of the more perfect type, *Fig. 9*), to treat only the main line as a running-road for interlocking purposes.

Dead Sidings versus Loops.—The inherent defect of the dead siding form of lie-bye is the delay involved in backing a train into or out of it. When traffic is heavy, such delays mount up. Even with the simplest system of interlocking, the time spent by a heavy train in entering and emerging from a dead siding is almost equal in many cases to that which it would occupy in running between two neighbouring stations. On account of this defect, although a yard arranged on the plan just described would reduce the delay to a minimum, traffic-officers do not take kindly to the dead siding principle for crossing-purposes, and would welcome any loop-system that combined facility of movement with safe working. Where the platform is on the straight, it is customary for a second loop to take off the first, and although in the absence of efficient trapping this arrangement is not conducive to the safety of fast through trains, it undoubtedly saves time when three trains have to be dealt with. It is worth while considering, therefore, whether a second loop can be provided without sacrificing any of the principles involved in the adoption of the type shown in *Fig. 10*.

Accepting the two hypotheses that a raised platform is not necessary and that tracks may intervene between the "permanent" platform and a stopping passenger-train, it would be easy, by setting back the permanent platform another 15 feet, to introduce a second loop between the first loop and the platform. The straight would still be used, in the ordinary course, for the reception of trains, passengers merely having to cross two intervening tracks instead of one; and for the crossing of two trains the straight and the first loop would be used as before. But when three trains have to be accommodated there is no doubt that the second loop would be used on all occasions in preference to the lie-bye. The latter would thus become a goods-siding only. In the case of side-tracking a goods-train and a passenger-train, the passenger-train would take the platform-line and the goods-train the middle line, as a matter of course, no

matter which train arrived first. The goods-train might even be able to carry on its shunting during the interval. The second loop therefore presents considerable advantages, but it is doubtful whether it could be safely used without complicating the interlocking arrangements. Supposing the interlocking to be initially confined to the facing-points of the main line, combined with the use of coupled cross-overs as described in connection with *Fig. 10*, the insertion of a second loop would involve two sets of facing-points for all trains turned off the main line. If such trains had continuous brakes, it would certainly be necessary to ensure the correct setting of the second facing-points before the loop-signal was lowered. This could only be done by extending the system of interlocking so as to provide for three-armed interlocked signals at the main-line facing-points, the third arm referring to the second loop. The expenditure involved in such extra interlocking would not be justified except perhaps at selected stations of growing importance. But in laying out a new line of railway the future development of wayside stations can never be foreseen with any certainty. It has often happened that a station which has originally been inserted midway between two other stations merely for crossing-purposes, and for no other reason, has subsequently developed a local traffic which has necessitated in the course of a few years its expansion out of all recognition. It is therefore necessary, when first laying out a station, no matter how insignificant its traffic prospects may appear at the time, to allow for future development. The Author therefore ventures to suggest that when the platform-on-loop type of station, as shown in *Fig. 9* or *Fig. 10*, is adopted, the permanent platform should be set sufficiently far back to enable a second loop to be put in at any future time, if found necessary. This involves merely placing the station-building about 15 feet farther back than it would otherwise be in the first instance.

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The Paper is accompanied by ten diagrams, from which the Figures in the text have been prepared.