

Discussion

Mr J. I. Campbell said that since the publication of Mr Kubale's Paper¹ 15 years previously there had been many important developments, particularly in France and the United States, so the present Paper was very welcome. The information given in it was, in certain respects, more extensive than the ground covered by Mr Kubale. The information in the Appendices was particularly valuable.

Most of the data had been obtained from practical experiments at Whitemoor. It was the first time that the running characteristics of British railway wagons had been recorded. It was certain, therefore, that for many years the Paper would serve as a useful reference guide and would be found in the drawing offices of British Railways.

Apart from technical data the Author had propounded several new and interesting variations in what seemed to have become accepted standard practice in lay-out design in Great Britain. During the past year or two Mr Campbell had had many discussions with the Author about marshalling yards and he was largely in agreement with the views expressed in the Paper.

He was well aware that those views were not unreservedly accepted by all interested parties and he therefore hoped that during the discussion there would be some constructive criticism of the Author's suggested innovations. It should be realized that in a small country of intensive freight traffic such as Britain there were only five mechanized marshalling yards. It seemed obvious therefore that there must be a wide field for development on mechanized lines, especially when consideration was given to the considerable economies resulting from the provision of large marshalling yards at strategic points and the closing down of out-of-date yards.

That technique had been adopted and developed energetically in both France and the United States. It produced cheaper operation, quicker transit, and the employment of fewer wagons. In France, it was estimated that those developments had resulted in a 20-per-cent decrease in the number of wagons which passed through the marshalling yards.

The principal suggestion made by the Author concerned secondary retardation, which would be an innovation in Britain and, indeed, in Europe, though not in the United States, where it was quite common. Mr Campbell thought that the Author's reasoning was sound and that the introduction of secondary braking would go a long way towards solving two important present-day problems on British railways—first, pushing down, and, secondly, the damage to wagons, which was undoubtedly high. There was another benefit, which could not be assessed in terms of money—the number of satisfied customers who received their goods all in one piece.

¹ See ref. 1, p. 776.

Nor should the district engineer be forgotten ; he was enabled to repair his sidings without first having to remove several hundred tons of spillage.

With only one set of brakes an operator was expected to perform both functions of maintaining the separation of the cuts and regulating the distance run. In the very short distance of a single retarder that was rather too much to expect. If secondary brakes were available, the cut could be allowed to leave the primary brake at a slightly higher velocity with the assurance that the distance it still had to travel could be regulated in the secondary brake.

Furthermore, the cuts could be allowed to pass through the switching area immediately below the retarder at a higher speed, diminishing the chance of a collision. In any event, the case for secondary braking as propounded by the Author was worth very careful consideration, even to the extent of incorporating it in a yard on an experimental basis. That would produce positive proof which could not be obtained by discussion.

Mr J. C. Kubale said that if the operating authorities wanted any evidence of the advantages of modernization, they needed only to look at a few yards in Great Britain and at yards in France and the United States, where it seemed that ample dividends were being reaped from capital investment. But the marshalling yard itself was only one of several problems connected with the ideal of getting more ton-miles per day from each wagon. The aim was to get a better paying load and a greater availability of wagons.

On p. 760, the Author had drawn attention to the fact that Mr Kubale, in his earlier Paper, had mentioned a humping speed of 4 feet a second. Admittedly, that was not a normal speed, but he had had in mind some acceptance tests organized by the railways to prove the apparatus. Lower speeds were normal.

The Author had suggested that the length of the switching zone was of minor importance. In the past it had been thought that the zone should be as short as possible, but the Author believed that it did not matter if it were made a little longer to suit certain features. Mr Kubale, on the other hand, thought the limitation of the switching zone was of great importance, because one of the fundamentals of design was that the switching zone should be as short as possible so that the amount of retardation necessary was the minimum, which meant that the cost of providing the brakes was also the minimum. For every additional 100 feet of length Mr Kubale estimated that about 50,000 foot-lb. of retardation would have to be installed for each fan of sidings.

Pushing down was a severe problem and a solution of it would be of great advantage to the operating department. The Author had not gone far enough. He had suggested secondary retarders controlling six sidings, but the need for pushing down generally arose from wagons being pushed over the hump too fast or an error of judgement by the brake operators. The same errors could be made in the yard suggested by the Author, and

there was the added difficulty of two retarders working in series, both of which, according to theoretical calculations, should be operated in a certain manner. Mr Kubale did not know how that could be practicable for a single operator. It might be that a solution of that problem would arise from present American experiments on automatic braking to obtain the speed control of wagons by means of retarders. If the manual element was eliminated more confidence could be placed in the application of the theoretical requirements.

The whole question of primary, secondary, and tertiary retarders seemed to arise from a misconception of the origin of the American-type brake. American brakes were limited in capacity by the height at which the braking rails of retarders could be applied above the top of the running rails (the maximum being about $2\frac{1}{2}$ inches). With a given braking capacity and a certain length of yard, the length of retarders required was known, and a simple calculation showed that if the retarders were distributed in several track leads, less total length of retarders was required.

The Author had referred to remarkable economies achieved by having secondary retarders, but installing a retarder between the hump and the King point would have effected further economy but would raise other problems. When commenting on the length of time required for renewal of the pits at Whitemoor, the Author had failed to point out that those pits were changed because of changes in the type of brakes, and the long time needed for the change-over was abnormal. The present idea was to have a spare brake, and about every 8 years the whole brake was taken out; the work could be done in a period which might be described as a long week-end.

Mr Kubale asked how many wagons had been tested to provide the data for *Fig. 12*. Referring to *Figs 9*, Plate 1, he could find no mention that curve resistance had been taken into account in the calculations in the Appendices. What would happen if a fourth wagon similar to No. 2 followed No. 3? It seemed that it would overtake the previous wagon before the jack points, which was a poor feature of the design of the yard.

Mr D. G. Shipp was interested in the comparisons that had been made between hydraulic and electro-pneumatic retarders. He felt that the most remarkable was that which concerned the time required to make a complete renewal of the retarders, which had been given as 2 months for the hydraulic type, where renewal of the pits was also involved, while the corresponding figure for the electro-pneumatic type was 4 to 8 hours.

The Author had stated that the ease with which the electro-pneumatic brake could be renewed was attributable to the fact that all the work could be carried out above ground level, for no pit was needed below the track; Mr Shipp added that that was also because the whole brake was set down very simply on timbers so that it could be raised as a complete unit by means of jacks and removed from the site on suitable trolleys.

He then showed a number of slides illustrating the procedure of removing and replacing a typical retarder, having a length of 23 metres and an overall weight of 33 tons. The first stage was to remove the pipe connections to the retarder and the fish plates joining the running rails to the adjacent track. The complete retarder was then jacked up, five jacks on each side, and its place taken by a temporary track laid on temporary timbers. The rail chairs would not be spiked down, but fish plates would be used to attach the temporary rails to the adjacent track. Trolleys were brought up and run underneath the old brake, which was then lowered on to the trolleys by means of the screw jacks and wheeled away. Installation of the new brake involved the same procedure in reverse order.

The next point of comparison concerned the provision of track circuits throughout the length of the retarder. Unlike the electro-pneumatic retarder, it was not possible to provide track circuits within the length of the hydraulic retarder, and that brought some operational disadvantage where it was desired to have fully automatic control of the points or speed control of the retarder. Complete automatic point-setting usually necessitated continuous track circuiting from the hump to the final clearance point. If those track circuits had to be omitted at the retarders, it was necessary to provide some kind of electrical relay storage so that track of the cuts should not be lost as they passed through the non-track-circuited areas. That was a complication compared with the simple track circuit through the retarder, and would use additional relays.

An example of control of the retarder by the speed of the cut passing through it was the installation at the Milwaukee Air Line Yard in the United States. The speed of the cars had to be measured, and a convenient method was to register the time taken as the leading axle of the cut passed over successive short track circuits provided throughout the length of the retarder. Where track circuiting could not be employed, Mr Shipp thought that the timing could be achieved by means of a series of mechanical devices; they would be more complicated and would involve more maintenance than electrical track circuits.

On p. 766, the Author had stated that with a hydraulic retarder the whole length of the brake shoe was in one piece and therefore any application was uniform throughout. If one tire were thicker than another, would the full braking force act substantially on the one wheel? Was that why it was generally accepted that there was a considerable amount of metal "swarf" surrounding hydraulic retarders in comparison with the electro-pneumatic type?

On p. 764 the Author had referred to the point setting at Toton Up yard as being of much later design and completely automatic. That was not the first installation of complete automatic point operation in England; the Hull Inwards yard installation had been made 15 years earlier in 1935.

Mr A. R. Dunbar said that three questions arose: first, was the topic worth while; secondly, should an engineer talk about it; and thirdly,

had that engineer found the right answers? There was no difficulty in giving a forthright affirmative answer to the first question. Sometimes there was an impression that shunting was a diversion indulged in by railway operators for their own amusement. The time it took to shunt a given number of wagons or the amount of money spent on the job never hit the headlines—and it was time it did. Freight engines were used for shunting for about half the total time they were in traffic. During 1952, on British Railways, freight shunting engine-hours had totalled 17 million, and freight train engine-hours 16 million. Shunting was an item of great importance in operating expenditure. Its importance in transit time was equally significant. Each shunting yard through which a wagon had to pass on its journey meant another delay, and each time a train was split up there was a risk of damage and missed connexions. It was axiomatic that the fewer yards a wagon had to pass through, the better were its chances of getting through safely and quickly. To design modern yards to take the place of a number of small ones was vitally important to economical working and good services.

The time was ripe for a general review of British marshalling yards. The advent of increased competition—directly, between road and rail; and indirectly, in the export markets—made it a matter of urgency to speed up and cheapen the freight services.

Was it the engineer's job? Should he talk about it? The Author believed that the Chief Regional Officer should send for his technical officers when the question arose. It was not exclusively their job, but they had an important part in it. The breadth of their interest depended on the approach. Some would say that the traffic operator, with knowledge and experience of working marshalling yards under all conditions, knew exactly what he wanted and could lay down a clear specification for gradient, braking, and so on. Others would say that the user or operator should indicate only the general aims and leave the design entirely to the engineers.

Mr Dunbar thought it was essentially a joint matter, to be developed together. It should start with a critical approach beginning with the assumption that all works could be improved. The operator's approach to planning with the engineer might be to say, "I can see the prospect of greatly improved efficiency if you give me a yard to handle 4,500 wagons a day and to shunt fifty main sorts. An effort should be made to reduce to the minimum two weaknesses of present designs—wasteful pushing down of wagons which have not run far enough into the sidings and damage to the goods and wagons by sharp impacts."

The next step was for the engineer to calculate all the ascertainable factors and to give the results. That might be thought highly theoretical and therefore suspect to practical men, but a new work was never undertaken without counting the cost, and it was equally essentially to calculate, in advance, as much as possible about efficiency of performance.

The next step was for those calculations, and the designs that would flow from them, to be examined with the critical eye of the man who was going to do the job. That was the point from which there was constant interplay of interest between the designer and the user. There was always a certain element of risk with a new idea or the adoption of one which had been tried elsewhere under different conditions, but much could be done by observation and calculation to reduce that risk.

In the field of marshalling-yard design the dividends to be reaped were so great that some degree of risk was worth while in any event.

Had the Author the right ideas? It was certain that he had made a valuable contribution to the evidence for the scientific design of marshalling yards. His principal contribution was the working out of the rolling resistances of wagons related to the force of gravity, and from that his calculations for the correct design of gradients and the location of retarders.

Not all his conclusions would command universal acceptance at first. But, whether they carried conviction or not, the attempt must be made to design hump gradients and yard equipment, in a way which would drastically reduce the unproductive time of about 30 per cent now spent in closing down in mechanized yards.

If the attempt were successful, it would raise the capacity of such a yard from 3,500 to 4,500 wagons a day and, with other improvements, a yard with a capacity of 5,000 wagons a day was within reach. If the Author's conclusions could find general acceptance, there was prospect of great savings in engines and men, great improvement in service, and less damage to wagons. With such a capacity it was conceivable that any main line or any large town in Britain could be served by one double-direction yard.

Mr Arthur Moss said that when marshalling yards had been introduced into Great Britain, the view was expressed that it was paradoxical to arrange both steep gradients so that wagons could gain speeds over short distances and brakes to slow them down. How much more paradoxical to provide additional, secondary brakes for the same purpose? Obviously, the economics had to be justified by the possibility of more speedy humping and the possibility of keeping the whole yard working should one of the main retarders be out of commission.

It was on record that the late Mr C. J. Brown, an eminent civil engineer, had said the designer of any mechanized yard should include three essential features—first, gradients; secondly, brakes; and thirdly, automatic points. The Author had dealt with the first two features but had said little about the third.

It had been suggested that the Chief Regional Officer should send for his civil engineer to design him a yard. Mr Moss hoped the C.R.O. would be wise enough to send also for his signal engineer to make sure that it worked.

In Figs 9, Plate 1, the end of the primary retarder was 5 feet from the Queen switches. If the controlling track circuit commenced at the end of the retarder, any wagon entering the track circuit at the same time as the automatic points commenced to throw would be derailed. The speed of the wagon over the Queen switches was shown as 17.5 feet per second. Automatic points would operate in 0.6 second. In that time the wagon travelled about 10.5 feet, and to keep the wagon on the rail under the conditions mentioned the circuit must commence at least 16 to 17 feet on the approach side of the Queen switches. The Author would have to move his brake back 20 feet if it were of the hydraulic type, but if it were of the electro-pneumatic type he could have an insulated joint that distance within the brake. The same remarks applied to the secondary retarder.

The distance there was 7 feet from the switches. If a wagon were to travel 9.2 feet per second, obviously a distance of more than 7 feet was needed to hold the points. Once the wagon had left the secondary retarder and the points commenced to throw, it had to be ensured that the points threw over to the full reverse position before the wagon arrived.

There was little in the Paper about the human element. The successful operation of any mechanized yard was in a large measure dependent upon the human element. Whether a yard had primary retarders or primary plus secondary plus time control, much of the success depended upon the operator. The Author himself had stated, on p. 762, that the degree of retardation would vary at the will of the operator.

Mr G. D. S. Alley said that the gridiron at Edge Hill was not an ordinary shunting yard. It consisted of a system of sidings laid on a bank formed by the excavation from tunnels and cuttings nearby, and worked by gravity. All traffic had to be held at one end of it and the sidings were ordinary ladder sidings. The hook and chain at Edge Hill had still been working in 1950. Would any of the brakes described by the Author still be working after such an interval?

There was a hook at the outlet of each of the sidings. It was connected to a small chain which gradually increased in weight and strength, so that if there was a real runaway or a whole train going down the sidings, the appropriate length of chain could be pulled out and the slowing down would be gradual. It was easy to maintain and cheap to install, and simply acted in place of sand drags.

In 1932, in South Wales, there had been cause for complaint about the lack of information on the running of vehicles with grease boxes and oil-boxes on different gradients. A coal-hoist was being installed and there had been some doubt about the gradient to use. When a full wagon of coal had been weighed on the weighbridge and then tilted to a gradient of 1 in 8, it often had to be pushed off. When coal traffic was normal and flowing well, trains came straight down the valleys on to the tip and the grease was free, but when trade slackened off they were standing in the

sidings for long periods. It was difficult to find conditions which met all cases.

Dealing with renewals, Mr Alley said that like-for-like replacements of the hydraulic brakes could be carried out at Toton in a normal week-end.

Mr R. L. McIlmoyle said that the Author had had three objectives. The first was to give a full and up-to-date description of modern practice in marshalling yards; he had done that very well and had given a lot of information which was not readily available. His second objective was to sell the need for more marshalling yards. He had put that over fairly well, but it was doubtful whether there were many places where savings of the order given in the Paper could be achieved. His third objective was to sell the need for secondary retarders. He had made a strong case, but it was probable that they were justified only in a number of special cases and not for general adoption in mechanized marshalling yards.

Mr McIlmoyle dealt with the length of time taken to change retarders. The yard he was concerned with had eight hydraulic brakes and a complete spare, and the spare could be installed in a normal week-end. With more experience, it would require less time.

The Author had mentioned three types of brake, but there was a fourth very popular in America but not common on the Continent—the fully electric brake. Mr McIlmoyle had been told that in America the electro-pneumatic type was steadily being replaced by the fully electric type, for which a number of advantages were claimed.

The Author had also omitted to mention a very fine yard near Montreal where the lay-out was much superior to anything which Mr McIlmoyle had seen elsewhere.

**** Mr M. Marchand**, of the S.N.C.F., Paris, referred to the centralization of marshalling yards. The Author had stated that the reduction in the number of marshalling yards had very important advantages from the point of view of economy in running costs and speed of dispatch—far beyond the most optimistic predictions which could be made by the few technicians who had made a special study of those problems. That should be emphasized, because to many railway workers the construction of modern marshalling yards only raised the spectre of unemployment, which they believed to be always attendant upon mechanization.

But economies in labour were merely secondary effects when compared with the other benefits which could be obtained by the establishment of large modern yards. A considerable reduction in maintenance costs, resulting from the closure of nearby secondary marshalling yards, was accompanied by improvement in dispatching arrangements which, independently of commercial interests, resulted in even larger economies—particularly from the point of view of reduction of rolling stock.

It was certainly very difficult in the planning stage to calculate the overall

****** This contribution was submitted in writing upon the closure of the oral discussion.—**SEC. I.C.E.**

effect of those factors ; nevertheless, appraisal of them was becoming easier consequent upon the experience gained by the French railways. Between 1946 and 1951, S.N.C.F. had concentrated the marshalling of long-distance traffic into forty big yards, of which seven had been modernized before the war and seven had recently received some modern equipment ; at the same time, fifteen yards had been closed and the work of a score of others had been considerably reduced.

The results obtained had been subjected to various estimations ; for instance, the Dijon marshalling yard had shown economies of the order of 15 per cent of the capital cost. For the scheme as a whole, comparable statistics for traffic and marshalling-yard operations were given in Table 3, which showed that the number of wagon-sortings had been reduced by 9,700,000 ; after making allowance for the number of complete trains made up by manufacturing and mining establishments, the portion of the reduction of wagon movements attributable to the reorganization of the marshalling yards had been estimated at 3,700,000, that was to say, about 6 per cent of the total working.

Furthermore, since the average time spent by a wagon in a marshalling yard was about half a day, it could equally well be stated that approximately 2,000,000 wagon-days could be saved, which represented a reduction in rolling stock of 5,000 to 6,000 wagons. It followed that, at current

TABLE 3

	1946	1948	1951
Number of wagons loaded : millions	10.9	13.5	13.7
Number of wagons handled in yards : millions	60.8	72.1	63.7

French prices, economies in rolling stock alone had almost paid for the outlay involved in the seven new modern marshalling yards completed between 1946 and 1951.

Regarding the distribution of marshalling yards, Mr Marchand pointed out that it was tied up with numerous factors, particularly train loads and wagon loads. The aim of railway operation should be to enable the formation of the greatest possible number of regular fully loaded long-distance through trains. Increasing the average loading of goods trains required an increase in the number of wagons handled by the marshalling yards and consequently a reduction in the number of the latter ; lack of respect for that axiom in many countries had led to the present need for reorganization.

Furthermore, increasing the wagon load decreased the number of wagons to be handled and therefore the number of marshalling yards required ; that was particularly so in France, for between 1946 and 1951

the average wagon load had risen from 13 to 17 (French) tons. As a result, some retrenchment had been possible in the programme of modernization drawn up in 1946. It seemed that when establishing the distribution of marshalling yards, consideration might be given to the eventual use of larger wagons.

So far as the operation of a gravity marshalling yard was concerned, Mr Marchand stated that it depended fundamentally upon the characteristics of the rolling stock, and the greatest possible caution should be exercised when applying the methods used on one railway system to the operation of another. For example, the heavy free-rolling wagons used in the United States justified the use of long braking distances and multiple retarders. But it appeared from current literature that American ideas were changing and that the present tendency in the United States yards was to reduce the number of braking stages.

Furthermore, although most European railways employed "chasers" and slippers to complete the work of single-stage retarders, the Americans did not appear to take the same precautions; it should be borne in mind, however, that the American type of automatic couplings permitted a higher buffing speed. The numbers of "chasers" employed might depend upon the prevailing policy; some French yards appeared to employ too many, but the competition of road transport obliged S.N.C.F. to take extra precautions against damage.

The Author believed that two-stage retardation presented a two-fold advantage in (a) accelerating the rate of sorting, and (b) eliminating the need for "chasers." No experience of that type of installation had been obtained in France, but it was felt that, at least with regard to (b) above, two-stage braking would not produce the advantages claimed.

The rate of sorting had to be regulated so as to eliminate the risk of overtaking in the "danger zone," which lay between the last retarder and the siding switch. It was necessary, therefore, to ensure rapid sorting, for the "danger zone" to be short and also for the variation in time taken between hump and retarder to be small. In France, the length of the danger zone ranged up to 90 metres (about 100 yards) when serving eight sidings; the possibility was envisaged of reducing that length by installing one retarder per six sidings, but research had shown that the use of a three-way switch wasted space and the improvement for a span of six sidings was almost negligible.

The time taken by different trucks to run from hump to retarder was fairly constant in French yards (variation was of the order of 1-2 seconds); the characteristics of British rolling stock gave rise to wider variation, and there arose the temptation to iron out the difference by installing an intermediate or "primary" retarder.

But the steep run down from the hump and the congested arrangement of the switches, as described in the Paper, contrasted with American layouts. The primary retarder would be placed at the foot of the hump.

Would the variation of speed at entry to the brake be sufficiently pronounced for the operator to be certain which wagons were good and which were bad runners ?

On the other hand, on p. 762, the Author had suggested that both primary and secondary retarders could be controlled by the same operator, the idea being that he could correct, by means of the secondary, any error he had made when passing a wagon through the primary. Mr Marchand doubted if that would be practicable, since at the high humping speed envisaged, it was quite possible that both retarders might be occupied simultaneously.

With regard to "chasers," the views of S.N.C.F. were at variance with those of the Author, and it was not believed that multiplication of braking stages could lead to any reduction in the number of runners employed. In theory, the operator should bring the wagon to rest in the siding just touching the stationary train. He should, therefore, know the distance to run after the last brake and the rolling characteristics of the wagon concerned, in order to deduce the speed with which the wagon should leave the brake. Errors were, however, inevitable, and Mr Marchand did not think that the operator could achieve greater accuracy with two brakes than with one. The main cause of error of judgement was the variation of rolling friction—a factor which was more apparent in Britain than elsewhere.

S.N.C.F. did not think, therefore, that any economy in the employment of "chasers" could result from the installation of two-stage retarding.

The importance of the question of the number of runners to be employed should not be exaggerated. The possible reduction of personnel was secondary to the greater overall efficiency obtainable by the centralization and mechanization of marshalling. It could not be denied, however, that there was something to be said for the partial elimination of a difficult and somewhat dangerous task. Researches in both Germany and France were leading to the development of automatic or semi-automatic brake control.

The Author, in reply to Mr Kubale's comments upon the speed of humping, pointed out that a test upon four consecutive trains at White-moor at 2.5 feet per second had proved rather too much for the retarder operators, since the existing gradients did not engender sufficient clearance between single cuts of wagons. Such a test at 4 feet per second, anywhere in Great Britain, would degenerate into a brake test only, and sorting, if it occurred at all, would be a secondary matter.

Longer initial gradients would be necessary to provide the all-important spacing between wagons which was required, *inter alia*, to effect all the conditions of the signal and telecommunications engineer. To obtain those and secure other benefits resulting from consistent performance was

surely worthwhile when set against a possible additional retardation of 50,000 foot-lb., as suggested by Mr Kubale.

Doubt had been expressed about the ability of the brake operators to perform the functions which had been allocated to them in the specimen calculations. Judging by what the Author had observed at Whitemoor, there should be no difficulty at all; the operators appeared to "sense" the wagons extremely well. They could, however, receive advice of any exceptional case broadcast from the hump cabin through a loud-speaker system.

The Author could not agree with Mr Moss, who was sceptical about the ability of one man to work one primary and four secondary retarders. Having seen one man work, with ease, twelve levers attached to six brakes at Villeneuve St. Georges, the Author was unable to appreciate how any difficulty could arise when one man was called upon to operate only half the number of levers. Since every wagon presented itself twice for attention, prior knowledge at the second brake application was a valuable asset.

The Author could not give any particulars about automatic speed control, but hoped they would soon be available. That new development was certainly of the utmost importance, and he understood that a method employing photo-electric cells for speed determination was in course of development in Western Germany, for a new yard at Cologne, and by radar technique on the Southern Railway of the United States.

Mr Kubale raised the question of a fourth wagon in Figs 9, Plate 1. The Author felt that that was taking the case of the exception to the exceptional case. For shunting on that very abnormal basis, that was, into two adjacent sidings only, there would be no necessity for a hump yard.

However, on reflection, the Author would ask Mr Kubale to observe that an unlimited number of slow-running wagons could be humped into adjacent lines, after the three examples shown in Figs 9, Plate 1, without trouble. Furthermore, good runners could be intentionally converted into bad runners by appropriate brake applications.

Mr Shipp's comments about tires on hydraulic retarders were probably right; there was certainly a noticeable amount of very fine swarf deposited near the brakes.

The Author was obliged to Mr Dunbar for his lucid and authoritative remarks, and was glad to learn that an operating superintendent felt the necessity to call in a civil engineer in the design of a marshalling yard, to effect sorting of wagons. He reminded Mr Dunbar that Dr Johnson, in his dictionary, had defined "sorting" as "restoring order out of chaos." A civil engineer was, indeed, the right choice for that purpose, together with the signal and telecommunications engineer, and mechanical and electrical engineer. An estate surveyor was also sometimes useful.

The paradoxes referred to by Mr Moss were essential to produce the requisite wagon spacing which the signal department decreed as a *sine qua*

non for the proper operation of their automatic apparatus. It was quite a logical way of achieving that.

Mr Alley's remarks were of interest. However long-lasting the hook-and-chain brake might be, it possessed one serious disadvantage in that it could not be released easily and quickly. The Edge Hill brake was essentially a "run-away" brake.

The justification for secondary brakes, referred to by Mr McIlmoyle, was mentioned in Appendix 4, where it was made clear, in general terms, that secondary retarders were not suggested as a matter of course.

Mr Marchand's written contribution was very informative, particularly in respect of the resultant effects of good yards upon traffic generally. The Author was surprised to learn that the American centre automatic coupling was credited with being able to sustain a higher contact speed than the twin buffers fitted to European stock.

It was significant that Mr Marchand did not support the arrangement of tandem retarders. (The Author had not, so far, been presented with a detailed supporting statement, including calculations on the lines of the Paper, against the use of secondary retarders in the larger yards. That observation also applied to some members of the operating department in British Railways.) Mr Marchand's remarks about the simultaneous operation of retarders were considered pessimistic. The total number of wagons proposed to be dealt with per unit of time in the British yards, as compared with the French yards, was as 1.45 : 1, on account of the shorter stock generally in use in Great Britain. However, as explained in the Author's reply to Mr Moss, one brake operator would be given six levers to work, in the proposed design, as against twelve in some installations in France. But with those six levers only half the yard would be served. Assuming a relatively even distribution of wagons into the sorting sidings, the British operator would be called upon to deal with about three-quarters of the number of wagons offered in France. Putting it another way, the British proposal would offer three brake-sections to 75 per cent of the number of wagons passing through a two-brake-section French installation. The possible brake manipulations, being as 2.25 : 2, fortuitous rest gaps in the former arrangement should not be overlooked.

Figs 14 illustrated why, in certain circumstances, it was not possible to compare British with Continental practice. Being unaware of the precise friction values of Continental stock, the Author illustrated his case with British coefficients. Nevertheless, they were suitable for demonstration and, in fact, resulted in an under-representation of the exercise.

Correspondence

Mr H. C. Johnson observed that there seemed to be an inference in one paragraph of the Paper that small yards should be abolished in favour of large mechanized units. Certainly there should be, under