Wagon retardation equipment in hump marshalling yards

by

N. J. B. Alexander

Mr A. W. T. Daniel (Queen Mary College, University of London) said that he wished first to congratulate Mr Alexander on his Paper and on his subject. It seemed to him that the particular subject was very important for the railways and introduced many important items in modernization.

62. In the old type of yard with clasp brakes, if the wagon did not conform or the weather conditions changed one had the problem of the wagon stopping short or buffing-up at too high a speed. The Dowty units solved the problem of varying rollability.

63. The Dowty installation was the latest development in marshalling yards but, of course, all kinds of developments had been going on through the years both in Britain and abroad. He had read most of Mr Alexander's papers and accounts of yards in the United States, Canada, and the United Kingdom and Europe, and there was one item which seemed to him to be most important and yet never seemed to be mentioned. If one followed the processes of a marshalling yard step by step and took these in conjunction with the types of wagon to consider what was the best type of wagon for any process, one reached the rather strange conclusion that the most satisfactory wagon for the purpose was the old-fashioned British standard wagon, i.e. the wagon fitted with loose-link coupling and a hand brake which could be operated by the shunter from either side.

64. Modern wagons had screw couplings and piped brakes, either vacuum or pressure, but in either case the procedure was the same. To undo the brake the man had to step between the wagon and the rails, and he had to do the same for screw coupling. The net effect was that the processing of a series of modern wagons through a yard of this type actually took longer than a series of the older wagons. Also, when the shunter disconnected the pipe at a cut, owing to the requirement that when a train divided by accident the brakes must go on, the mere act of loosening the pipe would put the brakes on, and the shunter still had to exhaust the reservoir before the trucks became mobile. Because of this need, in the case of countries with long trains to which power brakes were fitted, when a train arrived at a marshalling yard the first act of the shunters was to bleed the pipe throughout the train. In some cases this might take about an hour. One therefore had the peculiar anomaly that the most sophisticated yard seemed to be built in order to process the most old-fashioned type of wagon, and it appeared that if one had a modern wagon in that yard it would take longer to process and cause more trouble.

65. It would seem that the answer to the problem was an automatic coupling which would operate both the couplings and the brakes simultaneously. The requirements of such a coupling should be as follows:

- (a) if there was an accidental parting of two halves of a train the brakes must come on immediately;
- (b) the shunter must be able to pull a lever which would automatically release the coupling and the pipe, and also operate the valve so that the brakes would not be thrown on, after which the cuts could be humped;

- (c) when the cuts were pushed over the hump they must not re-engage so that they would then go over the hump and down the other side;
- (d) when they collided at buffing speed they must engage and it was preferable that the brake should then be re-set.

There was such a system on the market but it could not marry with all the other types of coupling in use.

66. The marshalling yard at Tinsley was the most sophisticated in the world, but the old-fashioned wagons were the easiest to process; this was an extraordinary contradiction, and the problem must be overcome. A coupling would have to be designed and must be for universal use, because with the building of the Channel Tunnel it would be necessary to use it throughout Europe.

Mr C. F. Rose (British Railways, Eastern Region, Doncaster) thanked the Chairman for the opportunity, as a member of the Institution of Mechanical Engineers, to talk to the Institution of Civil Engineers. He wished first to stress a point which the Author had made, that there was virtually no damage to the loads in wagons, and in this context the Dowty system was undoubtedly successful, but it would be idle to suggest that the yard had worked without trouble, and there was no doubt that a great deal had yet to be done before maintenance costs could be reduced to an acceptable level.

68. Fig. 11 showed the sorting sidings of the Tinsley yard. Each siding was capable of holding a complete train. The figure also gave some idea of the number of trains which could be dealt with and how the 4000 wagons/day capacity was achieved.

69. The mechanical engineering problems had been as important as the civil engineering ones, not all of which had a bearing on the civil engineering work. At Tinsley a great deal of mechanical equipment was attached permanently to the tracks and created problems for the civil engineer. Two basic ones were the protective pots around the individual units and the ducting carrying high- and low-pressure pipe lines to the Dowty units from the power-pack houses.

FIG. 11: SORTING SIDINGS AT TINSLEY

70. It was his understanding that Messrs Dowty had never guaranteed that their equipment would be 100% leak-proof, and although one might have hoped that oil losses would be considerably lower than the current rate and in consequence that the ballast pollution would be less, would it not have been wise to have formed the pots into 'containers' and arranged for the adequate drainage of the ducts?

71. This led to the question of maintenance, and in particular to the point raised by the Author of 'excessive fluctuations in line pressure'. From the commissioning of the yard these fluctuations had proved to be a major problem, causing failure of many of the components. There were four basic types of pressure fluctuation with the hydraulic system used at Tinsley: (a) pressure sag due to sluggish servo-response from variable-speed pumps; (b) high-pressure pulsations at high frequencies caused by unit operation; (c) resonance of the oil caused by oil oscillation between two centres of capacity at a frequency equal to the strike frequency of the wagon wheel on the units; (d) (perhaps the most difficult of all) transient surge pressure of the order of 1800 lb/sq. in. above the normal level of 1500 lb/sq. in., causing failure of hoses, welds on units and seals long before these were expected.

72. Following consultation with Messrs Dowty, a number of accumulators had been fitted in the main pipework, but these had not, unfortunately, dealt satisfactorily with the transient surges. Ideally, the answer would be to fit an individual accumulator to each hydraulic unit, but as there were some 23 000 units in the Tinsley yard this was an impracticable solution.

73. Steps were in hand to alter the hydraulic pipework to give more satisfactory flow conditions by placing additional accumulators strategically in the system and extending the pipework to form a series of ring mains. Another attempt to overcome the problem had been to fit a nylon flexible hose which was resilient enough to absorb some of the pulses. Perhaps the Author would care to comment on these problems, the solution of which was so essential for the smooth operation of the yard and the reduction of the maintenance costs.

Mr E. A. Rogers (Assistant Signal and Telecommunications Engineer, British Railways Board) said that, like Mr Rose, he was a visitor to the Institution of Civil Engineers, but in his case from the Institution of Electrical Engineers. As a member of the Chief Signal and Telecommunications Engineer's staff he had been associated with the development of the Dowty system from its earliest days. They had been responsible for the submission which resulted in the British Railways Board agreeing to finance, jointly with Messrs Dowty, the development of the system, including the trials at Goodmayes. They had also strongly supported the Eastern Region's proposal to adopt the system for the Tinsley Yard.

75. Mr Rogers then referred to his activities as British Railways' representative on a Committee of the International Union of Railways concerned with the problems of controlling wagons in marshalling yards. He thought that the meeting might be interested to hear about developments on the Continent.

76. The problem there was very much less severe than in the United Kingdom. A previous speaker had referred to the British wagon as being suited for automatic operation, but in practice it was far from ideal. Its rollability factor varied from 0.002-0.02, whereas the range used as a basis of yard design on the Continent was between 0.0037 and 0.0065. Despite this advantage, the Continental administrations had already come to the conclusion that the orthodox clasp type of retarder, even with automatic control, was not adequate to achieve the required throughput without excessive damage to wagons. They had reached the same conclusion as British Railways, i.e. that a much more continuous control of wagon speed must be exercised, particularly after leaving the switching area. The German railways were working on a system which retained the clasp retarder in the switching area and then fed the wagon into a series of speed-sensitive retarders similar in effect to the Dowty retarder unit but without any boosting capability. Consequently, in order to maintain the

speed of the worst running wagons, a steeper gradient was necessary in the classification sidings. The Germans claimed that this system permitted a humping speed of 1.4 m/s but Mr Rogers thought that this was optimistic since it made no provision for variation in the humping locomotive speed or in retarder performance.

77. The Swiss were developing a further system, using no retarders at all in the switching area, and allowing the wagon to run free into the classification sidings, where wagon speed was reduced comparatively quickly down to 1.5 m/s by means of an electro-magnetic retarder. These were, in fact, a more advanced form of an earlier electro-magnetic device once used in the yard at Whitemoor. These retarders were followed by an ingenious electro-dynamic booster which was applied continuously for about $\frac{1}{4}$ the length of the sidings. The retarder appeared to function in a satisfactory manner but the performance of the booster had not been particularly convincing and left a lot of questions in the mind. The boosters required extremely high current (some 40 000 amps at 6 volts) in order to create the necessary magnetic field, and as a result extremely heavy currents were induced in the wagon axles, possibly to the detriment of the axle boxes. In the course of a demonstration at Milan it was noted also that there was obvious pitting of the rail head.

78. In order to compare the relative performances of the different systems his committee had adopted a formula produced by Professor Grassmann of the German Railways, which made all the necessary allowances for the loss of time in the operation of the yard due to successive shunts reaching the hump top, pushing up the wagons which had failed to close up in the sidings, and all other operations that needed to be carried out. The German and Swiss representatives on the committee had produced figures claiming that with their systems a throughput of 9500 wagons/day could be achieved. Mr Rogers considered this to be unrealistic since it would be impracticable to maintain the maximum humping speed continuously and, in the case of the German system, which had no means of accelerating the wagons, more time would be required for pushing up short-running wagons than had been allowed for in the calculations. A hypothetical calculation was based on the Dowty system but using Continental rolling resistance figures for the wagons. A humping speed of 1.5 m/s was shown to be possible but in making the capacity calculations a more realistic value of 1.3 m/s was used in order to allow a margin of error in humping speed. This calculation indicated a throughput of 9000 wagons/day, which compared reasonably with the actual performance at Tinsley of 4000 wagons/day, the latter, of course, operating with wagons of a much wider range of rollability.

Mr R. Langstaff (British Railways, Eastern Region, Doncaster) said that with reference to Fig. 2, he did not think that it made the point which Mr Alexander wished to bring out about clasp retarders, since if acceptable limits of ± 1 ft/s were superimposed, then over 88% of the wagons were effectively controlled.

80. Turning now to § 22, since the Paper had been written the design of high speed retarders had changed. There was now no return spring since the units were pressure-charged with nitrogen. With regard to § 33, again events had rather overtaken Mr Alexander. Dowty had now produced a unit which would fix to flat-bottomed rail, in addition to the bullhead rail which was used at Tinsley.

81. With regard to § 40, the experiences at Tinsley had shown that the adverse gradient on the sidings had not been as satisfactory as was originally envisaged when Mr Alexander was closely associated with the yard, and those concerned had since that date put in retarders at the end of the sidings to ensure that wagons did not go out at the other end.

82. Turning to §§ 41 and 42 which referred to the life expectancy of the head weld on the Dowty unit, this had always been in doubt in the original concept of the working of the Dowty yard. Those concerned had been worried from a research point of view as to whether the weld between the head and piston of the unit would stand up to the required number of wagon passes. However, no problem with this had been

experienced up to the present time. § 54 referred to the switching area and the effect of the removal of some of the 12-ft/s retarders. For the information of Mr Alexander, there were a number of catch-ups when the retarders mentioned were removed. This was due to heavy wagons running at excess speed.

83. With regard to Mr Alexander's remarks at the beginning of his Paper on the initial planning from the civil engineering and mechanical engineering point of view, the Dowty system was the only one which could be used to achieve the required wagon throughput. Mr Langstaff thought that it would perhaps have been better if the design problems had been overcome first in a smaller yard.

Mr R. E. Sadler (formerly Assistant Civil Engineer (Modernization) British Railways, Eastern Region) said that he thought one of the most significant points which had come to light at Tinsley was that there was no longer a limit to the figure of approximately 50 sorting sidings. It had been shown that by having power-operated feed roads one secondary yard could be placed on one side of the main yard and one on the other, thus effectively increasing the number of main sidings. If space was available even more sidings could be provided in a fan formation. It would now seem possible to have a yard with sorting sidings exceeding 100 in number.

85. With regard to the surging problem, he suggested that fixing a series of air bottles in the pipeline might ease the situation.

86. Mr Alexander had made the point in § 4 that one operator could hardly manage two stages of retarders at once. In the yard with which the Author had been concerned it was always expected that there would be two men, one for the primary and one for the secondary retarder.

Mr J. D. West (British Railways, Eastern Region) said that although the Paper was essentially about the Dowty system of retardation, something should be said about the yard in which the equipment had been installed. The yard was the focal point of freight movement in Sheffield and its reliability in operation and sustained performance was an essential part of the rationalization of the freight services in the area. The size of the yard compared well with other large marshalling yards of the United Kingdom. Its earthworks involved $3\frac{1}{2}$ million cu. yd of excavation, and ten contracts dealing with the civil engineering works, including bridges and canal works, were placed.

88. As the Author had said, the yard was first planned on traditional lines, and work began in 1961 at high pressure. In mid-1962 a major variation was decided upon when the decision was made to adopt the Dowty system of retardation. This decision was supported only by experience of success with plain line in a smaller yard at Hull. In one part of this yard the traditional type of retarder was combined with Dowty units, the latter being fixed in the sorting sidings. As the result of improved performance, the chasers were seen to ignore wagons destined for the Dowty sidings whereas in the remaining sidings they would concern themselves with each wagon throughout its run.

89. With the revision of the design of the profile in the yard the behaviour of wagons under the new system in the switching areas had to be reconsidered. This was aided by full-scale tests at Goodmayes, where a group of sidings was laid out to simulate the more important conditions to be met at Tinsley. Sufficient data were accumulated with this layout to enable the units to be arranged so as to achieve a remarkably high standard of operational perfection.

90. In the design stage, the installation and maintenance problems arising from the presence of equipment physically attached to the tracks were largely overcome. Other problems arising during operation of the equipment must be followed up. He would say from the civil engineering side they had no quarrel with the Dowty system of retardation, except for the rather excessive losses of oil which were polluting the tracks.

91. In conclusion, he wished to pay tribute to the memory of Mr Norman Allcorn,

who had been so closely concerned with the work and had applied his skill and commonsense to so many of the problems which arose.

Written contributions:

Mr M. G. R. Smith (G. Maunsell and Partners) wrote that it would be helpful if the Author would give his views on the use of the Dowty system in existing or projected marshalling yards considerably smaller than the yards at Tinsley or Bescot, and where capital costs must be kept as low as possible.

93. He would also be glad to know if it was the view of the Author that the increase in space created by the constant closing up towards the outlet end of the classification sidings could be of such significance as to affect the size of a yard in the planning stage.

Mr J. K. Dodds (Westinghouse Brake and Signal Co. Ltd) congratulated Mr Alexander on his Paper. Having been closely associated with the equipping and design of a number of marshalling yards Mr Dodds wished to comment on some of the points mentioned.

95. Referring to § 10, he thought there were reasons for the sophisticated equipment not achieving better results than with manual control other than the inconsistency of running in wagons. One was that maintenance of the electronic control equipment was rather new to signal linemen. A course of training was offered, but was not always accepted. Secondly, in automatic yards there was always an overriding manual control for the retarders, and sometimes a weather-adjustment control, which could raise or lower leaving speeds. Operators, being human, often thought they could improve on the performance of the machine, and did not record this 'help', which instead of improving the performance usually degraded it.

96. His firm had been called upon to check the equipment in a yard because the performance was far from good, and could find nothing of moment wrong with the equipment. After checking it the inspector watched humping from the control room, when everything went well. Some time later they were called again, and checked with the same result, but in this instance the inspector after leaving the control room watched what was happening on the retarder-indicating equipment in the relay room. It was noticed that many of the cuts were then being manually controlled. The matter was discussed with the engineer concerned and a recorder was fitted to record all manual operations, with the result that it was shown that about $\frac{1}{3}$ of the cuts was manually controlled. This was stoutly denied by the gentlemen concerned until the proof was presented to them. Thereafter the yard performance improved enormously.

97. Regarding the variation in rolling resistance of wagons, to check the method, recording instruments were connected to each rail circuit on the worst route in one yard, so that any cut would produce its own time/distance curve for the route. The actual rolling resistance, measured by the Velac equipment controlling the retarder, and the weight categories were also recorded. Three wagons were then picked at random in the train to be run on the testing programme that day, and their weights were noted. Using the rolling resistances and the mid-weight of each weight category recorded, time/distance curves were produced to compare with the curves produced by the wagons. There was never more than 1 s variation between any pair of curves, the maximum being at the clearance point on the third pair.

98. The braking effort of retarders did vary, and could be overcome by making the group retarders longer. In the U.K., except on the N.E.R. yards which were only semi-automatic, the practice had been to make the primary retarders long enough to stop a 35 ton two-axle wagon, and the groups just long enough to control it to the desired speed. This was the most economical way to use the retarder length, but in the light of experience (some wheels having been shown to be extraordinarily slippery) this might have been too economical. An extra 10 ft in the group retarders would have been worth while.

99. Regarding the permissible error in gradient, Mr Dodds thought the Author

was a little too stringent in requiring no more than $\frac{1}{16}$ in. in 20 ft. Accuracy of gradient was of course essential in the Rt and Rc measuring sections. The Rt section should be 100 ft minimum if possible, but if maintained to $\frac{1}{4}$ in. in 50 ft would give very satisfactory results, providing the actual ends of the section were $\pm \frac{1}{4}$ in. from their correct position. The Rc section, i.e. that between the primary and group retarders, might be 250–300 ft long, but again required a tolerance of $\pm \frac{1}{4}$ in. at the ends, and $\pm \frac{1}{4}$ in. between these points, so that there was never more than 1 in. in 80 ft.

100. The choice of Temple Mills for comparison with Tinsley was possibly a mistake. Temple Mills was a manual yard, with automatic control added only to the primary retarders, because, as Mr Sadler had intimated, it was too much to expect one operator to watch and control cuts in the primary and group retarders at the same time. The group retarders were manually controlled, the operators having weight and rollability indications to assist them. The group retarders themselves were shorter than was desirable for a number of very good reasons. Lastly, the gradient of 1:333 in the sidings was an accelerating gradient for the good running wagons, which made accurate control very difficult because slowing these wagons down sufficiently to produce the minimum gain in speed in the sidings might cause stalling and/or a mis-shunt in the switching area.

101. In one British automatic yard with which Mr Dodds was familiar and which maintained its gradients to a satisfactory degree, the acceptance tests showed that 70% of cuts were buffering at up to 7 ft/s, 15% were up to about 8 ft/s, and the remaining 15% were divided between heavy buffs and stallers. In actual service some of the heavy buffs would of course be covered by stallers being hit before the operator had reset his siding fullness, so that these could be nudged gently down, as in the Dowty system when the occasional wagon stopped short in the siding. Records of wagon damage from August 1961 to the end of 1963 showed a fall from 0.75–0.5% to an average of less than 0.1%. This was not, of course, perfect, but was better than the record at Temple Mills.

102. Mr Dodds considered that the hybrid yard referred to in §§ 41–45 provided the best solution, as it materially improved the track or rail circuit position in the switching area, and gave an appreciably lower hump than the usual crest-to-clearance figure of 17 ft; 10–11 ft should be sufficient, which compared well with the 9 ft for the Dowty system. For conventional yards the rolling resistance limits were 0.001–0.01 basic, without wind or air resistance or the effect of wheel inertia. Would Mr Alexander please indicate what limits had been taken for the Dowty yards?

103. Mr Dodds added that of the four other automatic hump yards in Britain with which he had been concerned two were in a mining subsidence area which made profile maintenance difficult and would produce problems in a Dowty yard. These yards were now usually operated on semi-automatic control. In the other two more unevenness than had been anticipated had appeared but was being corrected. Even so, Mr Dodds was confident that the performance of these yards was better than the 30% quoted for Temple Mills, except for certain cases which were not due to equipment.

The Author, in reply, agreed with Mr Daniel that wagons with screw couplings and piped brakes required additional time in the reception sidings to prepare the train for shunting. In a Dowty yard this was of little importance as the high reliability of the retarder equipment eliminated wagon damage and enabled all wagon inspection and routine maintenance to be concentrated in the reception sidings, so that both tasks could be done at the same time. The guaranteed low impact speeds in sidings fitted with the Dowty equipment could be a significant factor in the design of automatic couplers.

105. He thanked Mr Rose for the catch-phrase 'Dowty undoubtedly works', and for his account of the hydraulic problems. He could not claim to be a hydraulics engineer and therefore did not dare to comment. He thought that the dynamic behaviour of the pipe-work system must be one of the most complex hydraulic

problems in the world and could only hope that further experience would yield a solution.

106. The idea of a base to the ballast pots had been considered but was discarded because of cost. In retrospect it might be argued that this was a wrong decision.

107. In reply to Mr Langstaff, he thought 12% of wagons leaving clasp retarders with more than 1.0 ft/s difference from the correct speed was 12% too many if satisfactory wagon spacing was to be maintained.

108. He was glad to hear that units for flat-bottom rail were now available and hoped that this would give Dowty the opportunity to compete on the Continent against the other innovations described by Mr Rogers.

109. So far as the adverse gradient at the outlet of the sorting sidings (§ 40) was concerned, the site had made it impossible to provide the full rise that the Author considered desirable. The first wagons into an empty siding stopped on the gradient as intended but were gradually pushed forward when impacted by further wagons. A flatter gradient through the sorting sidings (1 in 500 instead of the 1 in 360 which had to be provided at Tinsley) would have reduced the problem.

110. In connexion with the high-speed retarders (§ 54) there was evidence in the tests that these had a speed setting above 12 ft/s which did not match that of the booster-retarders (11.4 ft/s). This disparity had permitted a few catch-ups which would have been accentuated when the retarders were removed. The need for the speed settings of all units in any section to be closely matched could not be over-emphasized.

111. Mr Alexander joined Mr West in paying tribute to Mr Allcorn whose untimely death early in 1966 had been a sad loss. Mr Allcorn had assisted Mr Sadler in the designs of clasp retarder yards and had watched over the development of the Dowty system as well as being responsible for many other aspects of the Tinsley project.

112. In reply to Mr Smith, he thought that a yard like that at Bescot with 21 sidings was about the smallest for which the Dowty system could normally be justified. For a smaller yard the amount of standby equipment and reserve capacity for peak hydraulic demand compared to average loading would probably make the running costs disproportionately high, since an efficient non-mechanized knuckle yard could be designed for layouts with up to about 14 sidings. Dowty equipment would only be justified in such a yard if a very high rate of shunting was called for.

113. The length of sorting sidings was usually dictated by the operating department anticipating future increases in train length. The ability of the Dowty equipment to keep wagons closed together might enable some economies in siding length to be made.

114. He agreed with Mr Dodds that there were clasp-retarder yards giving a significantly higher standard of performance than the one quoted in the Paper. The yard described by Mr Dodds had a relatively small number of rather short sidings for a fully automatic yard. It was also able to operate at a low humping speed so that many of the problems of a larger yard were absent. This should be taken into account when considering the high standard that the particular yard achieved.

115. The fixed energy absorption of each Dowty unit made a different range of rolling resistance possible for different weights of wagon. Typical values (including air resistance) were:

Gross wagon weight on 2 axles	7 tons	20 tons	35 tons
Switching area (9-chain curve)	— 0.028 to 0.040	— 0.005 to 0.019	0.001 to 0.014
Deceleration section (7-chain curve)	— 0.037 to 0.020	— 0.004 to 0.016	0.003 to 0.014
Sorting sidings (straight)	— 0.008 to 0.011	— 0.001 to 0.005	0.000 to 0.004

(N.B. The curve-memory section provided spare retarding capacity for heavy free-running wagons leaving the deceleration section at above 4 ft/s.)

116. The Dowty system was not susceptible to local variations in track level but the total change in level in each section needed to be maintained fairly accurately. Although it was theoretically possible to adjust the leaving speeds of the retarders in a clasp-retarder yard subjected to mining subsidence, it was not likely that a satisfactory performance could be guaranteed, and therefore the usual practice of reserving the coal under a hump yard or of packing the track to reinstate the design profile was desirable with both systems of wagon control.