HANDLING LOCOMOTIVES AT TERMINALS.

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INTRODUCTION.

Detail methods in the handling of locomotive terminals vary so widely that the scope of this Paper has been limited to well-established practices along certain definite lines, in the United States and Canada, with some personal suggestions. Steam locomotive terminals alone are sufficiently developed to permit of extended discussion.

2. Terminals differ very much in importance, and the Paper will be confined largely to the more important ones, leaving it to the judgment of the reader to decide what parts apply to the smaller terminals. By the designation "important terminals" is meant those caring for about 100 locomotives during each 24 hours.

LOCATION OF TERMINALS.

3. Starting with a terminal at each end of a railroad the intermediate terminals are located as the topography of the line, the location of important towns, or other factors, may indicate. Some years ago the distance between locomotive terminals was shorter than is considered desirable now, and generally the divisions have been lengthened so that at the present time they range in length from 100 miles to 200 miles; divisions approximately 150 miles in length are quite common. Frequently there are locomotive terminals between the division extremes, but these are

usually for local and suburban runs and are of lesser importance, although a few years ago they were the important terminals.

4. From the standpoint of operation, the engine-house and its accessories at the divisional point should be located close to the freight yard, for freight locomotives, and to the passenger station, for passenger locomotives. This condition is more readily fulfilled for freight than for passenger service. For the latter it is sometimes necessary to place the engine-house 5 to 10 miles from the passenger station where the locomotive is detached from the train. This requires the introduction of separate crews for handling the locomotives between the engine-house and the station, and also necessitates exceptional methods of inspection, and reporting and calling the crews, and equipping the locomotives for the next trip. Such conditions exist at Buffalo on the New York Central and Hudson River Railroad. On the other hand, if the station is not a terminal of the road, the through trains may be stopped near the engine-house and the locomotive detached and attached there; such is the method on the Lake Shore and Michigan Southern Railway at Cleveland.

APPROACH TO THE TERMINAL.

5. The route between the train terminal and the engine-house should be as direct as possible and independent of all other movements. This is not always possible, however, and in passenger service, more particularly, the route is largely made up of main line track. Especially is this true when the locomotive terminal is at some distance from the station.

LINE OF SEPARATION OF RESPONSIBILITY.

6. So far as concerns the mechanical operation of the locomotives, the mechanical department must be responsible. There are two well-recognized and quite different forms of railroad organization: the departmental, in which the mechanical department has supervision over the design, maintenance, and mechanical operation of the locomotives; and the divisional, in which the mechanical department has supervision over the design, construction, and

general condition of the locomotives, and the transportation department has supervision over running, maintenance, and mechanical operation. In either of these organizations the responsibility for the locomotives must change, so far as individual officials are concerned, at some place adjacent to the engine-house. In some organizations this change is made at the turntable, or its equivalent; there is a very limited number of rectangular engine-houses, notably at the St. Louis passenger terminal, where a transfer table is used and a turntable is not necessary. In these organizations the official in charge of the engine-house, who is a part of the mechanical department, has supervision over the movement of the locomotives between the table and the house and over the locomotives in the house; and the coaling plant, ash-pit and other accessories are handled by the transportation department. In other organizations the engine-house official has supervision over the entire engine-house premises, including the coaling plant, ash-pit, and all other accessories.

7. It is not well established which is the better organization; and not only does the organization differ on different roads, but often the same road has changed several times from one arrangement to the other. It is probable, however, that the best arrangement is the one which provides the highest class official nearest to the place to be handled. The best results probably will be obtained from the present tendency to place a master mechanic at each of these important locomotive terminals, and assign to him supervision over the entire plant. Such an arrangement will place the line of separation of responsibility for incoming locomotives on the approach to the engine-house and outside of the coaling-plant; and for outgoing locomotives at the track assigned for locomotives ready for service.

SEPARATION OF LOCOMOTIVES ON A DIVISION.

8. On a division having only one important locomotive terminal it is not necessary to designate where the important repair work will be done, but on many divisions there are two or more engine-

houses thoroughly equipped for the complete maintenance of a certain number of locomotives, and on these divisions it is necessary to designate those which will be maintained at each house. Each engine-house will do the periodic work and the running repair work on the locomotives assigned to it, and the inspection and safety repair work on any locomotive which is run into the engine-house. The assignment of the locomotives to the different houses is made by the divisional mechanical officer, usually designated master mechanic. There is more or less transference of locomotives from one division to another for temporary service, but there are serious objections to this, especially when the periodic work and reports are to be considered, and when the duration of the temporary service is more than a few days. On the large railroad systems it seems quite necessary that an individual locomotive record of periodic inspection and work be kept by the divisions, and the transferring of locomotives from one division to another for a week or two results in annoyances, errors and loss of records incident to transferring records when the locomotives are transferred.

LAYOUT OF A LOCOMOTIVE TERMINAL.

9. It is not the intention of this Paper to cover this item in such detail as would be necessary for the preparation of an ideal layout, but rather to deal in generalities which may be of greater interest in an international discussion. It will be in order to consider, first, the capacity of the various facilities which are to be supplied. It is desirable to rate the capacity on the maximum demand for a comparatively short interval of time, say 1 hour or 2 hours, for the coaling, ash-plant, turntable, water and sand facilities; and for longer periods of time for other facilities. Some of these ratings may be consistently higher than the sustained rating of 24 hours. There should be considered also, how much of the terminal will become inoperative in case of accident to any one of the important units of the terminal, and the approximate length of time the resulting disorder may continue; and to provide the necessary assurance of continuous operation, by the installation of duplicate

units. The water and coal plants and the turntable are the most important units, and these will need special study.

10. Water columns are usually so well distributed at a division terminal that only a failure of the entire water-system need cause much delay, so that the important consideration is convenience of location. The insurance may be taken care of in the general water-system. An ample supply of water is also of prime importance.

11. For insurance of the coaling operation there may be selected one of several schemes, one of which is to place the cars of coal on one, and the locomotives on another of two or more adjacent tracks, transferring the coal from the cars to the tenders by hand or by locomotive crane. Another scheme is to coal the locomotive at the coal-stocking plant, if one is near by; or by other means, none of which seriously affect the general arrangement of the locomotive terminal.

12. On the contrary, insurance of turntable service will very decidedly affect the general layout of the terminal, because the spare table must be capable of serving the whole or a considerable part of the engine-house capacity, inasmuch as failure of one table may occur when a large number of locomotives are in the house served by it. The only way in which more than one turntable can serve one unit of engine-house capacity, in a circular engine-house, is by dividing the house unit into parts and having a turntable for each part. To accomplish this result, it is considered very good practice to limit the size of a separate engine-house to approximately a half-circle, and to provide any additional capacity in another half-circle, offset from the first at least enough to permit of a separate turntable for each. The separate turntables should have track connections to the inbound and outbound tracks, and usually have interconnecting tracks.

13. For further insurance of uninterrupted turntable operation two motors for revolving each turntable are considered desirable, and even necessary, but both should not be operated from the same power plant. Sometimes two gasolene motors are used, and sometimes one electric motor is provided for general use and a gasolene motor for emergency use.

14. If the house is made up of parts of two circles, one end of each part will be placed near one end of the other, and the machine shop, store-house, power-house and offices will drop in very naturally between the two. The drop-pits, overhead crane, and other special facilities necessary in a limited section of the engine-house, will be placed convenient to the shop.

15. There remain to be located only the coaling plant, ash-pit, sand house and water columns, which will be placed primarily for convenience in getting the inbound locomotives to them. There must be ample water facilities on the outgoing tracks, and it is desirable to have a small ash-pit and a sanding place on these tracks. If provision is made to get the outgoing locomotives to the coaling plant on special occasions, then a coaling place is not necessary on the outgoing track. Of these facilities on the inbound tracks the ash-pit will be nearest the turntable, so that the locomotives may be moved the shortest distance when there is little or no fire on the grates. Sometimes it has been thought desirable so to arrange the facilities that coal, water, and sand can all be taken at the same time; but if the ostler is to stay in the cab so as to be ready for moving the locomotive promptly, it is probable that the difficulty in arranging these facilities for the various lengths of locomotives will make it desirable to place them somewhat more than a locomotive length apart if the ground space permits. Sometimes a track arrangement is made that permits of advancing one or more locomotives around other locomotives, and when the ground space is available this is a good thing to do. The tracks on which the ash cars are taken to and from the ash-pit should be independent of the inbound and outbound locomotive tracks.

ENGINE-HOUSE.

16. The cross-section and other details of construction of the engine-house have such important relations to the prompt handling of locomotives at terminals, especially in the colder climates, that it is well worth while to refer to them.

17. The two items which have been given most consideration during the last few years, for houses located in the colder climates, are the heating and the ventilating; they are so closely related that they should be considered together. For low cost of heating, the area of the cross-section should be as small as the locomotives will permit, and until recent years it was the practice to follow this principle in the design. Unfortunately, good ventilation, which is equally important, has not been obtained with the small cross-area, and as a result the condition of fog and smoke, and principally fog, in these low-roofed houses in cold weather is such, at times, as scarcely to be understood until seen.

18. A decided improvement in ventilation has resulted from raising part of the roof somewhat higher than the necessary headroom would require, placing the ventilators at the top of this higher portion. The design of these ventilators is undergoing a process of development, and at present practically each road has its own preferred design. An advantage of this high roof section is that additional area for windows is given in the enclosing wall, and this additional lighting is important for the wider houses now necessary.

19. In the effort to reduce to a minimum the fog in the house in cold weather, special efforts are also made to prevent the escape of steam from the locomotives. To this end a pipe line of large diameter is placed around the house, usually above the locomotives, with terminals conveniently arranged for making quickly a pipe connection to a valve in the top of the boiler. To reduce the steam-pressure in a boiler, the steam is blown through this pipe into the atmosphere, or to water-heating tanks or hot wells.

20. Pipe lines, including cold-water, hot-water and steam lines, are similarly arranged for washing out boilers, and provision made for mixing the cold water with hot water or steam to get the desired temperature for washing. The same pipe-lines, or others, conduct the water from the boiler to storage tanks and reheaters. The smoke-jacks have elongated bases which cover the safety-valves as well as the stack.

21. The heating is done by one of two methods: by direct

radiation from steam-pipes placed on the side walls of the pits; or by hot-air blast. Probably the latter is preferable. The place of delivery of the heat is as near the locomotive as possible. The capacity for the steam heating is usually all that can be obtained from two to six 2-inch pipes on each side wall in the pit and some on the outer wall of the house; for the hot-air system the capacity is the volume of the house every 10 to 15 minutes, at a temperature of about 60° F. A very important point about heating engine-houses is to keep the doors and windows closed, and to cover the usual openings at the bottom of the doors. It is desirable also that the roof timbers be so placed as not to interfere with the flow of air upward along the roof to the ventilator outlets.

22. It is the general practice to provide several tracks in the house, with a drop-pit into which to drop driving and truck wheels, and to provide in the same section of the house an overhead crane for loading to and unloading from cars these wheels, and for handling air-pumps, cabs, boiler fronts, and other heavy parts to and from the locomotives. Light portable cranes are provided for lifting steam-chest covers, rods, and other heavy parts which do not require high lifts.

23. There are many smaller details about engine-house design and equipment which contribute to the rapid and efficient handling of locomotives, but it will be best not to burden the Paper with them.

COALING PLANT.

24. The uninterrupted operation of this plant is of prime importance, and with this in mind, that the design should be chosen which is least liable to be deranged and which can be repaired most quickly. With sufficient ground space available, these considerations will make the choice a trestle, so that cars of coal can be pushed or hauled up an incline and the coal dumped direct from the cars into the bins from which it slides by gravity into the locomotive tender. This kind of plant reduces the breakage of fragile coal to a minimum, sometimes an important feature. If the incline approach is too steep for steam-locomotive operation, the motor and winch should be in duplicate and the motors not dependent

upon the same source of power, unless there is little chance of total disability of the source.

25. When the ground space is limited, the mechanical hoisting plant, of the bucket or a similar type, is a necessity, and it has been selected sometimes when the available space would permit of a trestle. There are various forms of the mechanical plant, but it will be unnecessary to consider them in detail. Usually they are placed crosswise of the tracks. Sometimes the same apparatus used to elevate the coal is used to convey ashes from the pits and to deliver them into storage bins or into cars. This combination has the advantage of concentration of facilities when such concentration is necessary, but there are objections to it otherwise. To give the necessary capacity at the coal pockets and ash-pits, a greater number of tracks are necessary, and the risk of personal injury from coal falling from the tender and striking the men who must be about the ash-pit is increased. This concentration will shorten and widen the approach to the engine-house.

ASH-PIT.

26. It is desirable to have a pit capacity immediately beneath the locomotives for several hours' busy dumping of pans and grates, whether the ashes are handled by hand or by machinery from the pit to cars. If handled by hand this is to provide for economical time distribution of labour; if handled by machinery, to provide for continuous dumping when the machinery is out of order. The economical transferring of ashes from pit to car by hand requires a lower pit for the ash-cars, adjacent to the ash-pit, and sometimes conditions do not permit of such an arrangement or of the necessary track approach. If the ash-pan and fire cleaners can be used for transferring the ashes from pit to car, at intervals when there are no pans or grates to be cleaned, the manual labour can be most economically distributed. The mechanical plants usually operate crosswise of the pit, limiting the length of pit undesirably, and making necessary several pits side by side or a further mechanical installation for transferring the ashes lengthwise of the pits to the cross-conveyor. With each addition to the mechanical

devices, complications are multiplied. Water hydrants for hand-hose are located conveniently about the ash-pits, and shelters are provided near by for the men to occupy when there is a lull in the work.

SANDING PLANT.

27. The sand-drying plant should be located convenient to the inbound tracks, but not necessarily adjacent to them. Convenience in delivering wet sand to the drying plant is important. As air-pressure is used to elevate the dry sand to the storage bin from which it falls by gravity to the locomotive sand-box, air-pressure can also be used for transferring the dry sand for some distance horizontally, so that the place of delivery for the wet sand may be conveniently located for such delivery. Sometimes the sand is dried on steam-heated tables, but since the temperature cannot be raised high enough for satisfactory drying, the preferred dryer is the stove. The dry-sand bin, from which the sand is delivered to the locomotive, is usually located between the coaling plant and the ash-pit.

WATER SUPPLY.

28. Water columns should be conveniently located on both inbound and outbound tracks.

ORGANIZATION.

29. *The Master Mechanic.*—The usual divisional organization places one man, the master mechanic, in charge of the locomotives on the division, both when the locomotives are away from the engine-house and when at the engine-house. One of the division terminals is under his supervision, and his headquarters are generally at that terminal because it is the important point of his jurisdiction. He may have assistants with duties both at terminals and between them, and he always has assistants who confine their efforts to the terminal, and others who confine their efforts to the road work. If at the divisional terminals the freight locomotives and the passenger locomotives are separated, as is often the case, one assistant may have supervision over freight locomotives and terminals, another over passenger locomotives and terminals, and a third over the intermediate

division engine-houses, in which both passenger and freight locomotives may be cared for.

30. *Travelling Foremen*.—The assistants in the operation on the road are usually designated as travelling engineers or road foremen of engines, and travelling firemen. Some are assigned to passenger service and others to freight service, and they report to the master mechanic, or if there are assistant master-mechanics, then to the proper assistant master-mechanic. Their duties are, nominally, to instruct the engine-drivers and the firemen; to report the conditions of the locomotives as delivered from the engine-house; to foresee, when possible, and to report work on the locomotives which may require special preparation or special attention for the preparation of material, etc. Too often, and it may be said usually, they are kept busy ascertaining and reporting what has already happened and explaining it, whereas their efforts should be directed to preventing the repetition of undesirable occurrences. It is conceded, however, that a general knowledge of what has happened and the causes are essential for the intelligent direction of means for preventing recurrence.

31. All of these officials, from master mechanic to travelling firemen, are subject to call at any hour.

32. *Engine-House Foremen*.—The organization at the locomotive terminal will begin with the general foreman, who will have general supervision of the terminal 24 hours a day and seven days in the week. He will have personal supervision in the daytime; the assistant general foreman will report to him and have supervision at night. These two may arrange between themselves, subject to the approval of the master mechanic or the assistant master-mechanic, for regular rest days. The division of the 24 hours between these two men means somewhat more than 12 hours a day service for each, that there may be time for the necessary consultation between them. Because of this and the fact that the change in supervision is made in the morning and evening, the busiest hours at most engine-houses, and at about the same time the other employees change shifts, there is being considered, and in fact put into operation at a few places, an arrangement for 8-hour shifts, so assigning the terminal men that the entire shift

will not change at any one time. In such an arrangement the general foreman would be present during a part or the whole of every shift and one of his three assistants would be assigned to each shift. Twenty-four-hour operation is necessary at engine-houses, and two complete breaks in each 24 hours are not conducive to best results, nor can a man deliver his best efforts for 12 hours a day continuously. Hence the tendency to shorten the hours of daily service and to minimize the effect of each change of shift.

33. In addition to the assistant general foreman, the store-keeper and chief clerk will also report to the general foreman. To the assistant general foreman in charge of each shift, the yard foreman, the house foreman, the shop foreman, the foreman of labourers, the despatcher and the necessary clerks, will report.

34. *The Yard Foreman.*—He should have complete charge of the locomotives at the terminal and outside of the house. He should take from the house foreman instructions as to the particular stall in which each locomotive is to be placed and report as soon as it is placed; and should take instructions from the despatcher about delivering the locomotives to the transportation department. This arrangement will place under the supervision of the yard foreman, the coaling, sanding, watering and ash-pit plants, and the turntables; the care of the locomotives which are standing outside of the house; and also the special crews that run the locomotives between the engine-house and the train terminal, when such crews are necessary.

35. *The House Foreman.*—He should have supervision over the workmen in the house, and over the inspectors on the incoming track, if there are such inspectors. The various foremen reporting to him are those in charge of repairs to tenders, boilers, machinery and air-brakes, and others similar, depending on how far the work is specialized. In working out the 8-hour shift arrangement, it has been suggested that there be assistant house foremen, each with supervision over certain stalls assigned to him; the special work, however, such as air-brake and similar work, to be done by special gangs for all the stalls. The shop foreman will also transfer machinists, boiler makers, etc., from one assistant foreman to

another, as conditions may demand. This arrangement of dividing the house into sections, each in charge of an assistant foreman, is being used with satisfactory results. It makes of the assistant foreman a high-class inspector, because it places him in such close touch with the conditions that he can say just what work should be done, and know how thoroughly it is done. This is a most important consideration because the enginemen and inspectors may report a lot of work to be done, partly to clear themselves, as well as to inform the foreman thoroughly. The man who does the inspecting and repairing on a locomotive, or on a number of locomotives day after day, is well informed on what must be done and how it should be done; which leads to the suggestion of the further step that the maintenance of certain locomotives be assigned to certain gangs. This ought not to be impossible in passenger locomotive terminals.

36. *The Shop Foreman.*—The importance of the shop foreman depends largely upon the importance of the shop. Sometimes his duties are assumed by the engine-house foreman. The tendency seems to be in the direction of providing larger shop facilities, and as these are increased the importance of the shop foreman will increase.

37. *The Work-Report Clerk.*—The clerical force perform the usual duties of such employees. There is one clerical position, however, which is growing in importance, and the qualifications for the filling of which are becoming more and more exacting; this is the position of work-report clerk. He should understand clerical work and know enough about locomotive parts and repairs to make out a satisfactory report of work to be done. He first comes into contact with the arriving engineman, who reports on conditions which can be observed only when the locomotive is in action. Enginemen do not like to write, hence their written reports are short and unsatisfactory. The tendency at present therefore is for the clerk to write these reports for the signature of the engineman, and the clerk must understand what work is necessary and report it properly. As the clerk is almost always accessible, the information is thus available in case further explanations are required. This clerk also makes a record of the

incidents of the trip as reported by the engineman, so that, in case of inquiry, the desired information is already on file.

38. The engineman's report of work to be done and the report of the inspector should reach the work-report clerk at the same time, that there may be no delay in distributing the work to the respective gangs.

39. *Bulletin for Completed Work.*—Quite as important as having the work to be done promptly reported to those who are to do it, is the reporting back promptly when the work is completed, and to have this information easily available for those who need to have it. For this purpose various arrangements are provided, the details being worked out to suit the peculiar layout of each house. The essential features are provided by a blackboard located conveniently for those who make the records, and for those who must read them. This board is ruled into vertical columns, one for the number of the locomotive, one for the number of the stall in which the locomotive is located, and other columns, depending upon how the work in the house is distributed among the repair men. For instance, there may be a column headed "air-brake," another "boiler," another "machinery." As each class of work is completed each foreman marks on the board in the proper column, and opposite the particular locomotive number his "O.K.," indicating that his work on the locomotive has been completed. When all the spaces opposite a locomotive number are marked "O.K.," it is evident that the locomotive is ready for service. The record is erased as soon as the locomotive is taken out of the house. The convenience and despatch with which these records can be made are important factors.

40. *Outfitting the Locomotive.*—Contrary to the previous practice of requiring the locomotive crew to do some cleaning, fill oil cups, and in general look after the outfitting of the locomotive, the present tendency, and it is pretty well established, is for the engine-house force to outfit each locomotive completely for service on the road. There remains for the crew, of course, the responsibility to know that the necessary repairs and outfitting have been done even though the locomotive is delivered to them at the station.

41. *The Despatcher.*—It remains for the despatcher to know what locomotives and crews are arriving, and to care for the proper despatching of locomotives and crews.

POOLING.

42. Some years ago it was the general practice to assign a locomotive to a crew and both crew and locomotive to particular runs, and when the locomotive was taken to the shop for repairs the crew worked in the shop until the repairs were completed, usually devoting much, or all of its shop time to its locomotive. At that period there were few extra passenger runs and the freight runs were very largely scheduled runs, under which conditions it was easy to assign locomotives to crews and crews to runs, keeping each crew on its particular locomotive and run. As the maximum freight service increased and the fluctuation between maximum and minimum freight service widened, it became necessary to move a large proportion of the freight trains as extras, which made it quite impossible to assign crews and locomotives to runs not scheduled. It was also necessary to increase or to decrease the number of locomotives in proportion to business demands, which could be done only by withdrawing locomotives from service, during which time there would be only the interest and depreciation charges on them.

43. As a result a plan was developed to increase the service of the locomotives by placing any crew on any locomotive for service, instead of holding it until its assigned crew could obtain the necessary rest. While this prevented the assignment of locomotives to crews, it made possible a larger individual locomotive mileage per month or per year. The first experience with this arrangement in freight service seemed so satisfactory that it promised well for passenger service to which it was extended, so that a locomotive used one day on one train would be used the next day on a different train, permitting the operation of a certain number of trains per day with greater or less number of locomotives than trains. The idea, of course, was to operate a number of trains with a less number of locomotives.

44. The criticism most generally made upon this system is that the personal interest which the man had originally in his own locomotive is lost. This has been valued very highly by some officials, more particularly those of the motive power department, and less highly by others, usually of the transportation department, and more particularly those who are not so well versed with the trials and tribulations of the motive power department. Under the pooling system the effort of the average crew is to get through with the particular locomotive as quickly and as easily as possible, and to let the next crew get along as best it can.

45. Such conditions necessitate careful watching of the reports from the enginemen, so that everything that the engine-house inspector cannot well find is included, and also careful inspection and repairing at the engine-houses. It may make necessary also an additional expense per locomotive for wear and tear, as some argue, and at the engine-houses, as others argue; but whatever the cause or amount, this additional expense is the cost of getting the additional mileage per locomotive per month or per year, and it is a question of whether the cost is more than offset by the gain. The argument that it is as well to get the mileage-life of a locomotive in 15 years as in 10 neglects the fact that possibly 50 per cent. more locomotives will be required if it is gotten in 15 years than if in 10 years, with a resulting interest charge.

46. Possibly, also, those who hearken back to the times of assigned locomotives and crews, and picture to themselves the enginemen setting box wedges and rod brasses, adjusting the piston-rod packing and doing a long list of other work, overlook the difference in the size of the parts of present and past locomotives, and that a crew, even if it knew a certain work was required and was willing, would be unable to do it, at least alone. Extensive experiments have been made to determine the relative costs of the assigning and the pooling systems, and in some of these experiments, at least, no material difference in cost has been found. However, there may be, and probably is, some loss in reliability of service in pooling.

47. The fundamental idea of pooling is to obtain from each locomotive the maximum mileage per month or per year, in other words to keep the locomotive going, and various schemes have been devised to accomplish this and to obtain at the same time any advantages there may be in the personal interest of a crew in its own locomotive. One of these is to assign one locomotive to two or, at times, three crews, each crew making a round trip from terminal to terminal. A variation is to change the crews about midway in the trip; this has some decided advantages, the principal one being that a fresh crew is obtained at the beginning of each quarter of a round trip, or each half of a single trip, and while the rest at each terminal is not of long duration, yet it means much to the crew, especially in hot weather; also, inasmuch as the crew are not at home at the divisional terminal, the men are anxious to start back so that they may reach home. To work out satisfactorily this system of changing crews at the middle of a division, it is necessary that the divisions be so arranged, or of such length that there shall not be too much constructive mileage for the crew; that is, that the mileage for which the crew is paid shall not be materially more than the actual mileage made by it.

48. Since it is quite certain that a locomotive in proper condition for service can be used a greater number of miles or hours per week or per month than one crew is able to stand, it would seem to be good policy to get full returns in some way and not limit the output in miles or in hours' service to the capacity of the crew; on the other hand, the men must be given proper consideration and be permitted to make fair wages. The pooling of locomotives and of crews in the different kinds of service makes it possible to use each locomotive the maximum number of miles in a certain period of time, which maximum will be about the same as for any other locomotives in the same service, granting, of course, that nothing serious goes wrong with it; it also makes possible maximum and equal earnings by men of physical equality.

49. The assigning of one locomotive to one crew limits the output obtained from the locomotive during a month or a year to the capacity of the crew; assigning one locomotive in road service

to two or more regular crews need not limit the output of the locomotive, but may place the earnings of the crew below its ability and below average earnings for similar work. In yard service it is possible, and is the general practice, to assign one locomotive to two crews. If in road service one locomotive is assigned to two or more crews, the run should be arranged to permit each crew fair earnings. Another variation of the pooling system is to assign two locomotives to three crews, to which resort may be made when two crews on one locomotive cannot make the average earnings.

50. It will be noted that the original idea of pooling was to obtain maximum mileage from the locomotives, which resulted, apparently, in taking from the crews and placing upon the engine-house a large part of the responsibility of the condition of the locomotives. Then appeared variations which had in view this original idea, coupled with the effort to place upon the crews at least a part of the responsibility for the condition of the locomotives taken from them or voluntarily given up by them under the straight pooling system; each arrangement having in mind a fair earnings return to the crews.

[*The Discussion on this Paper was combined with that on the Papers by Mr. C. W. Paget, Mr. F. H. Clark, Mr. W. Forsyth, and Mr. H. H. Vaughan, and commences on page 904.*]

(Mr. Aspinall's remarks, President I.Mech.E.)

Hydraulic Wheel-drop, Bolton Shed, L. & Y. Ry. (See also p.910).

Fig. 25. Top Position, Empty.

Fig. 26. Wheels lowered part way.