The Author. diameter. With further reference to the question put by Mr. Bailey, the general arrangement of the empty and full sidings was entirely due to the contour of the ground, and had been planned with a view to economy of construction and subsequent working. At the present time the railway-company delivered the empty wagons into the sidings behind the colliery, and from this point they gravitated under the screens to be loaded, and thence over the full weighing-machine into the full sidings, ready for despatch to their destinations. The whole of this operation was performed by gravity, the sidings being laid out at a uniform gradient of 1 in 72. In reply to the President, he was sorry to be unable to express an opinion as to the relative values of the English and the Continental methods of tubbing shafts, as he had not given the subject sufficient consideration; moreover, he thought the question was large enough, and of sufficient importance, to warrant a separate Paper, and he would be glad to contribute one at a later date.

Correspondence.

Mr. Gillott. Mr. THOMAS GILLOTT considered that great credit was due to the Author for sinking successfully through water-bearing sands without having to resort to extraordinary methods; and although no costs were given, it was plain that the work had been well and economically done. He would be glad to know what clearance had been given between the cages, and also between the cages and the shaft-sides, with the wire-rope guides mentioned. Apparently the screening-plant had not had to be designed so as to avoid, as far as possible, the production of small coal, as the whole output passed over jigging screens, which must, by shaking the lumps, reduce a certain amount of large coal to small. As the plant included coke-ovens, the coal was presumably of a coking quality; in which case the shaking of the large coal was not such an objection as might otherwise appear. The residue from the ends of the main belts would evidently be very variable as regarded size, but mention was made of "a conveyor and classifier . . . for the purpose of making various sizes of hard steam coal." Did the seam contain coal of different qualities, and if so what arrangements were made to separate them? As each belt was placed above adjacent lines of rails, Mr. Gillott would like to know how many sizes were made, how the loading was arranged, and if any

appliances were used to prevent undue breakage. With the comparatively short and deep high-capacity trucks now coming into use, he doubted whether the lowering belt was the best method for loading coal containing large lumps. With trucks running under the main belt, the height of the belts rendered the loading of coal picked off an awkward matter; and unless there were separate roads for hand-picked coal, the removal of the loaded trucks was often interfered with. Mr. Gillott.

Mr. A. L. STEAVENSON regarded the Paper as a very valuable account of a most difficult undertaking, in which, notwithstanding various schemes for getting through the Permian sand-beds by the Kind-Chaudron system, or by freezing, the Author had reverted to the good old method of using plenty of pumping-power and forcing his way through all difficulties, even against more than 40 tons of water per minute. The quantity of water met with must of course vary somewhat with the diameter or area of the shafts which gave an outlet to the lake of standing water upon which they had been sunk, and with the depth or pressure driving it out. A comparison of the costs of dealing with this important problem by various methods would be very valuable if it could be made. It seemed to be a question which the Royal Commission on Coal-Supplies could have best dealt with, but if Mr. Steavenson had been a younger man with more time he would have attempted it. Was it too much to ask the Author to supply the deficiency? Such a Paper as this ought to serve as a caution to those who still held that England had an ample supply of coal to serve for many generations yet to come. It was all very well for the Royal Commission to say that there was still 100,914,668,167 tons of coal remaining, but the bulk of it was like the Irishman's purse, which, although at the bottom of the sea, was not lost, because he knew where it was. When Mr. Steavenson began his apprenticeship in 1852, he could and did walk into drifts in the hill-side and find a seam of coal 6 feet thick and yielding coke with less than 4 per cent. of ash. Where were such conditions to be found now? They had disappeared like snow on the hill-sides in sunshine, and it was necessary to spend £200,000 to £300,000 to reach the coal, with proportionate cost in working. For these reasons he entirely approved of the recent coal-tax. Mr. Steavenson.

Mr. EDWARD B. WAIN observed that, by the kind permission of the Author, he had had several opportunities of seeing in progress the work described in the Paper, and from the plain matter-of-fact description given by the Author it was somewhat hard to realize how great and difficult a piece of mining work he had successfully undertaken. The sinking of the Horden shafts was without doubt Mr. Wain.

Mr. Wain. one of the most notable achievements in the annals of English coal-mining, and the masterly and expeditious manner in which the work had been done had won the admiration of the mining-engineers of the country. The careful forethought shown in the design and arrangement of the plant had enabled the progress, in face of great difficulties, to be such as would seem almost incredible; and there were many cases on record where the sinking and equipment of new collieries with no particular difficulties to contend with had occupied far longer time. In sinking shafts through heavily-watered strata various special methods had been adopted, notably the freezing-process, but the progress under such methods was necessarily slow: Mr. Wain thought the Author had chosen the better part in deciding to deal with the water by direct pumping, and, in fact, the results had fully justified his plan. The simple, though massive, design of the pumps, the interchangeability of the parts, and the fact that, even in case of temporary breakdown and flooding, the whole of the pumps could be handled and removed from the surface, together with the ease and expedition with which extensions could be made as the shaft-sinking progressed, had all proved their value. As an instance of the thorough manner in which the work had been done at Horden, Mr. Wain could not forget how on one occasion, after measuring a discharge of 4,500 gallons of water per minute at the outlet drift from the pumps, he had, in light summer clothing, descended the shaft from which the water was being pumped and where sinking-operations were in full progress, and had returned to the surface as dry and as clean as when he left. Apart from other considerations, the importance of duplication of the pumps could be more fully realized when it was remembered that there were times when the cessation of pumping for less than 1 minute would have allowed sufficient rise in the water-level at the shaft-bottom to have drowned every one of the men working there. As regarded the permanent surface-equipment as described in the latter part of the Paper and illustrated in Figs. 12 and 13, Plate 4, the work described was an example of the best modern design, and the Author was to be congratulated on having been able to prove that a colliery-heapstead was not necessarily an altogether hideous erection. He welcomed the Paper not only as a record of work ably planned and well executed, but also as a contribution to the Proceedings of the greatest practical value for future reference.

Mr. Wood. Mr. E. Seymour Wood had read with interest this description of shaft-sinking at Horden Colliery by the open-pit pumping process which had been used in sinking most of the coal-shafts through the magnesian limestone and Permian sand on

the east coast of the county of Durham. The magnesian limestone contained, as had been pointed out, large feeders of water. These varied locally. At South Hetton, about 3½ miles from the coast, in sinking the No. 2 shaft (then under Mr. Wood's management) the feeders in the limestone were found to be 3,500 gallons per minute, and were of fresh water. At Dawdon Colliery, the property of the Marquis of Londonderry, on the sea-coast adjacent to Horden, the magnesian limestone, 356 feet 10½ inches thick, was as usual full of large gullets. Some of these gullets were undoubtedly connected with the sea; the water issuing from them was salt and the water-level in the shafts was affected by the rise and fall of the tides—a corresponding rise and fall of 9 to 24 inches being found in the shaft water-level 3 to 4 hours after high- and low-water time at Seaham Harbour. The largest feeder met with was 6,075 gallons per minute.[1] The greatest difficulty presented itself in sinking through the "yellow sand" underlying the magnesian limestone, the latter being usually found as a quicksand containing a large quantity of water. The thickness varied: at Murton it was 27 feet thick, at Dawdon 92 feet 4 inches, at Easington 102 feet, at Horden 48 feet.[2] The great question for consideration in attempting a sinking through this strata into the coal measures, was whether to disturb the strata and sand-bed by pumping or to sink through them in a solid or frozen state. At Dawdon Colliery, after attempting to put the shafts down by the open-pit pumping process, and the feeders pumped in the limestone having amounted to 7,050 gallons per minute, it was considered advisable, in view of the probability that the feeders would be greatly augmented in sinking through the sand-bed, to abandon the pumping process and institute the freezing-system. The sinking by that process had been a great success. The sand, which was 92 feet thick at a depth of 367 feet, was frozen solid. So great was the intensity of freezing that the sand resembled hard grey freestone, although pieces readily crumbled when held for a short time in the hand. On being exposed to the atmosphere the sand soon became soft and fell to pieces. In the shaft-bottom the frozen sand was so hard that blasting had to be continued through the deposit. The total time occupied in sinking through the quicksand itself, tubbing

Mr. Wood.

[1] E. Seymour Wood, "Sinking through Magnesium Limestone and Yellow Sand by the Freezing Process at Dawdon Colliery, near Seaham Harbour, County Durham." Transactions of the Institution of Mining Engineers, vol. xxxii, p. 551; vol. xxxiii, pp. 197 and 251.

[2] For a section along the east coast, see Transactions of the Institution of Mining Engineers, vol. xxxii, plate 27.

Mr. Wood. it off, and securing the strata below the freezing-pipes and the frozen ground, was 6 weeks.

The Author. The AUTHOR, in reply to the Correspondence, stated that the clearance between the cages and at the corners of cages was 12 inches. A large proportion of the output was sent away as "through and through" coal—in other words, as it was drawn out of the pit, except, of course, that all foreign substances were cleaned out. Three seams were being worked at present, and the coal from two of these seams was divided into four sizes, each size being loaded up on a separate line of railway, the large coal being lowered from the end of the cleaning-belt by lowering jibs, and the whole of the operations being performed mechanically to the satisfaction of users of the coal. The soft portion of the blue, or so-called yellow, sand under the magnesian limestone was usually only about two-thirds of the total thickness of this stratum, the balance being siliceous sandstone of the same colour, but quite strong; and the difficulties in sinking depended on the thickness of the soft sand, and not of the bed as a whole. This thickness varied very considerably within comparatively small areas: for instance, at Horden it was 39 feet in the south, 48 feet in the north, and 61 feet in the east pit, although these shafts were only 66 yards apart; and these thicknesses might be taken to represent the maximum thickness of the really difficult ground to be sunk through in this part of the Durham coal-field Failure to sink shafts by the ordinary methods in operation in this country to meet the usual difficulties incidental to the winning of coal had been due almost entirely to the short-sighted policy of endeavouring to carry out the work with a heterogeneous collection of second-hand plant, bought from time to time to overcome additional difficulties as these presented themselves, without much regard to the machinery already on the works, so long as it was considered to be adequate for the immediate purpose. Consequently, it was not by any means unusual to find side by side new and also antiquated samples of several kinds of pumping-machinery in use for sinking pits, and it was therefore not surprising to hear of failures to sink shafts and of the peculiar difficulties incidental to certain undertakings; but, with a fairly complete knowledge of the subject, and of the various difficult shaft-sinking operations that had been carried out during the past 25 years, the Author had no hesitation whatever in asserting that shafts could be sunk more quickly, and therefore more cheaply, through the magnesian limestone feeders by means of the old-fashioned bucket-pumps, properly designed and arranged, than by either the boring or the freezing system.