GRAIN ELEVATORS AND THEIR APPLICATION TO THE PUNJAB WHEAT TRANSPORT PROBLEM.

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Function of grain elevators.

The rate of consumption of grain by the human race per head is approximately constant throughout the year. The rate of production, however, by nature is not so. The harvests of the great grain-producing countries of the world are produced at certain definite times of the year and in order to distribute the supply evenly over the year the vast mechanism of storage and transport has been evolved. The farmer naturally wishes to get rid physically of his grain as soon as possible and is content to receive in exchange for it vouchers which can be cashed at some subsequent date. The consumer, however, does not want his grain in large quantities at a time and so some system of grain storage must inevitably arise. In cases where a moderate amount of grain has to be dealt with it can all be shipped away immediately in railway cars or in the holds of ships without the mediation of granaries. This system breaks down as soon as the quantities to be dealt with become large. Ships and cars are not intended to act as grain storage bins and if anything happens to check the demand for grain during the rush of transport, great losses must result owing to the partial stoppage of the transport system and owing to the grain being spoilt through being stored in unsuitable places. This system is also wasteful from a railway point of view since it involves the reconstruction of a large number of railway wagons, locomotives, sidings, terminal handling appliances, etc., which can only be used efficiently immediately after the grain harvest and must lie in whole or in part unproductive during the remainder of the year. There is the additional disadvantage that it is undesirable to fling large quantities of grain on the market owing to the fall in price this entails, since the consumer has to be induced to take over more grain than he really needs by offering it at a reduced price. The so-called grain elevator or granary plays a very important part in the handling of grain in America. The grain-growing areas are dotted with country elevators

situated at railway stations. The farmers despatch their loaded farm wagons to the local elevator and sell their grain to it either for cash or for a receipt realisable in cash later. The local elevator despatches its grain as soon as possible in bulk-grain railway cars, either direct to mills or to larger central elevators situated in the more populous areas, which in turn deliver as required to mills and thence through the trade to the consumer. The elevators perform the important subsidiary service of cleaning the grain before or after storage. It will thus be seen that grain elevators are a link in the chain of transport between farmer and consumer and the engineering problems connected therewith are essentially those concerning the transport engineer. The elevators act upon the flow of grain in the same manner as a tank or reservoir acts in order to convert an intermittent flow of water into a constant flow.

General description of granary.

The modern granary is called a grain elevator in America and a Silo in Europe. It consists of large bins for storing the grain and various transporting and elevating mechanisms for handling the grain. The bins consist of large cylinders standing on their ends. These cylinders are sometimes as large as 30 ft. dia. by 100 ft. high, and they are associated together in groups of any number required to provide the requisite total storage capacity. The grain is transported to the granary by means of a more or less horizontal system of conveyors terminating at the "boot" of a vertical elevator which hoists it to the top of the bins. On being discharged from the top of the elevator the grain is again caught by a horizontal transporter and carried to the top of the bin required to be filled where it is discharged into the bin. Where there is only a small group of bins the grain may be discharged directly from the top of the elevator into the bins through inclined shoots. When grain is required to be delivered from the granary a gate or cock is opened in the bottom of one of the bins and the grain then flows on to a horizontal conveyor or into an inclined shoot delivering it at the required spot. During its passage from the bin the grain passes through an automatic weighing machine.

Types of grain handling appliances.

Elevators are almost invariably of the chain and bucket type. The grain is hoisted by means of buckets carried on an endless chain or belt in much the same manner as a dredging machine. The chain passes round pulleys at top and bottom

and these pulleys are usually vertically placed above each other. The buckets scoop up grain from the boot of the elevator while passing round the lower pulley and discharge it into a hopper while passing over the top pulley.

Transporters are usually of the belt conveyor type, although steel screw conveyors, push plate conveyors, and a few other types have been used. The belt is carried on pulleys at frequent intervals and should be as nearly horizontal as possible. In any case the inclination should not exceed 15°. The belt is naturally flat but is slightly hollowed by means of side pulleys and the grain then displays no tendency to leave the belt but lies in the middle half of the belt during its progress. The belt is endless and passes over a pulley at the end of its run to return underneath itself. This lower half of the belt does not of course carry any grain. The belt cannot turn a corner in a horizontal plane and if the direction of the flow of grain has to be changed the grain must be thrown off the belt on to another one travelling in the required direction. The grain can be thrown off the belt at any point by an ingenious contrivance. By means of a moveable arrangement which can be fixed at any point of the run of the belt, the latter is deflected vertically downwards over a pulley and then resumes its original horizontal direction after passing round a second pulley immediately below the first. The belt runs at about 500 feet a minute and so when it suddenly changes its horizontal direction for a downward vertical one, the grain shoots off it into the air in a continuous stream which is caught in a hopper whence the grain flows through a shoot by gravity to another belt or to any desired point.

Pneumatic hoists are sometimes used for unloading bulk grain from the holds of ships. The grain is sucked up through flexible pipes, guided by men holding the nozzles, from the hold into large vacuum receivers from which the grain is discharged at intervals into hoppers. The appliance is very like an enormous vacuum cleaner. It is very convenient in action but expensive to work as compared with a bucket elevator and modern practice seems to tend towards the use of a portable bucket elevator which can be lowered into the hold of a ship, combined with a pneumatic trimmer for delivering the grain from distant corners of the hold to the boot of the elevator.

Storage.

Grain storage may be of two kinds—bulk storage and floor storage. Bulk storage is sufficiently described by its name

and is extensively used where the grain is of only a few distinct kinds or grades so that the different kinds can be dumped in large quantities into a few separate bins. Floor storage has, however, occasionally to be resorted to. In this case the granary is more like a warehouse and is a large building divided up into floors. Each floor is again divided up into a large number of compartments by wooden partitions. Vertical shoots of about 8″ dia. run from top to bottom of the building through each set of compartments, communicating at the top with the upper system of belt conveyors and at the bottom with the lower system. By means of traps and gates in the vertical shoots grain can be delivered to or from any compartment on any floor in the granary. The object of this system is to enable a very large number of different kinds of grain or different grades and qualities of any one kind of grain to be dealt with. A passenger lift runs to each storey and grain merchants are able to go to the floors and sample and select any grain for purchase. The system is convenient but more expensive than bulk storage, since a large amount of storage room is wasted in passage ways and headroom on each floor. The actual grain storage capacity of a floor-storage granary is only about 60 per cent. of the total volume of the granary.

Description of a granary at the Port of London.

The author has been fortunate during his recent visit to England in meeting the Grain Engineer to the Port of London Authority on several occasions, and the latter has very kindly placed a vast amount of information on grain handling at the author's disposal as well as permitting him to inspect the up-to-date plant possessed by the Port of London at several of their docks. A brief description of one of their granaries and of the appliances connected therewith may be of interest. The granary is situated close to the dock wall and the grain ship berths alongside. The grain is unloaded by means of four pneumatic elevators which deliver the grain to four independent belt conveyors for transporting the grain to the floor of the granary. Here the grain is caught by another system of belt conveyors which transports the grain to the boot of the main elevator which in turn hoists the grain to the top of the granary. The elevator delivers into a hopper which pours it on to a system of belt conveyors for carrying the grain to the mouth of any desired bin. This completes the storage of the grain. When delivery is required, a gate in the bottom of the bin is opened and the grain pours on to a system of belt conveyors for delivering the grain through a weighing machine either to a flour mill close by

or to railway trucks or to a gang who fasten the grain up in sacks for carting. Provision is made for receiving grain from other sources than a ship. The grain can be dropped from a sack or a bulk grain railway wagon, etc., into a hopper which delivers to the lower horizontal system of belt conveyors communicating with the boot of the main elevator. If necessary, the grain can be passed through a cleaning machine. The storage is of both kinds, bulk and floor storage. The power and lighting is electric throughout and fire appliances are installed. The granary is under the immediate control of a foreman, who is in telephonic communication with all parts of the plant.

Effect of storage on the grain.

No bad results follow from storing grain in bulk so long as proper precautions are taken. If the grain is at all damp, it has a tendency to heat up with disastrous results. The remedy is, however, simple. On the first signs of heating in any bin being observed the gate at the bottom of the bin is opened and the grain pours on to the lower system of transporters and is delivered to the boot of the elevator. The grain is then raised and poured back into the top of the bin whence it came. The grain is thoroughfy aired and cooled during this process which is known as "turning over". The operation is so simple and so quickly performed that it is customary to turn over all bins every few days. In India it is possible that insect pests might cause damage owing to the hot climate. In this case it might be necessary to cool the bins by a refrigerating plant of small size.

Application to Indian grain traffic.

The growing importance of India as a grain growing and exporting country makes it of importance to examine whether the granary system could be applied with advantage in India. The grain export traffic is at present dealt with as follows:— The grain is made up in bags and delivered at country stations for transport in ordinary goods wagons to Karachi. The bags of grain arrive in Karachi and a portion is loadad direct on to the steamer and the remainder is opened out at Karachi and sorted, etc., and then reloaded in bags for shipment. The cargo of grain thus leaves India entirely in bags, and not in bulk. On arrival in London the bags are slashed open while still in the steamer's hold in order to enable the appliances at the Port of London for dealing with bulk grain to get at the grain. The author was unable to ascertain what became of the old bags. They are probably sold as scrap. This is about as unsatisfacto

a method of handling grain in large quantities as could be devised. The packing of grain bags into covered goods wagons, the unloading of the same by hand, the stacking for hoisting by cranes on to the steamer, and finally trimming by hand in the steamer's hold involve a great deal of labour costs. There are also incidental losses through bags leaking or bursting and through theft of complete bags. The bags, while lying about in the open awaiting shipment, are also liable to damage and loss by rain or theft. A great deal of trouble arises from the fact that practically the whole of the wheat harvest is hurried to the railway for despatch to Karachi owing to the almost complete absence of any system of grain storage. The effect of flinging the whole of the Indian harvest on the market in a space of about three months is one which the transport engineer is not in a position to discuss. Its effects, however, must be far-reaching. The existence of the "grain rush" (as the sudden flow of grain to Karachi is called in railway circles) is shown by the following figures:—

Tons of grain consigned to Karachi per mensem in thousands of tons.

		1910.	1911.	1912.
	January ...	132	108	200
	February ...	131	149	226
	March ...	92	107	167
	April ...	90	115	131
PERIOD DURING WHICH "RUSH" MAY BE EXPECTED	May ..	103	161	316
	June ...	165	312	397
	July ...	231	238	323
	August ...	144	104	110
	September ...	119	98	242
	October ...	100	132	220
	November ...	75	123	139
	December ...	108	139	101
	Total ...	1,490,000	1,786,000	2,572,000

The railway succeeds in carrying this enormous traffic only by working at high pressure during the hot weather and by building sufficient goods wagons to handle it, powerful engines to draw long and heavy trains and long sidings capable of holding the trains at each station. All this means heavy capital outlay on plant which is only earning money during a portion of the year. The completion of the Triple Canal Project will open a new era in Punjab grain production. We must look forward in the near future to seeing the amount of grain exported double what it is now and it would seem that means must be devised for carrying this grain on its long journey to Karachi promptly and economically. The only way in which this promptness can be obtained under present transport *conditions* is by doubling and quadrupling existing lines of railway and by building sufficient engines and goods wagons to take up and move the whole anticipated harvest in a space of three or four months time. The necessary storage required to spread out the traffic over three or four months would be entirely in bags lying in the open or in sheds in the Punjab and at Karachi and in the goods wagons themselves during transit.

Proposed granary system for India.

Contrast the foregoing with the granary system. The Punjab would be dotted with granaries at each grain consigning station of importance sufficient in the aggregate to store about one half of the harvest. These granaries would vary in size according to requirements up to a maximum of say, 4,000, tons capacity. The farmers would deliver their grain in bags to the granary and receive payment for it on the spot. The bags would be emptied through an automatic weighing machine into the boot of the elevator and the grain would thenceforth be free from human handling. The bulk grain would flow from the granary into bulk grain railway wagons provided by the railway. On arrival in Karachi, the grain would usually be discharged direct into the holds of steamers, and the promptness with which this would be done would doubtless commend itself to the Karachi Port authorities and the N.-W. Ry. staff at Kiamari. In order however, to enable the stream of grain to flow continuously from the Punjab, in the event of a shortage of shipping, a very large granary of, say, 50,000 tons capacity would be provided at Karachi. The primary function of the granaries would be to convert the present concentrated rush into a steady stream flowing through Karachi to Europe. The important subsidiary services

of cleansing and protecting the grain from damage and theft would also be performed by the granaries.

Cost.

The cost of the granary scheme would be heavy but so is the cost of doubling and quadrupling lines of railway and building additional rolling stock and siding accommodation. It would probably be found that the granary system would be cheaper if adopted in time and would certainly be cheaper in operation. There is little doubt that the railway would on sound economic grounds far prefer dealing with a steady paying grain traffic throughout the year to facing the present annual grain crisis. They would have to build special bulk grain transport wagons but these would be in use throughout the year whereas a large number of their present wagons are only used during the grain rush and are laid up in sidings during the remainder of the year. Under this system the railway could no doubt deal with any future grain traffic when the main line is double throughout from Khanewal to Karachi.

Conclusion.

This paper has been written by the author from the point of view of the Railway Engineer. The adoption of the granary system is strongly advocated by him on purely transport grounds. Its adoption, however, would give rise to a very much altered situation from the point of view of the grain export Merchant and also to a less extent of the Indian cultivator and it is hoped that this aspect of the question will be ventilated during the discussion. Two things, which will interest members struck the author very much during his inspections of plant at the Port of London and during his conversations with those concerned in the trade at Home. The first was the deliberate destruction of millions of bags in the holds of incoming vessels in order to enable the grain to be dealt with in bulk. The second was the fact that Karachi wheat is a byword at Home for filthiness. Other wheat flows out of ships holds in a clean golden stream along the conveyor belts and elevators whereas Karachi wheat comes out in the midst of a disgusting fog of dirt and dust clogging the machinery and exasperating by standers. This being so, it is easy to understand the fact that Karachi wheat commands a less price than any other on account of its dirtiness. If the granary system were adopted in India, the grain would arrive in England as clean as any other and would command as good a price as any in the market

The author desires to express his indebtedness to Mr. A. H. Mitchell, Bulk Grain Engineer to the Port of London Authority, for information supplied so liberally and for permission to inspect the plant in his control under his personal guidance.

DISCUSSION.

COLONEL R. S. MACLAGAN, C.B., C.S.I., Chief Engineer, Buildings and Roads Branch, in opening the proceedings, said he was sorry to inform the members that Sir Henry Burt, who was to have presided at the Congress, had been detained in Calcutta to investigate some urgent matters connected with the East Indian Railway and consequently was unable to be present. The chairman had received the following telegram from him that morning :—

" All success to Congress. Very sorry cannot be present.—Burt."

Every one would regret that Sir Henry Burt was not able to preside.

Several very interesting papers had been presented to the Gongress, and the chairman hoped that those who were experts on the subjects dealt with would give the members the benefit of their opinions, so that the discussions, as well as the papers themselves, might be of interest and use.

In accordance with the rules, the papers, which had already been circulated to all members, would be taken as read and would now only be discussed. The first paper for consideration was one on Grain Elevators and their application to the Punjab Wheat Transport Problem by Mr. Victor Bayley. This would now be briefly introduced by the author.

MR. BAYLEY said his attention had first been directed to the problem of grain transport when he officiated as Deputy Carriage and Wagon Superintendent on the North-Western Railway, and he had therefore subsequently investigated the question when recently at home on six months' furlough. On seeing the ease and celerity with which grain was handled in bulk at the Port of London, it occurred to him that a similar system would be applicable to India, and therefore in his paper he had endeavoured to put before the Congress a proposed system of dealing with the grain traffic, resembling the elevator system now in operation in most grain producing countries. The scope of the paper was sufficiently indicated by its sub-heads, and was more intended to stimulate discussion than to describe minutely the mechanism of grain elevators, and the author hoped that the various aspects of the question would be ventilated during the discussion.

CAPT. ANDERSON thought that the paper rather mixed up the two functions of the grain elevator : first, the storage, and, secondly, the cleaning of the grain. As far as the question of steadying the traffic in grain from the Railway point of view was concerned, it was only necessary to store the grain, but, if that was to be done, it meant that every producer of grain must have his own bin. That might be possible in some places where large quantities of grain of the same sort were produced, but at a place where there were numerous small producers, it would not do. In such a case cleaning arrangements would be necessary to standardize the contents of each particular bin. If the grain was to be cleaned at the despatching station, the grain elevators would have to be managed in such a way as would inspire absolute confidence both in the seller and in the buyer as to the quality of the grain from a particular bin. If both were not certain of what they got in the way of quality, nothing could be done with the scheme. There was another point about which the speaker would like some information, and that was, whether it would be possible to ship grain from Karachi in bulk during the monsoon ? Grain in bulk was very liable to shift in the hold of a ship, and it might result in disaster occurring to a vessel taking such a cargo in a heavy monsoon. Perhaps Mr. Bayley could say whether vessels from other parts of the world, with grain in bulk in their holds, passed through such bad weather as is often experienced in the monsoon between Karachi and Aden.

MR. ASHFORD referred to the necessity in India of recording weights automatically and plainly so that the zemindar should not feel any want of confidence in bringing his grain. Mr. Ashford also called attention to a suggestion by Mr. J. H. Barnes, that a layer of grain at the base of the elevator should be wetted and allowed to ferment and thereby produce carbonic acid gas which would effectually destroy all insect life present in the grain.

MR. CARNE said that some members of the Congress might not perhaps be aware that at Faridkot (Faridkot State) a grain elevator had been erected by the President of the Council of Regency, Sirdar Bahadur Sardar Dayal Singh Man, and the speaker was sure that the President would be only too pleased to show it to anyone visiting the State, and to explain its working. In connection with the question of destroying insects in the elevator, the President had found that the fumes of burning sulphur were very effective, and, at the same time, harmless

to the grain. Anyone interested in this matter should write to the Superintendent of Agriculture, Faridkot State, and ask for a copy of the President's pamphlet describing his insecticide and rat killer, and for a drawing of the apparatus in use for producing the fumes from the various substances used for the destruction of insects and vermin.

MR. A. E. JEFFRIES said that since the author of the paper had distinctly stated that he had confined himself to the point of view of the Railway Engineer, it was not quite fair to attack him for not treating the question from other points of view, the paper had been written in the hope that others would deal with the subject from the point of view of the producer and the exporter. For the rest, as a result of some conversation the speaker had had with a big zemindar of Faridkot State where an elevator had been installed for some time, he thought that the elevator system would be a very good thing for the zemindar, but it would be necessary to work the system in such a way as to win his confidence.

MR. MONTGOMERY said he would like to put one question to Mr. Bayley. A grain elevator on a large scale was going to be erected at Lyallpur, and every thing was ready for starting work. It had struck the speaker that the first thing to decide was, whether the railway, on the arrival of the grain in trucks at Karachi, would be in a position to deal with it in bulk. If grain had to be put into sacks in Karachi, then matters had not been advanced much. If grain was landed in Karachi in bulk, and then taken out of the trucks and put into bags for shipping, little had been gained.

MR. MITCHELL said that the subject was one which had caused many long and heated discussions in Lyallpur, where a large wheat despatching elevator was shortly to be built, and consequently he would like permission to say a few words, although Mr. Bayley had laid it down that the question was one for the transport engineer only. The merchants, whose opinion, though not disinterested, was of importance, were full of scorn, though perhaps they had not studied the subject thoroughly. The paper, though very interesting, hardly dealt with the subject as set forth in the title. Mr. Bayley had studied the grain handling plant at the London Docks in a very thorough manner, but had ignored the fact that he model was in England and might not be suitable to Indian

conditions, and that the experience gained was of a plant to receive grain from ships, while it was now proposed to apply this to the despatch of grain in railway trucks. Mr Mitchell thought the matter should be dealt with analytically. The two chief functions of the usual type of elevator were (1) storage and (2) handling in which was included drying, cleaning, etc. The advantage of storage was a gradual flow of grain to Karachi benefiting the railway in its running expenses, while the disadvantages were that Indian wheat commanded a better price immediately after the harvest than at other times. So that storage would mean loss to the producer or the dealer, due to a lower price, and the longer period before he could get any turnover on his capital. The advantages in handling had been dealt with by Mr. Bayley, and the only disadvantage was the chance of dishonest practice on the part of the man in charge, who had to be trusted absolutely to give correct figures for each consignment as regards dirt and wheat present. Mr. Bayley mentioned in his paper that on depositing wheat in an elevator, the owner received a voucher which was to be value for cash, *i.e.*, the wheat had been sold : but to whom ? Presumably to the elevator or its owner or lessee, and, as the proposal was for a State Railway to build these elevators, that meant a state monopoly, which was impracticable. Mr. Mitchell had endeavoured to work out the cost approximately on Mr. Bayley's figures ; and working on the table of exports, it could be seen that the maximum storage required was 500,000 tons, and that, including the cost of sidings which would have to be made for the elevators, could not be much less than Rs. 65 per ton ; adding thirty lakhs for the large elevator proposed at Karachi, the total would come to just over three-and-a half crores of rupees, and the speaker wondered whether any one could give the cost of the alternative, *i.e.*, providing extra track, locomotives, and trucks to deal with the grain rush. The Lyallpur elevator, though designed as cheaply as possible, had been estimated to cost Rs. 53 per ton of storage capacity, while the machinery was costing another Rs. 42 per ton of grain stored. The pressure on the soil had, however, to be limited to a ton to the square foot, and this necessitated costly foundations which ran up the price of this elevator considerably. In conclusion, as far as the speaker could see the advantage of the elvator system seemed to be with the railway, and the disadvantage with the exporter. Could the railway make this up to the exporter in any way ?

MR. HAMILTON, Director of Agriculture and Industries, said that a large part of the advantage of elevators came in the facilities given for trading, but that Government could not well enter into the wheat trade ; so that elevators would have to be erected by private individuals or companies. If large zemindars, or Co-operative Societies of zemindars or grain dealers, were to put up elevators, they must first be convinced that elevators simply as grain handling machines—apart from the gains on grain trading—would pay. The Lyallpur elevator would cost two lakhs of rupees and the capacity was just over a lakh of maunds. Interest, depreciation, and working expenses, as worked out by the Public Works Department, came to Rs. 27,600 per annum. The estimated income was based on a charge of five pisa a maund, for receiving, cleaning, weighing, and storing for ten days, and delivery into trucks, and it had been assumed that the elevator would be filled and emptied three times in the exporting season. A storage charge of one pisa a maund a month after the first ten days was also proposed. The charges were based on existing payments, and could not possibly be more and they would yield only Rs. 30,000, which left a very small margin over expenditure. If, then, elevators were to be introduced generally, the Public Works Department would have to work out some cheaper method of construction. In America there were cheap wooden elevators all along the railways, and these were said to cost only nine or ten pence per bushel of capacity. Such elevators would be necessary in the Punjab ; but probably could not be constructed of wood. The size might be 10,000 or 20,000 maunds. Could the Public Works Department work out a standard plan for a 10,000 maund roadside elevator, costing about Rs. 8,000 ?

MAJOR C. B BYERS, Supply and Transport Corps, stated that for several years he had been studying the subject of cleaning and handling grain mechanically,—and its storage in pucca bins or silos,—to meet the requirements of the Military Department. The main point he had to consider was, that, in the event of mobilization, the Supply and Transport Corps would have to despatch in the first few days large quantites of grain for feeding Government animals. Under the existing system of handling grain by cooly labour, the rush, within the limited period that rolling stock would be available for conveying supplies, could only be coped with, provided that large numbers of

coolies were immediately procurable. It was probable, however, that hired labour ordinarily obtainable locally would not suffice to meet the sudden demands of all departments on mobilization, and delay would occur in importing gangs of men from other districts. Various kinds of plant for mechanically handling grain were accordingly carefully considered. General Sir Alfred Pearson, K.C.B., then Commanding the 3rd (Lahore) Division, took a keen personal interest in the subject, and it is due to him that the first grain elevator in India, for military purposes, was erected at Lahore Cantonments, under the speaker's supervision. This had been working for the past two years, and the initial expenditure for machinery and setting up the elevator would be entirely recouped within the next 3 or 4 months, by the saving effected by cleaning and handling grain through the elevator, instead of by cooly labour. Grain for feeding Government animals at all cantonments in the 3rd Divisional area, from Multan to the Simla Hills, was cleaned and despatched from the elevator at Lahore Cantonment, at less cost than it could be supplied and cleaned by hand locally at each cantonment. It was a large subject, however, and would take too long to describe fully, but Major Byers mentioned a few points which he thought would be of general interest. It used to take five hundred coolies eight hours to clean and handle the quantity of grain which is now dealt with by the grain elevator every two hours, with only twelve coolies to handle the bags, and attend to the mechanical appliances. The general method of filling, weighing, and sewing grain bags by hand was slow and laborious. In the cantonment elevator there was a sewing machine, as well as an automatic weighing machine so that the correct qnantity of grain was poured into each bag, which then travelled along a conveyor band under the sewing machine, which sewed the mouth of each bag securely, at the rate of 300 bags per hour. The bags of grain were then shot down an iron shoot into a railway wagon on the siding alongside the elevator. It was predicted that there would be some difficulty in establishing confidence with native dealers when the elevator first started to work. However, trade conditions both as regards payments and refraction were adopted, and dealers were invited to attend and see their consignments of uncleaned grain pass through the elevator. It did not take long to convince them that the mechanical appliances worked correctly, and that they could not be swindled as regards the amount of dirt and admixture extracted. As a result greater competition had been

secured, and the grains obtained more favourable rates, as dealers had learnt that prompt payments were made, and a rebate allowed when, after running each wagon load of grain through the elevator, the percentage of dirt and admixture was found to be actually less than the refraction quoted by the dealer. It had been proved that grain could be cleaned by the elevator far quicker and more thoroughly and at a fraction of the cost of hand labour. Moreover, there was a concern working in peace time which, in the event of mobilization, would very considerably expedite the despatch of grain to the front.

MR. DHODY noted that the author seemed to have treated the subject from one point of view, *viz.*, transport difficulties. The chief question to be determined was, who was going to gain by the introduction of grain elevators, was it the railway, or the cultivator, or the grain merchants? The gain to the Railway would be in the form of savings on account of not having to double or quadruple their line, and not having to provide a large quantity of rolling stock which would probably be lying idle for the greater part of the year, but this saving would go in a great measure to build the elevators. If it was the cultivator who was going to gain then he must be shown to what extent in rupees, annas and pies, for, if any gain that he might expect from using elevators was to be absorbed in their construction, he could hardly be expected to make any investment. If the elevators were built by some other agency for storage, and the cultivator only paid rent, he would probably be equally doubtful of their advantage. There was of course the possible gain if the grain were held for the cultivator and only sold when the market was most favourable, but for this purpose a complicated control system—something on the lines of the co-operative system—would be needed and the cost of working after defraying all expenses would have to show a clear gain before the cultivator could be induced to patronise it. As regards the merchant, if he bought from the cultivator at the time of the crop, and then stored the grain to sell when the market was favorable, he stood to gain, but he again would have to calculate all charges before deciding whether the venture would pay. It was thus very essential to work out actual figures of cost before doing anything. The railway and the merchant might combine, but the gain to the small cultivator seemed negligible, unless he was able to join in a co-operative system. In a hot climate the grain was almost sure to be attacked by insects and the periodic cleaning would necessarily result in shortage, so that the possible safety from loss on

account of freedom from weevils would not be sufficiently attractive for the cultivator. The railways stood the direct gainers by as much as a system of elevators would cost less than the doubling of lines, and the provision of extra rolling stock, and, if the merchant could go with them, they would both get the benefit. The cultivator seemed to be the last link in the chain to derive any benefit from the adoption of elevators unless they were worked on a co-operative system and even then the advantages accruing to the cultivators would be small.

MR. BAYLEY, in reply, said that there appeared to be a misapprehension in the minds of some of the speakers as to his point of view. In his opinion the question was primarily one of transport. The major portion of the vast Indian wheat harvest was of course absorbed in the country and this fact should be borne in mind when reading this paper. The remainder not being required in the country was available for export, and it was only with this remainder that the author concerned himself, although it was only a small proportion of the whole harvest, still the harvest was so gigantic that the quantity exported was immense and, what was very much to the point, was rapidly increasing. The railway was, therefore, faced with the problem of how to deal with this vast traffic and the author had endeavoured to indicate the way. From his point of view, therefore, the building of one or two elevators in the Punjab, though interesting was of no value when the elevator system as a whole was being considered. The railway at present would only accept grain for transport in bags, hence passing the grain through an elevator before handing it over to the railway in bags was of little or no interest, from the author's point of view. It must not, however, be thought that the author considered the non-transport aspect of the question of no importance. On the contrary it is of the highest importance.

Major Byers had demonstrated how he had been able to effect large savings by adopting the mechanical handling of grain, and his practical experience was enough to stifle any doubts as to the financial results of adopting the system.

The author decided to confine himself to the transport view of the case in his Paper since that in itself was such a large question. If it was granted that the establishment of the granary system was necessary for the railway, then the other function of the system, *viz.*, cleaning, &c., followed as a corollary. Several speakers felt a doubt as to the position of the cultivator, the

export agent, and the state which owned the railway, under the granary system, and feared that the cultivator would fare badly. In the author's opinion the cultivator did not come into the question. The agents of the export firms would deal directly with the cultivator and buy his grain exactly as at present. It was only on the arrival of the grain at the railway station that there was a difference. At present the grain bags lay about the place until they could be loaded into wagons and it was not therefore such a revolutionary proceeding, as some critics thought, for the railway to provide adequate storage. It was on the contrary the natural consequence of the offer of a large quantity of goods for consignment, and it was by carrying out this principle to its logical conclusion that the need for the grain elevator arose. The existence of a number of different grades of wheat certainly constituted a difficulty, but the author had been told that these could be reduced to four, thus necessitating only four groups of bins in each elevator ; grading, cleaning and weighing would all be performed automatically, thus reducing the human element as far as possible. The issue of a receipt for grain deposited in an elevator was a source of difficulty to Mr. Mitchell. In the author's opinion this should in India be no other than a railway receipt to Keamari. Any small intermediate traffic could easily be dealt with in bags. Since one maund of a particular grade of wheat put into an elevator was exactly equivalent to another maund of the same grade wheat at Keamari, the holder of the railway receipt could draw out of the Keamari elevator the quantity shown thereon. The railway receipt therefore became a guarantee on the part of the railway to produce so many maunds of grain on demand. It would only be another step to make the railway receipt a negotiable instrument which could be passed through a bank and on which it would give advances. This brief sketch would perhaps satisfy Mr. Mitchell as to the author's meaning. There was of course no question of the state becoming a dealer in wheat—that was of course impossible. The same speaker was also doubtful as to whether the type of elevator at the London Docks was suitable for India and for loading grain into trucks. The author could assure him that appliances existed and were seen by him in London for loading and unloading both ships and trucks. There was no engineering difficulty involved either in the construction of the elevators or in determining a type suitable for India. Various other points raised by speakers which have not been dealt with above would now be answered. In reply to

Captain Anderson bulk grain ships from South America passed through as bad weather as is experienced in the S.-W. Monsoon without harm. Mr. Ashford's suggestion for damping a layer of grain in the base of each bin was impracticable and unnecessary owing to the turning over of each bin every few days which dried the grain and got rid of weevils without further trouble. The author was in complete agreement with Mr. Montgomery since the elevator at Lyallpur would be of little use in assisting transport until both railway and ship consented to accept wheat in bulk. No doubt however invaluable experience would have been gained in its construction and working. Messrs. Mitchell and Hamilton both held somewhat pessimistic views of the financial results of elevator working. Major Byer's experiences however were a more effective reply than any the author could make. If they would further contemplate the reduction in railway freight, and terminal charges, reduction in handling at port of loading and unloading, saving in bags, higher price due to clean and correctly graded grain, and absence of theft of bags during transport, they would, the author hoped, cease to think that the loss on the present inefficient transport system was compensated for (according to Mr. Mitchell) by the slightly higher price commanded by that portion of the Indian export wheat which reached England in time to come on the market between the other great harvests of the world. The author would refer Mr. Dhody to his remarks about the cultivator not coming into the system at all. The agent would make his terms with the cultivator and if, as the author believed, the cost of transport became considerably less as the result of the adoption of the granary system, the cultivator could force up the price at which he sold to a corresponding degree. It should also be remembered that any advantage to the railway by enabling it to lower its rates or to keep them down was an advantage to everyone. If, on the other hand, in the absence of the granary system the railway was obliged to embark on only partially productive capital expenditure it must inevitably raise its rates. The author regretted that he was unable to give a comparative statement of the cost of establishing a granary system on the one hand and of necessary railway improvements on the other. Both would be immense, and the question was too big to be dealt with in the scope of the present paper. The author, however, believed the former to be much less than the latter. A proper estimate could, however only be worked out as the result of several months detailed and laborious investigation.

THE CHAIRMAN in moving a vote of thanks to Mr. Bayley said he thought the author had answered most of the points raised by the different speakers. Mr. Hamilton mentioned the high cost of construction of the elevator which was going to be put up at Lyallpur, but this was largely due to the nature of the soil which necessitated expensive reinforced concrete foundations. The walls were to be of brickwork reinforced with H. B. bonding and the elevator was more or less in the nature of an experiment. The next elevator would probably be a good deal cheaper.

Regarding the sacks, Mr. Bayley had mentioned in his paper that, on arrival in London, the bags were slashed open while still in the steamer's hold in order to enable the appliances at the Port of London for dealing with bulk grain to get at the contents. The Chairman had mentioned this point sometime ago to the agent of Messrs. Simons & Co., and the latter had replied that they did not slash open the bags, but merely cut the strings which tied the mouths of the sacks; certainly from what he had seen at Birkenhead the Chairman was under the impression that the bags were cut as described by Mr. Bayley. There was another point which struck one not in the trade as being very extraordinary. It was the one Mr. Bayley mentioned about the mixture of earth with grain. It certainly appeared a curious custom to mix up earth with the grain in order to make sure of getting the full weight of dirt allowed. Colonel Maclagan added that he had been informed (though he could not vouch for the truth of the statement) that a special class of earth was imported for the purpose.

NOTE.

Subsequent enquiries made by Captain Anderson from a Liverpool Shipowner elicited the information that monsoon conditions between Karachi and Aden are considered no worse than those experienced in the Atlantic. There are stringent laws about shifting boards, and the proportion of bagged wheat to wheat in bulk, applying to all ports under British rule.

Canadian and Black Sea wheat is imported entirely in bulk ; Australian and Indian grain, as well as wheat from most of the American Pacific ports, is carried in bags. The Argentine grain is mainly shipped in bulk, but 15 per cent. of the total is in bag, in order to comply with the Merchant Shipping Act,

About half the maize from the Argentine came in sacks for condition purposes.

Karachi wheat is very dusty, and importers feared to ship it in bulk owing to the danger of its becoming heated on the passage. Further, owing to its dusty nature, some difficulty might be experienced at the discharging ports in getting men to handle it.