BULK HANDLING OF WHEAT ON THE FARM. *

by

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Bulk handling of cereal grains on the farm has been common practice in North America for some time, but it is only in recent years that Australian wheat farmers and machinery manufacturers have shown any considerable interest in this problem. The initiative in designing equipment suitable for Australian conditions has been taken mainly by a number of enterprising farmers and small machinery manufacturers situated in wheat-growing districts. Consequently, attention has been centred on converting the conventional header for bulk use, rather than on producing a new type of header fitted for bulk handling[1].

Bulk handling of wheat on the farm has been made possible by the use of the spiral grain elevator, or grain auger, which by virtue of its lightness, manoeuvrability and high speed of work, is well adapted for use in conjunction with harvesting equipment. It enables grain to be transferred quickly from the harvesting plant into trucks for transport to the rail or farm storage, or into temporary storage facilities erected in the paddock.

The principal advantage of bulk handling at the present time is the saving of the cost of bags. However, since bags provide a very convenient form of temporary storage between the harvesting and carting operations their elimination means that those two activities

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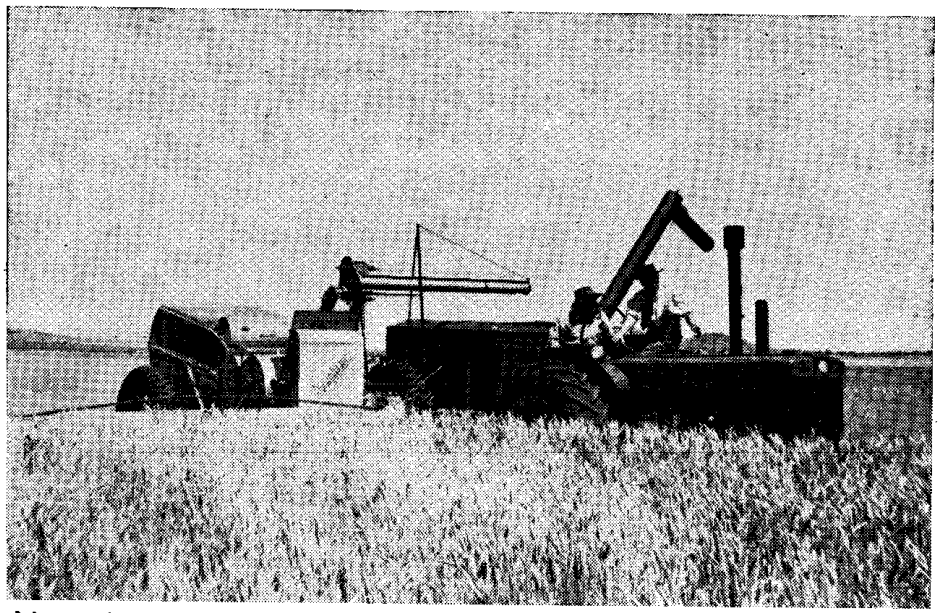
[1] However, a self-propelled header of American design and British manufacture suitable for bulk or bag handling has recently been placed on the Australian market. As might be expected it is considerably more expensive than orthodox headers of local manufacture.

must be much more closely synchronized when wheat is handled in bulk. This is the central problem of bulk handling and the solution at present offered by Australian manufacturers consists in using several pieces of equipment designed to (*a*) increase the grain storage capacity of the harvesting outfit, and (*b*) provide temporary or permanent storage facilities for wheat on the farm.

To enlarge the storage capacity of the header, the grain box or bagging platform is removed, and replaced by a bulk hopper (capacity 70-140 bushels) which is either cradled between an outer wheel and the header frame, or mounted independently on two or three wheels and towed alongside the header. Wheat is carried from the top of the header elevators into the hopper either by means of a short cross-auger, or by gravity. Since it is only in exceptional circumstances that a truck servicing a header has time to carry its load to the railway and return to the paddock before a new trailer-load of wheat has been stripped, bulk wheat storage facilities on the farm are usually necessary. There is room for considerable variation in the capacity and quality of storage installations, depending on the circumstances of the individual farm (*e.g.*, its distance from the rail, the adequacy of the railway receiving facilities, the existence of special selling arrangements, etc.). Existing sheds may be modified for this purpose, or new sheds built, or alternatively galvanized iron or concrete grain silos may be erected. Field bins, marketed in capacities of up to 550 bushels, and mounted on skids so that they may be towed from place to place, provide a convenient form of temporary storage in the paddock.



A harvesting plant converted for bulk handling by the addition of a 120-bushel header trailer fitted with an emptying auger. A cross auger carries wheat from the header to the trailer.

Bulk handling is an innovation in which the services of machinery are substituted for those of labour and bags. In order to assess the likely profitability of bulk handling as compared with bag handling, the farmer should compare the expected future savings in labour and materials during the life of the equipment with the estimated costs of installing, maintaining and running it. These costs consist of the

equipment's purchase price amortised over the period of its expected life, interest on the non-depreciated portion of the original debt, maintenance costs and running expenses. Of the information necessary to make this type of calculation, the only items known with certainty are the present purchase price of the equipment and the current interest rate on overdrafts and loans. It is not known how long the equipment will last, nor what maintenance and running costs will amount to. Although it may be possible to estimate with a fair degree of accuracy the savings in labour and bags *in physical terms,* the future prices of these factors are unknown. Consequently it is probable that few, if any, farmers have made a detailed estimate of likely costs and savings before investing in bulk handling equipment. Most have probably assessed its advantages and disadvantages with reference to a much shorter time period than the expected life of the machinery. Circumstances favouring bulk handling in recent years have been the high price of bags and the uncertainty of their supply, the scarcity, costliness and poor quality of casual harvest labour, buoyant farm incomes, high rates of taxation, and the constant appreciation of the money value of real assets due to inflationary conditions. Other subsidiary but nevertheless important factors influencing farmers in favour of bulk handling are the mechanical aptitude and love of machinery characteristic of many younger farmers, a widespread belief that greater mechanization is inevitable and "progressive," and the prestige associated with being a pioneer of new methods.

In this article it is proposed to describe the various types of bulk handling machinery being marketed at present; to make some suggestions concerning the efficient employment of this equipment; to describe a system of bulk handling which, it is hoped, may prove acceptable to many wheat farmers; and to compare the costs, at current factor prices, of bag handling with the costs of bulk handling by means of the suggested system.

I. BULK HANDLING EQUIPMENT.

In the following paragraphs, the various types of bulk handling equipment being marketed will be described. All prices quoted are on an f.o.b. basis at the place of manufacture. Since in many cases this is Victoria, the prices (including freight) paid by farmers in New South Wales will be considerably higher.

Header Trailers and Hoppers.

Bulk attachments to headers may be classified, according to their method of mounting, as either bulk hoppers or header trailers. The former are suspended between the header framework (to which they are attached by a hinged mounting) and an outer wheel, or double wheel. This method of attachment is similar to that used for bagging platforms. Header trailers, on the other hand, are mounted on a trailer undercarriage and towed alongside the header. So far as is known, only one type of bulk hopper is being marketed in New South Wales at present. However, several farmers who have designed their own equipment have favoured the bulk hopper type.

The most common type of header trailer consists of a self-emptying bulk body mounted on two wheels. A shaft, offset and braced, projects from the front of the trailer for attachment to either the header framework or the tractor. This shaft is rigidly attached to the trailer in

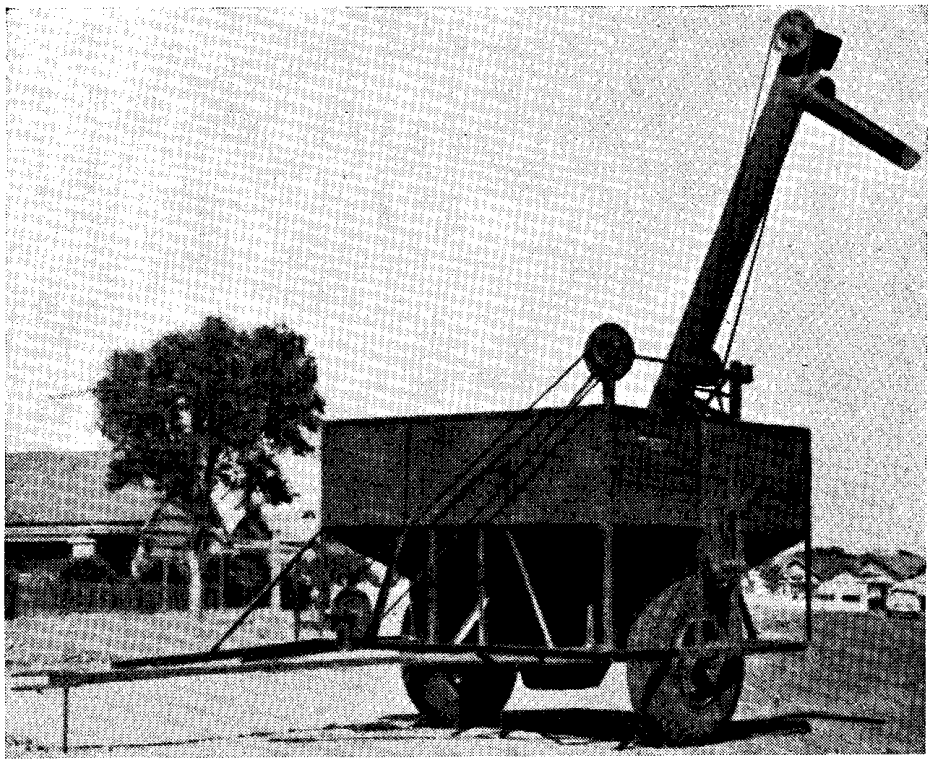
Two home-made bulk harvesting outfits. In each case a bulk hopper, fitted with an emptying auger, has been attached to the side of the header. Both augers are driven from the tractor power-take-off.

Photo by courtesy of "The Northern Daily Leader," Tamworth.]

order to keep it upright. Provided that the trailer's wheels are in line with the header's, this single-point hitch in front is all that is required for the trailer to follow the header faithfully. Since trailers are unsprung and when fully loaded carry between 2.5 and 3.75 tons of wheat, their axles, wheel mountings and towing shafts are subject to considerable stresses when towed over bumpy ground. Robust construction of these parts is essential, but some of the earlier machines were deficient in this respect, and breakages have occurred. Hitching the trailer to the header framework has sometimes resulted in bending of the latter, so that direct attachment to the tractor would appear to be the more satisfactory arrangement.

Another type of header trailer has two wheels mounted towards the rear, and a single wheel in front. The front wheel is castored so that the trailer will track with the header. This arrangement allows the towing shaft to be pivoted at the point of attachment to the trailer, and consequently less stress is transmitted to it, and via it, to the header framework.

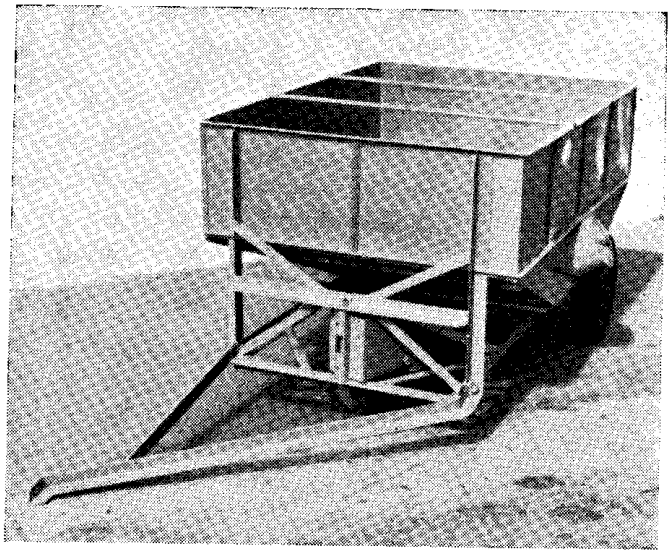
To convey the grain to the bulk trailer some form of attachment is necessary on the elevator of the header. If the elevator is high enough, the grain may simply be gravitated into the trailer by means of a chute, but frequently a short auger projecting horizontally, or slightly upwards, is necessary. These cross augers cost between £30 and £40.



This header trailer has a capacity of 140 bushels, and is equipped with a 9-inch extracting auger, which is intended to be driven from the tractor power-take-off.

An auger is used to transfer grain from the hopper or trailer to the bulk truck or field bin. The auger may be fixed to the trailer or a portable auger may be used. Where a fixed auger installation is used, the floor of the bin slopes to a bottom central point, where the auger mouth is located. The auger tube is usually 12 feet long, and projecting upwards and outwards, gives adequate clearance for a bulk truck to drive underneath the outlet in order to receive the wheat. Where the trailer is used in conjunction with a large capacity field bin, a longer (14 feet) auger may be necessary to clear the side of the bin. The auger may be driven by an auxiliary motor mounted on the trailer, or from the tractor power-take-off. Driving it from the tractor enables the auger to be engaged more quickly and, if necessary, while on the move, since it dispenses with the necessity of starting the engine. A disadvantage of this method is that it involves running the header while

stationary, which causes unnecessary wear and makes greasing and servicing difficult during the halt period. However, it should not be beyond the ingenuity of manufacturers to devise some type of clutch which would enable the header mechanism to be disengaged while the auger was being operated.



A 90-bushel header trailer mounted on three wheels. This trailer is emptied by means of a portable auger, which is inserted through a chute in the side.

Photo by courtesy of "The Northern Daily Leader," Tamworth.

A suitably equipped auger may be driven from the tractor by means of an hydraulic pump and transmission. This equipment obviates the need for exterior drive shafts, pulleys and sprockets, but is expensive.

Where an auxiliary engine is used, it should be connected to the auger through a clutch so that it can be started without a load. Some trailers have been supplied with the engine connected directly to the auger by a belt. Finding this arrangement unsatisfactory, some farmers have improvised a clutch by hinging the engine mounting so that the belt can be loosened for starting.

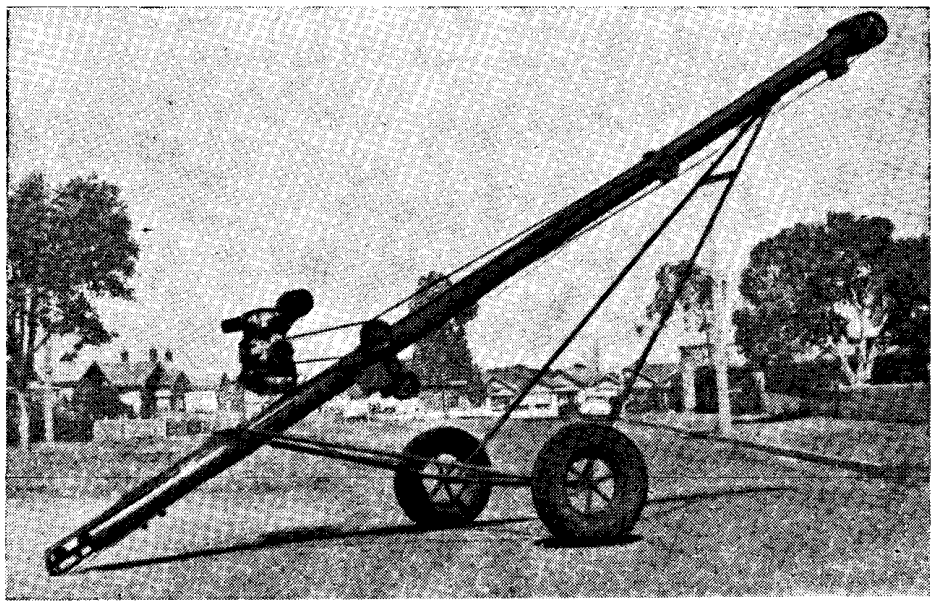
Trailers designed for use in conjunction with portable augers are of several types. In some makes, the grain is extracted by inserting an auger into the trailer through a cylindrical auger chute; in others, the grain is allowed to gravitate through a trap-door into a receptacle in which the auger mouth is placed; another type of trailer has a flat floor and a tipping body, tipping being effected by means of a hand winch.

Header trailers with emptying augers fitted are available in 120 and 140-bushel capacities. When fitted with auxiliary motors (or hydraulic power transmission) their prices range from £503 to £850. A 140-bushel trailer without a motor is available for £431, but the farmer has to devise his own connection from the auger to the tractor power-take-off shaft. A 70-bushel bulk hopper with auger fitted is being marketed for approximately £220.

Trailers without augers are being marketed in capacities of 90, 110 and 140 bushels. Prices range from £225 to £342.

Grain Augers and Blowers.

Grain augers are being manufactured in six, seven and nine-inch diameters. Lengths vary from eight to thirty-six feet. Nine-inch diameter augers over sixteen feet in length are not recommended since they require more power than can be supplied by the light industrial engines normally used. Their elevating capacities range from fifteen to thirty-six bushels per minute, depending on the diameter of the auger, its angle of elevation, and the number of revolutions of the spiral per minute (which in turn depends on the horse-power of the engine



A portable auger. The angle of elevation can be adjusted by moving the top arm of the transporting frame up or down the tube, for which purpose a winch is fitted. The particular machine illustrated is 21 feet long ; the diameter of the tube is 7 inches.

driving the auger). They can be supplied "bare", or with engine and transmission for fixed installation, or as portable units complete with engine, transmission, transporting frame, two rubber-tyred wheels, winch for adjusting elevation and towing bar. Portable augers are available in lengths from ten to thirty-two feet. There is considerable variation in the prices of different makes of auger, which is only partly a reflection of quality differences. The following list shows the approximate price range for portable augers of several lengths:—

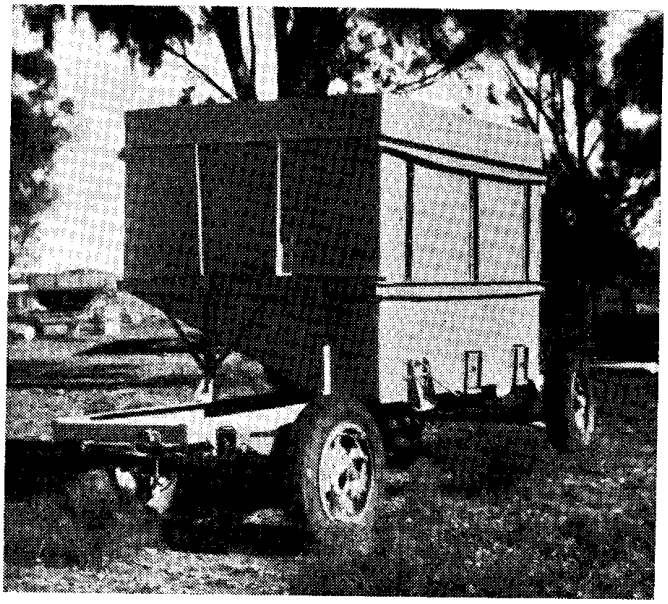
Length.	*Price Range.*
14 feet	£250–300
19 „	230–340
20 „	250–350
24 „	280–380
27 „	290–390

Blowers are non-portable and consequently are used mainly as fixed installations at farm silos or bulk heads. The blower consists simply of a fan which impels a stream of air at a high velocity through a large diameter pipe which leads to the silo or grain shed filling inlet. Wheat is fed into the airstream, not into the blower where the blades of the fan would shatter it. The blower is less efficient than the auger since

although it requires a greater horse-power, its elevating capacity (four to eight bushels per minute) is much smaller. However, it is cheaper and due to its simple construction can be expected to have lower maintenance costs and a longer life. Typical prices for blowers are from £112 to £170, depending on size. Six-feet lengths of piping cost between £6 and £8.

Field Bins.

Field bins to provide temporary storage for grain in the paddock are being manufactured in various capacities. They are usually fitted with skids so that they can be moved about the paddock, and from



This mobile field bin mounted on an old truck chassis has a capacity of approximately 60 bags.

paddock to paddock, and may be of the self-emptying or tipping type. Bins may be fitted with a fixed emptying auger and engine, or a portable auger may be used. A 400-bushel bin is being marketed for £225, and one of 550 bushels capacity for £280; if fitted with an extracting auger and engine, the latter bin costs £495. Since bins are of relatively simple construction and are bulky, it would pay farmers located far from the centres of manufacture to investigate the possibility of having a bin made to order locally, thus saving freight charges.

Truck Bulk Bodies.

Motor trucks may be equipped with four types of bulk wheat body:—

(*a*) Self-emptying bodies which rest on the table-top of the truck. These have an inverted "V" shaped floor which causes the wheat to gravitate to the sides, where trap-doors are located.

(*b*) Self-emptying bodies which are fitted to the chassis of the truck after the table-top has been removed. The floor is "V" shaped, discharging the wheat along the centre-line between the main chassis members.

(*c*) Flat-floored bodies suitable for tipping trucks.

(*d*) Flat-floored bodies which rest on the table-top and incorporate their own tipping device which is operated by means of a hand winch.

The first three types of body are being manufactured to individual orders by a number of small engineering works located in country towns. Prices vary somewhat, but typical quotations for the self-emptying type of body are £150 for a 12 ft. and £175 for a 14 ft. body. The capacities of the 12 ft. and 14 ft. bodies are 235 and 270 bushels respectively, when fitted to the table top, or 250 and 300 bushels respectively, when fitted to the chassis.

A firm intends to manufacture the fourth type of body in prefabricated sections, 6 ft., 7 ft. and 8 ft. long. Each section will have its tipping mechanism, and one or more sections will be fitted to each truck. The cost of equipping a 12 ft. tray with these bodies will be £490, and a 14 ft. tray £580. Capacities are 280 and 330 bushels respectively.

Grain Silos.

Grain silos may be constructed from concrete, galvanized iron, steel, or pisè[2]. Several makes of prefabricated iron and steel silos are being marketed, in the following sizes:—1,100; 1,680; 2,000; 2,900; 3,000; 3,500; 4,500 bushels. The prices of these silos are £178, £299, £198, £320, £249, £272, £321, respectively. Price variations between the several brands are associated with quality differences. Also available are ready-made tank-type silos in 750 and 900 bushel capacities, priced at £162, and £195 respectively.

In order to ascertain the total cost to the farmer of a grain silo, freight and erection costs must be added to the factory price of the prefabricated article. In the case of a 2,000 bushel silo mounted on a flat concrete floor it is estimated that these costs would amount to at least £100.

2. CHOICE OF EQUIPMENT.

Various systems of bulk handling and storage are possible, using different combinations of the equipment described above. Some of the more important factors which a farmer should consider when deciding which system to adopt, are as follows:—

(1) Areas of cereals intended to be sown; number of varieties likely to be used; whether premium quality wheats are, or can be grown; average yields and their reliability.

(2) Risk of rain during the harvesting period.

(3) Topography and lay-out of the farm—degree of slope, size and location of cropping paddocks, suitable sites for storage installations.

(4) Distance of farm from railhead(s).

(5) Capacity of railway receiving installations; facilities for receiving bulk wheat; likely rates of turn-around of trucks delivering to railways.

[2] See *The Agricultural Gazette of New South Wales*, Vol. LXIII, Part 5. (May, 1952), pp. 229-231.

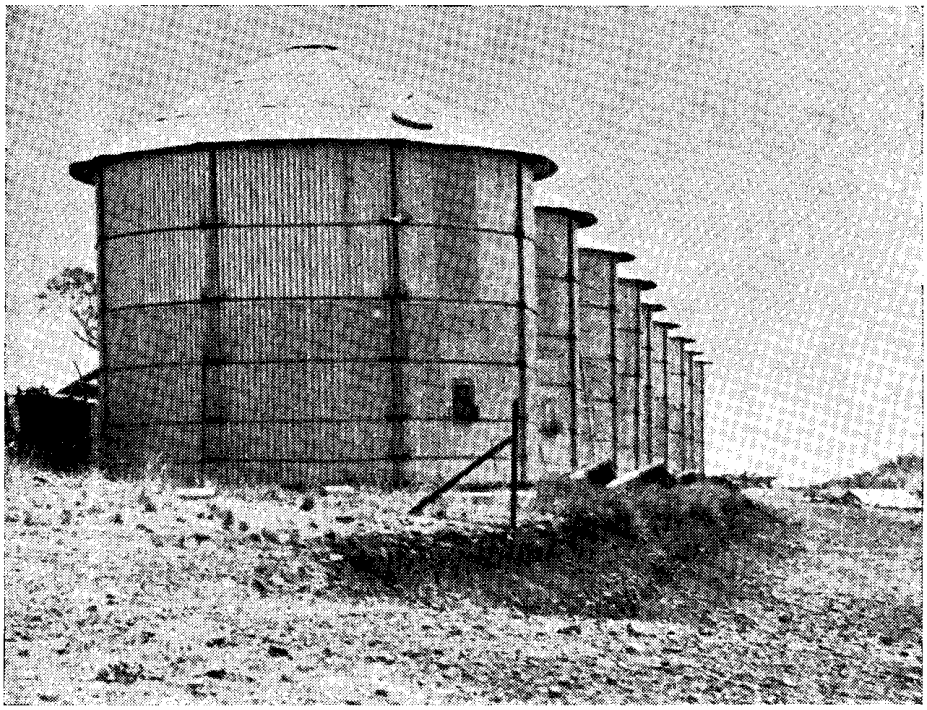
(6) Existing harvesting plant, motor trucks, trailers, grain sheds, silos; their estimated future usefulness and suitability for use in conjunction with bulk handling equipment.

(7) Permanently employed farm labour force.

(8) Resale value of stocks of bags and/or of other equipment rendered obsolete by bulk handling.

(9) Whether local carriers are willing and able to cart wheat in bulk.

These factors vary so much from farm to farm that it is not possible to recommend any *one* combination of equipment as the most efficient. However, after the general requirements of a bulk handling plant for a particular farm have been decided, there is considerable scope for careful planning in choosing the various items of equipment, and here it is possible to make some specific recommendations. Some of the points to be made below may appear so obvious as to be hardly worth committing to print. Yet it is surprising how many farmers have made mistakes in assembling their plants which could have been avoided by the exercise of a little more foresight.



Advantage has been taken of a hillside site in the erection of this battery of grain silos.

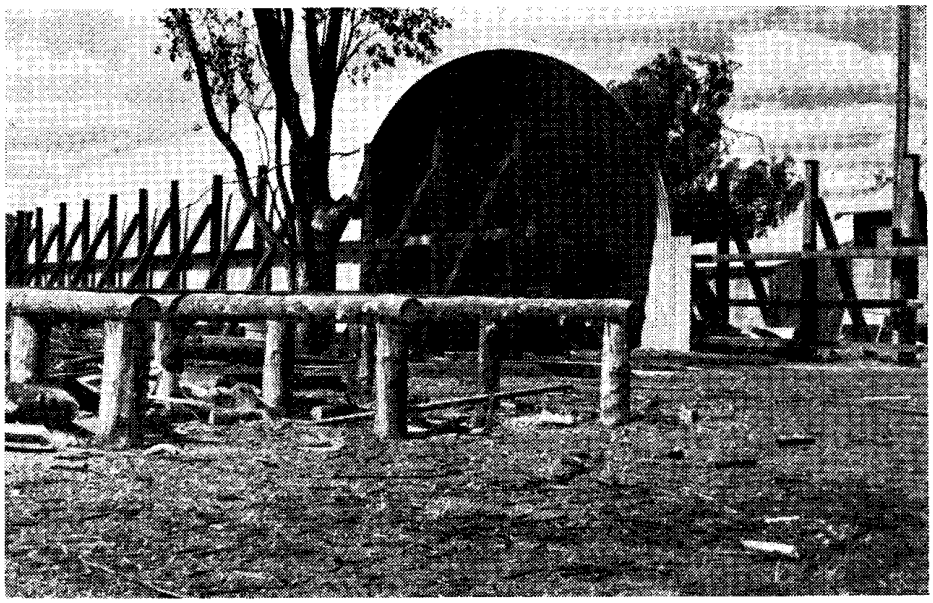
1. Unless it is intended to store grain all the year round for use as fodder, or to hold grain for later sale by special arrangement, it seems wasteful to construct elaborate storage facilities if an existing structure (*e.g.*, a machinery shed) could be modified to provide temporary storage space.

2. Various pieces of equipment should be "matched" to each other as much as possible. For example, bulk bodies suitable for 3-5 ton trucks are usually from twice to three times the capacity of header trailers. It

is an advantage to choose a bulk body the capacity of which is an exact multiple of the capacity of the header trailer, *e.g.*, a 270-bushel body used in conjunction with a 90-bushel trailer. Similarly, field bins should be matched to bulk bodies and trailers.

3. Another consequence of the fact that it requires two or three trailer or hopper loads of wheat to fill a bulk truck is the desirability of some form of temporary bulk storage in the paddock, *e.g.*, a field bin, into which wheat can be discharged from the header. This eliminates the need for the truck to be in attendance every time a trailer load of wheat is stripped. However, the use of a field bin has the disadvantage that, as stripping proceeds, the harvesting plant moves further away from the bin, and time is lost travelling to and fro.

4. Since augers are expensive, the saving effected by using one portable auger to do the work of several fixed ones probably offsets the loss of efficiency that results from having to transport it from place to place and manoeuvre it into position.



A shed in which it is intended to store bulk wheat in course of construction.

5. Standardization of fittings for the various pieces of equipment should result in worthwhile economies and minimize delays due to breakdowns. For example, worn truck tyres can be fitted to header trailers and portable augers if their wheel sizes are the same.

6. Bagging outlets on header trailers, field bins, bulk trucks and silos are likely to prove useful in emergencies, such as a breakdown of the elevating equipment, the exhaustion of bulk storage capacity (either on the farm or at the railhead) or the refusal of the authorities to receive wheat in bulk due to its poor quality.

7. Where silos or grain sheds are to be erected, advantage should be taken of any available hillside sites, so that filling and emptying may be assisted by gravity.

8. Two or more small grain silos are more useful than one large one—and a multi-compartment grain shed more useful than a single compartment one—since they enable poor quality wheat to be stored separately, and facilitate the turning of stored grain, should this become necessary.

3. BULK HANDLING AND BAG HANDLING COMPARED.

Despite the many elements of uncertainty associated with any estimate of the profitability of bulk handling, such a calculation has been attempted. Its purpose is to determine the output of wheat at which the overhead costs of bulk handling are offset by savings in running costs, *i.e.*, the output above which bulk handling becomes profitable.

The system of bulk handling chosen for comparison with bag handling is not identical with any that have so far been employed in New South Wales. It embodies some of the suggestions made earlier in this article and is designed to combine low initial cost with reasonable efficiency. The circumstances in which it would be possible to use this system are defined below; it is thought that these conditions prevail on many New South Wales farms.

1. Only one header is used for harvesting.

2. A farm truck is available to which a 250-300-bushel bulk body could be fitted.

3. The farm is sufficiently close to the railhead, and the receiving facilities there are adequate to allow the full day's harvest to be delivered by this truck the day it is stripped.

4. There is a machinery or other shed on the farm which could be modified, at little expense, for the purpose of storing bulk wheat. Wheat stripped at week-ends or other times when the silos were not open to receive it could be stored in it and delivered after the harvest was completed.

All the equipment necessary to undertake bulk handling in these circumstances would be (*a*) a header trailer (without fixed auger), (*b*) a portable auger, (*c*) a field bin, and (*d*) a bulk truck body. The auger and field bin would be towed into the paddock where stripping was to commence. As each trailer-load of wheat was harvested, it would be emptied by means of the auger into either the field bin or the bulk truck. Since the capacity of the bin would be four or five times that of the header trailer, and approximately twice that of the truck, this arrangement allows considerable flexibility in the harvesting and carting operations. Delays might occur at week-ends since the auger might have to be towed backwards and forwards between paddock and shed with each delivery made by the truck.

The cost and efficiency of the suggested plant will vary with the capacity of its various components. For the purpose of the profitability calculation which follows, two combinations of plant are considered. In both a 270-bushel bulk truck body and 14 ft. portable auger are used, in combination with either (*a*) a 90-bushel header trailer and 400-bushel field bin, or (*b*) a 140-bushel trailer and 550-bushel bin.

Costs Associated with Bulk Handling.

I. *Overhead Costs.*

The annual overhead costs of a bulk-handling plant consists of depreciation and interest charges. These depend on (i) its purchase price, (ii) the rate of interest, and (iii) the "life" of the plant.

(i) Current prices of the various items comprising each of the two suggested plants are set out below. Estimated freight costs have been added to the prices of augers and trailers, but not to prices of bulk bodies and field bins, since it is assumed that the latter can be made locally for the same price that regular manufacturers are charging. The item "modifications to shed" is an estimate only.

Item.	Cost. £
Plant No. 1—	
90-bus. Header Trailer ...	225
Freight[3]	10
400-bus. Field Bin ...	225
270-bus. Bulk Body ...	175
14ft. Portable Auger ...	250
Freight ...	20
Modifications to Shed ...	100
Total	1,005
Plant No. 2—	
140-bus. Bulk Trailer ...	280
Freight[3]	40
Cross Auger (to be fitted to header) ...	40
550-bus. Field Bin ...	280
270-bus. Bulk Body ...	175
14f t. Portable Auger ...	250
Freight	20
Modifications to Shed ...	100
Total	1,185

For ease of calculation, the first plant is considered to cost £1,000, and the second £1,200.

(ii) The current rate of interest on overdrafts is five per cent.

(iii) No empirical evidence is available concerning the life of the equipment under consideration. For income tax purposes this type of plant is assumed to have a life of ten years. This assumption is maintained here since it almost certainly doesn't over-estimate, and probably under-estimates, the equipment's life, and a conservative estimate is more appropriate than a optimistic one. However, as a matter of interest, costs based on a life-span of fifteen years have also been calculated; it is left to the reader to decide which of these assumptions he considers the most realistic.

[3] The difference in estimated freight charges is due to the fact that the first trailer is manufactured in N.S.W., the second in Victoria.

The average annual interest and depreciation costs which result from amortising the purchase price of each plant over ten and fifteen year periods are set out in Table I.

TABLE I.

Average Annual Overhead Costs of Bulk Handling.

Estimated Life of Plant.	Type of Plant.	Overhead Costs.		
		Depreciation.	Interest.	Total.
		£	£	£
10 years	1	100	28	128
,, ...	2	120	33	153
15 years	1	67	27	94
,, ...	2	80	32	112

2. *Maintenance Costs.*

These have been arbitrarily estimated at 0.5 pence per bushel harvested.

3. *Running Costs.*

The extra fuel, oil, etc., used by a bulk-handling plant would be small compared with the total quantity used during the harvest, and its cost has been disregarded here.

Savings in Running Expenses Effected by Bulk Handling.

1. *Cost of Bags.*

The Wheat Cost of Production Committee's 1947 survey analysed the operations of 538 wheat farms throughout Australia and assessed the average distribution of gross costs between various items. Cornsacks were found to cost, on the average, 1.5d. per bushel, *i.e.*, 4.5d. per three-bushel bag. Since the price of cornsacks (including distributors' margin) at the time of the survey was 28s. 1½d. per dozen, or approximately 2s. 4d. each; the cost allowed indicates that each sack is used, on the average, approximately six times. Estimates given by farmers tend to confirm this figure, and it is accepted as a basis for the calculation which follows.

The price of cornsacks last season was over 70s. per dozen, or approximately 6s. 0d. each. Bags used for conveying wheat to the silo are usually not filled to capacity; farmers have estimated that they contain, on the average, $2\frac{5}{8}$ bushels. If each bag is used six times before being replaced, it serves to transport $15\frac{3}{4}$ bushels. At last year's prices, then, the average cost of bags per bushel of wheat delivered was approximately 4.6d.

2. *Labour Costs.*

There is some difficulty in assessing, on a per bushel basis, the labour costs of bag and bulk handling, for these, unlike the cost of bags, depend not merely on the quantity of wheat harvested, but also on the yield per acre, the condition of the crop, the type of plant used, the distance

from the farm to the railhead, and other similar factors. In order to reduce the problem to manageable proportions, various simplifying assumptions have been introduced.

First, it is assumed that in all cases the crop is grown on level ground, is well standing and that harvesting conditions are good. Second, the harvesting plant used is assumed to be an efficient, modern one, consisting of a 12 ft. header, mounted on pneumatic tyres, drawn by a "large" tractor [4]. The header is power driven from the tractor, and a hydraulic comb-lift enables the tractor driver to operate the header as well.

The procedure adopted has been to estimate the quantity and area of wheat stripped per day under varying yield conditions, using different types of equipment. Low, medium and high-yielding crops have been considered, and twelve, twenty-four and thirty-six bushel crops chosen as representative of these yield classes. Separate estimates have been made for each of the following types of equipment:—

(*a*) A 30-bushel grain box,
(*b*) a bagging platform (tipping type),
(*c*) a 90-bushel header trailer, and
(*d*) a 140-bushel header trailer.

Detailed estimates have been made of the number of men employed, and on what tasks, for each combination of yield and equipment, and of the speed of work of both men and machines. These estimates are set out in the Appendix.

By comparing the quantity of wheat stripped per day[5] with the number of men employed, and valuing their services at last season's wage rate—which was, typically, £3 per day—the per bushel labour costs of harvesting and carting have been assessed for each combination of yield and equipment. These costs are given in Table II.

TABLE II.

Labour Costs of Harvesting and Carting Wheat. *

(Pence per bushel).

Type of Equipment.	Type of Yield.		
	Low 12 bushels.	Medium 24 bushels.	High 36 bushels.
30-bushel Grain Box	2.886	2.667	2.667
Bagging Platform	2.734	2.130	2.037
90-bushel Header Trailer	2.610	1.643	1.582
140-bushel Header Trailer	2.215	1.424	1.379

* Assessed at least season's wage rate.

A study of this table leads to the following conclusions:—

(1) Over the range of yield considered, the platform provides a more efficient method of harvesting than the grain box. For the purpose of comparing bag with bulk handling, it is therefore appropriate to drop the grain box from consideration.

[4] *i.e.*, a tractor of over 28 rated drawbar horse-power.
[5] Shown in Table IIA in the Appendix.

(2) The labour costs of handling in bulk are less than the labour costs of bag handling in all cases. The savings in labour costs which result from the use of each type of bulk handling equipment in place of the bagging platform are set out, for each yield class, in Table III.

TABLE III.

Savings in Labour Costs Effected by Bulk Handling.
(Pence per bushel).

Type of Equipment.	Type of Yield.		
	Low.	Medium.	High.
90-bushel Header Trailer	0.124	0.487	0.455
140-bushel Header Trailer	0.519	0.706	0.658

In order to assess the average annual savings in bag and labour costs brought about by bulk handling, a certain distribution of yields during the life of the plant has to be assumed. The assumption is made that, excluding crop failures, low, medium and high-yielding crops occur in the proportion of 7:2:1. On this assumption, the average yield, excluding failures, is 16.8 bushels per acre and the average saving in labour costs is 0.299d. per bushel [6], when the small bulk handling plant is used, and 0.602d. per bushel [6] when the larger is used. By adding the per bushel cost of bags (4.6d.) to these savings in labour costs, and subtracting maintenance costs (0.5d. per bushel), the average net savings in running expenses are found to be 4.399d. and 4.702d. per bushel in the two cases.

The annual acreages at which the total savings in running costs equal the fixed overhead costs (given in Table I) have been calculated. These have been called "critical" acreages since they represent the areas below which bag handling is profitable, and above which bulk handling is profitable, for each combination of plant and depreciation rate. They are shown in Table IV.

TABLE IV.

Estimated Critical Annual Wheat Acreage, for the Suggested Bulk Handling System.

Estimated Life of Plant.	Type of Plant.	
	90-bus. Header Trailer, etc.	140-bus. Header Trailer, etc.
10 years	416	465
15 years	306	340

[6] These figures represent a weighted average of the per bushel savings calculated separately for low, medium and high-yielding crops (given in Table III). Weights have been assigned in the proportion that each type of crop contributes to the total *quantity* of wheat stripped over a ten-year period.

In addition, the average annual profit which would result from employing each type of bulk handling plant instead of bag handling, has been calculated for several annual wheat acreages.

TABLE V.

Average Profitability (in £s. per annum) of Bulk Handling, Compared with Bag Handling, for Various Wheat Acreages.

Estimated Life of Plant.	Type of Plant.	Area Harvested Per Annum (acres).		
		250	500	750
		£	£	£
10 years	1	—51	26	103
,, ...	2	—71	12	94
15 years	1	—17	60	137
,, ...	2	—30	53	135

Any forecast of the likely future profitability of bulk handling would have to take into account probable changes in bag prices and wage rates. Since the critical acreages and profit estimates given in Tables IV and V are based on last season's prices only, they are not to be interpreted as predictions. They should be regarded, rather, as a tentative effort to provide a basis for making such predictions. But so many elements of uncertainty entered into their calculation that their usefulness for this purpose is very limited: they apply, literally, only in the case of a farm where all the assumed conditions are fulfilled, *if* the future distribution of yields and the life of the plant are as conjectured [7]. Nevertheless, they will be useful to the extent to which actual conditions approximate to those assumed. The reader, if he is a farmer, will be better able than the author to assess the reasonableness of these assumptions, and it is left to him to draw his own conclusions regarding the value of the results obtained. Parts of the analysis are, however, sufficiently empirical for the following conclusion to be drawn with a fair degree of confidence.

At current prices, the principal saving affected by bulk handling is in the cost of bags. The suggested system of bulk handling would not bring about very appreciable savings in labour costs, but the use of other more elaborate systems—such as have been installed on a number of farms in this State—would result in greater savings in this direction. Recent reductions, overseas, in the price of jute have not yet influenced

[7] The assumptions made concerning the life of the equipment are, perhaps, the most questionable, and are also of great importance since they determine the annual incidence of overhead costs However, accuracy in this matter may not be so important, for the following reason: a farmer may decide that future prices, etc., are so uncertain that he is unwilling to plan further ahead than, say, five years, and will only make investments which he expects to pay for themselves within that period. For a farmer with this attitude, the critical acreage will be twice as great as when the cost of the equipment is amortised over a ten-year period.

the local price, since large stocks were accumulated at the previous high prices. When present stocks are sold, some, perhaps a large, reduction in the local price of bags can be anticipated. This would have a considerable influence on the profitability of bulk handling.

In comparing bulk with bag handling, consideration must be given to factors other than those which can be translated into money terms. Advantages of this kind which bulk handling possesses are that it makes harvesting easier, less dependent on outside assistance, and less subject to weather risks (since grain can be protected from the weather immediately it is harvested). Farm storage lessens the farmer's dependence on Government-erected storage facilities, and may allow harvesting to continue when it would otherwise be inconvenient. Uncertainty surrounding the supply of bags, and labour, is eliminated, or reduced. Bulk handling has the disadvantage that it increases the rigidity of the farm cost structure (*i.e.*, it increases overhead costs relative to running costs), which tends to make it more difficult to adjust the output of competing products (*e.g.*, wheat and wool) in response to changes in their prices.

Recently introduced special depreciation allowances enable the cost of bulk handling plant to be written off, for taxation purposes, in five years. Where the marginal rate of taxation is high, the savings resulting from this concession are considerable.

4. SUMMARY AND CONCLUSIONS.

1. The number of firms manufacturing and marketing bulk-handling plant has increased rapidly in recent months, with the result that the farmer is now able to choose from quite a variety of lines of equipment. Prices of the various makes differ considerably, and since these price variations seem only partly to reflect quality differences, it is to the farmer's advantage to investigate the market fully before deciding what type and make of equipment to purchase.

2. A number of systems of bulk handling can be devised by selecting and combining, in different ways, the individual items of equipment being marketed. The system best suited to any particular farm will depend on the farm's physical characteristics (*e.g.*, size, location), the cropping policy being pursued, the farmer's financial resources, and the extent to which he wishes to achieve technical perfection. Some general considerations regarding the choice and efficient employment of equipment have been enumerated.

3. A system of bulk handling has been described, which may prove suitable for the farmer who is moderately favourably situated with respect to railway receiving facilities, and who is able to modify an existing structure to provide temporary storage for wheat. By comparison with the types of plant installed on a number of farms in New South Wales, the suggested system sacrifices some technical efficiency for cheapness. Costs are reduced by dispensing with elaborate storage facilities and by using a single portable auger instead of a number of fixed augers. To allow flexibility in the harvesting and carting operations the use of a field bin is suggested. The total cost of the suggested plant would be in the vicinity of £1,000 to £1,200, depending on the capacity of its various components.

4. An attempt has been made to assess the profitability, at current prices of machinery, labour and bags, of this bulk handling system compared with bag handling. An hypothetical budget approach was employed, requiring many assumptions regarding, *inter alia,* the life of machinery and bags, the frequency of high, medium and low yielding crops and the speed of work of men and machines. Insufficient confidence was felt in the reality of these assumptions to draw general conclusions from the calculations made. However, the results may prove useful, provided they are always considered in conjunction with the assumptions used in deriving them. In the course of the calculations it became reasonably clear that, at present prices, the greatest cash saving effected by bulk handling is the cost of bags, and that the suggested system of bulk handling would not appreciably reduce labour cost of harvesting.

5. The recently announced twenty per cent. depreciation allowance on farming plant for taxation purposes has increased the profitability of bulk handling, particularly where the marginal rate of taxation is high.

6. Many of the advantages of bulk handling cannot be expressed in terms of money. It takes the hard work out of harvesting, and gives the farmer greater security against weather damage, uncertain supplies of labour and bags, and hold-ups due to inadequate wheat receiving facilities.

This article has been concerned with the problems and prospects of bulk handling solely from the point of view of the individual farm operator. Its prospects appear favourable, particularly on larger-than-average sized wheat farms. Its widespread adoption, should this eventuate, would have repercussions throughout the wheat industry and associated industries, and in the national economy. These effects would, in turn, modify the situation facing the individual farmer. Some of the more important of these likely effects are set out below:—

(*a*) As knowledge and experience of the new technique increased, more efficient machinery could be expected to be produced.

(*b*) If demand increases to the point where firms employing mass production techniques enter the bulk-handling equipment field, considerable price reductions could be anticipated. It is likely that locally-produced headers specifically designed for bulk handling would be marketed.

(*c*) Industries serving the wheat industry might be expected to adapt themselves to bulk handling. For example, wheat-carrying contractors may, as standard practice, fit bulk bodies and perhaps, loading augers, to their trucks.

(*d*) To the extent to which farm storage accompanied bulk handling, rail silo congestion would be reduced.

(*e*) The demand for casual harvest labour would be lessened.

(*f*) The demand for bags would be reduced, and their supply increased, as second-hand (used and unused) bags were released. In the long run, reduced imports of jute would effect substantial savings in foreign exchange.

APPENDIX.

Assumptions made in Calculating Labour Costs.

1. Harvesting plant consists of a 12-ft. power-driven header, mounted on pneumatic tyres, equipped with either (*a*) a 30-bushel grain box, (*b*) a bagging platform (tipping), (*c*) a 90-bushel header trailer, or (*d*) a 140-bushel header trailer. The header is drawn by a large tractor, *i.e.*, a tractor rated at over twenty-eight draw-bar horse-power.

2. The crop is grown on level ground and is well-standing.

3. The harvesting plant, however equipped, strips at five m.p.h. in low or medium yielding crops, and at 3.5 m.p.h. in high yielding crops.

4. The time available for stripping is nine hours per day.

5. The time taken to bag the contents of the grain box (thirty bushels) is ten minutes.

6. In the case of bulk handling, twenty minutes are required to empty the header trailer; this includes the time consumed in travelling from the crop to the field bin, manoeuvring the mobile auger into position, emptying the trailer and returning to the crop.

7. One man working on the bagging platform can handle approximately 300 bags (containing on the average $2\frac{5}{8}$ bushels of wheat) in nine hours.

8. The 90-bushel header trailer is used in conjunction with a 400-bushel field bin; the 140-bushel trailer with a 550-bushel bin.

9. The farmer does his own wheat carting. For bag handling his truck is equipped with a hydraulic bag loader; for bulk handling with a 270-bushel bulk body.

10. When bulk handling is used, two men are employed, one operating the tractor and header, and delivering wheat to the field bin, and one driving the bulk truck between field bin and railway silo, or farm storage shed.

11. For bag handling, one man drives the tractor and operates the header in each case, and additional labour is required as follows:—

(*a*) *Grain Box* (i) for low yielding crops, one man bag sewing and carting, provided that the tractor driver assists in loading wheat on to the truck.

(ii) for medium and high yielding crops, one man bag sewing and assisting in loading, and one man carting.

(*b*) *Bagging Platform* (i) for low yielding crops, one man on platform and one man carting, the header crew assisting with loading.

(ii) for medium and high yielding crops, two men on platform, and one man carting. To assist with loading, one man leaves the platform, while the other two continue stripping at reduced speed.

The total number of men employed for each combination of yield and equipment is set out in Table IA.

TABLE IA.

Number of Men Employed on Harvest.

Type of Equipment.	Type of Yield.		
	Low 12 bushels.	Medium 24 bushels.	High 36 bushels.
30-bushel Grain Box	2	3	3
Bagging Platform	3	4	4
90-bushel Bulk Trailer	2	2	2
140-bushel Bulk Trailer	2	2	2

12. Four loads of bagged wheat each of between 80 and 100 bags, on six loads of bulk wheat, can be delivered to the railhead per day.

These assumptions enable us to estimate the quantity and area of wheat stripped per day, for each combination of yield and equipment. These estimates are set out in Table IIA. In making them, the complications which result from the fact that, in several cases, a man principally employed on another task devotes part of his time to loading, have been disregarded, and consequently areas and quantities have been over-estimated in these cases. In assessing labour costs, these inaccuracies have been corrected (see (i) below).

The labour employed for harvesting has been valued at £3 per day. To the daily labour bill, calculated from Table IA, the following additions have been made:—

(i) The value of the services of the man assisting with loading [8].

(ii) Labour costs of carting any wheat which is carried over when the rate of harvesting exceeds the rate of carting—as when a bagging platform is used in a medium or high yielding crop.

(iii) Labour costs of double-handling bulk wheat stripped at weekends and held temporarily in farm storage.

TABLE IIA.

Estimated Quantity and Area of Wheat Stripped per Day.

Type of Equipment.	Type of Yield.					
	Low 12 bushels.		Medium. 24 bushels.		High 36 bushels.	
	Area.	Quantity.	Area.	Quantity.	Area.	Quantity.
	acres.	bushels.	acres.	bushels.	acres.	bushels.
30-bushel Grain Box ...	45.0	540	33.8	810	22.5	810
Bagging Platform ...	65.4	785	65.4	1,570	45.9	1,650
90-bushel Bulk Trailer ...	48.3	580	39.6	950	27.5	990
140-bushel Bulk Trailer ...	54.2	650	46.3	1,110	31.9	1,150

[8] In making this assessment, it is assumed that two men, with the aid of a hydraulic bag loader, can load a truck with 100 bags of wheat in forty minutes.

It is appreciated that the estimates given in Table IIA are considerably higher than the average quantities and areas stripped per day in practice. They are intended as estimates of what can be done in optimum conditions. For the purpose of this article, which is to *compare* the various harvesting methods, it is of little consequence whether average or optimum estimates are used, so long as they are used consistently.