A STUDY OF THE ECONOMICS OF BULK HANDLING OF WHEAT ON FARMS*

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1. SUMMARY

This article is the result of a survey of wheat harvesting methods carried out in November, 1958. The survey was prompted by the question: *Is there any clear financial gain for the small farmer in adopting bulk handling?* This was felt to be an important question since the adoption of full bulk handling can involve a wheatgrower in an investment of from £1,000 to £2,000 or more. This article aims to supply information to help farmers decide whether to adopt bulk handling at the present time. A single, best, harvesting system for all farmers has not been found (and doubtless never will be found) but some conclusions, which are at least worthy of consideration, are presented.

CONCLUSIONS

1. *Wheat should be carried to the rail-siding in bulk.*—The investment required is only about £170 for a bulk-body and conversion to a bag-to-bulk loader, and it saves bag-sewing and eliminates the need for a truck-driver's assistant. The saving on bag sewing alone is worth 30s. 0d. a hundred bags.

2. The small wheatgrower needs to balance the 20 per cent faster operation and convenience of bulkhandling against the money he would have to tie up in bulk-handling equipment.

3. Many premium wheatgrowers would do well to consider getting a firm quote from a mill for March delivery and then storing their wheat on the farm until bulk rail-trucks are available.

To many wheatfarmers the first conclusion may appear extremely prosaic, yet the 1956-57 survey of the wheat industry by the Bureau of Agricultural Economics showed that no less than 64.5 per cent of the wheat covered by the survey in New South Wales was emptied from unsewn or silo-sewn bags at receival points. If it is assumed that saving the truck driver's assistant pays for the conversion to bag-to-bulk loading, then the saving on bag sewing is a *net saving* and on the basis of a 60 million bushel State crop, the saving to the industry in New South Wales alone would be £200,000 per year.

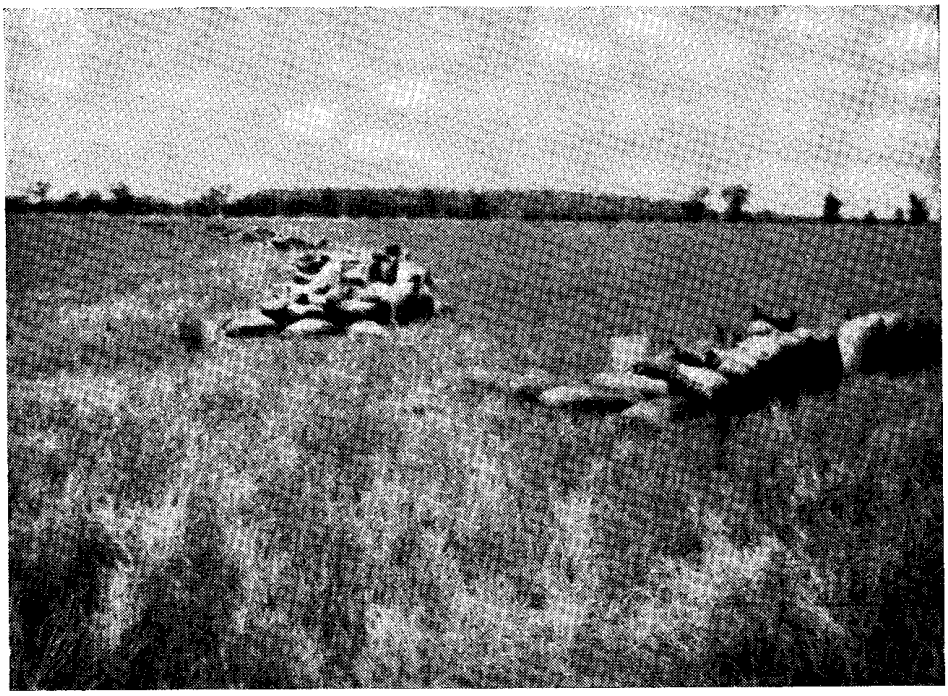
The second and third conclusions may appear rather vague. It is, however, the purpose of this article to provide some of the information required to help the smaller wheatgrower *balance* the extra speed and certainty of bulk-handling against the extra cost.

2. INTRODUCTION

The objective in writing this report (and in conducting the survey that preceded it) has been to assemble information useful to farmers who are currently using bags, and have wondered whether it would pay them to adopt bulk handling methods. By and large most big wheatfarmers have already adopted bulk handling, or if they have not, they have special

reasons for not doing so. There are several reasons why bulk handling has been adopted faster on large than on small farms ; larger farmers have more capital available ; the larger acreage means that the outlay required is smaller per bushel or per acre ; and labour problems are generally greater on the larger farms.

Conversely, these same reasons suggest that the small farmer will gain less from bulk handling than has his larger neighbour. It was exactly this problem *"is there any clear financial gain for the small farmer in adopting*



Typical Bag Stacks in the Paddock

bulk handling" which prompted the investigation. This means the main interest is in the problems of the smaller wheatgrower—the man who has a trailer header and from 150 to 400 acres of f.a.q. wheat. Special problems of bulk handling for premium wheatgrowers will be discussed in a section at the end of this report. The "truck" referred to in this report, whether owned by the farmer or a contractor, is capable of carrying from 90 to 100 bags.

It was felt that an attempt to find "the best bulk handling system" would be defeated by the important differences between farms and between farmers. It was clear even before starting this study, that it would be impossible to find one harvesting system which would meet the needs of both a well-established farmer who prides himself in being one of the first farmers in the district to complete his harvest, and a farmer who is just getting established and in any case is willing for harvesting to continue from three to four weeks.

In this study, as in most farm management work, it has continually been necessary to face the importance of *individual farm* problems. Each farm has its own location, its own stock of machinery, its own particular area of wheat, a certain number of permanent employees, and its own financial problems. This means that while it *might* be possible to find "the best harvesting system" for a given farm, it would be completely unrealistic to attempt to find "the best (single) harvesting system" for all farms in New South Wales.

In visiting farms, it was impressive to see how well the harvesting equipment in use had been adapted to the needs of the particular farm on which it was being employed. Neighbours would often report quite contradictory experiences. One man would claim to have turned 2,000 bags every day for a week, and a neighbour would say that he had only had to turn 50 bags in his life—obviously these two men would have entirely different attitudes to the importance of having all wheat covered at night!

Again it makes about £700 difference to the capital cost of a harvesting system whether the farmer already has his own truck, or whether he would have to buy one.

Finally, there was the problem of assessing the "economics" of harvesting systems where one farmer might have built a bulk truck body from £30 worth of scrap he "happened to have on the place" and his neighbour might have bought a similar body for £120 to £150.

In assessing costs of equipment "conservative market prices" have been used. That is, a farmer should be able to buy equipment for the prices mentioned in this report, if he is willing to look around a bit. *Many farmers would be able to build or buy items cheaper than the prices suggested in this report.* However, even farmers who do not have welding equipment, and who cannot afford to spend too much time at sales, should be able to get into bulk handling for about the figure suggested below.

In this report quantities have been given in bags where bags are actually used, and in bushels elsewhere. In making cost conversions it may be important to remember that silo-sewn bags *usually* contain less than three bushels.[1]

The distance wheat has to be carted and the delay at the siding differs from farm to farm, and from siding to siding. To overcome this difficulty attention has been given to "loading and unloading time". That is, the time spent actually filling and emptying the truck. Thus to estimate the round trip time for a truck it is necessary to add travelling and waiting time to the "loading and unloading time" mentioned in the report. Since travelling and waiting time differ very markedly from property to property and siding to siding there seemed little point in trying to estimate an average time. A difference of half an hour in loading time will be much more important when five loads a day are being taken, than when only two loads are getting away.

[1] During the survey the number of bags and tare weight of a number of deliveries to a silo were obtained. Unfortunately the bushel weight of the individual loads was not obtained and since there was a lot of light wheat about, this prevented a useful figure for the bushels per silo-sewn bag being obtained.

The cost of a bulk-handling system should be set against all the crops which it will harvest. The farmer who is a "small wheatgrower" with 150 acres, might well find that when he took account of the savings from bulk handling his oats, barley and sorghum, that it would pay him to go into a full bulk system. Though the report deals only with wheat harvesting, it is clear that the farmer should take his other grains into account in deciding if bulk handling would pay.

The main body of the report will first describe the four main harvesting methods employed in New South Wales (together with associated or modified harvesting methods). This description will be given mainly to ensure that the reader and the author are thinking of the same sort of problems. Clearly "the typical bagging system" might have either one or two men on the header—and it is important for the reader to know which alternative is being considered. The descriptive section will be followed by a comparison of the relative advantages and disadvantages of the various harvesting systems. Finally, there will be a section on farm storage.

3. METHODS OF WHEAT HANDLING

Bag Handling

Summary of Requirements

This system requires:

(i) *Four men*:
- (*a*) One header-driver,
- (*b*) One Bag-sewer,
- (*c*) One truck-driver, and
- (*d*) One truck-driver's assistant.

(ii) *One truck.*

(iii) *One hydraulic bag-loader.*

(iv) *A supply of bags* (say, 1,000).

General Description

The first method of harvesting wheat to be considered in this report relies on wheat being carried to the rail siding in bags. This system calls for one header-driver, one bag-sewer, one truck-driver and one truck-driver's assistant. The first man drives the header and empties the header bin into bags. The bag-sewer sews the bags with a quick silo-stitch which can be conveniently and quickly released at the siding. The header-driver establishes one or more dumps in the paddock, at which the bin is emptied on each trip round the paddock. The truck-driver and assistant load the (sewn) bags on to the truck, with the aid of a hydraulic bag-loader. The truck

is then driven to the silo or siding where the strings holding the bags are cut and the wheat released. Depending on the crop, the speed at which the header can thrash it, and the distance and delay at the rail siding, the truck-driver and assistant may, or may not, be able to cart wheat from the paddock faster than the header can cut it.

Modifications

In most cases the bag-sewer will be able to sew a day's bags in two to three hours, so that he may only be part-time employed. The same bag-sewer may sew for several headers (on different properties) just as the truck-driver and assistant may cart wheat from several properties. This system is sometimes modified so that the bag-sewer acts as a second header-driver. Thus the bag-sewer will be employed full-time on the one property where he will sew bags, relieve the main header-driver at smoko and lunch-time, will help grease up the machine, and help unload bags at the main dump. He will also be available to help repair any breakages which may occur.

A contract bag-sewer is usually employed when the farmer has no permanent help. Where there are two men on the place it is usual for the second man to act as relief header-driver and bag-sewer. Depending on the time spent greasing, on repairs and for lunch and smoko a relief header-driver is likely to save from two to three hours heading time per day.

Another modification often employed where a small farmer has his own truck, is for the truck-driver to sew the bags and then have the assistance of the header-driver to load the truck. This means, of course, that heading has to stop while the truck is being loaded, but it does provide a two-man harvesting system, which may appear quite adequate on a small acreage where the crop will be harvested in reasonable time in any case.

Another modification which usually implies that the farmer owns his own truck, calls for a relief header-driver who helps load the bags as well as sew them. The third man employed in this case is likely to save up to four hours heading time per day (smoko, lunch, greasing and loading the truck) over the two-man harvesting system described in the last paragraph.

Summary of Performance

Rate of Heading: From 12 to 24 minutes to fill a 12-bag box.

Rate of Emptying: From 4 to 9 minutes to empty a 12-bag box.

Rate of Heading and Emptying: From 22 to 45 bags per hour.

Rate of Silo Sewing: From 50 to 100 bags per hour.

Rate of Loading Truck: From 3 to 6 bags per minute.

Time Unloading at Silo: From 9 to 18 minutes per load (of 100 bags).

Truck Loading and Unloading Time: From 26 to 51 minutes.

Bag Life: Approximately 12 trips to the siding.

Observations

Since wheat can be stored in the paddock in bags, this system allows stripping to continue, even when the siding is closed, or the truck has broken down. At the same time, there are many farmers (especially after a wet

season) who feel that storing wheat in bags in the open is too risky to be satisfactory—there is the continual worry that a spell of wet weather will occur, and with it the necessity of turning the bags daily, and loss of weight of the wheat.

The capital expense required for this system is a minimum. Apart from the header which is required for any harvesting system, the only capital outlay would be £150 for, say, 1,000 bags. Even this capital outlay can be reduced if the farmer does not head on Sunday, and is willing to risk having to stop heading until his bags return from the silo. However, there is a considerable direct cost associated with each bag sent to the siding. In particular:

	Pence per bag
Silo sewing (30s. 0d. per hundred)	3.6
Depreciation of bags (3s. 0d. per bag, 12 trips to siding)	3.0
Total cost per bag	6.6

Since silo-sewn bags usually contain less than three bushels, this direct cost works out at something over 2.2d. per bushel.

Bag-to-Bulk Handling

Summary of Requirements

(i) *Two men*:
  (*a*) One header-driver,
  (*b*) One truck-driver.

(ii) *One truck.*

(iii) *One hydraulic bag-to-bulk loader.*

(iv) *One bulk truck body.*

(v) *A supply of bags* (say, 800).

General Description

The semi-bulk method of harvesting relies on emptying bags into a bulk truck body in the paddock so that the wheat is carried to the siding in bulk. This system calls for two men, a header-driver and a truck-driver. The header-driver unloads the bin when full, and the truck-driver uses a hydraulic bag-to-bulk loader to empty the bags into a bulk-bin on his truck. The truck is then driven to the siding and emptied.

Filling the bulk truck body results in dumps of full bags being replaced by dumps of empty bags. These bags have to be collected before they can be used again. However, this is light work which can usually be done in the morning before the crop has dried sufficiently for heading. The truck used can belong to the farm, or an outside contractor can be employed to carry the wheat to the rail siding.

A modification of this system calls for a relief header-driver who keeps the header moving over smoko and lunch, helps load the truck and helps grease the header.

Summary of Performance

Rate of Heading: From 12 to 24 minutes to fill a 12-bag box.

Rate of Emptying: From 4 to 9 minutes to empty a 12-bag box.

Rate of Heading and Emptying: From 22 to 45 bags per hour.

Rate of Loading Truck: From 2 to 4 bags per minute.

Time Unloading (well designed) Truck at Silo: From 6 to 11 minutes per load (of 100 bags).[2]

Truck Loading and Unloading Time: From 30 minutes to an hour.

Bag Life: Approximately 12 tips into bulk body.

Observations

Both bag and bag-to-bulk handling provide for wheat to be stored in bags in the paddock. This paddock storage has both advantages and disadvantages. It is an advantage if there is a delay at the rail siding, or if the carrier is held up in any way, since heading can continue even though wheat is not being removed from the paddock. In particular it means that if the carrier is tending to remove wheat from the paddock faster than it is being stripped, he can do an occasional extra trip for someone else, without unduly embarassing the farmer he deserts. The disadvantages of bags in the paddock are, of course, the danger of rain, or attack by pests.

It has been assumed that the bag life for bag and semi-bulk handling is the same. This probably is unduly charitable to bag handling, but undoubtedly the claws for the bag-to-bulk loader will have the same sort of effect as the sewing, opening and manhandling of bags which occurs with the bagging system.

The time spent loading and unloading is likely to be from 5 to 10 minutes longer per trip with the semi-bulk system. One man and a bag-to-bulk loader would take from 25 to 50 minutes to load 100 bags (versus 17 to 34 minutes with two men and an ordinary bag loader), however, the bulk truck can be emptied in from 6 to 11 minutes (versus from 9 to 18 minutes for a load of bags). Thus the loading and unloading together takes from 5 to 10 minutes longer with a bag-to-bulk loader. How important this is will depend largely on the amount of time spent travelling and waiting. In any case, the advantage of having the truck loaded by one man rather than two, is likely to more than offset the slight delay.

It should also be noted that a bulk truck body weighs from 10 to 20 cwt. This means that if a farmer is loading his truck to capacity with bags, he will have to cut down his carrying on each trip appropriately if he adopts

[2] The requirement for a "well designed" bulk body is that all wheat must flow out without shovelling. This in turn means that the floor of the truck must have sufficient slope (22 degrees) either by being built up, or by the body being tipped, and that wheat must not be expected to empty through a narrow opening, unless it flows to that opening. Specifically it is bad to have only one bagging door on the back of a truck or three bagging doors on the side. As this means that wheat will have to be shovelled out, and shovelling can easily double the time taken to unload. Where wheat is being emptied into an auger, a narrow opening may be necessary; however, this is typically one of the problems associated with farm storage.

bulk cartage. In practice, however, it appears that trucks carry about the same amount of wheat in bulk as in bags. Presumably the extra loading with bulk wheat will tend to reduce the truck's useful life. However, this cost is probably not important.

In addition to the equipment required for bag handling of wheat, this system requires a bulk truck body, and a bag-to-bulk loader. The latter replaces the simple bag loader required for bag-handling systems. A 300 bushel bulk body should be obtainable for £150 and conversion of a bag loader to empty into a bulk body costs about £37. (If a bag-to-bulk loader is purchased instead of a bag-loader, the extra cost is only £23). The extra cost is thus about £190, but because the bags never leave the paddock it would be reasonable for the farmer to get by with a supply of 800 rather than 1,000 bags. This means a saving of £30, hence *the net extra capital cost of the semi-bulk* system is likely to be about £160. This extra expenditure results in the farmer being able to dispense with silo-sewing. Thus *reducing his direct cost by* 30*s.* 0*d. a hundred or* 3.6*d. per bag.*

Bulk Without Storage

Summary of Requirements

(i) *Two Men*:
  (*a*) One header-driver
  (*b*) One truck-driver
(ii) *One truck.*
(iii) *One bulk body.*
(iv) *One* 120-*bushel header-trailer.*
(v) *One* 600- *to* 900-*bushel field-bin.*
(vi) *One* 18-*foot auger.*

General Description

Probably the most widely used method of bulk handling requires modification of the header (costing about £30) to empty into a 120-bushel bulk-trailer which is drawn by the tractor, parallel to the header. This tractor-trailer costs about £450 including an auger which will empty it in about 5 minutes. If the truck is in the paddock the wheat is augered direct from the bulk-trailer into the truck bulk-body. The header almost always has to stop to allow the trailer to be emptied. If the truck is in the paddock it will usually be driven into position so that the header does not have to leave the crop. When the truck is away, the trailer is emptied into the field-bin. This may involve one or two minutes' travelling from the crop. On most of the farms visited in the survey, the time travelling between the crop and field-bin was of the order of 30 to 45 seconds. When the truck returns to the paddock it is driven up to the field-bin and filled. An auger is almost always placed beside the field-bin to enable the truck to be filled.

Header Delivering Wheat to Bulk Truck

There are numerous modifications to the above system: Generally they can be described as:—

(i) *Modifications involving the header* usually mean that the number of bushels carried with the header, and hence the time between emptyings, are reduced. One modification of the above system eliminates the header-trailer, by using a header with 36 or 38 bushel "bulk-box" and auger on the header. Since a header-trailer costs about £450, whereas a header with a 38-bushel bulk-box can be bought for only £80 more than a standard bagging header, this represents a considerable cost reduction. It seems to take 4 to 6 minutes to auger 120 bushels from a header-trailer and $1\frac{1}{2}$ to 2 minutes to empty a 38-bushel bulk box. Thus the actual time spent emptying wheat is about the same for each method. Where, however, time taken travelling from the crop to the field-bin is important, the header with the smaller bin will be at a disadvantage; it has to make the trip three times as often as the header-trailer. Clearly, if it saves an investment of £370, a few minutes' waste time a day travelling to and from the crop may be well spent. After wet weather it is sometimes found that the wheat is ready for heading while the ground is still damp. In these conditions a header-trailer may be rather heavy to pull and the smaller bulk bin will be at an advantage. The smaller grain box has the disadvantage that it may be necessary to work inconveniently small blocks in order to get back to the field-bin before the bulk box has filled. With a 120-bushel box the farmer can work a block of almost any size and still be sure of getting back to

the field-bin before the trailer has been filled. At least one header is available with a 135-bushel bulk box on the header but this machine costs about as much as a normal header-bulk-trailer combination.

Replacement of a trailer header with a self-propelled header is the next important modification to be considered. Self-propelled headers usually have a 60-bushel bulk-bin. This means that they too, have to return to the field-bin more frequently than the header-trailer.

Small blocks, worked by a self-propelled machine, however, do not necessarily mean a loss of crop, since self-propelled machines can harvest in any direction.

(ii) *Modifications involving the field-bin* are usually designed to replace it with a waiting truck. The commonest of the modifications replaces the field-bin and auger with a second truck and bulk body. With this system one truck is being filled in the paddock while the other truck is being emptied at the siding. When the empty truck returns from the siding it is parked near the crop and full truck is taken away. Thus this method calls for two trucks, but only one truck-driver. Since a field-bin costs from £300 to £350 and an auger £250 to £300, the second truck is likely to replace an investment of about £550. A satisfactory second-hand tipping truck can probably be purchased for about £700, hence the equipment for a two truck harvesting system costs only about £150 to £200 more than the equipment for a field-bin system. That is, the two-truck system is not quite as extravagant as it might appear at first sight. There will, however, be the annual cost of registering a second truck over the harvest period.

Another possible modification, where a header-trailer is being used and a round trip to the siding can be made in less than 40 minutes, dispenses with field-bin entirely, and relies on the truck re-appearing in the paddock again before the trailer needs to be emptied. Needless to say, this is a system which is very vulnerable if the truck is held up in any way.

Alternatively, instead of having two trucks and no field-bin, some farmers have two tractor-drawn field-bins, and no truck. This has the disadvantage that the field-bins are only useful for their one job, while a truck can be used for many other jobs during the rest of the year.

Where the truck can cart wheat from the paddock faster than the header can harvest it the truck-driver should have some "idle" time in the paddock. If the truck-driver is employed by the farmer, this time can be used to keep the header moving. The truck-driver can relieve the header driver for lunch and smoko (possibly the header-driver will eat his lunch in the course of delivering a load to the rail siding), help with greasing and generally be helpful in case of a header breakdown.

Summary of Performance

Rate of Heading: From 40 minutes to 1 hour 20 minutes to fill a 120-bushel trailer.

Rate of Emptying: From 4 to 8 minutes to empty 120 bushels.

Rate of Heading and Emptying: From 80 to 160 bushels per hour.

Rate of Loading Truck (from Field-bin): From 8 to 15 minutes for 300 bushels.

Time Unloading (well designed) Truck at Silo: From 6 to 11 minutes.

Truck Loading and Unloading Time: From 15 to 30 minutes.

Observations

The first observation about bulk handling without farm storage is that *it is extremely vulnerable to a breakdown in the transportation of wheat from the paddock.* This cannot be too strongly emphasised. If the silo closes down (as it does typically at 5.30 p.m. or over the weekend) then once the truck (300 bushels), field-bin (800 bushels) and header-trailer (120 bushels) are full—*heading cannot continue, unless the farmer is willing to dump his wheat on the ground.*[3] Further, heading cannot continue until the truck has returned empty to the paddock and relieved the congestion. The above system provides for only 900 bushels of paddock storage. If the header gets 900 bushels ahead of the truck then heading has to stop. As this is less than a good day's harvesting, and the rail siding typically closes for 43 hours over the weekend (and delays of from one to three hours at the silo are not unknown) it should not be necessary to emphasise further the dangers and probable delays inherent in attempting to harvest wheat in bulk without farm storage.[4]

The next point to be made is that not only does full-bulk handling require much more equipment than semi-bulk handling, *but also the equipment used must be owned by the farmer.* It is obvious that the farmer must own the field-bin, auger and header-trailer, it is not so obvious that he must own the truck and bulk body. The shortage of paddock storage inherent in bulk handling means that the farmer is too dependent on his cartage from the paddock for this to be left in the hands of anyone not directly concerned with the crop. Thus if the carrier fails to call for a day (or 900 bushels heading time) then heading has to stop. If the carrier fails to call for three days, the farmer immediately loses two days' harvesting. With the semi-bulk system on the other hand, failure of the carrier to call for three days would only mean there were 1,000 bags in the paddock. The farmer would be vulnerable if a wet period set in, but at least heading would not have to stop.

Full-bulk handling reduces the time unloading the header. If it takes from 4 to 8 minutes to unload 36 bushels into bags and 4 to 8 minutes to unload 120 bushels into a field-bin, the saving is from 9 to 18 minutes per 120 bushels. This could result in an extra one to two hours spent actually heading wheat on a good day. Stated in another way it means that for every 100 bushels bagged, about 122 bushels would be delivered to the field-bin using the bulk system.

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[3] He could also dump his wheat into temporary (weldmesh) silos—this possibility will be discussed later.

[4] It also emphasises the cost inherent in closing silos over the week-end. If this delays harvest by one day (or even one hour) and because of a thunderstorm wheat is lost, then this is a real loss to the community in general, as well as to the individual farmer concerned.

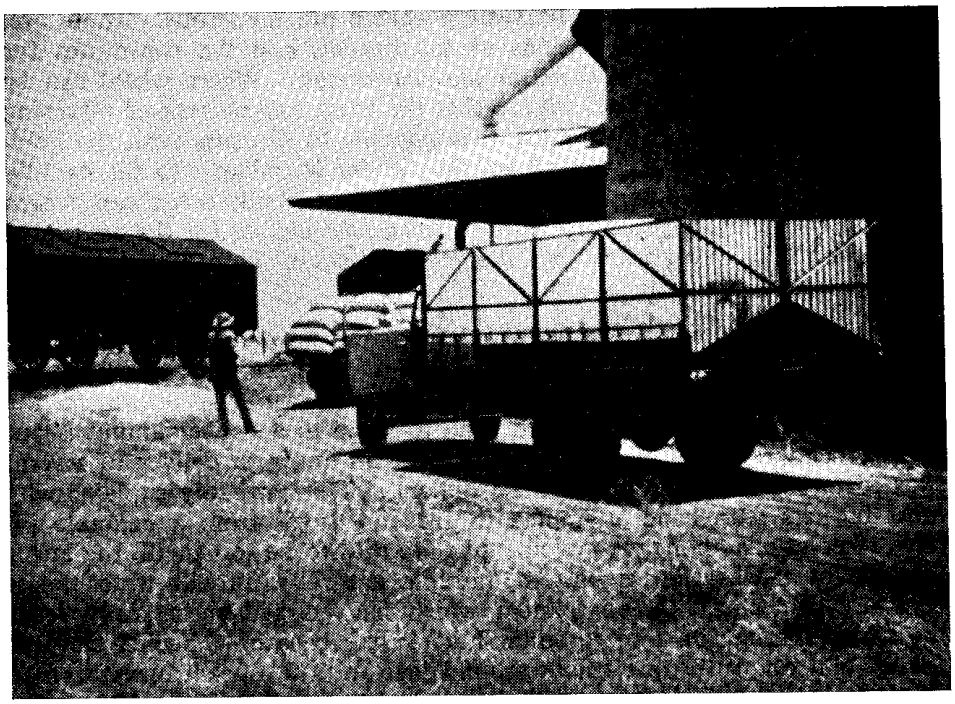
Bulk with Storage

Summary of Requirements

(i) *Two men*:
  (*a*) One header-driver.
  (*b*) One truck-driver
(ii) *One tipping truck.*
(iii) *One bulk body.*
(iv) *One* 120-*bushel header-trailer.*
(v) *One* 600- *to* 900-*bushel field-bin.*
(vi) *Two augers*:
  (*a*) One 18-ft. auger.
  (*b*) One 32-ft. auger.
(vii) *Appropriate galvanised iron silos.*

General Description

This harvesting system is essentially the same as bulk without storage, except that instead of delivering wheat to the rail siding, it is delivered to farm storage. The paddock organisation is exactly the same as discussed



Delivering to the Silo in Bulk

in the last section. At present galvanised iron silos appear to be the most popular farm storage, and these are typically filled by an auger. The auger may be dipped into a concreted hole into which the truck drops the wheat, or it may be fed from a small bin at the bottom of the auger. In either case (unless the concrete hole is extremely capacious) the rate of delivery of wheat from the truck has to be limited to the rate at which the auger

can remove it. Manufacturers' specifications for farm augers vary from 18 to 36 bushels per minute. Allowing for inefficient running they are more likely to deliver from 12 to 24 bushels a minute. Hence a 300-bushel load will take from 12 to 25 minute to empty into the auger. Allowing a few minutes for starting the engine, and getting the load into position, it is reasonable to allow the truck from 15 to 30 minutes to auger its load into the farm storage. Even with a half-hour delay delivering wheat to the farm, one truck should have no difficulty in keeping the wheat away from the header, since even in a heavy crop it will take the header something over an hour and a half to strip 300 bushels, and the distance from paddock to storage will seldom be more than 3 or 4 miles. The truck-driver is likely to have a certain amount of idle time in the paddock, which can be used to keep the header moving if the header driver is relieved for smokos and lunch.

Where the truck has to deliver wheat in a regulated stream to an auger, it is necessary to have a tipping body or a bulk body sloped to a single delivery point. Many of the simpler types of bulk body, where a whole side opens to allow the wheat to escape, are unsuitable for delivering wheat to an auger. Thus a small "hidden cost" of providing farm storage, may be the purchase of a tipping rather than a table top truck, or the purchase of a more expensive bulk body.

Modifications to the above harvesting system are numerous. There are, for instance, all the modifications of the header, and the substitutes for a field-bin, which were discussed in the last section. Where wheat can be delivered to farm storage quickly, so that the truck can be sure of returning to the paddock within 40 minutes, it is possible to dispense with the field-bin entirely. Even in a heavy crop, the header is unlikely to fill its 120-bushel trailer in less than 40 minutes, and if the bulk truck can return within this time there is clearly no need for a field-bin, or for the associated auger. This in turn means that the money tied up in equipment in the paddock can be reduced by about £550.

The secret of quick delivery to farm storage appears to be a hole in the ground; that is, it is necessary to have a bin which can accept a full 300-bushel load at once, and hence allow the truck to return to the paddock. A 300-bushel bin would need to slope to a delivery point about 10 feet below ground level. To arrange for an auger to deliver to several silos from such a position would be difficult. This probably explains why most farmers who have attempted to feed an auger from a concrete pit have reservations about the system—pits are said to be too small, the auger leaves a lot of wheat at the bottom, and pits, naturally, fill with water unless carefully protected. A bin system which has worked successfully feeds the wheat through an underground shute to the base of a bucket elevator (at a point about 20 feet below ground level). The bucket elevator then raises the wheat to a delivery point from which it can flow by gravity to any one of the four silos. Wheat can also flow by gravity from the silos to the base of the elevator. By this means the elevator can also be used for emptying the silos into bulk trucks. Wheat is emptied into the bin through a cattle-stop type grid. In the two examples of this system inspected during the survey, the grid was slightly raised above ground level. It is imporant that if the grid is raised the slope to and from it should be gentle. A gentle slope to it enables loaded trucks to ascend the gradient.

A gentle slope from it ensures that when a tipping truck is being emptied, the downward slope from the grid will not prevent the tipped tray from emptying. The grid must, of course, be adequately protected from the weather, since rain would naturally tend to accumulate at the bottom of the bin.

For a quick turn round the truck must be able to return to the paddock as soon as it has emptied its load into the bin. This means that the engine used to elevate the wheat should be as foolproof as possible. Preferably the engine should be electric. If this is impossible, then the next safest engine would probably be a diesel, and in any case a time switch should be attached so that the engine will switch off once its work has been completed.

Another modification to the above system concerns the type of farm storage used. Some farmers store their wheat in galvanised iron sheds, while still others erect temporary weldmesh silos inside their machinery and other farm sheds. Farm storage is discussed as a separate section below.

Summary of Performance

Rate of Heading: From 40 minutes to 1 hour 20 minutes to fill a 120-bushel trailer.

Rate of Emptying: From 4 to 8 minutes to empty 120 bushels.

Rate of Heading and Emptying: From 80 to 160 bushels per hour.

Rate of Loading Truck (from Field-bin): From 8 to 16 minutes for 300 bushels.

Time Unloading Truck at Farm: From 15 to 30 minutes for 300 bushels.

Truck Loading and Unloading Time: From 23 to 46 minutes for 300 bushels.

Observations

The main observation on bulk handling with farm storage is that the extra expense of farm storage and of an extra auger, buys the farmer immunity from the various hold-ups which can occur if his harvesting system is not self-contained. The farmer has neither the worry of bags in the paddock when it rains, nor the worry of whether his truck will return in time to permit him to continue heading.

Some people feel that by carting to farm storage, and then later carting to the siding the farmer is double-handling his wheat unnecessarily. If indeed it is equally quick and convenient to deliver to the siding this argument must be accepted, but farmers who use farm storage say that it results in a quicker, more regular, turn-round of their trucks and that the second-handling comes at a time when they are not over busy ; that they can afford to spend two hours at a less busy time of year in order to save one hour at harvest. In any case, they feel that a second handling is little enough to pay for the security of knowing their wheat is safely under cover.

Even if it takes half an hour to unload at the farm, the shorter haul is likely to result in the truck-driver being in the paddock for more of the time than when wheat is being carted to the siding. This extra time may appear to be idle time. However, in case of a header breakage an extra pair of hands can be very valuable.

4. HANDLING SYSTEMS COMPARED

Having described and discussed the four main types of harvesting systems in use in New South Wales, the report will now compare them. It is hoped that in the process the advantages and disadvantages of each system will be highlighted.

Consideration will now be given to the main advantages and disadvantages of bag handling. The conventional bagging method has the advantage of being "tried and proven". It has been in use for many years, and the whole routine of using bags is well known to all wheatgrowers. The only capital investment required to convert a normal flat-top truck for the cartage of bagged wheat is £100 invested in a bag loader. So long as the farmer can have his bags sewn by contract and the carter has no difficulty in obtaining an assistant to help him load his truck, this system is simple, straightforward, and minimises the capital investment necessary for harvesting.

Thus for the small wheatfarmer bag handling has the following advantages:—

(1) The wheat harvest requires no extra labour if bag sewing and carting are done by contract.

(2) Heading can continue even when the siding has closed, or when the carrier is held up.

(3) The system requires a minimum capital outlay by the farmer. Indeed if capital is really short bags can be purchased on credit (i.e., out of the forthcoming first payment) for a surcharge of only a penny a bag.

(4) "The method worked satisfactorily last year."

These are four good reasons why bag handling of wheat has tended to persist amongst small to medium-sized wheatgrowers. The farmer who concentrates on the "art" of bagging-off, can obtain quite high speeds using this method. One farmer interviewed claimed to have averaged 575 *bags per day over his whole harvest,* using a bagging system where an assistant sewed the bags and kept the header moving while the driver knocked off for smoko and lunch. In a heavy even crop it may not be unreasonable to expect the header to strip a bag a minute. If the farmer can empty a 12-bag box in 4 minutes, then 12 bags can be taken off every 16 minutes and 51 bags can be stripped per hour. If the header can be kept moving for 11 hours a day this means that it is not unreasonable for this bagging system to give 560 bags per day.[5]

[5] In practice even a good day's heading is more likely to yield 200 to 300 bags. This is because of light and down crops, because of breakdowns and adjustments, because of stops for smoko, lunch and talk, because emptying the box takes longer than has been assumed, and because the header is more likely to work from 8.30 to 6.30 than for a full eleven hours. However, it is probably true that a farmer who is getting 250 bags off a day can increase the speed of his harvest almost as much by improving his bagging system as by changing over to bulk handling. Typically, his harvesting system could be speeded up by a careful check of the header before harvest (to reduce harvest breakdowns of the header), not wasting time dragging grain from the header bin unless it is necessary to reach the next dump, and concentrating at all times on keeping the header moving.

Turning now to consider the bag-to-bulk system outlined above. It is clear that this system has the very important advantage of saving the labour of sewing bags, and the need to stack bags on the lorry. This, in turn, means that there is no need to employ a bag-sewer or a driver's assistant. To convert from bagging to semi-bulk handling requires an outlay of £150 for a bulk bin, and £36 to convert a bag loader to a bag-to-bulk loader.[6]

For an expenditure of about £190 *it is possible to dispense with the services of a driver's assistant and a bag-sewer.*

If the bulk body and loader conversion is allowed a 10-year life (and as there are few moving parts on the bulk body its life is likely nearer 20 years) depreciation amounts to £19 per annum. If interest is allowed at 10 per cent on half the cost of the equipment, this comes to £9 10s. 0d. Thus conversion to semi-bulk handling can be achieved for an annual cost of less than £30. This annual cost could be covered by saving the services of a driver's assistant (earning £4 per day) for only eight days, *or* by eliminating the sewing of 2,000 bags (at 30s. 0d. per hundred). Semi-bulk handling involves the truck in a slightly slower turn-round and the bags may have be sewn in a hurry if they are rained on (so that they can be turned). However there appears to be an overwhelming advantage in converting from bag to semi-bulk handling.

It is always dangerous to make blanket recommendations in agriculture, but in view of the above discussion it is probably safe to say that *unless a farmer has a particular reason for delivering silo-sewn bags to the rail, it may be assumed that by bagging his wheat rather than carting it in bulk, he is increasing his costs by* 30*s.* 0*d. per hundred bags.*

It seems to be general practice for carriers to charge the same amount for carrying bulk or bagged wheat. This seems to be a satisfactory arrangement since it gives the carrier a generous return on his investment,[7] and the wheatgrower enjoys a significant cost saving, without any additional capital outlay.

The picture which emerges from an attempt to compare semi- and full-bulk handling is less clear cut. It should not be necessary at this stage to *repeat the warning that any one who goes into full-bulk handling without any farm storage must expect to have to stop his header just* 24 *hours after the siding stops receiving wheat.*

One limit on the saving to be expected from full-bulk handling is that saving on wear and tear of bags is likely to be only 1d. per bushel,[8] since a bag costing 3s. 0d. can be expected to survive at least 12 trips on the bag-to-bulk loader.

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[6] If a farmer or carrier is thinking of buying either a new bag loader or a new bag-to-bulk loader the extra cost is only £23. However, the cost of *conversion* from one loader to the other is about £36.

[7] It has been shown above that if the carrier carries for only 8 days he earns 10 per cent on his investment in a bulk body. For every day he carries in excess of 8 he will earn an extra profit of £4.

[8] If bags rose again to 6s. 0d. each the corresponding saving would, of course, be 2d. per bushel.

At present prices a farmer could not provide farm storage in special purpose silos or sheds for a capital outlay of less than 2s. 0d. a bushel (3s. 0d. a bushel is probably more realistic). If these silos are given a 20-year life, depreciation is 1.2d. per bushel per annum and interest at 5 per cent on the average value of the storage is .6d. per bushel per annum. Hence the annual cost of farm storage, at 1.8d. per bushel, is almost twice the cost of bag depreciation using semi-bulk handling.

In addition to farm storage, the farmer has to purchase bulk handling equipment. This will cost him from £1,400 to £2,000 according as he has, or has not, already got a truck on the place. Allowing his bulk handling equipment a 10-year life and interest at 10 per cent, this corresponds to an annual cost of from £210 to £300. Even allowing a 20-year life and 5 per cent interest, the annual cost is still £105 to £150. At the present price of cornsacks and machinery it would appear that the direct cash savings from full-bulk handling are insufficient to justify the investment involved.

Other important factors which may affect the decision to bulk handle are:—

(i) *The desire to reduce risk.*

(*a*) Bulk handling is a "weather-proof system". All wheat is under cover at night, and the danger of having to turn bags is removed.

(*b*) Bulk handling reduces header unloading time and heading proceeds about 20 per cent faster.

(*c*) There are no bags in the paddock subject to damage by fire or animal pests.

(ii) *The desire to cut out "unnecessary" and hard work.*

(iii) *The desire to "do the job properly".*

(iv) *The desire to be independent of casual labour.*

Bulk handling is obviously technically more efficient (even if it costs a little more), and naturally this tends to attract those farmers who can afford to be technically efficient.

It is obviously reasonable for a farmer to be influenced by the above ideas in deciding to adopt bulk handling but it is equally clear that it is extremely difficult to quantify their importance.

One farmer met on the survey was carting his wheat an extra 30 miles rather than leave his bags in the paddock until his local silo opened. This meant that he was paying approximately 10d. per bushel for the security of knowing his wheat had been delivered to the silo. It is clear that in this case it would be cheaper for the farmer to get into bulk handling with farm storage, rather than pay for this extra carting. Another farmer might have delayed harvesting or been willing to leave his bags in the paddock until the local silo opened. This latter farmer would probably not value very highly the "security" of bulk handling.

Farmers vary widely in their estimate of the urgency of harvesting itself. Some farmers will work a 7-day week during harvest. Others will work a 6-day or 5½-day week. Still others will stop harvesting in the middle of the week to attend a rodeo, or other special entertainment which may be

offering. There will be a corresponding range of values put on the increased speed of harvesting which can be obtained by bulk handling. For the farmer who harvest 7 days a week, a 20 per cent increase in the speed of harvesting is likely to be very important. For the farmer who works less than 6 days, increased speed is not likely to be thought so important.

It is interesting to note that the 20 per cent increase in heading time obtained from adopting bulk handling is approximately the same increase which could be obtained by employing a relief driver for a standard bagging system. Bulk handling has an annual cost of about £200, while the relief header driver would likely cost £5 per day. (Bulk handling, of course, offers other advantages than speed; in particular it saves the farmer from the sort of casual labour which costs £5 per day and can easily do £50 of damage to a header by sheer carelessness.)

We can probably fairly summarise this discussion of semi-versus-full-bulk handling for the small man by saying that *there are no evident financial advantages at present in switching from bag-to-bulk to full-bulk handling, but that full-bulk offers advantages which will be important to some farmers; namely, increased speed of harvesting, reduced worry about the weather, and a self-contained system of harvesting which cannot be disrupted by factors beyond the farmer's control.*

5. BULK HANDLING AND THE PREMIUM WHEATGROWER

One of the difficulties in making a survey of farms is that intelligent and neighbouring farmers may have entirely different views on questions of fact. From talking to premium wheatgrowers there appear to be two views on bulk handling of premium wheat:

(1) The first view is that bulk handling can never pay a premium grower because his wheat has to be bagged to go in the stack.

(2) The other view is that bulk handling and farm storage is particularly advantageous for the premium grower, since this allows him to save the cost of his bags.

It appears that, as usual, both statements are true. The extra costs associated with the delivery of bagged wheat to the stack rather than bulk wheat to the silo are:—

	s. d.	s. d. per bag
Cost of a bag	3 0	
Less AWB payment	1 6	
		1 6
String for stack sewing		2
Contract sewing (£3 per 100)		7.2
Total extra cost of bagged wheat		2 3.2

Thus the extra cost of delivering to the stack rather than the silo is about 9d. per bushel. If the wheatgrower is in a premium district the silo may be expected to pay a premium of about 1s. and it will pay the farmer to deliver to the stack if his premium offer exceeeds 1s. 9d. per bushel.

Stated in this way it looks as if anyone getting more than 1s. 9d. per bushel premium should deliver in bags. This argument neglects, however, the fact that if the grower has his own farm storage, then he can keep his wheat until bulk trucks are available (in late February or March). *He will then be able to obtain a premium for bulk wheat.* It has just been shown that bulk handling can save about 9d. per bushel. If the depreciation and interest on farm storage cost 3d. per bushel the saving is reduced to 6d. If then the annual interest and depreciation on say £1,400 of bulk-handling equipment is about £200, the premium wheat grower would only need to be harvesting 8,000 bushels for his bulk-handling equipment to pay for itself.

The above figures are a little rough but they do suggest bulk handling may be a financial advantage to medium-sized premium wheatgrowers. If they are in a position to invest £2,000 in additional machinery, the advantages of increased speed, safety and freedom from casual labour can be obtained without a serious financial sacrifice.

It may be objected that there are disadvantages in having to hold your wheat on the farm for three months, the most important disadvantage being that the AWB will not make the first payment until the wheat has gone across an official weighbridge. This will be an important consideration for the farmer who is just getting established. However, the farmer who can afford to wait would probably be able to get the mill to pay him bank interest on the value of the wheat held. By having wheat held on the farm the mill is able to reduce its need for overdraft accommodation. Typically if wheat is going to be held on the farm the contract for its sale is drawn up as soon as a sample is available, but the contract specifies March (or later) delivery.

Roughly it would appear that *if a premium wheatgrower has a harvest in excess of* 8,000 *bushels, then it is only if he cannot afford to wait three months for his first payment that he should refrain from going into bulk handling.*

6. FARM STORAGE

The main points to look for in selecting farm storage are:—

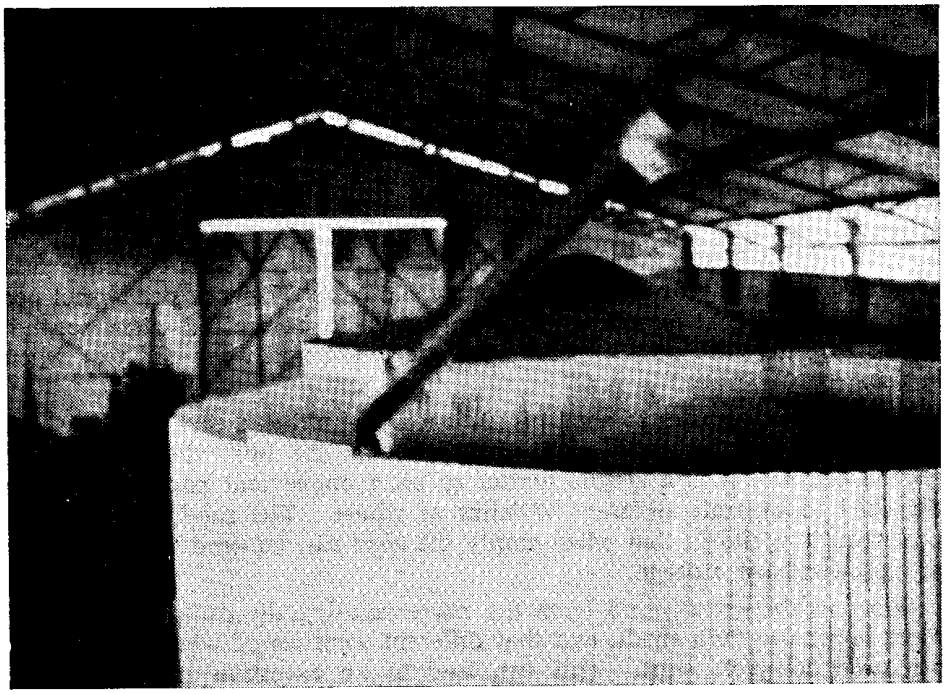
(1) Cost per bushel.
(2) Ability to separate different types of wheat or other grain.
(3) Convenience in filling and emptying.
(4) Mobility.

The dominant factor in deciding on a form of storage is likely to be cost. It is important, however, to be able to separate different quality wheats, and to be able to fill and empty the storage without too much fuss and bother. Mobility refers to the fact that if it is possible to move the storage to the crop, i.e., take it down after use and re-erect it near next year's crop, then this will save time carting from the paddock to the farm storage, and hence will increase the overall efficiency of the harvesting system.

The three main forms of storage which suggest themselves are:—

(1) Permanent silos.
(2) Wheat sheds.
(3) Temporary (weldmesh) silos.

The approximate capital costs per bushel of these different forms of storage are given in Table I.



A Temporary Silo with Auger

TABLE I

Capital Costs of Different Types of Farm Storage

Form of Storage	Capacity	Cost Item			Total Cost	Cost Per Bushel
		Materials	Foundation	Labour		
	Bushels	£	£	£	£	s. d.
Permanent Silo ..	3,000	275	86	116	477	3 2
Permanent Silo ..	8,500	720	117	311	1,148	2 8
Permanent Shed ..	8,000	630	30	200	860	2 2
Permanent Shed ..	12,000	940	45	300	1,285	2 2
Temporary Silo ..	1,900	13	7	2	22	3

The permanent silos referred to above, are conventional galvanised silos with a conical concrete foundation. The permanent sheds refer to galvanised iron sheds, with buttressed walls, and a flat stabilised earth floor. The temporary silos refer to 19-foot diameter silos made from 7 ft. 6 in. high weldmesh, and sisalkraft paper, and with a flat stabilised earth floor.

It is clear from the table that the use of temporary silos results in a big reduction in the capital cost of wheat stored on the farm. These temporary silos may be erected either within machinery sheds or other farm sheds or out

in the open. If the former alternative is used, then there is an additional "cost" of farm storage, in that machinery which would otherwise be protected has to be exposed to the elements.

It is reasonable to expect the permanent structures to have a longer life than the temporary installations. This difference is, however, insufficient to bring the annual cost of permanent installations into line with the temporary silos. If the permanent silos are allowed a life of 20 years and interest is charged at 5 per cent, the annual cost of a 3,000 and an 8,500-bushel silo is 2.85 and 2.4 pence per bushel, respectively. With the same rate of interest and a 4-year life the temporary silo costs .77 pence per bushel per year. The fact that temporary silos only need to be erected when needed, means that they are only exposed to depreciation and wear and tear when in use.

If the farmer decides to erect permanent wheat storage, then a bulk wheat shed has advantages over silos. In particular the bulk shed is cheaper per bushel, and it is a simple matter to erect convenient partitions within the shed to separate different varieties of wheat. The shed is also to be preferred to a silo in that when empty the shed can be used for machinery or miscellaneous storage.

Silos on the other hand have the corresponding disadvantage of being more expensive than sheds, and that different varieties of wheat have to be allocated complete silos. This can lead to an excessive amount of silo space having to remain empty.

The temporary silos discussed above are made from a circle of No. 8 weldmesh 60 feet in circumference and 7 ft. 6 in. high. Wheat is augered into and out of them. A description of the general procedure for the construction of one of these silos follows.

Construction of a Temporary Silo

To Fill:—

1. A suitable area of level ground is selected and the earth is stabilised and waterproofed with a bituminous compound.[9]

2. The weldmesh is set on edge and the two ends of the 60-foot strip are joined. This results in a circle of weldmesh 60 feet in circumference and 7 ft. 6 in. high.

3. A 30 to 40-foot auger is positioned to drop its wheat in the centre of the circle of weldmesh.

4. Wheat is emptied into the silo via the auger until the edge of the pile of wheat approaches the wire sides.

5. The first round of sisalkraft is now placed inside the weldmesh and a small amount of wheat is pushed up against the paper to hold it in place. The sisalkraft should be laid down in three or four sheets overlapping at the ends since the pressure of the wheat tends to force the paper through the holes of the weldmesh and hence some "give" is required in the paper lining.

6. Additional wheat is augered into the silo until another round of sisalkraft paper is required. It is important to see that the wheat is dropped

[9] Shell Terrolas is suitable for sealing the floor. This compound costs about four shillings per gallon on the farm, which is sufficient to seal one square yard of the floor of a silo.

into the centre of the silo since if it is off-centre there is an uneven force on the wire framework, and hence the silo will tend to become lopsided (if it does not actually fall over).

To Empty:—

1. A hole is cut in the weldmesh and paper to allow an auger to be inserted at ground level.

2. A 10-foot tube of sufficient diameter is pushed through this hole, and a sweep auger is inserted into the tube. Alternatively, this tube can be placed in position before the silo is filled. This 10-foot tube allows the wheat to be extracted *from the centre* of the silo. This ensures an *even pressure* on the walls and hence there is no tendency for the silo to tip over.

3. When no more wheat can be extracted in this way, the tube is removed, and the sweep auger is rotated to collect as much as possible of the wheat remaining in the silo.

4. A little shovelling and brushing is required to collect the last of the wheat.

5. The temporary silo is rolled up and stored away for use next year.

These weldmesh silos have been used inside sheds for a number of seasons with considerable success. When the necessary shed space is available they may be considered as a proven form of storage.

In the course of the survey three farmers said they were thinking of using these weldmesh silos *outside*. The first point which should be made is that it would make a great difference to the "economics of bulk-handling" if this plan proved practical. The point has repeatedly been made that some form of farm storage is of the utmost importance if bulk handling is to be independent of delay at the siding, but the annual cost per bushel of permanent silos or sheds is more than the corresponding saving on bags. If temporary silos could be used this cost would be eliminated. In case of delay at the siding the header could be emptied into a temporary silo in the paddock and hence heading could continue. The farmer would, of course, aim to catch up and empty his silos as soon as possible, but at least they would allow him to continue heading until all his wheat had been taken off.

Unfortunately, in the survey we did not contact anyone who had actually used temporary silos in the open, and many of the farmers to whom we mentioned the idea were sceptical, yet they did not think that there was any great loss if their bagged wheat was out in the rain. It would appear that if the temporary silo (covered with sisalkraft or polythene and sitting on a waterproofed floor) was thought of as a large wheat sack then it should suffer less loss from rain than bagged wheat, because the silo would be:—

(i) Better protected from the rain,
(ii) free from moisture seeping up from below, and
(iii) the surface area would be smaller in proportion to the volume of wheat.

The above ideas are just speculation at the moment, but they do suggest that some future research monies could profitably be allocated to the study of open air storage in New South Wales. It is unreasonable to expect an individual farmer to risk his whole crop testing a hunch about temporary silos! The point is that satisfactory temporary silos would be a great help in reducing the capital cost of a satisfactory bulk-handling system for the smaller wheatgrower.