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Potatoes - Storage  
L.M.B.

POTATO MARKETING BOARD

# SUTTON BRIDGE EXPERIMENTAL STATION

REPORT No. 5

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## The Economics of Potato Storage

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2. Finding the most efficient methods of dressing out samples to a quality standard.
3. The test marketing of quality grades.
4. The disposal to the best advantage of outgrades.

Its purpose, therefore, is to find ways of obtaining the best possible return from the potato crop and to pass on the information to producers.

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Sutton Bridge Experimental Station

## Report No. 5

# The Economics of Potato Storage

R. J. Callis

### SUMMARY

This report aims to provide information on the costs, returns and profits of potato storage.

The possibilities of different combinations of lengths of storage, types and sizes of store and methods of store management are discussed.

Increased returns from storage are assessed by considering the average monthly ware prices over the past six storage seasons and the expected ware losses with different methods of store management. It is found that a significant increase in ware prices is needed to cover the decrease in returns from ware losses.

The costs of storage are examined in relation to the storage structure (clamps, Dickie Pies, Dutch Barns or purpose-built bulk or box stores), the method of store management (convective ventilation, forced draught ventilation or recirculation of refrigerated air) and the method of loading/unloading (bulk or box). Those storage systems which seem preferable on the basis of costs are selected.

By considering the costs and returns together the profitability of potato storage in general and of certain systems in particular is assessed. It would appear that in many cases potato storage has not shown a great profit in the past. Certain more profitable systems of potato storage are then outlined.

Head of Scientific Research  
C. P. Hampson

### ACKNOWLEDGEMENT

Acknowledgement is made to Mr. J. D. Young of the Farm Buildings Centre, Stoneleigh, for help with the building costs.



# SUTTON BRIDGE EXPERIMENTAL STATION

## REPORT NO. 5

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# The Economics of Potato Storage

## INTRODUCTION

About eighty-five per cent of maincrop potatoes are put into storage (P.M.B., 1970). The purpose of this report is to provide information on the profitability of potato storage, which can be used by a farmer or adviser in costing and judging individual situations. The main source of this information is experience gained at the Potato Marketing Board's Experimental Station at Sutton Bridge.

In the first part possible systems of storage are outlined. The second and third parts analyse the increases in returns from storage and the costs of storage. Finally, the last part considers the situation as a whole. A great deal of relevant background information is given in the Appendices.

The United Kingdom will change over to decimal currency on 15th February, 1971. Shillings and pence have been used throughout this report but information about decimal currency and a conversion table can be found in Appendix I.

Certain definitions and explanations of abbreviations used in the text can be found in Appendix II.

## PART 1

### Systems of Storage

Whilst producers as a whole must store a large percentage of the potato crop to meet the demands of the market, the individual farmer may sell all his crop off the field, store it all, or sell and store in varying proportions. In deciding which of these alternatives to follow there are three main financial factors to be considered: the availability of working and long term capital for investment in storage, the profits to be expected from different storage systems, and the rates of return these give on the capital invested.

These aspects will be dealt with in the following parts. It is intended in this part to mention the non-financial factors which may affect the choice of storage system and to outline briefly those systems which will be considered in this report.

The decision to sell off the field or to store can be affected by the conditions at lifting time. Damp, muddy conditions may make potatoes unfit for sale off the field and at the same time may prevent anything more than temporary storage. Selling off the field may also be impracticable because of the extra labour required for grading at a time when labour is already in great demand and because of the risk of over-supplied markets.

Having decided to store, there is a large array of possibilities as to (1) length of storage; (2) type, and (3) size of store; and (4) method of store management.

#### 1. Length of Storage

Potatoes can be sold out of store any time up to the beginning of June or still later, particularly for processing. Many arable farmers empty their potato stores during the winter when there is no other important work, even though this may result in lower returns. Furthermore, on these farms there is usually a priority for field work during fine spells in the months of March, April and May. Many producers, for these reasons, are unable to store until later in the season unless the potatoes are sold without grading to a pre-packing station or unloaded by casual labour.

It usually takes several weeks to empty the potato stores on one farm, depending on the amount stored and the size of riddling gang. This work need not be done continuously but may be spread over a number of months; thus, there is some degree of flexibility in the time of sale. Large-scale producers and co-operative storage and marketing groups usually sell throughout the storage season in order to make the maximum use of the grading and marketing facilities at their disposal.



In this report the sale of potatoes at varying times of the storage season will be discussed. It seems practical to consider November and December as a period of temporary storage.

## 2. Type of Store

In the past the majority of stored potatoes were kept in outdoor stores, but today most are stored in buildings (P.M.B., 1965 and 1970a). One advantage of outside stores may be the reduction of the distance between field and store which can be very important at harvest time, when labour is short and the rate of harvesting must be kept as high as possible. A well drained, level site is essential. The main disadvantage of outside storage is the difficulty of emptying the stores in bad weather. Polythene shelters can give protection at riddling; but even so the stores cannot be emptied in very cold weather in case the potatoes get frosted. With indoor storage, riddling can continue in bad weather when little other work is possible. Indoor storage is essential for potatoes kept for crisping because they are usually maintained at a temperature of above 48°F.

If indoor storage is to be used, there is then the choice between bulk and box systems. The differences between these two are mainly financial and this aspect will be dealt with in later sections of this report. It is easier with boxes to store a number of different types of potato separately. When considering new methods, account should be taken by the producer of his existing system of harvesting and storage. A comparison of harvesting, handling and storage in bulk and box systems is the subject of a forthcoming report. (P.M.B., 1971).

Two types of outdoor store—clamps and Dickie Pies—and several types of indoor storage—Dutch Barns and permanent buildings with different types of walling, under both bulk and box systems—will be considered in this report.

A farmer who has existing buildings which can be converted for storage will normally use these in order to save capital expenditure, although they may impose some limitations on the amount which can be stored and the method of store management.

## 3. Size of Store

Certain types of store are limited in size because of the large ground area covered, in relation to the tonnage stored. Clamps for example, are limited by the length of the site and Dickie Pies rarely exceed 300 tons to ensure adequate ventilation at the centre of the Pie. With these outside stores it is sometimes better to have several small ones at different places in order to keep the travelling distance short.

Dutch Barn stores are usually limited to 500-600 tons because of the large volume taken up by the straw walls. Purpose-built stores in which potatoes are stored up to 12 ft. high can hold up to 2,000 tons or more; because of the volume taken up by the boxes, box stores hold considerably less than bulk stores of similar dimensions unless the potatoes are stored higher in them.

## 4. Store Management

There are four main methods of store management which will be considered in this report: minimal control, convective ventilation, forced draught ventilation and recirculation of refrigerated air (abbreviated respectively throughout this Report to M.C., C.V., F.D., and R.R.). The control over the condition of the potatoes increases with these methods in the order given, from none with minimal control to the greatest with refrigeration. A sprout suppressant is often used in conjunction with convective ventilation and may also be necessary with forced draught ventilation, depending on the actual temperature of the potatoes.

Minimal control is traditionally used with clamps. Dickie Pies, on the other hand, usually have convective ventilation. With storage in purpose-built and Dutch Barn stores some form of controlled ventilation is likely. Refrigeration is only fully effective if there is some means of recirculation which can be provided by a return duct.

All methods of store management can be used for storing potatoes to any part of the season although, as will be seen later, they are not equally suited for this. A highly insulated building is needed for potatoes kept into the summer, especially if refrigeration is being used.

Methods which give greater control over the storage environment are generally more complex and consequently require a higher degree of skill and a greater amount of attention.



## 5. Summary

Table 1 below summarises the different systems of storage which will be considered in the following chapters. These systems have been formed by combining the types of store with the appropriate methods of store management, sizes and unloading times.

TABLE 1.

<i>Type of Store:</i>	<i>Store Management:</i>	<i>Approximate Size (tons)</i>	<i>Times of Unloading:</i>
Highly Insulated Bulk Store	R.R. F.D. (+C.I.P.C.) C.V. +C.I.P.C.	500 2,000	January—June
Highly Insulated Box Store	R.R. F.D. (+C.I.P.C.) C.V. +C.I.P.C.	500 2,000	January—June
Standard Insulated Bulk Store	R.R. F.D. (+C.I.P.C.) C.V. +C.I.P.C.	500 2,000	January—April
Standard Insulated Box Store	R.R. F.D. (+C.I.P.C.) C.V. +C.I.P.C.	500 2,000	January—April
Straw Insulated Bulk Store	R.R. F.D. (+C.I.P.C.) C.V. +C.I.P.C.	500 2,000	January—April
Straw Insulated Box Store	R.R. F.D. (+C.I.P.C.) C.V. +C.I.P.C.	500 2,000	January—April
Dutch Barn Bulk Store	R.R. F.D. (+C.I.P.C.) C.V. +C.I.P.C.	200 500	January—April
Dutch Barn Box Store	R.R. F.D. (+C.I.P.C.) C.V. +C.I.P.C.	200 500	January—April
Dickie Pie	C.V. +C.I.P.C.	200	January—April
Clamp	M.C.	200	January—May

### Notes:

1. C.I.P.C. is a sprout suppressant. (Other sprout suppressants may be used—see Appendix 8)
2. In the description of specific purpose-built stores throughout this Report:
  - “Highly Insulated” implies a U value of 0.1 or better for the roof and walls using a proprietary insulation material;
  - “Standard Insulated” implies a U value of 0.2 for the roof and walls using a proprietary insulation material;
  - “Straw Insulated” implies the use of straw bale walls, two bales wide, to give a U value of 0.2 for the walls.



## PART II

### Increased Returns from Storage

Increased Returns from Storage are defined for the purpose of this report as:

Increase in Returns =  $\text{Tonnage Out} \times \text{Average Value per Ton Out}$

—  $\text{Tonnage In} \times \text{Average Value Per Ton In}$ .

The tonnages into and out of store can be divided up into various economic categories—ware, stockfeed and waste—and the values of these used instead of the average values. It can be profitable at times to sell mids but at other times there is little market for them and they have to be sold with stockfeed. In this report mids will not be considered separately.

Using these different categories (waste has no value) the above equation can be expressed in a more suitable way for later calculations as:

Increase in Returns =  $\% \text{ Ware Out} \times \text{Ware Price Increase}$

—  $\% \text{ Loss in Ware} \times \text{Ware Price Before Storage}$

+  $\% \text{ Stockfeed Out} \times \text{Increase in Stockfeed Price}$

(where prices are per ton and percentages are per ton into store).

There are thus three factors affecting the increase in returns from storage:

- (1) Gains from Increased Ware Prices.
- (2) Decrease in Returns from Loss of Ware.
- (3) Gains from Sale of Stockfeed.

#### 1. Gains from Increased Ware Prices

The gain from increased ware prices is affected by four factors.

##### (a) Increased Ware Price Through the Storage Season.

The monthly price changes for ware potatoes of the varieties King Edward, Red King and Redskin over the last five storage seasons are shown in Figure 1 and Table 2. Large surpluses were produced in the years 1964-65, 1965-66 and 1967-68. Despite this the October average prices in both 1964 and 1967 were fairly high because of poor harvesting conditions. Consequently, there was little gain (in fact in some months a loss) through the storage season. This is in contrast to 1965-66 when the October price was low but, due to a successful market support programme by the Board, supplies on the market were reduced and there was a substantial increase in prices over the latter part of the season.

TABLE 2.  
AVERAGE MONTHLY PRODUCERS' PRICES THROUGHOUT THE STORAGE SEASON  
FOR ENGLAND AND WALES

For King Edward, Red King and Redskin								
Year:	Oct. Price:	Nov.	Dec.	Change from the October Price				
				Jan.	Feb.	March	April	May
1964-1965	£16 8s.	+22s.	+33s.	+27s.	+ 7s.	+24s.	+38s.	+61s.
1965-1966	£13 18s.	—14s.	+ 6s.	+23s.	+24s.	+65s.	+198s.	+201s.
1966-1967	£19 18s.	+34s.	+37s.	+55s.	+44s.	+65s.	+160s.	+207s.
1967-1968	£16 8s.	+16s.	+10s.	+ 9s.	— 8s.	+12s.	+33s.	+36s.
1968-1969	£17 17s.	+17s.	+34s.	+46s.	+21s.	+24s.	+111s.	+136s.
1969-1970	£18 18s.	+59s.	+84s.	+140s.	+146s.	+239s.	+389s.	+150s.
Average	£17 4s.	+22s.	+34s.	+50s.	+39s.	+71s.	+155s.	+132s.
For Majestic and other 'White' Varieties								
Year:	Oct. Price:	Nov.	Dec.	Change from the October Price				
				Jan.	Feb.	March	April	May
1964-1965	£12 12s.	+14s.	+19s.	+18s.	+ 0	+27s.	+45s.	+97s.
1965-1966	£11 15s.	—13s.	+ 3s.	+29s.	+30s.	+66s.	+130s.	+182s.
1966-1967	£17 5s.	+27s.	+26s.	+54s.	+19s.	+38s.	+110s.	+238s.
1967-1968	£13 15s.	— 1s.	—11s.	— 4s.	—16s.	+ 2s.	+16s.	+33s.
1968-1969	£13 0s.	+14s.	+25s.	+34s.	+36s.	+37s.	+136s.	+178s.
1969-1970	£16 10s.	+50s.	+77s.	+128s.	+138s.	+254s.	+394s.	+167s.
Average	£14 3s.	+15s.	+23s.	+43s.	+34s.	+71s.	+138s.	+149s.

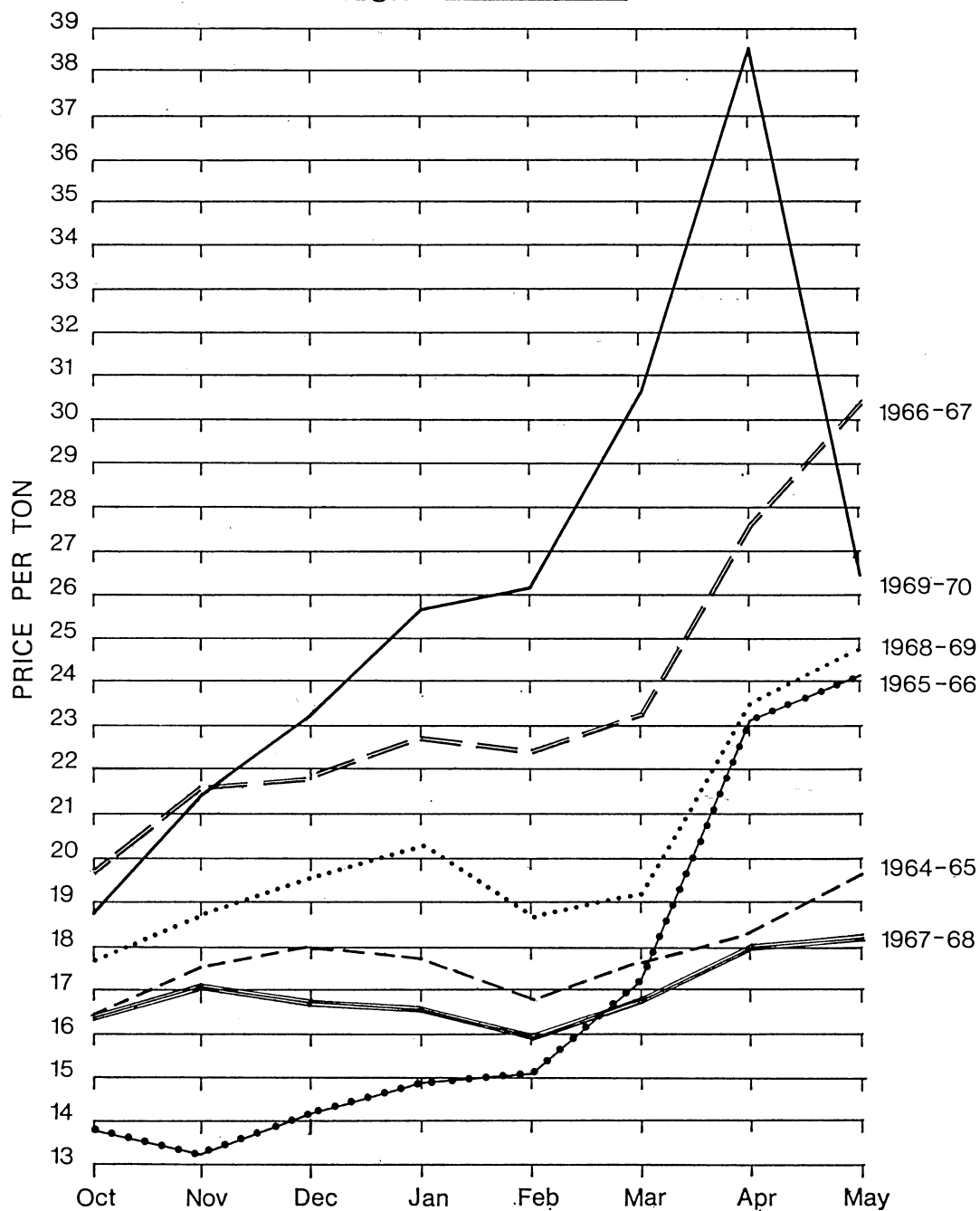
Notes:

(a) All prices are to the nearest shilling.

(b) Prices for Scotland are given in Appendix 3.



Fig 1 Average Monthly Producers' Prices for  
England and Wales for the Varieties King  
£ Edward, Red King and Redskin



An important point to note is the usual fall in the average market price from January to February. Farm labour is usually as much available for potato riddling in January as in February; presumably, therefore, many farmers delay emptying their stores until February hoping for higher prices, which do not usually materialise. In the 1968-69 season, the low prices in February continued into March, probably because normal field work was late starting because of the wet conditions at the time. Reduced supplies, due to producers concentrating on planting the new crop and rumours of a serious shortage, caused prices to rise extremely high in April, 1970. The resumption of normal supplies during May coupled with higher imports of earlies and a lower demand for old potatoes because of the warm weather, led to a significant fall in prices.

The picture for Majestic and other white varieties is very similar (see Table 2) except that the prices are less than the corresponding ones for King Edward potatoes.

The monthly average figures hide the weekly fluctuations caused mainly by the effects of weather on market supplies. Cold weather no longer has such a marked effect on prices as in the past because of the increasing predominance of indoor storage; dry weather in late February, March and April tends to reduce the movement of potatoes because of the priority of field cultivations on most potato growing farms. Farmers who can take advantage of these fluctuations obviously stand to gain above average price increases.

**(b) Increased Ware Price—Good Appearance after Storage.**

Above average increased prices can also be obtained for potatoes which maintain a good appearance throughout storage. After storage until April and May, potatoes in stores with refrigeration and recirculation are affected much less by silver scurf than those under other methods of store management because of their lower storage temperature. This is of great importance in the marketing of washed, quality graded potatoes as the extraction of a high percentage for the top grade is essential. (P.M.B., 1968). King Edward potatoes also keep their colour better under refrigeration and may fetch a premium of £2 or more per ton over average ware prices.

**(c) Increased Ware Price—Sale for Special Requirements.**

Growers of potatoes for special purposes (e.g. crisping) usually have a graduated seasonal price rise specified in their contracts. They are, therefore, in a more secure position than other producers and are protected from poor markets, but cannot take advantage of high prices.

One way of increasing the returns after storage may be the marketing of quality graded potatoes. (P.M.B., 1968). This involves dressing potatoes for sale into several different grades to meet the requirements of different types of user.

**(d) Ware Percentage.**

Not all potatoes put into store are of ware standard and after storage this quantity is likely to be reduced. The percentage of ware from the tonnage put into store is an important factor affecting the gains from increased ware prices. Table 3 shows how the potential gains can be seriously reduced by lowering this ware percentage.

TABLE 3.  
INCREASED RETURNS (£) PER TON OF POTATOES PUT INTO STORE

Ware after Storage as a % of Tonnage in	Increase in Ware Price during Storage (£ per ton)							
	1	2	3	4	5	6	7	8
90	0.90	1.80	2.70	3.60	4.50	5.40	6.30	7.20
85	0.85	1.70	2.55	3.40	4.25	5.10	5.95	6.80
80	0.80	1.60	2.40	3.20	4.00	4.80	5.60	6.40
75	0.75	1.50	2.25	3.00	3.75	4.50	5.25	6.00
70	0.70	1.40	2.10	2.80	3.50	4.20	4.90	5.60
65	0.65	1.30	1.95	2.60	3.25	3.90	4.55	5.20
60	0.60	1.20	1.80	2.40	3.00	3.60	4.20	4.80

The ware percentage after storage is influenced by two factors; one of these is the ware percentage before storage which has averaged 85% at Sutton Bridge over the past few years with



the figures for individual stores ranging from 75% to 93%. The second factor is loss of ware during storage.

## 2. Decrease in Returns from Loss of Ware

Store losses can be of three kinds: first, an actual loss of weight of stored potatoes (shrinkage); second, damage, and third, disease, which result in a lowering of the ware percentage.

### (a) Shrinkage.

Shrinkage results from respiration, evaporation of water vapour and sprout growth. Table 4 shows the average daily weight loss and its probable range for King Edward potatoes kept under different methods of store management. This data is taken from results of experiments carried out on many different stores over several years at Sutton Bridge. Very wide ranges are given because weight losses are also affected by the initial condition (amount of damage, disease and soil) of the potatoes. It has been assumed that weight loss is constant throughout the storage period. This is not strictly accurate as weight loss is higher at the beginning and end of storage; and in stores with forced draught or convective ventilation, it can vary with the outside temperature. However, if a fairly long storage season is considered and only potatoes under full environmental control are kept into the summer, the approximation is reasonable. Forced draught ventilation is not effective for cool storage after the end of April through lack of cold outside air. (Nash and Lennard, 1970). For potatoes stored until May with convective ventilation or forced draught ventilation, the daily weight loss is likely to be nearer the higher end of the range.

TABLE 4.  
DAILY WEIGHT LOSS %

<i>Management</i>	<i>Average</i>	<i>Range</i>	<i>No. of Stores *</i>	<i>Years</i>
R.R.	0.024	0.016—0.031	28	4
F.D.+C.I.P.C.	0.030	0.015—0.040	13	4
C.V.+C.I.P.C.	0.035	0.022—0.047	20	5
Nil **	0.029	0.019—0.041	3	3

\* total number over all years.

\*\* sprout suppressants may be used in clamps

The Table shows that recirculation of refrigerated air has the lowest weight loss. Forced draught ventilation has the third lowest and convective ventilation has the highest on average. Both are less consistent than refrigeration, having much wider probable ranges. Minimal control, as applied to clamps, results in a fairly low weight loss but more sprouting than other methods, confirming earlier results (Wilson, Twiss and Lessells, 1962). These weight losses do not include disease losses (e.g. from bacterial soft rot) which can be very much higher but may be controlled by temperature management during storage.

Neither type nor size of store has had any consistent effect on these weight losses from convective ventilation, forced draught ventilation and refrigeration. Experiments at Sutton Bridge comparing the weight losses of King Edward with those from Majestic and other maincrop varieties have shown that King Edward potatoes consistently lose more than the others.

Table 5 shows weight losses per day converted into total weight losses for different storage periods, again assuming a constant daily weight loss.

The figures in this Table show that over a fairly long storage period (180 days) convective ventilated potatoes are likely to lose about 1% (6.3 compared with 5.4) more weight than those stored under forced draught ventilation. These in turn are likely to lose about 1% more weight (5.4 compared with 4.5) than potatoes kept under refrigeration. The real advantage of refrigeration is that under this method of store management, potatoes can be safely stored in good condition until June. Potatoes stored until May or June under forced draught or convective ventilation could lose 2.5% more weight (7.4-9.5 compared with 5.3 and 8.4-10.8 compared with 6.0) than those with refrigeration. When weight losses reach about 10% potatoes tend to go soft. They are then difficult to peel and consequently fetch a lower price.

TABLE 5.  
TOTAL WEIGHT LOST (%) FOR DIFFERENT DAILY WEIGHT LOSSES  
OVER DIFFERENT STORAGE PERIODS

	<div style="display: flex; justify-content: space-around; align-items: center;"> <span>← × →</span> <span>← × →</span> <span>R.R.</span> </div>						M.C.	C.V. 0.05
	<div style="display: flex; justify-content: space-around; align-items: center;"> <span>← × →</span> <span>← × →</span> <span>← × →</span> </div>						F.D.	
	0.015	0.02	0.025	0.03	0.035	0.04	0.045	
90 days (mid Oct.-mid Jan.)	1.4	1.8	2.3	2.7	3.2	3.6	4.1	4.5
120 days (mid Oct.-mid Feb.)	1.8	2.4	3.0	3.6	4.2	4.8	5.4	6.0
150 days (mid Oct.-mid Mar.)	2.3	3.0	3.8	4.5	5.3	6.0	6.8	7.5
180 days (mid Oct.-mid Apr.)	2.7	3.6	4.5	5.4	6.3	7.2	8.1	9.0
210 days (mid-Oct.-mid May)	3.2	4.2	5.3	6.3	7.4	8.4	9.5	10.5
240 days (mid Oct.-mid June)	3.6	4.8	6.0	7.2	8.4	9.6	10.8	12.0

The cash value of a reduction in weight losses is shown in Table 6. Not all the shrinkage occurs in ware potatoes. It has been assumed, in the calculation of this Table, that 20% of potatoes would be non-ware after storage and so the saving has been reduced accordingly.

TABLE 6.  
SAVING FROM REDUCED WEIGHT LOSSES  
(PER TON PUT INTO STORE)

Decrease in Weight Loss %	Ware Price (per ton) After Storage				
	£15. 2s. 6d.	£18. 15s. 0d.	£21. 17s. 6d.	£25. 0s. 0d.	£28. 2s. 6d.
1.0	2/6	3/-	3/6	4/-	4/6
2.0	5/-	6/-	7/-	8/-	9/-
3.0	7/6	9/-	10/6	12/-	13/6
4.0	10/-	12/-	14/-	16/-	18/-
5.0	12/6	15/-	17/6	20/-	22/6

*N.B.*—The ware prices in this Table were chosen to cover a wide range and to give exact savings for convenience.

For a 1% expected difference in weight loss, e.g. between refrigeration and forced draught, and between forced draught and convective ventilation over a fairly long storage season (180 days), the saving of losses is worth between 2/6 and 4/6 per ton depending on the sale price. If potatoes are kept until the end of May, the difference between refrigeration and convective ventilation may increase to 9/- or more per ton.

**(b) Damage.**

Serious damage makes a potato unfit for human consumption; it may be a complete loss or usable for stockfeed. Any damage can allow the spread of disease and so increase indirectly the amount of stockfeed and rotten potatoes. Damage nearly all occurs during harvesting and the loading and unloading of the stores and so is independent of storage period or method of store management (Twiss & Jones, 1965). No consistent difference in damage levels has been found between bulk and box systems used in loading stores; but limited experience at Sutton Bridge suggests that unloading by hand fork is likely to cause more damage than carefully carried out tractor bucket or box unloading.

**(c) Disease.**

Rotting diseases make potatoes unfit even for stockfeed and so they represent a complete loss to the producer. Widespread development of rotting diseases can also reduce the expected increase in returns by forcing the farmer to empty his store earlier than planned even if prices are unsatisfactory. But if only those potatoes in good condition are stored for a long time (the rest being sold as soon as possible) and good store



management is carried out (P.M.B., 1969), there should be little risk of serious development of rotting diseases, especially if refrigeration is used.

(d) **Overall Loss of Ware.**

Experience at Sutton Bridge suggests that damage and disease probably cause a loss in ware percentage of about 5% in potatoes stored in a reasonably good condition and with good store management. This figure would be affected very little by the length of storage but could increase markedly if care is not taken to minimise damage. When there is a widespread development of rotting diseases, disastrous losses of 10-20% or more can occur and these will increase with time unless the spread of disease is checked.

Combining these ware losses from shrinkage, damage and disease gives an expected minimum fall in the ware percentage of 6-7% of potatoes stored until the beginning of January and a probable total fall of between 10% and 15% for potatoes in good condition stored until March or later.

The costs of different decreases in the percentage of ware potatoes are shown in Table 7. The higher the October ware price the greater the cost for a given ware loss. It is assumed, for ease of calculation, that the amount of ware loss going to stockfeed is equal to the amount of stockfeed which is wasted through rotting and weight loss. All the ware loss can then be considered worthless and the stockfeed percentage remains unchanged during storage.

TABLE 7.  
THE COST OF DIFFERENT WARE LOSSES  
(PER TON PUT INTO STORE)

<i>Loss in Ware %</i>	<i>£12 10s. 0d.</i>	<i>£15 0s. 0d.</i>	<i>£17 10s. 0d.</i>	<i>£20 0s. 0d.</i>
5	12/6	15/-	17/6	20/-
10	25/-	30/-	35/-	40/-
15	37/6	45/-	52/6	60/-
20	50/-	60/-	70/-	80/-

**3. Gains from the Sale of Stockfeed.**

In recent years stockfeed has usually been worth about £3-£4 per ton after storage, and £2 or £2 10s. per ton before storage. The gain from storage could be £2 per ton but is much more likely to be £1 or 10/- per ton. Assuming 15% of the tonnage into store goes for stockfeed afterwards this gives respectively gains of 6/-, 3/- or 1/6 per ton put into store.

**4. Calculation of Increased Returns from Storage.**

The following example should allow those interested to work out the increase in returns for the situations they are concerned with, using the figures in this Report. Farmers who wish to use their own figures must weigh the potatoes into and out of store and estimate the ware percentage before storage.

*Example:—Calculation of Increased Returns.*

*Assumptions:* King Edward potatoes stored for sale in April.

1. Ware % before storage—85% (Page 6)
2. Ware loss—10% (Page 9)
3. Ware price before storage approximately £17 10s. per ton (Table 2)
4. Ware price increase—£8 per ton (Table 2)
5. Stockfeed price—£2 per ton before storage; £3 per ton after storage (Page 9)
6. Stockfeed %—15% before and after storage (Page 9)

(All percentages are of the tonnage of potatoes put into store).

*Then:*

$$\% \text{ Ware Out} \times \text{Ware Price Increase} = 75\% \times £8 \text{ per ton}$$

$$= £6 \text{ per ton (from Table 3)}$$

$$\% \text{ Loss in Ware} \times \text{Ware Price Before Storage} = 10\% \times £17 \text{ 10s. per ton}$$

$$= £1 \text{ 15s. per ton (from Table 7)}$$

$$\% \text{ Stockfeed Out} \times \text{Increase in Stockfeed Price} = 15\% \times £1 \text{ per ton}$$

$$= 3\text{-} \text{ per ton (from Section 3).}$$

*Therefore:* Increase in Returns = £6 — £1 15s. + 3/- = £4 8s. per ton into store.

Fig 2

The Increase in Returns for Different Ware Price Increases and Different Ware Losses from the Total Crop Stored

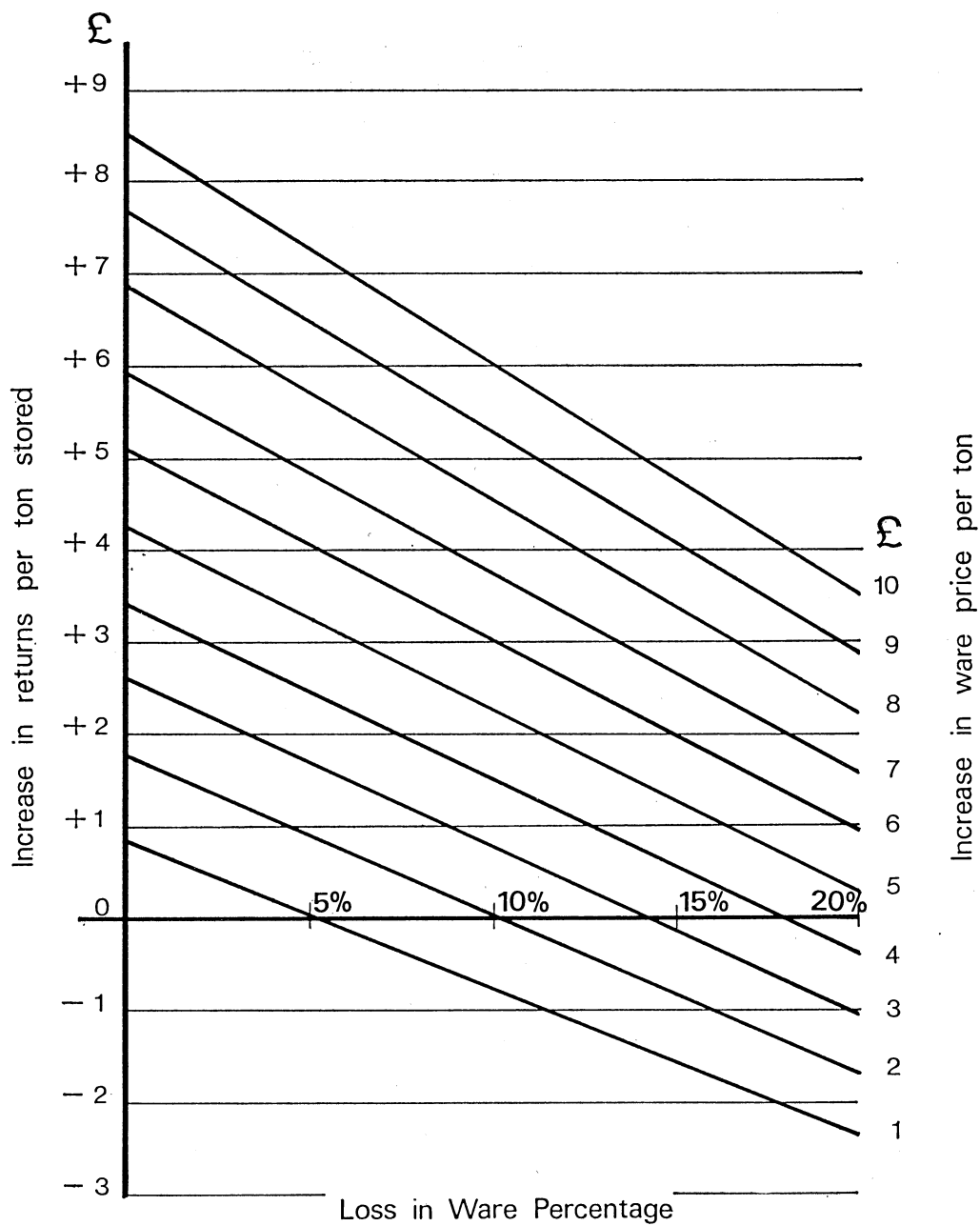




Figure 2 is derived from Tables 3 and 7. It shows the breakeven increase in returns per ton stored for different price increases and ware losses. Any gains from the sale of stockfeed have been ignored but their possibility should not be forgotten. This graph assumes an initial ware percentage of 85% and an October ware price of £15 per ton. A higher initial ware percentage and a lower October ware price would each improve the increase in returns shown in Figure 2. Conversely, a lower initial ware percentage and a higher October ware price would have the opposite effect. It can be seen from this graph that price increases of about £1, £2 and £3 per ton are required to cover ware losses of 5%, 10% and 15% respectively.

Bearing this in mind it is interesting to re-examine Table 2. Clearly these ware losses are not all covered in those seasons (e.g. 1964-5, 1967-8) in which large surpluses persist right through until April and May. Even in seasons with good price increases ware losses must be kept to a minimum if other costs are to be covered and any profit made. In these years, storage until late in the season can be very profitable if losses are small.

Increased returns from potato storage are affected by the whole situation in which the potatoes are grown as well as stored. How they are stored and the resulting costs will be discussed in the next part.

## PART III

### The Costs of Storage

Storage costs may be divided into (1) structure costs, (2) store management costs and (3) loading/unloading costs. These categories are inter-related and so it will be necessary to consider them together in (4) total costs.

Costs vary from one situation to another. The costs given in this report are only meant to provide general guidance and form a basis for discussion. It is important for the individual farmer to have costings prepared for his own case. For this reason, the background information and assumptions used in the calculations of these costs are given in Appendices 4-10. A more detailed technical report on the construction of potato stores is to be published by the P.M.B. (P.M.B., 1971).

#### 1. Structure Costs

This section is concerned with the costs of providing different structures of various sizes for the storage of potatoes.

##### (a) Capital Investment

Table 8 shows the capital investment required for the types and sizes of store outlined in Part I and described in Appendix 4. Clamps involve no fixed investment and Dickie Pies only a small amount of short term capital, but Dutch Barn stores need a substantial amount of both short and long term capital. Use of an existing Dutch Barn would remove the need for long term investment but the eaves' height would probably be higher in a Dutch Barn intended for other purposes so that a greater amount of straw would be required for the walls. When boxes are used for storage in Dutch Barns the investment in them is greater than that for the building even when the costings are based on an inexpensive box of light construction. Two 10 cwt. boxes cost more than a 1 ton box of similar construction and the investment in them would therefore be greater still.

Purpose-built stores involve a much greater long term investment and for bulk storage very little short term investment. There is a saving of capital in those stores using straw bale insulation—and with proprietary insulation materials it costs little more to insulate a store to a high U value (0.1) than to achieve the minimum insulation necessary (U value=0.2). For this reason, the standard insulated store is only considered once in the Table and it is assumed thereafter that if any insulation material is to be built into the walls, a highly insulated building will be chosen.

With convective ventilation it is not recommended to store potatoes in bulk to a height much above 8 ft., while with forced draught ventilation or refrigeration, potatoes can be stored up to at least 12 ft. Storage to a height of 8 ft. necessitates a larger building to hold a given tonnage. The cost of this larger building does not increase in proportion to its size because of a saving in the height of the building and of the thrust walls (Appendix 7), but the total cost is still greater compared with corresponding 12 ft. storage. In view of this greater cost and the size of the building which would be needed, 8 ft. storage has not been considered at the 2,000 ton level.

Straw bale insulated box stores have not been considered because they would involve little saving of the thrust walls compared with a purpose-built box store. In contrast to bulk stores it does not matter to what height boxes are stored with convective ventilation provided there is adequate head room. Air can circulate around boxes without the need for ducts. If forced draught ventilation or refrigeration is used, ducts are necessary. From Table 8 it can be seen that a marked saving can be achieved if underfloor laterals and a main duct are not required.

One ton boxes stacked six high, instead of four high, have been costed in at the 2,000 ton level, and show a marked lowering of building costs. An industrial fork lift truck with an extended lift would be needed to stack the boxes this high. A comparison with 1 ton boxes stacked four high has not been shown in Table 8 as the building costs would be similar to those for 10 cwt. boxes.

TABLE 8.  
CAPITAL INVESTMENT IN POTATO STORAGE STRUCTURES

	<i>Clamp 200 tons £</i>	<i>Dickie Pie 200 tons £</i>	<i>Dutch Barn Bulk 200 tons £</i>	<i>500 tons £</i>	<i>Dutch Barn (1 ton) Box 224 tons £</i>	<i>504 tons £</i>	<i>Dutch Barn (10 cwt.) Box 225 tons £</i>	<i>495 tons £</i>
LONG TERM Building	—	—	900	1,900	900	1,700	900	1,700
SHORT TERM Boxes	—	—	—	—	1,120	2,520	1,415	3,095
Straw walls	—	—	225	420	225	375	225	375
Ducts	—	80	162	383	54	117	54	117
Sleepers	—	—	18	33	—	—	—	—
Cost per ton	0	0·8	6·5	5·5	10·3	9·4	11·5	10·7

	<i>Straw Insulated Bulk Store 8' Storage 520 tons £</i>	<i>Standard Insulated Bulk Store 8' Storage 510 tons £</i>	<i>Highly Insulated Bulk Store 8' Storage 510 tons £</i>	<i>Straw Insulated Bulk Store 12' Storage 470 tons £</i>	<i>1,880 tons £</i>	<i>Highly Insulated Bulk Store 12' Storage 520 tons £</i>	<i>1,880 tons £</i>
LONG TERM Building	4,200	4,540	4,610	3,220	9,090	3,980	10,530
SHORT TERM Doorway retaining boards	50	50	50	70	140	70	140
Cost per ton	8·2	9·0	9·1	7·0	4·9	7·8	5·7

	<i>Highly Insulated (10 cwt.) Box Store</i>			<i>Highly Insulated (1 ton—stacked 6 high) Box Store</i>	
	<i>With Ducts 470 tons £</i>	<i>Without Ducts 470 tons £</i>	<i>1,940 tons £</i>	<i>With Ducts 1,960 tons £</i>	<i>Without Ducts 1,960 tons £</i>
LONG TERM Building	4,060	3,160	9,060	9,380	7,420
SHORT TERM Boxes	2,940	2,940	12,125	9,800	9,800
Cost per ton	14·9	13·0	10·9	9·8	8·8

- Notes: 1. Long term—6 years and over; Short term—2 to 5 years.  
2. The present rate of grant of 40% (Farm Improvement Scheme and Investment Grant) has been deducted from the cost of the buildings.  
3. See Appendices 4 to 7 for background information and assumptions.  
4. Ducts only necessary for F.D. or R.R. in Dutch Barn Box Store.

In some cases (e.g. 500 ton level with ducts) box stores cost more than corresponding bulk stores; in others (e.g. 2,000 ton level, 1 ton boxes stacked six high) they cost less. The capital investment in boxes is again greater with 10 cwt. boxes than 1 ton boxes and is of similar magnitude to the building costs.

Shallow bulk storage (up to 6 ft. high) without ventilation ducts in an earth floor building may be considered as a means of providing cheap storage. No control over the condition of the potatoes is possible in this type of store and so it should only be used for short term storage. This type of storage is widely used in existing buildings, but as it is considered unlikely that a large store would be specifically built on this basis, such a store has not been costed. Also, because of the wide variety of existing buildings which could be used for potato storage, the cost of adapting and running these types of store will not be investigated. It should be remembered though, that existing buildings will probably cause some restraint on the type and size of the store, the method of store management and on the loading and unloading.

Besides the level of capital investment it is important to consider the type of capital. Those types of store involving long term investment require a confident view in the long



term profitability of growing and storing potatoes. If necessary, the purpose-built bulk stores could be used for grain storage but the walls of the box stores would need strengthening. Stores with only a short term investment, or none at all, allow the possibility of storing or not storing potatoes whenever the farmer wishes.

(b) Annual Structure Costs

The structure costs per ton per year for the different types and sizes of store are shown in Table 9. Capital costs are derived from Table 8 and the background information on the other costs can be found in Appendices 5, 6, 7 and 10. All these costs are fixed in that once the potatoes have been put into store they are incurred no matter when the potatoes are sold.

TABLE 9.  
STRUCTURE COSTS (PER TON PER YEAR (1))

	<i>Clamp</i> 200 tons	<i>Dickie Pie</i> 200 tons	<i>Dutch Barn Bulk</i> 200 tons    500 tons		<i>Dutch Barn (1 ton) Box</i> 224 tons    504 tons		<i>Dutch Barn (10 cwt.) Box</i> 225 tons    495 tons	
FIXED COSTS								
Buildings(2)	—	—	13/6	10/6	12/-	10/-	12/-	10/-
Boxes(3)	—	—	—	—	25/-	25/-	31/6	31/6
Straw walls(4)	—	—	6/-	4/6	5/6	4/-	5/6	4/-
Ducts(4)	—	3/6	6/6	8/-	2/-(7)	2/-(7)	2/-(7)	2/-(7)
Sleepers(4)	—	—	6d.	6d.	—	—	—	—
Straw(5)	10/-	12/-	—	—	—	—	—	—
Polythene(5)	3/-	2/-	1/-	6d.	1/-	6d.	1/-	6d.
Labour(6)	2/6	3/-	1/6	1/-	1/6	1/-	1/6	1/-
TOTAL	15/6	20/6	29/-	25/-	47/-	42/6	53/6	49/-

	<i>Straw Insulated Bulk Store</i> 8' Storage 520 tons	<i>Standard Insulated Bulk Store</i> 8' Storage 510 tons	<i>Highly Insulated Bulk Store</i> 8' Storage 510 tons	<i>Straw Insulated Bulk Store</i> 12' Storage 470 tons    1,880 tons		<i>Highly Insulated Bulk Store</i> 12' Storage 520 tons    1,880 tons	
FIXED COSTS							
Buildings(2)	24/-	26/6	27/-	20/6	14/6	23/-	16/6
Doorway retaining boards(3)	6d.	6d.	6d.	6d.	6d.	6d.	6d.
Straw walls(5)	4/-	—	—	4/6	2/-	—	—
Labour(6)	1/6	..	..	1/6	6d.	..	..
TOTAL	30/-	27/-	27/6	27/-	17/6	23/6	17/-

	<i>Highly Insulated (10 cwt.) Box Store</i>			<i>Highly Insulated (1 ton—stacked 6 high) Box Store</i>	
	<i>With Ducts</i> 470 tons	<i>Without Ducts</i> 470 tons	<i>Without Ducts</i> 1,940 tons	<i>With Ducts</i> 1,960 tons	<i>Without Ducts</i> 1,960 tons
FIXED COSTS					
Buildings(2)	26/-	20/-	14/-	14/-	11/6
Boxes(3)	31/6	31/6	31/6	25/-	25/-
Labour(6)	..	..	..	..	..
TOTAL	57/6	51/6	45/6	39/-	36/6

Notes:

1. To the nearest 6d. .. indicates less than 3d.
2. Amortized over 10 years at 8% interest (1% above present bank rate) after deduction of grant.
3. Amortized over 5 years at 8% interest.
4. Depreciation over 3 years plus interest at 8% on average investment.
5. Replaced every year—see Appendices 5, 6 and 7.
6. Labour involved in store preparation, closing, opening and clearing. For clamp, includes a charge for earthing-up by a contractor. See Appendix 10.
7. Only necessary for F.D. or R.R.

Labour costs throughout this report have been calculated using a basic hourly wage. In farming it is the value of doing alternative work, that is the opportunity cost, which is important—not the actual hourly cost. For example, most farmers empty their potato stores during the winter when there is little or no other work to be done. The opportunity cost of labour is then small. On the other hand, in the autumn, if more winter wheat could be sown instead of loading potatoes into store, the opportunity cost of labour would be very high. To take account of this, labour planning and costing is best carried out on a whole farm basis. Clearly, this cannot be done here but these remarks should be remembered when interpreting these costings.

With purpose-built stores and Dutch Barns it is undesirable to store much less than the maximum the building can hold, as it would make the cost per ton higher. For example, storing 10% less than the maximum would result in an increase of between 2/- and 5/- per ton in the annual structure costs, depending on the store. It has been assumed in the calculation of these costs that all purpose-built stores are filled to the maximum. In many cases it may be better to plan purpose-built stores to take the minimum expected tonnage and deal with any extra by selling off the field or putting into temporary storage. No space has been allowed for grading when the store is full. It is assumed that grading would be carried out outside the store or on a grading line situated elsewhere, at least initially.

As clamps involve no fixed investment and Dickie Pies very little, they can be built to take the appropriate tonnage each year. The cost per ton for clamps is low, with the Dickie Pie a little higher as ducts and more straw are needed. At the 200 ton level the Dutch Barn bulk store is much more expensive but if an adapted Dutch Barn is being used the cost would be similar to the clamp. A large part of the Dutch Barn is taken up by the straw walls. With a larger barn this part becomes a smaller proportion. The cost per ton stored for the buildings, the straw walls and the polythene is then lower. Duct costs are higher with the 500 ton store as the A ducts are depreciated over two years instead of three to allow for damage by tractor bucket unloading. A greater tonnage can be stored in a given barn with boxes than with 8ft. high bulk. Hence the building and straw wall costs per ton are lower in the Dutch Barn box stores. It is important that box stores and boxes are of appropriate dimensions to allow the maximum use of the floor space (except for a small gap round the outside); otherwise the cost per ton will rise. Only main ducts and not laterals are needed in the Dutch Barn box stores so the cost per ton for ducts is lower than with bulk.

Despite a lower building cost, when labour and straw costs have been added, the straw insulated purpose-built stores come out more expensive than the highly insulated ones. The difference is very small at the 2,000 ton level because, as in the larger Dutch Barn, the straw walls occupy a smaller proportion of the store. If the straw walls are still in good condition after one season's storage, they may be left up for another year and so reduce the costs. Two major disadvantages of the straw-insulated stores are that they have a theoretical U value of 0.2 (two bales thick) as opposed to 0.1 for the highly insulated stores and that fewer potatoes can be stored in a given size building if straw bale insulation is used.

As expected from Table 8, 12 ft. high storage and the larger stores are cheaper per ton than 8 ft. storage and the 500 ton stores respectively. If it was desired to use refrigeration on a 2,000 ton bulk store it might be necessary to divide it into four completely separate units. The cost of these divisions would add about 2/- per ton per year to the amortized cost of a bulk store (Appendix 7), thus eliminating some of the advantage of the larger store.

A comparison of the total structure costs of bulk stores with other types of store, reveals a similarity between the 500 ton 12 ft. bulk stores and the 500 ton Dutch Barn. The larger 12 ft. bulk stores compare well with the clamp for costs.

The picture for box stores has changed little between Tables 8 and 9. The building costs per ton are higher in stores with ducts and 10 cwt. boxes (and the 1 ton boxes stacked

four high) than with 12 ft. bulk storage, because more potatoes can be stored in a given size store with 12 ft. high bulk than with 10 cwt. boxes stacked five high. If 1 ton boxes are stacked six high, the position is reversed and building costs are cheaper than for bulk storage. When the costs of the boxes are added, however, box storage is much more expensive, whatever the construction of the store.

## 2. Store Management Costs

While store management has already been shown to affect structure costs, this section is more concerned with the costs of equipping and running the different methods outlined in Part I. Details of these costs are given in Table 10. They are based on the information in Appendix 8. Variable costs are those which change with the time of sale; fixed costs do not.

TABLE 10.  
STORE MANAGEMENT COSTS  
(PER TON PER YEAR (1))

		<i>Recirculation of Refrigerated Air</i>	<i>Forced Draught Ventilation</i>	<i>Convective Ventilation</i>
<b>FIXED COSTS</b>				
Fan and Thermostats <sup>(2)</sup> .. ..	.. ..	1/6	1/6	—
Refrigeration Equipment <sup>(2)</sup> .. ..	.. ..	7/6 to 9/6	—	—
Temperature Indicators <sup>(2)</sup> .. ..	.. ..	6d.	..	..
Return Ducts .. ..	.. ..	—	—	—
Top Straw .. ..	.. ..	—	1/-	1/-
<b>TOTAL</b> .. ..	.. ..	10/6	2/6	1/-
<b>VARIABLE COSTS</b>				
Maintenance <sup>(3)</sup> .. ..	.. ..	6d. to 1/6	..	—
Equipment Running Cost <sup>(4)</sup> .. ..	.. ..	5/- to 12/-	1/- to 2/-	—
Sprout Suppressant <sup>(5)</sup> .. ..	.. ..	—	0, 4/-, 7/6 or 8/-	0, 4/-, 7/6 or 8/-

### Notes:

1. To the nearest 6d. .. indicates less than 3d. A dash indicates no cost.
2. The equipment is amortized over 5 years at 8% interest after deducting a grant of 40% on the assumption that the equipment is fixed.
3. Maintenance based on 2½% of the price of the equipment per year for a whole season's running. Experience at Sutton Bridge has shown this figure to be roughly correct. Assumed to be proportionately less for a shorter season.
4. Approximate ranges for mid-January to mid-May. For storage after mid-May add 6d. per ton for every extra week of refrigeration.
5. Costs are for C.I.P.C.

### (a) Minimal Control.

This is not included in this Table as, when used with clamps, it has no special costs. If used with shallow indoor bulk storage, the cost for top straw would apply.

### (b) Convective Ventilation.

With this method, no equipment is needed except for a number of thermometers in polythene tubing dispersed at various points in the stack. The cost per ton for these is negligible. One application of C.I.P.C. sprout suppressant would be used for storage to between January and March plus a second for later unloading.

### (c) Forced Draught Ventilation.

In addition to thermometers, a fan capable of blowing air at 40 c.f.m. per ton (at 1.5 s.w.g.) through the whole store plus frost guard and differential thermostats is required. The costs for both depreciation and running of the equipment are small. There is likely to be no increase in the running costs after the end of April because of the lack of cold outside air. None, one or two applications of C.I.P.C. sprout suppressant may be necessary depending on the sprouting characteristics of the variety stored, the time of unloading and the highest temperature within the stack.



(d) **Recirculation of Refrigerated Air.**

Fans for forced draught ventilation are also needed in this system to carry out the initial heat reduction. At present there is a lack of practical knowledge on the commercial costs of the recirculation of refrigerated air. The figures used in this report (both for depreciation and running costs) are based on limited practical assessments. However it is fairly certain that the depreciation costs should be in the range of 7/- to 9/- per ton per year for a 500 ton store. With much smaller stores than this the relative cost of the refrigeration unit is higher. It is probably best to aim for a minimum size of about 500 tons for a refrigerated store. Much larger refrigeration units are feasible but the size of refrigerated stores may be limited to about 500 tons by the practical problems in unloading and marketing a much greater tonnage than this in the months of April and May.

In a method such as this which has greater control over the environmental conditions in a store it is worthwhile spending more on temperature measuring equipment, and a cost for this has been included in Table 10. A return duct is needed to allow the recirculation of air but its cost for depreciation over 500 tons and five years is negligible.

The use of a sprout suppressant and top straw should not be necessary with this method of store management. The saving from not using top straw is small in terms of material and labour costs but would be larger if a value could be put on the nuisance caused by bits of straw at grading. The running costs are expected to be within the range shown in Table 10 depending on the length of storage.

The expected overall costs for the different methods of store management, as shown in Table 11, were arrived at by combining the fixed costs with the variable ones for different periods of storage.

TABLE 11.  
TOTAL STORE MANAGEMENT COSTS (PER TON)

<i>Unloading Date</i>	<i>Recirculation of Refrigerated Air</i>	<i>Forced Draught Ventilation</i>		<i>Convective Ventilation</i>	
		<i>Bulk</i>	<i>Box</i>	<i>Bulk</i>	<i>Box</i>
Mid-January ..	16/-	3/6 or 7/6*	3/6 or 11/-*	5/-*	8/6*
Mid-February ..	17/6	3/6 or 7/6*	3/6 or 11/-*	5/-*	8/6*
Mid-March ..	19/6	4/- or 8/-*	4/- or 11/6*	5/-*	8/6*
Mid-April ..	21/6	8/6* or 12/6**	12/-*	9/-**	8/6*
Mid-May	24/-	8/6* or 12/6**	12/-*	9/-**	8/6*

\*—one application of C.I.P.C.

\*\*—two applications of C.I.P.C.

In relation to the cost of store losses, there is little difference in total costs between forced draught and convective ventilation. With little fixed investment and better control over storage conditions, forced draught ventilation has more flexibility than convective ventilation in decisions on whether or not to store and when to sell out of store. The recirculation of refrigerated air to maintain a storage temperature of 38°-40°F is, on the other hand, definitely more expensive than the other two methods. Because of the high capital investment, it must be planned for use every year for storage until that part of the season when its extra costs can be more than recouped by increasing returns.

### 3. Loading and Unloading Costs

This section is only concerned with the way potatoes are put into and removed from a store. How this fits in with the methods of harvesting and handling potatoes at other times is very important and can have a marked effect on the costs. This is to be covered in another report (P.M.B. 1971). The individual farmer must judge the methods and their costs in the light of his own overall situation.

Loading and unloading costs for several methods of handling different quantities of potatoes, for particular stores, are shown in Table 12. The background information and assumptions used in the calculations of this Table are given in Appendices 9 and 10.

The main factor affecting the costs is the quantity of potatoes that is moved with the equipment, even though higher depreciation and maintenance rates are assumed with the higher tonnages. It is stressed that this quantity of potatoes need not all be in one store.

TABLE 12  
LOADING AND UNLOADING COSTS  
(PER TON PER YEAR(1))

	Clamp 200 tons(2)	Dickie Pie 200 tons(2)	Dutch Barn Bulk 200 tons(2)    500 tons		Purpose-Built 500 tons	Bulk Stores 2,000 tons
FIXED COSTS						
Elevator(3) .. ..	—	7/6	7/6	6/-	6/-	2/-
Bucket Unloader(4) ..	—	—	—	1/-	1/-	..
Elevator Running Cost ..	..	..	..	..	..	..
Tractor Running Cost ..	—	—	—	6d.	6d.	6d.
Elevator Maintenance ..	—	1/-	1/-	6d.	6d.	6d.
Labour .. .. .	10/6	9/6	9/6	2/6	1/6	1/6
TOTAL .. ..	10/6	18/-	18/-	10/6	9/6	4/6

	10 cwt. boxes (Tractor Fork Lift)			1 ton boxes			1 ton boxes (Fork Lift Truck)
	200 tons	500 tons	2,000 tons	200 tons	500 tons	2,000 tons	2,000 tons
FIXED COSTS							
Tractor Fork Lift(3)	6/6	3/-	1/-	6/6	3/-	1/-	—
Fork Lift Box Tipper(3)	3/-	1/6	6d.	—	—	—	—
Static Box Tipper(3)	—	—	—	6/-	3/-	6d.	—
Fork Lift Truck(3) ..	—	—	—	—	—	—	8/-
Running Cost ..	2/-	2/-	2/-	1/-	1/-	1/-	..
Labour .. .. .	2/-	2/-	2/-	1/-	1/-	1/-	1/-
TOTAL .. ..	13/6	8/6	5/6	14/6	8/-	3/6	9/-

**Notes**

1. To the nearest 6d. .. indicates less than 3d. A dash indicates no cost.
  2. Unloading by fork. 500 tons and 2,000 tons unloaded by tractor bucket.
  3. Amortized over 5, 8 and 10 years for 2,000, 500 and 200 tons respectively at 8% interest.
  4. Amortized over 8 years at 8% interest.
- See Appendices 9 and 10 for background information.

With the high cost of labour for unloading by hand fork it would be cheaper to use a tractor bucket even on 200 tons. Against a saving of 7/- per ton per year in the labour costs, the bucket unloader and tractor running costs would only amount to 2/6d.—a net saving of 4/6d. per ton per year. To allow mechanical unloading, clamps and Dickie Pies must be on hard ground or a concrete base. Also, stores with above floor laterals must set an increased depreciation rate on the laterals against this saving. No cost has been included for the front-end loader as this will vary greatly from farm to farm but it should be taken into account in individual farm costings.

Clamps do not require elevators for filling but may do so for unloading into bulk transport for grading elsewhere. In this case, a cost of 7/6d. per ton per year should be added in.

The boxes are assumed to have been filled prior to the loading operation and so no cost has been included for this. There is a choice between using 10 cwt. or 1 ton boxes. As mentioned in the previous section, two 10 cwt. boxes cost more than a 1 ton box. They also require twice as much handling. Both types can be lifted on a tractor fork lift but the 1 ton boxes are too heavy to be tipped by the usual mechanism attached to a medium-powered tractor fork lift. A tipper capable of managing 1 ton boxes can be purchased on a one-off basis. Alternatively, a static box tipper can be used but boxes can only then be tipped in one place and much of the versatility of the system is lost. The static tipper and the special (1 ton) fork lift tipper cost more than the ordinary one attached to the tractor fork lift (Appendix 9). With smaller tonnages the versatility aspect is likely to outweigh the slightly greater amortization cost of 10 cwt. boxes and equipment. For large tonnages (2,000 or more), a fork lift truck and 1 ton boxes are likely to be used instead of either of the other two methods. The fork lift truck can tip 1 ton boxes and with an extended lift stack them six high, resulting in a saving of building costs (see previous section). It may be possible to hire a fork lift truck for the loading and unloading periods. At a cost of £30 per week for a total of 15 weeks this would give a cost of 4/6d. per ton per year for 2,000 tons and would, therefore, be better than buying one.

TABLE 13.  
SOME USEFUL SYSTEMS OF STORAGE

Type of Store	Method of Store Management	Loading/Unloading	Tonnage	Total Fixed Costs per ton per year	
				Structure <sup>(1)</sup>	Management <sup>(2)</sup> Handling <sup>(3)</sup>
Clamp	Minimal Control	Hand Fork	Up to 200 each	15/6	—
				20/6	18/6
				26/-	
Dickie Pie	Convective Ventilation	Elevator Hand Fork	Up to 200 (or 300) each	20/6	— <sup>(4)</sup>
				18/6	38/6
Adapted Dutch Barn Bulk Store	Convective Ventilation	Elevator Hand Fork	200	15/6 <sup>(5)</sup>	1/-
				18/6	34/6
			to 500	14/6 <sup>(5)</sup>	1/-
				10/6	26/-
Highly Insulated 12' Bulk Store	Force Draught Ventilation	Elevator Tractor Bucket	500	23/6	2/6
				9/6	35/6
			to 2,000 or more	17/-	2/6
				4/6	24/-
Highly Insulated 10 cwt. Box Store	Convective Ventilation	Tractor Fork Lift and Box Tipper	500 or more	51/6	1/-
				8/6	61/-
Highly Insulated 1 ton, 6 high, Box Store	Convective Ventilation	Fork Lift Truck and Box Tipper	2,000 or more	36/6	1/-
				5/6 <sup>(6)</sup>	43/-
Highly Insulated 12' Bulk Store	Recirculation of Refrigerated Air	Elevator Tractor Bucket	500 or more	23/6	10/6
				9/6	43/6

- Notes: 1. From Table 9.  
2. From Table 10.  
3. From Table 12.  
4. The convective ventilation cost for top straw does not apply to Dickie Pies.  
5. Does not include building costs.  
6. Not taken from Table 12. Fork Lift Truck is assumed to be hired instead of bought.

This fork lift equipment could be used for other handling purposes thus spreading the costs, though increased depreciation and maintenance rates would reduce some of the benefit. Again, the costs in these cases should be re-calculated for individual situations.

#### 4. Total Storage Cost

The total of all these costs is likely to vary between £1 and £4 per ton stored per year. No cost has been included so far for interest on the working capital employed in potato storage. Little working capital is involved in storage structures, store management and loading/unloading. For example, the interest on the working capital involved in a clamp would only be 6d. per ton for six months' storage at the current rate of 8% per annum. The value of the potatoes themselves is far more significant. If valued at £18 per ton the cost for interest would be approximately 2/6d. per ton per month at 8% per annum on a bank overdraft or alternative possible investment.

It is pointless to give a total cost for each of the different systems of potato storage; there are too many possible systems; and further, there can be wide variations in the total cost for any one system caused by different unloading dates, the use of second-hand materials or equipment and the use of equipment for other purposes besides potatoes, apart from the intricacies of labour costs and interest charges. It is much easier for the individual farmer to have his own costs calculated for his particular case and then to see how these can be effectively reduced or how they compare with possible alternative systems.

The discussion of costs in previous sections has yielded information about which systems of storage are likely to be preferable. Adapted existing buildings with minimal control or convective ventilation will be the first choice in most cases for storage of small quantities. Table 13, page 19, summarises some other useful systems with their total fixed costs taken from Tables 9, 10 and 12. The costs in this table refer to the tonnages used in the examples given in Tables 9, 10 and 12. A marked change in these or the use of the same equipment on more than one store would significantly change the costs.

With these points about storage costs in mind, it is now possible to relate these costs to the appropriate increases in returns discussed in Part II.



## PART IV

### Discussion and Conclusions

#### 1. Costs and Increased Returns

Part II (page 4) showed that in the past only small increases in returns from storage occurred before the end of March—in fact, in some seasons there were decreased returns. In Part III it was shown that the lowest total storage cost is about £1 per ton. Under these circumstances there can have been little or no profit from storage for sale before the end of March. But in seasons when there were good price increases in April and May, some profit was likely from sale at this time even with high storage costs.

Because of the generally small increase in returns from storage prior to the end of March, potato growers would be justified in limiting their expenditure on storage buildings and equipment, unless they were storing until April or May. For the producer unloading in March or earlier, a low investment in storage buildings and equipment has the advantage of allowing flexibility in decisions on whether to store or not and when to sell.

In general, once potatoes have been put into store most of the cost and a good deal of the ware losses are then incurred, however long the potatoes are kept. It is best, therefore, to store potatoes as long as possible, providing the running costs, interest charges and increase in ware losses are more than covered by the price increase. Field sales from late lifting affect prices well into November so that little increase in prices can be expected before January. These points add weight to the consideration of November and December as a period of temporary storage.

Depending on the length of storage and type of store, one method of store management will be more appropriate than another. Table 14 shows the benefits of using forced draught ventilation and refrigeration methods instead of convective ventilation on potatoes stored until May and March. Refrigeration is clearly better for storage after March, when a significant premium can be expected for the appearance of the crop. Even a £1 per ton premium will give a good profit and a good return on the capital invested in refrigeration equipment. In March or earlier there are usually plentiful supplies of good potatoes and forced draught ventilation, with its low equipment cost, becomes the better method. Much of the advantage of forced draught ventilation comes from the saving in building costs through allowing higher bulk storage. In stores where the storage height is limited to 8 ft. convective ventilation is likely to be as profitable as forced draught ventilation, except in those cases where forced draught is used for drying damp potatoes, cooling overheated ones, or preventing sprouting without the need for a sprout suppressant. As it costs little to install and use a fan for forced draught, it is probably worthwhile even with 8ft. storage.

TABLE 14.  
PARTIAL BUDGET FOR FORCED DRAUGHT VENTILATION AND REFRIGERATION  
STORAGE OF 500 TONS OF KING EDWARD POTATOES IN A HIGHLY INSULATED BULK STORE FOR SALE IN MAY  
(MARCH FIGURES IN BRACKETS)

	<i>Forced Draught Ventilation per ton</i>	<i>Recirculation of Refrigerated Air per ton</i>
<b>GAIN OVER CONVECTIVE VENTILATION</b>		
Building Cost (Table 9)(1) .. ..	4s. 0d.	4s. 0d.
Top Straw Cost (Table 10) .. ..	—	1s. 0d.
Sprout Suppressant Cost (Table 10) .. ..	—	8s. 0d. (4s. 0d.)
Sale of Extra Weight (Tables 5 and 6) .. ..	4s. 0d. (3s. 0d.)	12s. 0d. (6s. 0d.)
Premium for Appearance (page 6) .. ..	—	£2 10s. 0d. (10s. 0d.)
<b>TOTAL .. ..</b>	<b>8s. 0d. (7s. 0d.)</b>	<b>£3 15s. 0d. (25s. 0d.)</b>
<b>EXTRA COSTS OVER CONVECTIVE VENTILATION</b>		
Depreciation of Equipment (Table 10)(2) .. ..	1s. 6d.	10s. 6d.
Maintenance (Table 10) .. ..	—	1s. 6d. (1s. 0d.)
Running Cost (Table 10) .. ..	2s. 0d. (1s. 6d.)	12s. 0d. (8s. 0d.)
<b>TOTAL .. ..</b>	<b>3s. 6d. (3s. 0d.)</b>	<b>£1 4s. 0d. (19s. 6d.)</b>
<b>NET GAIN OVER CONVECTIVE VENTILATION ..</b>	<b>4s. 6d. (4s. 0d.)</b>	<b>£2 11s. 0d. (5s. 6d.)</b>

Notes: 1. 8 ft. storage with Convective Ventilation. 12 ft. storage with Forced Draught and Refrigeration.  
2. Equipment includes: Fans, Thermostats, Refrigeration Units and Temperature Indicators.

Box storage is cheapest with convective ventilation but even then it is more expensive than similar capacity bulk storage. To justify this extra cost there must be a better increase in the returns after storage or a particular advantage in box storage, such as the ability to keep different lots separately. Some farmers who store potatoes in boxes find that they can get a premium which more than covers the extra expense of boxes, through sale for special markets because of the good appearance of their potatoes.

## 2. Conclusions

Although it is necessary for the individual farmer to cost and assess his own storage situation (an example using the information in this report can be found in Appendix 11), it is still possible to draw some general conclusions which may provide useful guidance.

The comparison of the costs of storage with the increased returns has shown that in the past there has usually been little or no profit in storing potatoes for sale prior to the end of March but that longer storage has often been profitable. The least profitable storage seasons were those in which a large surplus was produced but autumn prices did not fall much below their average. In these cases it clearly would have been more profitable for some farmers to sell their crops straight off the field.

The production of undamaged, disease-free potatoes is extremely important. This should not only result in a larger amount of saleable ware off the field but should also improve the returns from storage by maximising ware percentage and minimising ware losses.

Clamps, Dickie Pies, adapted buildings, general purpose loading/unloading equipment, forced draught and convective ventilation all involve low fixed capital investment and so allow flexibility in decisions of whether to store or to sell off the field. They also result in low costs per ton and are thus suitable for use with potatoes stored for sale prior to the end of March.

Highly insulated bulk stores with 12 ft. high storage and forced draught ventilation can provide reasonably cheap and better storage, especially for large tonnages, but a greater profit must be achieved to give a satisfactory return on the amount of capital invested. This can be done by extending the storage period into April and selling a high proportion late in the period. There is some flexibility in this system as the building could always be used for other storage purposes (e.g. grain) if it was decided to discontinue storing potatoes.

Refrigeration and box storage involve increased costs. The premium above the average ware price obtained when selling the potatoes in April or May makes refrigeration worthwhile. Convenience aspects, such as the ability to store different lots separately, may justify box storage.

There is a wide choice of potato storage systems. If the best alternatives are chosen in accordance with the information set out in this report, storage could be made more profitable. Improvements in production and marketing could have a great effect on the profitability of storage.

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## APPENDICES

- APPENDIX 1—Decimal Currency.
- APPENDIX 2—Abbreviations and Definitions.
- APPENDIX 3—Average Monthly Producers' Prices throughout the Storage Season for Scotland.
- APPENDIX 4—Description of Stores used in Costings.
- APPENDIX 5—Calculation of Structure Costs for Clamps and Dickie Pies.
- APPENDIX 6—Calculation of Structure Costs for Dutch Barns.
- APPENDIX 7—Calculation of Structure Costs for Purpose-Built Stores.
- APPENDIX 8—Equipment for Store Management.
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- APPENDIX 10—Labour Requirements.
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## DECIMAL CURRENCY

The £1 remains the major unit of currency but is divided into 100 new pence each worth 2·4d.

The £ symbol is used for the pound, always before the amount; the small letter p. is used for the new penny or pence, always after the amount. The decimal point separates pounds from new pence. When the point is used the £ must appear before it and there must always be at least two figures after it, with no p. symbol. Thus £ and p. never appear in the same expression.

Conversion Table		
£ s. d.	New pence	
6d.	2½p.	£0·02½
1s.	5p.	£0·05
2s. 6d.	12½p.	£0·12½
5s.	25p.	£0·25
10s.	50p.	£0·50
£1	£1	£1·00
£1 2s. 6d.	£1·12½	£1·12½
£1 10s. 0d.	£1·50	£1·50

## ABBREVIATIONS AND DEFINITIONS

R.R.—Recirculation of Refrigerated Air.

F.D.—Forced Draught Ventilation.

C.V.—Convective Ventilation.

M.C.—Minimal Control.

c.f.m.—cubic feet per minute.

s.w.g.—standard water gauge.

Amortization—The combination of depreciation and interest on the written down balance to give a fixed figure per year for the life of the investment.

Indoor Storage—Storage in buildings, e.g. Dutch Barns, converted buildings and purpose-built stores.

Outdoor Storage—No permanent structure involved even if the site is permanent and has a concrete base. e.g. Clamps, Dickie Pies.

U value—The quantity of heat (B.t.u.) which will flow through 1 sq. ft. of structure in one hour when there is 1 deg. F. temperature difference between the air on each side. (B.t.u./ft.<sup>2</sup> h deg. F.)

### AVERAGE MONTHLY PRODUCERS' PRICES THROUGHOUT THE STORAGE SEASON FOR SCOTLAND

#### For Kerr's Pink, King Edward and Redskin

Year	Oct. Price	Nov.	Dec.	Change from the October Price				
				Jan.	Feb.	March	April	May
1964-1965	£13 3s.	+1s.	+32s.	+27s.	+ 6s.	+29s.	+58s.	+120s.
1965-1966	£13 5s.	+14s.	+45s.	+72s.	+94s.	+103s.	+146s.	+204s.
1966-1967	£17 9s.	+42s.	+57s.	+64s.	+70s.	+67s.	+117s.	+159s.
1967-1968	£14 0s.	-16s.	-24s.	-10s.	-16s.	-13s.	- 7s.	- 20s.
1968-1969	£14 2s.	+13s.	+30s.	+32s.	+31s.	+48s.	+109s.	+180s.
1969-1970	£16 17s.	+31s.	+59s.	+123s.	+149s.	+242s.	+339s.	+258s.
Average	£14 16s.	+14s.	+33s.	+51s.	+57s.	+79s.	+127s.	+150s.

#### For Majestic and other 'White' Varieties

Year	Oct Price	Nov	Dec.	Change from the October Price				
				Jan.	Feb	March	April	May
1964-1965	£10 10s.	- 5s.	+ 1s.	+ 8s.	- 5s.	+27s.	+41s.	+118s.
1965-1966	£11 2s.	-22s.	+11s.	+48s.	+25s.	+60s.	+123s.	+171s.
1966-1967	£15 18s.	+ 3s.	+ 8s.	+23s.	+ 3s.	+18s.	+92s.	+165s.
1967-1968	£11 17s.	- 3s.	-18s.	+ 3s.	-16s.	+ 1s.	+ 9s.	+ 30s.
1968-1969	£12 18s.	+ 4s.	- 5s.	+ 5s.	- 6s.	+18s.	+100s.	+150s.
1969-1970	£16 10s.	+22s.	+36s.	+110s.	+133s.	+213s.	+336s.	+152s.
Average	£13 3s.	+ 0s.	+ 6s.	+36s.	+22s.	+56s.	+117s.	+146s.

(NOTE: All prices are to the nearest shilling)

### DESCRIPTION OF STORES USED IN COSTINGS

#### Clamp

Traditional construction except for the use of a polythene sheet and baled straw instead of trussed straw. Size: 200 tons.

#### Dickie Pie

Typical construction of straw bales and polythene with top and bottom ventilation ducts. Size: 200 tons.

#### Dutch Barn Stores

Typical Dutch Barn building, with concrete floor. Straw bales walls, three bales wide to the eaves (12 ft.). Potatoes stored 8 ft. high in bulk, five boxes high with 10 cwt. boxes, four boxes high with 1 ton boxes. Sleepers used for reinforcing the walls of the bulk stores. Main ducts for ventilation in all types with A duct laterals in the bulk stores.

Bulk	200 tons—Dutch Barn, size	60' × 40'
	500 tons— " " "	135' × 40'
10 cwt. boxes	225 tons— " " "	60' × 40'
	495 tons— " " "	120' × 40'
1 ton boxes	224 tons— " " "	60' × 40'
	504 tons— " " "	120' × 40'

#### Purpose-Built Bulk Stores

All buildings are of similar construction in respect of thrust resisting frame, foundations, concrete floor and inflow ducts set at 6' centres, except for the eaves' height. This is 12' in those buildings with potatoes stored 8' high for convective ventilation and 16' in those buildings with potatoes stored 12' high for forced draught ventilation or the recirculation of refrigerated air.

The walls and roof consist of single skin asbestos cement in the straw insulated building, but of double skin asbestos cement in the insulated and highly insulated buildings. In these latter stores 1" and 2" thick fibreglass with spacers are respectively sandwiched between the two skins of asbestos cement to give respective theoretical U values of 0.2 and 0.1. The insulation in the straw insulated store consists of straw bale walls, two bales wide, up to the eaves' height. High tensile wire is used to take the load from the straw bale walls onto the frame. In the other stores a timber wall fixed inside the stanchions is used to take the thrust of the potatoes. The main ducts run internally for the length of the building. In the 500 ton buildings the main ducts are along one of the walls but in the 2,000 ton buildings they are central with wooden divisions on top up to the height of storage.

Type	Storage	Depth	Tonnage	Size of Building
Straw Insulated Bulk Store .. ..	8'		440 tons	120'×40'
Standard Insulated Bulk Store .. ..	8'		510 tons	90'×45'
Highly Insulated Bulk Store .. ..	8'		510 tons	90'×45'
Straw Insulated Bulk Store .. ..	12'		425 tons	75'×40'
			1,880 tons	120'×90'
Highly Insulated Bulk Store .. ..	12'		520 tons	60'×45'
			1,880 tons	105'×90'

#### Purpose-Built Box Stores

All the buildings are of similar construction to the highly insulated 12' bulk stores except:

- There are no timber thrust resisting walls.
- The frame is not built to take the thrust of potatoes.
- In some cases there are no underfloor laterals or main ducts.
- Where there are main ducts they are outside the building in the 500 ton stores but central without divisions on top, in the 2,000 ton stores.
- The eaves' height is 20' in the 2,000 ton stores containing 1 ton boxes stacked six high.
- Carriage rails are set on the inside face of the walls at heights of 2' 6" and 4' 6" to prevent damage to the walls.

Box sizes throughout the report are:—

10 cwt. boxes—60"×36"×34" high (26" deep inside).

1 ton boxes—72"×48"×36" high (28" deep inside).

The 10 cwt. boxes can be stored five high and the 1 ton boxes four high using a tractor fork lift. The 1 ton boxes can be stored six high using a fork lift truck with an extended lift.

Type	Tonnage	Size of Building
Highly Insulated .. .. . 10 cwt. boxes	470 tons	75'×45'
With Ducts	1 ton boxes (4 high) 452 tons	75'×45'
	1 ton boxes (6 high) 1,960 tons	105'×90'
Highly Insulated .. .. . 10 cwt. boxes	470 tons	75'×45'
Without Ducts	1,940 tons	150'×90'
	1 ton boxes (4 high) 452 tons	75'×45'
	1,904 tons	150'×90'
	1 ton boxes (6 high) 1,960 tons	105'×90'

#### APPENDIX 5

#### CALCULATIONS OF STRUCTURE COSTS FOR CLAMPS AND DICKIE PIES

N.B. 1. Costs are adjusted to the nearest £1.

2. No labour charges are included.

#### Clamp—200 tons

	Cost (£/Yr.)
Straw .. .. .	100
Polythene .. .. .	30
Earthing-Up .. .. .	10
	<hr/>
	£140

#### Dickie Pie—200 tons

	Cost (£)	Life (Yrs.)	Cost (£/Yr.)
Straw	120	1	120
Polythene	22	1	22
A ducts	80	3	27
Top ducts	12	3	4
			<hr/>
			£173

#### Notes:

- Straw: 60 bales per ton. Cost £5 per ton delivered.  
Re-use value: £1 per ton for Dickie Pie only  
Requirements for: Clamp —2 cwt. per ton of potatoes.  
Dickie Pie —3 cwt. per ton of potatoes.
- Polythene sheeting—300 gauge, black. 9' high. Cost 1/- per foot run.
- Earthing-up by a contractor with a trench digger.
- Both stores unloaded by fork.  
If Dickie Pie is unloaded by bucket the life of the A ducts should be reduced to 2 years.
- 40 A ducts, 6' long, at £2 each.

## CALCULATIONS OF STRUCTURE COSTS FOR DUTCH BARN STORES

- N.B. 1. Costs are adjusted to the nearest £1.  
2. No charges are included for use of farm labour.

		<i>Bulk</i>		<i>Cost (£/Yr.)</i> <i>1 ton boxes</i>		<i>10 cwt. boxes</i>	
		<i>200 tons</i>	<i>500 tons</i>	<i>224 tons</i>	<i>504 tons</i>	<i>225 tons</i>	<i>495 tons</i>
Buildings .. ..		90	190	90	170	90	170
Straw walls .. ..		75	140	75	125	75	125
Ducts .. ..		55	170	18	39	18	39
Sleepers .. ..		6	11	—	—	—	—
Polythene .. ..		9	16	9	15	9	15
Boxes .. ..		—	—	224	504	281	619
		<u>£230</u>	<u>£509</u>	<u>£416</u>	<u>£853</u>	<u>£473</u>	<u>£968</u>

## Notes:

## (a) Buildings

Typical cost per sq. ft. with concrete floor:

12/6d. for smaller size

11/6d. for larger size

(Typical cost of concrete floor—5/- per sq. ft.)

Grant under Farm Improvement Scheme—40%.

Net cost per sq. ft.—7/6d. or 7/- for larger size.

Depreciation over 10 years.

## (b) Straw Walls

Wire bales at 40 bales per ton. Cost £5 per ton delivered.

Re-use value £2 per ton.

Depreciation over 3 years.

*Size of Building*

60' × 40'

120' × 40'

135' × 40'

*Requirements*

45 tons

75 „

84 „

## (c) Ducts

- (i) BOXES: Main duct—30" × 27" made from rough sawn timber and marine ply. Built into one of the side walls.

Approximate cost: £1 per foot length of duct.

Depreciation over 3 years.

*Length of Main duct (ft.)*

200 ton store

54

500 „ „

116

- (ii) BULK: Main duct—30" × 27" made from rough sawn timber and marine ply. Positioned along the outside of one of the side walls.

Approximate cost: £1 per foot length of duct.

Depreciation over 3 years.

*Length of Main duct (ft.)*

200 ton store

54

500 „ „

131

A ducts at 6' centres.

Approximate cost of a 6' A duct—£2.

6 × 6' A ducts required for each lateral.

Depreciation over 3 years for the 200 ton store but only 2 years for the 500 ton store as this would be unloaded by tractor bucket.

*No. of Ducts required*

200 ton store

54

500 „ „

126

## (d) Sleepers

Two sleepers per bay.

Cost per sleeper—16/-.

Depreciation over 3 years.



(e) Polythene

300 gauge black polythene inside the straw walls to a height of 9'.

Cost of a 9' wide sheet is approximately 1/- per foot length. Replaced every year.

<i>Size of building</i>	<i>Length required (ft.)</i>
60' × 40'	176
120' × 40'	296
135' × 40'	326

(f) Boxes

1 ton box—cost £5—Depreciation over 5 years.

10 cwt. box—cost £3 2s. 6d.—Depreciation over 5 years.

(g) Fixed Capital Cost (£ per ton)

			<i>Bulk</i>		<i>1 ton boxes</i>		<i>10 cwt. boxes</i>	
			<i>200 tons</i>	<i>500 tons</i>	<i>224 tons</i>	<i>504 tons</i>	<i>225 tons</i>	<i>495 tons</i>
Buildings	..	..	4.50	3.80	4.00	3.40	4.00	3.40
Straw walls	..	..	1.10	0.85	1.00	0.75	1.00	0.75
Ducts	..	..	0.80	0.75	0.25	0.25	0.25	0.25
Sleepers	..	..	0.10	0.05	—	—	—	—
Boxes	..	..	—	—	5.00	5.00	6.25	6.25
			<u>£6.50</u>	<u>£5.45</u>	<u>£10.25</u>	<u>£9.40</u>	<u>£11.50</u>	<u>£10.65</u>

Notes: 1. All costs are to the nearest £0.05.

2. Grant of 40% deducted from building costs.

APPENDIX 7

CALCULATIONS OF STRUCTURE COSTS FOR PURPOSE-BUILT STORES

1. Buildings

See table on next page and the notes following it.

Depreciation over 10 years after deducting grant of 40%.

2. Straw Walls (including doorways)

60 bales per ton. Cost—£5 per ton. Replaced every year. Re-use value of £2 per ton.

							<i>Amount of Straw required</i>
520 ton—8' Bulk Store	..	..	..	..	..	..	34 tons
470 ton—12' Bulk Store	..	..	..	..	..	..	34 tons
1,880 ton—12' Bulk Store	..	..	..	..	..	..	63 tons

3. Doorway Retaining Boards

4/6d. per sq. ft. covered. Depreciation over 5 years.

4. Boxes

1 ton—Cost £5. Depreciation over 5 years.

10 cwt.—Cost £3 2s. 6d. per ton. Depreciation over 5 years.

5. Extra Divisions for the Recirculation of Refrigerated Air in 2,000 ton Stores

(a) BULK

Two lateral divisions (across the width of each side of the central main duct) of thrust resisting walling of size 43' × 12' each. Cost £4 per sq. yd.

These divisions plus the longitudinal division over the central duct continued up to the roof with reinforced plywood at a cost of 1/6d. per sq. ft.

Depreciation over 5 years.

(b) Box

Divisions as for bulk, except consisting entirely of reinforced plywood at a cost of 1/6d. per sq. ft. Depreciation over 5 years.

# BUILDING COSTS

Building	8' Bulk Stores			12' Bulk Stores				Highly Insulated Box Stores				
	Straw	Standard	Highly	Straw	Highly	Straw	Highly	10 cwt. boxes		1 ton boxes		
	Insulated	Insulated	Insulated	Insulated	Insulated	Insulated	Insulated	5 high		6 high		
								no ducts	ducts	no ducts	no ducts	ducts
Tonnage .. .. .	520	510	510	470	520	1,880	1,880	470	470	1,940	1,960	1,960
(a) Roof, frame and foundations for stanchions .. ..	£1885	£1560	£1560	£1260	£1140	£4380	£3830	£1370	£1370	£5200	£3780	£3780
(b) Concrete floor .. ..	1160	980	980	725	650	2380	2080	820	870	2990	2080	2080
(c) Infloor ducts .. ..	860	740	740	545	495	1970	1720	—	640	—	—	1720
(d) Apron .. .. .	320	360	360	320	360	720	720	360	360	720	720	720
(e) Walls .. .. .	460	680	680	440	705	900	1370	810	810	1860	1880	1880
(f) Roof insulation .. ..	—	420	420	—	280	—	980	170	170	710	500	500
(g) Extra insulation .. ..	—	—	95	—	75	—	190	—	70	—	—	170
(h) Main duct .. .. .	630	470	470	395	315	720	630	—	390	—	—	550
(i) Timber thrust walls .. ..	—	575	575	—	750	300	1920	—	—	—	—	—
(j) Doors .. .. .	330	350	350	390	410	780	820	410	410	820	920	920
(k) Lighting, power sockets ..	400	400	400	400	400	500	500	400	400	500	500	500
(l) Carriage rails .. ..	—	—	—	—	—	—	—	210	210	420	280	280
(m) Gable end ventilators .. ..	15	15	15	15	15	60	60	15	15	60	60	60
(n) Fan house .. .. .	—	—	—	150	150	400	400	—	150	—	—	400
(o) High tensile wire .. ..	10	—	—	10	—	20	—	—	—	—	—	—
(p) Builders' preliminaries ..	240	325	330	230	290	655	760	230	295	655	535	680
(q) Contingency allowance ..	545	685	695	490	600	1380	1600	480	615	1375	1130	1425
TOTALS .. .. .	£7015	£7570	£7680	£5370	£6625	£15165	£17580	£5275	£6775	£15110	£12385	£15665
£ per ton .. .. . (after grant of 40% deducted)	8.1	8.9	9.0	6.9	7.7	4.9	5.6	6.8	8.7	4.7	3.8	4.8

## NOTES ON THE CALCULATION OF BUILDING COSTS

*N.B.*—All costs include erection charges.

**(a) Roof, frame and foundations for stanchions**

(including extra cost for thrust resistance of 2% where required).

500 ton 8' Bulk Stores 7.7 shillings per sq. ft. of floor area

500 ton 12' Bulk Stores 8.4 —do.—

2000 ton 12' Bulk Stores 8.1 —do.—

500 ton Box Stores 8.1 —do.—

2000 ton Box Stores 7.7 —do.—

High 2000 ton Box Stores 8.0 —do.—

**(b) Concrete Floor**

For 500 ton store—£0.242 per sq. ft.

For 2000 ton store—£0.220 per sq. ft.

Extra £50 for 500 ton Box Store with external main duct.

**(c) Infloor Ducts**

For all appropriate stores £0.182 per sq. ft. of floor area.

Extra £25 for 500 ton Box Store with external main duct.

**(d) Apron**

20' wide on each end of building—£0.2 per sq. ft.

**(e) Walls**

Asbestos cement. 1 skin thick. 16s. 7d. per sq. yd.

Asbestos cement double skin containing 1" thickness of fibreglass plus timber battens used as spacers—34s. 6d. per sq. yd.

Plus 5/- per sq. yd. for sheeting rails in each case.

**(f) Roof Insulation**

Extra cost for double skin asbestos cement containing 1" thickness of fibreglass, plus battens, 17s. 8d. per sq. yd.

**(g) Extra Insulation**

Additional cost for using 2" thickness of fibreglass in the walls and roof instead of 1"—2s. 3d. per sq. yd.

**(h) Main Duct**

6' high. £6 per ft. run. Less 15/- per foot if thrust of potatoes from one side only.

**(i) Timber thrust resisting wall**

Consists of  $\frac{1}{2}$ " plywood, timber struts and supporting channel. Cost—£3 14s. 3d. per sq. yd.

Also included for use as a division above the central main duct in 2000 ton Bulk Stores.

**(j) Doors**

2 sub-stanchions for each door at a total cost of:

£28 to 12' high

£32 to 14' high

£36 to 16' high

Size of doors: 14' wide  $\times$  12' high in 8' Bulk Stores

14' wide  $\times$  14' high in 12' Bulk Stores and ordinary Box Stores

14' wide  $\times$  16' high in high Box Stores

Cost for doors: 15/- per sq. ft. plus 1/- per sq. ft. for insulation in appropriate cases.

**(k) Lighting, power sockets**

Sufficient lighting to provide 50 lux over the whole store area. Plus additional lighting in main duct and outside the building. Three-phase and single phase power sockets. Wiring and control gear.

Cost of £400 in 500 ton Stores.

Cost of £500 in 2000 ton Stores.

**(l) Carriage rails in box stores**

6"  $\times$  3" channel at heights of 2' 6" and 4' 6". Cost 10/- per foot.

**(m) Gable end ventilators**

15 sq. ft. in each gable for 500 ton Store.

60 sq. ft. in each gable for 2000 ton Store.

Cost: 10/- per sq. ft.

**(n) Fan house**

One at £150 for 500 ton Store.

Two at £200 for 2000 ton Store.

**(o) High tensile wire**

To take the thrust from the straw bale walls onto the stanchions. One strand for every layer of bales—cost: 1d. per foot.

**(p) Builders' preliminaries**

5% of total of costs (a) to (o).

**(q) Contingency allowance**

10% of total of costs (a) to (p)

## STORE MANAGEMENT COSTS

## (a) Convective Ventilation

At least one mercury-in-glass thermometer with polythene tubing for every 100 tons. Cost: £1 each.  
One max.-min. thermometer for each store. Cost: £2.

Depreciation over 3 years.

Top straw—60 bales per ton. Cost: £5 per ton.

1 ton on 1,000 sq. ft. Replaced every year. Labour for placing and removal roughly 2 man-days for 500 tons. Nets at 1d. per sq. ft. Depreciation over 3 years.

## C.I.P.C. Sprout Suppressant

	<i>Cost/ton</i>	<i>Effective Period</i>
One application of CIPC vapour .. .. .	4/-	100 days
One application of CIPC granules .. .. .	7/6d.	150 days
Two applications of CIPC vapour .. .. .	8/-	2×100 days

The C.I.P.C. granules are used with box stored potatoes and are applied when the boxes are filled. Only one application is possible. With bulk storage the first application is not made until at least three weeks after loading.

Note.—Other sprout suppressants may be used, for example Nonanol and T.C.N.B. (Tecnazene). Nonanol is applied on a 14 day on, 14 day off cycle from just before the time at which sprouting occurs. Cost 4—10s. per ton depending on variety and length of storage. T.C.N.B. is applied as a dust. Cost 12/- per ton. Effective period—3-4 months.

## (b) Forced Draught Ventilation

(i) Thermometers, top straw and nets as for convective ventilation.

(ii) A fan capable of providing 40 c.f.m. per ton.

	<i>Approximate Cost</i>
200 tons—fan to provide 8,000 c.f.m. at 1.5 s.w.g. .. .. .	£90
500 tons—fan to provide 20,000 c.f.m. at 1.5 s.w.g. .. .. .	£220
2,000 tons—2 fans each to provide 40,000 c.f.m. at 1.5 s.w.g. .. .. .	£500 each

The costs given are for axial flow fans.

Depreciation over 5 years after deducting grant of 40% for fixed equipment.

(iii) Frost guard thermostat. One for each fan. Approximate cost: £10. Depreciation over 5 years.

(iv) Differential thermostat. One for each fan. Approximate cost: £20. Depreciation over 5 years.

## (c) Recirculation of Refrigerated Air

(i) All equipment for forced draught ventilation except top straw and nets which are not required with this method.

(ii) For refrigeration of 500 tons of potatoes a unit nominally capable of extracting between 50,000 and 60,000 B.t.u. per hour, plus for recirculation, a fan capable of delivering 7,500 c.f.m. (15 c.f.m. per ton). Total cost whether for direct or indirect refrigeration is likely to be in the range of £1,300 to £1,600.

Depreciation over 5 years after deducting grant of 40% for fixed equipment.

(iii) Remote Temperature Indicator with 12 stations. Approximate cost: £80. Depreciation over 5 years.

(iv) Return Duct for Recirculation. Approximate cost: £30. Depreciation over 5 years.

## Notes:

1. No cost for connecting the equipment up to the electricity supply is included as it could vary greatly depending on the proximity of a suitable supply. In cases where there is no suitable supply this cost may be so high as to rule out the use of electrically powered ventilation equipment.

2. The costs of tractor driven fans are not considered in this report. On farms which use them for other purposes or where there are problems with the electricity supply, they may well be used for the ventilation of potatoes in which case the costings should be changed accordingly.

## LOADING AND UNLOADING COSTS

Essential Equipment								Cost
<i>Bulk Stores</i>								
200 tons—general purpose elevator	..	..	..	..	..	..	..	£500
500 tons—swinging head 14' elevator	..	..	..	..	..	..	..	£850
potato bucket (7½ cwt.)	..	..	..	..	..	..	..	£120
2,000 tons—swinging head 14' elevator	..	..	..	..	..	..	..	£850
potato bucket (7½ cwt.)	..	..	..	..	..	..	..	£120
<i>Box Storage</i>								
10 cwt. boxes	200 tons	} one tractor fork lift	..	..	..	..	..	£425
(5 high)	500 tons		..	..	..	..	..	£200
	2,000 tons		..	..	..	..	..	
1 ton boxes	200 tons	} one tractor fork lift	..	..	..	..	..	£425
(4 high)	500 tons		..	..	..	..	..	£495
	2,000 tons		..	..	..	..	..	£400+
1 ton boxes	2,000 tons	—one electric fork lift truck with box tipper and extended lift						£3,200+
(6 high)		..	..	..	..	..	..	

Note: The prices quoted above are approximate ones for new equipment.

## Maintenance

Costs to cover maintenance have been calculated on the following basis:

- 200 tons—1½% p.a. of initial cost.
- 500 tons—2% p.a. of initial cost
- 2,000 tons—3% p.a. of initial cost

## Running Costs

An elevator with a 2 h.p. electric motor would use about 2 units of electricity if run continually for an hour. At a cost of 2d. per unit this would give a cost of 4d. per hour. For every hour's running of the elevator over 40 tons of potatoes could be moved. The cost per ton is negligible.

A tractor used with a potato bucket or fork lift is costed in at 6/- per hour to cover fuel, repairs and depreciation. It is assumed that 12 tons per hour can be unloaded by tractor bucket and with tractor fork lift 15 tons per hour can be loaded/unloaded in 1 ton boxes and 7½ tons per hour in 10 cwt. boxes.

A fork lift truck would use about 2/- worth of fuel per hour or much less if run on electricity. With a loading/unloading rate of 20 tons/hr. the cost per ton is negligible.

## LABOUR REQUIREMENTS

Loading into Store								Typical requirements
Clamp	..	..	..	..	..	..	..	*20 man mins. per ton
Dickie Pie.	..	..	..	..	..	..	..	*13 —do.—
<i>Bulk Store:</i>								
(a) Above floor laterals and general purpose elevator	..	..	..	..	..	..	..	*10 —do.—
(b) Underfloor laterals and swinging-head elevator	..	..	..	..	..	..	..	6 —do.—
<i>Box Store:</i>								
(a) Tractor fork lift, 1 ton boxes	..	..	..	..	..	..	..	4 —do.—
(b) Tractor fork lift, 10 cwt. boxes	..	..	..	..	..	..	..	8 —do.—
(c) Fork lift truck, 1 ton boxes	..	..	..	..	..	..	..	3 —do.—

\* Source—Austin 1969.



The figures for Bulk Stores depend a great deal on the soil content of the potatoes and could be better than those shown, in a dry year.

Unloading Stores							Typical Requirements
Hand fork	..	..	..	..	..	..	1 man hour per ton
Tractor bucket (7½ cwt):							
(a) above floor laterals	..	..	..	..	..	..	6 man mins. per ton
(b) Under floor laterals	..	..	..	..	..	..	5 —do.—
Tractor fork lift: 1 ton boxes	..	..	..	..	..	..	4 —do.—
10 cwt. boxes	..	..	..	..	..	..	8 —do.—
Fork lift truck, 1 ton boxes	..	..	..	..	..	..	3 —do.—

### Top Strawing

It takes approximately 1 man day to put nets and top straw on a 500 ton store.

### Store preparation, closing, opening and cleaning

Store:	Size (tons)	Typical Requirements (man days)
Clamp .. .. .	200	5 <sup>(1)</sup>
Dickie Pie .. .. .	200	10
Dutch Barn Bulk .. .. .	200	9*+2
	500	18*+2
Dutch Barn Box .. .. .	200	9*+2
	500	15*+4
Straw Insulated Bulk .. .. .	500	12
	2,000	22
Highly Insulated Bulk (2) .. .. .	500	1
	2,000	2
Purpose Built Box Store .. .. .	500	½
	2,000	1

#### Notes:

(1) Does not include earthing-up as this is charged at contractor's rates.

(2) Also Standard Insulated Bulk.

\* Figures for building and removing Dutch Barn walls. Only done once every 3 years.

### Labour Cost

8/- per hour to cover the minimum wage, national insurance, other extras plus an average premium over the basic. Alternatively taken as £3 per man day.

## APPENDIX 11

### CALCULATION OF PROFITS FROM STORAGE

For readers interested in using the information in this report for calculating the profits from storage in specific situations, an example is given below.

#### Example

Storage of 500 tons of King Edward potatoes for sale in April, in a new highly insulated bulk store using forced draught ventilation.

1. Increase in Returns	..	= 88s. 0d. per ton in store	(Example 1, page 9)
2. Structure Costs	..	= 23s. 6d. " " " "	(Table 9)
3. Store Management Costs	..	= 8s. 6d. " " " "	(Table 11)
4. Handling Costs	..	= 9s. 6d. " " " "	(Table 12)
5. Interest Charge	..	= 15s. 0d. " " " "	(page 20)

Then:

Profit per ton into store	..	= 88s. 0d.—23s. 6d.—8s. 6d.—9s. 6d.—15s. 0d.
		= £1 11s. 6d.

Therefore:

Profit on 500 tons	..	..	..	..	= £822 10s.
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