NEW HOUSING FOR DAIRY COWS IN THE EAST MIDLANDS

A Technical and Economic Survey

Kenneth A. Ingersent *Peter Manning*

UNIVERSITY OF NOTTINGHAM

DEPARTMENT OF AGRICULTURAL ECONOMICS

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FOREWORD

Interest in farm buildings has been stimulated in recent years by the introduction of the Farm Improvement Scheme. It can safely be assumed that since the introduction of this Scheme, the volume of farm building has been greater than for many years past. Hence, there is an urgent need for as much guidance as possible, both technical and economic, to help farm-owners to make wiser and more sensible decisions regarding the erection of new buildings. The findings and conclusions emerging from this enquiry have therefore been arranged in a sequence of chapters which follows, as nearly as possible, the successive stages of planning, erecting and utilising a new building. The report also embodies a number of appendices which deal with research methodology and the more technical details of building design, construction and maintenance. These latter have been primarily written for those with specialist interests, and may be omitted by the more general reader.

A somewhat novel aspect of this enquiry is that it represents the co-operative endeavour of an agricultural economist and an architect. Although, on the whole, this collaboration was remarkably harmonious, careful readers will no doubt detect some unresolved differences of outlook within the report. No apology is made for this — the subject matter of the enquiry is wide enough to accommodate slightly differing points of view.

Although this report is written mainly from the farm occupier's point of view, it is hoped that it will also be of interest and assistance to landowners and their professional advisors, to architects, to builders and to farm economists. All of these groups have a vital role to play in ensuring that the farm buildings of the future contribute their due share to greater farming efficiency and prosperity. If this report is of any assistance to those discharging this responsibility, it will have served a useful purpose.

R. BENNETT JONES
Acting Head of the Department.

ACKNOWLEDGMENTS

This enquiry was carried on with the aid of a special grant from the Ministry of Agriculture, Fisheries and Food to whom we are therefore especially indebted on this account.

There are many persons to whom we owe a debt of gratitude for supplying us with much of the information on which the work is based. Amongst these, the most numerous are the farmers and landlords who patiently answered many questions — often on several different occasions — or allowed us to examine their records. Many also afforded us the facilities for carrying out a measured survey of their buildings. Additionally, our thanks are due to many others, including a large number of builders, who answered questions or supplied information by correspondence.

Above all, we wish to acknowledge the help of Mr. K. Rasmussen, Head of this Department from the time of the commencement of the enquiry until July, 1959, and Mr. R. A. Rathbone, of the University of Cambridge, Department of Estate Management who not only gave much valuable advice, but also allowed us to draw extensively on his own work.

CONTENTS

CHAPTER 1

INTRODUCTION

AT THE time when the possibility of pursuing this enquiry was first considered little factual information was available regarding farm buildings erected in this country since the war. It was known that during the five year period from 1949 to 1953 there was in England and Wales an annual expenditure of approximately £5 million on farm building projects costing more than £1,000. During the same period building licences were issued in the East Midlands for approximately 750 farm building projects of a cost exceeding £1,000. On the other hand, nothing was known either about the number or kinds of buildings, or of the total volume of expenditure on building projects costing less than £1,000.

As a preliminary to the main enquiry, therefore, an enumeration was made of plans for the erection of entirely new or largely reconstructed farm buildings approved by local authorities in the East Midlands during the five years from 1951 to 1955.[1] The results of this enumeration showed that, in terms of the numbers of plans approved, livestock buildings predominated over other types and, furthermore, nearly half of the livestock buildings were cowhouses or yards and milking parlours. It was for this reason that the housing of dairy cows was made the subject of the main enquiry.

Objectives

The main objectives of the enquiry were partly technical and partly economic.

The main *technical* objectives were:

(i) To obtain factual information about the numbers, types and sizes of recently constructed cowhouses, and yards and parlours, in the East Midlands.

(ii) To find who was responsible for the design and erection of the buildings.

(iii) To evaluate the adequacy of building design and workmanship and the more important reasons for shortcomings in these respects.

The main *economic* objectives were:

(i) To ascertain the average cost of erecting buildings of different types, and to examine the extent of cost variations and the reasons for them.

(ii) To assess the magnitude and importance of the costs of building maintenance and repairs.

1 INGERSENT, K. A. *Farm Building Plans in the East Midlands.* Farm Management Notes, No. 18, p. 13, 1957. University of Nottingham Department of Agricultural Economics, Sutton Bonington.

(iii) To examine the siting and layout of new buildings within the farmstead from the point of view of the economic use of labour.

(iv) To attempt an assessment of the average rate of return on capital investment in this class of building, and to show some of the reasons why the rate of return was likely to be relatively high or relatively low on individual farms.

An overriding objective was to make recommendations, based on the results of the enquiry, which might help farm-owners and others actively engaged in this field, to plan more useful and more profitable buildings in the future.

Method of Conducting the Enquiry

The enquiry was planned and carried out in two main phases.

The *preliminary survey,* which included new buildings on over 260 farms, was carried out to get a rapid overall picture of the variation in building types and designs, methods of erection and costs. In the case of tenanted farms, information was sought from the landlord normally by means of a postal questionnaire.

The *detailed survey* was carried out to obtain further particulars about a selection of the buildings covered by the preliminary survey. Seventy-three farms were revisited to obtain more detailed information about building design and construction, siting and layout, herd size, kinds and quantities of feeding stuffs fed to the cows, quantity of milk produced and other particulars affecting the profitable use of the new building.

Three postal questionnaires were also sent out.

The *Contract Questionnaire* was sent to owners (visited during the preliminary survey) who had had buildings erected by building contractors. Its purpose was to obtain more information regarding the responsibility for building design, the procedure followed by owners in placing building contracts, and the nature of such contracts.

The *Builders' Questionnaire* was sent to building contractors who erected buildings seen during the preliminary survey, and was designed to yield information about the types of firm engaging in farm building work.

The *Farm Buildings Association Questionnaire* was sent to all the members of that body to obtain information about the sources from which advice may be obtained on the design of farm buildings, the kinds of advice and other services available from different classes of advisor, and the fees charged by individuals and firms engaging in this kind of work. The replies to this questionnaire also yielded supplementary information about the frequency with which farm owners employ professional farm building designers.

The Preliminary Survey Sample

In the enumeration of farm building plans approved by local authorities, plans for cowhouses outnumbered plans for yards and parlours by approximately 16 to one. Moreover, the total number of plans for yard and parlour schemes, including those involving the adaptation of existing buildings, was so small as to suggest that all such schemes could and should be included in the survey. On the other hand, in view of the limited time and other resources available for the enquiry, it appeared that it would be impracticable to include all new cowhouses in the preliminary survey. It was, therefore, decided to restrict this survey to entirely new cowhouses within specified size limits, selection being based on the number of standings. Three size groups were chosen for survey, as follows:—

Small	- - -	10 to 14 standings.
Medium	- - -	20 to 29 standings.
Large	- - -	40 or more standings.

The complete contact list contained the addresses of 284 farms, 229 of them with a new cowhouse and 55 with new or converted yard and parlour buildings. The number of buildings actually surveyed was 264, of which 213 were cowhouses and 51 yards and parlours.[2] However, due to errors in the initial information about the sizes of cowhouses, some buildings outside the three selected size groups were surveyed. Excluding these, the total number of cowhouses included in the preliminary survey was 187.

The Detailed Survey Sample

(i) COWHOUSES

New cowhouses were selected for detailed survey according to three criteria: the number of standings, the plan form, and the cost per cow. The *complete* sample contained a total of 43 buildings divided into 11 small and partially homogeneous groups of which the details are shown in Table 1.

COMPOSITION OF DETAILED SURVEY SAMPLE

COWHOUSES

TABLE 1

Group No.	No. of Standings	Plan Form				Costs per cow	Number of buildings surveyed
		Rows	Feeding passage	Dairy	Feed-store		
1	20	Double	Without	With	Without	Various	3
2	12	Single or Double	Without	With	Without	Various	3
3	20	Single	With	Without	Without	Various	2
4	20	Double	With	Without	Without	Various	4
5	40	Double	Without	With	With	Various	4
6	40	Double	With	With	With	Various	4
7	Various	Single or Double	With	Without	With	Various	4
8	10	Single	With	Without	Without	Various	2
9	Various	Single or Double	With or Without	With or Without	With or Without	Highest	6
10	Various	Single or Double	With or Without	With or Without	With or Without	Lowest	6
11	Various	Single or Double	With or Without	With or Without	With or Without	Average	5

With one exception, the buildings in Groups 1 to 6 inclusive were surveyed with the twin objectives of examining firstly, the relationships between building cost and the technical aspects of

2 See Appendix I for further details regarding the selection of buildings for the preliminary survey.

building design, and secondly, assessing farm managerial factors affecting economic returns from the building, including siting and layout, herd size and milk production.

The buildings in Groups 7 and 8 were surveyed only regarding the farm managerial factors.

The buildings in Groups 9, 10 and 11 were, with one exception, surveyed only regarding the building cost/design factors.

Thus, information pertaining to building cost/design factors was obtained for a total of 36 new cowhouses, and information pertaining to farm managerial factors for a total of 26 such buildings.

(ii) Yards and Parlours

The detailed survey of yard and parlour schemes was confined to those incorporating a substantial amount of entirely new building. A total of 30 farms was visited and the buildings fell into three groups as shown below.

TABLE 2

COMPOSITION OF DETAILED SURVEY SAMPLE

Yards and Parlours

Group No.	Character of Buildings		Number of buildings surveyed
	Parlour	Yard(s)	
1	New	New	15
2	New	Converted, improved or existing	7
3	Converted	New	8

Within all three groups, building costs were very variable and the buildings themselves also showed considerable diversity of internal layout.

All 30 of these buildings were surveyed with the object of establishing the relationship between building cost and the *area* of new work. The study of layout and other farm managerial factors affecting economic returns on building investment was confined to 19 of the 23 buildings in Groups 1 and 3.

The Farms

(i) Size

The size distribution of the farms included in the preliminary survey is shown in the following table.

TABLE 3

DISTRIBUTION OF FARM SIZE

Farm acreage groups	With cowhouses	With yards and parlours	All buildings
	No. of farms		
Less than 20	3	—	3
20 to 39	21	1	22
40 to 59	28	4	32
60 to 79	28	8	36
80 to 99	26	5	31
100 to 149	33	13	46
150 to 299	34	8	42
300 to 499	13	7	20
500 and over	1	5	6
All sizes	187	51	238

On average, the farms with cowhouses (mean size, approximately 140 acres) were smaller than those with yards and parlours (mean size, approximately 200 acres).

(ii) Geographical Distribution

The geographical distribution by county of the buildings included in the preliminary survey is shown in the following table.

DISTRIBUTION OF SURVEYED BUILDINGS BY COUNTY

TABLE 4

Type of Building	Size of Building	Leics.	Notts.	Rutland	Derbys.	Lincolnshire: Lindsey	Lincolnshire: Kesteven	Total
		No. of buildings surveyed						
Cowhouses	10 to 14 standings	29	8	2	25	12	5	81
Cowhouses	20 to 29 standings	35	7	—	30	3	3	78
Cowhouses	40 or more standings	12	4	—	9	1	2	28
Yards and Parlours	Various	11	16	—	3	17	4	51
All Types	All Sizes	87	35	2	67	33	14	238

Whereas a high proportion of the cowhouses were in Leicestershire and Derbyshire, the yards and parlours were principally in Nottinghamshire and Lindsey.

CHAPTER 2

THE DECISION TO BUILD

FARM buildings are tools which may assist the farmer in the profitable production of crops and livestock. Compared with the other tools which the farmer uses, such as breeding livestock, tractors, fertilisers and feeding stuffs, the importance of buildings varies with the type of farming. However, important differences between buildings and most other farm resources are that the former entail relatively heavy capital expenditure, normally have a comparatively long life, and are renewed very infrequently.

Most of the farm buildings with which farms in this country are now equipped are a legacy from past generations and it is widely acknowledged that many of them are not well adapted to present-day farming conditions. It is also a widely held though controversial opinion that, both now and in the future, new farm buildings should be planned with an eye to their adaptability to changing conditions, and also, perhaps, for a lesser degree of permanence than in the past.

Nevertheless, in spite of these changes in outlook, it seems likely that, for most farm-owners, changes in policy involving the erection of new buildings will still entail heavy long-term capital expenditure and continue to have far reaching effects on the long-term profitability of the farm.

The decision to build, then, is not one to be lightly undertaken. What are the main points to be taken into account before arriving at such a decision ?

Competition for the Use of Capital

The farmer employs capital for many different purposes and in many different forms. Livestock, implements and machinery, stocks of seeds, fertilisers or feeding stuffs, and money held in the bank to cover the payment of wages and the many other day to day commitments met with in the running of a farm business, all represent part of the farming capital. In addition there is the capital required for fixed equipment such as buildings, roads, fences, supplies of water and power, and field drainage. These latter items constitute part of what is sometimes called landlord's capital, since they are normally financed by the landlord, to distinguish them from tenant's capital of which the main constituents are the remaining items listed above. For the farmer who is an owner-occupier this distinction is somewhat artificial, since he must procure the *whole* of the capital employed on the farm.

At any particular time, a large part of the farming capital is fixed, i.e. it cannot readily be switched from one use to another. The capital invested in a tractor, for example, cannot be transferred to another use, such as the purchase of additional dairy cows, unless the tractor is sold before it is worn out.

New capital for use in the farm business may be obtained from numerous sources and may be either owned or borrowed, but for many farmers the main source will be accumulated farm profits. Moreover, irrespective of the source from which it is obtained, capital cannot be put to work in a business without incurring the liability of the costs of using it.

For many farmers and farm landlords the supply of free or liquid capital available for fresh investment in any part of the business at a particular time will be scarce and expensive in relation to the many uses which could be found for it.

Since he is usually only responsible for the buildings and other fixed equipment of the farm, the landlord may have somewhat more restricted opportunities for the use of capital than the owner-occupier who plays the dual role of landowner and farm operator. Nevertheless, the outlet for new landlord's capital is by no means restricted to buildings, and on the large agricultural estate there is the additional problem of portioning out the available capital between the rival claims of the various tenant farmers who wish for improvements on the farms they occupy.

But, for the owner-occupier farmer, the problems of allocating a limited amount of capital amongst various rival claims on its use are, in a sense, more complex because he is faced with a greater diversity of possible uses.

The Costs of Using Capital

The object of new capital investment in a business is to enable that business to earn higher profits for its owner in the future. However, it is not sufficient that the capital asset shall earn additional income during its life; a profitable investment must yield an income which exceeds the costs of employing the capital. What are these costs ?

Although they may be more readily apparent with respect to borrowed capital, the costs are essentially of the same kind irrespective of whether loan capital or equity capital is employed. In the case of a project involving the use of loan capital, the borrower needs to satisfy himself that the additional income which the asset is expected to earn during its productive life will more than cover the repayment of the loan plus whatever interest charge is agreed between the borrower and the lender.

In the case of a project involving the use of equity capital it may be best to separate the functions of capital ownership and capital usage, although in reality these two functions are combined in the same person. In effect, the farmer (or other business man) in the role of a business manager borrows from himself in the role of a business financier. Thus, although the terms of the "loan" may be somewhat more flexible than where the money is borrowed from an outside source, provision must still be made for the eventual recovery of the invested capital or, alternatively, for the accumulation of a fund to finance the replacement of the capital asset when it is worn out or obsolescent. In addition, the interest charge still has to be met, this being determined by the highest rate which could be earned by the same amount of capital in the most profitable alternative employment. This is really no more than an adherence to the principle of " selling to the highest bidder." If the principle were not adhered to, then the result could only be that the business was less profitable than it might have been. For example, suppose a farmer is considering putting up new buildings at a cost of £2,000. Suppose further that the same £2,000 could be profitably employed for the purchase of additional farm machinery. A farm budget might suggest that the net results of acquiring and using the new machinery, together with associated changes in the organisation and management of the farm, would be an extra profit of £200 per year. Assuming that this were the *most* profitable alternative use to which the £2,000 could be put, then it would be appropriate to charge the proposed new building with interest at £200 per annum, which is of course, the equivalent of an interest rate of 10 per cent. on the investment. The question then to be decided would be whether the projected buildings would pay interest at this rate, plus an appropriate allowance for depreciation, and still show a profit. The best way of deciding this would again be by means of a budget showing all the anticipated changes in farm costs and farm revenue which the adoption of the project would involve. If the budget failed to indicate an increased farm profit, then it would be no more than common sense to give the machinery project priority over the building project. Only if sufficient capital were available to finance *both* projects would proceeding further with the building project be justified.

Opportunity Costs are Paramount

The preceding discussion of the costs of employing *borrowed* capital now requires some qualification. It is important to recognise that even if a proposed capital project appears to be capable of paying the rate of interest agreed between the borrower and the lender, this in itself will not ensure that the loan is employed to the maximum economic advantage. This is because the loan might be used to finance a number of alternative projects each earning a different profit but all earning enough to pay the rate of interest attaching to the loan. Again, the optimum use of capital will only be achieved when priority is given to the project which may be expected to earn most in return for a given outlay. The ability of a project to pay the market rate of interest on a loan is of little importance, except in the absence of alternative opportunities for employing capital to earn at least this amount.

The Maintenance of Capital

The useful life of a capital asset such as a building can often be prolonged by maintenance. The working life of a car or tractor can be lengthened considerably if it is serviced regularly and if worn or damaged parts are replaced when they cease to function efficiently. Similarly with a building, because of the varying durabilities of the materials used in its construction, some parts of the structure may be expected to wear out more quickly than others. Timber and metal, for example, may deteriorate quite rapidly unless they are protected by periodic painting or application of other preservative treatment.

The costs of capital maintenance depend on the nature and frequency of operations, and also to some extent on the design of a building or machine, and the quality of the materials used in its construction. The quality of workmanship going into the construction may also have a bearing on future maintenance needs.

The question of how much a farmer or landlord is justified in spending on the maintenance of farm buildings poses some difficult economic problems. In the first place, there is no point in prolonging the life of a farm building beyond the time when it has become obsolescent due to changes in farming methods or the requirements of the market. In the second place, the amount of maintenance justified from the economic point of view may well be less than that deemed to be desirable from a purely technical point of view. If a technical advisor, such as an architect or surveyor, were called in to advise on the maintenance of a farm building, he might tend to work out a maintenance programme designed to keep the building as nearly as possible in its original condition, by the regular repair or replacement of defective or damaged parts, and by the regular renewal of paintwork and other preservative treatments. Furthermore, at the design stage, such an advisor might be disposed to recommend that components and materials of high durability should be incorporated in the building in order to avoid the extra maintenance that would be required later on if less durable materials were to be used.

In what respects would the advice of an *economic* advisor differ from that of the purely technical advisor? In the first place, he would only concern himself with those maintenance tasks which were essential to preserve the *economic* utility of the building. Every £ spent on maintenance would need to be more than offset by some economic gain. For example, if there were a leak in the barn roof, the cost of repairing it might well be much less than the cost of the feeding stuffs which would be spoiled and wasted if the defect were not made good. On the other hand, the barn doors might continue to perform their essential functions of protecting the contents of the building from the effects of weather and the entry of unwanted intruders even though, from a technical point of view, attention to the paint work was long overdue. Such "neglect" might shorten the life of the doors by several years, but the important consideration would be whether painting was essential to keep them in operation until the time when the entire building became obsolete due to a change in farming policy or of farming methods. From the standpoint of efficient farm management, there is no point in trying to preserve any part of a building longer than this.

On the other hand, landlords may sometimes need to take a somewhat longer view and adopt a maintenance policy which is mindful of the probable needs of a future tenant as well as the requirements of the present occupier.

Secondly, at the stage of building design, the economic advisor would not endorse the specification of specially durable materials to avoid subsequent maintenance liabilities, without a most careful scrutiny of the costs involved. Of course, if materials of a higher durability but equal functional utility can be obtained without extra cost, it will be no more than prudent to specify them. On the other hand, if such materials do cost more, then the cost of the completed building will be correspondingly greater. Hence, in these circumstances, savings of future maintenance costs are obtained only at the expense of an increased burden of depreciation and interest charges carried by the building. The latter are fixed costs, i.e. they represent an inescapable liability once the building has been erected. On the other hand, maintenance expenditure tends to be flexible in that the amount spent can be varied at will to match any revision of policy regarding the purpose for which a building is used or how soon it should be entirely displaced.

Therefore, unless the extra capital costs of the more durable building are very small in relation to the anticipated saving of future maintenance costs, many farmers are likely to prefer a less durable but cheaper building because it will require a smaller outlay of long-term capital and therefore make less stringent demands on the future earnings of the business.

THE ECONOMIC PLANNING OF A FARM BUILDING PROJECT

Before any farm building project is proceeded with, it is necessary that carefully considered answers be given to a number of questions. The most important of these are as follows:

(i) For what purpose is the building required and what functions will it be expected to perform ? — e.g. to house additional livestock, to save labour through the simplification of work with livestock, to provide a healthier or more comfortable environment for the animals, or a combination of these reasons.

(ii) What type of building is likely to be most suitable for the purpose in view, and what size should it be ?

(iii) With the facilities afforded by such a building, what production could reasonably be expected and what would this be worth in terms of extra farm revenue ? Similarly, by how much would farm costs (other than those associated with the building itself) be increased or decreased ?

(iv) How many years of useful life will be required of the building ?

(v) What will it cost to erect a building of the size and type required and what are the costs of maintaining it in useful condition over the required period likely to be ?

Having answered the above questions to the best of his ability, the farmer should then be in a position to make the best possible estimate of the *net* addition to farming profit which might be expected to result from the completion of the building project under consideration. To this end he should construct a budget showing all the anticipated changes in yearly farm costs and returns, which would be entailed. The likely rate of return on the capital required to erect the building can then be estimated fairly easily.

The next step is to apply the economic test described in the preceding part of this chapter, in order to ensure that the capital required to erect the building could not be put to any more profitable use. In the event that the project does appear to represent the most profitable investment opportunity, it may be put into effect without modification, on one condition. This is that the design and layout of the building are such that the required facilities are afforded at the minimum cost, taking into consideration not only the costs of the building itself, but also the costs of the operations carried on in and around it, e.g. if the building is to be used for the housing of dairy cows, the operations of feeding, milking, littering and cleaning. Given the functions which the building is to perform, and the required standards of finish and durability, then the objective should be to satisfy these requirements with the minimum of expenditure on bricks and mortar. In practice, this usually means that the building should be designed by someone well versed in the arts of both building and farm management. Since farmers rarely seem to specify their requirements in detail, the architect undertaking farm work is usually faced with preparing his own brief. It is also desirable that there should be keen competition between the builders submitting quotations for the work.

If the building project fails to pass the economic test of more profitable alternative methods of employing the capital involved, then either of two courses of action may be adopted :

(i) The original plan may be modified with the object of securing a higher rate of capital return.

(ii) The building project may be abandoned altogether, and the capital employed for the more profitable alternative purpose.

A successful outcome to the first course might be achieved in more than one way. As a first alternative, the cost of the building might be reduced by eliminating from the design some of the less essential features and facilities provided for in the original plan. For example, modifications might be made to the overall building size, the choice of site, the specification of basic building materials, and the specification of finishes and fittings. All these factors may have a material effect on tender prices and the final cost of the building. However, savings in initial building costs will only be of value so long as they are greater than any consequent reduction in the earning capacity of the redesigned building compared with the original. To take a simple example, if, over the long-term, five extra dairy cows could be expected to increase the farm profit by £200 per year, there would be no point in trying to reduce the cost of a new cowhouse by the elimination of five cow-standings, unless this would secure a saving of more than £200 per year in building depreciation and interest charges.

As the second alternative, it may be possible to redesign the building in such a way that for the same, or perhaps a somewhat greater initial cost, extra facilities can be provided, the use of which may be expected to increase farming profit sufficiently to bring about a material improvement in the expected rate of return on the investment. For example, there are still many farms where the cows are milked, and also housed and fed during the winter-time, in as many as four or five widely separated buildings in different parts of the farmstead. Such an arrangement is usually much more inconvenient and time-consuming than where all the cows are housed in one, or even two buildings. Moreover, these buildings are frequently of widely varying ages and of differing designs, and thus markedly dissimilar in their suitability for the purpose for which they are now used. Some may be in quite good repair, and of a design which accords reasonably well with modern methods of milk production, whereas others are in an advanced state of disrepair and of a design quite unsuited to present-day needs and requirements. The time eventually arrives when something has got to be done about these sub-standard buildings, and in such a situation some farmers and landlords seek to minimise capital expenditure by undertaking as little new building as possible, i.e. by only replacing the sub-standard buildings and continuing to use the other buildings as before. However, the adoption of such a policy does little or nothing to improve the general convenience of the layout of the buildings, and the tasks of milking and caring for the cattle remain as time-consuming as before.

On the other hand, several instances are known to the authors of farm-owners in this situation who have adopted a bolder policy. Instead of contenting themselves with a piecemeal scheme of building improvement which does nothing to relieve the inadequacies of the original layout, they have decided to erect a new building big enough to house the entire herd, or even a larger herd than before, thus rendering the existing buildings obsolete. The adoption of such a policy will often require a larger capital outlay than a policy of piecemeal improvement, but it may well be more profitable in the long-run. Comments made by farmers such as, " Since I got the dairy herd under one roof I have been able to keep more cows *and* save a man's labour," bear testimony to this.

If neither of the foregoing methods of modifying the original building project is successful in raising the expected rate of return on the investment above the rate likely to be secured from the most profitable alternative capital outlet, then the second course of action —the abandonment of the whole project—should be adopted, though it may be reconsidered at a later date as additional capital funds become available and after other capital requirements with a higher economic priority have been met.

GRANTS AND ALLOWANCES ON NEW FARM BUILDINGS

This chapter would be incomplete without reference to the special financial assistance now available to farmers and landowners carrying out schemes of farm building improvement, for these may have a material effect on the decision to build.

One of the facts revealed by the National Farm Survey, carried out in the early 1940's, was that on less than 40 per cent. of farms in England and Wales were the buildings considered to be in a " good " structural condition. Although the suitability of their design and the convenience of their layout for contemporary farming needs were not directly assessed at the time, it may be surmised that the proportion of buildings passing these additional tests would have been even smaller.

Although there may have been some improvement in the immediate post-war years, there was little to suggest that the leeway was being made up with any rapidity. Furthermore, in more recent years, it has been strongly argued that in the increasingly competitive conditions in which British Agriculture now finds itself on the world market, one of the brakes on increasing efficiency is the unsuitability of our farm buildings. An additional argument is that this deficiency is particularly great on small farms and others where livestock enterprises are of prime importance. Moreover, on many such farms, unsuitable buildings impose severe limitations on the efficiency of livestock production, and perhaps even more important, hinder the expansion of such enterprises where more intensive stocking would be the key to greater economic success.

A necessary condition of improving this situation is that there should be additional capital available for investment in improvements to farm buildings. In 1955, it was suggested by one authority that the average requirement for this purpose would be £2,000 of additional capital per farm, or a total of about £300 million for England and Wales as a whole.[1] Moreover, the building problem is often most acute on those farms where the capital position is most difficult, i.e. small owner-occupied farms with a low level of net income.

A further difficulty is the degree of confidence with which landowners and farmers view the long-term prospects for particular products or the agricultural industry as a whole. The greater their uncertainty about long-term trends in the market the greater their reluctance to sink large amounts of additional capital in buildings which might fail to pay their way before the full amount of the investment had been recovered or before loan capital had been repaid. The market for the main products of British Agriculture has now been underpinned by the "long-term assurances" incorporated in the Agriculture Act, 1957. Nevertheless, it is inevitable that some degree of uncertainty should remain in the minds of landowners regarding the prospects 10, 15 or 20 years hence and this is likely to influence decisions concerning the erection of permanent farm buildings.

In addition to the long-term assurances, post-war governments have taken more direct action to encourage farm building and indeed, during the last 15 years two kinds of financial incentive have been enacted to stimulate this type of investment. Firstly, there have been fiscal measures giving tax relief on specially favourable terms in respect of capital expenditure on farm buildings. A second and more recent development is the Farm Improvement Scheme under which persons carrying out farm building improvements are entitled to receive, in approved cases, a direct grant-in-aid, based on the cost of the work.

Fiscal Incentives

The fiscal measures are somewhat complicated and the details of the allowances are liable to change from time to time. At the present time, three types of allowances may be claimed in respect of capital expenditure on farm buildings:

1 CHEVELEY, S. and PRICE, O. *Capital in U.K. Agriculture Present and Future.* Netherall Press. 1956.

(i) An *annual allowance* whereby the whole of the original cost of the building may be written off in instalments over a period of 10 years.

(ii) An *investment allowance* of 10 per cent. of the original cost, allowed only in the year when the expenditure is incurred, but which does *not* affect the depreciated value of the building or the annual allowance in subsequent years.

(iii) An *initial allowance* of five per cent. of the original cost, also allowed only in the first year, but which does affect the balance on which the annual allowance is claimable in subsequent years.

To take a simple example, a landowner spending £2,000 on a new farm building would be entitled to the following allowances in the year the building was completed.

	£
Annual allowance (10 per cent. of £2,000)	200
Investment allowance (10 per cent. of £2,000) - - - - -	200
Initial allowance (5 per cent. of £2,000) -	100
Total allowances - - -	£500

At the beginning of the second year the book value of the building would stand at £2,000 - £300 = £1,700, and this could be written down annually by £200 for a further eight and a half years, at the end of which time the whole of the original cost would have been written off against taxable income.

These allowances have a twofold effect on decisions concerning investment in farm buildings. In the first place, the investment allowance of 10 per cent. of the original cost is a once and for all benefit which varies in value according to the total size of the investment and the marginal rate of tax for which the owner is liable. For example, with an investment allowance of £200 and the rate at which the owner was liable to pay tax on the last £200 of his income at 6s. 0d. (the current standard rate of 7s. 9d. in the £, less the earned income allowance of two ninths) the amount of the benefit would be £60.

In the second place, since the other allowances permit the whole of the original cost of the building to be set off against taxable income within a period of 10 years, the owner-occupier can recoup his investment out of the earnings of the building after tax at a faster rate than if the allowances were spread over a period of, say, 20 or 30 years, which in many cases would probably accord more closely with the real life of the building. The quantitative value of this concession will again depend on the marginal rate of tax. It will obviously be most valuable to owners with a liability for payment at the highest rates.

To the majority of farmers and landlords likely to undertake major schemes of farm building improvement, these taxation allowances should enable investment decisions to be made with greater confidence than would otherwise be possible.

Farm Improvement Scheme

Under this Scheme, first introduced in 1957 under Part II of the Agriculture Act, 1957, in approved cases Government funds are available as grants to meet one third of the capital costs of new farm buildings or improvements to existing buildings. The Scheme provides for certain tests of eligibility the best known of which have come to be referred to as the " sufficient livelihood test " and the " prudent landlord test."

The sufficient livelihood test is intended to avoid the payment of grant where a holding would be likely to remain economically " non-viable " even after the proposed improvement had been carried out. The official yardstick is whether the net farm income after the proposed improvement was completed would be likely to exceed the average earnings of a farm worker, i.e. approximately £500 per annum.

The prudent landlord test may lead to the rejection of any proposed improvement which a prudent landlord would be unlikely to carry out himself or regarding which he would be unlikely to consent to pay compensation to the tenant (at the end of the tenancy) where the latter had carried out the work himself.

The Scheme also requires that proposed improvements must be for the benefit of agricultural land occupied together with buildings and that they should not be over-costly in relation to the expected benefits. Grants are restricted to permanent improvements likely to be of value to the " average occupier." A specialist building, which a subsequent occupier would be unlikely to use, will not usually be accepted for grant.

Most of the buildings surveyed for the purposes of this enquiry were completed before Farm Improvement Grants became available. At the time when they were erected, the owner had to find the whole of the necessary capital himself and had to lay out a considerably greater amount than would be required today for an equivalent grant-aided building.

The effect of the present scheme is to tilt the balance of advantage in favour of increased investment in farm buildings and, consequently, to divert more of the farmer's own capital into buildings from alternative channels such as increased expenditure on machinery, livestock or fertilisers. However, even in the changed situation brought about by the Farm Improvement Scheme, farmers and landlords should bear two points in mind. Firstly, even where a building project would qualify for assistance under the scheme, it may still be more profitable to give a higher priority to other forms of capital expenditure which open the way to a higher profit from the farm as a whole, and a higher rate of return on capital. Secondly, if increased investment in buildings is to be turned to profitable account, a complementary increase will frequently be required elsewhere on the farm. On a livestock farm, for example, more buildings will often entail the purchase of additional livestock, and this, in turn, may involve the purchase of extra fertiliser, or even machinery, to enable additional feeding stuffs to be produced. Little benefit is likely to accrue from additional capitalisation in buildings, unless this can be matched with the extra capital required to make full use of the extra building space so provided.

CHAPTER 3

DESIGN

THE word "design" used with reference to a building project means the sum of the innumerable decisions which taken together determine the characteristics of the completed building in advance of construction. These decisions cover every aspect, from the initial broad conception to the smallest detail, including:

(i) function, e.g. siting, layout, size, shape, environment,

(ii) construction, e.g. structure, cladding, finishes, services,

(iii) appearance, and

(iv) costs.

Most buildings tend to be special cases and separate designs will be required for each building. Obviously, where buildings are made to a standard or "type" design—such, for example, as a mass-produced dutch barn—many questions to be settled will be common to all buildings of that specific type. But individual judgments will usually be required for details of design controlled by the site, such as orientation, foundations and drains. A good decision requires background knowledge of the subject, judgment, and a broad view of the whole project, so that each individual consideration is assigned its proper level of importance. During visits to farms it was obvious that in many cases these conditions had not been met.

In the preliminary survey farmers were asked to state what planning or design defects had become apparent in their new buildings, and the answers (Table 5) showed that in many cases the designers of the buildings had lacked the necessary technical knowledge. It was perhaps not surprising that technical knowledge of planning and environmental matters was absent, for the designers of the buildings were commonly the farmers themselves, or their builders, or advisors in other spheres such as milk production[1]. What was curious was the frequency with which defects of a purely agricultural nature were remarked upon in buildings which had been the responsibility of "practical" (i.e. not professionally qualified) designers possessed of a farming background.

A notable aspect of Table 5 is that at the time of the survey none of the new buildings was more than seven years old, and they were all specifically erected to house dairy cows. One or more design defects were mentioned by the farmer-users of more than 80 per cent. of the surveyed buildings. There would have been a considerable improvement in design, in many cases accom-

1 At the time of the preliminary survey, in some counties Milk Production Officers of the National Agricultural Advisory Service were advising farmers on the design of dairy buildings. In 1958, however, the functions of these officials were redefined and advice on building design is now solely the responsibility of the Agricultural Land Service.

PLANNING AND DESIGN DEFECTS IN NEW BUILDINGS
REMARKED UPON BY FARMERS

TABLE 5

Type of Defect	Cowsheds	Yards and Parlours
	Number of defects	
VENTILATION Inadequate ventilation; condensation; absence of window vents; draughts; air inlets at unsuitable levels.	77	3
COW STANDINGS Incorrect depth, width or step height; preference for alternative type of division; division too long or too short; unsuitable tie-ing devices.	54	6
DRAINAGE Dung channels, standings, floors, etc., not suitable for easy washing down; wrong size or position of drain outlets from building.	35	9
MANGERS AND FEEDING ARRANGEMENTS Wrong shape, size, material, level, divisions; no facilities for cleaning or for separating; unsuitable design of barriers between manger and feeding passage.	33	12
DIRT, VERMIN AND SAFETY Surfaces difficult to clean or slippery and unsafe; ingress of vermin.	20	3
FEEDING PASSAGES Position of; absence of; access to; feeding passage too wide or too narrow.	20	1
ANCILLARY BUILDINGS Position, absence or size of dairy or feed-store.	17	5
LIGHTING Inadequate natural or artificial light; lights in wrong position; electric light equipment not waterproof.	17	2
PENETRATION OF RAIN, DAMP AND SNOW Due to siting or detailed design. (Not due to structural failings.)	14	14
STRUCTURAL IMPEDIMENTS: BADLY DESIGNED CIRCULATION Inconvenient stanchions or wall projections; low eaves; unnecessary steps; badly positioned doors and gates; inconvenient work routes	13	12
DOORS, GATES Too narrow; preference for sliding doors; liability of door runners to freeze; inadequate construction; unsuitability of design.	12	9
WALKWAYS Unsuitable width or height of walkways.	12	4
PLUMBING Water system liable to freeze or otherwise defective; water bowls of unsuitable pattern, or in wrong position.	9	3
VARIOUS.	10	6
TOTAL	343	89
NUMBER OF BUILDINGS SURVEYED	187	51

panied by lower costs, if one of two procedures which are common in other industries had been adopted:

(i) Consultation with those individual advisors or institutions who are able and prepared to offer free advice, and the examination of available literature on the subject,

(ii) The employment of a qualified designer with specialist experience.

The remainder of this chapter consists of a discussion of these two procedures, followed by an examination of some basic design decisions.

ADVICE AND LITERATURE

British farmers have many free sources of advice. Perhaps their very number induces user-resistance, for it seems that much useful advice is neglected. During visits to farms it became apparent that apart from the free advice which was available not being sought, it was very common for a farmer not to know that it was obtainable. For this reason, there follows a summary of some of the sources of advice which are available to farmers.

Free Advice

In England and Wales the Agricultural Land Service of the Ministry of Agriculture, Fisheries and Food, and in Scotland the Farm Building Departments of the Agricultural Colleges, maintain staffs of architects, land agents, surveyors and others whose task it is to give free advice on farm building design and construction. Other individuals attached to farm institutes, colleges, research institutions, etc., give advice from time to time[2]. Working drawings are rarely provided but surveys of existing buildings are fairly commonly undertaken as a free service. Ideas are usually presented in the form of "sketch plans"—i.e. plans drawn to scale showing the main lines of the scheme but containing insufficient detail for constructional purposes.

A small number of farmers declared that their buildings were designed by officials of the Milk Marketing Board. The Board denies giving this type of assistance but when asked will give advice of a "preliminary or basic nature."

Farmers can expect much advice from the building and ancillary industries, some intended to ensure that materials are used correctly and some in the interests of sales promotion. Advice of the first type is provided by research and development associations, e.g. the Timber Development Association[3] and the Cement and Concrete Association[4], and most manufacturers of building materials provide some form of advisory service. While these bodies will advise against particular structures or materials when they are likely to be unserviceable, there is usually reluctance to make any comparisons of the economic advantages of alternative materials.

Of 38 replies to the Farm Buildings Association Questionnaire from manufacturers of steel or concrete framed buildings, building materials producers, and other members with commercial interests, over 80 per cent. indicated that it was normally necessary for their firms to provide a design and drawing service. Except for verbal advice, which was usually free, the proportions charging and not charging for services were approximately equal. Thus, in respect of the 14 replies which indicated a complete service of advice, survey and standard and purpose-made drawings, seven made no extra charge and seven charged amounts varying from less than 5 to over 10 per cent. of the building cost.

Where a building manufacturer does not charge for his advisory services it can be assumed that the costs of the advice are included in the price of the actual goods. It does not necessarily follow that if the advice is not sought the total cost will thereby be reduced.

Literature

Practically all the bodies which have been previously mentioned publish advisory handbooks and leaflets of one sort or

2 Of 38 official advisors, teachers or researchers, replying to the Farm Buildings Association Questionnaire, 20 give free advice upon farm buildings regularly, and 11 intermittently.

3 Timber Development Association, 21 College Hill, London E.C.4.

4 Cement and Concrete Association, 52 Grosvenor Gardens, London S.W.1.

another. The following are likely to be particularly valuable to the farmer:

"Code of Clean Milk Practice" (Ministry of Agriculture, Fisheries and Food).

"Fixed Equipment of the Farm" leaflets (Ministry of Agriculture, Fisheries and Food) including:

No. 1. "Cowhouses in Modern Practice."[5]

No. 3. "Farm Dairies."

No. 5. "The Milking Parlour."

For the farmer intending to do his own concreting, or interested in supervising his building, the "Man on the Job" leaflets, obtainable free of charge from the Cement and Concrete Association, would be helpful, particularly:

No. 3. "How to mix better concrete."

No. 17. "Building with Concrete Blocks."

No. 18. "Protecting and Curing Concrete."

In addition, this Association now produces a range of pamphlets describing particular applications of concrete on the farm.

A publication of the West of Scotland College of Agriculture describes Scottish cow-housing practice, but should be of interest and use to farmers in other regions[6].

The farming press publishes frequent articles on "do it yourself" farm building. Some are excellent, but the advice in others is sometimes dubious. These articles, when written by laymen for laymen, should be regarded with caution.

THE EMPLOYMENT OF PROFESSIONAL DESIGNERS

During the course of the enquiry it appeared that in some cases money might have been saved, or spent more wisely, if owners had had the services of a professional building designer before they commenced building work. Although there was considerable reluctance on the part of farmers to incur professional fees, there was a minority who would have been prepared to pay for advice. In a number of cases an owner declared that he would have been willing to engage a consultant but did not know where to find one. For these reasons it was decided that some guidance should be given in this report. Since it was not possible to do more than touch upon the subject, a start was made by circularising the members of the Farm Buildings Association. This appeared to be a body to which designers interested in farm buildings would be likely to gravitate. Similar enquiries were addressed to those professional persons who had been responsible for the design of dairy cattle buildings seen during the preliminary survey.

5 If the advice contained in this leaflet had been followed more often there would have been many fewer remarks about design defects by farmers. Single copies of this or other "Fixed Equipment" leaflets are available gratis on application to the Ministry of Agriculture, Fisheries and Food, 3 Whitehall Place, London S.W.1.

6 FORSYTHE, R. J. *Building a Byre*. West of Scotland College of Agriculture, 6 Blythswood Square, Glasgow W.2. Bulletin 151. 1956.

Farming makes comparatively little use of professional designers. The results of the Contract Questionnaire gave an indication of the frequency with which designers of different categories are employed (Table 6).

TABLE 6 FREQUENCY WITH WHICH DIFFERENT CATEGORIES OF DESIGNERS WERE EMPLOYED

Designer	Cowshed	Yard and Parlour	Total
	No. of buildings		
Land agent	24	12	36
Agricultural Advisory Officer	17	5	22
Owner or tenant	16	4	20
Owner and builder	18	—	18
Builder	16	1	17
Architect	7	7	14
Other combinations	13	—	13
TOTAL	111	29	140

As might be expected, land agents, who are the traditional designers of farm structures, were the largest single category and formed nearly 26 per cent. of the total. Architects formed a further 10 per cent., but the description may need some qualification, for the term was sometimes used to describe individuals who were probably not professionally qualified. But assuming that one in three buildings was professionally designed, this is still a smaller proportion than for almost any other building type[7].

Many of the land agents and architects included in Table 6 were employed as salaried officers of government departments, local authorities, and other substantial landowners. A large volume of farm building work occurs as small individual projects on numerous owner-occupied farms or very small estates, and it is here that it is the exception rather than the rule for a consultant to be employed.

Some of the reasons why professional designers are not employed more often appear to be as follows:—

(i) The fees of a consultant are seen as an addition to building cost.

(ii) Farmers consider that the normal run of farm building design and construction is so simple that there is no need for professional expertise.

(iii) Architects have acquired a reputation for increasing building costs, demanding higher standards than are needed and, by their ignorance of agricultural matters, erecting "white elephants."

(iv) There is a strong bias amongst farmers in favour of "practical experience" and scepticism of the non-farming theoretical specialist.

(v) Considerable advice and assistance is available free.

(vi) Many farmers thoroughly enjoy both designing and erecting their own buildings and would be unlikely to call in a consultant because it would deprive them of this pleasure.

7 *A Survey of Private Architectural Practice*. Journal of the Royal Institute of British Architects. Vol. 66, Nos. 6 and 8, April and June, 1958.

In the Contract and Farm Buildings Association Questionnaires owners were asked whether for future building work, they would be prepared to pay fees of between 6 and 10 per cent. of the building cost for competent specialist advice, design and supervision. Answers indicate that farm building consultants have considerable leeway to make good before their services are required as readily as, for example, are those of the veterinary surgeon (Table 7).

FREQUENCY WITH WHICH BUILDING OWNERS WERE PREPARED TO INCUR PROFESSIONAL FEES

TABLE 7

	Contract Questionnaire			F.B.A. Questionnaire
	Cowsheds	Yard and Parlour	Total	
	No. of owners			
Prepared to pay fees of between 6 and 10 per cent of cost of building for "competent specialist advice, design and supervision"	15	4	19	28
Not prepared to pay	48	8	56	25
Agent, architect, etc. already retained or employed	37	16	53	—
Other answers	4	1	5	10
No answer given	7	—	7	8
Total	111	29	140	71

The Contract Questionnaire covered a larger number of owners, was probably more representative of the general view of owners of dairy farms and could, therefore, be expected to show a more typical response. Approximately 22 per cent. of these owners who did not already retain or employ a designer were prepared to pay fees under the stated conditions. The Farm Buildings Association Questionnaire, on the other hand, could be said to represent the views of those farmers most conscious of the value of good design of buildings, and here the corresponding percentage was nearly 40. These figures demonstrate the difficulties in the way of any designer intending to specialise in this field—even under the most favourable circumstances, it seems doubtful whether more than two farm owners out of five are at present prepared to pay for the services of a professional farm building designer. A more realistic estimate of the potential market for the sale of design skill is one farm-owner in five not already employing a professional advisor.

What Benefits Arise from Employing a Consultant?

The advantages which may be claimed for the services of independent professional consultants are:—

(a) Different builders will tender different prices for a given piece of work. One of the functions of a consultant is to draw up the documents (i.e. plans and specifications) which describe what building work is required. Only on the basis of such detailed descriptions can a building owner have the advantages of proper competitive tendering.

(b) A farmer who builds on only a few occasions in a lifetime cannot hope to match the accumulated experience of a specialist. This experience, applied to the consideration of major issues such as siting, layout, size and structure will determine the efficiency of a project from its inception.

(c) It may be expected that advice given will be unbiased and solely in the best interests of the building owner. This, of course, applies to professional consultants who are strictly bound by codes of professional conduct (see p. 24). Much advice available to farmers is *not* unbiased.

(d) Building quality is reflected in building life. Good quality work is best ensured by professional supervision—few farmers have the requisite background knowledge.

The Work of a Farm Building Consultant

The work of a farm building consultant concerned with a new building project may be described as:—

(i) Considering, in conjunction with the owner, the building needs of the farmstead and drawing up a "programme" or "brief" of building work required. Ideally, and by no means impossibly, present needs are seen within the framework of a "Master Plan." This is an outline schematic plan for the development of the farmstead over a number of years. It allows for the greatest flexibility and change in farming policy, but provides an allotted place for each stage of development as it becomes necessary or possible. Such a plan should be considered a necessity, for by organised planning the haphazard growth which on so many farms results in heavy expenditure of time, labour and money can be eliminated.

(ii) The preparation of measured surveys. The starting point of any consideration of a new building project should be the scale drawing of the farmstead. Only a scale plan can show the relation of a project with existing buildings and the work routes which will be necessary.

(iii) The preparation of "sketch designs," to show the main elements of a proposed planning arrangement, taking into account all the relevant technical and other requirements, and estimation of the approximate cost of the scheme.

(iv) Preparing "working drawings" and written specifications of work and materials from which builders can prepare estimates of cost.

(v) Obtaining competitive tenders from builders and advising the owner upon those tenders.

(vi) Arranging a contract with the selected builder, supervising the builder's work and settling the accounts on completion.

These duties correspond to those normally performed by an architect in private practice or an agent in the employ of a landlord.

The names of 37 consultants in private practice were obtained from the various enquiries. Many of these had more than one qualification, the combination of land agent and surveyor (occurring 14 times) being particularly noticeable. The frequency with which various qualifications occurred, either singly or in combination, is shown in Table 8.

FREQUENCY OF OCCURRENCE OF VARIOUS CATEGORIES OF QUALIFICATION AMONG CONSULTANTS

FARM BUILDINGS ASSOCIATION QUESTIONNAIRE

TABLE 8

Type of qualification	No. of times occurring
Surveyor	21
Land agent	17
Architect	14
Agriculturist	8
Civil or structural engineer	3
Mechanical or electrical engineer	2
Other	5

Fees Charged by Farm Building Consultants

The only nationally recognised scale of fees for building consultants is that of the Royal Institute of British Architects, which has also been adopted by the Royal Institution of Chartered Surveyors. In brief, the percentage charge of the R.I.B.A. scale, for new works and including payment for advice, design and supervision varies from 10 per cent. for work up to £500, reducing to six per cent. for work costing over £4,000. Where payment is by time, the R.I.B.A. scale fees are a minimum of one and a half guineas per hour for the principal's time. In all cases, travelling and expenses are extra.

The majority of consultant members of the Farm Buildings Association base their fees upon the R.I.B.A. scale (including some who modify the scale "to suit circumstances and jobs"). Another published scale in use is the Model Form of Agreement of the Association of Consulting Engineers: for building work, this amounts to 10 per cent. and expenses.

Other systems of percentage charges, not based on the R.I.B.A. scale, are in use. Of these, the lowest appeared to be one described as "varying from four per cent. for straightforward new building to six per cent. for complicated alteration work: prints, telegraph, travelling, etc., at cost." Another consultant, normally charging 10 per cent. of gross cost reduces this to 2½ per cent. "for dutch barns and straightforward jobs." The highest percentage charge appeared to be "between 12½ per cent. and 6 per cent., according to the type of building." Where payment is by time and not based on the R.I.B.A. scale, the lowest rate appeared to be £1 0s. 0d. per hour and the highest £2 0s. 0d. per hour, or fifteen guineas per day. In most, but not all cases, travelling and expenses are additional to percentage or time charges.

There are a number of individuals in the field of farm building design who charge low fees to their "clients" and in addition, obtain commission from the builders or manufacturers whose products they specify. Architects, chartered surveyors and land agents are not allowed to do this.

How to Find a Suitable Consultant

A prospective building owner can usually obtain the names and addresses of suitable designers from the secretaries of the appropriate professional institutions. The more important of these are as follows:

Architects: Royal Institute of British Architects, 66, Portland Place, London, W.1.

Land Agents: Chartered Land Agents' Society, 21, Lincoln's Inn Fields, London, W.C.2.

Surveyors: Royal Institution of Chartered Surveyors, 12, Great George Street, Westminster, London, S.W.1.

Copies of the list of 37 farm building consultants who responded to the Farm Buildings Association Questionnaire may be obtained from the Secretary of the Farm Buildings Association[8]. This includes architects, surveyors, land agents, agriculturists and others, and is arranged geographically, by counties. It must be stressed that the list contains no more than the names of individuals and firms who have described themselves to this Department as engaging in the practice of farm building design. There must be many competent designers who are not included. Moreover, this is not an "Approved List" of consultants. A farmer must satisfy himself as to the ability of any particular designer—reputation and successful previous jobs are the best recommendation.

BASIC DESIGN DECISIONS

Considerable limitations had to be imposed on the scope of this investigation and only a few aspects of design could be studied in detail. Of these, the principal one was building costs, and in one form or another this subject was considered in every chapter of this report. Another aspect which received some detailed consideration was the siting of new buildings in relation to ancillary buildings and work routes; this forms the subject of Chapter 4. These aspects were studied in sufficient detail for certain principles to be established and specific recommendations made. But in addition many individual instances were seen of basic design decisions profoundly influencing the efficiency and economy of buildings. These tended to be peculiar to particular farms and occurred too infrequently to permit the formation of general rules. However, it is the basic design decisions relating to such things as siting, layout, size and structure which, translated into bricks and mortar, are least amenable to change. Some discussion, therefore, even if brief and inconclusive, is likely to be more constructive than an avoidance of the issues involved.

8 Secretary, Farm Buildings Association, Westfield. Braunston, Oakham. Rutland.

Costs of Adapting Old Buildings

The enquiry was principally concerned with new buildings, but yard and parlour schemes were seen where parts were new and others existing or modified. The average cost of 22 new parlours was £80 per milking stall or 21s. 0d. per square foot. The average cost of adapting six buildings to form milking parlours was £68 per stall or 17s. 0d. per square foot. The ranges of cost were wide, and there were several cases of more money being spent on adapting old buildings than it is likely would have been incurred in building anew, to exact requirements. The small saving in costs indicated by these figures seems scarcely sufficient to justify the compromises which are inevitable in almost any conversion scheme (Plate 1).

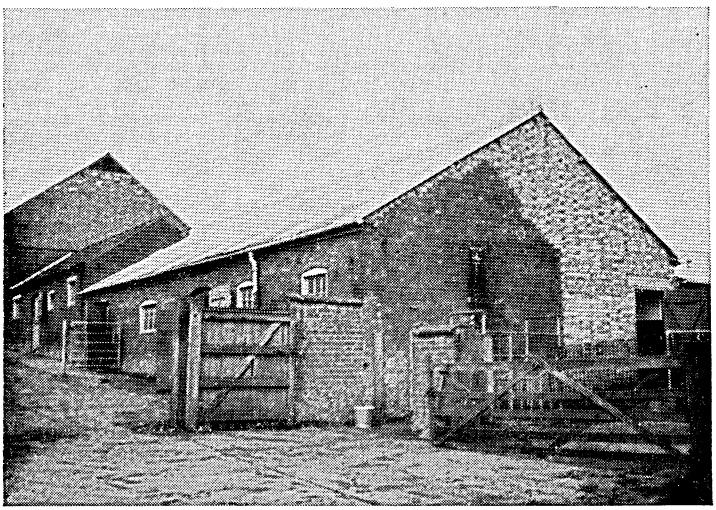

Plate 1: Conversion schemes inevitably involve compromise.

Roof and Rainwater Design

Rainwater is the greatest potential source of trouble and deterioration in the fabric of a building. In designing roofs, the aim must be to collect water simply and rapidly and convey it clear of the walls to the drains. Complicated intersections of roofs and involved junctions of rainwater fittings easily lead to rainwater being diverted from its intended route (Plates 2 and 3).

Simple roof shapes are to be preferred, and valley gutters eliminated whenever possible (Plate 4). Unforeseen expansion of an enterprise can produce a picturesque silhouette but in addition a probable source of future maintenance troubles (Plate 5).

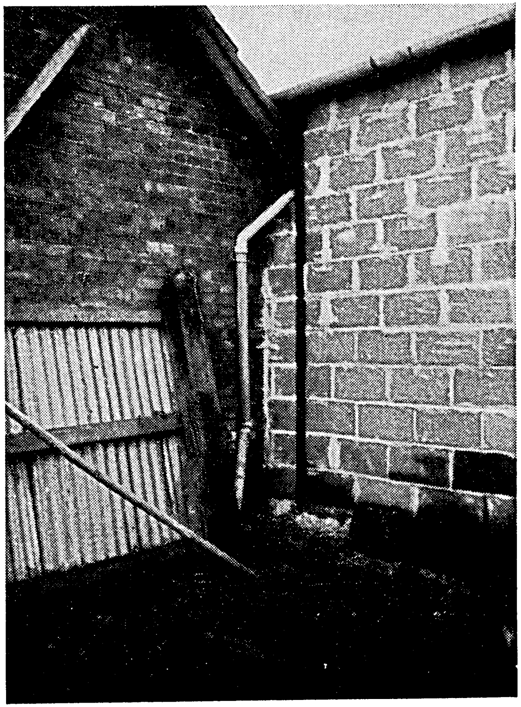

Plate 2

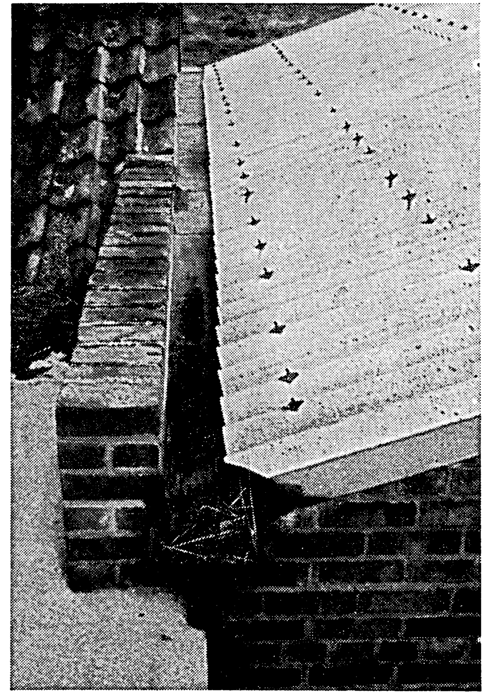

Plate 3

Complicated roof intersections may lead to rainwater being diverted from its intended route.

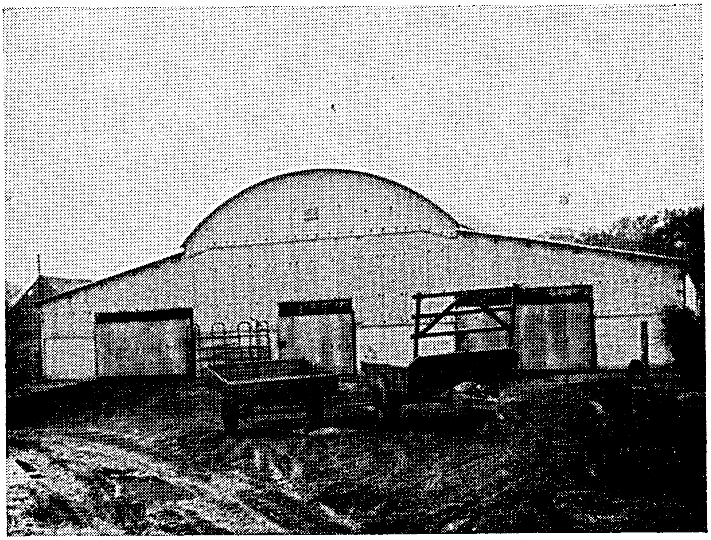

Plate 4: Simple roof shapes and the elimination of valley gutters are to be preferred.

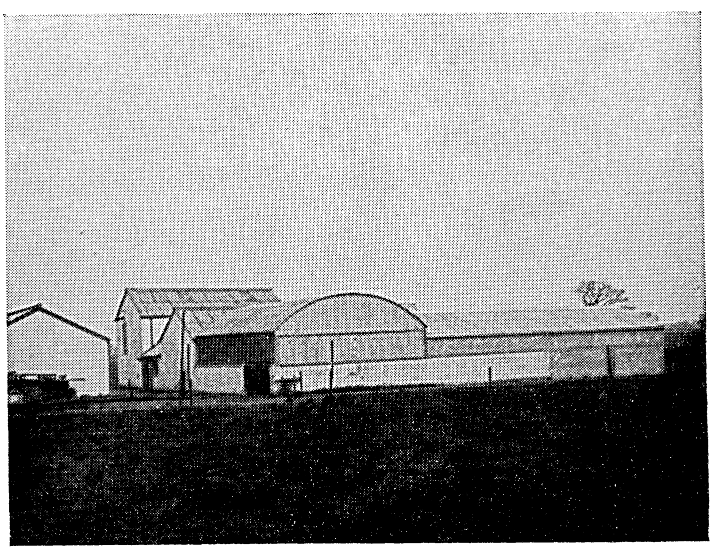

Plate 5: Unforeseen building expansion may be a source of future maintenance troubles.

Building Shape

In general, the simpler the enclosing envelope of a building, the cheaper it is likely to be. Plate 6 illustrates a well built but expensive cowshed. The expense might have been justified on grounds of building effort and quality obtained, but buildings of equal quality, and possibly greater efficiency, have been achieved less expensively by the design of simpler shapes.

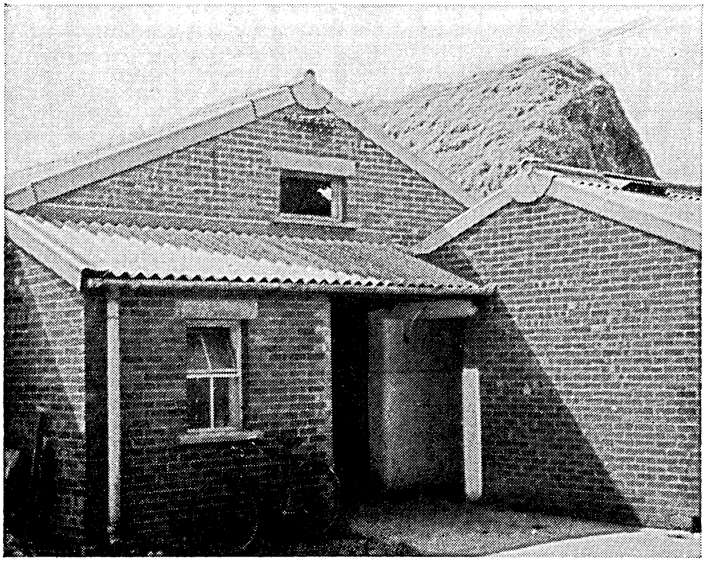

Plate 6: A well-built but expensive cowshed.

Provision for the Extension of Buildings

To impose too rigid a building pattern upon the housing of a small herd may lead to serious disadvantages if later it is desired to expand. The cowhouse shown on the left of Plate 7 could not be extended. When the herd was increased in size a second building of similar size was built alongside. This obviously resulted in much extra and needless labour. Even quite small herds can often be accommodated as cheaply in a double row as in a single row building, and the double row building is suitable for subsequent elongation. "A double row layout is preferable to a single row of stalls even for the 15-cow shed"[9].

9 REID, I. G. and DOMINY, J. *The Dairy Farmstead—An Enquiry into the Layout of Farm Buildings.* University of Reading. 1954. The authors compare the work routines of various plan forms and sizes of cowshed.

Plate 7: Provision should be made for building extensions.

Basic Structural Dimensions and Manufactured Buildings

There is a need for an objective evaluation of the structural spans and bay spacings required for farm buildings, together with a comparison of the dimensions of standard buildings which may be purchased. At present there is often little correspondence between the products of any two manufacturers. According to replies to the Farm Buildings Association Questionnaire, this is a situation which many manufacturers would like to see changed. For the farmer, it means that truly competitive tenders for framed buildings are virtually impossible, and once a building has been erected, he may be tied to the same manufacturer for any extensions because a particular dimension cannot otherwise be matched.

Basic structural dimensions tend to be permanent and impose a stringent control over future uses of a building. Internal columns may obstruct (Plate 8) but they can, at a pinch, be moved. Internal clear height is perhaps the most critical dimension, for it is rarely practicable to raise a whole roof should it be found to be too low for a particular purpose.

In answers to the Farm Buildings Association Questionnaire several manufacturers of standardised buildings mentioned that they were often asked to modify their standard structures to suit existing buildings. This is usually a highly expensive practice and one where the savings resulting from the use of existing walls, and other components, do not compensate for the extra cost. A covered yard is shown in Plate 9 where the end bay of the two spans is wedge-shaped, the only apparent reason for this being the utilisation of an existing wall which saved the construction of a few square yards of 9in. brickwork. This seemed an expensive way of "saving money."

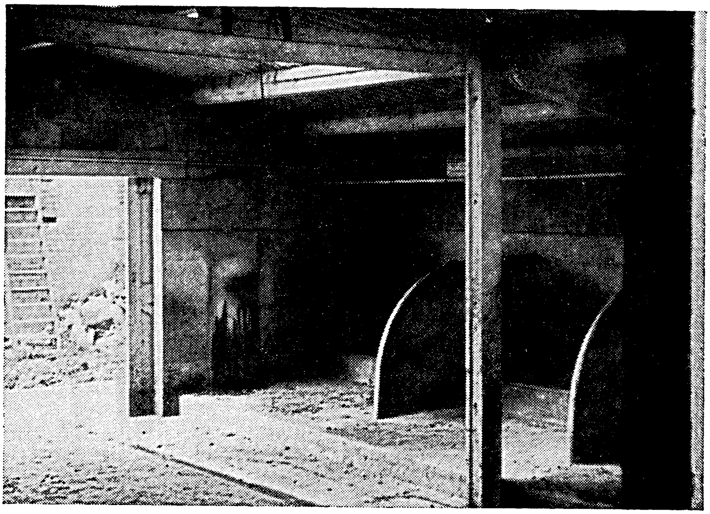

Plate 8: Internal columns may cause obstruction.

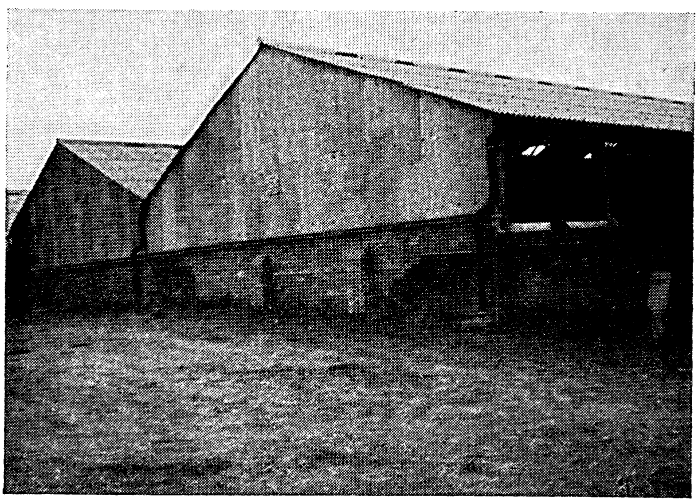

Plate 9: Modification of standard structures to "fit" existing buildings is not to be generally recommended.

Falls to Concrete Floors and Yards

The gradients to which the floors of cowsheds and yards are laid are usually insufficient to permit proper drainage. A typical fall was found to be ½in. in 3ft. 0in., which appears to be quite inadequate to allow for any minor irregularities in the floor surface or small deposits of soil. Forsythe[10] advocates a fall in the cow-standing of at least 3in. from manger to heelstone, and it is suggested that a minimum gradient for cowhouse floors should be 1in. in 3ft. 0in., and for external yard paving 1½ in. in 3ft. 0in. *away* from covered yards.

Yard and Parlour Design

Although more recently erected buildings were added to the original list of buildings intended for survey as and when they became known, the basic sample related mainly to work built in the early 1950's. Thus many of the surveyed yard and parlour schemes were constructed at a time when they represented a comparatively new building type, and this may be the reason why they often displayed so little imaginative design. To a large extent it seemed that the yards were conceived as another form of cowshed, with feeding and bedding arrangements influenced by traditional methods. It was only rarely that yard and parlour schemes were seen to be designed with an understanding that this system of housing requires completely different attitudes towards working methods. Intending designers of new schemes are strongly advised to study recent publications dealing with this subject[11].

The numbers of cows which could be housed in a set of yards were calculated for 23 schemes and, where possible, compared on three bases:—

(i) An (arbitrary) allotment of 100 square feet of yard space per cow[12].

(ii) By counting the numbers of yokes, or allowing 2ft. 6in. per cow for undivided mangers.

(iii) The farmer's estimate of the capacity of the yards.

In general, there was a close affinity between the farmer's estimate of capacity and the number of yokes or manger spaces, but there was usually a discrepancy between either of these measures and the number calculated from yard area. In practice, considerably more than a total of 100 square feet of yard space was usually allowed to each cow[13]. There appear to be opportunities for making economies by reducing the overall areas of yard space available to the cow. This will only be practicable if the resulting space is sheltered—some of the yards seen during the survey were so exposed as to be virtually unusable.

10 Op. cit.

11 e.g.,STURROCK, F. G. and BRAYSHAW, G. H. *Planning the Farm to Save Labour.* University of Cambridge, School of Agriculture. 1958.

12 Total of covered and uncovered yard area available to the cow.

13 There are a number of likely reasons why surveyed buildings were not always being utilised to their full capacity: for further discussion of this, see Chapter 8.

SUMMARY

The preliminary survey showed that farmers were not satisfied with the design of their new buildings. This usually arose from their failure to make one or both of two particular decisions:

(i) To use available information, and/or

(ii) To employ a capable designer.

Many farmers do not know that free information, literature and advice can be obtained from the Ministry of Agriculture, and various development associations.

Approximately one third of the buildings surveyed were designed by professionally qualified persons, mostly land agents and architects in the employ of official or institutional landlords. It is exceptional for professional designers to be employed on small estates or owner-occupied farms. Only one farmer in five who does not already employ a designer would be prepared to incur fees for any building work he might undertake in the future. The responsibilities of a farm building designer are similar to those of an architect or land agent. Fees currently charged by consultants vary, but tend to follow the pattern of the R.I.B.A. scale. The professional institutions and the Farm Buildings Association will usually suggest the names of suitable designers to landowners requiring this information.

Certain basic decisions determine the efficiency and economy of a building. Once constructed, buildings may be difficult to change. Adaptation of old buildings often costs nearly as much as new construction. Where possible, simple shapes should be used in the design of new buildings and rainwater run-off given particular attention. In the design of yard and parlour schemes the system of housing should be seen to be part of a comprehensive management policy where a principal aim is the conservation of labour. Buildings should be capable of being enlarged. The choice of structural dimensions for a framed building, particularly the clear internal height, will control the use of that building during its entire life. Standard buildings should not be modified.

CHAPTER 4

CHOICE OF SITE AND EXTERNAL BUILDING LAYOUT

SITING and external layout are matters of considerable importance in the planning of a new farm building. As already remarked in an earlier chapter, building layouts on many farms in this country are not well adapted to the requirements of present-day farming, and particularly to the need for greater economy in the use of labour. This situation has resulted partly from the handing down, by previous generations, of farmsteads designed in an age when farm labour was more plentiful and therefore cheaper than it is now, and partly from the piecemeal development of farm buildings over the years by the conversion of existing buildings from one use to another, by the enlargement or extension of existing buildings, or by the haphazard addition of new buildings without sufficient thought being given to the interdependence between the new and the old.

A convenient layout of buildings is particularly valuable in the management of livestock and, indeed, on many farms the buildings are primarily used for this purpose. A livestock enterprise such as milk production entails a daily routine, often occupying a major part of the day for one or more men, during which much time is spent in and around the buildings, performing tasks such as milking in the cowhouse or parlour, washing up in the dairy; fetching feeding stuffs from various storage points for feeding in the cowhouse or cowyards; removing manure from cowhouse, parlour or collecting yard, and fetching straw for use in the cowhouse or yards. It is clearly advantageous that these tasks should be performed with the minimum of time, effort and trouble, and although the layout of buildings is not the only factor deciding how nearly this goal is achieved, its influence is undoubtedly of importance. The best type of layout is one permitting the freest and least impeded movement of men and materials in and around the buildings and enabling the most efficient work methods and modes of transport to be used.

One measure of the efficiency of a transport operation is the distance travelled. Taking as an example an everyday operation such as the transport of hay between the hayshed and the cowhouse, for any one method of transport, the time required to complete the operation will be proportional to the distance involved. Hence, the nearer the hayshed is to the cowshed the shorter each journey will be and hence the shorter the time required to complete each journey. However, the total time required to get the hay from the hayshed to the cowshed depends not only on the time required to complete one journey, but also on the number of journeys required to complete the operation, and this will in turn depend on the method of transport employed. Hay may be carried on a man's back, one bale at a time; a hand-trolley may be used carrying, say, six bales at a time; or a tractor and trailer may be used carrying 50 or more bales per load.

At first sight, the tractor method might appear to be the most efficient method under all circumstances, since its use will enable the maximum quantity of hay to be carried at each journey. However, a number of additional factors need to be considered. Firstly, the quantity of hay required in the cowshed at any one time will be determined not by the capacity of the vehicle used, but by the feed requirements of the cows in a day, or longer period, and the amount of storage space in the cowshed. For example, if the total requirement for any one feed is four bales, and there is temporary storage accommodation in the cowhouse for a further 20 bales, the maximum amount which can be taken from the hayshed to the cowhouse at any one time will be 24 bales. Assuming the existence of a building layout where any of the three modes of transport referred to above could be used, the necessary number of journeys to get this quantity of hay from the hayshed to the cowhouse would be 24 for the man-handling method, four for the hand-trolley method, and one for the tractor-trailer method.

Secondly, the two methods involving the use of vehicles entail the operations of loading and unloading, in addition to the operation of actually travelling with the hay. These additional operations will absorb a considerable proportion of the total time required for the job, particularly in the case of the tractor-trailer method, and the overall saving of time, compared with the man-handling method, may be much less than a mere comparison of the times spent in actual travelling would suggest. If an overall saving of time is to be secured from the use of vehicles, this will obviously be greatest where there is the greatest distance between the hayshed and the cowhouse, and vice versa. But, there will also be a minimum distance below which it will not be worthwhile to use a vehicle at all, because the loading and unloading time is greater than the saving of time spent in actual travel.

Thirdly, the use of vehicles involves additional costs which need to be set off against the value of any time which may be saved. These are the costs of depreciation or replacement as the vehicle wears out, and, in the case of mechanically propelled vehicles, fuel and other running costs.

Thus, although reducing the distances over which loads have to be carried is not the only criterion of a good building layout, it is still an important one. Furthermore, many progressive farmers and other designers of farm buildings are aware of the principle, as is shown by a number of recent developments in the design of livestock buildings. For example, it is now widely acknowledged that the best place for a silage clamp is usually as near as possible to where the silage is actually fed.[1] If cattle are housed in yards, one of the best arrangements is to have the clamp running parallel to the yard fence so that the silage can be thrown directly into the

1 But see p. 41 for a qualification of this statement.

yard. The same principle is now being applied to the storage of hay and straw, by making provision for stacks to be built immediately adjacent to one or more sides of a yard, often with a movable fence between the stack and the yard so that, again, the material is always within forking distance of the yard.

In one of its most extreme forms, the application of the principle of reducing travel to a minimum may be seen in the present vogue for self-feed silage. However, this involves not only the adoption of a special building design, but also a fundamental change of feeding method which may not be acceptable to all farmers.

THE EXTERNAL LAYOUT OF DAIRY BUILDINGS ON THE SURVEY FARMS

The owners of the farms on which a detailed survey of new dairy buildings was carried out did not all have the same opportunity for achieving an efficient building layout. Some had only been able to undertake a small amount of new building which they had attempted to integrate with a much larger amount of existing building of the "traditional" type. On the other hand, a few were in the fortunate position of planning an entirely new farmstead. This accounts for some of the variation between farms in the efficiency of the layout of buildings used by the milking enterprise. Nevertheless, there were also marked differences in this respect between farms where the starting points from which new building was developed were broadly similar.

The external layout of the buildings, the routes followed and the weights carried in moving feeding stuffs, milk, and farmyard manure within the farmstead were studied on 26 farms with a new cowhouse and 19 farms with new yard and parlour buildings.

A full explanation of the survey methods used and a complete analysis of the results will be found in Appendix 4. The remainder of this chapter deals only with the main findings, the conclusions and their implications.

Main Survey Findings

The analysis of the quantities of materials handled per cow revealed that the overall weight of feeding stuffs and litter straw generally exceeded that of milk and, of course, that the weight of bulk feeding stuffs was greatly in excess of the weight of concentrates.

The analysis of transport routes showed that milk routes (between the cowshed or parlour, and the dairy) were generally shorter than feed routes (between the points of storage and consumption). Moreover, concentrate feed routes were generally shorter than bulk feed routes. On farms with yards and parlours, although the routes for milk and concentrates were generally shorter than those on farms with cowhouses, the bulk feed routes were, on average, no shorter.

" Transport effort " may be defined in terms of ton-miles per cow, i.e. the weight of material multiplied by the distance over which it is carried. Common sense would suggest that the greater the weight of material to be transported, the greater the need to cut the distance to a minimum. Yet inter-farm comparisons showed that route distances were more variable than weights of materials handled per cow. Furthermore, there was little or no correlation between weights of materials handled and the corresponding ton-mileages per cow. On the other hand, there was a high and direct correlation between route distances and ton-mileages per cow.

Conclusions and their Implications

Arising from the consideration of weights of materials handled and the distances over which they were transported, the first main conclusion is that the least satisfactory aspect of the dairy building layout on these farms concerned the arrangements for storing and handling bulk feeding stuffs. " Transport effort " could have been substantially reduced on many farms if in planning the layout of new buildings, provision had been made for the storage of hay, straw, roots, silage and other bulky feeding stuffs, as near as possible to the point of consumption in cowhouse or yard. Somewhat surprisingly, farms with yard and parlour buildings were, as a rule, no better in this respect than those with cowhouses. Thus, although the users of yards and parlours usually had the benefit of relatively short transport routes for concentrates and milk, they rarely enjoyed the more important supposed advantage of this system of housing—that of especially convenient handling arrangements for bulk feeding stuffs.

The second main conclusion is that in spite of the fact that the survey was limited to farms where a major cowhousing improvement had been made, the transport of feeding stuffs and milk on different farms nevertheless entailed a very wide range of ton-mileages per cow. Moreover, this was much less due to different farmers feeding different types and quantities of food to their cows, or to variation in average milk yields, than to the effects of different building layouts, and dispositions of available storage space, on the lengths of feed and milk routes. The implications of this conclusion are important.

First of all, it is important to recognise that, as regards the individual farm, it cannot be said that feed and milk route distances have a more decisive influence than the weights of feeding stuffs and milk on the total ton-mileage or effort expended in the handling of these materials. Obviously, since ton-mileage is merely the expression of weight multiplied by distance, both factors are equally decisive. The important point is that whereas the weights of materials to be handled are largely given (i.e. they cannot be altered to suit the buildings) route distances can be minimised by careful planning of the building layout.

The weight and bulk of feeding stuffs fed per animal are largely determined by management and farming policy. Such matters as the level of milk yield likely to be most profitable, the proportion of home grown to purchased feeding stuffs, and the extent to which the cattle can feed or be fed outside the buildings at different times of the year, need to be considered before drawing up the plans for building alterations, improvements or additions. It would clearly be ridiculous for a farmer to reduce the input of feeding stuffs or the output of milk in order to reduce work effort as an end in itself.[2] Feeding policy should be determined with a view to obtaining the highest possible profit from the dairy enterprise and from the farm as a whole, and by no other consideration.

Route distances are much less directly affected by management practices and farming policy. For example, although the choice between the cowhouse and yard and parlour systems of management will broadly determine the types of building that are required, whichever system is adopted, the details of building layout determining the distances over which feeding stuffs and milk have to be carried are subject to variation over a very wide range. Compelling evidence of this fact was provided by the results of this survey.

Thus, whatever system of dairy herd management is followed, farmers generally have considerable latitude in planning the layout of their buildings. Of the building owners included in the survey, some used this freedom to plan the building layout to suit the farming system to much better purpose than others.

CASE STUDIES OF BUILDING LAYOUTS

The main point of practical interest is that feed and milk route distances varied widely as between farms with the same system of housing, feeding broadly the same kinds and quantities of feeding stuffs, and producing similar quantities of milk. One example of this may be seen by comparing Farm 33 with Farm 160. Both of these were farms with large double-row cowsheds with a dairy and concentrate store attached to the main structure. The size of the milking herd on Farm 33 was 40 cows and on Farm 160, 32 cows. Details of the quantities and kinds of food fed and the quantity of milk produced, together with the corresponding route distances, are shown below.

Materials	*Tons per cow per annum*		*Route Distance (feet)*	
	Farm 33	Farm 160	Farm 33	Farm 160
Hay	1.0	1.5	42	269
Feeding straw	0.2	0.7	73	269
Brewer's grains (wet)	1.0	—	172	—
Bedding straw	—	0.8	—	269
Total bulk feeds and bedding straw	2.2	3.0	104	269
Home grown grains	0.1	0.5	73	223
Purchased concentrates	1.8	1.2	72	47
Dried beet pulp	—	0.1	—	100
Total concentrate feeds	1.9	1.8	72	100
Total all feeds and bedding straw	4.1	4.8	89	206
Milk	5.0	5.6	104	57

2 With the possible exception of elderly farmers who, as the years go by, may be increasingly prepared to sacrifice income in order to gain more leisure.

It will be seen that on both these farms the composition of the cow ration was similar, except that on Farm 33 the bulk ration included wet brewer's grains, whereas on Farm 160 it consisted entirely of hay and oat straw. The total weight of bulk feeds per cow per annum was the same on both farms, though if bedding straw is also included the total weight on Farm 160 was somewhat higher. Farm 33 being in an upland area where straw is scarce and expensive, the only bedding used was uneaten feeding straw. The weight per cow of the concentrate rations was virtually the same on both farms: the weight of milk was slightly higher on Farm 160. Overall, the quantities and kinds of materials to be handled in connection with the dairy enterprise were very similar on both farms.

On the other hand, the route distances were markedly dissimilar, the contrast being most marked with respect to bulk feeds. On both farms the new cowhouse had been erected to replace obsolete buildings, but whereas on Farm 160, hay, straw and feed grains continued to be stored in the original buildings, now much further from the cows than previously, on Farm 33 the storage buildings were altered so as to bring bulk feeds as near as possible to the cowhouse. The consequences of these differing approaches to building layout are clearly reflected in the average route distance for bulk feeds and bedding straw. On Farm 160 this was two and a half times as great as on Farm 33. The average route distance for the transport of concentrate feeds was also shorter on Farm 33, though here the contrast between the two farms is much less marked. With regard to the transport of milk, Farm 160 had the shorter route, due to the cowhouse being somewhat smaller and the dairy more conveniently sited.

On Farm 160, an annual total of 0.189 ton-miles per cow was attributable to the transport of feeding stuffs and bedding straw, and 0.060 ton-miles to the transport of milk. On Farm 33, 0.069 ton-miles were attributable to feeding stuffs and 0.093 ton-miles to milk. Compared with Farm 33, the overall "effort" per cow entailed by the transport of feeding stuffs and milk was approximately half as great again on Farm 160. On Farm 33, these transport operations were estimated to involve a *total,* for the whole milking herd, of approximately 6½ ton-miles per annum: if the milking herd on Farm 160 had been of the same average size (40 cows), the comparable operations would have entailed a total of 10 ton-miles per annum. Due to the frequency of journeys and the fact that individual loads would, of necessity, often be small, it is likely that the difference in miles "actually travelled" would have been greater than this.

A second example of widely differing route distances between two farms where the feeding of the cows was in other respects similar, can be taken from the yard and parlour group. Farms 191 and 257 were both farms where there had previously been no milking enterprise and where yard and parlour buildings had been provided partly by the adaptation of existing buildings and partly by new construction. Farm 191 had a milking herd of 22 cows and Farm 257 one of 33 cows. Both farms had a converted milking parlour with a dairy and concentrate store conveniently attached. Again the main difference lay in the arrangements for the storage of bulk feeding stuffs and bedding straw. Details of the quantities and kinds of food fed, and the quantity of milk produced, together with the route distances, are shown below.

Materials	*Tons per cow per annum*		*Route Distance (feet)*	
	Farm 191	Farm 257	Farm 191	Farm 257
Hay	0.9	0.6	58	329
Feeding straw	—	0.8	—	305
Silage	2.3	2.7	58	305
Roots	0.8	—	13	—
Bedding straw	0.7	0.9	68	337
Total bulk feeds and bedding straw	4.7	5.0	51	314
Home grown grains	—	0.4	—	60
Purchased concentrates	0.6	0.2	17	60
Dried beet pulp	0.1	—	102	—
Total concentrate feeds	0.7	0.6	28	60
Total all feeds and bedding straw	5.4	5.6	48	286
Milk	3.1	2.7	34	34

The outstanding feature of the comparison between the two farms is again the dissimilarity between the route distances for bulk feeds and bedding straw. On Farm 257 this was more than six times as great as on Farm 191. The explanation is that whereas on Farm 191 the hay, silage and bedding straw were stored in a building adjacent to one side of the cow-yard, on Farm 257 they were stored in a dutch barn at the back of the block of buildings containing the yards and parlour, and on the side furthest away from the entrance to the yards.

On Farm 191 a total of 0.050 ton-miles per cow was attributable to the transport of feeding stuffs and bedding straw, and 0.020 ton-miles to the transport of milk. For Farm 257 the corresponding figures were 0.304 ton-miles and 0.017 ton-miles respectively. Overall, the " transport effort " per cow was approximately four-and-a-half times greater on Farm 257 than on Farm 191. For identical sized herds of 40 milking cows, the *total* ton-mileages would have been 12.8 and 2.8 respectively, i.e. a difference of no less than 10 ton-miles per annum.

Farmstead plans showing the relevant buildings and feed and milk routes, for each of the four farms discussed above will be found at the end of Appendix 4, and a study of these should help the reader to appreciate the differences in building layout.

THE IMPORTANCE OF BUILDING LAYOUT IN PERSPECTIVE

As with other specialised interests, over-concentration on problems of farm-building layouts and their improvement may lead to the neglect of more fundamental considerations. Therefore, in order to put questions of building layout in perspective, it is necessary to emphasise two points.

Firstly, building design and layout is only one of several factors affecting the efficiency, cost and profitability of the operations carried on in and around the buildings. Secondly, work in the buildings represents only a part of the total work load carried by the farm as a whole. Furthermore, work in the buildings is often closely integrated with outside work, the one interacting with the other to form the overall picture of farm labour economy.

Regarding the first point, the results of several investigations suggest that in view of the diversity and comparative inefficiency of many of the work methods now used on farms, for many farmers the gains from the adoption of more efficient work techniques within the framework of existing buildings are potentially greater than the gains likely to be secured solely from improved building design and layout. For example, in the report on a recent survey of milking practices on farms in Gloucestershire it was concluded that " the variation in organisation of the (milking) routine was wide and was the most significant factor in accounting for the great range in performance, while inconvenient layout of buildings did not influence output to the same extent."[3] A similar conclusion was reached by workers at Reading University investigating differences in the distances travelled by stockmen following alternative work routines for milking, feeding, bedding and manure removal, with varying assumptions regarding the size, design and layout of the cowshed. They state in their report that " the worst layout with the better routine is almost as economical of labour, or more so, than the best layout with the poorer routine."[4] Still more evidence comes from Germany, where the labour economy of " traditional " building designs was compared with that of " ideal " buildings designed by a farm buildings research institute.[5] There it was concluded that, in view of the prevalence of inefficient work methods on farms, the adoption of a good work routine would usually be a far more fruitful source of economy in the use of labour than an improved layout of buildings. In support of this conclusion, factual information was presented showing that for work connected with the care of livestock on farms in Germany, the time spent actually travelling in and around the buildings accounts for only 15 to 20 per cent. of the total work time. The relative importance of transport and non-transport operations on farms here may not be exactly the same as in Germany, due to differences in farm buildings and husbandry methods between the two countries. Nevertheless, if a similar investigation were to be carried out in Great Britain there is every likelihood that the results would be broadly the same.

It may be concluded then, that for many farmers looking for ways of improving their farming efficiency and profit, improvements in the layout of buildings are likely to come much lower in the scale of priorities than the adoption of better work methods and management practices generally. With the dairy enterprise, for example, it is more important to ensure that time and money could

3 READ, S. H. *A Survey of Milking Practices.* Mimeo. report. Gloucestershire Agricultural Executive Committee. Undated.

4 REID, I. G. and DOMINY, J. *The Dairy Farmstead—An Enquiry into the Layout of Farm Buildings.* University of Reading. April, 1954.

5 WANDER, J. F. *Der Einfluss der Gebäude auf die täglichen Stallarbeiten.* Paper presented to the 7th Congress of the C.I.O.S.T.A. September, 1956.

not be saved by altering the milking routine, or that the composition of the feeding stuffs ration is such that no alternative ration would be cheaper in relation to the total quantity of milk produced, than to be equipped with an ideal set of buildings.

Turning now to the inter-relationships between work in the buildings and work elsewhere on the farm, the problem is that of avoiding situations where greater convenience and time saved in the performance of work in the buildings interfere with work elsewhere on the farm so that there is no overall gain, or, at worst, an overall loss is sustained. This sort of situation may arise in connection with the storage of home grown feeding stuffs. With hay or silage, for example, if the crop is grown in a field a long way from the buildings it may pay to store it near to the field where it is produced, rather than near to the buildings where it is consumed. The reason for this is that although the journey from the field to the buildings will take the same time whenever it is made, its real cost may be greater in the summer, during the time of hay or silage making, than in the winter when the overall demands on man and tractor-labour are less pressing.[6] An additional consideration is that the use of certain types of field equipment, such as a buck-rake for silage making, may be better adapted to storage of the crop in or near the field than to storage at more distant points.[7] It need hardly be added that field storage should not be considered on sites likely to become inaccessible to vehicles during the winter.

However, on many farms this problem is unlikely to arise, either because the fodder crops are harvested in fields near to the buildings or, even where they are not, enough vehicles and men are available at harvest time to enable the long hauls to the buildings to be achieved without detriment to the timely accomplishment of other tasks or the necessity for an excessive amount of extra labour paid for at overtime rates. The storage of feeding stuffs as near as possible to the point where they are to be consumed remains as the general objective, only to be departed from under exceptional circumstances.

Some farmers farm very successfully despite a poor set of buildings: there are others who, although they have the advantage of better buildings, nevertheless fail to secure a satisfactory profit. Good buildings alone will not guarantee satisfactory profits though they may contribute to the realisation of that goal if the farmer is a competent manager in other respects.

6 Field storage of home grown feeding stuffs was occasionally encountered on farms included in the survey. In such cases, since one trailer load of hay, silage, or roots would normally be sufficient for several feeds, the trailer was regarded as the feed storage point and the feed route was measured from the point where the loaded or part-loaded trailer was parked at the farmstead.

7 PATRICK, R. W. *Siting Silos*. Agriculture. (Journal of Ministry of Agriculture). Vol. LXV, No. 10. January, 1959.

CHAPTER 5

BUILDING COST IMPLICATIONS OF PLANNING AND DETAILED DESIGN DECISIONS

Many factors influence building costs, building type and size being two of the more important. This study is confined to buildings designed to house dairy cows. According to the point of view, such buildings might be regarded as belonging to one or many types. For example, although cowhouses and yards with milking parlours fulfil the same general functions—those of housing cows during the winter and providing a place where they can be milked and fed—there are marked differences between them in building design and layout. Similarly, even with a "standardised" building such as a cowhouse, many detailed differences in design and planning are encountered such as whether there is a single or double row of standings, whether or not there is a feeding passage, and whether or not the building incorporates ancillary accommodation such as a dairy or feedstore. Thus, in this enquiry, some degree of cost variation was to be expected between individual buildings, due to major differences in their design and planning.

With regard to building size, some common denominator was required for purposes of cost comparison. For comparing the costs of cowhouses, "cost per cow" seemed to be the most suitable basis.[1] With yards and parlours, on the other hand, this method of comparison seemed to be less reliable because of the wider range of facilities afforded by different buildings and variations in the amount of building space provided per cow. So, in making cost comparisons between yard and parlour buildings on different farms, and in comparing the costs of buildings of this type with those of the conventional cowhouse, "cost per square foot" was used.

THE EFFECTS OF PLANNING AND DESIGN DECISIONS ON THE COSTS OF COWHOUSES

The effect on building costs of planning and design decisions can conveniently be considered in three parts.

As defined here, planning mainly concerns inter-relationships between buildings, or between different parts of a single building.

1 As used in this study, the term "cost per cow" may be defined as the total cost of the building divided by the total number of cow standings. It is not necessarily synonymous with the cost per cow actually housed.

Whilst it is recognised that the most generally adopted cost yardstick for non-agricultural buildings is "cost per square foot of floor space", this was not used in analysing and comparing the costs of cowhouses in this study for the following reasons:

(a) Farmers are more accustomed to thinking of building costs in terms of the number of animals housed than in terms of floor area.

(b) Floor areas were only determined for the relatively small number of cowhouses included in the detailed survey whereas the number of standings was recorded for *all* the buildings covered by the enquiry. Hence, adoption of cost per square foot as the main yardstick, would have seriously limited the scope of the statistical analysis of building costs.

The extra costs of ancillary accommodation, like a new dairy or new feedstore, are therefore the expression of a planning decision.

Design decisions affect building costs at two levels. Firstly, there are those affecting the size, shape and general layout of the buildings, secondly, there are those concerning the choice of particular types of building materials and equipment. For convenience, these can be respectively referred to as " layout decisions " and " detailed design decisions."

Planning Decisions — Ancillary Accommodation

Of the total number of new cowhouses for which costs were obtained, 117 incorporated a new dairy, a new feedstore, or both a dairy and a feedstore: the remaining 56 were without new ancillary accommodation of any kind. The average cost of cowhouses with such ancillary accommodation was £81.4 per cow, whereas, of those without, it was £64.4 per cow.[2] Thus, on average, cowhouses with ancillary accommodation were the more expensive by approximately £17 per cow.

The actual cost information obtained from building owners was rarely sufficiently detailed to show the *separate* costs of dairies and feedstores. On the other hand, 36 cowhouses were surveyed in detail and analysed on the basis of standard costs.[3] It was found that where a new dairy was incorporated with a new cowhouse, on average, the standard cost of the dairy was approximately 22 per cent. of the standard cost of the cowhouse alone:[4] similarly the standard cost of a new feedstore averaged about 13 per cent. of the standard cost of the cowhouse alone.

Thus, with cowhouses without ancillary buildings averaging approximately £64 per cow to erect (at the September 1959 level of building prices) the incorporation of a new dairy in the plan might be expected to cost an additional £14 per cow, and a new concentrate store a further £8 per cow.

Layout Decisions

Three major features of cowhouse layout were examined to determine the extent to which they affected costs. These were size (number of standings), rows of standings (single or double), and feeding passage (included or excluded).

At an early stage in the analysis, it was found that no consistent relationship could be established between cost per cow and the number of standings in the building. The costs of individual buildings within each of the three size groups studied—those with 10 to 14 standings, those with 20 to 29 standings and those with 40 or more standings — were so variable that no significance could be attached to the differences in *average* cost between the groups. Moreover, no consistent *trend* in average costs was apparent between the groups. This survey yielded no reliable evidence, there-

2 Unless otherwise stated, all quoted building costs are actual costs "normalised" to the September 1959 level of building prices. For further details see Appendix 5B.

3 See Appendix 5A.

4 Excluding one surveyed building where, due to exceptional conditions, over a third of the overall floor space and nearly half the overall standard cost was accounted for by the dairy.

fore, that costs *per cow* are likely to be significantly affected by the decision concerning the number of standings in the cowhouse.

A similar conclusion emerged regarding the relationship between cost per cow and rows of standings. Although there was some prima facie evidence of the double-row type of layout being, on average, slightly cheaper, the costs of individual buildings within each group were again too variable for any reliable conclusion to be drawn.

A more positive result was obtained from an analysis of the relationship between cost per cow and the provision of a feeding passage within the cowhouse. It was found that, on average, the decision to have a feeding passage involved an extra cost of approximately £9 per cow.

Synthesised Cost of a Cowhouse with a Feeding Passage Dairy and Feedstore

The average cost of cowhouses without a feeding passage *and without ancillary accommodation* was approximately £59 per cow.[5] The building cost implications of planning and layout decisions (at September 1959 building prices) can then be summarised as follows:

	£	
Cost of basic cowhouse - -	59	per cow
Extra for feeding passage -	9	,, ,,
Extra for dairy - - -	14	,, ,,
Extra for feedstore - -	8	,, ,,
Cost of cowhouse with feeding passage and ancillaries -	90	,, ,,

It is to be expected, therefore, that a cowhouse complete with feeding passage and ancillaries in the form of a new dairy and feedstore will cost at least half as much again as the simplest type of building without these extra facilities. Furthermore, on average, decisions about these aspects of cowhouse planning and layout may well account for building cost differences of up to £31 per cow.

Detailed Design Decisions

The cost information obtained from building owners was rarely sufficiently detailed to show the pattern of expenditure on different parts of the building structure. However, with the cowhouses that were surveyed in detail, it was possible to reveal this pattern by analysis of their standard costs. The total standard cost of each building was obtained by adding together the standard costs of a large number of building "elements," each representing a different part of the building, either structurally or functionally. Thus, for example, "walls," "windows," "doors," and "upper floor and stairs" were all regarded as separate building elements and were grouped together under the head of "substructure."[6] Analysis of

5 For further details of the statistical analysis on which these findings are based, see Appendix 5B.

6 This term is adopted following its previous use in connection with farm buildings by Denman and Rathbone of the University of Cambridge, Department of Estate Management. Its use is more generally confined to work below ground.

the standard costs of individual building elements and groups of elements showed two things : firstly, the average distribution of costs between different parts of the building structure and, secondly, the relative degrees of cost variation to which particular elements or groups of elements were subject, due to decisions regarding the choice of building materials and constructional methods.

This part of the analysis was confined to 28 cowhouses erected by building contractors. The standard costs per cow presented in the following pages relate to cowhouses plus ancillary accommodation wherever this was included in the contract. The total number of separate building elements used in the analysis was 17 and these were classified in five groups.[7] These groups are shown in Table 9 together with the average standard costs per cow pertaining to each.

TOTAL STANDARD COSTS BY ELEMENT GROUPS
28 Cowhouses Erected by Building Contractors

TABLE 9

Element Group	Average Standard Costs	
	£'s per cow	Per cent
Ground and site works	34	37
Substructure	23	24
Superstructure	20	21
Finishes and fittings	10	11
Services	7	7
Complete building	94	100

The Broad Pattern of Costs

It is clear from the figures shown in Table 9 that some parts of the structure absorbed a relatively higher proportion than others of the total costs of the building. A further point, not revealed in the table, is that the standard costs of each of the five element groups showed a positive correlation with overall standard costs. In other words, where, due to detailed design decisions, overall building costs were much above or below the average, extra costs were incurred, or savings were made, on *all* the main parts of the structure.[8]

This points to the conclusion that, with the more expensive buildings, there might have been some scope for all round reduction of costs at the design stage. Nevertheless, it is clear that a comparatively small *percentage* cost saving on, say, " ground and site works " or " substructure," might frequently have reduced total building costs by as much as, or more than, a much larger percentage reduction in the costs of " services " or " finishes and fittings."

The average cost structure does not reveal relative *degrees* of cost variation occuring in different parts of the building. Further analysis of standard costs showed that, relative to their own average costs, the costs of the " substructure " were the most variable and the costs of " finishes and fittings " least variable. In the following table the five element groups are arranged in descending order of

7 For details of the individual building elements and element groups see Appendix 5A.

8 For further details, see Appendix 5B.

cost variation according to a standard method of comparison, the "co-efficient of variation."[9]

RANKING OF ELEMENT GROUPS ACCORDING TO THE DEGREE OF VARIATION IN STANDARD COST PER COW

TABLE 10

Element Group	Co-efficient of variation
Substructure	46
Superstructure	46
Services	37
Ground and site works	36
Finishes and fittings	26

A relatively high degree of cost variation (denoted by a relatively high co-efficient of variation) in a particular part of a building would suggest considerable scope for varying costs by means of design decisions. Conversely, a relatively low degree of cost variation, suggests less scope for varying costs in this way.

The Pattern of Detailed Costs

The costs of individual "building elements" within the five main groups varied considerably in their magnitude and importance.[10] Of a total of 17 building elements used in the analysis, 13 were common to practically all the surveyed buildings and also had an average standard cost of more than £1 per cow. In Table 11 these are listed in descending order of average standard cost per cow.

RANKING OF BUILDING ELEMENTS BY AVERAGE STANDARD COST PER COW

TABLE 11

Building Element	Average Standard Cost per Cow (£'s)
Work below ground floor level	23.2
Roof	17.3
Walls	16.6
Fittings	8.0
Drains	6.0
Paving	5.0
Doors	4.7
Cold-water installation	4.2
Finishes	2.3
Roof-lights	2.0
Electrical installation	1.6
Windows	1.6
Rain-water disposal	1.5

9 This is a statistical concept expressing the "standard deviation" of an average as a percentage of that average. On the assumption that the sample was taken from a population which was "normally distributed", the standard deviation indicates the limits on either side of the average within which about two thirds of the individual results fall.

10 For a full description of the building operations contained within individual building elements, see Appendix 5A.

This list shows the building elements which were, on average, the most costly and those that were the least costly. However, an analysis of the extent to which the standard costs of individual building elements varied around their own averages suggests a different order of priorities. In the following table the same 13 building elements are arranged in descending order of cost variation according to their co-efficients of variation.

RANKING OF BUILDING ELEMENTS ACCORDING TO THE DEGREE OF VARIATION IN STANDARD COST PER COW

TABLE 12

Building Element	Co-efficient of Variation
Finishes	104
Paving	98
Windows	88
Roof-lights	80
Drains	67
Electrical installation	56
Doors	51
Roof	50
Rain-water disposal	47
Walls	46
Cold-water installation	33
Work below ground floor level	28
Fittings	16

In some respects, the ordering of the elements in this table is seen to be in marked contrast with that of Table 11 where they were arranged in order of average standard cost per cow. For example, " work below ground floor level " and " roof," which were at the head of Table 11 are both in the lower half of Table 12. This suggests that although, on average, both these elements had a high standard cost per cow, their costs were relatively less susceptible to variation through design decisions than the costs of some elements with much lower average costs per cow, such as " finishes " and " paving."

General Conclusions about Detailed Design Decisions

Farm-owners should aim at getting the kind of building they want at the minimum cost which is consistent with their requirements. All costs must, therefore, be carefully scrutinised at the design stage.

Substantial savings in building costs may be secured in several ways. One of these is through comparatively large savings on a few major items; a second through the accumulation of comparatively small savings on a larger number of items; a third, through a combination of large and small savings on different parts of the structure. The results given here show how, on average, costs are distributed between the different parts of a cowhouse. This distribution clearly reveals the major items of expenditure where a small percentage increase or decrease may have a substantial effect on the total cost of the completed building.

On the other hand, since some items of expenditure exhibited a much greater *degree of variation* than others, it is concluded that, due to technical or other considerations, some parts of the structure, and some building elements, show greater cost flexibility than others. Moreover, items of expenditure which seemed to be of only minor importance in the average cost structure exhibited a higher degree of flexibility than some much larger items. It is to these more flexible items of expenditure that the building designer should pay particular attention in seeking a comparatively large reduction in overall building costs through the accumulation of savings which may be small individually.

It was *not* one of the aims of this enquiry to examine the technical details of " cost control " applied to farm buildings or to recommend particular designs and methods of construction. This is essentially a job for architects and others who are directly concerned with the design of farm buildings. On the other hand, one of the aims was to show the extent of cost variations directly attributable to decisions regarding the detailed designing of a particular type of farm building, and to give a broad indication of some of the design factors thought to have been responsible for this variation. The evidence obtained seems to point to the need for a higher degree of cost control on the part of farm building designers than has been exercised hitherto.

A final word may be necessary concerning standard costs. Some readers may be tempted to regard the standard cost averages, presented on the preceding pages, as building cost " targets." It must be stated, quite emphatically, that they should *not* be so regarded.

The standard costs presented in this chapter do *not* show what the cost of a cowhouse, or any part of it, ought to be, but merely the *proportionate* costs of different parts of the building.[11] It was necessary to employ this rather artificial method of cost analysis because actual cost information was not normally available in sufficient detail. Regarding the relationship between overall actual costs and overall standard costs per cow, the latter were, on average, somewhat higher than the former. Notwithstanding this fact, it is claimed that standard costs reflect, with reasonable accuracy, the *relative* costs of different parts of a building structure.

THE COSTS OF YARDS AND PARLOURS

The yard and parlour system of housing dairy cows is a comparatively recent innovation. Consequently, the building designs and layouts used for this method of housing are still in the process of development and show great diversity as between one farm and another. It is, therefore, virtually impossible to devise a simple system of classification for buildings of this type. In fact, practically every set of yard and parlour buildings surveyed appeared to be unique in some important respect.

The great diversity of building types, sizes and layouts greatly limited the scope for useful cost analysis. No practicable application of the standard cost technique, similar to that used for cowhouses could be devised to show the main features of the cost structure.

11 *Adjusted* standard costs are employed as a yardstick of "building value" in Chapter 6.

A further difficulty was that comparatively few *completely new* yard and parlour layouts were available for survey. This system of housing appears to lend itself particularly well to the adaptation of existing buildings, either through structural alterations or merely a change of use. Out of the total of 30 farms visited for a detailed survey of yard and parlour buildings, there were 15 where an existing or modified yard, or an adapted parlour, was being used. Since the survey was only concerned with the costs of *new* buildings, these latter farms only yielded *partial* cost information about new yards and parlours.

The analysis of building costs with respect to yards and parlours was, therefore, confined to three simple measures, at least one of which was applicable to all 30 of the farms included in the detailed survey. These were, firstly, the overall cost per sq. ft. of new yard space; secondly, the overall cost per sq. ft. of new parlour space; thirdly, the combined overall cost per sq. ft. of yard *and* parlour space.

The Cost of New Yard Space

On eight farms a new yard was erected for use in conjunction with a milking parlour adapted from an earlier building, and it was possible to separate the cost of the yard from that of the adapted milking parlour. On a further four farms both the yard and parlour were new, but cost information was available in sufficient detail to permit the separation of overall building costs into two parts, the one relating to the new yard, the other to the new parlour. Hence cost information relating specifically to yards was available for a total of twelve farms. On nine of these farms all the work was carried out by a building contractor; on two the farmer himself supervised the work but had some professional assistance with actual building, and on one farm the farmer did all the work himself with the assistance of farm labour.

The yards were very variable, not only regarding total yard space, but also the relative proportions of covered and uncovered space. On average, approximately 60 per cent. of the total yard space was covered, but individual yards ranged from approximately one third covered to fully covered. The average area of new *covered* yard space per farm was approximately 2,840 sq. ft., though on individual farms the area was as low as 930 sq. ft. and as high as 7,000 sq. ft.

The most satisfactory method of expressing building costs was in terms of a square foot of *covered* yard space. Thus the total cost of the yard, including both covered and open yard space was divided *not* by the total enclosed area, but only by the covered area. This may be termed the *gross* cost per sq. ft. of covered yard space. Where a yard was only partially covered, the *net* cost per sq. ft. of covered yard space (i.e. that of the covered area *alone*), was naturally somewhat less than the gross cost. With fully covered yards the gross and net costs were the same. However, since a given area of covered yard space is invariably much more expensive than the same area of open yard space, and the majority of the yards actually surveyed were at least half covered, the discrepancy between gross and net costs per square foot was generally almost negligible.

Amongst the 12 new yards surveyed, the average gross cost per sq. ft. of covered yard space was approximately 15s. 7d. The gross costs of individual yards ranged from 6s. 8d. to 23s. 9d. per square foot of covered yard space. The cheapest yard (per sq. ft.) was erected by a farmer who had professional assistance only for the erection of steel work and roofing. This yard was also enclosed on two sides by existing buildings where it would otherwise have probably been necessary to build new walls to provide shelter for the cattle. The most expensive yard (per sq. ft.) was part of a complete yard and parlour unit, erected by a building contractor, and in no way integrated with older buildings.

However, differences such as these do not provide an adequate explanation of the very wide range of costs encountered. It seems probable that this was mainly due to varying details of building layout and design or, to some extent, to variations in building quality. Unfortunately, due to the limited time and resources available for the enquiry it was impossible to carry out detailed investigations to substantiate and categorise these impressions.

The Cost of New Parlour Space

On seven farms a new milking parlour was erected for use in conjunction with an existing or modified yard, and in each case it was possible to separate the cost of the parlour from that of any work connected with the improvement of the yard. In addition there were the four farms, already mentioned, where there was a complete new yard and parlour unit, and where it was possible to separate the cost of the parlour from the overall cost of the scheme. Hence, on a total of 11 farms, cost information was obtained relating specifically to the erection of a new milking parlour. On eight farms all the work was carried out by a building contractor, on two farms the farmer supervised the work himself but employed some professional building labour, and on one farm the farmer did all the work himself with the assistance of farm labour.

For the purpose of cost analysis, the " parlour " was deemed to include a dairy or concentrate store where these were erected with the actual milking parlour. The costs of external works such as collecting yards and concrete aprons were also included with those of the parlour. The costs of parlour fittings and dairy equipment were excluded from the cost of the parlour, except those normally regarded as a landlord's fixture. The principal items in the latter category were the fixed parts of the milking bail, i.e. stall divisions, gates, feed hoppers and mangers, together with water and electricity supply installations.

Parlour costs were expressed per square foot of covered building space, although, in the majority of cases, a small proportion of the costs were attributable to external concreting and fencing.

Amongst the 11 milking parlours surveyed, the average covered area was approximately 750 sq. ft., though individual buildings ranged from 400 sq. ft. to 1,780 sq. ft. The average cost per sq. ft. of covered area was approximately 36s. 6d., with the costs of individual buildings ranging from about 6s. 4d. to 54s. 3d. per sq. ft. The cheapest parlour (per sq. ft.) was farmer-built for use in conjunction with an existing yard, and extensive use was made of secondhand building materials. The cost of this building was extremely low compared with any of the others—the next lowest cost was nearly 20s. 0d. per sq. ft. of covered area—and may therefore be regarded as something of a freak. The most expensive parlour (per sq. ft.) was erected by a building contractor as part of a larger scheme involving a complete yard and parlour unit.

As with the yards, it is not possible to explain why the costs of parlour space varied so much between different farms. It can only be guessed, as before, that details of building layout and design, and possibly differences in building quality, were mainly responsible.

The Relative Costs of Yard Space and Parlour Space

A main conclusion arising out of this analysis is that the cost of parlour space is much more expensive than an equivalent area of covered yard space. On average, the cost of parlour space per sq. ft. of covered area was more than twice the gross cost of a sq. ft. of covered yard space.

For a complete yard and parlour unit, the *overall* cost per sq. ft. of covered area will naturally lie between the cost of a sq. ft. of yard space and the cost of a sq. ft. of parlour space. Since, in practice, the *total* covered yard space is usually considerably in excess of the *total* parlour space, it may be expected that the overall cost per sq. ft. will normally be much nearer to the cost of covered yard space than that of parlour space.

The Overall Costs of Yards and Parlours

On 15 farms a complete new yard and parlour unit was erected. The overall cost of the complete unit was expressed per sq. ft. of total covered area, inclusive of both parlour and yards.

Amongst the buildings surveyed, the average total covered area was approximately 3,950 sq. ft., though individual units ranged from just over 2,000 to more than 13,000 sq. ft.

The average cost per sq. ft. of total covered area was approximately 20s. 10d., with the costs of individual buildings ranging from 11s. 9d. to 35s. 10d. per sq. ft.

It is an interesting fact that all 15 of these complete yard and parlour units were erected by building contractors and, indeed, no entirely new unit encountered during the survey was built by any other method. Therefore, no part of the very wide range in the costs of yard and parlour accommodation can be attributed to savings of the type only available to farmers who do their own building. The difference of approximately 24s. 0d. per sq. ft. between the cheapest and the most expensive yard and parlour units may therefore be taken as an indication of the extent to which building costs are affected by decisions concerning building layout and design, differences in building quality, and possible variations in the prices different builders charge for the same or similar work.

The average overall cost of yard and parlour space was also estimated by another method. The *separate* average costs of yard space and parlour space, of which details have already been given, were themselves combined into a single overall average cost. This involved "weighting" the respective average costs of yard space and parlour space according to the required number of square feet of each of the two types of accommodation for a given number of cows.

It was assumed that the overall yard space requirement is 100 sq. ft. per cow. Since, on average, the surveyed yards had 60 per cent. of their total area covered, it was also assumed that the covered yard space requirement is 60 sq. ft. per cow.

On farms with new yards, the total yard area (covered and open) was measured, and the maximum yard capacity was worked out on the basis of the "standard" space requirement of 100 sq. ft. per cow. On the other farms, i.e. those using an existing or adapted yard, the farmer was asked to give his estimate of the maximum yard capacity. The maximum yard capacity, thus estimated for each farm, was then divided into the total covered area of the parlour (excluding dairy, feedstore, etc.) to find the minimum available parlour space per cow in the milking herd. On average, this proved to be approximately 10 sq. ft. of covered parlour space per cow, and this area was used as the "standard" parlour space requirement.

With the average cost per sq. ft. of covered parlour space and the average gross cost of covered yard space as previously determined, the overall average cost per sq. ft. of yard and parlour space was worked out as follows:

Cost of yard, 60 sq. ft. at 15s. 7d. (gross) -	£46	15	0	per	cow
Cost of parlour, 10 sq. ft. at 36s. 6d. - -	£18	5	0	,,	,,
Total cost of yard and parlour - -	£65	0	0	,,	,,

If a combined total of 70 sq. ft. of covered yard and parlour space costs £65, then the overall cost *per sq. ft.* is £65 ÷ 70, or 18s. 7d. This, the "synthetic" cost per sq. ft., compares with the actual average overall cost of 20s. 10d. per sq. ft. calculated from the sample of 15 complete yard and parlour units.

Thus, these two alternative methods of estimating the average costs of yard and parlour space give reasonably consistent results. However, it should be pointed out that the synthetic cost of 18s. 7d. per sq. ft. is based on the assumption that the yard is 60 per cent. covered. The most suitable proportioning of covered and open yard space is dependant on such factors as the siting and orientation of the building, and prevailing climatic conditions. In situations where less than 60 per cent. of cover was likely to be satisfactory, it could be expected that the *total* cost of the yard would be lower, and this, in turn, would reduce the overall cost of yard and parlour space. Conversely, in situations where more than 60 per cent. of yard cover was found to be essential, the cost would be correspondingly higher.

The Comparative Costs of Cowhouses and Yards and Parlours

A direct comparison between the capital costs of housing cows in cowhouses and in yards with milking parlours can now be made.

Earlier in this chapter, £59 per cow was seen to be the average basic cost of a cowhouse, i.e. excluding the extra costs of a feeding passage, dairy or feedstore. It was further shown the *extra* cost of a feeding passage was likely to be in the region of £9 per cow, making an overall cost of £68 per cow for a cowhouse with this extra facility.

If it is assumed, as in the previous section, that the overall *covered* space requirement is 70 sq. ft. per cow, and the overall cost per sq. ft. 20s. 10d. (as suggested by the first method of estimation) then the average overall cost of yard and parlour accommodation works out at approximately £73 per cow: if the overall cost per sq. ft. is taken to be 18s. 7d. (as suggested by the second method of estimation) then it is £65 per cow. It is to be noted that these figures also exclude the extra costs of a dairy or concentrate store.

On average then, the capital costs of housing cows in yard and parlour buildings may be slightly greater than those of housing in the simplest type of cowhouse without a feeding passage. However, the extra costs of yard and parlour buildings seem unlikely to exceed the extra costs of incorporating a feeding passage in a cowhouse.

The capital costs of yard and parlour buildings depend, to a considerable degree, not only on the amount of yard space per cow, but also on the proportion of the yard area which is covered. Where yards are only 50 per cent. covered it seems unlikely that, on average, the capital costs of housing cows in this type of building would be any greater than housing them in the simplest type of cowhouse i.e. one without a feeding passage. Where an even lower proportion of yard cover is practicable the yard and parlour system would probably be the cheaper method of housing.

The general conclusion is that, up to the present there has been little to choose between cowhouses and yards and parlours on grounds of building cost. This suggests that, in deciding which method of housing to adopt, farmers should mainly concern themselves with other considerations such as health, comfort and productivity of the cows, and economy in the use of feeding stuffs and labour.

CHAPTER 6

CHOICE OF BUILDING METHOD

HAVING decided what type and size of building will best meet his requirements, and the details of its planning and design, the owner must consider who is going to do the actual building work. Broadly speaking, he has the choice of two alternatives: he can either hand over the whole of the responsibility to a contractor, or he can supervise the work himself. The first type of arrangement is fairly clear-cut: apart from the possibility of supervision by an architect, the building contractor assumes full responsibility for acquiring the necessary building materials and labour and carrying out the work in accordance with the plans and specifications agreed between himself and the owner. The second type of arrangement may take a number of different forms, ranging from that where the farm-owner buys the materials and does all the work himself, usually with the assistance of farm labour, to that where he merely supervises the work of directly employed professional building labour.

Of the 187 new cowhouses included in the preliminary survey, 139, or approximately 75 per cent., were erected by a building contractor. With the remaining 48 buildings, the owner himself assumed responsibility for erection. A similar apportionment of the responsibility for building work was encountered amongst a further 51 farms on which a preliminary survey of new or converted yard and parlour buildings was carried out.

THE RELATIVE COSTS OF COWHOUSES ERECTED BY BUILDING CONTRACTORS AND FARM-OWNERS

In deciding whether or not to assume responsibility for building work himself the farm-owner must take into account not only the extent of his knowledge of building techniques and his proficiency in building skills, but also which is likely to be the cheaper method of erection. With regard to the erection of *cowhouses*, this enquiry yielded information which is of interest in this connection.

The average cost of cowhouses erected by building contractors was £80.0 per cow; that of those erected by farm-owners was only £62.6 per cow. Thus, on average, there was an apparent saving of about £17 per cow on farms where a building contractor was not employed[1].

It is suggested that there were three main reasons for this result. Firstly, farm labour is cheaper than building labour, and the owner's estimate of the man-hours of farm labour (including his own) utilised in erecting a new building was charged at the current farm wage rate, on the assumption that this was the rate the men

1 For further statistical details, see Appendix 6.

would have earned had they been employed elsewhere on the farm[2]. Secondly, unlike the building contractor, the farmer, in assessing the cost of a building he has erected himself, makes no allowance for overhead costs and profit, since, even if these were to be regarded as a legitimate charge on the building, they could not be separated from the general farm account, save on some purely arbitrary basis. Thirdly, there was a tendency for farmers doing their own building to make a much more extensive use of cheap, secondhand or "surplus" materials, than building contractors.

Another point to set against the apparent cheapness of the farmer-built cowhouse is that there may have been a tendency for farmers to underestimate the amount of time they or their men had spent on building work. A common practice was to fit building work into slack periods when other farm work was not pressing, and also long summer evenings and weekends which might otherwise have been used for leisure activities[3]. In such circumstances, the work was frequently accomplished spasmodically over an extended period, and except in the rare cases where detailed records were kept, it would not have been difficult for a farmer to forget at least a proportion of the odd times he or his men had spent working on the building. Certainly the estimates of the total labour input for similar types and sizes of building were highly variable.

All things considered, it would, therefore, be unwise to conclude that many farmers are likely to make spectacular savings by doing their own building. Nevertheless, given a reasonable degree of technical know-how and competence in building skills, there is little doubt that a minority can make useful savings in this way and, at the same time, derive a good deal of non-pecuniary satisfaction from the planning and execution of the work.

Other Considerations Affecting the Choice of Building Method

When considering how to get a new farm building erected the prospective owner should balance the possibility of saving cost by not employing a building contractor and doing the work himself with the following considerations:

(i) ERECTION TIME

Unless the need for a building can be seen well in advance, and plans and preparations made accordingly, there may be an economic advantage in employing a contractor so that a building can be in use (and adding to farm profits) in the shortest possible time.

(ii) QUALITY OF WORKMANSHIP[4]

Expectation that buildings erected by farm labour would always be inferior in quality of building work to those erected by building tradesmen was found to be unjustified when the

2 The rate employed for this purpose was the Average Weekly Earnings in Agriculture (England and Wales) as published annually in the Ministry of Labour Gazette.

3 Enthusiastic farmer-builders might be inclined to regard building itself as a leisure activity. Such people may be able to put up farm buildings really cheaply since, through substituting building work for other less productive forms of leisure activity, the real cost of their own labour may be little or nothing. On the other hand, there may sometimes be the danger that, as with other leisure activities, so much time is spent on building that other more urgent tasks are neglected to the ultimate detriment of farm profits.

4 See Appendix 3C(i) for more detailed consideration of this topic.

detailed survey was carried out. This may have been partly due to the fact that the farmer is frequently a person of considerable versatility, but unfortunately the general level of building workmanship with which the farmer's efforts were compared was not very high.

(iii) MAINTENANCE[5]

The results of the detailed survey showed that the two factors having the greatest effect upon the maintenance needs of buildings were:

(a) the age of building,

(b) quality of original workmanship.

The farmer who builds usually does so with the expectation that his new accommodation will stand for many years. In such an event, it is as well to ensure that the future is not blighted by the frequent time wastage and expense of remedying defects due to unskilled workmanship. The present standards of contractors' work are capable of improvement, and a good standard should be demanded. It is unlikely that amateurs could advance their standards very much.

(iv) EQUIPMENT

A builder will normally have at his disposal sufficient instruments for setting-out, e.g. a precision level, and equipment, such as barrows, concrete mixers, forms for shuttering, etc., which a farmer must either improvise or hire.

SURVEY OF BUILDERS EMPLOYED BY THE OWNERS OF SURVEYED BUILDINGS

During the course of the study it became apparent that differences in costs incurred by farmers for similar accommodation might be partially due to the type of builder employed. Since little was known about the type of builder engaged in farm building of traditional construction, the Builder Questionnaire was sent to the builders who had been responsible for the erection of cowhouses and yard and parlour schemes included in the preliminary survey. From this, 64 usable replies were received, which represented the builders of nearly 50 per cent. of the surveyed buildings erected solely by contractors. Nine other firms are known to have closed their building department or gone out of business altogether.

Type and Size of Building Firm

Of the builders replying to the questionnaire 78 per cent. described themselves as "General Builders." Of these firms, the majority employed no more than 30 building operatives. A small minority of firms (less than 10 per cent. of the total) described themselves as "Builders and Civil Engineers": all of these were relatively large employers of labour, having more than 100 building operatives per firm. Of the remaining firms, the majority were "Jobbing and Maintenance Builders" employing 10 operatives or less.

5 See Appendix 3C(iii) for more detailed consideration of this topic.

Area of Building Operations

Almost 70 per cent. of the firms stated that their operations were generally restricted to the area within a 20 mile radius of their headquarters. On the other hand, a few firms operated over much wider areas, up to 100 miles from their headquarters, or even beyond.

Turnover per Building Employee

Average annual turnover per employee may be used as an approximate gauge of a building firm's efficiency. Amongst this sample of firms, the overall average turnover per man was £1,983 per annum[6]. Fifty per cent. of the firms secured a turnover of between £1,000 and £2,500 per man. On the other hand, nearly 20 per cent. apparently averaged less than £1,000 per man.

Class of Building Work and Size of Contract

Thirty-six per cent. of the builders replying to the questionnaire ascribed less than one quarter of their total turnover to farm-building. Only 10 per cent. ascribed threequarters or more of their total turnover to this kind of work. The tendency, therefore, is for the builder of traditional structures, i.e. "bricks and mortar," as opposed to the manufactured frame and lightweight cladding, not to specialise in farm work.

All but three of the firms indicated the maximum and minimum values of work for which they were prepared to contract. Amongst these, the average maximum limit was apparently £36,000 though this was influenced by a few large contractors: excluding these, the average limit imposed by 78 per cent. of firms with between 1 and 30 operatives was only £6,700. One firm in six placed the upper limit as low as £2,000.

Seventy-eight per cent. of all firms were prepared to undertake contracts valued at less than £100. Only six firms set the minimum at over £500.

Sub-letting of Specialist Trades

In the building industry it is normal for builders to sub-let varying proportions of their work and a large majority of the builders replying followed this practice. Approximately 90 per cent. indicated that Electrical work was sub-let, 55 per cent. Plumbing, 47 per cent. Steelworking and 31 per cent. Plastering. Few of the traditional "carcase" trades such as Excavator, Concreter and Bricklayer were sub-contracted, though a small minority of firms did so with Carpentry and Joinery.

CHOICE OF BUILDING CONTRACTOR

Reasons for Choice Given by Farm Owners

Each of the building owners replying to the Contract Questionnaire was asked to state why, in the first place, the builder who actually carried out the work was invited to give a quotation. The

6 Each individual firm was asked to state its *average* annual turnover over the most recent three year period. This amount was then divided by the number of building operatives at the mid-point of the size group in which the firm was placed, in order to find the average annual turnover per operative employed.

answers fell in four main categories and some owners gave more than one reason. The most common reasons (of approximately equal importance numerically) appeared to be that the chosen builder had previously done work on the farm or estate, or that he was a "local man." A somewhat less frequently occurring reason was that the builder had been invited to quote on the strength of a recommendation given to the owner by a third party.

The Main Points to be Considered

Although the foregoing might be good reasons for choosing a builder, it is suggested that a number of other considerations might, with advantage, be taken into account by owners faced with this problem:

(i) It is always worthwhile seeing examples of similar work already executed by a builder; observe quality and finish, enquire about costs, duration of building period and "extras" i.e. payment for additional work which arose during the construction or at completion.

(ii) A builder who has done work on the same farm or estate in the past may tend to become complacent about the automatic acceptance of his quotation. If his work is satisfactory there is every reason why he should be asked to bid—but it ought to be in competition.

(iii) The distance over which a firm operates may not necessarily be a bar to its employment, for increased costs of administration, travelling and so on may be offset by greater efficiency, although obviously, a local firm ought to be able to offer better service than a distant firm of no greater efficiency.

(iv) Although comparatively few builders specialise in farm buildings, there are many non-specialists prepared to engage in this type of work. Therefore, provided the requirements can be made clear, there is little need to restrict the field to specialists.

(v) Ninety per cent. of builders replying to the questionnaire were prepared to tender for work costing less than £500. This indicates that it is unnecessary to restrict enquiries to the smallest firms.

(vi) A building which incorporates an unusually large proportion of a specialist trade such as steel erection may involve additional costs through discounts and profits to the general contractor from the specialist subcontractor. In such a case, it may be advantageous to make direct arrangements with the specialist. However, where the building is sufficiently complicated, it may be considered advantageous to make the builder responsible for organising and coordinating specialist subcontractors. In such circumstances, if the builder is an efficient supervisor, he may more than earn the discounts allowed by subcontractors.

(vii) A builder with a reputation for quick, though efficient, work is an obvious choice. Speed should be attractive to builder and farmer alike. To the builder there is the advantage that rapid work reduces overheads, capital is turned over and profit made in the shortest possible time. To the farmer there is the attraction that capital paid on account during construction is in active employment with the minimum delay. In spite of these advantages the rapid job seems to be the exception. Most cowhouses seen during this survey took over six months to build—some more than a year—from start to finish.

VARIATIONS IN BUILDERS' PRICES

If two builders are invited to give a quotation for the same job, it is normally to be expected that two different prices will be quoted. The degree to which quotations vary under such circumstances will depend not only upon the varying abilities of builders in the making of an accurate estimate and the efficiency of building operations, but also upon the keenness of the competition between them to secure the contract.

Only a minority of the farm buildings covered by this enquiry were put out for competitive tendering, but where two or more quotations *were* sought the variation in tender prices was frequently considerable. Further discussion of these findings will be found in a subsequent chapter dealing with contract procedure[7].

In view of the not inconsiderable amount of variation in tender prices for the same job, it seemed reasonable to suppose that the prices of *successful contractors* for identical work on *different farms* might also show significant variation, particularly since the majority of contracts were secured without competition. Furthermore, if its existence could be established, price variation of this kind would be an additional factor explaining overall variation in the capital costs of cowhousing.

A method was devised for estimating how much of the overall variation in the cost of cowhouses was due to variation in builders' prices. The analytical tool used for this purpose was "standard costs". The procedure was similar to the pricing of an approximate Bill of Quantities against a standard schedule of price rates. In practice, various methods of estimating are employed, and it must be stressed that many subjective factors enter into the compilation of a builder's tender.

Very briefly, the technique of standard costing entailed re-pricing all the buildings involved on a uniform basis[8]. The analysis was confined to 28 cowhouses erected by building contractors.

Adjusted Standard Cost per Cow

When the standard cost of each building was expressed as a percentage of the actual cost per cow it was found that, on average, this ratio exceeded 100 per cent[9]. This suggested that the prices originally used in the derivation of standard costs, which were necessarily somewhat arbitrary, were rather too high to be truly representative of this type of building. To counteract this tendency,

7 See Chapter 7.

8 For full details of how standard costs were determined see Appendix 5A.

9 The average value of this ratio was actually 109 per cent.

all the original standard costs were scaled down by an equal proportionate amount so that, *on average*, the ratio of standard cost to actual cost per cow was exactly 100 per cent. These have been called "adjusted standard costs."

"Building Value"

The percentage ratio of adjusted standard cost to actual cost was used as an index of "building value," that is, as a comparative measure of the quantity of "bricks and mortar" obtained in return for a given outlay. Thus, a ratio of 100 per cent. indicated average building value received in relation to the actual capital expenditure involved. A ratio of over 100 per cent. indicated that more than average value had been obtained. Conversely, a ratio of under 100 per cent. indicated that less than average value had been obtained.

As between individual buildings, the value of this index ranged from 63 per cent. to 160 per cent. Of even more interest, however, is the fact that in the *majority* of cases the value was less than 100 per cent. Thus, it would seem that although a minority of owners got exceptionally good building value for the money they spent, the majority were less fortunate or less prudent in this respect.

Apparently, therefore, only a minority of owners succeeded in finding a builder ready to erect a cowhouse at a keenly competitive price. On the other hand, attention should be drawn to the fact that the index of building value makes no allowances for possible variations in building quality. Where the index value was comparatively low the quality of building may sometimes have been relatively high and vice versa.

Relative Importance of Variations in Builders' Prices Compared with Other Factors Influencing the Cost of Buildings

Amongst the 28 new cowhouses subjected to detailed survey, the average adjusted standard cost was £85.4 per cow, whereas actual costs averaged £92.4 per cow. The difference between these two averages is of no special importance as it was due to a very small number of extremely high-cost buildings with a very low index of building value.

Of much greater interest were the comparative degrees of cost variation around the average. The *adjusted standard costs* per cow of approximately two thirds of the buildings were within £28 above or below their average cost. On the other hand, the *actual costs* per cow of an equivalent proportion of the buildings were only to be found within a range extending to £45 above and below their average cost. In other words, actual costs showed a markedly greater degree of cost variation than adjusted standard costs. This finding suggests that a significant proportion of the variation in actual costs was due to variation in builders' prices (which was eliminated from standard costs).

The next step was to quantify this relationship with the aid of correlation analysis. The purpose was to measure, on the one hand, how much of the variation in actual costs per cow was due to differences in standard costs and, on the other hand, the "residual" amount of variation, some or all of which might be attributed to variation in builders' prices.

The results obtained suggested that approximately 80 per cent. of the variation in actual cost per cow was due to variation in standard costs[10]. By implication, therefore, this proportion of the actual cost variation was due to factors affecting the level of standard costs, such as building design and layout, and specification of the materials used in construction.

The residual variation, unaccounted for by standard costs, was about 20 per cent. of the overall variation in actual costs per cow. Apart from the possibility that some of the residual variation might be due to shortcomings in the method of analysis, this proportion of the actual cost variation may be attributed to a lack of uniformity in builders' prices.

The general conclusion, therefore, is that "design factors" were relatively more important than "price factors" in explaining the very wide range in the costs of cowhouses revealed by this survey. Nevertheless, the evidence suggests that the prices charged by different builders for identical work can vary sufficiently to make quite a substantial difference to the final cost of the building. It also suggests that owners would be well advised to safeguard their own economic interests by inviting competitive tenders for all building work. This matter is discussed more fully in the next chapter.

10 For further statistical details, see Appendix 6.

CHAPTER 7

BUILDING CONTRACT PROCEDURE

DURING the course of the survey it became apparent that the methods by which farm-owners ordered and paid for their buildings were very diverse. This factor, it was thought, might have some influence upon the initial costs of erection which were clearly very variable.

The "Contract Questionnaire" was, therefore, sent to owners of contract-built cowhouses to discover what information builders were given on which to base their tenders, the number of separate quotations sought, the forms of contract between owners and builders, and other related matters. The response to this questionnaire exceeded 80 per cent of the total number of enquiries.

The information so obtained was subsequently combined with the building cost data collected from the building owners during the preliminary survey, with the object of verifying or refuting the hypothesis that building costs are influenced by contract procedure.

Information given to Builders as a Basis for Preparing Estimates

Owners were asked what information the builder was given when invited to quote for building work. Their replies are summarised in Table 13. Where more than one answer was given, the "highest" category of answer has been classified, i.e. a Bill of Quantities takes precedence over written specification, and written specification over plan only, etc.

BASIS FOR PREPARATION OF ESTIMATES

TABLE 13 — No. of buildings

Type of information given to Builder	Cowsheds					Yard and Parlour	Total (all buildings)
	10—14 standings	20—30 standings	40+ standings	Other sizes	Total		
Verbal statement of requirements	20	16	10	3	49	3	52
Plan of building	5	7	2	2	16	3	19
Detailed written specification	14	16	7	2	39	13	52
Bill of Quantities	1	1	3	—	5	8	13
No response	1	1	—	—	2	2	4
TOTAL	41	41	22	7	111	29	140

The replies show that for 45 per cent. of new cowhouses the builder was given no more information than could be conveyed by word of mouth. Broadly speaking, the proportion of replies falling in this category was the same irrespective of the size of building. This method of describing requirements was not nearly so common for yards and parlours—possibly because of the comparatively greater complexity of this type of building, though it might also have been because a higher proportion of such buildings were designed by professional agents or architects. At the other end of the scale, the proportionate numbers of buildings for which Bills of Quantity were prepared were markedly different—only 4½ per cent. of cowsheds, but more than six times this proportion of yards and parlours.

If a builder is given scant information upon which to base his tender one of three results may be expected:

(a) The builder will price high to cover any possible eventualities, and so that he will not have to amend his price when the detailed requirements inevitably come to light.

(b) A recognised but unwritten "scale of provision" will apply in a district. The builder will estimate for and provide on the basis of this scale, and this provision will be accepted by the owner. This alternative is likely to be more common for conventional types of building such as cowhouses erected in predominantly dairying districts.

(c) The builder will price upon one set of standards and the building owner will have another in mind. Therefore, it is likely to be in the builder's best interest to acquaint his client with the fullest details of the basis of his quotation.

It became apparent that builders invited to tender for construction on farms do not necessarily expect to receive the detailed information which will be given for other-than-farm work. Table 14 shows that the plans and working drawings for nearly 40 per cent. of cowsheds were prepared by the builder himself.

PREPARATION OF PLANS [1]

TABLE 14 — No. of buildings

Type of information given to builder	Drawing prepared by: Professional Agent or Architect	Builder	Agricultural Advisor	Owner	Other	No Response	Total
Cowshed:							
Verbal statement of requirements	7	37	1	—	1	3	49
Plan of building	4	1	8	2	1	—	16
Written specification	30	4	3	1	1	—	39
Bill of Quantities	5	—	—	—	—	—	5
No response	—	1	—	—	—	1	2
Total	46	43	12	3	3	4	111
Yard and Parlour:							
All categories of information	20	3	4	1	—	1	29

1 Such an enquiry as this is likely to produce some irreconcilable answers. Of the 49 owners of cowsheds who stated that the only information given the builder was a verbal statement of requirements, nine also stated that a drawing was used prepared by *someone other than the builder*. One owner of a yard and parlour building took the trouble to prepare a drawing himself, but did not give it to the builder.

The accepted practice in other fields is that for work up to £4,000 builders will give quotations on the basis of ⅛th inch scale working drawings and a written specification of materials and workmanship. Over £4,000, a Bill of Quantities will normally be supplied to the builder.

Tenders for Building Work

It would not be surprising if farmers, to whom marketing is an important part of everyday life, tried to ensure that the bids they obtained for building work were highly competitive. However, the reverse seems to be true. A majority of owner-occupiers sought only one tender for yards and parlours and a substantial majority did so for cowsheds. Most landlords, on the other hand, sought competitive tenders, and there was only one instance of a landlord inviting only one bid for a yard and parlour scheme (Table 15).

COMPETITIVE TENDERING

TABLE 15 — No. of buildings

Status of Owner	Number of Quotations Sought						No response		Total
	One		Two		Three or more				
	Cow-shed	Yard & parlour	Cow-shed	Yard & parlour	Cow-shed	Yard & parlour	Cow-shed	Yard & parlour	
Owner-occupier	40	6	8	3	15	2	—	1	75
Landlord	18	1	19	5	11	11	—	—	65
Total	58	7	27	8	26	13	—	1	140

As a generalisation, it may be expected that landlords, whether governmental, institutional or private, who engage in any quantity of building work will have adopted some routine system to safeguard their interests, such as standing orders detailing the number of tenders required. It is mainly owner-occupiers who tend to adopt unbusinesslike methods in this respect.

No builder's price can be considered reasonable unless it is seen in comparison with the prices other builders would require for work of exactly the same standard under precisely the same conditions. In very large and complicated projects there may be a case for "negotiated contracts," but farm building is—technically—very simple, and calls for little more than the execution of a multiplicity of minor routine operations. A builder's price may be said to be the sum of a materials component, a labour component, haulage and machinery charges, overheads and profit. The amount of material in a building is controlled by the design and the builder can do little to reduce its cost apart from buying in the best markets and ensuring that there is a minimum of waste. The use of labour offers more scope for the application of managerial skills, and it is in the methods by which he goes about the job that the builder has the greatest influence on cost. In a market not overburdened by too much work for its capacity, a reasonable element of competition should stimulate a builder to keep his methods under review. Provided owner and builder ensure that standards are not reduced, it is no more than a commonsense procedure for any farmer to obtain more than one quotation for the same job.

In respect of 22 cowsheds and nine yard and parlour schemes, exact figures were obtained of the tenders received when:

(i) the tenders had been submitted in competition, and

(ii) the lowest had been accepted.

Wide variations were found between the lowest and next lowest tenders, varying from less than one per cent. to more than 77 per cent (cowsheds) and one third of one per cent. to over 7 per cent. (yards and parlours). The moral is surely plain: when such large variations can exist, a farmer should consider very carefully before departing from the procedure of inviting competitive tenders.

Five owners of cowsheds stated that they did not accept the lowest bid for their building. In three of these cases the builder had been given no more than a verbal statement of the owner's requirements on which to base his tender. The lowest tenders for three yard and parlour buildings were not accepted. For one of these, tenders had been invited upon a Bill of Quantities and for the other two, upon a specification. Unfortunately, the questionnaire did not reveal the reasons for these decisions.

There has been much uninformed discussion in the farming press of the evil effects of competitive tendering upon the quality of building work[1]. The crux of the matter, surely self-evident, is that tenders can only be competitive when they are based upon exact information, such as would be provided by properly drawn up plans and specifications, and when it is insisted that the requirements so specified are met.

There are, of course, ways of making a farce of competitive tendering. As mentioned above, some authorities issue standing orders on tendering procedure. One such instruction might be that for work estimated to cost less than £1,000 two tenders are required. The practice of one firm of land agents, in their own words, is as follows:

> " . . . . . we always have more than one quotation for work of this nature and the two builders most commonly employed are Messrs. A. and Messrs. B . . . . . It is most likely that where A obtained the work, B was the unsuccessful tenderer and vice versa."

Although there is no suggestion that A and B were in collusion, they could have been, and consultants ought to ensure that such opportunities are minimised.

The preparation of a tender by a builder is an expense which must be treated as an overhead borne by the jobs where his tender is successful. Too many tenders for too small a job is wasteful of effort, and a needless overhead tacked on to the next job. As an arbitrary guide, three tenders ought to be adequate for the general run of farm work—i.e. work costing up to about £4,000.

Tenders for Manufactured Buildings

This chapter so far has been almost entirely concerned with the "traditional" building of brick or concrete block walls, steel or timber roof framing, and corrugated asbestos sheet roof. This is because the overwhelming majority of both cowshed and yard and parlour schemes surveyed were of this type. But in recent years the proportion of manufactured buildings (basically, those with a structural frame of steel, reinforced concrete or timber) has increased and, because this form of building is readily adaptable to many

1 For example, an editorial columnist in the *Farmer and Stockbreeder*, 28th April, 1959.

uses, will undoubtedly continue to increase. The most usual arrangement is direct negotiation between manufacturer and farmer. No building contractor acts as an intermediary, though the frame manufacturer may sometimes be nominated as a subcontractor to the general building contractor.

The farmer seeking competitive quotations for such buildings will encounter a difficulty—the products of different manufacturers will not be exactly comparable. Although there is fairly general, but certainly not complete, agreement on a 15ft. 0in. bay spacing, this is the maximum practical extent of the standardisation of farm buildings—in spite of British Standard Specifications. Each manufacturer adheres to his own dimensions for spans, heights, and sizes of members. To obtain properly competitive tenders for such buildings, the farmer must first be extremely selective in his list of firms, choosing only those which make the exact size he wants. To find them, he will have to make an extensive search through manufacturers' literature. It seems somewhat surprising that manufacturers themselves do not take effective action to improve this situation, for the Farm Buildings Association Questionnaire revealed that there was a considerable demand within the building industry for greater standardisation which, it was believed, would result in cheaper buildings.

Form of Agreement between Owner and Builder

More owners entered into some form of written or legal agreement with their builders than gave only a verbal acceptance of the tender. Nevertheless, the proportion who took this last course was quite large (Table 16).

FORM OF AGREEMENT
Cowhouses and Yards and Parlours

TABLE 16 — No. of buildings

Status of owner	Builder's quotation accepted verbally	Quotation accepted in writing	Legal Contract	No Response	TOTAL
Owner-occupier	44	22	6	3	75
Landlord	5	41	16	3	65
TOTAL	49	63	22	6	140

It is apparent that landlords saw more advantage in some form of written agreement than did owner-occupiers. This may possibly be due to the government departments, local authorities and similar institutions who comprised an important element among landlords, and who were likely to have "Standing Orders" controlling contract procedure. Alternatively, it could have been due to the greater ease with which an individual farmer can strike a bargain with a builder. Where each is well known to the other, a "gentlemen's agreement" might be considered sufficient. Moreover, the results of the Builder Questionnaire showed that one builder in four might increase his quotation where a legal contract was required.

It is recommended that a building owner has some written safeguard for his position. The most usual procedure in the building industry is the use of the "R.I.B.A. Form of Contract," a rather formidable document of some 18 pages, but an ideal basis for a contract. For small works, some short form of contract, such as that prepared by the Faculty of Architects and Surveyors (only 3 pages) might be acceptable. This includes a brief schedule of conditions of contract which assigns the responsibilities of owner and builder in a number of eventualities, including extra works, insurance, mode of payment, legal liabilities, and bankruptcy.

Payment of Builder

Over 40 per cent. of builders replying to the Builder Questionnaire stated that where payment is deferred until the end of a job their prices are higher. In actual fact, a majority of the building owners included in this enquiry made interim payments, and the practice of paying at the end appeared to be confined to owners of smaller buildings (Table 17).

METHOD OF PAYING BUILDER

TABLE 17 — No. of buildings

Class of building	Frequency of Payment				No response	Total
	Monthly	Occasional Interim Payments	At completion	Other		
Cowshed	8	69	28	3	3	111
Yard and parlour	4	22	2	1	—	29
Total	12	91	30	4	3	140

Builders are normally paid on account as the work proceeds, less some amount (usually 10 per cent.) known as the "retention money" as security for the responsibility of the contractor to make good any defects due to defective materials or workmanship which may appear during the "maintenance period," normally six months after completion. On larger works interim payments are often monthly, based upon a valuation of the work completed. On smaller jobs, such interim payments may be at agreed stages of the building's completion, such as,

(i) walls complete to damp proof course,
(ii) walls complete to eaves,
(iii) roof complete, and
(iv) final completion.

Contract Procedure and Building Costs

The replies received in response to the Contract Questionnaire, from owners of new *cowhouses*, were examined for any recognisable relationships between certain aspects of contract procedure and the ultimate costs of the buildings. For example, were costs per cow lower, on average, where two or more quotations had been obtained than where the owner sought only one quotation?

Three aspects of contract procedure were examined in this connection, namely:

(i) the type of information given to the builder prior to his quotation,

(ii) the number of separate price quotations the owner sought, and

(iii) the form of agreement between the owner and the builder.

Two alternative forms of procedure were considered in each case. Thus, the cowhouses were classified into eight sub-groups each of which represented a different overall contract procedure. The average cost of the cowhouses in each sub-group was then calculated in terms of the *adjusted* costs per cow for individual buildings. This latter was a measure of the *net* cost of the cowhouse exclusive of the extra cost of ancillary accommodation[2]. The results are summarised in Table 18.

THE RELATIONSHIP BETWEEN THE TYPE OF INFORMATION GIVEN TO THE BUILDER, THE NUMBER OF QUOTATIONS SOUGHT, THE FORM OF AGREEMENT BETWEEN OWNER AND BUILDER, AND ADJUSTED BUILDING COST PER COW

104 COWHOUSES — CONTRACT QUESTIONNAIRE SAMPLE

TABLE 18

No. of cowhouses	Average adjusted cost per cow (£'s)	Information to builder	Number of quotations	Form of agreement
29	67.1	Verbal statement or plan	one	verbal
15	65.5	ditto	ditto	written
9	63.2	ditto	more than one	verbal
9	64.1	ditto	ditto	written
2	55.5	Written specification or Bill of Quantities	one	verbal
8	84.4	ditto	ditto	written
1	45.0	ditto	more than one	verbal
31	72.6	ditto	ditto	written

This analysis failed to reveal any significant relationships between various forms of contract procedure and ultimate building costs. Although, at first sight, there appeared to be some differences in average cost between the sub-groups, these proved to be statistically non-significant due to the high degree of cost variation *within* the sub-groups[3].

The conclusion is that, in arranging a farm building contract, the adoption of a businesslike procedure involving, say, competitive tendering on the basis of a written specification combined with a legal agreement to safeguard the owner, need not *necessarily* entail any significant addition to the ultimate cost of the building. Therefore, in view of their many inherent advantages to building owners, there is every reason why businesslike contract procedures should be more widely adopted.

2 For details of the derivation of adjusted costs, see Appendix 7.

3 For detailed results of the cost variance analysis, see Appendix 7.

CHAPTER 8

THE RETURN ON THE INVESTMENT

By how much were the net earnings of the surveyed farms increased through the erection of new cowhousing accommodation? What rate of return on the capital invested in the buildings did this represent?

In order to give accurate and comprehensive answers to these questions it would have been necessary to go with considerable detail into the affairs of each of the farm businesses concerned over the period since the erection of the new building. It would also have been necessary to estimate what the farm earnings would have been had such a building not been erected. A further requirement would have been to separate the net effect of the new building on farm earnings from the effects of any other adjustments in farming policy and farm organisation which had taken place during the same period.

Even assuming that all the necessary information could have been obtained, such a detailed analysis was outside the scope of the survey. Instead, an estimate was made of the average annual *gross* income earned by new cowhousing accommodation on 44 farms.[1] This was then expressed as a percentage of the average building cost to give the estimated average annual rate of *gross* return on new building investment.

In making these estimates, all the buildings and farms were dealt with from the point of view of an owner-occupier though, in fact, some were occupied by tenant farmers.

Annual Gross Income

It was assumed that the whole of the gross income earned by new buildings came from the sale of milk produced by the cows they housed. However, since it was desirable to eliminate the effects of seasonal fluctuations in the price of milk, the actual sales revenue was not used. Instead, the actual gallonage produced was multiplied by an arbitrary but uniform price per gallon.

Each co-operating farmer gave particulars of the total gallonage of milk he had sold during the twelve months' period prior to the survey.[2] The assumed basic producer's price was 3s. 0d. per gallon. In the majority of cases, an additional allowance of 3d. per gallon was made to cover the value of the T.T. premium, giving an overall price of 3s. 3d. per gallon.[3]

1 25 with new cowhouses, and 19 with new, or partially new, yard and parlour buildings.

2 On some farms where only part of the milking herd was housed in a new building the total gallonage sold from the *farm* exceeded the gallonage sold from the *new building*. In such cases, the total sales gallonage was scaled down proportionately according to the relative numbers of cows housed in the new and other buildings.

3 The actual amount of the T.T. premium has been changed several times recently. Up to the 31st March, 1958, it was 2d. per gallon, from the 1st April, 1958, to the 30th September, 1959, it was 3d. per gallon; since the 1st October, 1959, it has been 4d. per gallon.

It should be noted that the estimates of annual gross incomes earned by buildings were based on only one year's production. As far as individual farms were concerned, the estimates were, therefore, subject to error to the extent that the particular period chosen may not have been a "normal year" regarding milk yields or cow numbers. On the other hand, the estimated *average* annual gross income earned by the group as a whole is less subject to criticism on this score.

The Rate of Gross Return on New Building Investment

The estimated average annual gross income per new building was approximately £3,390. The average number of cows actually housed was approximately 24 per new building. Hence the estimated average annual gross income per cow was about £140. The average capital cost of the new buildings was £2,780, or about £116 per cow actually housed.

Thus, the estimated average rate of gross return per annum on new building investment was

$$\frac{3{,}390 \times 100}{2{,}780} = 122 \text{ per cent.}$$

Should this figure appear unexpectedly high, readers are reminded that this is a *gross* rate of return. In other words, it excludes any allowance for the remuneration of other resources used in milk production, i.e. the labour employed, including that of the farmer himself and his family, the working capital invested in cows, dairy equipment, feeding stuffs and other resources used directly or indirectly by the dairy enterprise, and the depreciation and maintenance of the building itself.

Nevertheless, the estimated average rate of gross return seems sufficiently high to suggest that most of the surveyed buildings were "paying their way." With an average annual gross income of £140 per cow housed, most dairy farmers would be expected to "come out on the right side."

Why the Rate of Gross Return on New Building Investment Varied

Amongst *individual farms,* estimated rates of gross return on new building investment varied from less than 30 per cent. to over 500 per cent. The basic reason for this high degree of variation in the rate of return was that not only were estimated annual gross incomes and building costs both highly variable, but also, to a large degree, they varied independently of one another.

There were two principal reasons for variation in the annual gross income between different buildings. Firstly, on approximately one third of the farms, the number of milking cows actually housed deviated by 14 or more above or below the average of 24 cows per new building. Secondly, whereas the overall average milk yield was approximately 850 gallons per cow per year, the average yield on approximately one third of the farms deviated from this level by 190 or more gallons per cow.[4] Milking cow numbers and average milk yields varied independently, thus accentuating the variation around the average estimated annual gross income of £3,390 per new building. In fact, the annual gross income of approximately one third of the buildings was more than £2,000 above or below this figure.

The principal reasons for variation in building costs were also twofold. Firstly, there were differences in building size, or the number of cows for which accommodation was available. Whereas on average, the new buildings had accommodation for 33 cows, the capacity of approximately one third of them was 14 or more cow-places above or below the average. Secondly, there were differences in building cost, i.e. the level of new building investment *per cow*. The average cost of the new buildings in this particular group was approximately £83 per cow. Excluding one extremely expensive yard and parlour unit costing over £300 per cow, the costs of approximately two thirds of the individual buildings lay within £32 of the average cost per cow: the remaining third lay outside this range. These very considerable cost differences were due, of course, to differences in building design and other factors discussed in earlier chapters.

Building sizes and costs per cow varied independently, thus accentuating the variation around the average cost (or new building investment) of £2,780 per new building. Excluding the exceptionally large and expensive yard and parlour unit referred to above, the costs of approximately two thirds of the surveyed buildings were within a range £1,270 above or below the average cost, and the costs of the remaining third lay outside this range.

Under-utilisation of New Cowhousing Space

On each of the surveyed farms, the degree to which new cowhousing accommodation had actually been utilised, during the twelve months prior to the survey, was measured in terms of the difference between " total capacity " and " utilised capacity."

Total capacity was the maximum number of cows that could be housed in the new building. With cowsheds this was simply the number of cow standings (or twice the number of " double-standings ") with which the building was equipped.[5] With yard and parlour buildings, maximum capacity was calculated in terms of yard area, assuming a requirement of 100 sq. ft. of yard space (covered and open) per cow. *Utilised capacity* was the *average* number of cows in milk actually housed during the twelve months prior to the survey.

4 For the purpose of this study, "average milk yield" is defined as the total gallonage sold during the year divided by the *average number of cows in milk*. This differs from the generally accepted definition of "herd average milk yield", i.e. total gallonage sold plus milk fed to calves and consumed in the farmhouse divided by the *total number of cows in the herd*. Hence, to prevent confusion, the use of the latter term has been avoided.

5 It should be noted that this definition of capacity rules out the use of cowhouses as "semi-parlours", whereby more cows are milked than the cowhouse will accommodate, milking being in batches and "surplus" cows being accommodated in boxes or yards. In fact, this practice is thought to have been followed only to a very limited extent on the surveyed farms.

The average total capacity per new building was 33 cow-places, whereas the average utilised capacity was only 24 cow-places. Thus, on average, only about three quarters of the total capacity was being utilised at the time of the survey. The degree to which individual buildings were utilised varied considerably, but the usage of approximately two thirds lay between 55 per cent. and 95 per cent. of total capacity.

The utilisation of new buildings at less than their full capacity involved a sacrifice of extra gross income which might have been earned if more cows had been kept and more milk produced. Moreover, since the cost of the buildings concerned would not have been affected in any way, this potential addition to gross income would have been a net addition to the annual rate of gross return on new building investment.

Thus, the degree to which new cowhousing capacity was actually utilised also had an important influence on the rate of return on new building investment. The combination of a relatively high milk yield and high utilisation of new building capacity with a relatively low building cost per cow gave the highest rates of return on new building investment. Conversely, the lowest rates of return tended to be associated with low milk yields and low utilisation of new building capacity, coupled with a high building cost per cow. Evidence of this may be seen in Table 19, where average rates of gross return on new building investment are compared between two groups of buildings. The "High/high/low" group is composed of buildings on farms where the average milk yield per cow and the utilisation of new building capacity were above average but where the building cost per cow was below average. In contrast, the "Low/low/high" group contains all the buildings on farms where a lower than average milk yield and utilisation of new building capacity was combined with a higher than average building cost per cow.[6]

COMBINATIONS OF FACTORS ASSOCIATED WITH HIGH AND LOW RATES OF RETURN ON NEW BUILDING INVESTMENT

TABLE 19

Group	No. of buildings	Average milk yield per cow (gals.)	Utilisation of new building capacity %	Building cost per cow £'s	Estimated annual gross income £'s	Total building cost £'s	Estimated rate of gross return on new building investment %
High/high/low	8	983	91	60	4,219	1,825	231
Low/low/high	7	641	49	104	1,468	2,982	49

The Potential Rate of Gross Return on New Building Investment

In order to find the potential level of milk production from the new cowhousing accommodation on each farm, the average milk yield was multiplied by the total capacity of the new building. That is, it was assumed that the milking herd could have been

6 See Appendix 8 for details of the statistical analysis.

expanded to the limit imposed by available building accommodation without any reduction in the average milk yield. The whole of the potential gallonage was then priced at 3s. 3d. per gallon to find the potential annual gross income from the new building.[7]

The estimated average potential annual gross income per new building was £4,540, i.e. £1,150 more than the average *actual* annual gross income. Since the average capital cost of the new buildings was £2,780, the estimated average rate of potential gross return on new building investment was

$$\frac{4{,}540 \times 100}{2{,}780} = 163 \text{ per cent.}$$

i.e. over 40 per cent. higher than the estimated average rate of *actual* gross return.

Reasons for Under-utilisation of New Buildings

There are a number of possible reasons why there should have been unused cowhousing space on many of the surveyed farms.

Firstly, most farmers had to make provision for seasonal fluctuations in the number of cows in milk. Secondly, some farmers were still in the process of building up to a larger sized herd. Thirdly, due to uncertainty about future prospects for milk producers, some farmers had decided against further expansion, or even for some contraction in the size of the dairy herd, so as to release labour and working capital for what they adjudged to be more profitable enterprises.

Seasonal Fluctuation in Cow Numbers

The utilised capacity of each new building was based on the *average* number of cows in milk during the year. On the other hand, housing space is usually provided for the *maximum* number of cows in milk at any one time. The amount of short-term fluctuation in the number of milking cows on a farm depends on the breeding policy adopted. Some farmers, favouring winter milk production, will try to concentrate calvings in the autumn months, whereas others favour more level production with calvings more equally distributed over the year. Assuming a uniform lactation period of ten months and a situation where all the cows calved on the same date each year, there would be ten months during which the whole herd was in milk and two months during which the whole herd was dry. In such a case, the number of cows in milk during the ten months of lactation, and hence the required amount of housing space, would be one fifth greater than in a herd with exactly the same number of lactations per year, but following a policy of level all-the-year-round calvings. At the most, therefore,

7 In estimating potential annual gross income it was assumed that every producer would receive the T.T. premium allowance of 3d. per gallon. In actual fact it is thought that none of the 44 producers concerned would have been disqualified from holding a T.T. producer's licence on the grounds of *unsuitable buildings*.

short-term fluctuations in the number of cows in milk would justify the provision of a building with a total capacity one fifth greater than the average utilised capacity. Moreover, so long as the overall number of cows was not increased, such a building would provide housing for the entire herd, *including dry cows,* although on many farms these latter could be, or are, housed separately in simpler and cheaper buildings.

It has already been shown that amongst the surveyed buildings the average total capacity was approximately one third greater than the average utilised capacity, and on approximately half the farms the proportion of unutilised capacity was even greater than this. It has also been estimated that, on average, the annual gross income from milk production foregone due to unutilised capacity was approximately £1,150 per new building. Thus, it would seem that, *at the most,* reasonable provision for seasonal fluctuations in the number of cows in milk would, on average, have entailed the "loss" of no more than about £680 per new building.[8] But on farms where the pattern of calvings and lactation periods were such that there were some dry cows at all times during the year, and where some or all of the latter were housed separately, the unavoidable loss on this account would have been correspondingly less.

So, having allowed for the effect of seasonal fluctuations in cow numbers, there still remains an "unexplained" difference between the estimates of actual and the potential gross income per new building averaging, at the least, nearly £500 per new building.[9]

Delay in Herd Expansion

There were two main reasons for erecting new cowhousing accommodation on the surveyed farms. Firstly, to replace one or more obsolete buildings and, secondly, to provide supplementary accommodation for a larger dairy herd. There were a few farms where the new accommodation was purely supplementary, i.e. the original cowhouse remained in use even after the new one had been completed. There were also a number of farms where the new building was the first of its kind, i.e. they had previously had no milking enterprise and no buildings for the housing of dairy cows.

However, on the majority of farms the new building had been erected for both the above reasons: that is, to replace an old cowhouse (sometimes, at the instigation of the milk production licensing authority) and to make some provision for an increase in the size of the milking herd.

Particulars were obtained on each farm of the amount of cowhousing space available prior to the erection of the new building (all of which may, or may not, have been fully utilised) *excluding* any building which was still used for its original purpose. This

8 The estimated average annual gross income per new building was £3,390. If the average number of cows in milk over the year had been increased by one fifth, thus increasing the average utilised capacity in the same proportion, the average increase in annual gross income from milk production would have been, $\frac{£3,390}{5} = £678$.

9 £1,150 − £678 = £472.

was called the "replacement capacity" and averaged approximately 17 cow-places per farm. On the other hand, as previously stated, the total capacity of new buildings averaged 33 cow-places per farm. Thus, on average, after the erection of the new building, the available cow accommodation was nearly twice as great as it had been previously. In other words, there was a general tendency for owners to make provision for a comparatively large proportionate increase in the size of the milking herd. Furthermore, it can be seen that by the time of the survey, the expansion of numbers had already started since, compared with an average replacement capacity of 17 cows per farm, the average number of cows in milk was 24 per farm. That is, there had been an average increase of *at least* 7 cows per farm. Since it is very improbable that the buildings which were replaced had all been utilised to their full capacity, it is likely that the actual increase in cow numbers was even greater than this.

Nevertheless, even after allowing for seasonal fluctuations in the number of cows in milk, on many farms there was still a gap between the total capacity of new buildings (average, 33 cow-places) and the utilised capacity (average, 24 cow-places). Why was this?

It is suggested that there were two main reasons. Firstly, the costs of herd expansion, aggravated in some cases by the costs of attestation. Secondly, economic changes affecting the outlook for milk producers.

A substantial proportion of the farmers changed over from non-attested herds, and the production of ordinary milk, to attested herds and the production of T.T. milk at about the same time as they acquired new buildings. Indeed, the prospect of qualifying for the T.T. milk bonus was frequently one of the incentives to build. By the time of the survey, the majority of herd owners had, in fact, disposed of all their reactors and had attested herds. However, milking herd numbers had sometimes been seriously depleted during the changeover, and the rate at which the herd could be restored to its original size, or actually expanded, was dependent on a number of factors. Some farmers probably preferred to breed their own replacements rather than purchase on the open market. This would often have been a rather slow method of restoration. On the other hand, if resort were had to outside purchase, the rate at which additional cows were brought into the herd depended on capital considerations—the total amount required, how readily it was available, and its cost. The greater the scarcity of liquid capital, and the higher its cost, the longer a capital project such as the purchase of extra dairy cows may have to be delayed.

Thus the relative scarcity and cost of extra capital might well have slowed down the rate of herd expansion even if there had been no "wastage" of cows reacting to the T.T. test. On farms where a policy of herd expansion was combined with the changeover to an attested herd, the replacement of reactors often involved a heavy burden of additional capital expenditure, due to the wide divergence in market prices between attested and non-attested stock. During the course of the survey, more than one farmer remarked that two reactors "buy" only one attested cow. This may have been a slight exaggeration of the cost of replacing cows that "failed the test," but was, nevertheless, a succinct way of describing the problem.

Alternative Opportunities for the Profitable Employment of Farm Capital and Labour

The fact that, on average, the total capacity of new buildings was nearly twice as great as that of the buildings which were replaced is strong evidence that, at the time when the new buildings were designed, many owners planned a considerable increase in the size of their milking herds. However, for reasons already set down, on some farms it would necessarily have taken a number of years to fully implement such a plan. Moreover, any farming policy is subject to modification in the light of subsequent events and changes in the future prospects for different lines of production.

This is a study of building investment relating to a single farm enterprise—the milking enterprise. Although, on many of the farms visited, this was the *main* enterprise, it was hardly ever the only one. To a greater or lesser degree, they were all mixed enterprise farms selling not only milk, but also other livestock products such as fat cattle, fat lambs, pigs, eggs, and cash crops such as wheat, barley, potatoes and sugar beet. The primary objective of mixed enterprise farming is not to make the greatest possible profit from any single product such as milk: still less is it that all buildings should be utilised to their full capacity. The overriding objective is the highest possible profit from the farm as a whole. To obtain this objective, resources such as labour and working capital which, although limited in total amount, can readily be moved from one enterprise to another, sometimes need moving out of less profitable enterprises into those where future prospects are more favourable. It is more important that *mobile* resources such as man labour and machine power, and the money available for the purchase of feeding stuffs and fertilisers, should be deployed between enterprises so that they make their maximum contribution to overall farm earnings, than it is to make full use of *immobile* resources, such as a building, which cannot be readily used for more than one purpose.

It is probable, then, that after their new buildings had been erected, some farmers found the future prospects for a larger dairy herd less attractive than they had been at the time when the buildings were planned. This led them to modify their policy, so that some herds were expanded less than had been originally intended: as a corollary, new buildings were not used to their full capacity.

The trends in the average prices received by farmers for milk and other farm products during the relevant period lend some support to this hypothesis.

The surveyed buildings were all erected between 1951 and 1958, a large majority being completed during the first five years of this period. It may be surmised that, in making their building plans, owners were influenced by the price situation for milk and other farm products in the immediate post-war years. This was the period when due to the Government's agricultural expansion programme, the guaranteed prices of the majority of farm products were unusually favourable to producers: furthermore, feeding stuff prices were controlled.[10] However, between 1951 and 1958 (the present survey was started in the latter year) the trend in average annual prices received by milk producers was not particularly favourable compared with the price trends shown by a number of other farm products. Moreover, following the derationing of feeding stuffs and the removal of the price subsidy, the prices of feeding stuffs rose rapidly—much more rapidly than the price of milk. These relationships are shown by the price indices in Table 20.

ANNUAL PRICE INDICES (ENGLAND AND WALES)
1948-50=100

TABLE 20

PRODUCTS	1951	1952	1953	1954	1955	1956	1957	1958
Milk	112	118	120	119	121	120	112	114
Fat cattle	111	123	129	133	151	143	158	161
Fat lambs	107	117	124	141	137	144	151	148
Fat pigs (under 10 sc. liveweight)	120	125	141	127	135	134	127	117
Eggs	110	113	112	101	104	99	103	94
All livestock and livestock products	116	121	124	122	127	124	122	121
Cereals and other farm crops	117	115	117	117	123	132	120	145
PURCHASED FEEDING STUFFS								
Palm kernel cake	185	192	187	164	193	194	178	n.a.
Barley meal	138	145	144	125	138	143	126	n.a.

n.a.=not available

SOURCE: Price indices published in Agricultural Statistics, England and Wales, (converted from 1927-29 base).

Furthermore, some dairy farmers were undoubtedly influenced by official warnings of the likely consequences of continued expansion in milk supplies.[11] It was made clear that the Government could not continue to guarantee the price for an unlimited quantity of milk, and from April, 1954 onwards, the guarantee was, in fact, limited to the estimated requirements of the " liquid market." Since, at the prevailing retail price, the prospect of increasing the total consumption of liquid milk was unpromising, and in view of the much lower price realised by milk sold for manufacturing, there was every prospect of a decline in the annual average price paid to producers. This, in fact, happened between 1953 and 1954, and each year from 1955 to 1958 (see Table 20). Some farmers reacted to

10 Farmers' purchases of imported feeding stuffs were rationed from early in the War until September. 1953. Moreover, prices were controlled, by means of a subsidy, up to March, 1949. Half this subsidy was removed as from April, 1949, and the remaining half in April, 1950. At the latter date a special rebate was introduced to assist small farmers specially dependent on purchased feeding stuffs: this was removed in April, 1951. Price control over all imported feeding stuffs was reintroduced for one year in April, 1952.

11 The Government showed concern about the possibility of a "milk surplus", due to supplies increasing faster than demand, as early as 1951, when the guaranteed price for 1951-52 was fixed at a level which, it was hoped, would damp down further expansion of output.

this by going out of milk production altogether.[12] It is small wonder, then, that others, including some of those included in the survey, decided against further expansion of the dairy herd until future prospects became more favourable.

To sum up, market conditions in the immediate post-war years caused farmers to form optimistic expectations regarding the future prospects of milk production. The fact that they decided to erect new dairy buildings was in itself a reflection of their confidence in the future. The further fact that many of those included in the survey planned buildings allowing for a considerable expansion in herd size reflected this optimism. Subsequent events suggested that expectations had been placed too high and on some farms the policy of expansion was, at least temporarily, abandoned. Farmers decided that, in the changed situation, the extra capital and labour required to increase and maintain a larger dairy herd could be more profitably employed elsewhere on the farm. This remained true despite the fact that abandonment of the policy of herd expansion entailed using new buildings at less than their full capacity.

The Cost of Unused Building Capacity

Whatever the reason for it, unused building capacity represents a waste of resources which, because of the cost involved, cannot be justified except in the very short run. It has already been estimated that had all the buildings been fully utilised the average gain in annual gross income would have been at least £500 per farm. Except on farms where alternative opportunities for profitable investment were very limited, this may also be regarded as a rough measure of the annual gross return which might have been yielded by the "surplus" capital locked up in unutilised building space, had it been freely available for another purpose.

Over-investment in new cowhousing accommodation may, therefore, result either from over-confidence in the future prospects for milk producers, or from the inability to match building investment with the capital required for extra livestock. But in any case, over-investment easily results in the "sterilisation" of capital which cannot be used for any other purpose. Although, in the short run, surplus cowhousing capacity enables the milking herd to be expanded when the market is favourable, the real cost of the "flexibility" so secured may be higher than many farmers suspect, particularly on farms where there are many alternative opportunities for employing extra capital which would show a surer and quicker return.

BUILDING INVESTMENT AND BUILDING ENVIRONMENT

Two further questions arise which have an important bearing on the rate of gross return on new building investment. Firstly, were the new buildings generally superior to those they replaced from the point of view of the health, comfort and productivity of the cows? Secondly, apart from the fact that larger buildings

12 The number of producers registered with the Milk Marketing Board declined by approximately 10 per cent between 1954 and 1958.

housed larger herds, was there any correlation between the level of building expenditure and the level of milk production? In other words, is there any evidence that in terms of milk production and gross income, the environment of relatively expensive buildings was superior to that provided by relatively cheap buildings?

In answer to the first question, it was unfortunately not possible to make any direct comparisons between new buildings and those they replaced, for the simple reason that the latter were no longer in use, or even in existence, at the time of the survey. Moreover milk records relating to the period immediately prior to the erection of new buildings were rarely available, thus precluding a comparison between the present and past average milk yields. There is, therefore, no direct evidence on this point. On the other hand, it can be said that the surveyed buildings were generally "traditional" in design, and it seems doubtful whether, compared with the buildings they replaced, they offered greater scope for environmental control in any marked degree. Indeed, in at least one respect—that of the incidence of condensation inside the building—they frequently appeared to be inferior to some of the older buildings (see Appendix 3A).

The greatest change in the building environment probably occurred on farms that had changed over from the cowhouse to the yard and parlour system of housing. However, at present, most of the available evidence (from the U.S.A.) suggests that this change would be unlikely to have an appreciable effect either on milk yields or feed consumption.[13]

In answer to the second question, there was no apparent correlation between building cost and the level of gross income from milk production on the farms included in this enquiry.[14] Hence, if the environment of the more expensive buildings was conducive to higher production and gross income, its effect was entirely masked by those of other factors influencing milk yields, such as breeding, feeding and other aspects of management.

As already explained, one of the reasons why the estimated annual gross income earned by different buildings varied, was due to differing proportions of utilised and unutilised building capacity. Thus, in attempting to isolate the effects of yield variations and associated factors on the relationship between the costs of new buildings and the annual gross income from milk sales, it was desirable to assume that all new buildings were utilised to their full capacity: that is, to assume that each new building earned its estimated *potential* annual gross income.

The results of correlation analysis revealed that, amongst the 44 new buildings surveyed, approximately 83 per cent. of the variation in estimated potential annual gross income was due to differences in building size (i.e. total capacity). Thus, only about 17 per cent. of the overall gross income variation remained to be explained by other factors. Due to the method of analysis employed, it could be surmised that the remaining variation was

13 See: HEIZER, E. E. et alia. *A Summary of Studies Comparing Stanchion and Loose Housing Barns*. American Journal of Dairy Science, 36, (3).

14 For details of the correlation analysis, see Appendix 8.

almost entirely due to differing average milk yields (the effect of fluctuations in milk prices having been eliminated from the gross income estimates). On the other hand, there was the possibility of a relationship between milk yields and building costs if it were true that the more expensive buildings provided a more favourable environment for the cows. This hypothesis was tested by including the costs of erecting the buildings as a third variable in the correlation analysis. The results showed that when both size and erection cost were taken into account, the " unexplained " variation in gross income remained at 17 per cent. In other words, amongst farms where the level of new building investment per cow was relatively high, average milk yields were just as variable, and no higher on average, than on farms where the level of new building investment per cow was relatively low.

This result is not surprising in view of the fact that little or nothing appears to be known at present regarding the environmental requirements of cattle, at least under the conditions likely to be found on commercial farms. However, there is some experimental evidence suggesting that for optimum production cattle are less exacting in their environmental requirements than some other classes of livestock. For example, the interim results of American experiments on the physiological reactions of dairy cattle to differing climatic conditions showed that, although milk yield and efficiency of milk production appeared to be best at an environmental temperature of about 50°F, much lower temperatures down to 4°F did not result in a very marked decrease in milk production, so long as the cows were acclimatised to the lower temperatures.[15]

ALLOWANCE FOR BUILDING DEPRECIATION AND MAINTENANCE

Buildings depreciate for two reasons; physical deterioration and obsolescence. With a rapidly changing agriculture, such as that confronting farm-owners at the present time, it may well be that many new farm buildings are of a durability which is likely to outrun their useful *economic* life. Accurate forecasting of the number of years a building is likely to remain useful is extremely difficult, if not impossible. For the purposes of this study the useful life of all the surveyed buildings was fixed, quite arbitrarily, at 25 years.[16] This is the equivalent of a depreciation rate of 4 per cent. per annum on the original cost.

The life of a building may often be prolonged by maintenance and the problems of economic maintenance were discussed in Chapter 1. The standard costs of repairing defects, apparent in 36 cowhouses at the time of the survey, suggested that only exceptionally would the annual costs of maintenance be likely to exceed

15 See: RAGSDALE, A. C. et alia. *Environmental physiology with special reference to domestic animals. VI. Influence of temperature, 50° to 0°F, and 50° to 95°F, on milk production, feed and water consumption and body weight in Jersey and Holstein cows.* 1949. Research Bulletin No. 449. Agricultural Experiment Station. University of Missouri, Columbia, Missouri.

16 This should not be confused with the statutory 10 years life over which farm buildings may be written off against taxable profits.

one per cent. of the original building cost.[17] This makes no allowance, however, for the effects of inflationary price increases on the costs of repairs.

Therefore, on the basis of original capital costs, the combined annual costs of depreciation and maintenance, for this class of farm building, might be expected to be in the region of five per cent. Furthermore, depreciation costs are normally likely to be much greater than maintenance costs. Only if the economic life of a building greatly exceeded 25 years would annual depreciation and maintenance costs approach parity. It may, therefore, be concluded that, if much additional capital expenditure is involved at the outset, highly durable farm buildings deemed to require less than the usual amount of subsequent maintenance are likely to be a losing economic proposition. The greater the uncertainty about the length of time before a building becomes obsolescent, the more compelling this conclusion becomes.

Nevertheless, the importance of this matter needs to be seen in the right perspective. Compared with the average rate of gross return on new building investment presented and discussed earlier in this chapter, an annual depreciation and maintenance cost of 5 per cent. per annum looks comparatively insignificant. A quite small proportionate increase on the income side of the account, due to a change in the volume of production, or comparatively small savings in costs such as those pertaining to labour or feeding stuffs, might well cover depreciation and maintenance costs at double this rate, or even more. It is only to the less able farmer producing only a very low output in relation to his costs, that the level of depreciation and maintenance costs might spell the difference between a farming profit and a farming loss. It is possible that one or two of the farm-owners included in this survey, whose estimated rate of gross return on new building investment was very low, were in this position. But for the majority, it is doubtful whether the costs of building depreciation and maintenance were of critical importance.

SUMMARY AND CONCLUSIONS

New farm buildings should only be erected when they appear to represent the most profitable outlet for additional capital.

Because of limitations in the available data, it was only possible to estimate rates of *gross* return on new building investment. In spite of its limitations, this method of approach revealed by how much, and some of the reasons why, the rate of return on building investment is liable to vary between one farm and another.

The average rate of gross return per annum on new building investment was sufficiently high to suggest that the majority of the surveyed buildings were at least paying their way. There were few, if any, farms where building capital had been invested in a milk enterprise which was obviously unprofitable. On the other hand, there were clear indications that the building investment had been much more profitable on some farms than others. Estimated

17 See Appendix 3C, Table 27.

annual gross incomes from milk production and the capital costs of buildings both varied over a very wide range: they also varied independently of one another. Three factors were identified which appeared to have an important bearing on rates of gross return on new building investment. These were: the milk yield, the extent to which new building capacity was actually utilised, and the level of building investment *per cow*. High rates of gross return were associated with high milk yields, relatively full utilisation of building capacity, and low building costs per cow. Low rates of gross return were associated with low yields, low utilisation of building capacity, and high building costs per cow.

Milk yields are affected by breeding and feeding policies and other aspects of management. Farmers differ in managerial ability and variations in average milk yields, therefore, occasion no surprise. There is little or no evidence that milk yields are affected by building environment under ordinary farm conditions, either in this country or abroad where the climate is similar. Although above-minimum expenditure on buildings for dairy cows might be justified if it could be shown that milk yields were thereby enhanced, no association whatsoever was found, in the present survey, between average milk yields on different farms and the corresponding levels of building expenditure per cow.

It appears that in the light of present knowledge regarding the environmental requirements of dairy cows, there is much to be said for housing them as cheaply as possible. If there is any justification for above minimum expenditure on buildings, the case must be made out on other grounds: the simplification of work routines, for example, or merely more comfortable working conditions for the cowman.

Perhaps the most surprising result arising from this part of the survey was the wide variations in the degree to which new buildings were actually utilised. In view of the very considerable capital investments involved, it may appear strange that, at the time of the survey, so many of the farmers had surplus cowhousing capacity. It was estimated that, after allowing for month to month fluctuations in the relative numbers of milking and dry cows, the average loss of potential gross income from milk production, on this account, was nearly £500 per farm: on some farms it was a good deal more.

Two possible reasons for the occurrence of surplus building capacity have been suggested. Firstly, most of the new buildings were planned to house a larger herd than had been kept previously, and the capital costs of herd expansion may have been higher than originally anticipated. Furthermore, the costs of expansion were usually augmented by the extra costs of changing over from a non-attested to an attested herd. Secondly, farming policy may have been revised in the light of changed future prospects for milk producers between the immediate post-war period and the mid-1950's.

Some owners may feel justified in locking up capital in building capacity which is surplus to the current requirements of the farm, or their ability to finance the purchase of extra stock. Such a policy, nevertheless, is liable to prove costly if the excess capacity remains unused over a long period.

The facts about surplus building capacity brought to light by this survey also underline the need for farm buildings which can be more easily adapted for alternative uses and also, perhaps, for cheaper and quicker methods of extending existing structures.

When a notional allowance was made for the costs of building depreciation, and an allowance for estimated annual maintenance charges, based on the standard costs of repairing defects noted during the course of the survey, there was only a very small reduction in the average rate of gross return on new building investment. These costs are so small in relation to the amount of the building investment and the annual gross income from milk production, that they are likely to be of critical importance only to the marginal producer.

The general conclusion is that the rate of gross return on new building investment is likely to be extremely variable. This is in line with the results of farm economic investigations generally, being a reflection of the fact that within any sizeable group of farmers there is a wide range of managerial ability. Although the gross income per cow appears to vary quite independently of the amount spent on cowhousing, due economy in building expenditure will always be worthwhile so long as there remain opportunities for profitable investment elsewhere in the farm business. A capital saving of, say, £10 per cow on buildings may not of itself make much difference to the milk producer's future profits. But, if an amount equivalent to this saving is invested wisely in some badly needed alternative improvement, the overall increase in the return on farming capital, and in farming profit, may well be considerable.

CHAPTER 9

CASE STUDIES OF INDIVIDUAL BUILDINGS

THIS chapter contains five case studies of buildings included in the detailed survey. None of these is put forward as an "ideal building" and, indeed, it is doubtful whether such a building exists. Even if suitable standards could be devised for all the desirable features of a farm building, it is doubtful whether any actual building would be found to satisfy all the requirements. Most actual buildings represent a compromise between the ideal and the possible. Moreover, few, if any, buildings are so well conceived that they are thought to be incapable of improvement, even by their owners.

The five buildings which are described in detail were selected according to two main criteria. Firstly, they were all erected relatively cheaply and the estimated costs of maintaining them were relatively low. Secondly, although none of them was immune from criticism on grounds of siting and layout, the lengths of their feed and milk routes were generally short, and the overall transport effort, in terms of ton-miles per cow per annum, was in all cases less than the average for the entire group of farms for which this was estimated.

Three of the case studies relate to cowhouses and the remaining two to yards and parlours. For the yards and parlours, only actual costs were available: for the cowhouses both actual costs and standard costs were available. Thus it was possible to assess the cowhouses in terms of "building value" (see Chapter 6). As elsewhere in the report, all "actual" costs have been normalised to the 1959 price level.

The case studies omit any reference to the estimated rate of gross return on new building investment. This has been deliberately omitted for two reasons. Firstly, information concerning the earnings of individual farmers cannot be divulged. Secondly, the gross returns actually secured by the users of different buildings reflected differences in managerial ability rather than differences in the intrinsic merit of the buildings themselves.

These, then, are not model farm buildings, but rather examples of sound and sensible building investment on ordinary commercial farms. They represent a somewhat arbitrary selection: it would not have been difficult to select five other buildings of comparable all-round merit, or which were superior to the present selection in points of detail.

BUILDING 50

Description of farm

Lowland farm of 172 acres bordering the River Trent in East Nottinghamshire: owner-occupier with attested Ayrshire herd.

Building type

New single-row cowhouse for 20 with feeding passage. Dairy and feed-store existing.

I Construction

STRUCTURAL DETAILS

Frameless asbestos cement shell in prefabricated sections, erected on dwarf concrete block walls. End sections closed with nine inch concrete blocks.

DESIGN AND ERECTION

Main design by suppliers of the prefabricated shell sections: suppliers erected shell; skilled labour employed by owner to assist with blockwork, internal fittings and concreting.

Building commenced in Autumn 1953 and completed in the Spring 1954.

OWNER'S REASONS FOR ERECTION

Old buildings were inconvenient and unsuitable for T.T. milk production.

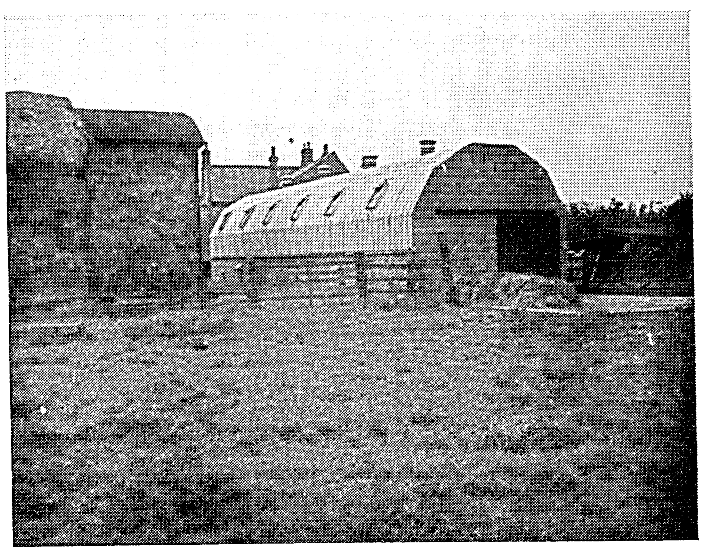

Plate 10: New cowhouse viewed from the south-east.

BUILDING No. 50

Type of Accommodation Replaced

Two separate single-row cowhouses with an overall capacity of 20 cows. These now used for housing young stock, without structural alteration.

Cost of Erection

Normalised cost: £51 per cow.
Adjusted standard cost: £73 per cow.
Index of Building Value 1.43.

Estimated Maintenance Cost

Standard maintenance cost per annum: 4s. 8d. per cow.

General Comments on Construction and Costs

The cost per cow was well below the average for cowhouses with a feeding passage but without ancillary accommodation: on the other hand, the adjusted standard cost per cow was slightly above average.

The relatively low cost per cow was partly due to low labour costs consequent on the owner doing a considerable part of the work himself. The very low estimated maintenance costs are a noteworthy feature of this type of building.

This is an example of a largely prefabricated building which appears to give very good value for the money spent on it.

II Siting and Layout

The main features are shown in Figure 1.

Lengths of Feed and Milk Routes

	Average length of route (feet)
Bulk feeding stuffs and bedding straw	118
Concentrated feeding stuffs	89
Milk (to despatch point at dairy door)	99

"Transport Effort"

	Ton-miles per cow per annum
Bulk feeding stuffs and bedding straw	0.055
Concentrated feeding stuffs	0.026
Milk	0.097

General Comments on Siting and Layout

Though not outstandingly good, the arrangements on this farm for handling feeding stuffs were somewhat better than average, despite the fact that the concentrate store was detached from the new cowhouse. Nevertheless, study of the site plan suggests that it would have been advantageous to have a door on the south side of the cowhouse, opening directly into the feeding passage, to reduce the distance travelled to the dutch barn. However, in view of the unusual nature of the construction, this might have been difficult to incorporate in the design.

The arrangements for milk handling were rather poorer than the average. They could have been improved by making a doorway in the wall of the dairy facing the cowhouse.

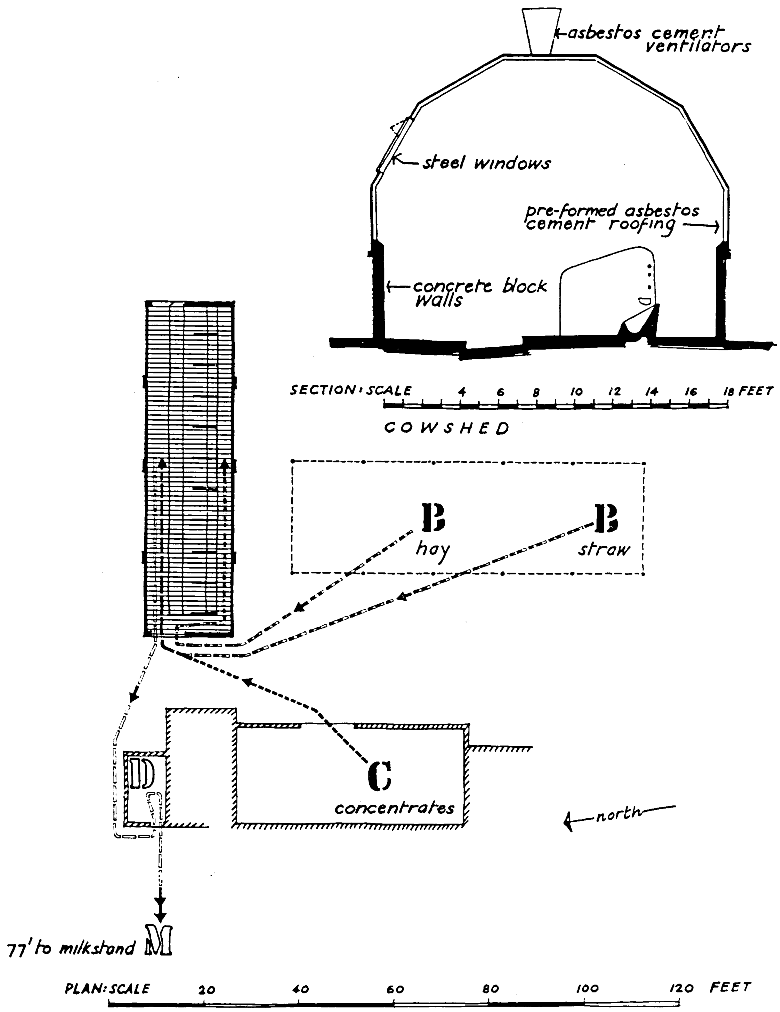

Figure 1: Plan of farmstead layout showing feed and milk routes.

BUILDING No. 50

The owner himself commented that the cowhouse was rather too narrow: had a slightly wider span been obtainable the extra width could have been used with advantage to widen the feeding passage and lengthen the cow-standings. This suggests that where a general purpose prefabricated building is adopted for a specialised use, such as the housing of cows, considerable care needs to be exercised in ensuring that the overall dimensions are suitable.

BUILDING 212

Description of farm

Lowland dairy farm of 84 acres in mid-Leicestershire: tenant farmer with mixed Friesian and Ayrshire attested herd.

Building type

New double-row cowhouse for 20, without feeding passage but with dairy. Feed-store existing.

I Construction

STRUCTURAL DETAILS

Pre-cast concrete M.A.F. frame, six inch concrete blocks and asbestos cement sheeting. Dairy abutting cowhouse, with block walls and flat reinforced concrete roof.

DESIGN AND ERECTION

Designed and erected by the firm manufacturing and supplying the concrete frame and blocks.

Building commenced and completed in 1956.

REASONS FOR ERECTION

The farm tenant wanted a larger cowhouse to enable him to milk more cows, and also a building of T.T. milk producers' standard.

TYPE OF ACCOMMODATION REPLACED

Single-row cowhouse for six, in poor state of repair: now used as calf-box.

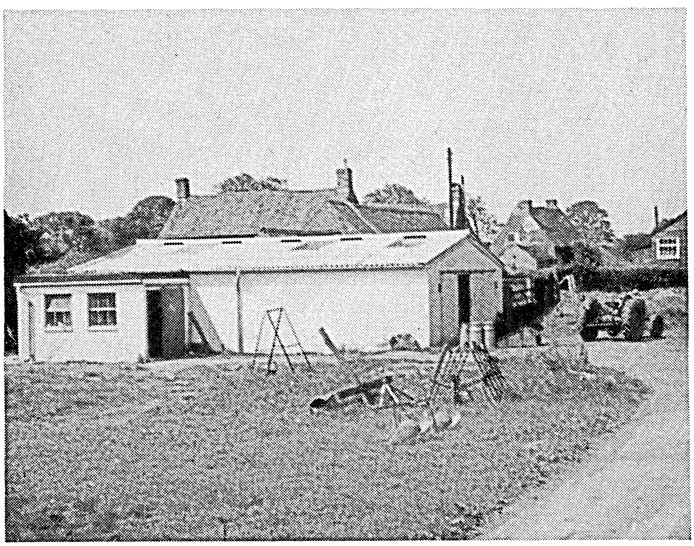

Plate 11: New cowhouse viewed from south-west.

BUILDING No. 212

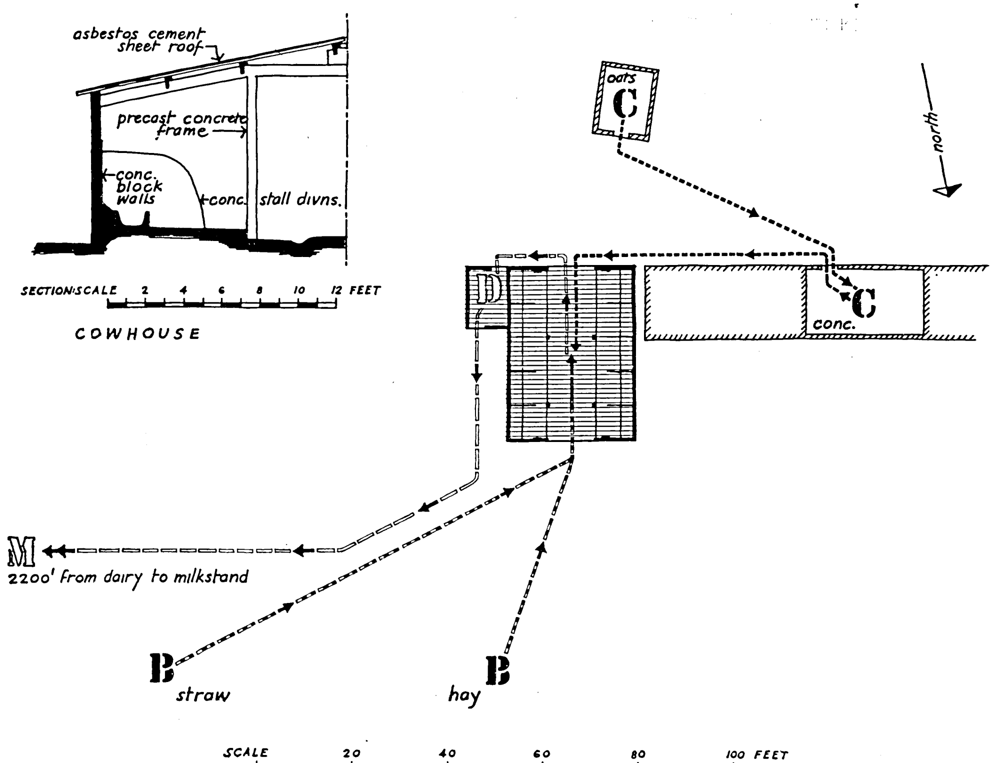

Figure 2: Plan of farmstead layout showing feed and milk routes.
BUILDING No. 212

Cost of Erection

Normalised cost: £62 per cow.
Adjusted cost (i.e. cowhouse only): £53 per cow.
Adjusted standard cost: £51 per cow.
Index of Building Value: 0.82.

Estimated Maintenance Cost

Standard maintenance cost per annum: 6s. 7d. per cow.

General Comments on Construction and Costs

The cost per cow was below the average for cowhouses with a dairy but without a feeding passage or feed-store. The adjusted standard cost per cow was also well below average. This was a cheaply designed building erected at a figure which appeared to represent good value for money. Nevertheless, the low cost was partly due to the "austerity" of the design, e.g. the building lacked water bowls and electric lighting.

II Siting and Layout

The main features are shown in Figure 2.

LENGTHS OF FEED AND MILK ROUTES

	Average length of route (feet)
Bulk feeding stuffs and bedding straw	80
Concentrated feeding stuffs	110
Milk (to despatch point at dairy door)	51

"TRANSPORT EFFORT"

	Ton-miles per cow per annum
Bulk feeding stuffs and bedding straw	0.041
Concentrated feeding stuffs	0.023
Milk	0.035

GENERAL COMMENTS ON SITING AND LAYOUT

On this farm the arrangements for handling bulk feeding stuffs were much better than average. The feeding system was simple—hay was the only bulk feeding stuff—and the cowhouse was sited so that hay and straw could be stacked in close proximity. Milk handling arrangements were also good due to the erection of a new dairy adjoining the new cowhouse. The storage of concentrates in existing buildings was less convenient, but due to the relatively small quantities involved, their movement did not involve an unduly high "transport effort".

BUILDING 33

Description of farm

Upland dairy farm of 150 acres in North-west Derbyshire: owner-occupier with attested Ayrshire herd.

Plate 12: New cowhouse and dairy conversion, viewed from the east.
BUILDING No. 33

Building type

New double-row cowhouse for 56 with feeding passages. Dairy and feed-store converted from existing buildings.

I Construction

STRUCTURAL DETAILS

External walls of limestone, 18 inches thick; steel roof trusses and purlins; roof covering of asbestos cement sheeting.

DESIGN AND ERECTION

Designed by owner: erected by the owner mainly with the assistance of farm labour, but some skilled labour employed for roof construction. Building commenced and completed in 1954.

OWNER'S REASONS FOR ERECTION

To bring the whole milking herd together under one roof in order to save labour.

TYPE OF ACCOMMODATION REPLACED

Four separate single-row cowhouses with an overall capacity of 35 cows. These now used for housing young stock, after minor structural alterations.

COST OF ERECTION

Normalised cost: £27 per cow.
Adjusted standard cost: £43 per cow.
Index of Building Value: 1.59.

ESTIMATED MAINTENANCE COST

Standard maintenance cost per annum: 7s. 8d. per cow.

GENERAL COMMENTS ON CONSTRUCTION AND COSTS

The cost per cow was well below the average for cowhouses with feeding passage but without a dairy or feed-store. This was principally due to the employment of farm labour and, in one important respect, cheap building material. The building stone was "quarried" from a disused part of the farmhouse and, therefore, cost nothing, apart from the labour of demolition.

The adjusted standard cost per cow was also low, due to the choice of an extremely simple and straightforward building design.

This is an excellent example of what may be achieved by the really competent farmer-builder.

II Siting and Layout

The siting and layout of the new cowhouse in relation to the storage of feeding stuffs and handling of milk are shown in Figure 3.

LENGTHS OF FEED AND MILK ROUTES

	Average length of route (feet)
Bulk feeding stuffs	104
Concentrated feeding stuffs	72
Milk (to despatch point at dairy door)	104

"TRANSPORT EFFORT"

	Ton-miles per cow per annum
Bulk feeding stuffs	0.043
Concentrated feeding stuffs	0.026
Milk	0.093

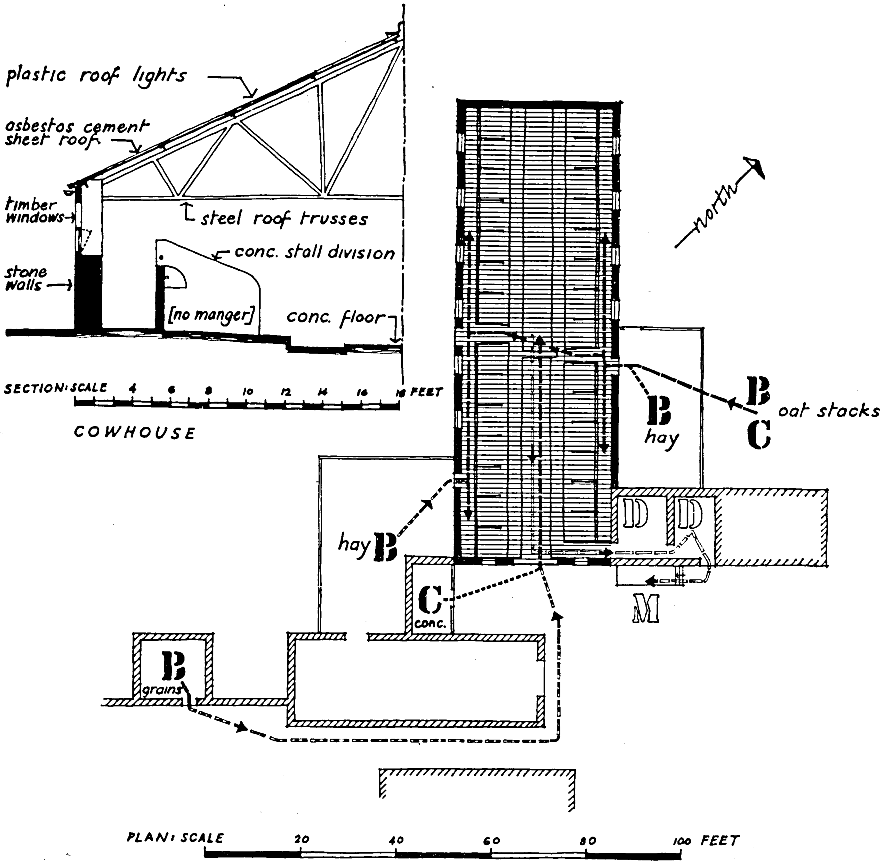

Figure 3: Plan of farmstead layout showing feed and milk routes.
BUILDING No. 33

General Comments on Siting and Layout

The arrangements for the handling of feeding stuffs consumed by the milking herd were considerably better than average, both in terms of the average length of feed route and the overall "transport effort", after taking account of the weights of materials handled. It is clear that much careful thought had been given to the siting of the cowhouse in relation to other buildings used in close association with it. The only apparent criticism is that the grain pit might with advantage have been sited nearer to the cowhouse: re-siting would not appear to be difficult, possibly in an existing building.

The milk handling arrangements, though not open to serious criticism, were no better than average. With such a large building as this, it is difficult to avoid a comparatively long journey between the centre of the cowhouse and the dairy.

It may be thought that double-doors at *both* ends of the cowhouse would have been advantageous, thus enabling vehicles to be driven straight through. However, this would not have been practicable with a building of the present size because the blind end is actually on the boundary of the neighbouring farm.

BUILDING 16

Description of farm

Lowland dairy farm of 162 acres in South-east Derbyshire: owner-occupier with attested Friesian herd.

Building type

New part-covered yard with estimated capacity of 65 cows. Parlour and feed-store converted from an old stable: dairy existing.

I Construction (yards only)

STRUCTURAL DETAILS

Yard cover consisting of steel portal framework with corrugated asbestos cement roof: closed at one end with corrugated steel sheeting and sheltered on one side by existing buildings. Covered area not concreted. Open area concreted and enclosed mainly with tubular steel fencing. Separate collecting yard. Portable feeding troughs.

DESIGN AND ERECTION

Designed by owner. Covered yard erected by contractor: external concreting and fencing by owner with farm labour.

Building commenced in Autumn 1955 and completed in Summer 1956.

REASONS FOR ERECTION

Old buildings were too dispersed. Owner wanted to streamline management of the dairy herd and save labour.

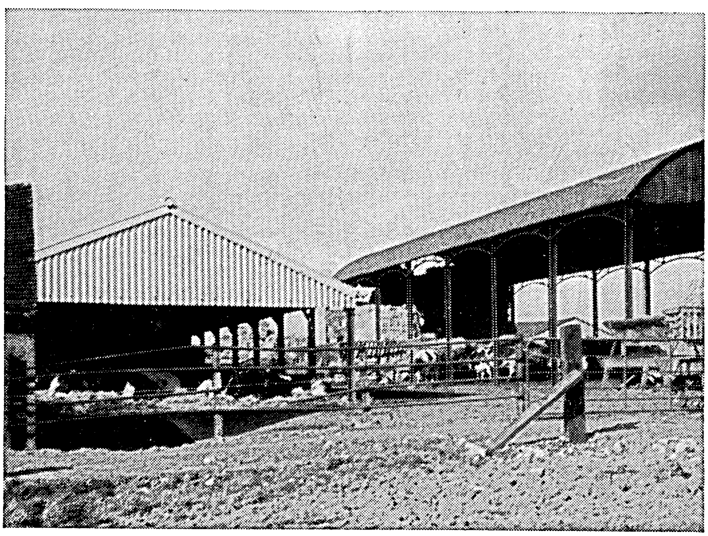

Plate 13: New part-covered yard adjacent to existing dutch barn, viewed from the south-west.

BUILDING No. 16

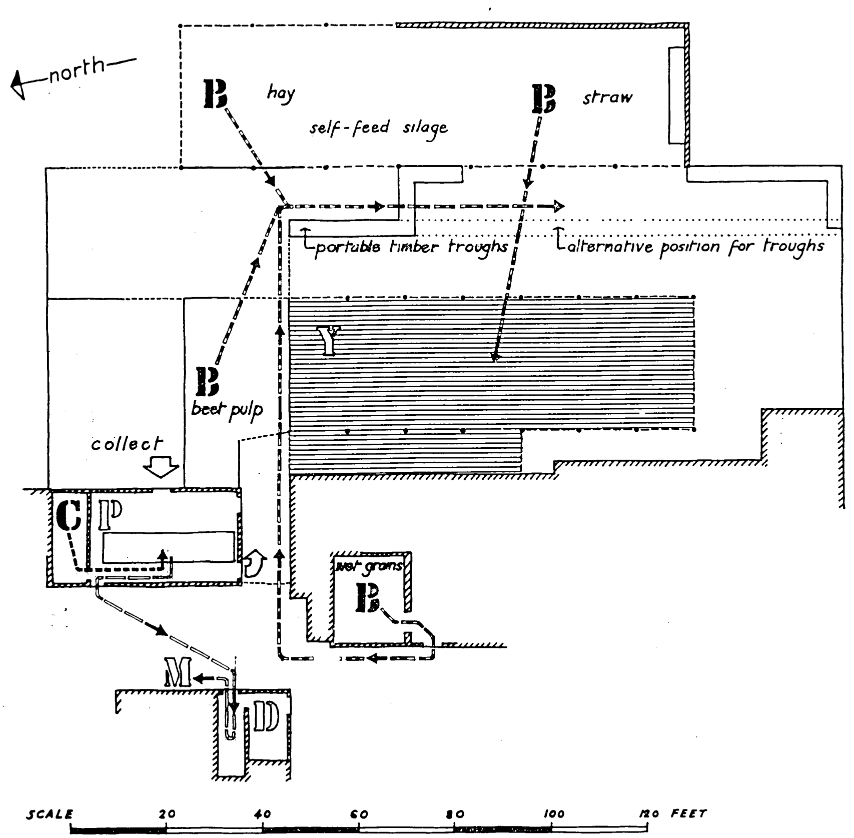

Figure 4: Farmstead layout showing feed and milk routes.

BUILDING No. 16

TYPE OF ACCOMMODATION REPLACED

Three single-row cowhouses with an overall capacity of 45 cows: now used for the housing of fattening bullocks and calves, without any major structural alterations.

COST OF ERECTION (excluding parlour conversion)

Normalised cost: 6s. 8d. per sq. ft. of *covered* yard area.

GENERAL COMMENTS ON CONSTRUCTION AND COSTS

The cost per sq. ft. of covered yard area was the lowest encountered during the survey. The yards were simply designed, with a minimum of permanent fittings, and the costs of side cover were largely eliminated by taking advantage of the protection afforded by existing buildings. The owner undoubtedly saved money by doing much of the work with farm labour.

II Siting and Layout

The main features are shown in Figure 4.

LENGTHS OF FEED AND MILK ROUTES

	Average length of route (feet)
Bulk feeding stuffs and bedding straw	26
Concentrated feeding stuffs	25
Milk (to despatch point at dairy door)	81

"TRANSPORT EFFORT"

	Ton-miles per cow per annum
Bulk feeding stuffs and bedding straw	0.040
Concentrated feeding stuffs	0.006
Milk	0.062

GENERAL COMMENTS ON SITING AND LAYOUT

On this farm, silage was the principal bulk feeding stuff, and this was mainly self-fed in the dutch barn adjacent to the east side of the yards. Consequently, the average length of transport route for bulk feeding stuffs and bedding straw was very low. Moreover, although the weight of self-fed silage consumed by the cows was high (nearly six tons per head) since feeding it involved no extra transport effort, the ton-mileage per cow of bulk feeding stuffs and bedding straw was also low.

The arrangements for handling concentrates were unusually convenient, even for farms with milking parlours. The arrangements for handling milk were not so convenient due to the continued usage of the original dairy in a detached building some distance from the parlour. Indeed, communication between the parlour and the dairy appeared to be awkward. The most direct route via the dispersal yard was not used because this involved opening and closing a gate and the risk of collision with cows leaving the parlour. The alternative route (the one actually used) via the door at the north-west corner of the parlour was awkward due to the narrowness of the passage between the last milking stall and the wall of the feed-store.

A second criticism of this layout is that, on leaving the parlour, the cows re-entered the yard via the door leading into the *covered* yard and thus had to track across the strawed area to reach the silage on the opposite side of the *open* yard. Such an arrangement is to be avoided on any farm where maximum economy in the use of bedding straw (and labour for spreading it) is desired. However, this is not a very serious criticism of the building layout on this farm since it would have been easy to slightly re-arrange the gates so that the cows returning from the parlour entered directly into the open yard.

BUILDING 222

Description of farm

Lowland farm of 115 acres in mid-Lincolnshire: owner-occupier with attested Friesian herd.

Building type

Complete new yard and parlour unit with estimated capacity of 29 cows.

I Construction

STRUCTURAL DETAILS

Covered yard: nine inch brick walls carrying steel roof trusses and purlins; corrugated asbestos cement roof; floor not concreted.

Open yard: enclosed by nine inch brick wall and with concrete bottom. Separate collecting and dispersal yards.

Construction of parlour, dairy and feed-store block resembles that of covered yard.

DESIGN AND ERECTION

Designed by the Milk Production Officer. Erected by local building contractor.

Building commenced in 1950 and completed in 1951.

OWNER'S REASONS FOR ERECTION

To anticipate more stringent enforcement of regulations concerning buildings used by milk producers.

TYPE OF ACCOMMODATION REPLACED

Two very small cowhouses with an overall capacity of eight cows: now incorporated with a crew yard for the housing of young stock.

COST OF ERECTION

Normalised cost: £73 per cow, or 17s. 11d. per sq. ft. of total *covered* area.

GENERAL COMMENTS ON CONSTRUCTION AND COSTS

The cost per cow and per sq. ft. of covered area correspond closely with the synthetically determined costs for this type of building (see Chapter 5).

This is a good example of a completely new yard and parlour unit costing no more to build than a conventional cowhouse, of average cost, with the same general facilities.

II Siting and Layout

The main features are shown in Figure 5.

LENGTHS OF FEED AND MILK ROUTES

	Average length of route (feet)
Bulk feeding stuffs and bedding straw	77
Concentrated feeding stuffs	24
Milk (to despatch point at dairy door)	30

"TRANSPORT EFFORT"

	Ton-miles per cow per annum
Bulk feeding stuffs and bedding straw	0.052
Concentrated feeding stuffs	0.005
Milk	0.029

Plate 14: New yard and parlour unit, viewed from the east.

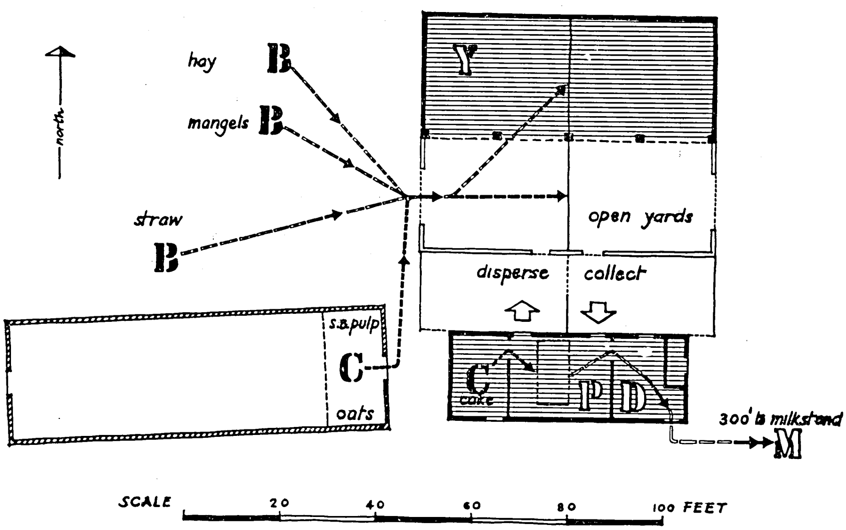

Figure 5: Farmstead layout showing feed and milk routes.

BUILDING No. 222

General Comments on Siting and Layout

The feeding system on this farm was quite conventional, the principal bulk feeds being hay and mangolds. On the other hand, transport effort was minimised by storing these bulky materials very close to the yards where they were fed.

The arrangements for handling concentrated feeding stuffs and milk were also very convenient, due to the compact planning of the "parlour block".

The main criticism is that the cows could not be fed from outside the yard. One solution would have been to have a "feeding fence" along the south side of the open yard. This type of arrangement was observed on a number of other farms (see Plate 15).

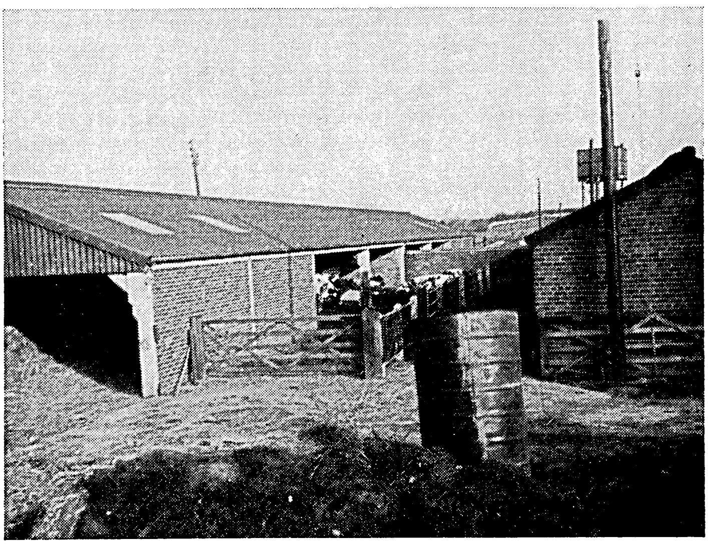

Plate 15: Wherever practicable, cows should be fed from *outside* the yard.

CHAPTER 10

SUMMARY AND CONCLUSIONS

A RAPIDLY changing agriculture has rendered much of the capital invested in farms by earlier generations obsolete, and many farm owners are aware that new investment on a considerable scale is needed to enable the industry to maintain its competitive position. If new capital were plentiful and cheap, re-equipment would present no serious economic problem. Farms could be equipped with new buildings, roads, fences and drains, and water or electricity supplies could be extended or improved, with but scant regard to the costs involved. But, for most farm-owners, this Utopian situation is far removed from reality. New capital is scarce and expensive and, therefore, needs careful "rationing" between numerous possible outlets. In order that the maximum overall return on capital may be secured, every project requires careful scrutiny at the planning stage, so as to avoid wasteful expenditure and unnecessary curtailment of the funds available for other purposes.

Thus, unlike most of the literature on farm buildings which is primarily technical, in this study the emphasis has been placed on costs. More particularly, the aim has been to assess the extent to which the capital costs of similar buildings erected on different farms varied and to pin-point the more important reasons for these variations.

Three broad groups of factors were examined for their effects on the cost of housing dairy cows: firstly, planning and design decisions, secondly, the choice of building method, and thirdly, detailed aspects of building contract procedure.

Broadly speaking, planning and design decisions concern the type of building to be erected, its size, its general layout and its detailed design including the specification of materials to be used in its construction.

The survey embraced two clearly distinguishable building types—the traditional cowhouse and the more recently introduced combination of yards with a milking parlour. Although the comparison of costs between these two types of building was not exhaustive, it was tentatively concluded that, provided the same basic functional requirements are met in each case, and the building itself is of the same quality, there is little to choose between them on grounds of capital cost per cow. This only applies, of course, to entirely new buildings. Where the renovation or adaptation of existing buildings is a feasible proposition, the comparison of costs between the two systems of housing will be on an entirely different basis: on some farms capital expenditure will be minimised by retaining the cowhouse whereas, on others, a yard and parlour will be the cheaper solution. No general rule can be given.

It is obvious that the cost of any building will be partially dependent on its size. Much greater interest attaches to the possibility that a relationship exists between overall building size and the unit cost of a given amount of building space, for theoretical principles suggest that the erection of large buildings might afford considerable scope for "economies of scale." However, detailed analysis of the survey data failed to show any statistically significant difference in average cost per cow between cowhouses with different numbers of standings. This result does not preclude the possibility that the erection of large buildings may in fact afford some scope for such economies: it merely suggests that any cost advantage so secured is insufficiently large to be a dominant factor.

A similar result emerged from the comparison of costs between cowhouses with only a single row and those with a double row of standings. No significant difference in average cost per cow was found between buildings in these two categories—a not unexpected result in view of the close association between plan-form and size of building. The majority of small cowhouses were of the single-row type, whilst the large buildings were all of the double-row type.

On the other hand, it was established that a new cowhouse complete with feeding passage, dairy and concentrate store is likely to cost at least half as much again as the simplest type of building without these extra facilities.

The results of an examination of the relationship between the actual costs and the "standard costs" of a sample of 28 cowhouses indicated the importance of detailed design decisions, such as the specification of building materials, in explaining the wide range in actual costs per cow. In fact, approximately 80 per cent. of the variation in actual costs per cow appeared to be due to differences in building design.

The classification of standard costs by groups of building elements showed that, on average, nearly two fifths of the cost of a cowhouse are absorbed by "ground and site works" (foundations, floors and drainage) and a further quarter by the "sub-structure" (walls, windows and doors). By comparison, the costs of "services" and "finishes and fittings" are much less important. This analysis revealed the parts of the building where careful design is especially necessary to ensure the avoidance of unnecessarily high costs.

Further analysis of the standard costs of cowhouses provided evidence that some parts of the building are subject to a much greater degree of cost variation than others. For example, on average, the standard costs of the substructure were twice as variable as the standard costs of finishes and fittings. The individual building elements and groups of elements showing a relatively high degree of standard cost variation are those which might afford the cost-conscious building designer the greatest scope for saving money.

The costs of farm buildings are also affected by the choice of building method. Analysis of the comparative costs of cowhouses erected by their owners and those erected by building contractors suggested that, provided they have the necessary knowledge of building techniques, farm-owners can make worthwhile, though not spectacular, savings by putting up their own buildings.

Examination of the replies given by farm-owners responding to the questionnaire on contract procedure suggested that where the decision to employ a building contractor is made, the choice of firm to carry out the work is largely dictated by custom and habit. In fact, the choice is rarely so restricted as the procedure followed by the majority of owners might suggest, and a number of factors which ought to be taken into account when exercising this choice are discussed in the report. In particular, farm building contracts should normally be put out for competitive tendering by at least two or three builders: at present, this procedure is clearly the exception rather than the rule.

The need for competitive bidding is underlined by the fact that different builders are likely to quote or charge different prices for the same or closely similar jobs. This assertion is backed by evidence of two kinds. In the first place, an examination of the relationship between the actual costs and the standard costs of cowhouses showed that up to 20 per cent. of the overall variation in costs per cow might be attributed to variations in builders' prices. In the second place, details were obtained of the quotations received for 31 cowhouses and yard and parlour schemes put out for competitive tendering. Differences between the lowest and the next lowest tender ranged in magnitude from less than one to nearly 80 per cent of the lowest quotation.

The replies to the questionnaire on contract procedure also revealed two other important factors; firstly, it became apparent that builders were frequently given only very imprecise instructions regarding the owner's building requirements, to guide them in preparing their estimates. Quite frequently, these instructions were given only by word of mouth. Secondly, a surprisingly high proportion of owners did not think it necessary to enter into a written agreement with their builders.

The hypothesis that the form of contract procedure might influence the ultimate cost of buildings was examined with respect to the erection of cowhouses. The conclusion reached was that the adoption of a procedure involving competitive tendering on the basis of a written specification of the owner's requirements and a legal agreement with the successful firm, need not *necessarily* result in any significant addition to building cost. Farm-owners will therefore be well advised to negotiate with builders in a businesslike manner, for this is the only way in which they can be sure of getting the kind of building they want at the lowest possible price.

During the preliminary survey of cowhouses and yards and parlours, a large number of defects in building design or planning were remarked upon by farm-owners or occupiers. In many instances, the cause of the complaint could probably have been avoided at little or no extra cost, had owners made greater use of existing sources of information and advice on farm building design. All too frequently, they were apparently unaware that such information and advice was available. For this reason, the report includes a list of the principal sources from which guidance can be obtained.

Except on some of the larger estates, where the permanent services of a land agent or architect are retained, very few farm owners seek the advice of professional building designers on a fee-paying basis. Although a minority of owners replying to the Contract and Farm Buildings Association Questionnaires intimated that they would be prepared to pay the usual fees for really competent advice, the majority clearly regarded this as an unnecessary expense.

It is unlikely that specialist building designers will be widely employed in the industry unless two conditions are satisfied. Firstly, more farm-owners must be made aware of the type of service offered by the professional designer, and how he can be found. Secondly, many more farm-owners must be convinced of the value of such a service in terms of hard cash. This report goes some way towards satisfying the first condition: the second condition can only be satisfied by those actually practising in the profession—"by their fruits ye shall know them."

The use-value of a farm building depends upon its earning power or ability to augment farm profits. Siting and external layout affect the use-value of new buildings, because good siting simplifies and cheapens the transport operations which are performed in and around them. On 45 farms, with either a new cowhouse or yard and parlour buildings, a measured survey was made of the farmstead layout, including particulars of the routes followed and weights carried in the transport of feeding stuffs and milk. The results indicated that transport effort could have been substantially reduced on many farms if provision had been made for the storage of hay, roots, silage and other bulky feeding stuffs nearer to the point of consumption in cowhouse or yard. It is a significant fact that, as a rule, farms with yards and parlours were no better in this respect than those with cowhouses.

Feed and milk route distances varied widely as between farms, with the same system of housing, feeding broadly the same kinds and quantities of feeding stuffs, and producing similar quantities of milk. There was considerable farm-to-farm variation in the total weights of feeding stuffs and milk handled per cow. But feed and milk *route distances* were much *more* variable, and were mainly responsible for the wide inter-farm differences in transport effort (measured in terms of annual ton-mileage per cow). The use-value of many of the cowhouses and yards and parlours surveyed would have been enhanced had they been more conveniently sited within the farmstead as a whole. In some instances, this could have been achieved at little or no extra cost.

A more comprehensive measure of use-value was given by the estimated annual rate of gross return on new building investment. Although, on average, this was sufficiently high to suggest that most of the surveyed buildings were at least paying their way, the amount of variation around the average was very large. Three factors appeared likely to have a particularly important bearing on the rate of return on new building capital realised on different farms. High rates of gross return on new building investment were seen to be associated with a high milk yield, relatively full utilisation of new building capacity and low building cost per cow. Low rates of return were associated with a low milk yield, low utilisation of building capacity and high building cost per cow.

Amongst the farms where new cowhouses and yards and parlours were surveyed in detail, there were wide variations in the degree to which the new buildings were actually being utilised and, on average, the estimated loss of potential gross income from milk production due to under-utilisation was substantial. In the short run, the occurrence of surplus building capacity can be explained and perhaps justified: in the long run, however, the locking up of capital in unused building space is liable to prove very costly. There would appear to be a need for the greater development of farm buildings which can be more easily adapted for alternative uses and also for cheaper and quicker methods of extending existing structures.

No association whatever was found between milk yields and differing levels of building expenditure per cow, and there is little or no evidence from other sources that milk yields are appreciably affected by building environment under ordinary farm conditions. Therefore, on these grounds alone, there is much to be said for housing dairy cows as cheaply as possible. This conclusion is reinforced by a consideration of building depreciation and maintenance costs.

An objective assessment of the maintenance requirements of the cowhouses included in the detailed survey showed that only exceptionally would the annual costs of maintenance be likely to exceed 1 per cent. of the original building cost. The costs of building depreciation may be largely ascribed to obsolescence and, for the purposes of this enquiry, the economic life of the buildings was arbitrarily fixed at 25 years. In view of the present rapid rate of technological change in the farming industry, it would be bold to predict any longer useful life for specialised buildings like cowhouses or yards and parlours. For buildings of this type, therefore, the annual cost of depreciation is, on average, likely to be at least four times as great as the annual cost of maintenance. Hence, additional capital expenditure on a building at the time of erection, in order to avoid some part of the subsequent expenditure on maintenance, is likely to be a losing economic proposition. The greater the uncertainty about the future, the more compelling the logic of this conclusion becomes.

The report ends with a number of case studies giving detailed descriptions of new cowhouses and yard and parlour units included in the survey. These are put forward not as "model buildings," but as examples of sound and sensible investment in dairy cow accommodation on ordinary commercial farms.

APPENDIX 1

THE PRELIMINARY SURVEY SAMPLE

(a) COWHOUSES

On the basis of information supplied by Rural District Councils, it was originally estimated that the " population " of new cowhouses erected in the East Midlands[1] during the years 1951 to 1955 inclusive was 342. These buildings were distributed amongst seven different size groups as follows:

No. of Standings	No. of Cowhouses
1 to 4	14
5 to 9	66
10 to 14	85
15 to 19	43
20 to 29	73
30 to 39	35
40 and over	26
All sizes	342

It appeared that a survey of all new cowhouses with 10 to 14 standings, 20 to 29 standings, and 40 or more standings would give an adequate representation of " small," " medium," and " large " buildings, and furthermore, would cover over 50 per cent. of all the new cowhouses built in the area during the period.

The local authorities who approved the plans for new cowhouses, did not always know whether the buildings had actually been erected. Hence the next step was to seek confirmation of erection from County Milk Production Officers who, at the same time, were asked to give addresses of any further farms, where, to their knowledge, new cowhouses falling within the three selected size groups had been erected since 1950.

As a result of this procedure a list of 219 buildings was drawn up for survey, and a further 10 addresses were added to the list during the course of the survey itself. Preliminary enquiries were, therefore, made about new cowhouses on 229 farms.

The number of cowhouses actually surveyed was 213 : the remaining 16 were not surveyed for the following reasons:

	No. of cases
(a) Owner not willing to co-operate	2
(b) Building not new, only reconstructed	5
(c) Size of building outside selected groups	3
(d) Not actually built	2
(e) Address could not be traced	2
(f) Building completed before 1951	1
(g) Landlord's questionnaire not completed	1

1 Comprising the counties of Leicester, Rutland, Derby, Nottingham and the Lindsey and Kesteven Divisions of Lincolnshire.

The initial information regarding the size of cowhouses, obtained from local authority plans and other sources, sometimes proved to be wrong. Hence the preliminary survey included a number of buildings falling outside the specified size ranges. Excluding these, the total number of cowhouses included in the preliminary survey was 187.

(b) YARDS AND PARLOURS

The information supplied by Rural District Councils brought to light only 27 yard and parlour schemes carried out in the area between 1951 and 1955. A further 28 addresses were subsequently obtained from Milk Production Officers and other sources, some of them relating to buildings of this type erected since 1955. Thus, in all, 55 yard and parlour schemes appeared to be available for survey. The number actually surveyed was 51. Of the remaining four, two belonged to owners who declined to co-operate, and two buildings proved, on inspection, to be outside the scope of the enquiry.

APPENDIX 3A

VENTILATION, THERMAL INSULATION AND CONDENSATION

Ventilation, thermal insulation, and condensation are related. Buildings are ventilated to introduce fresh air, expel used air and so control temperature and humidity. Thermal insulating materials are provided to prevent loss of heat through the structure. Condensation, which is the deposition of water vapour contained in the air, is the result of inadequate ventilation and/or insufficient thermal insulation.

In the preliminary survey of 187 cowsheds, more than 40 per cent. of farmers remarked upon the incidence of condensation or inadequacy of ventilation in their buildings. Farmers' opinions on what constitutes an acceptable level of condensation are varied and the proportion of buildings where there exists some degree of semi-permanent condensation is probably in the region of at least 80 per cent. Of 49 cowsheds subjected to a detailed survey, it was apparent (from actual condensation, or, in the summer, from stains upon roof, purlins, walls, etc.) that fairly heavy condensation occurred in 40 of these buildings. The signs were not nearly so marked in covered yards but, where milking equipment was sterilised by steam, it was noticeable in parlours, particularly if ridge ventilation had not been provided.

It is not surprising that condensation should occur in such a high proportion of buildings, for the almost universal practice of roofing with a single sheet thickness of corrugated asbestos cement offers little possibility of anything else happening.

A 1,200 lbs. cow exhales 22 lbs. of water vapour daily[1] and sheet asbestos cement has a high rate of thermal conductivity. Therefore, when the air in the cowshed meets the roof surface it will suffer a sudden drop in temperature and release the water vapour with which it is charged. Inadequate ventilation assists the process : where air within the building is changed infrequently air temperature (and moisture retaining capacity) remains high.

The visible effects of inadequate ventilation and of condensation are these : during winter the building is likely to be filled with a mist, which can at times be extremely dense; the underside of the roof sheeting will be wet, and moisture will run down the roof slope, dripping onto the cows or floor from purlins. Bedding straw and food will be dampened by the wet atmosphere, mangers may collect moisture which has run down the walls, and surfaces of walls become slimy. Steel roof members will rust, brickwork may be corroded by the condensation, and electrical installations can become dangerous.

1 DAVIES, C. N. *The Prediction of Condensation in Farm Buildings.* The Farm Buildings Association Journal. No. 2, 1958.

It is not known to what extent these conditions can affect the health or output of the stock, but it is of sufficient importance that workers at the University of Durham have been engaged upon the problem for over two years. The investigation was started because condensation had apparently resulted in a number of serious cases in the North East where the health of cattle had suffered.[2]

There is unlikely to be any insuperable difficulty in eliminating condensation. The scientific problems of ventilation and condensation generally are known and well documented. The decision is largely an economic one—" Is it worth while paying the extra cost of insulation and/or mechanical ventilation ? " This is a question on which, so far, farmers have had no guidance, but there is a suggestion that the Durham workers may come down on the side of providing insulation.[3] Without guidance, the great majority of farmers in the East Midlands had decided to do without. Of 187 cowsheds, only three had insulated roofs. Two of these were sandwich constructions of asbestos cement sheets with glass wool between (theoretical "U" value=0.18) and the third roof had been underdrawn with fibre-board (without a vapour barrier) by the farm tenant. These buildings were not seen in the worst winter conditions, but in all three cases the farmer was positive that condensation was completely absent.

Assuming that it can be economically justified, it seems fairly plain that the manner in which existing bad conditions should be remedied is, first, to improve the thermal insulation of the roof above the present normal "U" value of 1.40 for unlined sheets. This can be done in the case of existing buildings either by fixing to the underside of the roof an insulating material which is impervious to moisture (otherwise a vapour barrier is necessary) or by the fairly new technique of applying insulating quilt and additional asbestos cement sheet *over* the existing roof. Assuming 9″ brick walls exist, it is unlikely that any equally substantial gains in insulating quality can be obtained for the walls. For new work, where the roof will be insulated, there is every advantage in constructing cavity walls.

No examples of forced ventilation were seen during the detailed survey, and all published recommendations upon the ventilation of cowhouses are based on natural ventilation and seemingly arbitrary requirements of volume, and air inlet and outlet areas. An interesting publication on natural ventilation is Building Research Station Digest No. 34—" The Principles of Natural Ventilation of Buildings" (published by H.M. Stationery Office) which provides formulae for calculating the rate of air flow through a building due to the two forces of wind and stack effect. A certain amount of data was collected during field surveys so that buildings could be compared one with another on this basis. However, it became apparent, as the surveys progressed, that in general, absence of good internal climatic conditions was likely to be due to more fundamental issues, such as the presence or absence of insulation,[4] than to the compara-

2 HAWKER, M. J. F. *Research into Condensation in Cowhouses*. The Farm Buildings Association Journal. No. 2, 1958.

3 Ibid.

4 Absence of insulation permits rising air to be cooled and thus, at least in part, cancels out the stack effect.

tively minor matters of height of inlets and outlets and their relative sizes. Accordingly, these comparisons were shelved in favour of issues which seemed more within the compass of the enquiry. It was possible, however, to make comparisons of air space per cow. The following recommended volumes of air space per cow have been published:

Source of Information	Recommended air space per cow (cubic feet)
Ministry of Agriculture, Fisheries and Food, (Fixed Equipment on the Farm, Leaflet No. 1)	500—600[5]
Department of Agriculture for Scotland, (Farm Buildings for Scotland, Post-War Building Studies, No. 22)	530—548
"New Ideas for Farm Buildings", Farmer and Stockbreeder Publications Ltd., 1947	550

Buildings surveyed were found to provide air space per cow varying from 316 cubic feet to 969 cubic feet. Average volume per cow for different sizes of building are shown in Table 21.

AVERAGE COWHOUSE VOLUMES PER COW

TABLE 21 Cubic feet

No. of standings	Single Row		Double Row	
	With feeding passage	Without feeding passage	With feeding passage	Without feeding passage
10—14	(8) 685	(7) 566	—	(3) 515
20—30	(2) 671	—	(6) 737	(5) 540
40 and over	—	—	(8) 781	(5) 635

Note: Numbers in brackets show number of buildings from which the averages were calculated.

Mechanical Ventilation

Information is required respecting the installation, depreciation and running costs of mechanical ventilation equipment and its effectiveness in practice.

5 Calculated from drawings.

APPENDIX 3B

DAYLIGHT

The results of the preliminary survey of 187 cowsheds showed that lighting defects (e.g. inadequate natural or artificial light; lights in wrong position; electric light equipment not waterproof) ranked seventh in frequency amongst types of defect remarked upon by farmers.

In general, it may be expected that a good electrical lighting installation will cost more than a poor one, although like most other aspects of building design, variations in standards of functional design and mechanical efficiency can be expected within the same price bracket. On the other hand, daylighting is more a matter of design than expenditure. Practically any livestock building will require the admission of light through some source — window or rooflight—and it is upon the placing of these sources, their light transmitting qualities and their cleanliness, that good daylighting standards will depend. Cost considerations are unlikely to be great —standard cost analysis showed that for cowsheds an average proportion of the total cost assigned to rooflights was about 2.5 per cent., and windows about 2.0 per cent.

Natural light will be required in all parts of a building, of course, but in a cowshed or parlour especially, good daylighting will be required wherever milk is handled and for such tasks as examination of the cow by farmer or veterinary surgeon. In addition, all walking surfaces must receive sufficient light to ensure safety.

At present there is very little guidance on lighting requirements in cowsheds and milking parlours. It has been stated that wall-lighting is less efficient than roof lighting and that about three square feet of roof light per cow is necessary in a single row house (rather more for double-row housing); if wall-lighting only is provided, at least four square feet of window area is needed for each cow.[1] Barre and Sammet also suggest four square feet per cow for windows.[2]

However, these are imprecise standards of measurement, and light provided on the basis of these recommendations can be affected by the shape and height of the building, the quality of the internal reflecting surfaces, and the size, position, shape and frequency of the windows or roof lights.

The accepted scientific method of determining the amount of natural light within buildings is by "Daylight Factor," which is the total of direct and reflected light at a point within a building expressed as a percentage of the total illumination outside the building. Usual assumptions have been that Daylight Factor is measured

1 Committee appointed by the Minister of Agriculture and Fisheries. *Farm Buildings.* Post-War Building Studies No. 17. H.M. Stationery Office (out of print).

2 BARRE, H. J., and SAMMET, L. L. *Farm Structures,* Chapman & Hall, 1950.

in a horizontal plane, that the whole sky is the source of light and is densely overcast, and that the degree of brightness is equal over the whole sky. "Sky Factor," that is, the total of the direct light before the additional effects of reflected light have been allowed, can be calculated from drawings with the aid of special protractors designed by the Building Research Station[3] and Sky Factor is converted to Daylight Factor by allowing for the effects of internally reflected light[4].

The daylight factor can be measured within existing buildings and a small portable meter can be obtained for this purpose.[5]

Recommended daylight factors for various positions in farm buildings have been published.[6] It is stated that these factors were prepared by the Building Research Station, but the recommendations were probably unofficial—the Building Research Station now can find no records of any direct collaboration on this subject.

In the course of detailed field surveys of cowhouses and parlours, daylight factors of the best and worst situations in each building were measured by meter[7] and are compared with the recommended values in the table below.

COMPARISON OF FIELD METER READINGS OF DAYLIGHT FACTOR WITH PUBLISHED RECOMMENDATIONS

TABLE 22

Position in Cowshed or Parlour	Recommended Daylight Factor	Best Position		Worst Position	
		Less than recommended value	Equal to or higher than recommended value	Less than recommended value	Equal to or higher than recommended value
		No. of readings			
Position of cow's udder	3.5*	31	19	47	3
Manger	2.5	16	6	21	1
Floor level of feeding passage	1.0	3	3	6	—

* The daylight factor of 3.5 can be compared with Barre and Sammet's recommendation of 15 foot candles, this being equivalent to a 3 per cent daylight factor from a "Standard Sky" with a brightness of 500 foot lamberts.

It will be seen that a large proportion of buildings had daylight factors below the recommended values and this accords with a general subjective impression that most buildings tended to be dimly lit and shadowed.

An area of roof light will admit much more light than an equal area of window, though a window may have a subsidiary function as a ventilator. It will not be possible to avoid the admission of some sunlight, because the roof pitches normal to modern farm buildings (22°—25°) are not sufficiently steep to cast a shadow upon

3 Obtainable from H.M. Stationery Office.

4 *Building Research Station Digest No.* 80. H.M. Stationery Office. August 1955. Also, R. G. Hopkinson. *Calculation of the daylight factor.* Architects Journal. Vol. 120. No. 3107. 1954.

5 LONGMORE, J. and HOPKINSON, R. G. *A simple daylight factor meter,* Journal of Scientific Instruments. Vol. 31. June, 1954.

6 Association for Planning and Regional Reconstruction. *New Ideas for Farm Buildings.* Farmer and Stockbreeder Publications Ltd. 1947.

7 The instrument used was the "EEL" B.R.S. Daylight Factor Meter, obtained from Messrs. Evans Electroselenium Limited, Halstead, Essex.

themselves. However, it is inadvisable to place roof lights on a south-facing slope, and they should be positioned to concentrate light upon the hindquarters of the cow. This suggests that other things being equal a north-south orientation for the building is to be preferred. In most cases of low daylight intensities considerable improvements could have been made by better positioning of roof lights or by slightly increasing the number provided. But, in the majority of buildings, light could have been increased out of all proportion by good internal reflecting surfaces which more liberal use of white distemper would have provided.

To sum up, it can be said that among dairy farmers there is some dissatisfaction with present standards of lighting; there is little guidance as to what standards of daylighting should be, but the majority of buildings fall short of those recommendations which have been published. Provision of adequate light is more a matter of design knowledge and application than of expense, and the basic design knowledge is already available.[8]

8 See: Building Research Station Digest No. 80, op. cit.

APPENDIX 3C

(i) WORKMANSHIP

General

When this enquiry commenced there was an expectation, fostered perhaps by the farming press, that the number of buildings found to be erected by farmers would be relatively large proportionately to the whole. It was also believed that the quality of farm-built work would be greatly inferior to similar work by professional builders. Both these preconceptions were found to be untrue. There were fewer than one in ten buildings erected entirely by amateurs: although the worst building was probably perpetrated by farmers (and this is a fine distinction because some contract-buildings were very poor) their best work compared favourably with that of the better-than-average builder. The few buildings of really good finish were invariably the work of builders, supervised by architects. Equally invariably they cost more than other buildings of similar size. On the whole, the smaller buildings exhibited the worst standards, and this applied whether built by contractor or farmer.

Farmer-builders

The work of farmer-builders was at times impressive in its venturesomeness, particularly in the stone districts. When stone was used it was usually because the farmer had an existing "quarry" of material ready to hand in the form of redundant dry stone walls. One farmer, with a too large house, removed the roof and topmost storey, re-roofed the house and built the walls of a large cowshed with the salvaged material!

Workmanship, Design and Specification

Where buildings were designed by a professional advisor and built by a contractor, it should be a safe assumption that details of design and specification of materials were the responsibility of the designer. Workmanship is primarily the responsibility of operative and builder, only secondarily of the designer who supervises. In the many cases where the builder was also responsible for detailed design, the distinction between design and workmanship was not so clear. For example, should the omission of a rainwater pipe be called bad workmanship—or economy in design? Where two open ends of gutter (Plate 16) are allowed to drip into a rainwater head (and down the wall) is this the plumber's poor work or negligent design by his employer? When a brick-on-edge coping to a filter bed breaks up (Plate 17) is it bad design that common bricks were used—or due to the poor skill of the bricklayer who should have chosen more durable bricks for this position? The rendering shown in Plate 18 is breaking up on the wall, and, not surprisingly, the coving formed in the rendering at floor level is also showing deterioration. The plasterer should know that a cement and sand render, brought to a feather edge on top of a concrete slab in a wet position is unlikely to last. But should not the designer also know?

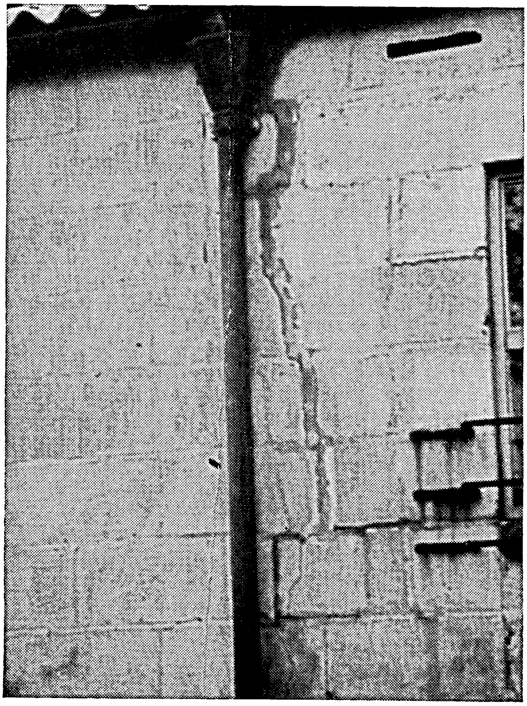

Plate 16: Escape of rainwater from gutter to wall.

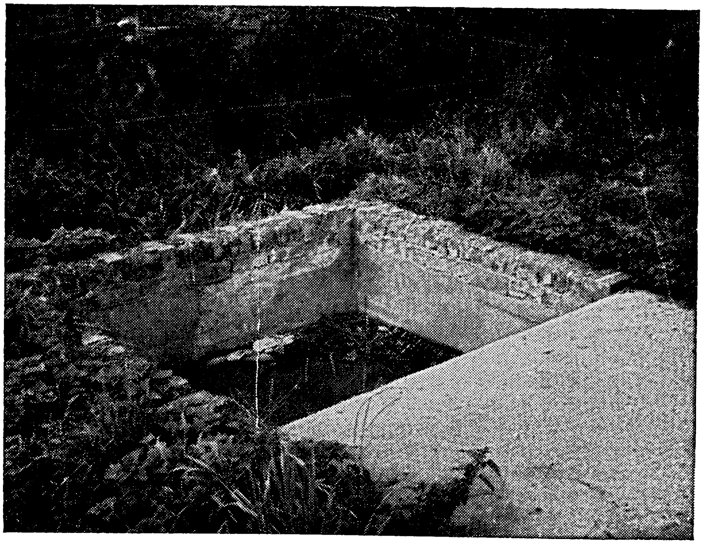

Plate 17: Disintegration of brick coping.

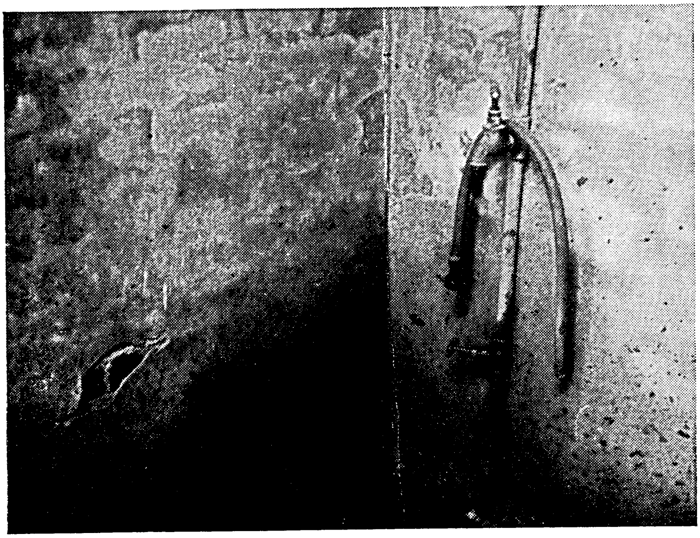

Plate 18: Defective cement rendering.

Examination of Workmanship During the Detailed Survey

During the detailed surveys quality of workmanship was assessed by two approximate comparisons:

(1) On a scale of five values (0=above average; 4=very poor workmanship) applying to the workmanship standards of the building as a whole[1].

(2) By brief check lists based whenever possible upon the recommendations of the appropriate British Standard Codes of Practice for building work.

The Cambridge Scale

Denman and Rathbone devised a scale in which the marking related to "the general efficiency of the workmanship"[2]. This scale was used in conjunction with photographic examples to attempt definition of the qualitative judgements involved. Since these were to a large extent subjective, some variation of interpretation by other users is to be expected. Table 23 shows the scale adopted for this study and the distribution, on this, of buildings subjected to a detailed survey.

1 This scale was based upon one devised by Denman and Rathbone of the University of Cambridge, Department of Estate Management, for use in a study of farmstead maintenance. The full report on this study has remained unpublished but parts of it have been incorporated in:
DENMAN, D. R., and ROBERTS, H. *Provision of Implement Accommodation.* Ministry of Agriculture, Fisheries and Food, Agricultural Land Service, Technical Report No. 5, and, RATHBONE, R. A. *Economic Criteria for Farm Building Construction.* Course of Summer Lectures, Cambridge University Estate Management Club. 1955.

2 DENMAN, D. R. and ROBERTS, H. op. cit.

DISTRIBUTION OF SURVEYED BUILDINGS ON THE CAMBRIDGE SCALE OF WORKMANSHIP

TABLE 23

Scale	Cambridge Definition	Definition adopted for this study	Cow-sheds	New Yards	New Parlours	Total	Per cent of Total
			No. of buildings				
0	Above average	First rate standard for any type of building	—	—	—	—	—
1	Good workmanship	Extremely good farm building standard	6	4	1	11	12
1.5		Farm building standard average plus	9	9	7	25	27
2	Fair workmanship	Farm building standard average	25	7	9	41	45
2.5		Farm building standard average minus	5	2	2	9	10
3	Unskilled workmanship	Unskilled and inadequate	4	—	2	6	6
4	Very poor workmanship	Very poor workmanship	—	—	—	—	—
Total number of buildings surveyed			49	22	21	92	100

The yards and parlour buildings in category 1 on the scale (extremely good farm building standard) were most frequently manufactured framed buildings whose standards were to a large extent imposed by factory quality control.

The Check Lists Based Upon Codes of Practice

This system of comparison provides an indication of the extent to which farm building constructional work follows published and authoritative recommendations. Codes of Practice are not yet published for all types of building work and some would describe those that have been published as counsels of perfection. To take them too seriously might be inappropriate: buildings to house dairy cattle are flexible in their functional requirements and modern building materials used on farms may not be so demanding of skilled workmanship as earlier materials. Nevertheless the use of a building may change; it may not matter overmuch if a little rain enters a cowshed roof—internal condensation is probably worse—but this condition might be more serious if, say, the building was used instead for grain storage. And it is reasonable to suppose that the workman who is particular in exercising the finesse of his trade will not skimp that work which is hidden and unseen. An example might be the bricklayer who punctiliously maintains the "perpends" of his vertical brick joints and whose bonding is regular and exact. Such a craftsman is unlikely to weaken or impair the weather resistance of his work by failing to completely flush the joints.

These were the principal conclusions to be derived from the check lists:

(i) FLOORS AND CONCRETE PAVINGS

Floors generally were of concrete, usually as left by the tamping board, but in cowsheds and parlours sometimes given a granolithic finish. Since concrete is such a basic farm building material it might be expected that standards would be high—but they are not. This is probably due more to contempt for "theoretical" methods, and ignorance of the advantages of exact methods of manufacture than to any desire to cheat on materials or labour—in fact, a case can be made for the advantages to a builder of concrete quality control, and to many large contractors scientific manufacture is now usual. Most farm builders, however, are small firms and the advances in building technology of the last few decades have yet to reach them. Meanwhile their clients must suffer, unless they take steps to ensure quality. Basically, good concrete requires suitable materials, accurate proportioning, adequate mixing, careful placing, thorough compaction and proper curing. Where one or more of these steps is not properly executed the resulting floor may fulfil most of its functions, but nevertheless suffer some unnecessary defect. In the building shown in Plate 19 (otherwise a rare example of quality in farm building concrete) falls to the drainage channel are inadequate. Plate 20 shows uneven wear of the surface—water is retained and brushing down made unnecessarily difficult. It should not be possible to break concrete surfaces with a boot heel, but "concrete" of this quality was sometimes seen.

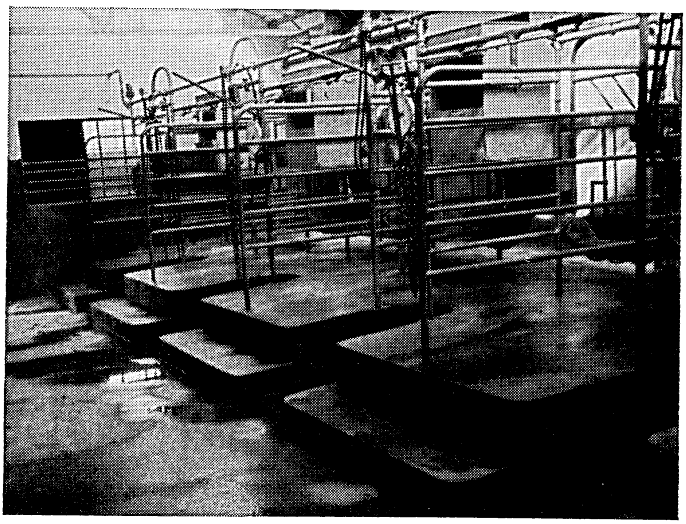

Plate 19: Inadequate falls to drainage channel, but otherwise an unusually good standard of finish to a concrete floor.

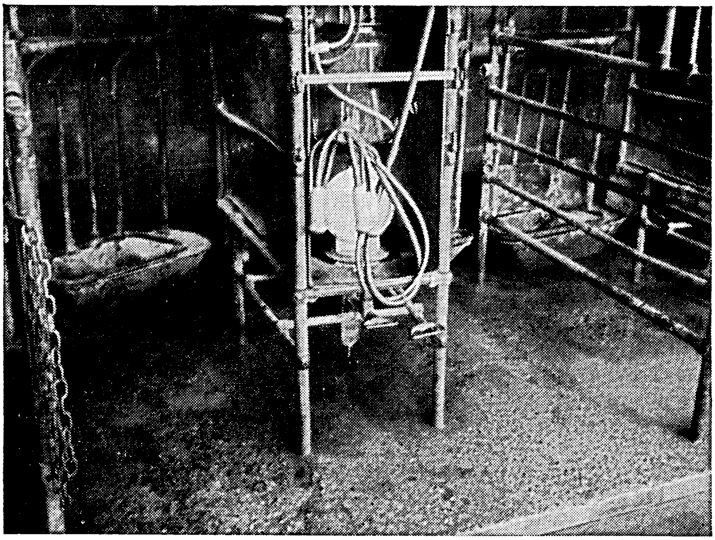

Plate 20: Uneven wear of floor surface.

Plate 21: Mortars are sometimes stronger than the bricks they join.

Plate 22: Poor quality mortar may shrink away from the brickwork . . .

Plate 23: . . . or crumble.

(ii) WALLS

Modern cement and sand mortars are usually as strong as or stronger than the bricks they join (Plate 21) and there is not the same need as in earlier days for accurate brickbonding. Knowingly or not, farm building bricklayers take full advantage of this fact, but irregular bonding is sometimes allied with poor quality mortars which may shrink away from the brickwork (Plate 22) or crumble (Plate 23), or merely be used sparingly (Plate 24). The quality of work to be seen in Plate 25 is very uncommon, yet here the common bricks have been exposed to rough handling at some stage. Plate 26 shows one of the better examples of block jointing.

(iii) ROOF FRAMING

Roof frame faults were generally " design " defects rather than defects of workmanship, apparent in purlins deflecting under load, crude scarf joints in purlins (Plate 27) and frames relying upon tosh-nailing for joints subject to tension stresses.

Plate 24: Joints should be thoroughly flushed up.

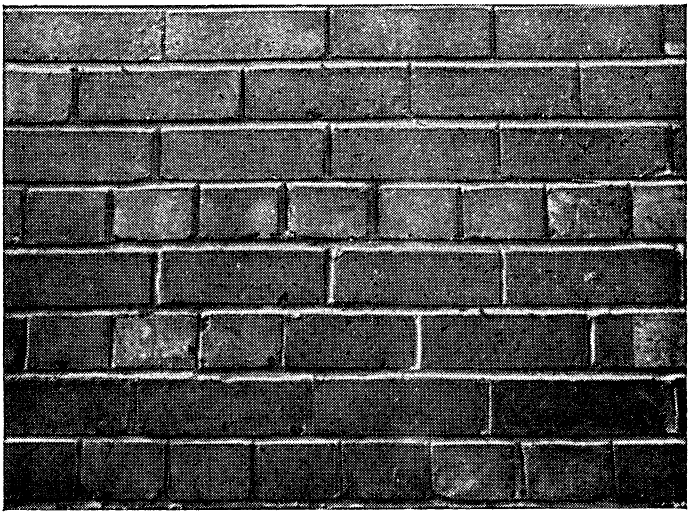

Plate 25: A better-than-average example of brickwork.

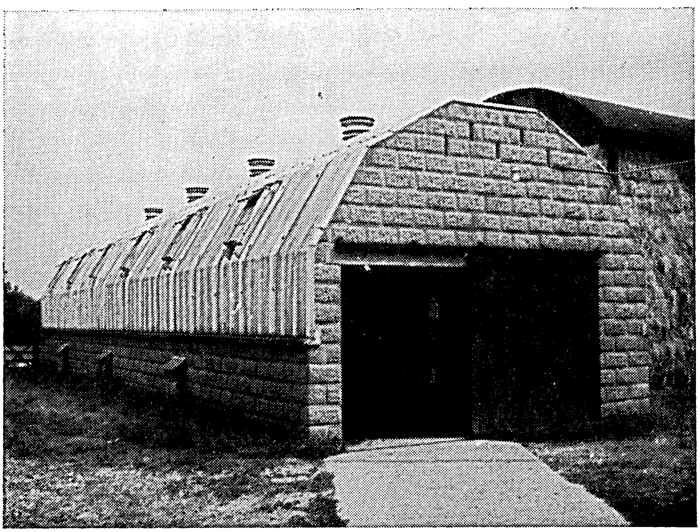

Plate 26: An example of good block jointing.

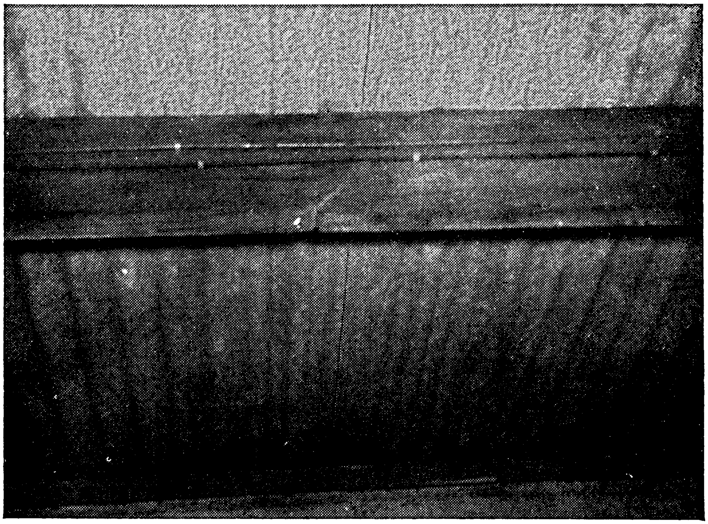

Plate 27: A crude scarf joint in a roof purlin.

(iv) ROOF SHEETING

Maximum purlin spacings of 4 ft. 6 in. for large and angular section and 3 ft. 0 in. for small section asbestos cement sheets were sometimes exceeded. More rarely, roof pitches lower than the usual accepted minimum of 22°—25° were adopted[3] (Plate 28). End-lap was often less than the required 6 in. and the minimum side-lap of one corrugation (large section) or two corrugations (small section) was sometimes not provided. Unskilled workmanship was apparent from crude mitreing (Plate 29) or a total absence of mitreing at the intersection of four sheets, sheeting nails driven on the skew through the sides of purlins, and the irregular line of the ends of sheets.

(v) RAINWATER GUTTERS AND DOWN PIPES

Codes of practice specify the required fixing for gutter brackets, the minimum being one at each joint and intermediately so that the distance between brackets is not greater than 4 ft. 0 in. At least one building in five failed to observe this requirement and to this can be attributed much of the inadequate functioning of gutters which was seen.

A commonly used type of fixing clip for rainwater pipes (Plate 30) relies upon one slender screw for the rigidity of the fixing. It rarely works.

3 The manufacturers advocate the roof pitches quoted. There may be a case for flatter slopes than these but *very* low pitches (e.g. 5°) permit water to enter through capillary action.

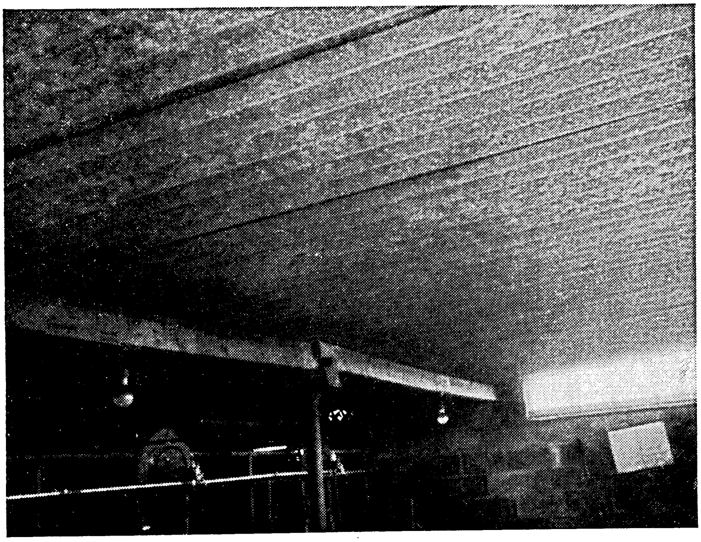

Plate 28: An example of too wide purlin spacing and too low a roof pitch.

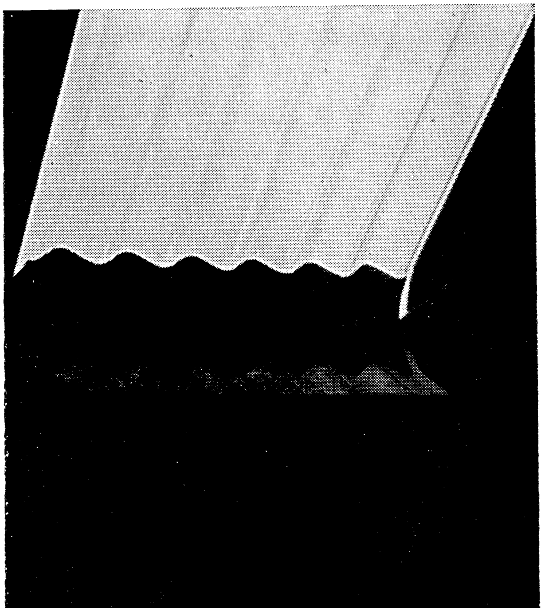

Plate 29: Crude mitreing at the intersection of roof sheets.

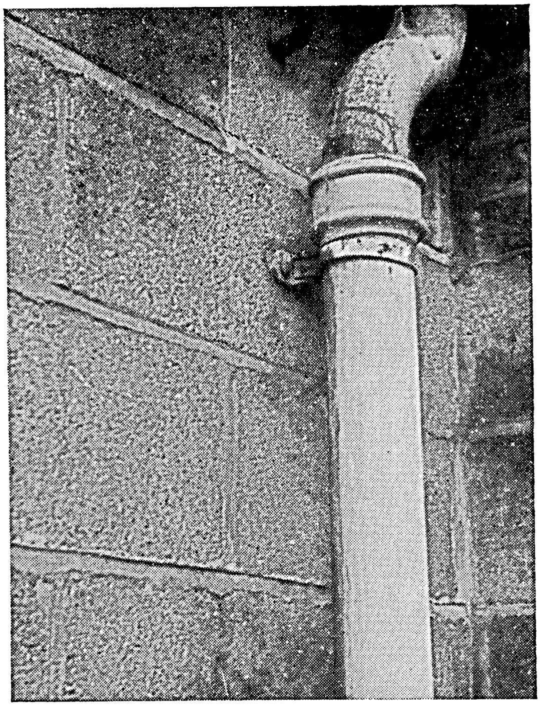

Plate 30: Fixing clips for rainwater pipes are often too insubstantial.

(vi) PAINTING

On the whole, painting probably demonstrated more failings of workmanship than any other trade. In half the cowsheds seen it was impossible to use a qualitative check list because so little paint remained (Plate 31). There are three basic considerations in the design of paint surfaces:

(i) that the surface is in a suitable condition,
(ii) that an appropriate paint is used, and
(iii) that an adequate number and thickness of paint coats are applied by craftsmen.[4]

When paintwork had deteriorated the reasons had to be deduced. Surfaces were often rough-sawn and only exceptionally rubbed smooth. Not uncommonly, only the priming coats had been painted by the building contractor and if further coats had been applied, these were by the farmer.

These considerations apply to the painting of doors and windows. It was very rare that paint was seen on steelwork. The works priming coat was the only paint applied to the vast majority of steel trusses and purlins.

4 MINISTRY OF WORKS. *The Painting of Buildings.* Post War Building Studies. No. 5. H.M. Stationery Office, (Revised 1946).

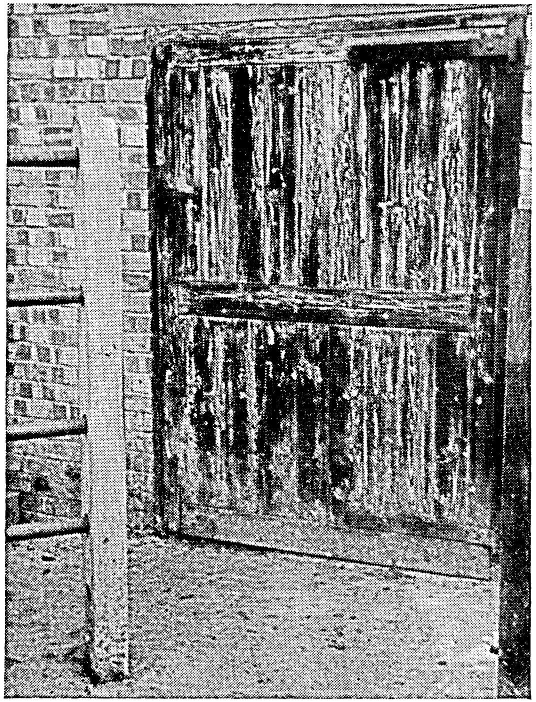

Plate 31: A typical example of the failure of paintwork.

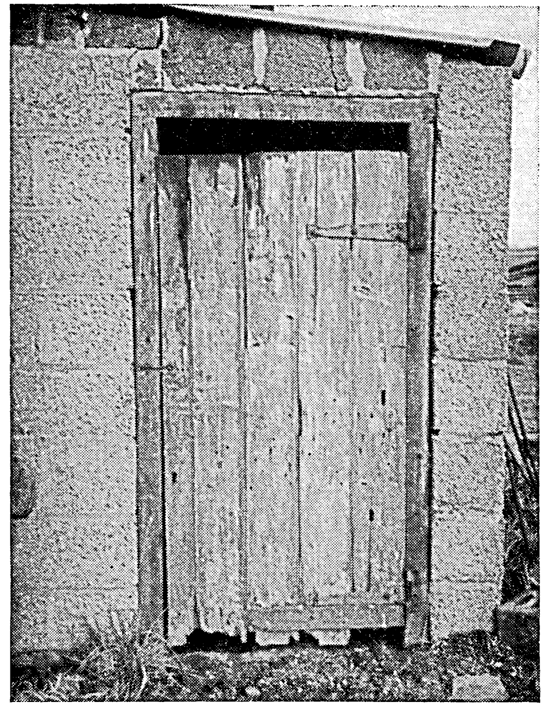

Plate 32: An example of sub-standard joinery.

(vii) JOINERY

There were wide variations in quality of joinery. Frequent criticism could be made of jointing and finish, and there were some cases of too-thin members which bowed. However, it was rare that joinery could not be considered at least functionally adequate for its purpose (Plate 32).

Conclusion

The quality of workmanship exhibited in farm building is distinctly lower than in other types of building work. The reasons for this may be that quality is not demanded by the building owner, a good standard being either unrecognised or considered unnecessary. Nevertheless, the durability of a building depends to some extent upon the quality of the workmanship, and this latter factor exercises considerable influence upon the ease with which a building may be kept clean. There is some evidence that a *very* high standard of finish results in higher costs, but there is no evidence to support a belief that the farmer who accepts poor workmanship thereby gets his building more cheaply. This seems to be sufficient justification to demand a better standard than is currently general.

(ii) DURABILITY

For the durability of buildings to be adequate for the purposes for which they are designed, the following factors should be taken into account[5]:

(i) Locality in which the building is situated.
(ii) Conditions to which it will be exposed.
(iii) Quality of workmanship.
(iv) Maintenance treatment to be given.
(v) Possible causes of deterioration of the component parts of the building.
(vi) Susceptibility to deterioration of the materials to be used.
(vii) Effect of design upon durability.

Examples of durability defects under each of the above headings, seen during the detailed field survey of 49 cowsheds and 29 yard and parlour schemes, are described below.

Locality

No analysis of the effects of location was made, but it appeared that those building defects seen were rarely the results of geography—buildings with many defects were found in similar numbers on the tops of Derbyshire hills and in low lying areas of Lincolnshire. Buildings with few defects and buildings with many defects were seen on the Midland "Sheltered Plain." This impression differs from that of Denman and Rathbone who were able, on the basis of a smaller sample of more varied structural types, to list Primary and Secondary defects and their order of prominence in five different types of geographical environment.[6]

5 THE COUNCIL FOR CODES OF PRACTICE FOR BUILDINGS. *Durability*. British Standard Code of Practice, C.P. 3—Chapter IX. 1950.

6 DENMAN, D. R., and ROBERTS, H., op. cit.

Conditions to which Buildings are Exposed

Briefly, the conditions to which the interiors of dairy cattle buildings are exposed are the sum of the effects of cattle (weight, dung, urine, milk, condensation, etc.) and of men and equipment (tractors, trailers, milk churns, wash-down hoses, brooms, sterilising equipment, etc.). The exteriors will be subject to the weather, usually with some degree of exposure. Denman and Rathbone rank exposure as one of the primary contributory causes of deterioration. Cattle often have access to the outside walls of buildings, which may additionally be subject to damage by the impact of vehicles or other equipment.

Quality of Workmanship

See Appendix 3C (i).

Maintenance Treatment

Maintenance, as described in the Code of Practice, includes application of paint and other protective coatings, renewal of putty and mastics, etc., replacement of worn units or parts, and repairs or replacements resulting from the wear and tear of normal use.

At the time of the preliminary survey, only about one third of all owners had made any repairs or carried out any maintenance tasks to their buildings, although some buildings by that time were at least eight years old. The average ages were $3\frac{3}{4}$ years (yards and parlours) and $4\frac{1}{2}$ years (cowsheds). When some maintenance had been done, it most usually consisted of painting work. Standards naturally varied—a few buildings might have been in better condition than when they were built, but most owners obviously looked upon maintenance as a necessary evil, to be performed only when essential—if then. Considerable reliance was placed upon the ability of materials to withstand neglect over long periods.

Possible Causes of Deterioration in Buildings

A number of causes of deterioration in buildings are listed in Appendix 1 of the Code of Practice[7]:

(a) ATMOSPHERIC AND CLIMATIC ACTION

There are several possible reasons for cracking of masonry, and it was often difficult to deduce the cause of those faults seen. One example (Plate 33) which occurred in a fairly long length of wall was probably due to thermal movement.

In respect of masonry pointing 20 per cent of the cowhouses inspected were classed on the Cambridge Scale[8] at a value of 2 ("Pointing fair but flaking in parts or showing localised efflorescence") or 3 ("Pointing up required"). In many cases it was obvious that the condition was due to poor workmanship or materials, but in a number of instances the farmer remarked that the pointing had been attacked by frost during construction. If this was true, the conclusion must be

7 THE COUNCIL FOR CODES OF PRACTICE FOR BUILDINGS. op. cit.

8 See pp. 114 and 115.

that the owner was fobbed off with work which any self-respecting builder would have rectified unasked. It is usual in written contracts for the builder to be responsible for protecting against frost damage. Nevertheless, in a few cases such damage was seen where a professional designer had been responsible for supervision.

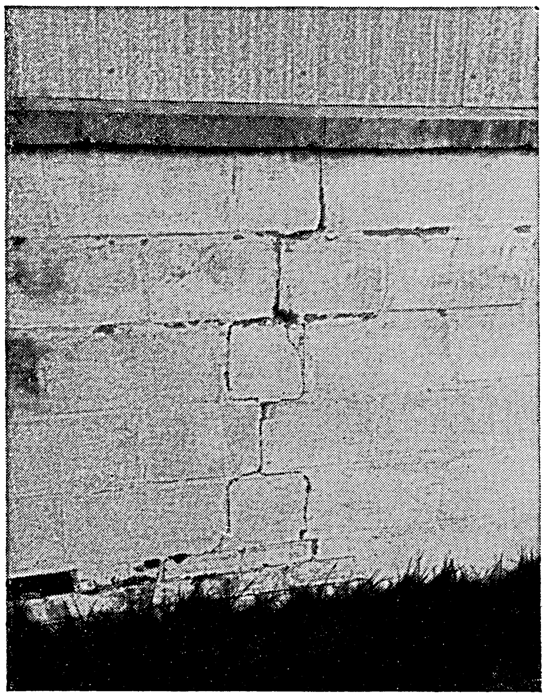

Plate 33: Cracking of masonry in a long length of wall—probably due to thermal movement.

Internal climate probably constitutes a more serious cause of deterioration than the sun, wind and rain outside. Condensation is certainly responsible for the high incidence of frame-rust and probably also for much disintegration of brickwork at eaves level (Plate 34).

According to their owners, the roofs of three of the new yards surveyed had at some time been blown off. Two of these buildings were sited in very exposed positions.

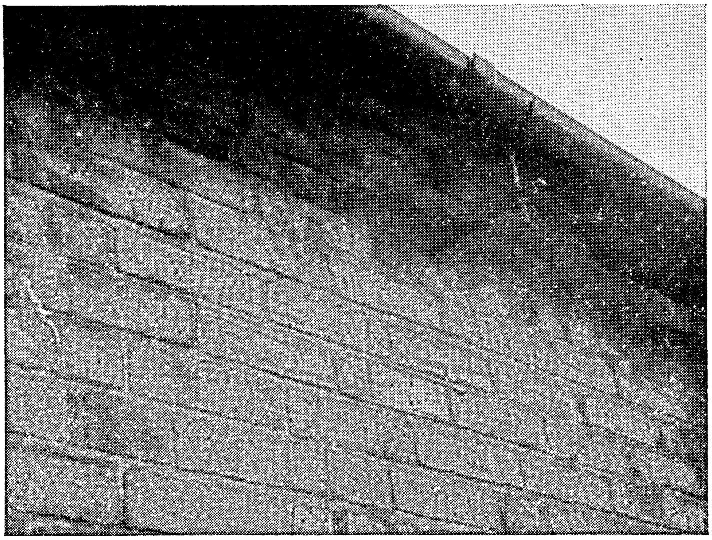

Plate 34: Disintegration of brickwork at eaves level—probably due to condensation inside the building.

(b) Wetting and Drying Defects

Alternate wetting and drying of materials may cause direct damage or provide conditions favourable to other forms of deterioration such as fungal attack. Although no cracking was visible on the 9 in. concrete blocks forming the gable wall shown in Plate 35, this is the sort of exposure condition which can in time lead to disintegration of the material through alternate shrinkage and expansion. In any case, such damp conditions are obviously undesirable in themselves.

Some patching of plaster or cement rendering was needed on a quarter of the cowsheds inspected but rarely in yards and parlours. In the examples seen, poor workmanship and/or materials were no doubt partly responsible, but the location of the trouble in many dairies suggests that a concentration of washing-down water in a small area is an important contributing factor (Plate 36).

(c) Soil and Ground Water Action

The effects of attack, if any, by soluble sulphates and other agents could not be seen.

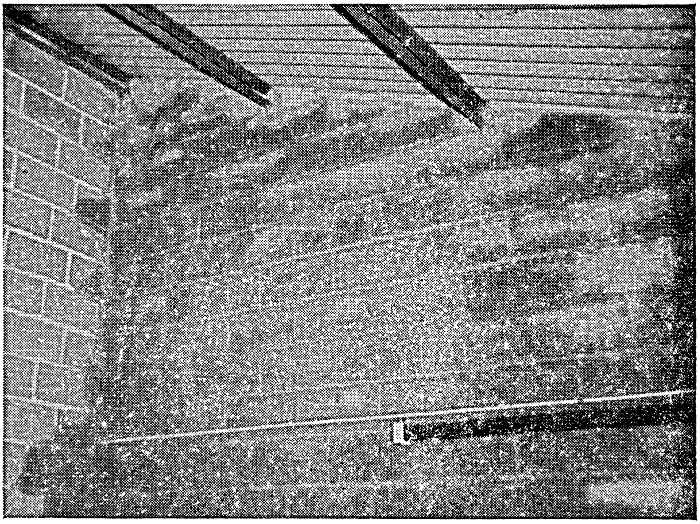

Plate 35: Penetration of damp through a gable wall.

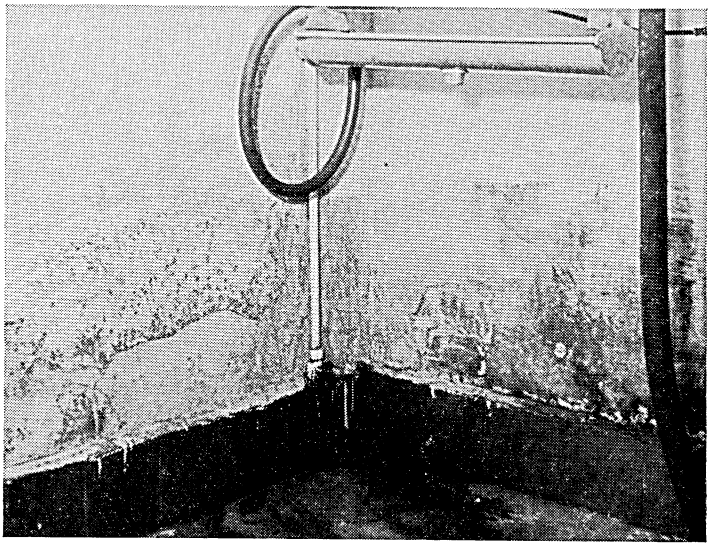

Plate 36: The concentration of washing-down water in a small area has led to the disintegration of wall plaster.

(d) Rodent, Insect, Bacterial, Fungal and Plant Action

No woodworm or fungal attack on timber was seen in any new building. In some buildings, sapwood had been used, and in most buildings severe condensation was evident. These defects form conditions in which the structure becomes very vulnerable to such attacks.

(e) Water Supply and Electrolytic Action

No defects were noticed which could be attributed to these causes.

(f) Association of Incompatible Materials

No defect in this category was noticed except that the failure of a cement rendering may sometimes have been due to soluble sulphates inherent in a backing consisting of common bricks.

(g) Specific Chemical Action

A number of examples were noticed in cowsheds and milking parlours of local erosion of standings immediately under the udder, probably due to milk leaking from a teat.

(h) Wear

The floors of dairies and milk stands were the areas most subject to wear and this was fairly obviously due to abrasion from milk churns. In some buildings, steel chequer plates had been inserted in the vulnerable areas with generally satisfactory results. Uneven wear of floors and standings was usually due to inadequate workmanship or materials.

(i) Impact

Rainwater down-pipes were often placed in vulnerable positions, and were frequently broken or dislodged. On nearly 50 per cent. of the cowhouses down-pipes needed to be either provided, replaced, or refixed, but the proportions were fewer for yards and parlours, being 18 per cent. and 33 per cent. respectively.

Only four per cent. of cowhouses were given a value exceeding 1 on the Cambridge Scale ("Slight damage of no structural importance "), and the rating of yards and parlours was similar in this respect (Plates 37 and 38).

(j) Action of Cleaning Agents or Industrial Wastes

These were not seen to be the contributing causes of any farm building defects.

(k) Mining Subsidence

Although the area of the survey extended over coalfields in Nottinghamshire, Leicestershire and Derbyshire, only one building seen had been affected by mining subsidence (Plate 39).

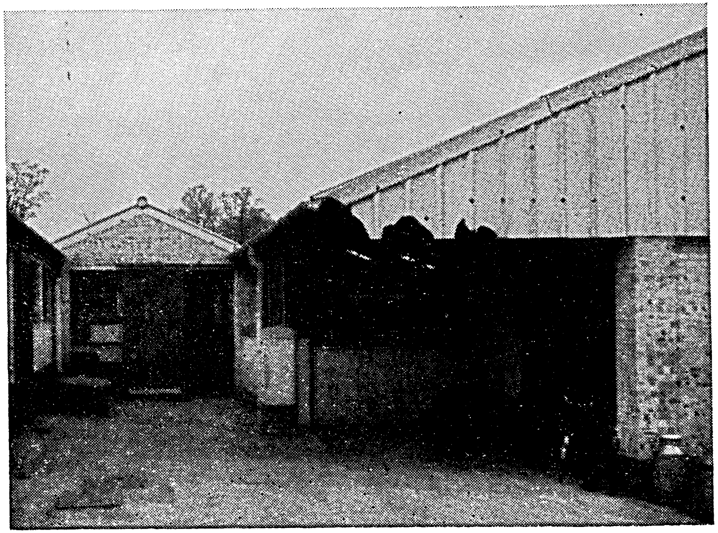

Plate 37.

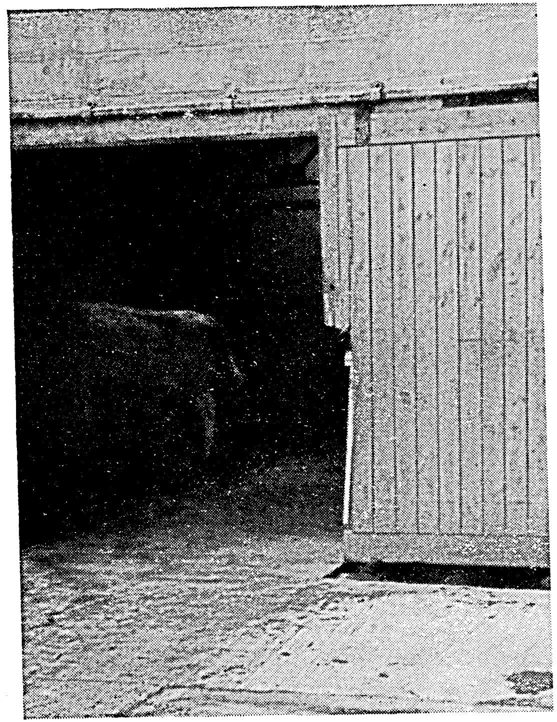

Plate 38.

Two examples of damage by impact.

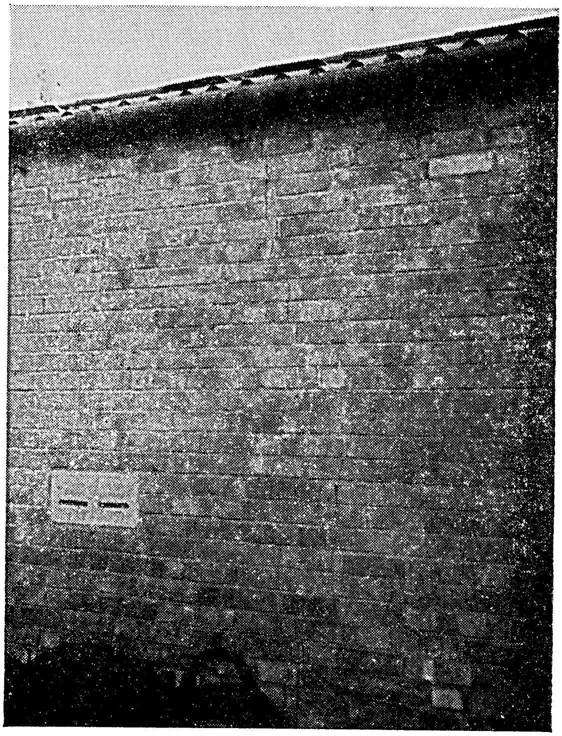

Plate 39: A building affected by mining subsidence.

Susceptibility to Deterioration of Building Materials

Comparatively little is known of the inherent susceptibility to deterioration of common farm building materials, and this is currently the subject of a field survey by the College of Estate Management. Only general impressions could be formed of the innate durability of those building materials most frequently employed in dairy cattle buildings, because all the surveyed buildings were less than nine years old. For what they are worth, these impressions are given below:

(a) CONCRETE

This is usually a perfectly durable material for flooring provided it is properly made.

(b) PRE-CAST CONCRETE UNITS

These appear to be most satisfactory when used as structural frames. Only a few were seen (five in covered yards, three in parlours, four in cowsheds) but no deterioration was noticed apart from a horizontal fracture through the leg of one frame, probably caused by the impact of a farm vehicle. There is no easy repair for such an accident: this illustrates a possible objection to the use of this material. One of the two buildings which employed some form of pre-cast concrete in-filling panel showed that the face of some units was spalling, and this was probably due to inexact positioning of the reinforcement. This is a defect which the concrete frames could take longer to show. It would be interesting to examine pre-cast concrete frames which had been erected on farms about 20 years ago in order to form some idea of the likelihood of such a defect arising.

(c) BRICKS

Facing bricks were exceptional and it is in the tradition of farm building that where bricks are used they are commons. Those seen were usually either Flettons or local red bricks.

Fletton bricks showed little tendency to flaking of the surface, but some erosion was general among the red commons, a typical Cambridge Scale description being "Distinct erosion or flaking in patches indicating crypto-florescence." On the other hand, structural cracks within brickwork were fairly similar as between Flettons and commons and were present on roughly a quarter of the brick buildings. The average extent of the cracking could be described as "a few cracks continuous through one or two joints" (or bricks).

(d) PRE-CAST CONCRETE BLOCKS

Those blocks seen were usually 9 in. × 9 in. × 18 in. and of a hollow pattern. The quality of their manufacture and finish appeared to vary considerably. No surface erosion was seen, but nine tenths of the block walls exhibited structural cracks and the extent of these was rather more serious than was the case with brick walls (Plate 40).

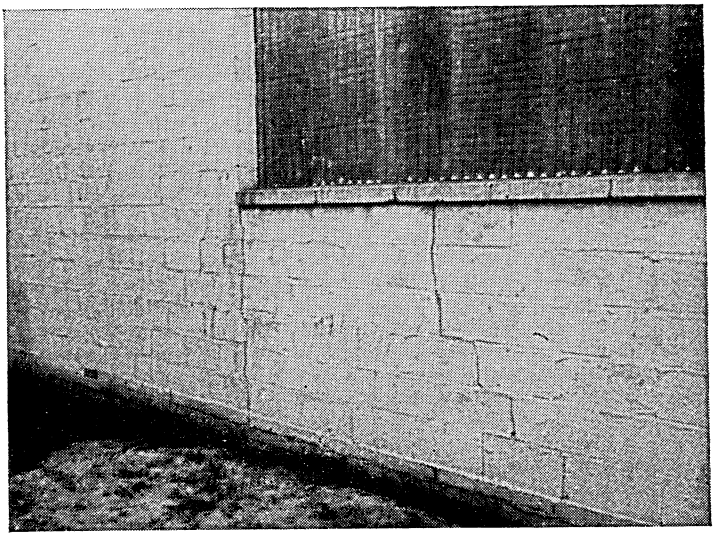

Plate 40: An example of structural cracking in concrete blocks.

(e) TIMBER

Little deterioration of timber was observed, provided it was properly protected by paint or other preservative. No serious deterioration was seen in roof timbers, but may well be expected in the future, because of the typically humid conditions. Where doors were not kept properly painted the joints deteriorated and matchings curled.

(f) STEEL

Few of the steel structures, particularly roof trusses and purlins, were maintained in good condition. Rust was very prevalent and laminations of rust were frequently observed. Properly applied and complete protective finishes were rare— and once roof sheeting is fixed it is virtually impossible to paint the hidden side of a steel angle purlin. This raises serious consideration of whether steel, with all its advantages, is a suitable material for framing buildings in which stock are to be housed. If it were properly protected and maintained it would be, but high initial cost in order to reduce maintenance costs is not acceptable policy to the overwhelming majority of owners and, as mentioned earlier, maintenance is more noticeable by its absence. Pressure impregnated timber should be competitive with steel, and requires practically no attention.

(g) ASBESTOS CEMENT SHEETING

This displayed little deterioration or damage even when the roof pitch was substantially lower than that recommended by the manufacturers (22°—25°).

(h) PAINT AND PROTECTIVE FINISHES

Workmanship was usually so poor that it is impossible to say how durable is paint properly applied to farm buildings. The present day tendency is towards do-it-yourself painting, and it is most unlikely that the farming community will reverse this. Some consideration ought, therefore, to be given to the question of whether paint is the most effective material for a farmer to apply to timber, and whether a solvent-type preservative would not be both cheaper and more easily applied by unskilled labour. Where such a course had been adopted, the condition of the timber appeared to be at least as good as painted joinery.

Effect of Design upon Building Durability

It is within the designer's power to control durability, to a considerable extent, by decisions made at the drawing board stage. These need not necessarily increase the initial building cost, though some may. Some suggestions are described below:

(i) By the choice of suitable materials (ii) By insistence upon good workmanship	These considerations are within the control of the designer and have been discussed above.

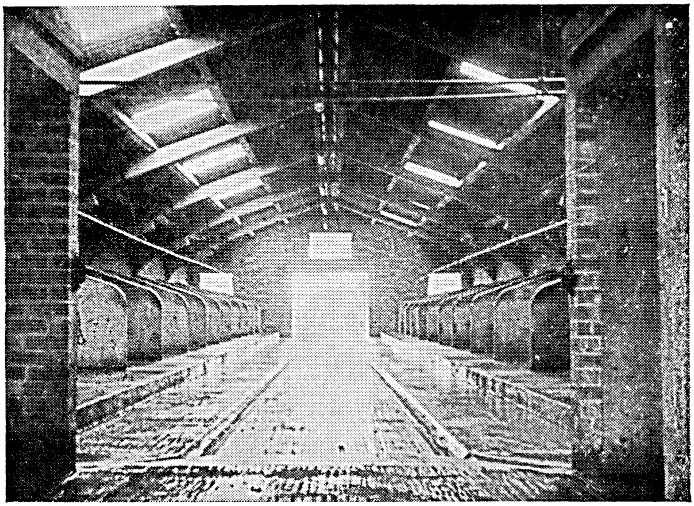

Plate 41: A pre-cast concrete portal frame may be more durable than . . .

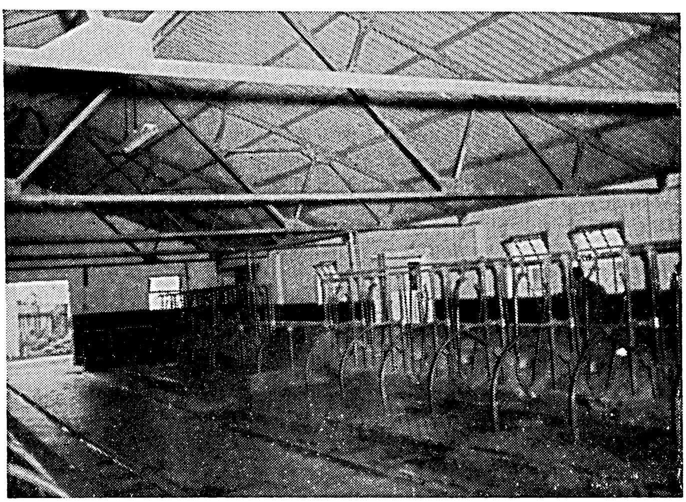

Plate 42: . . . the more usual roof frame of steel angle purlins and trusses.

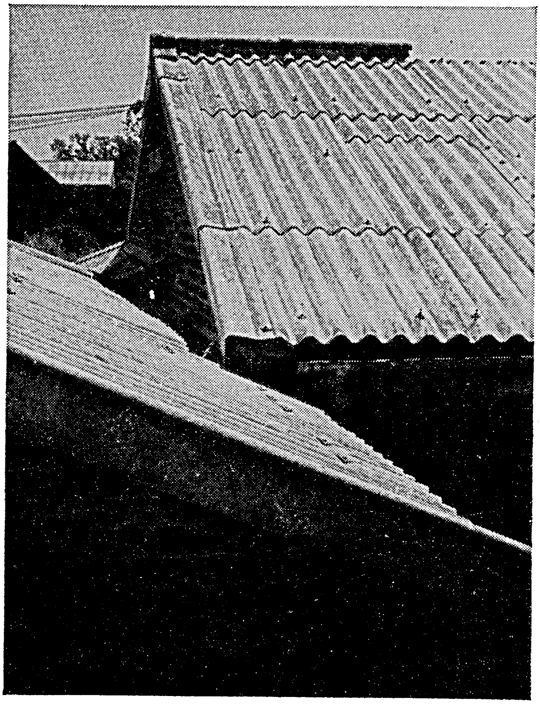

Plate 43: Complicated roof intersections are generally to be avoided.

(iii) By choice of structure: for example, in lieu of the more usual roof frame of steel angle purlins and trusses, substitute a pre-cast concrete portal frame. The cost will be higher, but probably not very much.[9] This extra cost would probably be less than subsequent maintenance expenditure (if buildings were properly maintained) and would permit increased flexibility of use, which is usually a considerable asset (Plates 41 and 42).

(iv) By simplifying roof shapes and avoiding complicated intersections (Plate 43) and valley gutters.

(v) By providing adequate and efficient rainwater drainage arrangements. Faulty gutters or down-pipes will discharge water from a large catchment area upon a relatively small area of wall: better no gutters than inefficient ones.

9 There were very few examples of framed buildings in the survey sample, but their standard costs (which in this instance must be regarded as being very approximate) suggest the following. Cost of frame=16 per cent of total, average cost of roof (normal unframed construction)=18 per cent of total, cost of roof (framed building) =7 per cent of total. Therefore the cost of frame plus roof is 23 per cent which is only 5 per cent more than unframed construction. To this must be added cost of additional foundations (say one per cent).

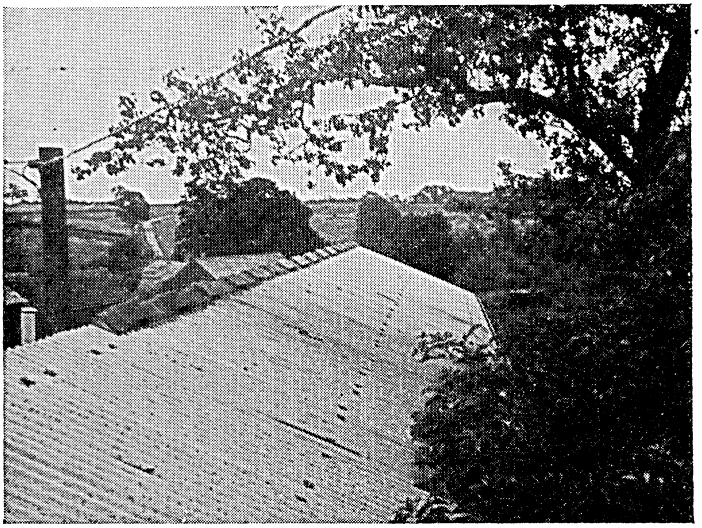

Plate 44: Trees should be cut back . . .

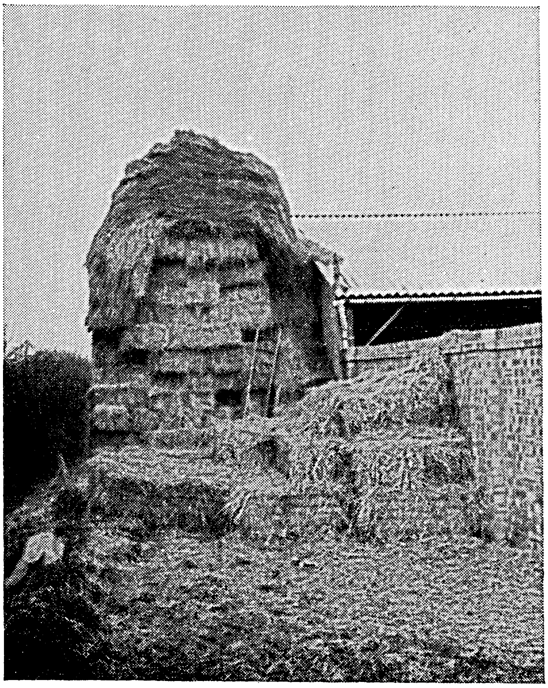

Plate 45: . . . and stacks built under or away from roofs.

(vi) Apart from initial design and mechanical damage, leaves and straw will do most to render rainwater drainage systems ineffective. Trees should be cut back and stacks built under or away from roofs (Plates 44 and 45).

(vii) By ensuring that vulnerable units (e.g. rainwater pipes) are protected or positioned away from damage (Plate 46).

(viii) By planning buildings with through routes so that mechanical equipment can enter a building and leave without reversing.

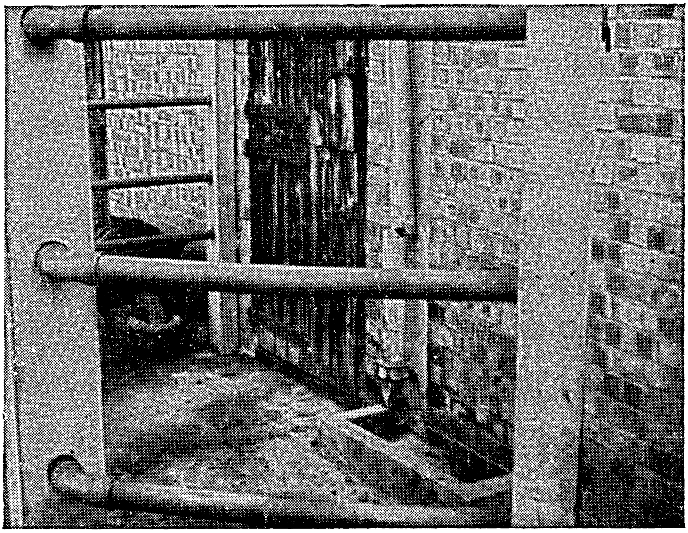

Plate 46: Rainwater pipes should be protected or positioned away from vulnerable points.

(iii) MAINTENANCE

General

The total cost of a building is more than the initial capital cost. Depending upon the quality of the original work (quality of design, workmanship and materials) more or less work will be required for the upkeep of the building. The results of the survey showed that very little had been spent on maintenance [see Appendix 3A (ii)] and it is possible that in many cases this neglect will result in considerable expenditure in years to come.

Nevertheless, one very strong impression to emerge from the survey is that if proper care was taken at the stages of building design, specification and construction, maintenance of farm buildings over the period of 25 years considered in this study could be negligible, and this need involve little or no capital expenditure above present levels.

Although maintenance absorbs the energies of over 27 per cent. of the building industry's manpower[10] it is a poorly documented subject. Repair costs for houses have received the most attention in this field, first from local authority treasurers, subsequently by the Building Research Station. In 1953 "The Cost of House Maintenance" was the subject of the Girdwood Report. All that is extant on the maintenance of farm buildings appears to be the Ministry of Agriculture's "Fixed Equipment on the Farm" Leaflet No. 26, and the work of Denman and Rathbone.[11]

The latter was a most valuable piece of exploratory work, but it hardly went beyond setting the stage and developing the techniques for a full-scale farm building maintenance enquiry. The sample on which the study was based was too small to yield conclusive results, and the findings were not presented in a form which can be readily applied to a consideration of the effect on costs of building design decisions. It is to be hoped that Denman and Rathbone will find an opportunity to develop this work.

Guidance is needed at the design stage when decisions are made which affect the life of a building and its annual costs. Some aspects of this problem are discussed in the following paragraphs.

Agriculture's Changing Needs

Prophetic vision, in some degree, is a necessary attribute of the designer of buildings and obviously involves intimate knowledge of the uses of buildings. Advances in agricultural knowledge and changes in farming techniques over the past quarter of a century have been considerable and can be expected to continue. Uses of buildings can be expected to change: a recent example of this is the increasing extent to which yard and parlour units have been built to replace traditional cowhouses. Obsolescence is therefore likely to be an important factor affecting the useful life of buildings: it may well be of more significance than durability. *For the purposes of this study the period of effective use of a building has been set at 25 years.*[12] This life-span has been fixed quite arbitrarily, because consideration of some definite period of use is desirable, but the *actual* economic life of a building may be much longer and will depend on such considerations as:

(a) the farming methods adopted

(b) the degree of flexibility of use afforded by the design.

In this context, the framed building with panel in-fill walls is likely to be more adaptable to changing methods than a building of load-bearing wall construction in which openings are fairly rigidly determined and where, usually, variability of use is only possible *within* the enclosing envelope. Nevertheless, the framed building has inherent features which might limit future use, exam-

10 Ministry of Works estimate for 1956, (quoted by T. Mitchell). Source: *Report on* 1957 *R.I.B.A. Conference*. Journal of the Royal Institute of British Architects. Vol. 64. No. 9. 1957.

11 RATHBONE, R. A., op. cit.

12 This assumption is markedly different from the basis on which Denman and Rathbone computed the maintenance costs of farm buildings. Their system was to fix an arbitrary maintenance cycle of 20 years, and devise the most economic routine for maintaining the building, so that at the end of 20 years the building would be in as good condition as when new. The maintenance cycle would then revolve again.

ples being the height of eaves, internal clear height to trusses or other obstructions, and the disposition and size of supporting stanchions.

Maintenance Requirements

Available records of money spent on farm buildings and repairs are too incomplete to be helpful to an understanding of expenditure to be anticipated—" If nothing else emerges from this work it has shown how hopelessly inadequate and ill-kept are many records . . . precise financial knowledge is unobtainable and a state of affairs exists which cannot be looked upon as satisfactory[13]". During the present survey, therefore, schedules of maintenance work were drawn up of work needed at the time, and these were subsequently costed on the standard cost basis.[14]

Maintenance schedules were drawn up for 49 cowsheds, 22 new covered yards, and 21 new parlours. In addition, the standard costs of maintenance were prepared for the 36 cowsheds previously chosen for standard cost analysis.

In the scheduling of maintenance requirements, each building was assessed as far as possible on exactly the same basis: to some extent this was made difficult by the widely varying quality of the original building work and the lack of any consistent maintenance policy on the part of farmers or owners. Only those repair tasks essential for keeping the effects of wind and weather at bay were recorded: other tasks, usually regarded as inessential, were only recorded where their neglect would result in increased deterioration, or affect the use of a building. No decorations apart from preservative coatings on wood or metal were recorded as being necessary. Uneven wear of concrete floors, which may be a serious hindrance to the efficient usage of buildings, was very common. The only really effective treatment for a worn concrete floor is to take it up and re-lay it, but such a measure can hardly be regarded as a routine farm maintenance task. So, for the purpose in hand, this condition was disregarded unless it appeared to be dangerous to workpeople or livestock.

Despite these limitations, an overall total of 361 separate and necessary maintenance tasks was recorded in respect of the 49 cowsheds surveyed, an average of more than seven tasks per building. For yards, the average was nearly four, and for parlours, over six defects per building. No building was entirely free of maintenance needs and in two cases no less than 16 tasks were recorded as needing attention. An outline analysis of the most frequently occurring items of maintenance need and their location by building elements is given in Table 24. The degree of severity of deterioration is not shown, nor is the range of severity between the least and most affected buildings. All the cowsheds under consideration housed between 10 and 60 cows and were typically constructed of concrete block or brick walls, steel or timber roof trusses and purlins, a corrugated asbestos-cement sheet roof, and a concrete

13 DENMAN, D. R., and RATHBONE, R. A. *Report on Farmstead Maintenance* (unpublished).

14 See Appendix 5A.

MAINTENANCE TASKS REQUIRED BY SURVEYED BUILDINGS

TABLE 24

	Element of building	Description of maintenance task	Cow-sheds	Covered Yards	Par-lours
			No. of buildings requiring attention		
FINISHES AND FITTINGS	Paint and Protective Finishes	De-rust steel roof members and paint	30	12	7
		Repaint joinery	29	7	12
		Creosote roof timbers	10	—	1
		De-rust steel windows and paint	8	1	5
		Creosote doors already treated	5	4	5
		Repaint R.W. fittings	5	2	5
		De-rust and repaint fittings, tubular manger barrier, etc.	4	—	—
		Paint steel roof members not needing de-rusting	3	4	—
		Various other tasks	5	2	6
		GROUP TOTAL	99	32	41
	Fittings	Re-surface manger	4	—	—
		Replace broken or cracked stall divisions	3	—	—
		Various other tasks	4	—	1
		GROUP TOTAL	11	—	1
	Finishes	Patch rendering	12	1	1
		Point hole or crack in rendering	3	—	—
		Various other tasks	2	—	—
		GROUP TOTAL	17	1	1
SERVICES	Services	Defective electric light	8	—	—
	Gutters and Rainwater Pipes	Clean out gutters	29	15	15
		Provide or replace R.W.P's	16	4	7
		Revise gutter levels	8	3	3
		Refix R.W.P's	7	3	3
		Provide or replace gutters	6	1	3
		Make good to gutter joints	2	5	3
		Various other tasks	3	1	—
		GROUP TOTAL	71	32	34
SUPER-STRUCTURE	Roof	Various maintenance tasks	13	—	7
	Frame	Repair fractured frame leg	1	—	—
SUB-STRUCTURE	Walls	Replace broken glass	16	1	6
		Repair door	13	3	4
		Point brickwork	8	1	1
		Make good decayed brick	7	—	3
		Make good window putty	6	—	4
		Clean off moss and slime	4	—	2
		Point up structural cracks	3	—	2
		Various other tasks	12	2	5
		GROUP TOTAL	69	7	27
GROUND AND SITE WORK	Drainage and External Works	Clean out gullies	9	1	2
		Clean out drains	7	—	—
		Provide R.W. drains	7	2	2
		Provide manhole cover	5	—	2
		Re-build top of manhole	3	—	2
		Provide gulley grating	3	—	—
		Remove shrubs and overhanging boughs	3	—	—
		Various other tasks	6	3	—
		GROUP TOTAL	43	6	8
	Work below floor level	Remove earth to below D.P.C. or floor	14	—	—
		Remove close growing vegetation	3	—	—
		Make good concrete	3	—	5
		Clear away rubbish	2	1	3
		Various other tasks	3	2	5
		GROUP TOTAL	25	3	13
		TOTAL NUMBER OF DEFECTS	357	81	132
		TOTAL NUMBER OF BUILDINGS	49	22	21
		AVERAGE number of defects per building	7.2	3.7	6.3

floor. Parlours were usually constructed similarly to cowsheds, though three incorporated pre-cast concrete frames. Yards were very much more varied, ten having proprietary steel frames, five concrete frames and seven were constructed of brick piers and walls with steel or timber roof framing.

The conclusions to be drawn from the scheduling of maintenance tasks are as follows:

(i) As between cowsheds and milking parlours, there was little difference in the numbers of observed defects, but yards averaged only half the number of defects found in cowsheds. This was probably because:

(a) Cowsheds and parlours were used more intensively than yards, i.e. there were more and more varied operations and movements of men and animals in small spaces.

(b) Yards were usually simpler buildings than the other two types, with less to go wrong, e.g. windows, doors, drains, etc.

(ii) The most frequently occurring defects were painting of roof members and joinery and blocked gutters; these were the most frequent in all three building types.

The classification of quality of design adopted for the survey was too crude for any connection to be seen between building design and the amount of necessary maintenance.[15] There was some slight evidence to suggest that the professionally erected building was no more immune to deterioration than the one built by a farmer. Not surprisingly, there is a tendency for the older building to have a greater number of maintenance requirements than the newer, and it is apparent that the better the quality of the initial building work, the less the likelihood that it will require subsequent attention [see Appendices 3C (i) and 3C (ii)].

Costing of Maintenance Work

The costs of making good to defects were estimated on the same basis as the standard costs of new buildings, i.e. on the basis of the rates in the " W.D. Schedule " (see Appendix 5A). The maintenance work costed was confined to the remedying of the particular defects which were apparent at the time of the survey in specific buildings. That is, unit prices were determined for particular types of repair work and these were multiplied by the appropriate area, number, volume, etc. in respect of the particular building. Individual maintenance tasks were grouped by elements and costs expressed in shillings per square foot of total area, and shillings per cow; the proportionate maintenance cost of each element was also expressed as a percentage of the whole.

15 It seems that at least one authority responsible for considerable maintenance programmes has evidence that bad design accounts for only a small proportion of the whole maintenance requirement. See: remarks by W. J. Jackson, Director of Maintenance, Ministry of Works, at a discussion on Building Maintenance, reported in the Architects' Journal. Vol. 122, p. 729. 1955.

The average standard costs of repairs, for the sample of 36 cowsheds, are shown in Table 25. These differ in their presentation from the standard costs of new buildings in that the items relating to "Paint and protective finishes" are here shown separately instead of being included within other elements.

AVERAGE STANDARD COST OF REPAIRS
36 COWHOUSES

TABLE 25

Group	Elements	Cost per Cow (shillings)	Cost per sq. ft. (shillings)	Per cent of Total
FINISHES AND FITTINGS	Paint and protective finishes	22.8	0.34	50.4
	Fittings	1.9	0.03	2.0
	Decorations	1.5	0.02	2.6
	GROUP TOTAL	26.2	0.39	55.0
SERVICES	Electrical and cold water fittings	0.5	—	0.3
	R.W. disposal	6.0	0.09	12.0
	GROUP TOTAL	6.5	0.09	12.3
SUPERSTRUCTURE	Roof lights } Roof }	1.4	0.03	3.4
	Independent structural frame	—	—	—
	GROUP TOTAL	1.4	0.03	3.4
SUBSTRUCTURE	Upper floor and stairs	—	—	—
	Doors } Windows } Walls }	8.7	0.14	12.7
	GROUP TOTAL	8.7	0.14	12.7
GROUND AND SITE WORKS	Fencing and Gates } Paving } Drains }	8.3	0.14	10.4
	Work below floor level	4.4	0.07	6.2
	GROUP TOTAL	12.7	0.21	16.6
	TOTAL STANDARD COST OF REPAIRS	55.6	0.86	100.0
	Average Total Standard Cost of Repairs per Year of Building Life	11.7	0.18	

If the W.D. Schedule is acceptable as a pricing basis for actual maintenance work to cowsheds,[16] it could be expected that the average cowshed built since 1950 would, by mid-1959, have required repair and renovation work costing approximately £2 15s. 6d. per cow housed or 10½d. per square foot of floor area. For the average cowshed, for each year of life, the figures would be 11.7 shillings per cow or 0.18 shillings per square foot.

Average maintenance costs per cow housed and per square foot of floor area for each year of life, are shown for particular categories of cowhouse in Table 26.

It is suggested that repairs to parlours (which are usually smaller buildings than the average cowhouse) could be costed on the same basis as cowsheds. On the other hand, for the majority of covered yards, the figures would not be appropriate.

16 A number of possible objections to the W.D. Schedule as a basis for the pricing of new farm buildings are discussed in Appendix 5A, and some of these may also be applicable to the pricing of maintenance work. However, the W.D. Schedule appears to be the best basis at present available for this purpose.

AVERAGE MAINTENANCE COSTS IN SHILLINGS PER COW PER YEAR OF LIFE
TABLE 26

Category of Cowhouse	Number in sample	Maintenance Costs per Year of Building Life	
		per cow	per sq. ft.
Buildings housing 10—14 cows	15	13.8	0.20
,, ,, 20—30 cows	10	9.5	0.18
,, ,, 40 cows and over	11	11.0	0.15
Double-row buildings	22	10.5	0.18
Single-row buildings	14	13.7	0.19
Cowsheds erected by building contractors	29	10.2	0.15
,, erected by farm owners	7	18.1	0.33
All buildings	36	11.7	0.18

The maintenance costs in Table 26 will no doubt appear high—especially to the "average" farmer who, as the survey has shown, expects to erect his buildings and, so far as the structure is concerned, forget it. The cost of 11.7 shillings per cow per year and 0.18 shillings per square foot per year may be compared with the average annual maintenance costs for local authority houses in England and Wales, which in 1952-53 averaged £9 1s. 3d. per house,[17] or at an average, say, of 900 square feet per house, 0.20 shillings per square foot. Human beings can be expected to require a much higher standard of amenity than cattle—therefore, house maintenance costs should be correspondingly higher. Furthermore, in a house it can be expected that the greater proportion of fittings and equipment will result in greater upkeep costs. In fact, according to Reiners,[18] *external* painting accounts for 32 per cent. of maintenance costs and plumbing 17 per cent. By comparison, the standard costs of "Paint and protective finishes" accounted for approximately 50 per cent., and of repairs to "Electrical and cold-water fittings" for only one quarter of one per cent. of the average total standard costs of repairs to cowhouses.

Some reasons why the average difference in costs per square foot between house maintenance and cowhouse maintenance is apparently not greater may be:

(i) Local authority houses are designed to be permanent buildings and therefore the materials are likely to be more durable. Cowhouses are built of the cheapest materials available which will provide shelter and satisfy the Milk and Dairies Regulations.

(ii) Although the standard of workmanship of local authority houses is often not as high as it could be, their building work is normally subject to fairly close supervision, with the result that a higher standard usually prevails than in either speculative house building or farm building.

Returning to Table 24, it will be noticed that few of the maintenance needs listed would be likely to directly impair building use. This is not altogether surprising: cowhouses, and yards and par-

17 REINERS, W. J., *Maintenance Costs of Local Authority Housing*. Proceedings of Institute of Municipal Engineers, Vol. 81, No. 9, 1955. These figures exclude internal decorations, which, if added, would make the total £11 2s. 3d. per house.
18 Ibid.

lours, as at present envisaged, are little more than waterproof shelters, and no very exacting environmental conditions are demanded. The most usual effect of some deterioration in the building fabric is to open the way for still further encroachment of the weather. In general, the defects in themselves were small, and it is likely that even the buildings which had the greatest number of maintenance requirements will last—without any attention—for a further 10 or 20 years and give some sort of useful service.

The preceding discussion is summarised below in question and answer form.

Q. *At what age will a farm building become obsolete?*

A. This can only be guessed. For the purposes of this study, it was assumed that buildings had an economic life of 25 years and should be written down over that period.

Q. *At this age, will the building be structurally sound?*

A. Probably yes, but it will depend considerably upon quality of materials, workmanship and possibly design.[19]

Q. *When obsolete, would there be other uses to which the building could be put?*

A. Not necessarily. One of the interim impressions given by the Agricultural Research Council's recent survey of existing farmsteads is that on a large number of farms a substantial amount of the available building space is not used.[20]

Q. *What effective life will be given by various combinations of materials?*

A. This is not known, though it is one of the long-term intentions of the Codes of Practice Committee[21] to establish effective lives of different materials. The current study by the College of Estate Management should do much to increase the knowledge of the durability of farm building materials. It is likely that the materials now used will give an effective life of at least 25 years.

Q. *What annual expenditure on repairs will be necessary to achieve this life?*

A. Estimates have been prepared of the maintenance liabilities in terms of cost per cow or cost per square foot for different categories of cowsheds. These are shown in Table 25. To a large extent these estimates are based upon surveyed buildings where defects needed remedying because initial building work was poor, or because initial preservative work was not done.

Q. *What would be the effective life of buildings constructed of various combinations of materials which were NOT maintained, and what would be the cost implications?*

19 Increased structural repairs to houses (e.g. to brickwork and roofing) occur principally after 20 years: see REINERS, W. J. op. cit.

20 SLATER, J. K., Head of the Special Survey Section, National Institute of Agricultural Engineering, (in conversation).

21 THE COUNCIL FOR CODES OF PRACTICE FOR BUILDINGS. op. cit.

A. It is probable that buildings constructed of brick or concrete block walls, steel or timber roof frames, asbestos cement sheet roofs and concrete floors will—*if properly built in the first place*—give a trouble-free life of at least 25 years.[22] At the end of this period extensive repairs might be needed if the building were to be rehabilitated for another maintenance-free cycle.

Q. *What combination of materials will provide the minimum initial costs, what will these costs be, and what will be the annual maintenance costs for building lives of different length?*

A. The materials of which cowsheds are commonly built now (noted above) are chosen largely because they are the cheapest available. Average building costs are given in Chapter 5. These materials may not necessarily remain those most attractive in first cost.

Maintenance Costs as a Proportion of Initial Building Cost

Since the standard costs of new buildings and the standard costs of repairs were estimated on the same price basis, comparisons of repair costs expressed as a percentage of initial building costs, can be made between buildings. Such percentages are shown in Table 27 for different categories of cowshed.

THE AVERAGE STANDARD COST OF REPAIRS PER YEAR OF BUILDING LIFE AS A PERCENTAGE OF THE AVERAGE STANDARD COST OF BUILDING ERECTION

TABLE 27

Category of Cowhouse	Number in sample	Percentage Standard Cost of Repairs
Buildings 10—14 cows	15	0.8
,, 20—30 cows	10	0.7
,, 40 cows and over	11	0.6
Double-row buildings	22	0.7
Single-row buildings	14	0.8
Cowsheds erected by building contractors	29	0.6
,, erected by farm-owners	7	1.4
All buildings	36	0.7

Although there may have been some minor variations in this respect between the different building groups shown in the table, the general conclusion is that with a maintenance programme such as that drawn up for calculating the standard cost of repairs, the annual maintenance cost for the types of building with which this enquiry was concerned should rarely exceed one per cent. of the initial building cost.

22 THE COUNCIL FOR CODES OF PRACTICE FOR BUILDINGS. *Asbestos Cement Sheet Roof Coverings*. British Standard Code of Practice, C.P. 143. 201. 1951. According to this authority "asbestos cement sheeting may be regarded as having a life of at least 30 years". However, under exposure to rural conditions, this might represent the *maximum* life.

APPENDIX 3D

APPEARANCE

The appearance of farm buildings is a marginal characteristic with no cash value and very often at odds with the concept of maximum profitability. It is quite obviously a matter to which the industry as a whole attaches little importance, being mentioned less than half a dozen times in nearly 200 replies to the Farm Buildings Association Questionnaire. Fulltime agents and managers of estates seem to show the greatest interest; the few architects working in this field appear to find it more politic to emphasise other aspects of their services.

The lack of interest concerning this aspect of design is serious, because farm buildings are often prominent features in the landscape, and the appearance of the countryside is of concern to wider circles than the farming industry. The absurd situation now exists that buildings to be erected in characterless suburban areas can be refused planning consent on purely aesthetic grounds while farmers can erect practically any sort of building almost anywhere without the necessity of ensuring that it does any more than comply with local byelaws.[1] Even this requirement is sometimes foregone.

One of the pleasing qualities of many old farm buildings is that they become part of the landscape. This is due partly to their form, and partly because they were constructed of local and natural materials. By contrast, farm buildings of to-day are made from manufactured materials possessing little intrinsic beauty, such as pressed common bricks, concrete blocks, and corrugated asbestos cement sheets. These materials tend to be conspicuous, particularly when seen against a background of fields and hedges (Plates 47 and 48). This does not mean that the resulting buildings need be crude or unlovely or that good buildings necessarily recede into the landscape. It does mean that the visual impact of a farm building can be felt over a wide area because the strident materials attract attention, and that the handling of these materials requires very considerable design skill.

A well designed building is one in which the requirements of such design elements as planning, structure and appearance have been successfully met. Since the end of the war there has been an increasing awareness of design, but no farm buildings were seen during the course of this enquiry which, as representatives of their building type, were in this sense comparable with the better than average post-war architectural achievements in schools, houses or factories. A number of farm buildings were designed for an estate in the south-west by one of the more progressive architect firms.

1 The position has recently been modified (February, 1960) with respect to really large farm buildings (those with a floor area exceeding 5,000 sq. ft.); plans for such buildings will in future have to be approved by Town and Country Planning Authorities.

Plate 47.

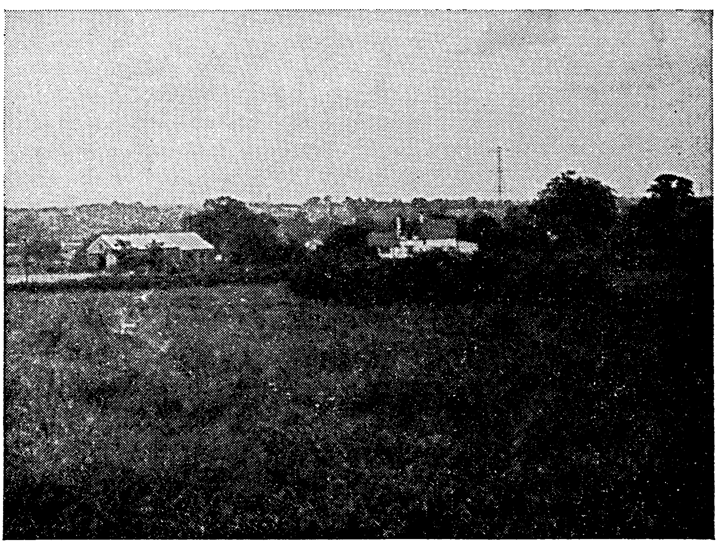

Plate 48.

Modern farm building materials tend to be conspicuous.

Photographs suggest that these buildings are very fine, displaying a use of modern structures and detailing which is most unusual in this field. Unfortunately they would fail the first test of the most broad-minded economist—in other words, they were very expensive.

By comparison with other building types, the functional requirements of farm buildings are simple and limited in range. Although strong traditions of design have existed, farming methods have changed radically in recent years and there need be no preconceived formal solutions for the buildings which provide the shelter wherein the new techniques are used. It ought, therefore, to be possible to evolve an approach to the design of farm buildings in which functional requirements and aesthetic considerations can be more evenly balanced than is the case at present.

A capable designer could do much to improve the appearance of the building types which have been the subject of this study. His consideration might be of siting, building shape, position and shape of door and window openings in masonry panels, and the design of detail. Further improvements might require the use of more expensive materials or finishes. However, one farm building tradition which is still valid because of its essential practicality is the use of simple, unpretentious and inexpensive materials. It would be unrealistic to advise any other policy, for such advice would not be heeded. External colour or lime-washing is traditional in some areas and costs very little. Such a finish can give a touch of distinction to the most prosaic building, and so will decent workmanship. There is no point in simulating old forms in modern materials, for the old forms are not appropriate for to-day's needs. The cowshed illustrated in Plate 49 was a praiseworthy attempt on the part

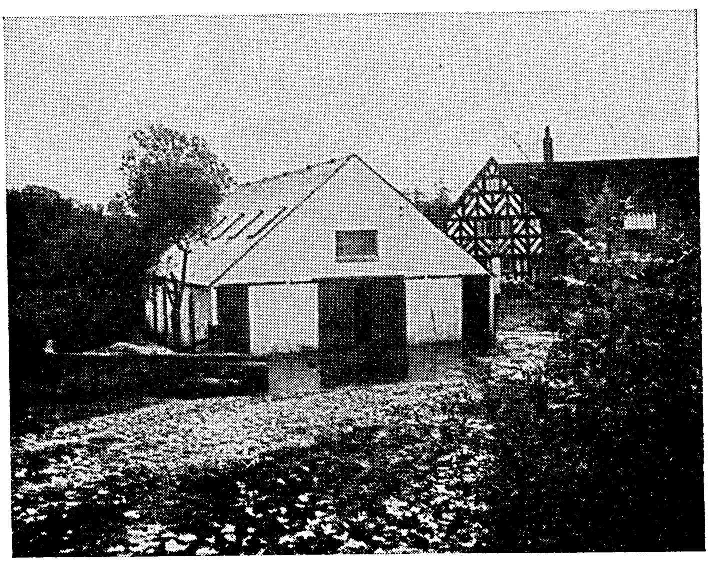

Plate 49: A praiseworthy but anachronistic attempt at achieving harmony between old and new buildings.

of an owner-occupier to erect a building which would be in harmony with his historic farmhouse. Nevertheless it is anachronistic to use corrugated asbestos cement sheets at a pitch more appropriate to thatch, and it results in the internal roof surfaces being practically inaccessible. Consideration of the proper use of contemporary materials in farm buildings has not been widespread and the literature is very scanty.[2]

Whatever action is taken to improve the appearance of farm buildings, it will misfire if it is directed at the individual farm project. The occasional cowshed may be dressed up in facing bricks to make it acceptable, but it will remain a sport, and rightly so, for it will be so much less of an economic proposition. Good design of the individual purpose-made farm building calls for ability of a very high order. However, few farmers are prepared to pay a designer at all, let alone a gifted one. It is obvious that since the agricultural industry is proverbially conservative it is of little immediate use to advocate the employment of " artists." Best results will come from the redesign of farm buildings from first principles.

There is to-day a tendency towards an increasing use of manufactured buildings, but there is little standardisation of building dimensions, materials or components. According to the replies to the Farm Buildings Association Questionnaire, received from building manufacturers, this is a matter of general concern within their industry. Since the end of the war there have been a number of systems of construction devised to meet the requirements of particular building types. At their most successful, these have permitted the utmost flexibility and freedom in the design of particular buildings because the system was based on the use of standard components rather than standard buildings, and the components were based upon a small " module." Farm buildings seem to be a very suitable subject for this form of development: the establishment of the principles of a suitable system would need some fundamental study, but the advantages could be very considerable. For the manufacturer, manufacture and stocking would be rationalised. The farmer would find that his buildings were almost infinitely variable, and graduated to within small limits. The appearance of the countryside would benefit from the good design standards of a first-rate designer employed to devise the basic system. Mass production methods would permit the development of more sympathetic materials. It is in this direction that not only the cheap and functional, but also the good-looking farm buildings of the future are likely to be found.

2 But see: *The raw materials of farm building design.* Paper by GERHARD ROSENBERG, read at the symposium on "Building for Agriculture", held at the Architectural Association, December, 1953.

APPENDIX 4

METHOD OF ASSESSING EFFICIENCY OF BUILDING LAYOUT AND DETAILED RESULTS

I. The Method of Assessment

Each co-operating farmer was asked for a complete list of the kinds of feeding stuffs fed in the cowhouse, milking parlour or yards, together with the total quantity of each kind consumed by the milking herd during the course of the previous twelve months. Information was also obtained about the quantity of straw used for bedding the cows.

The farmer also indicated the position of the main or bulk store for each type of feeding stuff and the route followed in conveying it to the building where it was consumed by the cattle. Due account was taken of feed processing and mixing operations such as the pulping of roots and the mixing of purchased with home grown concentrates, where these involved deviation from the most direct route between the storage point and the point of consumption.

Similar information was obtained regarding the quantity of milk produced[1] and the route followed in conveying it from the cow to the dairy and thence to the point of final despatch off the farm.[2]

The remaining bulk transport item associated with the housing of dairy cows is the disposal of farmyard manure. Methods of disposal vary a good deal between farms and are dictated partly by the system of housing, partly by the design of the building and partly by other considerations. For the purposes of this analysis the handling of farmyard manure was only taken into account in specially defined circumstances.

In the first place it was ignored where disposal did not form part of the *daily* routine during winter. This eliminated all farms practising the yard and parlour system of housing.

Secondly, it was ignored on farms where it was the practice to load the manure directly to a spreader or tractor-trailer *in the cowshed,* since this is a bulk handling operation which every farmer who returns the manure to the land must perform at some time.

1 Excluding milk used on the farm: the quantity was normally obtained from the monthly statements of the Milk Marketing Board. Gallonage was converted to tonnage on the basis of a gallon of milk weighing 10.32 lbs.

2 On the majority of farms this was at the dairy door, or virtually so. However, there were a number of farms where collection was at the farm gate, a considerable way from the dairy. During the early days of the survey the distance between the dairy and the farm gate was actually measured. This proved to be a very laborious and time-consuming procedure and, furthermore, since the point at which the milk is collected is not a matter entirely within the control of the farmer, it was felt that, for the purpose of inter-farm comparisons, it would be unfair to "load" these farms with this additional transport of milk. These measurements were later abandoned, therefore, and for the purposes of this analysis the despatch point for all milk has been regarded as being at the dairy door.

In effect, therefore, the only circumstances where manure was included in the analysis of materials handling was where it was carried or wheeled to a bulk vehicle parked *outside* the cowshed, or where it was carried on a wheelbarrow to a nearby midden or dungstead. In such cases an estimate was made of the total quantity of manure handled during a year[3] and a note made of the position of the midden or other first point of disposal.

For each of the surveyed farms, all buildings used by the milking enterprise were plotted on a scale plan of the farmstead, and the routes followed in transporting feeding stuffs, bedding straw, milk and farmyard manure to and from the cowhouse, milking parlour or yards were drawn and measured on the plan.

Thus, two key items of information were obtained regarding the handling of feeding stuffs and other materials used or produced in buildings used by the dairy enterprise:

(i) The total weight handled in a year.

(ii) The distance between the primary point of storage and the point of consumption or disposal.

Different farmers feed different rations. Hence it was not possible to compare all farms concerning the effort expended in handling individual types of feeding stuffs such as hay, roots, or dairy cake. This difficulty was circumvented by combining all the feeding stuffs used on each farm into two broad groups:

(i) "Bulk feeds and litter straw," the bulk feeds comprising hay, feeding straw, silage, roots, wet sugar beet pulp and wet brewer's grains.

(ii) "Concentrate feeds," comprising home grown grains, dried grass, and purchased concentrates including dried beet pulp and dried grains.

Average Length of Feed Route

A composite measure of the distance over which feeding stuffs had to be transported between the points of primary storage and consumption was arrived at, for each of these groups, by averaging the distances for the constituent items. In the calculation of this average, each separate kind of feeding stuff was weighted according to the quantity used during a year. To take a simple example, suppose the bulk feeds were hay, roots and bedding straw. Suppose, further, that the respective distances between the points of primary storage and consumption were 100, 150 and 50 feet and the respective quantities 20, 100 and 10 tons. Then, ignoring the differing quantities, the average length of feed route would be

$$(100+150+50)\div 3=100 \text{ feet.}$$

3 The weight of farmyard manure was estimated as follows:

(i) Straw was assumed to take up approximately twice its own weight in water. Hence the total weight of saturated straw was estimated by multiplying the dry weight of bedding straw by three.

(ii) Recent experimental work at the University of Nottingham School of Agriculture has shown that when adult cattle are fed 30 lbs. dry matter per day the average production of fresh dung is approximately 56 lbs. per day. Hence the total production of dung was found by multiplying this quantity by the number of cows in the herd and the number of nights during the year they spent in the cowshed.

(iii) The estimated total weights of saturated straw and fresh dung were then added together to find the estimated total weight of fresh farmyard manure removed from a cowshed in a year.

In this case, each of the constituent items is given *equal* weight for the purpose of calculating the average distance. However, it was thought that a truer measure of overall transport effort would be obtained if each of the constituent distances were given a different weight, this being the total weight of the feeding stuff to which it applied. Thus, taking the same example, the *weighted* average length of feed route would be,

$$[(100 \times 20) + (150 \times 100) + (50 \times 10)] \div 130 = 135 \text{ feet.}$$

For each farm a weighted average length of feed route was calculated in this manner for each of the two broad groups detailed above, and also for the sum total of all kinds of feeding stuffs and bedding straw.

With regard to the transport of milk and farmyard manure, no grouping problems were involved, and the lengths of the transport routes were measured directly on the scale plan of the farmstead.

Ton-mileage per cow

Even where the average distance over which feeding stuffs are moved is calculated in the manner described above, this does not give a fully adequate comparative measure of the effort expended in carrying out transport operations of this kind on different farms. The total bulk or weight of material handled per cow or per gallon of milk is also important, and this varies considerably according to circumstances on individual farms. Some farmers feed more heavily than others according to the milk yield at which they are aiming. Some farmers feed a higher proportion of bulky or succulent foods than others. Some put a low value on bedding straw and use it liberally for littering the cowhouse or yards, whereas to others it is scarce and expensive and they, therefore, use it sparingly. Finally, due to differences in soil and climatic conditions, there is considerable variation in the length of the period during which the full winter routine of feeding in the buildings is followed. Even within the small geographical area covered by the survey this was found to vary from three to nearly six months.

Broadly speaking, it requires twice as much effort (in terms of man or machine power) to carry a load of two tons for a mile as it does to carry one ton the same distance: similarly, with the same expenditure of effort, one ton can be transported twice as far as two tons. This may seem very obvious when it is stated in abstract terms, yet the principle is not always applied to the most practical effect in the planning of farm buildings. Stated in the simplest terms, the principle is that the greater the volume or weight of material to be handled the greater the saving in effort to be gained from reducing transport distances to a minimum.

For the purpose, then, of making comparisons between farms of the effort expended in carrying out transport operations, a composite measure of distance and weight is required. One such measure is "ton-miles," found by multiplying the distance (expressed in miles or fractions of a mile) by the weight (expressed in tons or fractions of a ton).

The basic information obtained from each farm regarding the weights of feeding stuffs and bedding straw consumed by the dairy herd, and the distance over which they are carried, was used to calculate the total ton-mileage represented by the transport of these materials during the course of a year.[4] As with the measurement of the average lengths of feed routes, the individual items were aggregated into three broad groups, using the same method of weighting as before and the results expressed in terms of " All Bulk Feeds and Litter Straw," " All Concentrate Feeds," and " All Feeds and Litter Straw."

Comparisons between farms could not be made without allowing for differences in the size of the milking herd. Hence, for each farm the total ton-mileage was divided by the farmer's estimate of the average number of cows in milk during the year, to give the average ton-mileage per cow per year.[5]

Similarly for each farm, the ton-mileage per cow for the transport of milk was worked out, and also, wherever appropriate, that of farmyard manure.

II. The Results

(i) Quantities of Materials Handled

The average quantities of materials handled per cow, in tons per annum are shown in Table 28[6]. These figures relate to 26 farms where a new cowhouse had been erected and 19 farms with new yard and parlour buildings. Separate figures are shown for these two groups in the first two columns of the table. The main points to notice are as follows.

WEIGHTS OF MATERIALS HANDLED PER COW:
COWSHEDS COMPARED WITH YARDS AND PARLOURS

TABLE 28

Type of Material	Cowsheds	Yards and Parlours	All Buildings
	— — — tons per cow per annum — — —		
Bulk feeds and litter straw	4.5	4.7	4.6
Concentrates	1.4	1.2	1.3
All feeds and litter straw	5.9(1)	5.9(2)	5.9(3)
Milk	4.1(4)	3.7(5)	3.9(6)
Farmyard manure	5.5(7)	—	—

(1) $\sigma = \pm 2.23 : V_\sigma = 37.7$
(2) $\sigma = \pm 1.72 : V_\sigma = 29.2$
(3) $\sigma = \pm 2.04 : V_\sigma = 34.6$
(4) $\sigma = \pm 0.89 : V_\sigma = 21.7$
(5) $\sigma = \pm 0.75 : V_\sigma = 20.3$
(6) $\sigma = \pm 0.85 : V_\sigma = 21.8$
(7) 15 farms only : $\sigma = \pm 0.69 : V_\sigma = 12.5$

4 Theoretically, it would have been possible to introduce a further refinement by relating the ton-mileage of each individual item to the particular mode of transport used. Thus for each farm there might have been "x" ton-miles of hand transport, "y" ton-miles of hand barrow or other similar transport, and "z" ton-miles of tractor transport. However, partly because the survey technique employed was not thought to be well adapted to collecting such information, and partly because choice of transport method is by no means only determined by building layout, this course was not adopted.

5 Note that this differs from the concept of "ton-mileage per cow *in herd*", which would be comparable to the basis on which feed requirements, milk yields, etc., are usually calculated.

6 Calculated on the same basis as "ton-mileages per cow", i.e. per cow *in milk*.

In the first place, of the two main categories of material under consideration, feeding stuffs (including litter straw) and milk, the total weight of the former exceeded that of the latter on the majority of farms.[7] The conclusion to be drawn from this is that where a farm building layout is being planned to minimise the effort of handling materials required for milk production, the arrangements for the handling of feeding stuffs will generally merit a higher priority than the arrangements for handling milk. On farms where the cows are fed a particularly bulky ration, due to the inclusion of a higher than average proportion of feeds such as roots or silage, adherence to this principle will be even more important.

With regard to the handling of farmyard manure, it will be seen that on the 15 farms with cowhouses where, due to building design or for other reasons, the manure was handled twice before being returned to the land, the average weight per cow was estimated to be virtually as great as the average weight of all feeding stuffs and litter straw. This finding is a strong argument in favour of the design of buildings giving ready access to bulk vehicles such as tractor-trailers and manure spreaders so that this double-handling can be avoided. It may also be used as one argument in favour of the yard system of housing for dairy cows.

Secondly, of the two groups into which feeding stuffs have been classified, bulk feeds and litter straw accounted, on average, for over three times as much weight as concentrated feeds. Concentrates, be they purchased or home grown, are usually stored separately from more bulky feeding stuffs such as hay, silage, roots and wet grains, and, not infrequently, storage space is provided for them in close proximity to the cowhouse or milking parlour. Yet a consideration of the relative quantities fed strongly suggests that it is the *bulk* foods which should be stored as near as possible to where they are to be consumed by the cows.

Thirdly, if the figures relating to the farms with cowhouses are compared with those relating to the farms with yards and milking parlours, it will be seen that on average, there was little or nothing to choose between them regarding either the weight of feeding stuffs or the weight of milk handled per cow. On the face of it, the average weight of milk per cow appears to have been a little higher on the farms with cowhouses than on those with yards and milking parlours, but the difference is small and not statistically significant. Moreover, the proportioning of bulk feeds (including litter straw) with concentrated feeds was, on average, about the same in both groups of farms.

There is no evidence then, that the adoption of the yard and parlour system is likely to result in any important changes in the quantities of materials handled, either the input of feeding stuffs or the output of milk per cow.

(ii) Route Distances

The average route distances, for feeding stuffs, milk and farmyard manure, are shown in Table 29. The main points emerging from these results are as follows.

7 Difference between means significant at the 1 per cent level.

Firstly, the route taken by the milk, from the cow to the point of despatch (at the dairy door) was, on average, considerably shorter than the average length of feed route.[8] Yet, as shown in the previous section, the average *weight* of milk per cow was less than the average weight of feeding stuffs per cow. These facts strongly suggest that, generally speaking, the surveyed buildings were not planned so as to minimise effort in the handling of milk and feeding stuffs. In other words, on some of the farms where the new building included a new dairy adjacent to the cowhouse or milking parlour it might have paid better, in terms of reduced time and effort, to have spent the extra money on more convenient feed storage facilities e.g. by the erection of a dutch barn or lean-to hayshed, or the construction of a silo or a pit for brewer's grains in close proximity to the cowhouse or yards. Nevertheless, it is hazardous to generalise, since much depends on the peculiar circumstances of the building layout on individual farms. A conveniently sited dairy may have distinct advantages quite apart from that of reducing the milk transport route to a minimum. The milking process consists of several operations carried on simultaneously; frequent journeys are necessary to keep the cooler going, yet the "machine-on time" must be closely regulated for quick and efficient milking. By contrast, the timing of the principal feed transport operations, which are not closely integrated with actual milking, may be much less critical.

ROUTE DISTANCES: COWSHEDS COMPARED WITH YARDS AND PARLOURS
TABLE 29

Type of Material	Cowsheds	Yards and Parlours	All Buildings
	— — average length of route (feet) — —		
Bulk feeds and litter straw	133	133	133
Concentrates	105	58	85
All feeds and litter straw	124(1)	119(2)	122(3)
Milk	78(4)	36(5)	60(6)
Farmyard manure	70(7)	—	—

(1) $\sigma = \pm 43.2 : V_\sigma = 34.6$
(2) $\sigma = \pm 76.8 : V_\sigma = 64.5$
(3) $\sigma = \pm 60.4 : V_\sigma = 49.5$
(4) $\sigma = \pm 34.6 : V_\sigma = 44.4$
(5) $\sigma = \pm 12.4 : V_\sigma = 34.4$
(6) $\sigma = \pm 34.5 : V_\sigma = 57.5$
(7) 15 farms only : $\sigma = \pm 44.6 : V_\sigma = 63.7$

Secondly, on the farms where farmyard manure was double-handled, the first handling involved, on average, a carry of 70 feet with hand tools (shovel and wheelbarrow, or shovel only). This may be compared with the practice of loading directly to a bulk vehicle in the cowhouse or yard when hand carrying can be virtually eliminated. Hence, designing buildings so that the double-handling of manure can be avoided is advantageous on the grounds of a material reduction in travel as well as the reduced weight to be handled.

8 Difference between means significant at the 1 per cent level.

Thirdly, the average distance over which bulk feeds and bedding straw were carried was no shorter on the farms with yards and parlours than on those with cowhouses. This fact is out of line with current ideas about the planning of yards to simplify the handling of feeding stuffs. On the other hand, during the course of the survey it was observed that bulk feeding stuffs were rarely stored in the immediate vicinity of the yard, and furthermore, few of the yards were planned so that hay, silage, roots and other bulky feeds could be fed without a man, or a man and a vehicle, actually going into the yard.

By contrast, the average distance over which concentrate feeds were carried was considerably shorter on the farms with yards and parlours than on those with cowhouses.[9] On the farms with cowhouses, concentrates were carried, on average, nearly as far as bulk feeds; on the yard and parlour farms the average route distance for concentrates was less than half that for bulk feeds. The most probable explanation for this is that, owing to differences in building size and design, it is generally possible to put the concentrate store nearer to the cows in a milking parlour than in a cowhouse of conventional design. It is the normal practice to feed concentrates in the parlour during milking. Moreover, even the relatively large parlour, with six or eight milking stalls, is a small building compared with all but the smallest of cowhouses.[10] It is also a common practice to put the concentrate store at the back of the parlour immediately adjacent to the passage by which the cows leave their stalls. With this type of arrangement the distance between the concentrate store and the feed hoppers between the milking stalls is minimised. By contrast, with a cowhouse, even if the concentrate store immediately adjoins the milking shed, it is usually placed at one end of the building, so that the average distance between store and manger—i.e. to the manger lying midway along the length of the building—is almost bound to be greater than in the parlour. Naturally, the difference will be most marked as between parlours and the larger-sized cowhouses.

The figures in Table 29 show that a similar situation existed in the handling of milk. Amongst the yard and parlour farms the average length of milk route was only about half that found on the farms with cowhouses.[11] The explanation for this would seem to be very similar to that put forward for the handling of concentrates. Because of differences in building size and design, the dairy can generally be sited nearer to the parlour-milked than to the cowhouse-milked cow.

Hence, amongst the surveyed farms, those with milking parlours generally afforded some advantages to their users in the easier handling of concentrates and milk. However, this finding is somewhat tempered by the fact that as regards the handling of bulk feeds and bedding straw the farmers with yards and parlours were, on average, no better off, in terms of handling distances, than those with cowhouses. Moreover, this should be linked with the fact that

9 Difference between means significant at the 1 per cent level.

10 No cowhouse in the survey had stall accommodation for less than 10 cows

11 Difference between means significant at the 1 per cent level.

the average weight of bulk feeds and bedding straw per cow was over three times as great as the weight of concentrates.

(iii) TON-MILEAGES PER COW

The average ton-mileages per cow per annum, for feeding stuffs, milk and farmyard manure, are shown in Table 30. The figures in this table indicate the magnitude of the transport effort resulting from the combined effects of weight and distance. Consequently, to a large extent, they only add supporting evidence for conclusions already reached in the preceding sections.

The first point to notice is that, on average, the ton-mileage of feeding stuffs far outweighed that of milk. This stems from the fact that, on the majority of farms, not only did the weight of feeding stuffs fed in the buildings exceed the weight of milk produced, but the average distance over which feeding stuffs were moved before reaching the cow was considerably in excess of the distance over which milk was moved between the cow and its despatch point.

Secondly, on farms where farmyard manure was double-handled prior to its removal in bulk from the farmstead, the extra handling involved, on average, about one fourteenth of a ton-mile per cow per annum, or rather more than the ton-mileage attributable to milk.

TABLE 30

TON-MILEAGES PER COW:
COWSHEDS COMPARED WITH YARDS AND PARLOURS

Type of Material	Cowsheds	Yards and Parlours	All Buildings
	— — — ton-miles per cow per annum — — —		
Bulk feeds and litter straw	0.107	0.125	0.114
Concentrates	0.027	0.014	0.022
All feeds and litter straw	0.134(1)	0.139(2)	0.136(3)
Milk	0.062(4)	0.026(5)	0.047(6)
Farmyard manure	0.072(7)	—	—

(1) $\sigma = \pm 0.062$ (4) $\sigma = \pm 0.037$
(2) $\sigma = \pm 0.107$ (5) $\sigma = \pm 0.010$
(3) $\sigma = \pm 0.084$ (6) $\sigma = \pm 0.034$
(7) 15 farms only : $\sigma = \pm 0.047$

Thirdly, taking the 45 survey farms as a single group, the average ton-mileage of bulk feeds and litter straw was five times as great as the ton-mileage of concentrate feeds. On the other hand, if the farmers with cowsheds and those with yards and parlours are considered separately, it will be found that the average difference in ton-mileage between bulk feeds and concentrate feeds was proportionately much greater on the farms with yards and parlours than on those with cowsheds. This result is principally due to the average ton-mileage of concentrates on the yard and parlour farms being only about half that on the farms with cowsheds,[12] whereas the respective average ton-mileages of bulk feeds and litter straw were not materially different.

12 Difference between means significant at the 1 per cent level.

This re-accentuates the conclusion that to the extent that the minimisation of transport effort is an objective in the re-planning of buildings on dairy farms, then the results of this survey suggest that attention should be concentrated on the arrangements for handling bulk feeding stuffs. Moreover, the scope for improvement in this respect would appear to be particularly great on farms going over to the yard and parlour system of housing.

The Relative Importance of Weight and Distance

The ton-mileages per cow shown in Table 30 are averages and they conceal considerable variations between one farm and another. The layout of the buildings on some farms was such that the ton-mileage per cow per annum was much less than the average, and vice versa. Some idea of the extent of this inter-farm variability is revealed by the standard deviations shown at the foot of the table. Thus, for example, on farms with cowsheds, although the average effort expended in the transport of all feeds and litter straw was 0.134 ton-miles per cow per annum, the standard deviation of 0.062 ton-miles indicates that on approximately one third of these farms the individual farm figure was either less than 0.072 or more than 0.196 ton-miles per cow per annum. Similarly, amongst the same group of farms, whereas the average annual ton-mileage per cow attributable to the transport of milk was 0.062, on one third of the individual farms the figure was less than 0.025 or more than 0.099 ton-miles.

The question arises as to which factor had the more decisive influence in causing the variability in ton-mileage, variation in the weight of material handled per cow or variation in route distances ? The answer is that, in general, weights of materials were less variable than route-distances and hence the latter was the more decisive influence. This conclusion is reached from a comparison of the co-efficients of variation[13] of the average weights of materials handled per cow (shown in Table 28) with those of the average route distances (shown in Table 29). The co-efficients of variation are shown alongside the standard deviations at the foot of each table. It will be seen that, with one exception, the co-efficient of variation relating to the average weight of materials handled per cow was smaller than the corresponding co-efficient relating to the average route-distance. For example, amongst the farms with yards and parlours where, on average, 5.9 tons per cow per annum of all feeding stuffs and litter straw were handled, the co-efficient of variation was 29.2, indicating that on approximately two thirds of these farms the *tonnage handled* was within the range of the average weight plus or minus 29.2 per cent. For the same group of farms the average *length of route* for the transport of feeding stuffs and litter straw was 119 feet and the co-efficient of variation 64.5 which is more than twice the magnitude of the co-efficient relating to the tonnage handled. Thus, for this group of farms considered as a whole, variations in feed route-distances were at least twice as

13 The co-efficient of variation expresses the standard deviation as a *percentage* of the average, thus making it possible to compare the magnitude of standard deviations expressed in different units such as tons and feet.

important as variations in the weight of feeding stuffs handled in explaining inter-farm differences in the ton-mileage of all feeding stuffs and litter straw per cow per annum.

Comparisons of variability between weights of materials handled and route distances do not reveal the *degree of association* between each of these factors and ton-mileage per cow. If, on a particular farm, the materials weight per cow was higher than average it would not necessarily follow that the ton-mileage was above average unless the route distance was also high.

The degree of association between interdependent factors may be measured statistically by means of correlation analysis. This technique was employed to examine the degree of association both between ton-mileages per cow and weight of materials handled, and between ton-mileages per cow and average route distances. The results of this analysis are shown in Tables 31 and 32.

DEGREE OF ASSOCIATION BETWEEN WEIGHT OF MATERIALS HANDLED AND TON-MILEAGE PER COW

TABLE 31

Type of Material	Cowsheds	Yards and Parlours	All Buildings
	value of r^2		
All feeds and litter straw	0.14	0.24(1)	0.15(2)
Milk	0.30(3)	0.14	0.29(4)

(1) Significantly different from $r^2 = 0$ at the 5 per cent level.
(2) Significantly different from $r^2 = 0$ at the 1 per cent level.
(3) Significantly different from $r^2 = 0$ at the 1 per cent level.
(4) Significantly different from $r^2 = 0$ at the 1 per cent level.

DEGREE OF ASSOCIATION BETWEEN ROUTE DISTANCES AND TON-MILEAGE PER COW

TABLE 32

Type of Material	Cowsheds	Yards and Parlours	All Buildings
	value of r^2		
All feeds and litter straw	0.56(1)	0.90(2)	0.77(3)
Milk	0.86(4)	0.76(5)	0.88(6)

(1) Significantly different from $r^2 = 0$ at the 1 per cent level.
(2) Significantly different from $r^2 = 0$ at the 1 per cent level.
(3) Significantly different from $r^2 = 0$ at the 1 per cent level.
(4) Significantly different from $r^2 = 0$ at the 1 per cent level.
(5) Significantly different from $r^2 = 0$ at the 1 per cent level.
(6) Significantly different from $r^2 = 0$ at the 1 per cent level.

The values of r^2, the co-efficient of determination, indicate the proportion of the variability in ton-mileage per cow, between one farm and another, which may be attributed to one or other of the two influencing factors. Thus, for example, Table 31 shows a value of 0.30 for the degree of association between the ton-mileage of milk and the weight of milk handled per cow on farms with cowsheds. This means that 30 per cent. of the variability in the ton-mileage of milk per cow, between the farms, was due to differences in the weight of milk handled per cow. By implication, the remaining 70 per cent. of the variability was due to the length of the milk route. On the other hand, Table 32 shows, from the same group of farms, a value of 0.86 for the degree of association between the ton-mileage of milk per cow and the length of milk route (i.e. the distance between the cow and the despatch point at the dairy door). This suggests that no less than 86 per cent. of the variability in the ton-mileage of milk per cow was due to differences between farms in the length of the milk route, and that only 14 per cent. was due to the weight of milk handled per cow.

Obviously these two results are not entirely consistent since 30 per cent. and 86 per cent. add up to more than 100 per cent. This suggests that there may have been some degree of association between the weight of milk handled per cow and the length of the milk route. For example, on the farms with the larger cowhouses where, due to mere building size, the length of the milk route would have tended to be above average, the milk yield per cow might also have happened to be above average. However, this discrepancy is not large either in this case or in making similar comparisons between the remaining pairs of values shown in Tables 31 and 32. The main point is that with regard to both feeding stuffs and milk, the degree of association between route-distances and ton-mileages per cow was considerably higher than the association between weights of materials handled and ton-mileages per cow. Furthermore, this was true both of the farms with cowsheds and of those with yards and parlours.

All of the values shown in Tables 31 and 32 were subjected to tests of statistical significance. Of the six values shown in Table 31 relating to the degree of association between weights of materials handled and ton-mileages per cow, two are too small to be significant. On the other hand, all the values in Table 32 relating to the degree of association between route-distances and ton-mileages per cow are large enough to be highly significant.

FARMSTEAD LAYOUTS

(Discussed in Chapter 4)

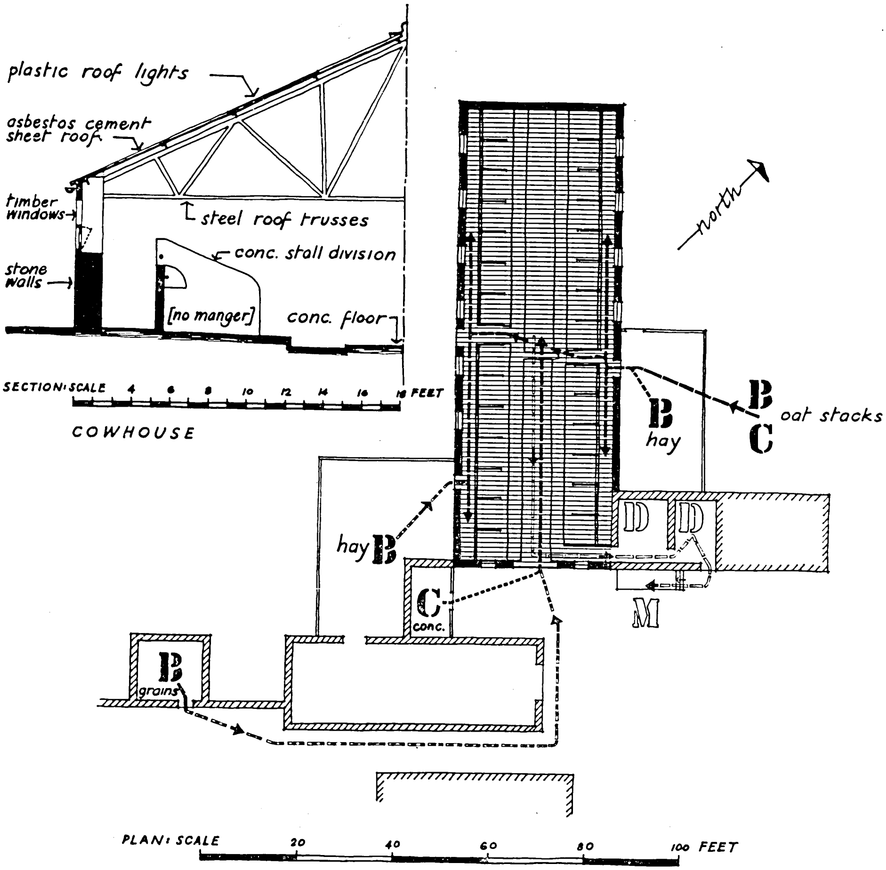

Figure 6: Feed and milk routes on Farm 33.

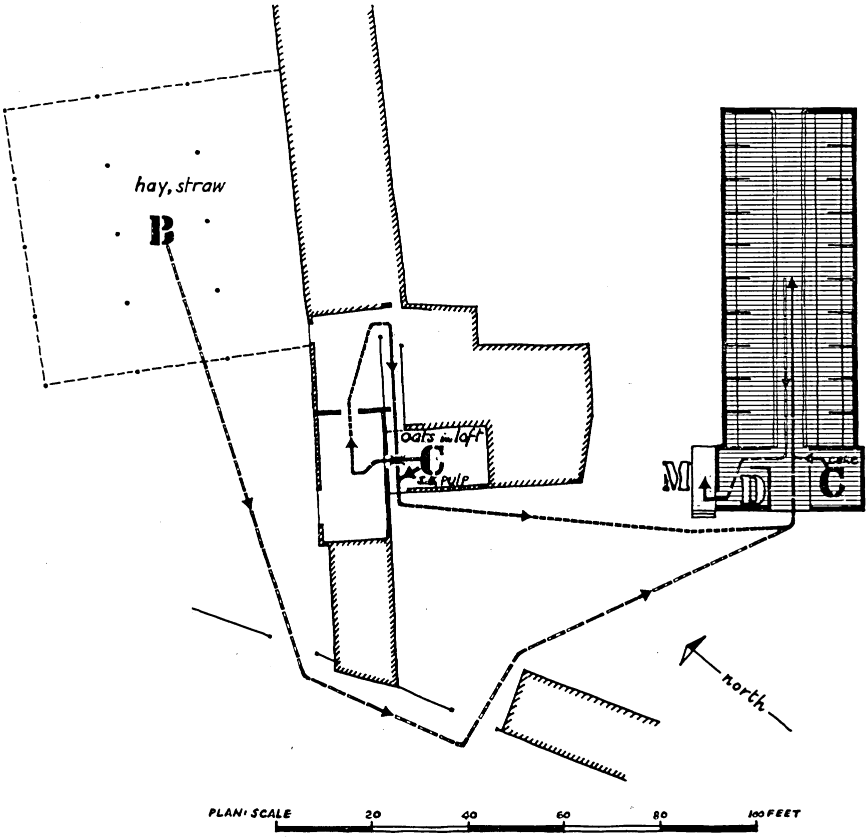

Figure 7: Feed and milk routes on Farm 160.

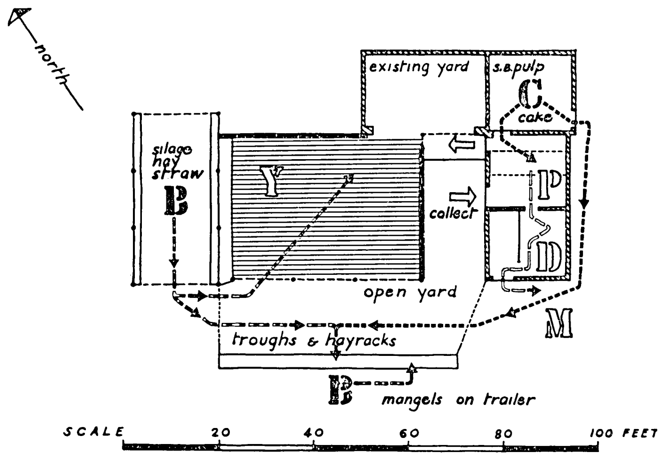

Figure 8: Feed and milk routes on Farm 191.

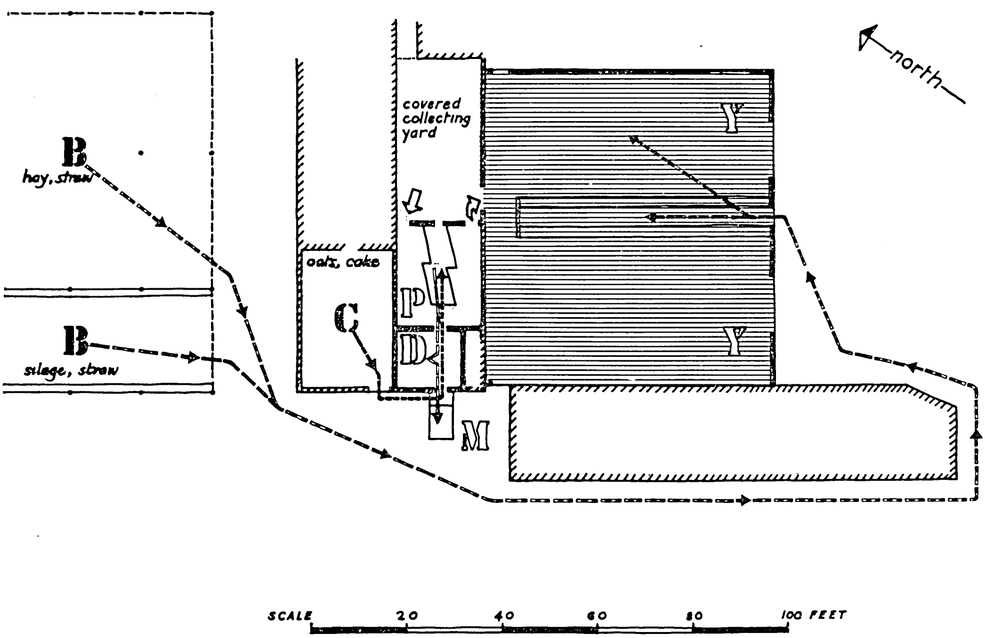

Figure 9: Feed and milk routes on Farm 257.

APPENDIX 5A

STANDARD COSTS

Actual costs were an insufficient basis for detailed analysis of expenditure on the surveyed buildings because:

(i) They did not necessarily reflect different standards of structure, finish, etc.

(ii) They were usually expressed as a total cost for a building, and it was impossible to apportion this between the cowshed proper and ancillary accommodation such as the dairy, feed store, etc.

(iii) For the same reason, it was not possible to isolate the effects on total building costs of particular differences in materials specification and design, such as the employment of unusually expensive items like patent glazing roof lights, facing bricks, lengthy drainage routes, etc.

Many functional characteristics of a building may, with some degree of accuracy, be reduced to quantities of building labour and materials. Thus, for a given number of animals to be accommodated, the roomy building will require more floor, walls and roof than the cramped building. The well-lit building needs more windows but less wall, than the under-lit. If the labour and materials are costed for each unit of building work, then the resulting total cost can be a reasonably objective estimate of the building effort which has been incurred. If, in the preparation of the costings, the "elements" of the structure, e.g. walls, roof, fittings, etc. are calculated separately, more detailed comparisons may be made, and their relative influence on total cost can be seen.

The techniques of "cost analysis" described below are not new, being formulated soon after the war by the Ministry of Education in collaboration with some Local Education Authorities. It is generally acknowledged that over the past few years school building costs have not risen nearly so steeply (per school-place or per square foot of floor area) as have the costs of other building types. Part of the reason for this relative price stability has been the Ministry's keen analytical approach to planning, but another major factor has undeniably been the understanding of the distribution of costs within a building, and the highlighting of expensive items, which cost analysis has provided. Starting with schools, the technique of cost analysis and the associated technique of cost-planning, which is derived from it, have been applied to almost all building types, so that there now exists a substantial literature of illustrated buildings complemented by detailed cost plans. Nevertheless, it is believed this technique has not previously been applied to farm buildings.

There is one major difference between cost analysis as practised for schools, houses, hospitals, factories, etc. and the type of cost analysis adopted here. Other buildings have usually been analysed on the basis of their *actual* costs—either tender cost or final cost—and the details have been worked out with certainty from builders' priced Bills of Quantity. The latter are unusual for farm building work—in fact, more buildings appear to be erected without the aid of the usual descriptive documents than with. An attempt might have been made to obtain cost details from the builders concerned, and this was considered at one stage, but even if the information could have been obtained, it was unlikely that it would have been presented in the same form by different builders. For these reasons it was decided to use "standard" or synthetic building costs, which also appeared to have advantages for other reasons:

(i) All buildings cost analysed could be measured by the same cost yardstick, so that intrinsically greater value ought to be noticeable. Thus, if the standard cost of building A was greater than that of building B (of the same size), it could be expected that building A would represent greater value in terms of building effort, which could be attributed to a higher standard of building design or specification.

(ii) The system could be used to compare buildings erected by different types of labour—e.g. contract and farm.

(iii) The personal idiosyncrasies of estimators could be eliminated (though those of the compiler of the standard costs could not) and it would be possible—if it were ever needed—for other and subsequent work to be cost analysed on exactly the same basis for the purposes of comparison.

Preparation of Standard Cost Analyses

The preparation of standard cost analyses involved the following operations:

(i) A survey of the building, and external works including drainage, during which detailed dimensions were taken.

(ii) Preparation of an outline specification of materials.

(iii) Wherever possible, ascertaining by questions and deduction the nature of work which could not be seen, e.g. depth and width of foundations; sub-floor construction; extent of work involved in making water connections.

(iv) Drawing out the survey; plans and elevations to $\frac{1}{8}$in. scale, typical sections to $\frac{1}{2}$in. scale.

(v) Wherever possible, checking the drawn survey with original plans, specifications, accounts, etc.

(vi) Taking off quantities and working them up on standardised bills of quantity.

(vii) Transfer of data to analysis sheets.

Basis of Standard Cost Prices

It was intended that standard cost prices should be taken from a nationally recognised building price book so that the authority for the figures used should be unquestioned, and identical data would be readily available for anybody wishing to adopt the same techniques. But it was found that the price books most familiar to architects, and also the prices published periodically in the professional press, gave insufficient detail—often none at all—of the types of construction and materials employed in farm building, e.g. pre-cast concrete building blocks, and variations in asbestos cement sheet roofs[1]. On the other hand, though far from ideal on some counts, the War Department Schedule of Prices for Works Services, 1948 ("W.D. Schedule") describes and prices many small details of building construction also found in farm buildings. This was the most comprehensive price guide that could be found, and was adopted as the basis for standard costs. Nevertheless some disadvantages were apparent:

(i) Since the W.D. Schedule was designed primarily for the pricing of maintenance and minor new works costing not more than £1,500, it was to be expected that estimates of work valued at more than £1,500, would be high.

(ii) The basic cost rates have not been amended since 1948, and to bring them up to date a block percentage has to be added to the work of each trade[2]. This complicates calculation.

(iii) Since the percentage rates differ between trades, an item which appears under two trades may have a different cost value in each. For example, under "Concretor," a 6in. concrete floor slab is very much more costly than a 6in. concrete hardstanding of similar specification under "Pavior."

(iv) Where comparison can be made between W.D. Schedule prices and those of other price books, the rates can be extremely varied, up or down (but see below).

1 More recently it has been noticed that detailed, though not complete, cost information of the kind required for this purpose is given in—GRIFFITHS, GEORGE H., *The Provincial and County Builders' Price Book*. (Obtainable from the author at Monks Barn, Lake Grove Road, New Milton, Hampshire).

2 These block percentages are varied from time to time, notification being given in "The Builder". The Percentage Additions adopted for this study were those which applied on the 11th July, 1958, and are as follows:

Section	Trade	Percentage Addition
1	Excavator	158
2	Concretor	125
3	Bricklayer	119
4	Asphalter	65
5	Drainlayer	108
6	Mason	113
7	Pavior and Road-maker	77
8	Roofer	101
9	Asbestos cement goods	98
10	Carpenter and joiner	98
11	Ironmonger	92
12	Ironfounder Smith and Structural Engineer	140
13	Gasfitter	121
14	Plasterer, floor and wall tiler	113
15	Plumber	103
16	Electrician	105
17	Glazier	114
18	Painter and Decorator	118

(v) Not all building components common in agriculture, e.g. agricultural pattern steel windows, cow-stall equipment, sliding door gear, etc., are described or priced. This limitation is common to all published price guides. Where this occurred, prices were taken from some other authority, or quotations were obtained from manufacturers or suppliers[3].

Variations in Costs for the Same Work

The costing of building work is not an exact science—if it were, there would be no point in competitive tenders. Two builders estimating for the same job can tender widely different quotations and this may be due to many variables, subjective as well as objective. It is one of the purposes of this study to attempt an explanation of these variables, but it need not cause surprise if unit prices for similar work are markedly different, whether they appear in published price guides or actual tenders for building work.

In Table 33, comparisons are made between "standard cost" unit prices, rates for similar work quoted by authorities other than the W.D. Schedule, and unit prices extracted from a number of actual Bills of Quantity. It can be seen that "standard cost" unit prices for some types of work (e.g. excavation, and 4in. concrete slab, etc.) appear roughly in the middle of the range of prices obtained from the various sources. On the other hand, for other items (e.g. hardcore fill, foundation concrete, and brickwork) "standard cost" unit prices are comparatively high, and there are no items regarding which they are conspicuously low. It can, therefore, be expected that when based upon "standard cost" unit prices, the estimated costs of complete buildings might tend to be rather high compared with estimates based on other price data, the degree of cost inflation depending upon the relative proportions of various trades incorporated in different buildings.

Method of Analysis

Following closely upon, but simplifying, the cost analyses described and published regularly in, for example, the "Architects Journal," the building is broken down into "Elements," which are defined as "parts of a building which more or less always perform the same function or functions irrespective of construction"[4]. The standard costs of each element are then calculated from the sum total of priced items of building work they contain. Thus the element "Walls" consists of the volume of pre-cast concrete blocks or the area of brickwork of various thicknesses (with additions for piers and other accretions, and deductions for door and window openings) multiplied by the appropriate prices per cubic foot (for block) or per super yard (for brick); to these are added additional sums if facing bricks are used, and so on.

3 Where the W.D. Schedule description approximated to the work found in farm buildings, the W.D. Schedule rates were approximated.

4 MINISTRY OF EDUCATION. *Cost study*. Building Bulletin No. 4 (2nd edition). H.M. Stationery Office. 1957.

COMPARISON OF TYPICAL "STANDARD COST" UNIT PRICES AND RATES FOR SIMILAR WORK OBTAINED FROM OTHER SOURCES

TABLE 33

Description of Work	Unit measure-ment	Standard Cost	Cambridge University, Dept. of Estate Management	Published Price Guides			Prices obtained from Priced Bills of Quantities for Actual Work					
							For Farm Buildings				For Schools	
				No. 1	No. 2	No. 3	1 (1951)	2 (1952)	3 (1953)	4 (1957)	1 (1953)	2 (1955)
		s. d.	s. d.	s. d.	s. d.	s. d.	s. d.	s. d.	s. d.	s. d.	s. d.	s. d.
General excavation to reduce levels	YC	7 4	As "S.C."	9 9	10 0	13 9½	7 0	6 3	—	—	—	3 3
Excavate for strip founds. n/e 5′ 0″	YC	9 8	As "S.C."	13 5	11 10	10 9	7 0	8 7	7 10	12 0	10 0	16 9
Return, fill and ram	YC	4 11	As "S.C."	4 3	5 0	6 8½	7 0	3 5	3 5	3 0	4 0	6 9
Throw excavated materials into building area as filling, spread, level and ram	YC	2 9½	As "S.C."	—	—	—	7 3	—	6 6	3 6	—	—
Hardcore fill.	YC	48 4	27 6	21 9	22 0	—	—	20 0	—	—	—	31 0
Concrete 1 : 8 in strip founds.	YC	90 7	75 6	67 4	71 6	76 11	57 3	58 0	65 0	88 0	65 0	—
9″ Common Brickwork in cement mortar	YS	43 3	42 6	33 3	36 2	—	26 0	25 3	28 0	38 0	41 0 (Class B)	52 3 (Class B)
11″ Cavity Brickwork	YS	50 4	45 6	39 2	43 10	—	—	—	29 0	39 0	28 9	—
Hardcore 4″ thick	YS	6 3	4 6	3 6½	3 3	3 8	2 3	4 6	2 10	3 0	2 3	—
4″ Concrete 1 : 2 : 5 slab	YS	12 8	10 6	9 4	13 11	9 10	7 6	8 3	9 0	15 0	8 0	—
9″ brickwork in gauged mortar	YS	41 0	36 6	39 2 (pointed)	42 2 (pointed)	33 2	26 0	29 6	28 0	36 0	28 9	—
Softwood roof trusses, purlins, etc.	FC	22 1	24 6	{22 3 / 20 3	26 6	23 8	—	—	21 6	20 0	—	—
Large section A.C.S. fixed to timber	Square	143 6	} W.D. Schedule less 12 per cent	123 0	—	126 6	90 0	—	—	—	—	—
Angular section A.C.S. fixed to steel	Square	153 11		—	—	132 0	—	107 6	—	—	—	—
⅝″ Cement render	YS	7 0	—	6 5	8 3	6 4½	4 6	3 4	4 0	7 0	5 6	—
5″ H.R. A.C. gutter	FR	3 4	} W.D. Schedule plus fittings	2 11	—	3 6½	1 10	—	4 9	2 3	—	—
3″ A.C. R.W.P.	FR	4 0		3 7	—	3 6½	2 0	3 9	4 6	3 0	—	—
¾″ dia. galv. water pipe fixed to walls	FR	2 10	—	2 8	—	2 9½	1 9	2 6	2 10½	—	3 4 (copper)	—
Excavating and reinstating drain trenches:												
av. 2′ 0″ deep	FR	3 6	2 10	2 7	2 8	1 8½	—	3 5	3 8	1 8	2 8	3 5
av. 3′ 0″ deep	FR	5 10	4 2	5 5	7 0	2 11½	—	6 0	—	2 6	2 0	5 6

Knowledge of actual costs was usually confined to a total for a building, irrespective of whether it was a cowshed only, or contained, in addition, ancillary accommodation such as a dairy. Apart from splitting the building into elements, each element was in turn split to show first, the standard cost of providing that element for the cowshed and secondly, the extra standard costs involved (after completion of an independent cowshed) in respect of, and separately for, dairy, feed store and "other accommodation". Dairies included washing and sterilising rooms, any covered porches attached thereto, built-on milk stands, and boiler or motor rooms. Feed stores were usually little more than simple rooms in which cake was stored. "Other accommodation" included loose boxes, offices and other spaces which were not directly used for the milking herd. The sums of elements for the cowshed, dairy, feed-store and "other accommodation" were totalled.

The total cost of each element was divided by the internal floor area of the particular space to which it related to give the standard cost per square foot, and by the number of cow standings to give the standard cost per cow. The proportionate standard cost of each element for each of the building spaces was also expressed as a percentage of the total standard cost.

Finally, for each spatial division of the building, groups of elements were totalled to provide summarised standard costs for:

(1) Ground and Site Works.
(2) Substructure, i.e. walls and upper floors.
(3) Superstructure, i.e. roof.
(4) Services, i.e. electricity and water supplies, and rainwater disposal.
(5) Finishes and Fittings.

Limitations of the Standard Cost Technique

It will be as well to state the limitations of the technique as developed for this study:

(i) Experience of cost analysis techniques, though growing, is limited to a comparatively few architects and quantity surveyors. The preparation of cost analyses is usually the work of a quantity surveyor and they are normally used by an architect advised by a quantity surveyor. The standard cost analyses developed here for farm buildings were prepared by an architect with little experience of professional cost analysis.

(ii) Cost analyses are normally abstracted from detailed working drawings and priced Bills of Quantity—information which should, at least in theory, be sufficient to enable a contractor to erect and complete a building without additional instructions and other guidance. The farm building standard costs were prepared from information obtained by examining the completed building. Many assumptions had to be made, and the Bills of Quantity were "Approximate Quantities" in the sense known to architects and surveyors — i.e. items were measured but many refinements of the quantity surveyor's art were omitted.

(iii) The system of measuring work followed that of the W.D. Schedule and differed from the otherwise generally adopted system[5].

(iv) The unit costs are synthetic and, as such, do not necessarily represent what a builder might tender for the work. Additionally, unit costs of some items appear to correspond to prices of similar work elsewhere, while some are higher. This may provide an unsought loading for some elements.

(v) No allowances were made for variations in quality of workmanship or materials.

(vi) The techniques employed to produce standard costs are, of necessity, involved, laborious, and time consuming.

(vii) Where it was neither possible to measure building work, nor to obtain reasonable-seeming circumstantial or hearsay evidence, constructional details had to be assumed. The principal assumptions were as follows:

(a) Foundation trenches 2ft. 0in. wide, 2ft. 6in. deep from ground level, concrete footings 2ft. 0in. wide and 6in. deep, with walls below ground level the same thickness and material as above.

(b) Concrete floors 6in. thick on 6in. hardcore: width measured between internal faces of walls, following the "girth" of the floor section. No shuttering measured.

(c) Nett area of wall deducted for openings such as doors and windows. Lintols and cills measured as wall, i.e. normally brick or block.

(d) Internal decorations not measured unless there was strong evidence that they were included in the contract.

(e) Water supply pipes 2ft. 6in. deep.

(f) $4\frac{1}{2}$in. walls, unless occurring externally, built off the concrete floor.

(g) Painted steel windows galvanised, unless rust gave evidence proving otherwise.

(h) Drain pipes laid direct to earth.

(i) Joinery prepared, primed, painted two undercoats and one finishing coat unless condition suggested a less complete treatment.

(j) Electrical circuits: only lighting measured: power circuits excluded. No allowance made for connection of service to building.

(k) External concrete paving: 6in. topsoil stripped, paving formed of 6in. concrete on 4in. hardcore.

(l) Lengths of drain pipes and gullies measured, but not bends, branches, etc.

5 *Standard Method of Measurement of Building Work*. The Royal Institution of Chartered Surveyors and the National Federation of Building Trades Employers. July, 1948. 4th Edition. Reprinted with Supplements, September, 1957.

LIST AND DESCRIPTION OF ELEMENTS

GROUND AND SITE WORKS

Work Below Floor Level

Removal of topsoil
All excavation
Disposal of soil
Hardcore or earth fill under floors
Concrete foundations
Walls up to floor level
Floor slab
Damp proof course
Insulation under cow standings
Integral floor finish, e.g. grano-topping
External water main between point of connection to existing supply and new building
Milk-stand when attached and forming part of building

Drainage

Excavation and reinstatement of trenches
All drain runs
Concrete surround to drains under buildings
Gullies
Manholes
Sewer connections
Soakaways
Settling tanks

Paving

Removal and disposal of topsoil
Hardcore filling
Concrete paved areas
Milk-stands when not attached to building

Fencing

Fences and walls
Gates

SUBSTRUCTURE[6]

Walls

External and internal walls from floor level to eaves
Facing bricks
Cills if an important item and not occurring only in separate windows

Windows

Windows
Glazing
Painting

Doors

Doors
Frames
Door-tracks
Painting

Upper floors, etc.

Supporting beams and joists
Timber or concrete floors
Timber or concrete steps

SUPERSTRUCTURE

Independent Structural Frame

Steel or pre-cast concrete portal frames and purlins

6 This term is adopted following its previous use in connection with farm buildings by Denman and Rathbone of the University of Cambridge, Department of Estate Management. Its use is more generally confined to work below ground.

Roof

Roof trusses, purlins, rafters, wind-bracing
Tiling battens
Wall plates
Fascias and soffits
Roof sheeting
Roof tiling
Ridge capping and ventilators
Concrete slab roofs
Ceiling joists
Walling above eaves level when used to support roof

Roof Lights

Corrugated perspex roof lights
Asbestos cement dead lights
Wired glass
Patent glazing
Windows above eaves level in gables including glazing and painting

SERVICES

Rainwater disposal

Gutters
Rainwater pipes
R.W. heads
Valley gutter construction and lining

Cold Water Fitting

Rising main from point of entry to building
Cold water storage tanks
Supporting steel work for water storage tanks
Supply pipe to draw off points and water bowls
Stop cocks and wash down taps
Drinking bowls

Electrical

Lighting circuits complete
Light fittings

FINISHES AND FITTINGS

Finishes

Cement rendering
Wall tiling
Skirtings
Ceiling linings

Decorations

Finishes such as cement washing or distempering which have no preservative functions

Fittings

Stall divisions
Mangers
Tie chains or yokes
Manger barriers (where feeding passage provided)
Gantries

COST ANALYSIS OF SURVEY BUILDINGS

A description of the cowhouses to which the techniques of cost analysis were applied is given in Chapter 1.

The average standard cost of individual building elements and groups of elements, within each of the cowhouse size groups covered by the survey are shown in Table 34.

AVERAGE STANDARD COSTS OF BUILDING ELEMENTS IN COWHOUSES WITHIN DIFFERENT SIZE GROUPS

TABLE 34

Group	Elements	Size of Buildings											
		10—14 Standings			20—29 Standings			40 or more Standings			All Sizes		
		Shgs. per sq. ft.	Per cent	£'s per cow	Shgs. per sq. ft.	Per cent	£'s per cow	Shgs. per sq. ft.	Per cent	£'s per cow	Shgs. per sq. ft.	Per cent	£'s per cow
Finishes and Fittings	Fittings	2.51	9.46	6.95	3.09	11.27	8.32	2.92	12.15	7.96	2.79	10.78	7.64
	Decorations	0.05	0.19	0.15	0.02	0.06	0.04	0.01	0.02	0.02	0.03	0.10	0.08
	Finishes	0.55	2.04	1.51	0.40	1.51	1.11	0.26	1.02	0.70	0.42	1.58	1.15
	Group Total	3.11	11.69	8.61	3.51	12.84	9.47	3.19	13.19	8.68	3.24	12.46	8.87
Services	Electrical	0.39	1.52	1.07	0.41	1.51	1.14	0.28	1.15	0.77	0.36	1.40	1.00
	Cold Water Fitting	1.52	5.49	4.16	1.36	4.87	3.67	1.24	5.12	3.33	1.39	5.20	3.77
	Rainwater Disposal	0.45	1.60	1.26	0.30	1.09	0.80	0.25	1.03	0.67	0.34	1.29	0.95
	Group Total	2.36	8.61	6.49	2.07	7.47	5.61	1.77	7.30	4.77	2.09	7.89	5.72
Superstructure	Roof Lights	0.52	1.89	1.38	0.65	2.39	1.69	0.74	2.98	2.09	0.62	2.36	1.68
	Roof	4.68	17.52	13.23	5.06	18.27	14.34	4.41	18.38	11.98	4.70	17.99	13.16
	Independent Structural Frame	—	—	—	0.37	1.71	0.85	0.42	1.39	1.29	0.23	0.90	0.63
	Group Total	5.20	19.41	14.61	6.08	22.37	16.88	5.57	22.75	15.36	5.55	21.25	15.47
Substructure	Upper Floor and Stairs	—	—	—	—	—	—	—	—	—	—	—	—
	Doors	1.02	3.75	2.98	1.45	5.39	3.81	0.87	3.63	2.39	1.10	4.17	3.03
	Windows	0.61	2.33	1.76	0.24	0.86	0.70	0.15	0.59	0.40	0.37	1.39	1.05
	Walls	5.34	19.63	15.16	3.75	13.23	9.92	3.79	15.72	10.28	4.42	16.66	12.21
	Group Total	6.97	25.71	19.90	5.44	19.48	14.43	4.81	19.94	13.07	5.89	22.22	16.29
Ground and Site Works	Fencing and Gates	—	—	—	—	—	—	0.02	0.12	0.06	0.01	0.04	0.02
	Paving	1.24	4.05	3.57	1.76	5.40	4.36	0.92	3.93	2.47	1.29	4.39	3.45
	Drains	2.12	7.00	5.66	1.91	6.41	4.97	1.59	6.37	4.39	1.90	6.65	5.08
	Work below floor level	6.32	23.53	17.94	7.13	26.03	19.37	6.36	26.40	17.30	6.56	25.10	18.14
	Group Total	9.68	34.58	27.17	10.80	37.84	28.70	8.89	36.82	24.22	9.76	36.18	26.69
	Total Standard Costs	27.32	100.0	76.78	27.90	100.0	75.09	24.23	100.0	66.10	26.53	100.0	73.04
	Number of buildings surveyed	15			10			11			36		

APPENDIX 5B

STATISTICAL ANALYSIS OF THE RELATIONSHIP BETWEEN BUILDING COSTS AND PLANNING AND DESIGN DECISIONS

1. Normalisation of Building Costs

All actual building costs collected during the course of this enquiry were "normalised" to September 1959. This adjustment was desirable for two reasons; firstly, to put buildings erected at different dates on a comparable cost basis, and secondly, to show as nearly as possible the estimated cost of erecting the same or closely similar buildings at current (September 1959) building prices.

The cost normalising factors, very kindly supplied by R. A. Rathbone of the University of Cambridge Department of Estate Management, are given below. They are based on the trend of costs for council houses in rural areas worked out by Rathbone with information from a number of sources.[1]

Year of Erection	Cost Normalising Factor
1959 (September)	1.000
1958	1.006
1957	1.016
1956	1.029
1955	1.043
1954	1.070
1953	1.093
1952	1.133
1951	1.172

2. The Effects of Cowhouse Planning and Layout Decision on Building Cost per Cow.

The separate effects of the number of rows, the incorporation of a feeding passage and the incorporation of ancillary buildings (dairy and/or feed store) on the normalised cost per cow were examined with the aid of variance analysis. Details of the groups of buildings subjected to analysis are shown in the table below, and this is followed by a summary of the results.

1 The sources included the following:
COMMITTEE OF INQUIRY (J. G. GIRDWOOD, CHAIRMAN). *Cost of House Building*. Reports published by Ministry of Housing and Local Government. 1948, 1950 and 1952.
INSTITUTE OF MUNICIPAL TREASURERS AND ACCOUNTANTS (INC.) *Housing Statistics*. (Various dates).
LOCAL GOVERNMENT AUTHORITIES, HOUSING DEPARTMENTS (VARIOUS). Annual Statistics.
SPON, E. & F. N. *Architects' and Builders' Price Book*. (Annual issues).
BUILDING RESEARCH STATION. *Confidential report. No. C384*.

THREE-WAY ANALYSIS OF BUILDING COST PER COW
ACCORDING TO PLANNING AND LAYOUT

TABLE 35

No. of cowhouses surveyed	(X_1) Average normalised cost per cow (£'s)	(X_2) Rows	(X_3) Feeding passage	(X_4) Ancillary buildings
22	88.09	Single	With	With
12	81.00	Single	With	Without
23	77.30	Single	Without	With
9	58.56	Single	Without	Without
27	82.41	Double	With	With
17	61.53	Double	With	Without
45	78.16	Double	Without	With
18	59.50	Double	Without	Without

Variance Ratios[1]

Relationship	Sum of squared deviations	Degrees of freedom	Variance	'*F*'
Due to number of rows (X_2)	68.15	1	68.15	1.57(2)
Due to feeding passage (X_3)	195.13	1	195.13	4.50(3)
Due to ancillary buildings (X_4)	534.15	1	534.15	12.31(4)
Within Groups	7,157.50	165	43.38	—

(1) Since none of them were significant, the variance ratios of the interactions between the independent variables have been omitted.
(2) Not significant.
(3) Significant at the 5 per cent. level.
(4) Significant at the 1 per cent. level.

Conclusions

The incorporation of a feeding passage or of ancillary buildings both tended to enhance the normalised cost per cow. On the other hand, there is no evidence that the costs of single-row cowhouses were significantly different from those of double-row buildings, when the other variables were held constant.

The cost data shown in Table 35 can therefore be simplified as shown in Table 36.

TWO-WAY ANALYSIS OF BUILDING COST PER COW
ACCORDING TO PLANNING AND LAYOUT

TABLE 36

No. of cowhouses surveyed	Average normalised cost per cow (£'s)	Feeding passage	Ancillary buildings
49	84.96	With	With
29	69.59	With	Without
68	77.87	Without	With
27	59.19	Without	Without

Alternatively, holding only one of the variables constant at a time, the average cost data are as shown in Table 37.

ONE-WAY ANALYSIS OF BUILDING COST PER COW ACCORDING TO PLANNING AND LAYOUT

TABLE 37

Planning or Layout	Average normalised cost per cow (£'s)
With feeding passage	77.27
Without feeding passage	68.53
With ancillary buildings	81.41
Without ancillary buildings	64.39

Here, the group average costs are *unweighted* averages of the appropriate pairs of values in Table 36.

3. CORRELATION BETWEEN THE STANDARD COSTS OF ELEMENT GROUPS AND OVERALL STANDARD COSTS PER COW.

The standard costs per cow of each of the five element groups, detailed in Part A of this appendix, were correlated in turn with the overall standard costs per cow. The simple correlation coefficients were found to be as follows :—

Element Group	'*r*'
Ground and site works	+ 0.81
Substructure	+ 0.89
Superstructure	+ 0.81
Finishes and fittings	+ 0.70
Services	+ 0.73

All of the above coefficients were significantly different, at the 1 per cent. level, from $r=0$.

Conclusion

The more costly buildings tended to be relatively expensive with respect to all of the principal groups of building elements.

APPENDIX 6

STATISTICAL ANALYSIS OF THE RELATIONSHIP BETWEEN BUILDING COSTS AND CHOICE OF BUILDING METHOD

1. Significance of the Difference in Mean Cost per Cow between Cowhouses Erected by Building Contractors and those Erected by Other Methods.

Actual difference between means : £17.4 per cow.

Standard error of the difference : $\pm$ £4.3

With 27 degrees of freedom, the actual difference is significant at the 1 per cent. level.

2. Correlation between Adjusted Standard Cost and Normalised Cost per Cow.

$$r = +0.89 \qquad r^2 = 0.79$$

Correlation coefficient significantly different, at the 1 per cent. level, from $r = 0$.

Conclusion

A relatively high proportion of the variance in the actual costs of cowhouses (per cow) is explainable in terms of the factors causing standard costs to vary.

APPENDIX 7

STATISTICAL ANALYSIS OF THE RELATIONSHIP BETWEEN BUILDING COSTS AND CONTRACT PROCEDURE

This relationship was examined by means of variance analysis, and a summary of the results is given below.

Building costs are expressed in terms of *adjusted cost* per cow. This represents the estimated normalised cost of the cowhouse *net* of the extra costs of ancillary accommodation (dairies and feed stores).

The analysis of the standard costs of 36 new cowhouses showed that where a new dairy was incorporated with a new cowhouse, its separate cost was typically about 15 per cent. of that of the entire building: similarly, a new feed store typically represented about 9 per cent. of the total cost.

In order to obtain the adjusted cost per cow, the normalised cost of each new cowhouse with ancillary accommodation was therefore reduced by 15 per cent. if it included a new dairy, 9 per cent. if only a new feed store, and 24 per cent. if the building incorporated both these extra facilities.

The variance analysis involved 104 new cowhouses, all of which were erected by a building contractor. The results were as follows :

Variance Ratios

Relationships	Sum of Squared Deviations	Degrees of Freedom	Variance	'F'
Due to Type of Information to Builder (X_2)	0.76	1	0.76	0.01(1)
Due to Number of Quotations sought (X_3)	94.74	1	94.74	0.92(1)
Due to Form of Agreement (X_4)	389.90	1	389.90	3.80(1)
Due to Interaction between (X_2) and (X_3)	35.92	1	35.92	0.35(1)
Due to Interaction between (X_2) and (X_4)	408.85	1	408.85	3.98(2)
Due to Interaction between (X_3) and (X_4)	0.19	1	0.19	..
Due to Interaction between (X_2), (X_3) and (X_4) ...	1.68	1	1.68	0.02(1)
Within Groups	9,852.44	96	102.63	—

(1) Not significant.
(2) Significant at the 5 per cent. level.
.. Less than 0.01.

Conclusions

The general conclusion is that none of the three factors considered had an independent effect on the cost of the cowhouse. On the other hand, the interaction between the type of information given to the builder and the form of agreement between owner and builder, appeared to have a significant effect on the cost of the building. The average adjusted costs per cow of the buildings in each of the four categories involved are shown below.

TWO-WAY ANALYSIS OF BUILDING COST PER COW ACCORDING TO CONTRACT PROCEDURE

TABLE 38

Type of Information given to the Builder	Verbal Agreement		Written Agreement	
	No. of buildings	Av. adjusted cost per cow (£'s)	No. of buildings	Av. adjusted cost per cow (£'s)
Verbal Statement or Plan	38	66.2	24	65.5
Written Specification or Bill of Quantities	3	52.0	39	75.1

The costs shown in this table are the unweighted means of the appropriate pairs of group averages taken from Table 19 in Chapter 7, i.e. pairing, so that the number of quotations was held constant in each case.

The average cost per cow shown in the bottom left hand cell of the table is of very doubtful validity due to the very small number of buildings involved. On the other hand, it appears that where a written specification or bill of quantities was combined with a written agreement between the owner and the builder, the average cost per cow was somewhat higher than where the instructions given to the builder were confined to a mere verbal statement of the owner's requirements or a plan of the building. But it is not at all certain that this relationship represents cause and effect. In those instances where a written specification or bill of quantities was employed, the buildings may generally have been larger or of a more elaborate design than where the builder was given less exacting instructions.

APPENDIX 8

STATISTICAL ANALYSIS OF THE RELATIONSHIP BETWEEN BUILDING COSTS AND THE RETURN ON THE INVESTMENT

1. SIGNIFICANCE OF THE MEAN DIFFERENCES IN ESTIMATED ANNUAL GROSS INCOME AND TOTAL BUILDING COST BETWEEN COWHOUSES IN THE HIGH/HIGH/LOW AND LOW/LOW/HIGH GROUPS.

(a) *Annual Gross Income*		
Actual difference between means	:	£2,751
Standard error of the difference	:	±£1,092
(b) *Total Building Cost*		
Actual difference between means	:	£1,157
Standard error of the difference	:	±£ 437

With 13 degrees of freedom in each case, the actual differences are both significant at the 5 per cent. level.

Hence the mean difference between the two groups in the estimated rate of gross return on new building investment must also be significant.

2. CORRELATION BETWEEN BUILDING SIZE (TOTAL CAPACITY), TOTAL COST OF ERECTION AND POTENTIAL ANNUAL GROSS INCOME FROM MILK PRODUCTION.

$R = 0.91$ $R^2 = 0.83$

The partial correlation coefficients are:

$r_{12.3} = +0.89$ $r_{13.2} = -0.03.$

where

X_1 = Potential Annual Gross Income from Milk Production.

X_2 = Building Size (total capacity).

X_3 = Total Cost of Erection.

The value found for $r_{12.3}$ is significantly different at the 1 per cent. level from $r_{12.3} = 0$. The value found for $r_{13.2}$ is not significant.

Conclusion

There was a high positive correlation between the potential annual gross income from milk production and building size. Variations in the total costs of erection, with building size held constant, appeared to be unassociated with variations in potential annual gross income.

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