An investigation into the feasibility and viability of the mechanisation of a bedding warehouse

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AN INVESTIGATION INTO THE FEASIBILITY AND VIABILITY OF THE MECHANISATION OF A BEDDING WAREHOUSE.

by

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The following companies willingly gave permission to reproduce photographs from their brochures:

Handling Equipment Ltd. (Fig.9).

psb Systemtechnik AG. (Fig,8).

Rapistan Lande. (Fig. 10.and Fig.12).

Rolatruc Ltd. (Fig.11).

Other companies willingly allowed me to visit their warehouses installations; these are listed in the Bibliography. To these companies I express my grateful thanks.

ABSTRACT.

An Investigation into the Feasibility and Viability of the Mechanisation of a Bedding Warehouse.

by G.N. Hindley.

The aim of the project was to examine various mechanical and automated warehousing systems and identify those that would be appropriate to the handling of beds in Silentnight's factory at Barnoldswick. In order to undertake this study the requirements of the future warehousing system were examined. The warehouse system is to be capable of handling the projected 1986 distribution volumes and on a peak despatch day this equates to the handling of 4,049 individual pieces over a 7½ hour period (The Company operates on a two shift system). The way the warehouse system interacts with the Production Department and the vehicle delivery system was studied, and it was found that what was needed was an efficient load assembly system. The Company have a policy of holding little or no stock, production being in direct response to orders received.

Once the requirements of the 1986 situation were known a detailed investigation of a wide variety of automated and mechanical handling equipment was undertaken to see if they could be applicable in this particular instance, On close examination only five systems were found to be feasible. The systems so identified ranged along a continuum from full automation through mechanised to those being entirely manual in operation.

The five warehousing systems were costed. Their capital costs and labour costs greatly differed. The schemes were finandially evaluated over a 4 year and a 10 year period using a variety of techniques. These techniques all gave a consistent result. The scheme which demanded least automation and mechanisation proving to be the most cost effective; the fully automated stacker crane system being the most uneconomic of the five.

The basic reason for this conclusion is that what is demanded in this case is a purpose designed load assembly system, not a conventional warehouse. Automation and mechanisation have so far only successfully embraced the conventional warehousing functions of storage and retrieval,not yet the load assembly operation, except in a few very specialised cases.

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INTRODUCTION

INTRODUCTION

1.1 WAREHOUSING

Various definitions have been put forward as to what warehouses are and why they should exist. They all have in common the fact that the warehouse acts as a store. Benson and Whitehead state "the warehouse exists chiefly as a storehouse where goods not currently required can be safely stored and cared for until required. It smoothes out fluctuations in supply and demand".

The need for a warehouse to exist cannot be seen in the context of warehousing alone; it is obvious from the above statement that warehouses exist to serve, not to be served. Burton when asking the question, "What is warehousing?"; gives some insight as to whom the warehouse may exist to serve. He states that in examining warehousing one must look well beyond the warehouse and examine the needs of the whole organisation. Warehousing is called into being by a great variety of needs and is therefore seen as an integral part of a business organisation and will rarely if ever exist as an end in itself. "The warehouse is a bridge between production and the customer and effective warehousing is a matter of matching the needs of the organisation with an appropriate and efficient service, neither too large and expensive, nor too small and ineffective".

The latter part of the above statement touches upon that most important part of finance; a warehouse must obviously be economic to operate and not a drain on company resources. Goods in a warehouse are only there to be stored, not to be processed or have value added to them. A common view of a warehouse from a financial standpoint is often quoted to be that "warehousing is just an overhead, in that it adds nothing of value to the product, and accruing only costs".

Bowersox sees the warehouse in the wider context of the total business organisation. Here emphasis is placed more on product flow as opposed to discrete processes. He defines a warehouse as "a specialised fixed facility included in the design of a logistical system to help accomplish the desired level of delivery service at the lowest total cost. Unless utilization of a warehouse meets this objective there exists no justification for the operation of such a facility". Bowersox is obviously looking at the warehouse in terms of product flow in contrast to storage. Stated simply "a warehouse should merely consist of a set of walls enclosing an efficient handling system".

The warehousing organisation therefore can be seen to exist to bridge the gap between the economic methods of production and the needs of the customer. "The task is to provide what is required, when it is required, in the condition in which it is required, and to do all these things economically.

Warehouses exist essentially to allow supply to be uncoupled from production, therefore allowing distribution and production to be undertaken in their own best ways. Warehousing is generally recognised as being part of Physical Distribution Management. This has been defined as "A term employed in manufacturing and commerce to describe the broad range of activities concerned with the efficient movement of finished products from the end of the production line to the consumer ... ... these activities include warehousing". (1962, National Council of Physical Distribution Management).

The relative necessity for holding stock, like all the other activities of the organisation, must be decided by hard economics. The cost difference in providing what is normally supplied and what might be required is very great indeed and is subject to the "law of decreasing returns".

Efficiency in the warehouse, starts with planning for the need, and this presupposes that the need itself can be forecast with some accuracy. Clearly this forecasting process must be subject to review and to the periodic resetting of the scale of operations. The art of warehousing is largely that of matching the resources to be used against the actual need and of controlling these resources. Time is a gap to be bridged and the size of stocks is proportional to time. Clearly an efficient warehousing operation depends upon an adequate understanding of the needs of the whole organisation and cannot be dealt with in terms of stock control, or distribution, or as an extension of the needs of production or of the accountant, although all these points of view are relevant. It is necessary to examine all the factors which bear upon our subject, so that one can properly assess the needs of the organisation which the warehouse will serve, thereby arriving at not just an efficient warehousing function but an economic function which meets the needs of all the users of the service.

In essence the task of Physical Distribution can be seen to be deceptively simple. It is to move goods from the end of the production line to the customer in an acceptable time and to do so economically. Obviously economy of operation is the key to an efficient warehouse and therefore there is a need to seek out the least expensive way. This involves the principle of minimum movement for by limiting the need to move an item this saves money because handling charges are not being incurred, regardless of whether those charges arise from mechanical or manual handling or a combination of both.

The need to consider the storage problem as an integral part of the total operation increases as space becomes more expensive and as more companies adopt the total logistics approach to these areas. So much of the handling of goods occur because of problems of trying to link together the various stages of production, storage and distribution to avoid buffer storage and consequent double handling (extra handling expense).

More emphasis is now being placed on removing these grey areas of duplication and this trend is likely to increase in the future. The consequence is that more attention is being paid to detailed input/output networks or to the more effective interfacing of one department with another. The systems view is therefore essentially an integrated one, a matter of analysing all the separate elements in the distribution function and bringing them together as a single cohesive entity. This wider view of the discipline results in more attention being paid to the method rather than the technology involved. This in turn can bring about changes in the overall organisation of systems which are generally more rewarding than the application of any technology.

Effective and efficient warehousing is becoming more vital these days and the need for this is clearly stated by A. Wilson (1982 Sweden Now) "The fact is, an efficient warehouse/ distribution system is a decisive element in keeping costs down, profits up and staying competitive in increasingly tough markets."

Warehouses can therefore be seen as just a part of the total business environment. They are best considered not just as a place of storage but as part of the total material flow.

For many years the typical warehouse was a single storey structure of vast extent which enabled internal transport to operate horizontally at a single level. The multi-floor warehouse with its need for expensive lifts or access ramps, strong construction and extra handling costs was deemed impracticable. In recent years the higher costs of sites and the development of specialist materials handling techniques has transformed warehouse design. The use of equipment such as reach trucks and specialist order pickers has meant it is possible to stack items to much greater heights than previously, thus securing more economical use of the land the warehouse stands upon. In designing a warehouse it is necessary to conceive the whole storage function as a handling system for particular commodities and this concept seeks to ensure economy, system and security.

Over the past decade or so, there have been a number of detailed changes in warehousing systems, most of which have been aimed at reducing labour charges, making better use of space and controlling overall unit storage costs. Such developments; all aimed at achieving a greater degree of automation in the operation have embraced:

a) greater unitisation in terms of pallets and containers,
b) increases in building heights to give greater utilization of floor area,
c) increases in the lifting capacities of mobile handling equipment which in turn have improved height utilization of pallets and racking,
d) the implementation of automated equipment for both horizontal travel and vertical working within rack structures, all designed to reduce the labour content of warehousing/storage activities.

The trend towards increased mechanisation and automation in the warehouse is taking place in order to reduce the total costs of the warehousing operation. However the selection of such equipment should be considered in detail only when the exami ination of a handling requirement has shown that it cannot be satisfied by methods change, re-organisation or a better layout of the storage areas and the workplace. Savings will not result automatically from mechanisation or automation. In fact the Department of Industry goes as far as to state "mechanisation is not synonymous with efficiency, nor are the economics to be expected necessarily determined by the sophistication and cost of equipment used. Indeed, the ill-considered adoption of mechanical aids can add much to the cost of existing procedures while adding nothing to their efficiency." Obviously the best solution to any handling problem is that which by simplifying it, demands the least, the simplest and therefore the cheapest equipment. Methodical analysis can often reduce a given requirement to the point where it can be satisfied by a relatively modest investment, possibly in unpowered equipment, and will in many cases show

how appreciable economies can be achieved without the use of any equipment at all. Mechanisation and automation techniques can play a very important part in the economical and efficient operation of the warehouse. The difficulty lies in finding the right mix of manual/mechanised/automated techniques which will allow maximum efficiency of operation at least cost. Is the most effective and economic cost reduction made possible by introducing automation in the warehouse going to mean a cheaper system to run than the most efficient and economic manual or mechanised system? If it is cheaper is there a sufficient margin to justify the high capital investment required by an automated system? Basically whatever combination of equipment and system is used, the warehouse functions remain the same, regardless of the type of goods; that is: a) to receive the goods,
b) to sort them,
c) to despatch the goods

Warehouse, planning and layout are essential if good operational results are to be achieved. In essence layout is the planning and integration of the overall materials, movement designed to achieve the most effective and economical relationship between men, equipment and the use of storage space. The main problem in planning is concerned with the flow of material which must not be allowed to develop into a complex or diverse pattern of activity. There are two basic planning requirements:

a) an efficient plan for the flow of materials will produce the most economical operation,
b) the material flow pattern becomes the basis for the correct arrangement of facilities and work within the warehouse.

A successful warehouse must not only be correctly designed to the purposes required, but the methods used in handling the goods must be carefully preplanned to ensure maximum economy in operation. The most suitable method of warehouse operation must be considered and many decisions will need to be taken before final plans can be drawn up.

In general the type of goods to be handled will give a good indication of the type of handling method needed. The whole field of handling equipment should be considered from entirely manual to 100% automation. The aim should be in designing a warehouse to make the fullest and best use of modern equipment, together with automation and mechanisation with a view to reducing the labour content of the job (so long as it is economical to do so). Future operations and expansion of trade should always be borne in mind and the building site and all the facilities planned must allow for development at a later date.

With many potential automated warehouses the heavy capital expenditure involved often makes it impossible to proceed with such projects. Obviously any such system must prove itself on a cost basis, such equipment and techniques should never be used simply because it is something new or because of its prestige value as a gimmick. Once such a system is installed it is not economically possible to abandon it, and there would be a tendancy to try and make the system work, irrespective of the cost of doing so. However there are certain possible exceptions to this rule, where a company is part of a large industrial conglomerate it can use the latest technology developed by its material handling company in warehouse applications so that they act as a shop window. Obviously then the financial criteria of the investment is not based solely on its applicability and financial viability in that one particular application, but on the potential sales it will generate. Therefore new technology could be used as a marketing aid or as a showpiece.

Whatever methods and systems are used, they should be carefully selected; the equipment should be such that it can be used or adapted into a semi or fully automatic system at some time in the future; in other words it should be compatible with the over all automatic system.

Hyam (in Foster) defines an automatic warehouse as "a highly mechanised storage system where there is some degree of remote control through electronic data processing equipment and usually through an on line or off line computer". What are the objectives of an automated warehouse? These can be listed as follows:

a) to reduce or stabilise the total cost of distribution by saving in wages, land costs, stock levels and other overheads.

b) to raise customer service levels in a competitive market by: i) prompter delivery

   ii) improved accuracy of order filling

c) to attain more control over distribution operations; that is to achieve the most profitable use of any given level of inventory.

In essence therefore the objectives of an automated warehouse do not materially differ from the objectives of any other type of warehouse. The only real difference, being the technology to achieve these aims is however more complicated. As Bowersox states "the choice among mechanised, semi-automated or fully automated handling systems depends upon the nature of the task confronted and the relative capital investment cost benefits".

The type of automatic warehouse obviously depends on what goes into it and what is required of the system; the variety of goods handled, the number of customers supplied, the number, shape, weight and density of goods, the variety of shapes, weights and densities and the average unit size. It then becomes a question of how the stock is to be sorted or re-orientated and of establishing the pattern and frequency of physical movement into and out of the system. Thus the cost of space has to be balanced against the cost of movement or throughput per unit.

In Europe where space is at a greater premium it is less easy to justify horizontal layouts than in the U.S.A. In a warehouse it is usual to store and handle in unit loads; a unit load is usually equated with a pallet load. Hyam states that the increasing popularity of high bay warehouses in Europe may to some extent be fashionable but it is noticeable that there is a close relationship between the density of population, the scarcity of land and the height of the warehouse buildings. In the U.K. it appears to be more of a problem not of an overall scarcity, but rather more the difficulty of finding what one wants in the right place. A high bay automatic warehouse typically consists of a three dimensional racking system, with several thousand storage locations served by unmanned stacker cranes. Input and output conveyor systems carry pallets to and from the crane pick up and dump points. The crane and conveyor equipment are fully computer controlled and typically the warehouse is staffed by a small team and monitor operations via the computer.

Most warehouse designers would in the interests of efficiency like to have handling equipment tailor made to meet the requirements of systems designed round a particular problem. But it is important in the interests of economy to use standard equipment based where possible on standard components.

It is very important to keep in mind the advantages which can arise from automation either fully or in part, as automation successfully used can reduce labour costs. Each installation is likely to be on a "one-off" basis and may be less flexible if things go wrong than a straight forward mechanised system. So much depends upon the individual requirements of the potential user and the type of work that, where automation is concerned, each problem should be dealt with as a separate entity. It is well worth remembering that the technical knowledge and ability required for maintaining an automated system is far greater than that required for a mechanical system and therefore adequate technical staff must be available to deal with problems as they arise. With respect to maintenance it is often quoted that automated systems can replace an operator, but it can be readily shown that it adds a skilled maintenance man. In the right circumstances automatic or even semi-automatic systems can reduce labour costs without loss of efficiency.

An examination of the different types of automatic warehouse in existence today reveals a wide range of techniques, layouts and methods of operation. It is obviously realised that all the warehouse functions and their automatic versions can be very complex, both with regard to the mechanical handling variations required and to the number of sorting and resorting operations involved. The only completely automated warehouses where manual picking is completely excluded are devoted to the storage and retrieval of complete pallets.

Far more of a problem than the automatic storage and retrieval of pallets is that of bringing the picking of less than pallet load orders for high variety, fast moving lines within the scope of the automatic system. It can be said that so far as order picking machines are concerned automation has never been more than an aid to manual handling. Obviously such installations are expensive to build and consequently everything possible must be done to ensure that the cost is kept as low as possible. Foster states, "automatic warehouses are expensive installations, ... the economics of such a system turn simply on the amount of effective use which is made of the capital invested". Obviously there are certain disadvantages inherent with automated warehousing installations. For the installation of such a system; the high capital cost must be more than outweighed by the potential labour savings of other considered systems whether they be manual, mechanised or semi-automated. The cost benefits of a high capital cost with lower labour cost scheme must be compared to potential savings to be achieved by not using a scheme with a lower capital cost but higher labour costs.

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DRAW BACK

Other major drawbacks with an entirely automated warehouse are centred around its lack of flexibility. It is designed to work at a given maximum rate for a certain range of product/pallet sizes. If the workload on the system exceeds its design capacity there is no way that more work can be got from the system, unlike a manual system where more labour can be put in. If the size of product the system has been designed to handle changes then again the automated warehouse would be unable to cope without expensive changes and probable redesigning.

An automatic warehouse is in many respects more vulnerable to external and internal factors which may cause breakdowns and or disruptions such as electric power cuts and loss of computer power than mechanical or manual warehouses.

A potential drawback which applies in all cases to modern automated equipment is the possibility of having to write down an expensive fixed asset over a short period of time in order to take advantage of further innovative technology when it appears. The second hand value of an automatic warehouse is nearly always less than that of a conventional warehouse.

Writing in 1981 Smart states that in comparison with other leading industrial nations, Britain has been slow to adapt automated systems to warehouse management. Although much pioneering work was done in the U.K. in the mid 1960's, since then Britain has been overtaken by other countries to the extent that currently there are over 2,000 automated high bay warehouses in Japan and over 1,000 in the U.S.A. compared with less than 100 in the U.K.

It has been estimated that as much as 63% of the cost of manufactured goods is attributable to storage and handling costs. If accurate this figure confirms the importance of materials handling in the U.K. economy. It also suggests that automated materials handling is best considered in the context of the total production - distribution system, rather than as an end in itself, if full benefits are to be realised.

Obviously the circumstances of all warehousing and materials handling operations are the result of a complex mix of factors. New methods are constantly being devised and should be incorporated into the project at the latest possible date. No one knows what form the warehouse of the future will take, so that all we can do at present is to plan on the most up to date lines possible, and to maintain the maximum degree of flexibility, in order to assimilate changes at a later date. The complex mix of factors will differ greatly between different industries and also between different companies in the same industry. The Department of Industry goes as far as to state "Extraneous factors differ so widely in different circumstances that ready made answers to specific handling problems are rarely to be found. The best possible answer to a given problem in one factory may be entirely the wrong answer to an apparently similar problem in another. Each case must be considered on its merits".

The installation of a warehouse regardless of what form it will take is therefore a matter to be very seriously considered.

The specific research carried out by this project was concerned with the feasibility and economic viability of the mechanisation of a bedding warehouse. This was carried out by examining the warehouse operations of Silentnight at Barnoldswick in Lancashire.

INTRODUCTION

1.2 SILENTNIGHT

A brief description of the Company

Silentnight (hereafter referred to as the Company) is the largest manufacturer of beds and headboards in the U.K., with a market share of around 20%. The Company is based at Barnoldswick on the Lancashire/Yorkshire border. Approximately 1,100 people are employed on four sites. Three of these are in Barnoldswick and one at Sutton. The main manufacturing plant is in Barnoldswick at Moss Shed, which is the name of an old weaving mill. Here is located a complete manufacturing unit for spring interiors (mattresses) and for conventional and storage divans (bases). The Company's central distribution system is also located at Moss Shed. The other two locations in Barnoldswick are concerned with the manufacture of the spring units and the preparation of items for export. The Sutton factory manufactures storage divans and headboards. Sutton products are transported by inter-site trailers to Moss Shed, Barnoldswick to be despatched by the Company's central distribution facilities which are located there.

The Company distributes throughout the U.K. mainland in the main using its own transport fleet. At the present moment in time the delivery vehicle fleet is in a period of transition. This is due to the Company changing to an all drawbar fleet with demountable box bodies from a mixed fleet of rigid and articulated vehicles. Obviously the capacity of these vehicles differ, therefore any warehouse system must have sufficient flexibility to cater for "non" standard vehicles in regards to the number of pieces it can hold. Even when the vehicle fleet becomes all drawbar, "non" standard vehicles will continue to operate due to the fact that at peak despatch times the Company makes use of outside hauliers. Silentnight is a member company of the group A.B.F. Ltd. (Associated Bedding and Furniture Limited), and because of its relationship within the Group also provides a Group Mail Order distribution service. Associate companies Sealy and Perfecta have their mail order products distributed alongside Silentnights; the service being organised and provided by Silentnight (see fig.1). The distribution operation is divided into two parts, Mail Order and High Street, the reasons for this are described later.

Silentnight have a basic policy of working from a "no stock situation" and as a general principle it can be stated that manufacturing only occurs in direct response to customer orders. Orders for the Production Department to make for stock are only given to level out fluctuations in the distribution requirement as opposed to the production capacity and to cover the distribution commitments during the annual holiday periods. (During the annual production holiday periods the despatch operation continues).

Since the Company mainly produces in direct response to customer orders; i.e. not for stock, ideally production should be scheduled according to the loading sequence of the individual van loads. This however is not possible due to the wide variety of product types and sizes involved. There were a total of 326 different lines at December 1982. These different lines were spread over 145 ticks (tick is the fabric type). This wide range of lines increases at times of catalogue changeover. Another reason is the large volume involved, up to 7304 pieces being produced in 15 hours working time (the Company operates a two shift system) and the number of production stages affected (see fig 2 and fig 3)

It is therefore necessary to operate both the production floor and the warehouse/loading area on a time cycle basis using a buffer stock of sufficient capacity to level out volume and structure changes between the incoming and the outgoing flow of goods in the warehouse area. The shorter the time cycle that is chosen, the smaller the required capacity in the buffer stock area. On the other hand if the time cycle becomes too short the productivity on the production floor is affected. Production Management indicates that the time cycle cannot

Fig 1.

FACTORS AFFECTING THE LOAD ASSEMBLY SYSTEM.

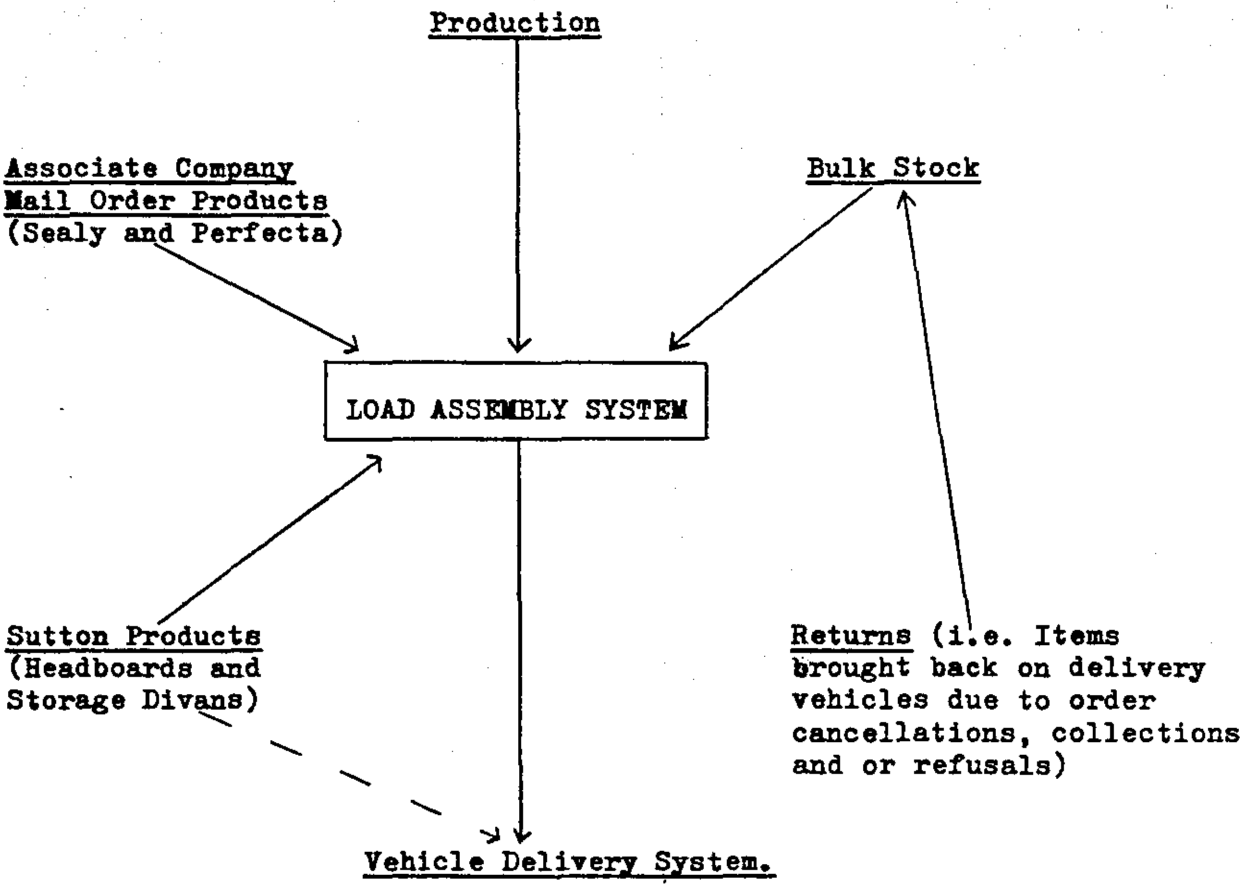


Fig 2.

SCHEMATIC DIAGRAM TO SHOW FLOW OF WORK.

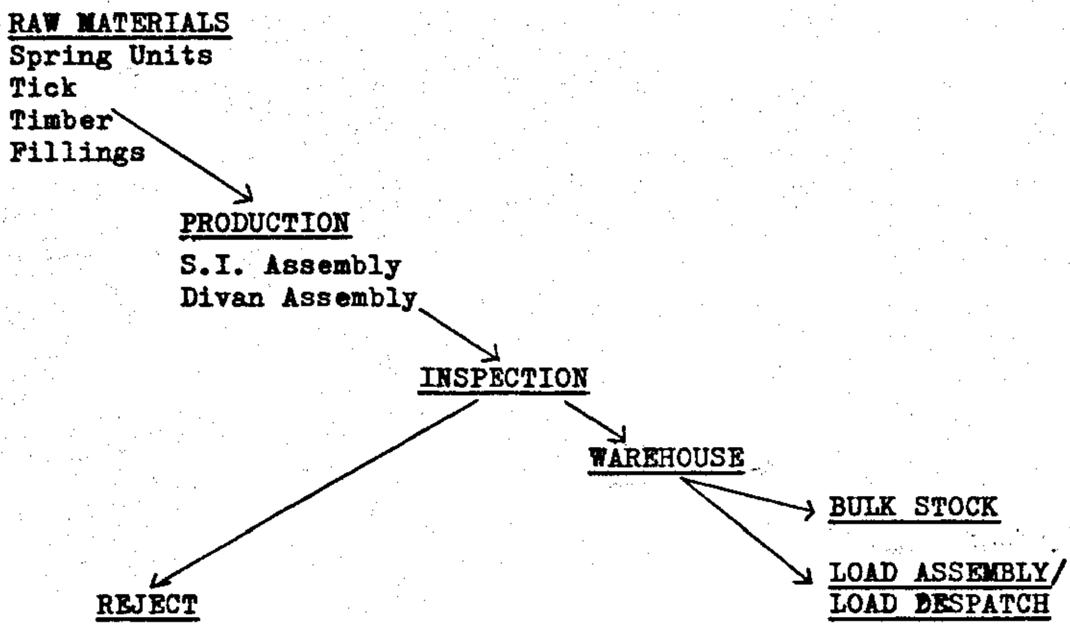
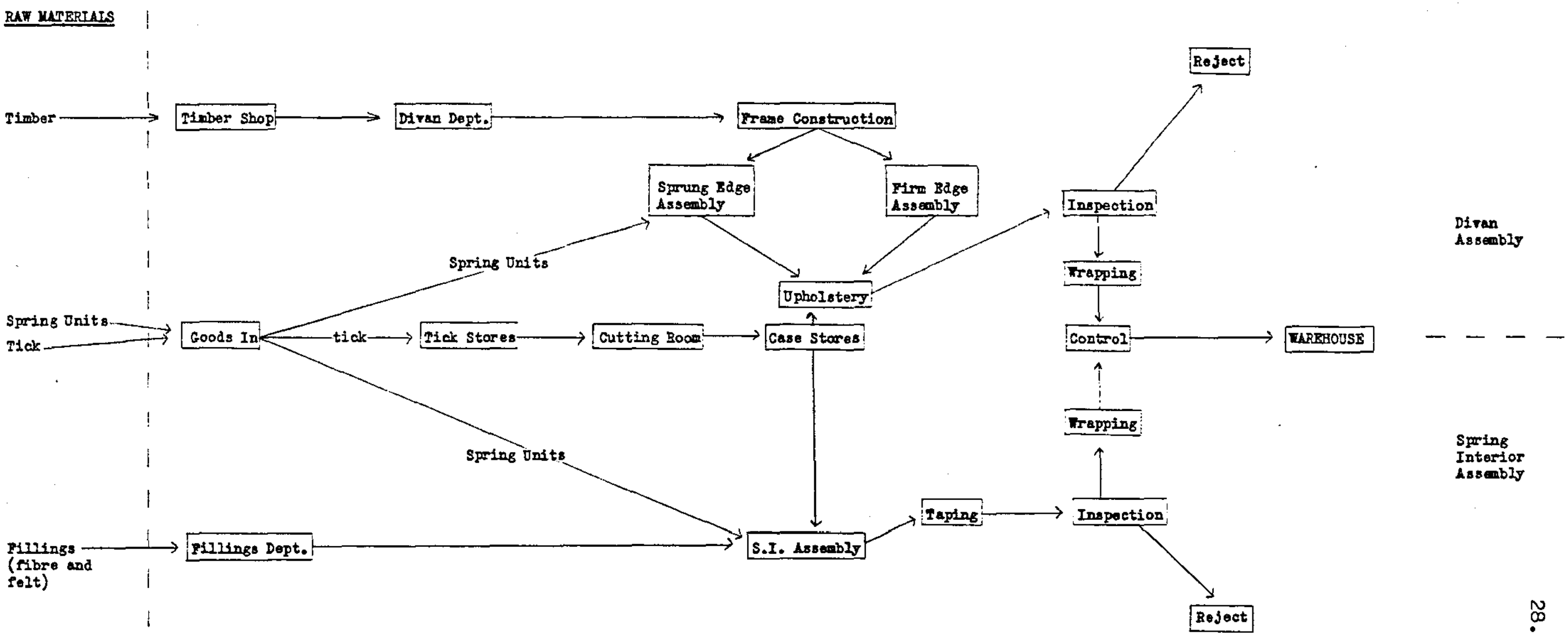


Fig 3.

PRODUCTION DEPARTMENT - FLOW OF MATERIALS.



practically be shortened below the present one shifts time without imposing additional costs and problems on the Production Department. These are unacceptable to the Company's Management (see later for the detailed reasoning behind this, under the proposed "Three Batch System per Shift").

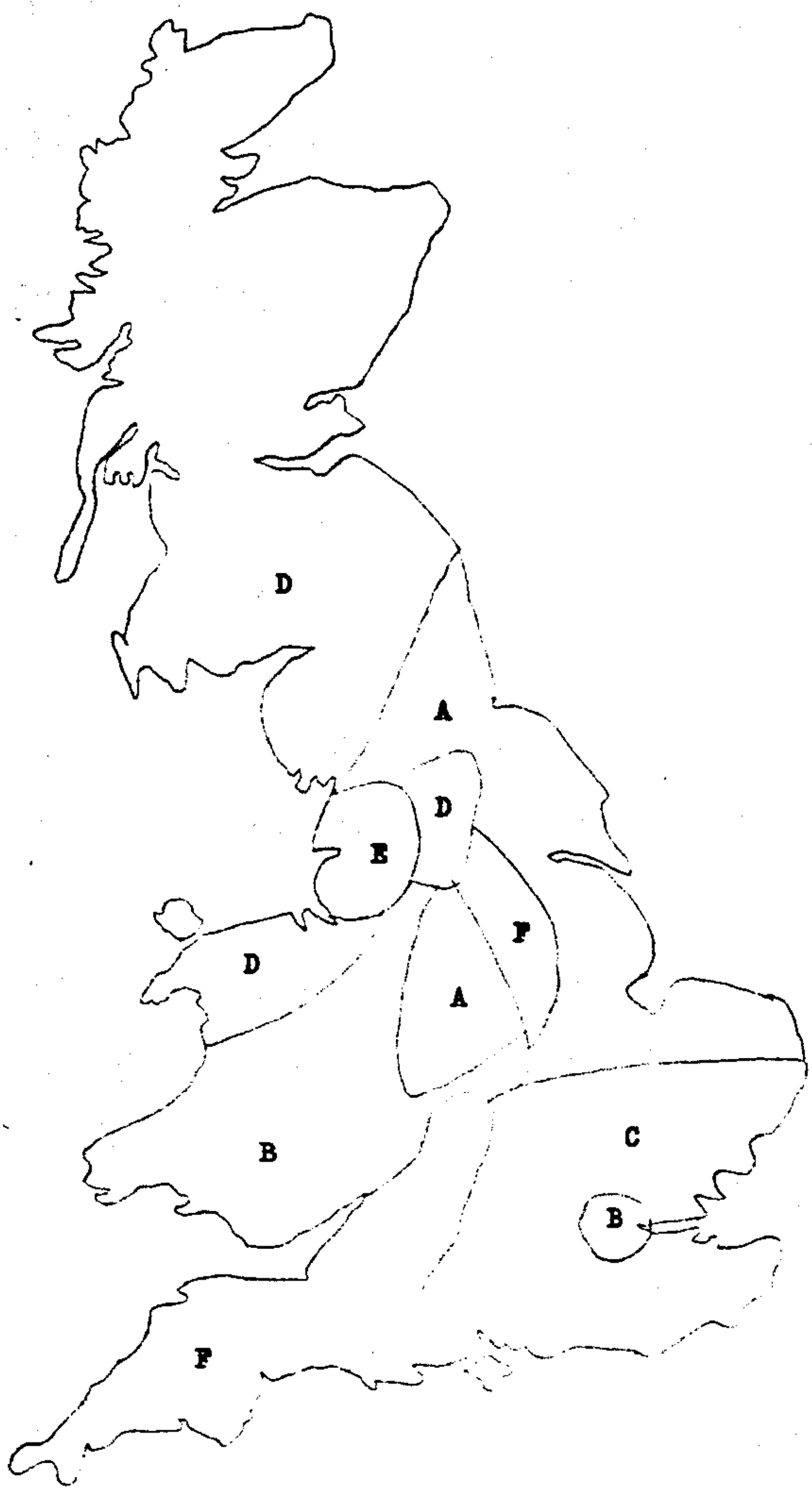
As stated earlier production is in direct response to orders received. There are two different order processing procedures in use, one for High Street and one for Mail Order. High Street is concerned with serving retailers shops and warehouses. Mail Order sales are generated by the Mail Order companies through their catalogues. The Mail Order Houses pass the individual customer orders through to Silentnight who undertake to deliver the bed direct to the customers home address. Already mentioned is the fact that Silentnight provides a Group distribution service for the Mail Order business of the associated companies, Sealy and Perfecta.

High Street orders are processed to suit a set weekly distribution schedule which is based on geographic areas (see fig 4). Incoming orders are entered into the computer and assigned a despatch day according to the distribution area in which they lie. On the following day the computer compares the orders on the customer file, the Mail Order production requirement and the stock list against the production capacity file to assist in generating the most convenient production plan. Once this is established the computer then prepares a component summary and a production summary, one for Moss production and one for Sutton production.

While manufacturing can now be started the Routeing and Planning Department sorts the orders into vehicle loads and then into delivery order. This information can only be sorted into vehicle loads once it is known what the production capacity will be for a particular High Street Distribution area. The reason for this is that the Routeing and Planning Department could place orders onto vehicles for which it is impossible for Production to make that day because it is oversubscribed.

Fig 4. HIGH STREET DELIVERY AREAS.

F=Loads Friday, Delivers Monday
A=Loads Friday, Delivers Monday
B=Loads Monday, Delivers Tuesday
C=Loads Tuesday, Delivers Wednesday
D=Loads Wednesday, Delivers Thursday
E=Loads Thursday, Delivers Friday



Once the vehicle loads have been built up this information is entered into the computer which then produces:

a) the loading sheets (for use in the warehouse)
b) the delivery notes (for use by the drivers)
c) the invoices

The loading sheets contain all the necessary information for the warehouse to ensure that the vehicle is correctly loaded, that is with the correct products in reverse delivery order. It will be noticed from the above that the routeing and planning operation for High Street deliveries is carried out while the products are being manufactured.

Mail Order orders are processed differently from High Street orders. The routeing and planning operation is completed before the production summaries are prepared. Mail Order loads are produced from all the orders on the house for regular prescribed areas each day of the week. The Mail Order areas are based on distinct geographical areas, each of which is served by a particular driver. Once sorted by the Routeing and Planning Department into vehicle loads this information is utilised by the computer to generate Mail Order production summaries as well as the loading sheets for use in the warehouse. Due to the fact that Silentnight provides a Group Mail Order distribution service the loading requirements for Sealy and Perfecta products are transmitted to these associate companies so as to enable their products to be at the Moss warehouse for the appropriate loading day. These products reach the Moss warehouse by what is known as inter company transport. Essentially these are articulated vehicles which are allocated to the trunking operation of Mail Order products between the associate companies and Silentnight.

Vehicle loading sheets for the Mail Order and High Street operations are therefore generated separately. For Mail Order products as they enter the warehouse it is possible to tell to which vehicle load they belong. This is because the Mail Order loading sheets are produced before production commences. For High Street products however it is not possible to tell which load they belong to, only to which shift's set of loads. In the warehouse, the Mail Order operation is segregated from the High Street system. Products for Mail Order and High Street distribution enter the warehouse together but in a random manner.

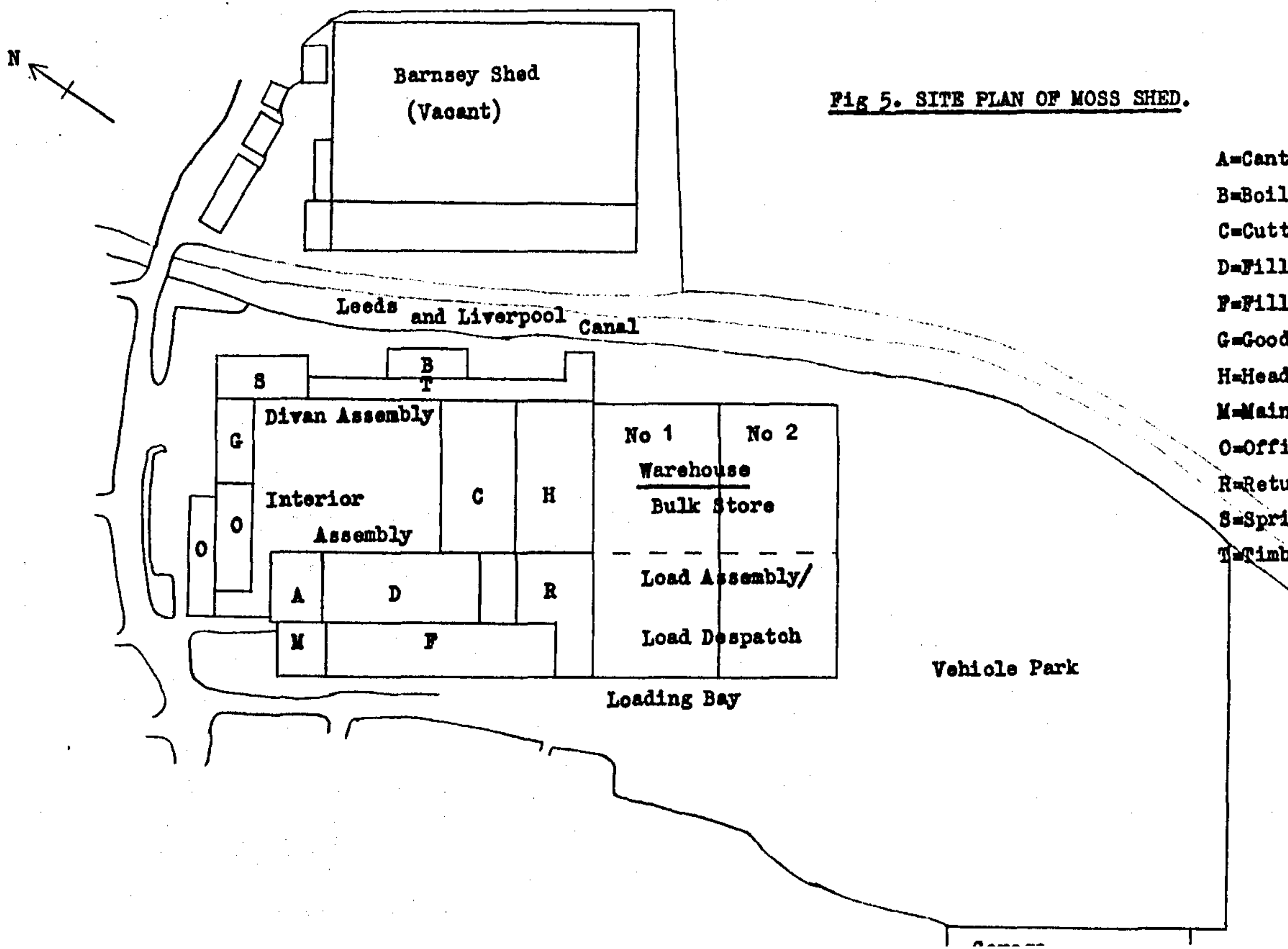
Mail Order and High Street products for loading are dealt with separately in the warehouse. This is because of the different range of products to be handled and the different loading requirements of the High Street and Mail Order vehicles.

These different loading requirements exist for various reasons. The basic reason is due to the different requirements at the delivery point. On Mail Order delivery vehicles a higher level of accessibility is needed to the individual pieces than on High Street. This is to save time in delivering if a Mail Order customer is not in, or the address cannot be located. On High Street obviously the problems of locating a customers' address is not a problem. Access to individual pieces is not as important because the average number of pieces per delivery is much greater than on Mail Order.

Another reason for the difference between the Mail Order and High Street operation is that on Mail Order certain drivers only deliver to set areas, whereas on High Street any drivers can be employed to deliver in any area. There are several reasons for this. The principle one being that the drivers need to have a good geographical knowledge of the area being served because of delivering to different addresses each time the driver goes to the region.

Mail Order and High Street products are segregated in the warehouse. No.1 warehouse deals with High Street products only. The front portion, ground floor and mezzanine serve as load assembly floors and load despatch floors on alternate shifts. The rear portion is used for High Street bulk stock (see fig 5). No.2 warehouse is primarily concerned with Mail Order. The rear portion with bulk stock and the front ground floor with Mail Order load assembly and load despatch.

Fig 5. SITE PLAN OF MOSS SHED.



A=Canteen
B=Boiler
C=Cutting Room
D=Fillings Department
F=Fillings and Fibre Store
G=Goods In
H=Headboard and Tick Store
M=Maintainence
O=Offices
R=Returns
S=Spring Units
T=Timber Department

The mezzanine in No.2 warehouse is used for those products being despatched to Eire and Northern Ireland (in future these are seen as being integrated into the High Street distribution system). Immediately prior to the main holiday periods in July and September No.2 warehouse mezzanine is also used to hold stock. Occasionally due to the sheer volume of products for despatch, High Street goods sometimes overspill into No.2 warehouse.

This research project was initiated because of the problems of capacity in the warehouse. When the warehouse was built despatches were averaging 5,100 sets a week. (A set is what is conventionally known as a bed; that is a mattress and base). By 1981 the average was 10,200 sets per week. Projections in the Company's 5 year plan which reaches 1986 suggests an average despatch volume of around 13,300 sets per week, but peaking at 15,363 sets per week. The present warehouse systems give rise to severe problems even with the current level of throughput. To achieve the projections in Silentnight's 5 year plan for 1986 it will be impossible for the warehouse and despatch facility to cope without modifications. Silentnight has for several years been interested in the introduction of an integrated mechanical handling and storage system which would relieve the problems of recruiting and retaining warehouse labour.

A high labour turnover rate has been a consistent feature of the warehouse in times of relative economic prosperity. Over the three years 1977/78/79 the warehouse had a labour turnover rate which averaged 60% as opposed to the Company average for the corresponding period of 34%. Since 1980 when the recession started to affect the availability of alternative employment the turnover rate has dropped and is now in line with the Company average. However it is believed that when the economic upturn comes a higher rate of labour turnover in the warehouse will become prevalent again.

These higher figures for the rate of labour turnover in the warehouse naturally affect the efficiency of that Department. The Company's Warehouse Management state that it takes approxiamately one month for a new person to become fully conversant with their job.

Various reasons can be identified as contributory factors to this high rate of labour turnover. Firstly it is heavy manual work, in fact the majority of the familiarisation period is concerned with learning how to handle the products. In times of high employment levels it becomes reletively hard to recruit suitable labour as not everybody is suited to heavy manual work. This factor exacerbates the problems of a high labour turnover rate. Other reasons are that the warehouse is subject to extremes of temperature being essentially an asbestos clad "barn" structure, which at the loading bay end is fully open to the elements.

The warehouse is therefore seen to offer a poor working environment. These are therfore internal factors which help to explain the high level of labour turnover. Obviously external factors also contribute to this and as seen at the present time by the Companys' management it is the external factor of the lack of alternative employment opportunities which is responsible for bringing the warehouse turnover rates in line with the Company average.

All the proposed warehouse schemes found to be feasible go some way towards ameliorating these internal conditions. In consultation with the Companys' management it is believed that the warehouse labour turnover rates would stay in line with the Company average should any of the proposed schemes (which are discussed later) be implemented when the economic upturn comes. There is no difference in turnover rates between any of the proposed schemes, just between these schemes and the existing.

All the schemes found to be feasible use manual labour in some form. Even in the most automated scheme the warehouse worker essentially uses the machine as an aid and it is he who conditions the speed at which the system works.

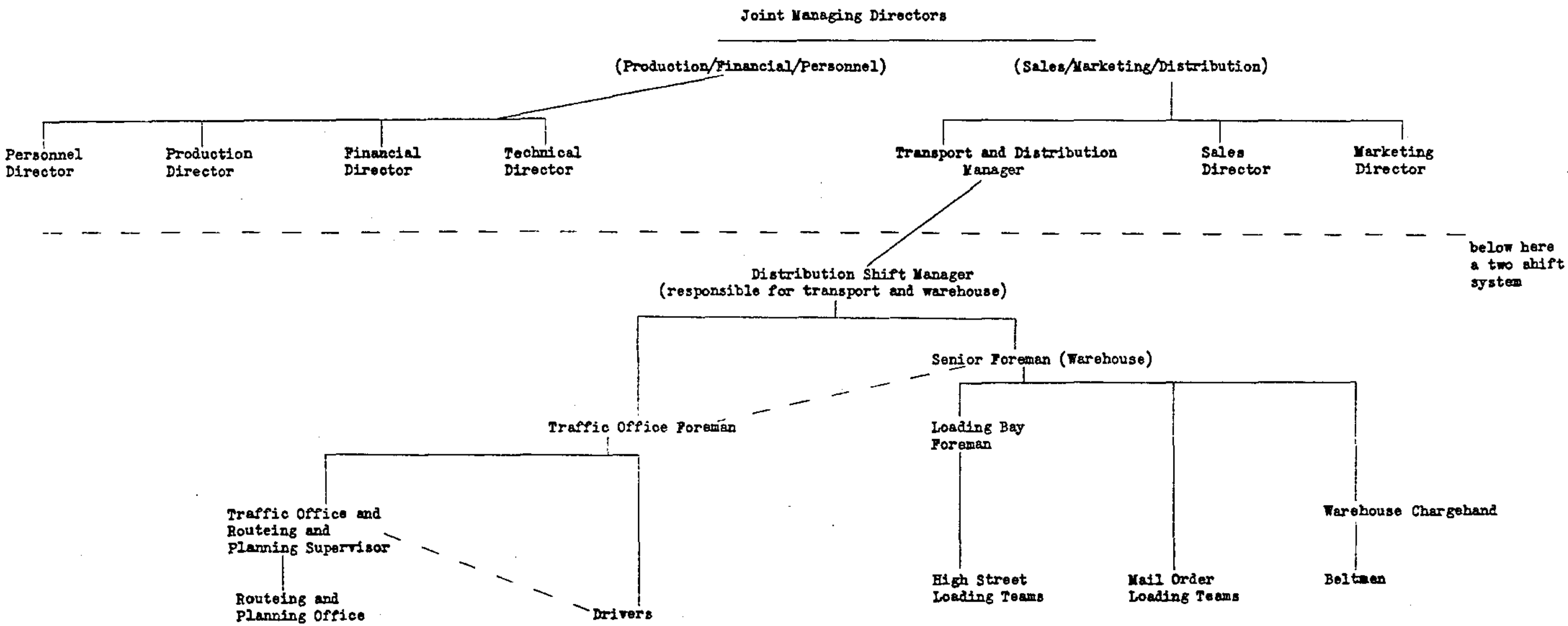
Assuming the recession and related unemployment ends it is proposed to examine the relative differences between the feasible schemes and the existing to see what effect if any these will have on the financial viability of these various potential solutions. These calculations can be found in Appendix 7.

The aim of this research is to investigate the feasibility of the mechanisation of the warehouse. If feasible methods are identified the next step in the study is to examine the economic viability of implementing such warehouse systems.

Simply stated, the aim of this project is to identify an efficient and economic method of handling beds.

Fig 6.

ORGANISATION CHART FOR DISTRIBUTION MANAGEMENT.



2) ANALYSIS OF PRESENT SYSTEM AND FUTURE REQUIREMENTS

ANALYSIS OF PRESENT SYSTEM AND FUTURE REQUIREMENTS

2.1 INTRODUCTION

The aim of this project is to identify a mechanised materials handling system suitable for a bedding warehouse which would be financially viable for Silentnight to operate. In order to examine the feasibility of possible handling systems a thorough knowledge is needed of

a) product characteristics
b) the way the present system operates
c) the requirements of a "new " system

2.2 GENERAL REMARKS

The requirement of any proposed handling system is that it is capable of dealing with the Company's proposed 1986 output. This equates to a 34% increase in volume on the base period of 1980/81. In dealing with this increase in despatch it is anticipated that the proportion of "bulk stock" (i.e. those items held in store and not for immediate despatch) will not increase. This continues the existing policy of working from no stock; production being in direct response to orders received. What stock is held is used to:

a) cover the days when production is oversubscribed;
b) cover the days when production is undersubscribed
c) to hold stocks to cover the annual production holiday periods (despatch works during these periods).

Essentially the warehouse acts as a buffer between production and despatch. The Production Department makes to order and passes items down to the warehouse. Here they are assembled throughout the duration of a production shift. Once a production shift is completed the items produced are ready for loading. Obviously the way the Production Department works will have a bearing on any proposed load assembly system.

Essentially what is therefore required is a load assembly system.

2.3 PRODUCT CHARACTERISTICS

This can be briefly summarised as a low weight but bulky product. The heaviest product weighs 60kg and the lightest 5kg. All are therefore quite compatible with manual handling.

The dimensions of the products vary. The vast majority are of 3' (90cm) and 4'6" (135cm) width. In many cases these sizes can account for 100% of a vehicle load. The Company uses the figures of 48% 3' and 52% 4'6" as an approximate breakdown of the size variations within both the Production and Transport Departments. The other widths in use are 2'6" (75cm) 4' (120cm) and 5' (150cm). Of these three sizes the 5' is the most common.

There is a standard length of 6'3" (187.5cm) on all sizes except the 5' which is 6'6" (195cm) long. Product depth varies for all widths between 4" (10cm) and 14" (35.5cm). Any system must therefore cater for a range in product dimension from 2'6" to 5' wide, 4" to 14" deep and 6'3" to 6'6" long. It is proposed at this stage to keep to imperial units as these are the units that Silentnight tend to work in.

2.4 THE PRESENT SYSTEM

The existing warehouse operation is split into two main areas; High Street and Mail Order; High Street is concerned with the delivery to the retailer, while Mail Order work is delivery to the individual customers home address. The split by volume between the two over the base period 1st August 1980 to 31st July 1981 being:

75% High Street
25% Mail Order

The warehouse is split between these two areas. There are two High Street loading floors and one Mail Order loading floor. Both areas are fed by the same conveyor belt from the Production Department. The conveyor belt splits the warehouse into two. The front portion is used for the loading floors, while the rear is used for the bulk stock area. The bulk stock areas are so split that one deals with High Street products and the other deals with Mail Order products. For the vast majority of the year the bulk stock areas are not full. They are only fully utilized just before the July holidays to hold stock to facilitate the despatch operation, which does not stop even though the Production Department does.

Products reach the loading floors from several different sources:

a) direct from the Production Department via the conveyor
b) via inter-site trailers from the Sutton Factory bringing in storage divans
c) via inter-company trailers from Sealy and Perfecta bringing in associated Mail Order products for Group Mail Order distribution.
d) from the bulk stock areas via the conveyor.

Standard divans, certain storage products and interiors are taken into the warehouse by the conveyor belt direct from production. Each piece carries a shift loading identity letter or number differentiating between High Street, numbers 0 to 9 and Mail Order letters V to Z. This information is used in the warehouse to determine which loading floor the piece is to go onto. On receipt in the warehouse the interiors and divans are manually stacked in piles of like types on the loading floors. The High Street despatches are assembled alternately on the ground floor and the mezzanine floor of No.1 warehouse.

The manufacturing cycle is that of a shift's production which goes into temporary storage for loading the following shift on High Street, or in the case of Mail Order on the following day. The items enter the warehouse in a random manner. Any production slack is taken up by making items for stock.

This therefore means that three distinct groups of products can be entering the warehouse at any particular moment in time, those for High Street loading, Mail Order loading or for the bulk stock areas.

Production summaries are issued to the production floor, one summary for High Street and one for Mail Order for each shift. The High Street summary is a geographic split, up to the capacity of the production unit after the Mail Order summary has been taken into consideration. Mail Order summaries are produced from all the orders on the computer for a regular prescribed area each day of the week. Whilst the Production Department is making the items as listed on the summaries, the Routing and Planning office are responsible for splitting down individual delivery notes into vehicle loads. When completed the computer then runs all the delivery notes in loading/drop order and produces the individual loading sheets in time for the commencement of loading at 6am on any day.

Identification of the product for despatch coding (by shift identity number or letter) is carried out adjacent to the production floor. At this point in time the individual vehicle loads have not been identified for the High Street products, although they have been for Mail Order. The products shift loading identity is marked on the plastic wrapping by hand with a marker pen. On receipt in the warehouse the interiors and divans are manually stacked in piles on the floor. Once the Production Department has finished making a particular shifts work, the items should be ready for loading. Due to a wide variety of reasons the Production Department can and does overrun the time allotted to complete a particular shifts loads. This causes problems throughout the despatch system by not having pieces available for loading when they should be.

Items are called off for loads from the loading floors and are manually brought to the vehicles and loaded in reverse drop order. The High Street loading points have fixed conveyors, vehicles backing down to them with most of the vehicle being physically situated within the warehouse. The loading conveyors take the products to the tailboard only. The products are then carried into the vehicle and stacked.

The present system operating in the warehouse is fixed by the physical structure of the two warehouse buildings. In the case of High Street despatches, assembly of bulk loads alternates between the ground floor and mezzanine floor. On peak days the throughput oversubscribes the floor with products being densely stacked and gives rise to the following problems:

a) handling damage in despatch assembly;
b) handling damage in load picking;
c) reduced efficiency in despatch assembly;
d) reduced efficiency in load picking. Frequently before a floor can be cleared of cancellations and excess by the loaders, the next production run needs to enter that floor and because products are assembled on floors by like types (model and tick), current production is placed on top of items still in the loading process. This gives rise to:
e) the identification and clearing to stock of cancelled items is impossible during normal working and can only be cleared back on overtime at weekends. In the peak despatch month of October great problems are caused because so much overtime working is needed for the loading operation. This aggravates the four problems listed earlier by making the loading floors even more congested.
f) the clearing of items to the bulk stock area during normal working hours generates cross floor handling problems due to having to pass items over the conveyor bringing items from production.

The Company also lists the following problems which particularly arise in the High Street loading warehouse:

g) vehicles take up valuable warehouse space;

h) vehicles tilt backwards shedding water into the warehouse;

i) vehicles tilted backwards reduce efficiency, the loaders need to keep pushing the stacks upright to achieve maximum utilization of cube;

j) on alternate shifts the loads are picked from the mezzanine floor and poorer communication between the load checker, loaders and pickers leads to inefficiencies.

Common to both warehouses:

k) The large warehouse doors are open to the elements and make working conditions in extreme weather difficult.

Limited mention has so far been made of the bulk stock areas which lie to the rear of the load assembly areas. These areas are designed for pallet stacking to a maximum of five high. Each bulk stock area is roughly capable of holding 4,500 sets and at peak periods there is space available on No.2 mezzanine floor to hold a further 2,000 sets. This gives rise to a total stockholding capacity of 11,000 sets.

Headboards are handled separately until the actual loading onto a vehicle. Headboards are sent from the Sutton factory on inter site trailers and assembled into individual loads in the headboard store on either trolleys or in pallets. When the headboards are required for loading, the particular trolley or pallet is moved adjacent to the appropriate vehicle. The loaders select the headboards as required. Headboards are in many respects treated separately from the interiors and divans.

The total volume of products distributed from the warehouse during the period 1st August 1980 to 31st July 1981 was:

510,757 interiors
464,630 divans

This equates to 487,693 sets.

Table 1 shows the despatch levels on a monthly basis. From the information contained in table 1 with 47.6 distribution weeks per year, the weekly average despatch figures can be shown to be:

10,730 interiors
9,761 divans

This equates to 10,245 sets per week

This figure gives an average despatch volume of 2,049 sets per day. Obviously there are great fluctuations from this average figure, both between months and within months. Within the period August 1980 to July 1981 the highest despatch week was 11,365 sets giving an average despatch volume per day of 2,273 sets.

The split by volume to the two areas of the warehouse was 75% High Street and 25% Mail Order.

In October 1981, the peak despatch figure of 11,474 sets per week was reached, and the maximum despatch volume on any single day was 2,696 sets. This peak volume completely swamped the High Street floor capacities, causing the feed conveyor from the Production Department to be stopped and resulting in the back stacking of interiors and divans on the production floor.

2.5 THE REQUIREMENTS OF A "NEW" SYSTEM

The basic requirement can be stated to be "to identify a handling system capable of dealing with the projected 1986 throughput". Obviously this presents an ideal opportunity to remove (or at least to try to) the constraints and problems of the existing system as described above.

Table 1

Despatch Summary August 1980 to July 1981

	High Street	Sets	Mail Order	
	/month	/week	/month	/week
August	29,432	7,348	12,659	3,165
September	27,401	8,059	9,822	2,889
October	41,771	8,354	15,053	3,011
November	30,431	7,608	9,420	2,355
December	19,657	5,781	4,935	1,451
January	34,297	8,574	8,774	2,194
February	28,839	7,209	11,757	2,939
March	29,506	7,377	11,576	2,894
April	28,900	6,568	11,378	2,586
May	29,122	8,565	10,562	3,106
June	32,913	8,228	8,892	2,223
July	31,342	8,706	9,255	2,571

Already identified have been the product dimensions the system must be capable of handling. Attention here will be confined to the volume the system has to be capable of dealing with. The 1986 projections show delivery as being composed of:

459,752 sets High Street
174,933 sets Mail Order (of which
71,461 sets are from associated Mail Order companies).

This therefore gives a distribution level of 634,685 sets in 1986. With 47.6 distribution weeks per year this gives a weekly average despatch of 13,334 sets per week. Table 2 shows the projected monthly and weekly despatch volumes.

However, certain of the divans are storage products and the 4'6" comes in two halves. This therefore increases the amount of handling required.

High Street:	interiors	=	470,029 pieces
	divans	=	530,607 "
Mail Order:	interiors	=	180,268 "
	divans	=	186,216 "

Obviously there is a distinct difference between the total number of sets and the total number of pieces. Both sets of information are useful in setting the parameters of any handling system. Detailed monthly working papers are attached in Appendix 1. These show both the number of sets and number of pieces which from the Company's projections any handling system would need to be able to handle in 1986.

It can be seen from the information presented that the peak despatch month falls in October. Any handling system must therefore be able to cater for the volumes projected to be despatched during that particular month.

High Street:	55,124 sets per month
	11,025 sets per week
	263 loads per week, average 42 sets/load
Mail Order:	21,693 sets per month
	4,338 sets per week
	129 loads/average 34 sets/load

Table 2

1986 PROJECTION

Sets

	High Street		Mail Order	
	/month	/week	/month	/week
January	38,159	9,540	10,831	2,707
February	34,252	8,563	15,082	3,770
March	35,401	8,850	16,342	4,085
April	35,585	8,087	17,566	3,992
May	35,263	9,280	15,117	3,977
June	39,493	9,873	13,233	3,315
July	37,884	9,471	15,099	3,775
August	42,021	10,505	14,820	3,704
September	34,665	10,196	13,139	3,864
October	55,124	11,025	21,693	4,338
November	39,493	9,873	13,103	3,276
December	32,137	10,712	8,906	2,969

This gives the maximum distribution level as being:

15,363 sets/week
392 loads/week

The workload within a maximum distribution week is not evenly split. The peak despatch day can be seen as follows:

High Street	=	2646 sets	=	63 loads
Mail Order	=	738 sets	=	22 loads
		3384 sets	=	85 loads

In terms of numbers of pieces this means:

High Street	interiors	=	2705
	divans	=	3054
			5759 pieces
Mail Order	interiors	=	760
	divans	=	785
			1545 pieces

This equates to 7304 pieces per day. A working day is equal to 15 hours. Obviously with a two shift system the question arises as to what will be the maximum volume the system will be expected to handle within a shift (i.e. 7½hrs working time):

	High Street	=	2688 'whole' pieces
	Mail Order	=	1085 'whole' pieces
			3773
or	High Street	=	2912 pieces (4'6" storage counted as two)
	Mail Order	=	1137 " (" " " " ")
			4049

Any handling system identified must therefore be able to cope in an efficient manner with the above volumes. With higher despatch volumes being predicted in 1986, it is necessary to raise the bulk store capacity to enable production to operate at a relatively even rate throughout the year against fluctuating demand levels and to cover holiday delivery commitments. The peak level is reached in June immediately before the two main holiday periods of July and September. Silentnight originally asked for a stockholding capacity of 24,000 sets. Once analysis of the situation started this figure was downrated, and came to be an average of 16,000 sets.

So far mention has only been made to the volumes to be dealt with over both a day and a shift. Attention at this stage of the analysis ought to perhaps focus on the loading operation. It has already been shown that the maximum distribution level in 1986 will be 85 loads a day. The number of pieces per load will obviously vary greatly depending on the split between 3' and 4'6" items. The average volume per High Street load is shown as 42 sets, while for Mail Order as 34 sets. There are several reasons for this difference between the two branches of distribution. The most important arises due to the different requirements of the end customer. Easier access is needed to the pieces in the vehicle on Mail Order than High Street. This is to save time in delivering if a Mail Order customer cannot be located or is not in to take delivery of the bed. This easier access to pieces is at the expense of the maximum utilization of the vehicles cube.

It should now be apparent that to gain the maximum utilization of the delivery vehicles cube loading cannot take place in a random manner. Another reason why loading cannot take place in a random manner is that virtually all vehicles carry products for more than one drop. Loading therefore needs to take place in reverse drop order. Apart from the above mentioned factors there is also the practice of placing divans at the base of the stacks and the spring interiors on top of them. This is to make the stacks more stable in transit. The loading operation is therefore not so straight forward. Pieces cannot be selected for loading in a random manner for a variety of reasons. This therefore explains the present need for loading floors to assemble all items for a shifts loading before loading commences.

The requirement of any load assembly system is to present the items to the vehicle for loading in the correct loading sequence taking into account:

a) reverse drop order
b) bottom part of the stacks to be formed of divans
c) cube maximisation

Any handling system therfore needs to have the facility to sort the pieces into the correct sequence for loading.

As stated earlier the proposed warehouse must be capable of handling the peak despatch requirements. By having the system so designed that it can cope with the peak despatch requirements as demanded by the Company it is realised that this may increase the cost of any warehouse so deamed feasible.

However it may be possible to reduce the cost of the warehouse system by syphoning off the peak volume into a separate system specifically designed to cope with these peak despatch volumes. Upon closer examination this proved not to be feasible. The major obstacle being that one shift's set of loads are not identified to individual vehicle loads till after the relevant production has been completed. It is therefore impossible to identify items to individual loads until all the items have been produced and assembled in the warehouse. In practice one cannot separate off some of the peak volume; the only realistic way to cope is for it to be contained within the existing system. If the timings of the routing operation in relation to production were changed it could then be possible to identify the items to the relevant loads. However this would loose the flexibility the Companys' management demands in this area. The system must therefore be able to cope with the peak despatch requirements because it is not possible to syphon off complete vehicle loads due to the information required to do this not being available at the relevant time.

If the operating parameters were different then it could be feasible to syphon off the peak volume into a separate system which exists to deal with the peak despatch levels. If the warehouse operations were concentrated in the two warehouses on the Moss site this could leave the Barnsey site vacant. Barnsey Shed is then theoretically available to be able to be used for the peak operations. However this would prove costly as a conveyor link from the main site to Barnsey Shed would need to be constructed, as well as repairs to this building to make it usable for the load assembly operation.

If this solution is possible then it must be realised that as the site is separated from the rest of the operations a certain level of supervisory labour would be needed. If the timing constraints discussed earlier did not exist it would be feasible to use Barnsey Shed as the site to deal with the peak operations. However in order to do this it must be realised that Barnsey Shed must be costed to the peak operations. With containment within the existing system certain of the costs associated with Barnsey Shed do not appear. Therefore if Barnsey Shed is used to deal with the peak despatches, it must bear the full economic costs of coping with the peaks.

Although the Company stipulates within its brief that any warehouse system must be capable of handling the peak volumes, it is realised that with the use of trade off analysis this may not be the most desirable way of dealing with the peaks. From the above discussion it can be seen that due to the way the Company operates, the peak despatch requirements must be incorporated into the system dealing with the rest of the Company's despatch requirement.

3) POTENTIAL HANDLING SYSTEMS

POTENTIAL HANDLING SYSTEMS

3.1 OBJECTIVE

To examine various mechanical and or automated handling systems for beds. At this stage it is proposed to identify feasible systems. Those systems so identified will in a later section be examined to see if they are economically viable.

3.2 REQUIREMENTS

a) The main objective is to be able to efficiently cope with the 1986 projection of a maximum despatch day of 85 loads which consists of 3384 sets (7304 pieces). Finished goods will reach the load assembly system from the following:

   i) direct from production
   ii) from Sutton production (i.e. storage products and headboards) via inter site trailers
   iii) from Sealy and Perfecta by inter company trailer
   iv) from bulk stock
   v) certain items of customer returns or refusals and cancellations from distribution vehicle to the bulk stock area and then to the load assembly system.

b) The handling system must be able to cater for a wide variation in the number of pieces in a load with an average of 84 pieces (all storage products counted as one piece). On a random sample, the number of pieces in the vehicles taken, fluctuated from 36 to 150 pieces.

c) The handling system must be able to allow vehicle loads to be built up in a predetermined sequence.

d) "The handling system should not constrain the efficient working of the Production Department". This statement is taken from the Silentnight briefing document. It is however realised that the principles of trade-off analysis ought to be applied in such situations, and the total Company looked at as one system, not with the various sections of it discrete systems.

To sum up, a system is needed that is capable of handling and sorting the quantities stated in an efficient manner. In order to remove some of the problems of the existing system caused by the relatively inflexible loading floor system which becomes cramped due to late running production and or loading, due to the loading operation being one shift behind production, it is proposed to have adequate capacity within any proposed system to cater for this. In effect this means creating three High Street floors and one and a half Mail Order floors. Mail Order works on a production day system, not a two shift system so that not so great a capacity is needed on those floors. By creating the equivalent of three High Street floors this should help to remove some of the congestion problems existing with the present High Street system. This will allow the clearance of cancellations and excess after a floor has finished being loaded from and before production starts to run onto that floor. Obviously the answer to the problems may not lie in "conventional" loading floors as used at present, but the basic principles as to the capacity of the system remain.

3.3 POTENTIAL SYSTEMS DESCRIBED

a) The Present System

Always to be considered in any project evaluation is the continuation of the existing system. Comparison should always be made with the do nothing approach in the financial appraisal of any contending system.

As has already been shown, the present system is working near to its capacity. In fact in October 1981 the system became swamped and despatch only continued because of constant improvisation and overtime working. In 1986 despatch volumes are above this level so it is obvious that the existing system would not be able to cope with the projected 1986 distribution levels. The present system is seen as being able to cope with the 1982 distribution levels but not beyond. The existing system although unable to deal with the 1986 distribution levels must be used as a base for the financial appraisal of possible alternative handling systems. This is to see if the extra profits generated by handling the projected 1986 volumes more than outweigh the costs of installing a system to deal with those volumes.

<u>b) Three Batch System per Shift</u>

As a first step towards identifying a handling system capable of dealing with the 1986 volumes, attention was turned to see if it would be possible to make the existing system workable. The problem with making the system workable was identified as the inadequate capacity of the loading floors. The question then became how to reconcile floor capacity with the demand placed upon it by the sheer volume of products manufactured in a shift. Obviously important to this examination is why does the demand for so large a loading floor exist.

In looking at the High Street operation on a maximum despatch day with 32 loads a shift (2688 pieces), it can be recognised that a large area is needed in which to store products till a shifts production has finished. This storage requirement arises because the Production Department makes in such a way as to randomly send items to the warehouse (i.e. in a random manner as far as the loading operation is concerned). A way to make the 1986 volumes fit the loading floors would be to cut down the number of pieces in a production batch. To enable the existing warehouse operation to continue it was proposed to operate production in three batches per shift of approximately 10 loads each, taking 2½ hours each, so equallying the present working time of 7½ hours per shift. Under such a situation the loading floors would be able to cope due to holding on any particular floor only 2½ hours loads as opposed to 7½hours loads as at present. Such a system should therefore enable the warehouse to operate more efficiently.

However on examination by the Company's production management it was found that this proposal would place inefficiences and constraints on the Production Department. Many of these can be seen by comparing the two tables shown in table 3 and headed "Full Shift and 3 x 10 loads".

The major difference is that on a 10 load batch summary the maximum and average batch size drops and the total number of batches of 10 items or less increases. Perhaps most useful to compare are the percentage values which reflect an increase in efficiency in a full shifts production over a 3 x 10 load system. The Production Department states that the maximum efficiency for them arises from the largest possible run of any like item. Obviously to split any production run down into three discrete sections would cause inefficiences in comparison with a full shift system.

Apart from the above effects, other points must also be taken into consideration:

i) each shift would need splitting into three discrete sections of roughly equal work.

ii) disparities between the interior and divan departments would need to be balanced three times a shift instead of once. This would create a need for extra managerial labour and or computer power.

iii) the time that an item has to be produced in, is now 2½ hours instead of 7½ hours. This therefore places more responsibility on the actions of the progress chasers and would almost certainly cause an increase in their numbers due to the extra workload.

iv) due to the 2½ hours time period for a production run, this would decrease efficiency, because it would create an increase in the numbers of change-overs on machinery.

Table 3

Full Shift

Batch Summary

Maximum batch size	=	144
Average batch size	=	8.4
Minimum batch size	=	1
No. of batches 10 items or less	=	198
Total no. of batches	=	232
% 10 items or less	=	85.3%
% 5 items or less	=	68.1%
% single items	=	37.5%

Piece Summary

Total pieces for a shift	=	1999
% 10 items or less	=	29.3%
% 5 items or less	=	14.5%
% single items	=	4.3%

3 x 10 Loads

Batch Summary

Maximum batch size	=	112
Average batch size	=	6.5
Minimum batch size	=	1
No.of batches 10 items or less	=	268
Total no. of batches	=	302
% 10 items or less	=	88.7%
% 5 items or less	=	73.5%
% single items	=	35%

Piece Summary

Total pieces for a shift	=	1999
% 10 items or less	=	39.7%
% 5 items or less	=	22.5%
% single items	=	5.3%

v) the changeovers on taping, quilting and divan and interior construction would increase when a shift is split into three discrete sections, again leading to inefficiences. This is caused because not all the assembly and manufacture of a certain product can take place together, but instead within three separate blocks.

vi) the feeding into the main production and assembly areas would need to be more tightly controlled, for example tick from the cutting room, so as to match exactly each 10 load block instead of a shifts work.

The conclusion to be drawn about the proposed three batch system per shift is that it would not be feasible because of the constraints and inefficiences imposed on the Production Department.

c) Modifying the Present System (Scheme A)

As already shown there does not appear to be a way forward in keeping the present system if the projected 1986 distribution levels are to be attained. The problem as already discussed revolves around inadequate floor capacity. At the start of this review of potential systems it was stated that what was required was the equivalent of three High Street floors and one and a half Mail Order floors in order to remove the problems which exist with the present system.

There are envisaged to be three High Street floors, No.1 warehouse ground floor, No1 mezzanine and No.2 warehouse ground floor. Mail Order would go onto No.2 mezzanine which has adequate capacity to hold one and a half days Mail Order stock. However by just using the present floor stacking area on the ground floors of both warehouses, the floors would be oversubscribed. It will be remembered that one of the problems stated to exist with the present system is that the vehicles being loaded take up valuable warehouse space.

On examination it was found that if the vehicles were moved out they would free sufficient space to accommodate floor stacking volumes which would cater for the projected 1986 distribution levels. This would remove the problems of vehicles tilting backwards into the warehouse:

i) shedding water

ii) reducing the loaders efficiency by having the need to keep pushing the stacks upright to achieve the maximum utilization of the vehicle cube.

However it would exacerbate the problem of the warehouse being open to the elements due to the removal of the buffer area between the outside of the warehouse and the area where floor stacking commences. This buffer area is the area where the vehicles at present stand while being loaded. It is proposed to solve this problem by the installation of dock shelters. By this system it would be possible to remove the problems which are seen as existing with the present system. Although the floor areas to be filled from production and picked from for loading are larger than at present, so increasing the walking distance, this is seen as more than outweighed by the problems removed. The floors would not become oversubscribed so would remove the stated problems of:

i) handling damage in despatch assembly

ii) handling damage in load picking

iii) reduced efficiency in despatch assembly

iv) reduced efficiency in load picking

v) inadequate clearance of cancellations and of excess before the next production run needs to enter the loading floor.

Overall the system by being laid out in an efficient manner with adequate stacking capacity would only require an increase in the labour force in direct proportion to the increased volume. The conclusion to be drawn about this handling system is that it is capable of handling the volumes projected by 1986 and deeper examination is therefore required.

d) Conveyor Belt

Manual Sortation in Existing Building (Scheme B)

This proposed handling system makes full use of No.2 warehouse building for loading while No.1 warehouse is given over entirely to bulk stock. High Street loading is on the ground floor of No.2 warehouse, with Mail Order on the mezzanine floor. Each of the three High Street floors are divided into two halves by a conveyor which runs centrally down each individual loading floor. Within each half of a loading floor there is sufficient space to floor stack 16 High Street loads. In order to improve the efficiency of the system it is proposed to have only 8 loads in any particular area. Each High Street floor is therefore effectively quartered.

From the Production Department and the bulk stock areas products are identified as belonging to a particular shifts loads. Within a shift, the item is then designated to a particular set of 8 loads. The item is then marked in an appropriate manner and travels on the main conveyor which enters No.2 warehouse. When the piece becomes adjacent to the appropriate loading floor it is manually transferred to the central conveyor in each loading floor. From here the piece is taken manually to the appropriate quarter and stacked. By placing the conveyor centrally in the loading floor this effectively cuts down the walking distance for the floor stacking operation. Loading can take place simultaneously from any 2 quarters. To bring products forward for loading the central conveyor can be used if required, as at these times it will not be needed to feed the loading floor with items from production.

No constraints are placed on the Production Department by the operation of this system. Its advantage over the modified present system is that all High Street despatch assembly takes place from one building on the ground floor. However the Mail Order operation still remains on the mezzanine floor.

The loading floors are generously laid out with adequate gangway widths. This allows for both an increase in efficiency of despatch assembly and load picking and cuts down on potential damage. As previously described a three floor High Street system allows the clearance of excess and cancellations before the next production run needs to enter the loading floor.

A conveyor belt sortation system utilizing the existing warehouse buildings is therefore capable of handling the projected 1986 distribution volumes.

e) Conveyor Belt
Sortation in Existing Buildings (Scheme C)

This system is virtually the same as that described above, the conveyor belt manual sortation system. The difference is that instead of having a manual transfer operation between the main conveyor from the Production Department and conveyors on the loading floors there is an automatic transfer device.

When pieces leave the Production Department and bulk stock area, the products are identified as belonging to a particular shifts loads. Within a shift the piece is then designated to a particular set of 8 loads. The item is then tracked throughout the conveyor system and when it becomes adjacent to the appropriate loading floor is automatically transferred to the central conveyor in each loading floor. From here the piece is taken manually and all further handling is as described in the previous system.

This system therefore saves in labour at an increase in the cost of the equipment. Apart from this there is no difference between the two schemes; the advantages remain the same. An automated transfer between conveyor belts only means that this scheme has a higher level of mechanisation and can therefore be considered to be technologically uprated.

f) Conveyor Belt Sortation in a Purpose Designed High Street Despatch Building (Scheme D)

The mechanics of this proposed handling system are identical to the previously described conveyor belt sortation system. That is products are placed on the conveyor belt in either the Production area or the bulk stock area and assigned to a particular quarter of a particular shifts loading floor if for High Street despatch. Mail Order products are assigned to a particular half of the Mail Order loading floor, each half roughly corresponding to a Mail Order loading day. Unlike in the previously described two proposed systems, Mail Order despatch does not take place from the mezzanine in No.2 warehouse but will go onto the ground floor area beneath this mezzanine.

The new High Street despatch building would be built outwards at a right angle from the side of No.2 warehouse with vehicle docking facilities on either side. The main conveyor bringing the items from Production and the bulk stock areas to the loading floors would go down the centre of the despatch building. Each shift loading floor would have itself equally divided by the central feed conveyor. From the central feed conveyor automatic transfers would send products to the appropriate half of the loading floor. The side belts then half these floor areas which means that a shifts set of loads can be effectively quartered. Due to the fact that this building has loading bays at either side the walking distance is drastically cut down for the loading operation, unlike in the previously described sortation system in No.2 warehouse. This is achieved by placing all the loading quarters immediately adjacent to the vehicle docking positions.

The loading floors even though now catering for a shifts loads in four distinct quarters are generously laid out with adequate floor stacking capacity with wide access gangways. This means that several of the problems existing with the present floor layout are removed. Efficiency will increase due to the generous provision of space on the loading floors and the fact that the areas by being quartered are now so much closer to the points of product intake and despatch.

This therefore increases efficiency in both despatch assembly and load assembly and means that the areas of potential handling damage are reduced.

Problems associated with vehicles taking up valuable warehouse space are removed by the provision of dock shelters and purpose built loading banks. The provision of a purpose built High Street despatch building means that many of the problems with the existing building for loading can be removed in the design stage. A major advantage of the complete system is that all loading, for both High Street and Mail Order takes place from the ground floor so removing the problems posed by operating from a mezzanine floor.

The load assembly system using automated conveyor belt sortation in a purpose designed High Street building appears to be a feasible system.

g) Horizontal Carousel System

The aim of a carousel is to take the goods to the picker instead of the picker to the goods. Simply stated, a carousel storage and retrieval unit is a horizontal rotating bin device that brings the parts to the picker, see Fig 7. Originally the equipment was introduced to provide the small parts stockroom with a simple, low cost unit that would bring the bin to the picker, thus eliminating the continuous movement of the picker through a maze of standard shelving units. The operator stays in one position and simply tells the machine the item and or the location required. The carousel rotates to bring the item to the picker. A carousel will therefore:

i) take items to the picker

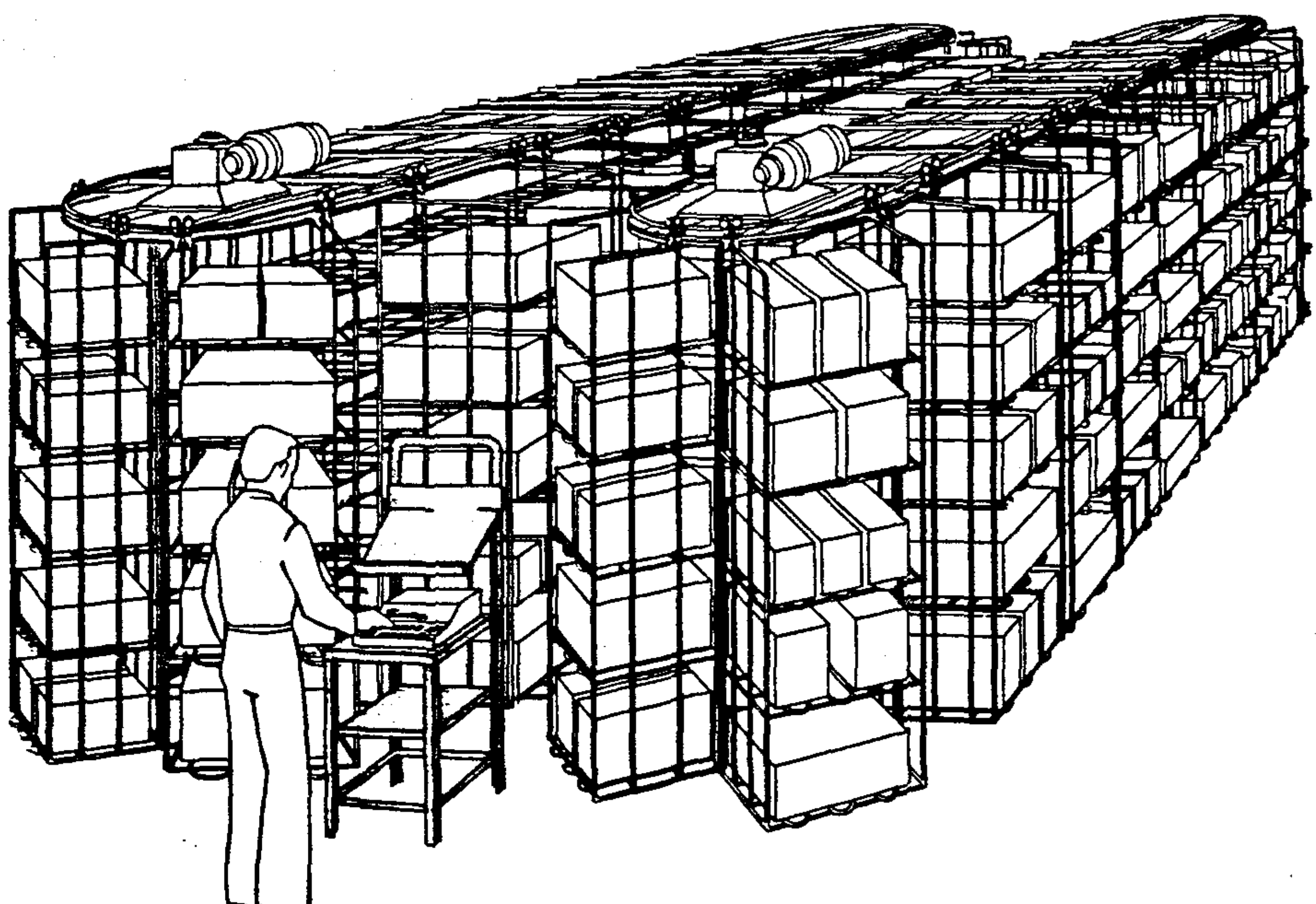
ii) cut down or remove walking distance and time for the picker

iii) maximise (or can do) the use of the warehouse cube by the careful use of the mezzanine floors

iv) increase the number of items picked in any given time unit because no walking time is involved.

FIG. 7

HORIZONTAL CAROUSEL SYSTEM.



v) increase labour productivity by reducing the time needed to pick an item

vi) possibly cut down damage due to man handling by reducing the distances over which a person will carry the item.

In principle the horizontal carousel seems to offer a potential solution, although it will have already been noted that they were originally developed for use with small parts picking. If they are able to be used to handle beds they therefore need to be built on a much larger size than at present.

The carousel units would be sited in the warehouse. Items entering the warehouse for despatch assembly would be manually placed in a carousel unit; so many units would be captive to a particular shifts loads. Due to the variations in actual load size, it would be proposed that any particular carousel would be designed to fit four average loads (336 pieces). The computer would be used to apportion the loads between the carousel units. There would be 8 carousel units per shift. This would ensure that carousel units would be capable of dealing with the volume of pieces involved by being able to balance out over average and under average size loads.

The carousels would have to be designed so as to be able to handle the largest pieces, that is 6'6" x 5' x 14". This means that in many cases there would be an under utilization of cube if the pieces were held in horizontal racking. However if the pieces could be held in a "mobile" vertical frame this could at least overcome the variations in depth dimensions. Take out from the carousel would be manual and the items would then be placed onto a loading conveyor to take them to the vehicles concerned. A carousel to take four average size High Street loads needs to have at least 264' of face if all the products are stood on end; and more if they are held in horizontal racks.

Such carousels are obviously much larger than those already in use. In many ways they would be used for different purposes than those carousels at present in use:

i) for large item storage, not small parts

ii) for short term storage, not long term. All the items in the carousel should have been picked at the end of the loading shift, so leaving the carousel completely empty.

iii) for direct picking feeding vehicles, and not to intermediate storage and packing before final despatch.

A carousel system as outlined above, appears to be able to cope with the 1986 distribution levels. It should also help to remove some of the problems as seen existing with the present system. However upon more detailed examination the system was judged not to be feasible. This came about after discussions with manufacturers and consultants. Both expressed initial enthusiasm but upon closer examination the manufacturers said there was no way such a system would be economically viable. Obviously in such circumstances it was not worthwhile for potential manufacturers to draw up budget prices.

Others viewed the system as unworkable. There were several reasons for this. The main one was that it was being proposed to use a carousel in a completely different area from that where it was initially developed; that is small parts storage and retrieval. The other reasons stem from this and all revolve around the physical size of the actual carousel; nothing on this scale exists anywhere for comparable purposes.

The idea of a horizontal carousel as a potential solution must therefore be discarded. This is due to manufacturers and consultants viewing the system as not feasible and as a consequence uneconomic and therefore unwilling to proceed on initial costings.

h) Overhead Carousel System

This system is basically a variant on the systems used by some companies in the hanging garment trade and has many similarities with the carousel systems already described see Fig 8.

In this system the individual interiors and divans are placed in or on specially designed hangers. Problems soon arise with this system concerning:

i) the design of the hangers to cater for a variety of product widths without causing damage;

ii) the difficulties in loading or unloading the hangers (whether with a manual, mechanised or automated system).

The manufacturers with experience in this field are concerned with items already on hangers, not with the design of a hanging system. If a suitable means of hanging the products could be devised, then obviously any suitable overhead carousel system would need scaling up in size from those systems in use in hanging garment warehouses. Information from consultants viewed such a proposed system as being non viable. It would involve too much research to devise a suitable hanging system that would eliminate any chance of damage. If such a system could be designed it would probably involve so much untried technology as to cause concern as to its feasibility and viability in use. Any such system would of necessity be a one-off and involve much capital investment which would not be outweighed by labour savings due to the need to load and unload products from the system.

Where hanging garment systems are in operation they are used as a storage system from which retrieval takes place to a load assembly area, before actually loading onto a vehicle. Any idea of an overhead carousel unit must therefore be discarded as a potential solution to dealing with the projected 1986 distribution levels.

FIG. 8

OVERHEAD CAROUSEL SYSTEM.

Overhead conveyor systems do exist which would be able to handle mattresses and divans. However these systems are designed for use in Production Departments where they are used to form production lines. Such uses obviously differ greatly from the load assembly function which is needed in this case. Discussions with manufacturers of such systems indicated their lack of suitability to such applications. Although load assembly forms a new potential market for such equipment, the costs of development were seen as uneconomic.

i) Automated Stacker Cranes (Scheme E)

The system proposed here can be considered to be fully automated.

Pieces leave production on a flat bed conveyor. A machine readable identity tag is placed onto each individual item. This is read by a scanner placed between the warehouse and production which decides if the item is for stock or the load assembly system. The load assembly system consists of racks served by automated stacker cranes (see fig. 9). The racking is designed to take the pieces as individual items. The distribution of the items in the individual alleys is controlled by the warehouse computer to give an even throughput of work to all the stacker cranes. Location of items throughout the system is therefore random. As soon as all the items required to form a load are in the racks this information is signalled to the loading bay.

Theoretically individual load assembly could be carried out by the stacker cranes collecting the items in the required order and delivering them onto a conveyor leading to the loading bay. This working method would result in a too slow and a too inflexible operation to fully serve the requirements of the loading crews.

Items leave the storage racks in inverted drop order and proceed to a load sortation system. This consists of flat bed conveyors with 90° diversions. The loaders can therefore call off pieces in the most convenient loading sequence. Final sorting is left to the individual load checker.

FIG. 9.

AUTOMATED STACKER CRANE SYSTEM.

The proposed automated stacker crane solution appears to overcome all the problems of the present system. No constraints are imposed on the Production Department by the system. Automated stacker crane systems are already in use for the storing of pallets so manufacturing capability exists. The proposed load sortation system for the items once they have left the main store has had certain doubts expressed about it, concerning its reliability once in service. This is primarily due to it handling higher volumes and bulkier items than any similar system already in use.

However, the stacker crane system does appear to be able to cope with all that is asked of it by the projected 1986 distribution levels and therefore ought to be considered in greater detail.

j) Individual Load Assembly Directly into Vehicles

All the previously described systems need a load assembly area in order to assemble all the pieces from a production shift ready for a loading shift. This is because the Production Department makes in a random order as far as despatch is concerned. One way to cut down the size of the load assembly floor has already been examined and discounted because it places too many constraints on the Production Department, i.e. the Three Batch System per Shift.

One way to overcome the necessity of having large loading floors so as to be able to handle a shifts production at any one time would be if it is possible to load directly into the vehicles. The Company projects that by 1986 virtually all the vehicles will be operating on a demountable box system. These boxes could then be loaded directly into, without the need to tie up motive power units. If the need to dispense with loading floors is carried out, then there must exist enough boxes to be able to cope with peak despatch days; that is on High Street delivery, 32 box loads a shift.

The total width required on a loading dock would need to be 32 times the box width, this is 32 x 8'4" = 267'. Obviously parking the boxes in such a manner is not practicable. On further examination this system as so proposed does not allow or take account that most vehicle loads are multi-drop; so that the loading sequence is of great importance.

To overcome this problem the use of curtain sided boxes was examined so that the individual pieces could be placed in the vehicle in their respective drop sequence. If this is the case then one shifts loads on a maximum High Street despatch day would take up 459' for box parking and access. This is made up as follows:

32 x 8'4" (box width) = 267'

32 x 6' (access alleys)= 192'

One box with access for loading therefore takes up 14'4".

A maximum despatch day including both High Street and Mail Order of 85 loads would need approximately 1,220' of despatch face in order to adequately cope with one day. Due to the way that the Production Department makes a particular set of shifts loads all the boxes would have to be ready at the start of the Production run for that particular shift, if any form of buffer storage is to be avoided. At times of shift changeover the Production Department would be making items for both shifts loads, so therefore 2 shifts set of boxes would have to be in position for loading. With the existing site there would be a problem to find enough space.

However other problems exist. The correct loading sequence would not always be attainable, as this would depend entirely on how the Production Department made. Another problem would be the increase in potential damage to the products once the vehicle is on the road.

It would be impossible to ensure that the divans formed the bottom part of any stack so that the stability of a stack would be poor. By the use of curtain sided vehicles giving access to all sections of the box at any one time the secure tying off of the stacks would present problems.

The idea of individual load assembly directly into vehicles must unfortunately be discounted due to several factors. The principle reasons being:

i) the vast amount of loading bay face required

ii) the system proposed is not able to allow the load build up to take place in a pre-determined sequence;

iii) the system seriously reduces the stability of the products once stacked in the vehicles so causing an increase in damage in transit;

iv) it reduces the utilization of the cube in the vehicle by not allowing flexibility in load build up

k) Individual Load Assembly in Mobile Racking

For all the systems described incorporating a conventional loading floor, labour is required to go into the load assembly area to pick pieces from an area containing a large number of loads. The minimum number of loads in any area being 8 and the maximum 32, in the schemes so far proposed, obviously it would be easier to pick from an area containing only 1 load.

A way forward was seen to be to assemble individual loads into a racking structure; divans on one side and interiors on the other. Picking would be done from a central alley. If the pieces were stood on end and took up a maximum of 5' a central alley for access estimated by the Company's management would need to be 7'. On a peak despatch day of 85 loads, the system would need 1,445' of racking and alley face. On the existing site this was seen as totally unpracticable, hence the idea of mobile racking with a need to have only a few access alleys. The number of alleys would be balanced against the number of loading teams.

At no stage in loading is there seen to be a requirement for more than five loading teams on High Street and three on Mail Order per shift. Normally there would be a total of six loading teams or less. For one shift therefore the loading alleys need take up no more room than 56' (i.e. 8x7') However more than one days equivalent of loading floor capacity must exist within the system. Due to the advantages of individual sets of racks per load, the equivalent of three shift floors capacity is not needed. Two and a half shift floors would have to be catered for on High Street.

The Mail Order operation does at this stage of the investigation present certain technical difficulties due to the different type of internal structure used in some of the interiors which prevents them from standing upright and rigid. Doubts therefore begin to appear about the validity of mobile racking so far as the Mail Order operation is concerned. This arises because of the risk of potential damage due to the incompatability of certain products within the system proposed.

On High Street alone the racks and access alleys would take up 905' (80 loads x 10' and 15 access alleys x 7').
The idea of mobile racking had to be discounted for several reasons:

i) it does not make full use of the cube necessary to be installed in the system to cater for variations in load size. Obviously with individual load assembly racks they must be planned around the maximum load size and not the average (unlike the conveyor belt sortation systems which overcome this problem by aggregating 8 loads together).

ii) problems of damage arising due to the nature of certain Mail Order products.

iii) the technical difficulties of automatically filling the racks

iv) the vast amount of rack face needed

A major factor against mobile racking was that the warehousing operation would need to consist of two systems one for High Street and one for Mail Order.

1) <u>Tow Line/Tow Cart Systems</u>

The tow line system consists of a truck installed in the floor which can pull trolleys around, see fig.10. The systems can be computer controlled and the trolleys sent to many destinations. Such systems find use in various warehouses and in production departments. The carts can be programmed to go to any particular area. In this respect they can be likened to a carousel in that the trolley with items on comes to the person and not the person to the goods. Tow carts/trolleys could dispense with the conveyor belt from production to the warehouse. The pieces would be placed on the trolley in the Production Department and then sent to the warehouse. On detailed examination of such a system certain logistical problems become apparent. These are concerned with coping with up to 9 pieces per minute on peak despatch days and then their subsequent sortation into individual loads. It is at the sortation to individual loads that problems with the concepts of this system arise. How to sort within a production shift up to 43 individual loads. Obviously in terms of the number of pieces in any particular load, no problems should arise, the number of trolleys can be automatically adjusted to suit the number of pieces.

Logistical problems however do arise in trying to sort items into individual trolleys to feed 43 loads in a non random manner. The problems basically arise because of the sheer volume of pieces involved.

Of the two companies approached concerning a tow line system both have backed down. Problems arise in the individual load assembly part of the system. One of the companies

FIG. 10.

TOW LINE / TOW CART SYSTEM.

said the problems might be solvable but at a tremendous price which would make the system entirely uneconomic, so it was not worth their while to proceed further. In discussion with consultants the same answer appeared. The sheer volume and the fact that only a load assembly system was needed would make the solving of the logistical problems very uneconomic if it did prove to be technically feasible.

In situations where tow cart systems are in use in warehousing they tend to feed into and out of bulk stores and are simply used as a carrier between goods received and storage or from storage to despatch. They are not used as a sortation system in their own right. In the warehouse system in question they would be used as the sortation system.

The tow line/tow cart system for handling interiors and divans must therefore be discounted as a potential answer to dealing with the projected 1986 distribution levels.

m) Automated Guided Vehicles

This is in many ways identical to the tow line/tow cart systems except that there is no track in the floor. They are directed normally by a wire guidance system or a light sensitive system see fig 11. Of these the wire guidance system is more common. Basically an automated guided vehicle may be defined as a driverless truck. Its route is normally determined by a guide wire buried 15-20mm below the surface of the floor. A high frequency transmitter feeds the guide wire with an alternating current which creates a magnetic field from which a scanning head on each truck takes its instructions. However current developments are looking at a "flight navigation" type of radio beacon system which would remove the expense of laying wires in the floor.

Obviously a wire guided system has some potential but falls down in the same area as the tow line systems in not being adapted to the load assembly function.

FIG. 11

AUTOMATED GUIDED VEHICLES

Authorities on the subject of automated guided vehicles state that because of problems involved in order selection and commodity mix only limited use can be forseen in certain warehousing areas. Again the logistical problems of working from a no stock situation appear.

The sheer volume to be dealt with also shows that at present such systems would be unable to cope. Only today are computer controlled systems being installed using 30 machines or so. As with the tow cart/tow line system a conventional warehousing solution is not required. What is required is a specialised load assembly system.

n) Automated Load Assembly Sortation

Products from production enter the sortation system. The product specification is identified to the system. The computer then asigns the piece to an individual load. The piece travels round the system till it comes to the shoot assigned to its particular load. See fig 12. The piece would either be pushed or tipped into the appropriate collection area. The system therefore sorts the pieces into individual loads.

Several problems exist with this system:

i) the vast amount of space required to collect individual loads from the sortation system

ii) problems of damage occurring to products when they leave the sortation system

iii) it only sorts products into loads not into the sequence required for the actual loading of the vehicle.

Such a system therefore does not offer a practical solution to dealing with the projected 1986 distribution levels.

FIG. 12

AUTOMATED LOAD ASSEMBLY - SORTATION SYSTEM.

o) Manual Racking Systems

The basis of all the racking systems is that pieces leave the Production Department and proceed to the racking zone. Due to the wide variations possible in the product mix, the products would have to be randomly installed in the racks. Obviously with the throughput levels predicted, the control of the individual item locations would have to be computer controlled.

The major problem with all racking systems is that regardless of how they are operated; narrow aisle stackers, order picking trucks, entirely manual picking they all show no labour saving over the existing practice of floor stacking items. This is for two main reasons;

i) high labour requirement is needed to place items in a racking system regardless of the type of equipment used

ii) a high labour requirement is needed to retrieve the items and take them to the vehicles for loading. This is due to the bulky nature of the product, only a limited number of items can be picked before the picker must come out of the system. Pallet storage methods cannot be used in this load assembly function due to the vast range of items it is possible to have to make up a single load.

Manual racking systems therefore seem to offer no advantages over the possible solution of modifying the present system (scheme A). They will naturally have a higher cost due to having:

i) the racking structure

ii) the need for computer control of the storage locations

iii) the cost of the storage and retrieval equipment

iv) a higher labour requirement

The utilization of the warehouse cube will be lower than in a floor stacking system, due to all the racks having to be made large enough to take the largest product. One way to partly overcome this would be to have racks of different sizes. Problems of possible changes in the mix of sizes in the future would cause potential problems. Again the warehouse cube would not be effectively utilized due to the actual racks and the fact that space would of necessity have to exist so as to facilitate easy manual storage and retrieval of the products.

Manual racking systems have a higher labour requirement than going to a fully automated stacker crane solution. They offer some of the advantages of a stacker crane solution but without the reduction in the labour requirement.

Due to their higher capital cost then the solution presented in modifying the present system and the similar, if not higher, labour requirement, it is proposed to discount manual racking systems at this stage of investigation. This is due to it not being able to offer any advantages over the proposed scheme A.

3.4 CONCLUSION

Fifteen main types of potential solutions to the Company's warehousing problems have been examined to see if they may be a feasible answer to dealing with the capacities and problems outlined earlier. Table 4 shows the results of this evaluation and it will be noted that only five possible systems meet all the evaluation criteria. These five schemes will now be looked at in greater detail in the next section.

Table 4

SUMMARY OF POTENTIAL SYSTEMS.

Proposed System \ Evaluation Criteria	Allows Load build up in a predetermined sequence	Caters for fluctuating load size	Does not constrain production	Manufacturers and or consultants see system as unworkable and or uneconomic	Does not damage products	Physical size of system fits into existing land (at Moss)	Caters for 1986 volume	Has 100% capability as a feasible system to deal with 1986 despatch volumes
1). The Present System	/	/	/	/	/	/	x	
2). 3 Batch per Shift	/	/	x	/	/	/	/	
3). Modifying the Present System	/	/	/	/	/	/	/	/
4). Manual Conveyor Belt Sortation	/	/	/	/	/	/	/	/
5). Conveyor Belt Sortation in Existing Building	/	/	/	/	/	/	/	/
6). New High Street Despatch Building	/	/	/	/	/	/	/	/
7). Horizontal Carousel	/	/	/	x	?	/	/	
8). Overhead Carousel	/	/	/	x	x	/	/	
9). Automated Stacker Cranes	/	/	/	/	/	/	/	/
10). Direct Assembly into Vehicles	x	/	/	/	x	x	/	
11). Mobile Racking	/	/	/	/	x	?	/	
12). Tow Line/Tow Carts	?	/	/	x	/	?	/	
13). Automated Guided Vehicles	?	/	/	x	/	?	/	
14). Automated Load Assembly Sortation	x	/	/	x	x	?	/	
15). Manual Racking Systems	/	/	/	/	/	?	/	

4. THE FEASIBLE SYSTEMS DESCRIBED

THE FEASIBLE SYSTEMS DESCRIBED.

4.1 SCHEME 'A' MODIFYING THE PRESENT SYSTEM.

In many ways this can be seen to be identical to the existing system. The underlying principle as to the methods of working are the same. The major difference, however, lies in the creation of three High Street floors and one and a half Mail Order floors. This will allow the loading floors to be cleared before Production needs to run on to that particular floor

The re-arrangement of the loading floors is :

High Street: Shift 1 - loaded from the ground floor - No. 1. warehouse
Shift 2 - loaded from the mezzanine floor - No. 1. warehouse
Shift 3 - loaded from the ground floor - No. 2 warehouse

Mail Order: All loaded from the mezzanine floor. No. 2 warehouse

However on its own, the above arrangement would not give adequate floor capacity on the ground floors. By placing the vehicles being loaded outside the warehouse. this would create extra ground floor capacity. On examination it was found that sufficient space would now exist to accommodate the floor stacking volumes to cater for the 1986 despatch levels. The ground floors in both warehouses would now have a holding capacity of 32 loads, that is 2,688 pieces. The other High Street loading floor, No. 1. warehouse mezzanine has a capacity for 32½ loads, that is 2,733 pieces. Therefore by moving the vehicle loading area outside the warehouse building, there would be created loading floors of a sufficient size to handle the projected 1986 distribution levels. The Mail Order load assembly and load despatch operation, as already mentioned, goes on to No,2 warehouse mezzannine. This floor has a capacity to hold just over 58 Mail Order loads, that is 3,978 pieces.

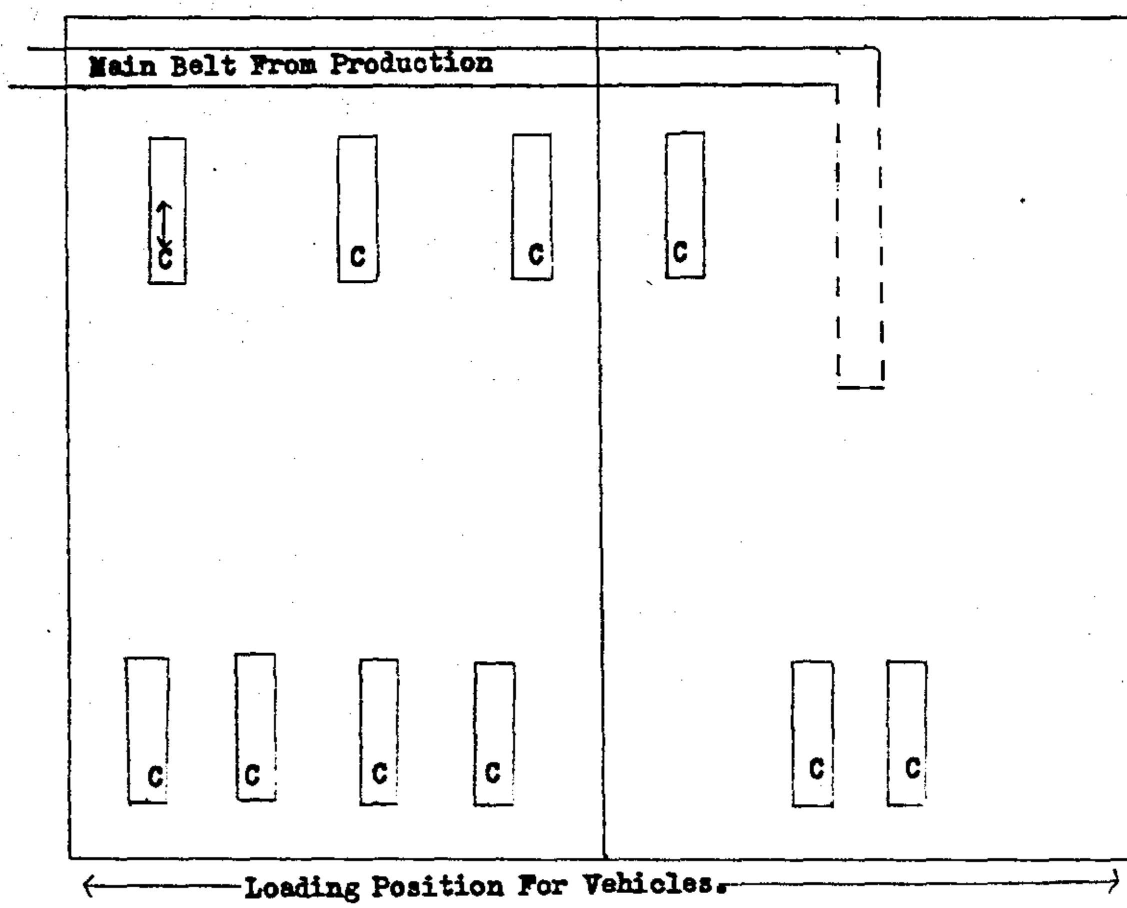
However, the expansion of the floor stacking areas on the ground floor would greatly add to the existing problems of the warehouse building being open to the elements. At present the vehicles stand inside the warehouse while being loaded and act as a buffer area to keep the weather out. With this area now proposed to be utilised for load assembly and load despatch some form of weather protection is needed. Weather seals and doors are now needed to go on to the outside of the loading areas of the warehouse

The main difference between this system and the existing one, excepting the larger floor areas is that the High Street load assembly and load despatch now operates on a three floor system. While Production is filling one floor,loading is taking place from another. During this time the third floor is being cleared of any excess stock, so that on the next shift Production can start to run on to a "clear" floor. This three floor system also acts as a buffer between the Production and loading operation.Essentially it creates a more favourable working environment which is able to cater for the inbalances in workload between production and despatch.

The use of wider gangways on the floors also allows work to proceed in a more efficient manner. The loading floors are therefore not as congested as under the present system. There will only be a maximum of one shift's set of loads on any particular floor at any moment in time. This will allow both the load assembly and load despatch operation to operate more efficiently, especially when considered with the fact that the gangways will be wider. This will therefore enable a High Street volume of 32 loads a shift to be efficiently handled.

To implement the above warehousing system certain modifications will need to be made to the existing system. Already mentioned has been the need for weather seals and doors on the front of the warehouse. To be able to cater for the 1986 volumes the main conveyor from the Production Department would need replacing and its arrangement altered in No, 2 warehouse so that it will not physically divide the new High Street floor. Other conveyor belt alterations would include the provision of a new up conveyor to No, 2 mezzanine floor. Fig.13 and Fig.14 can be compared to show the present conveyor belt arrangement in the load assembly area with that proposed for 1986.

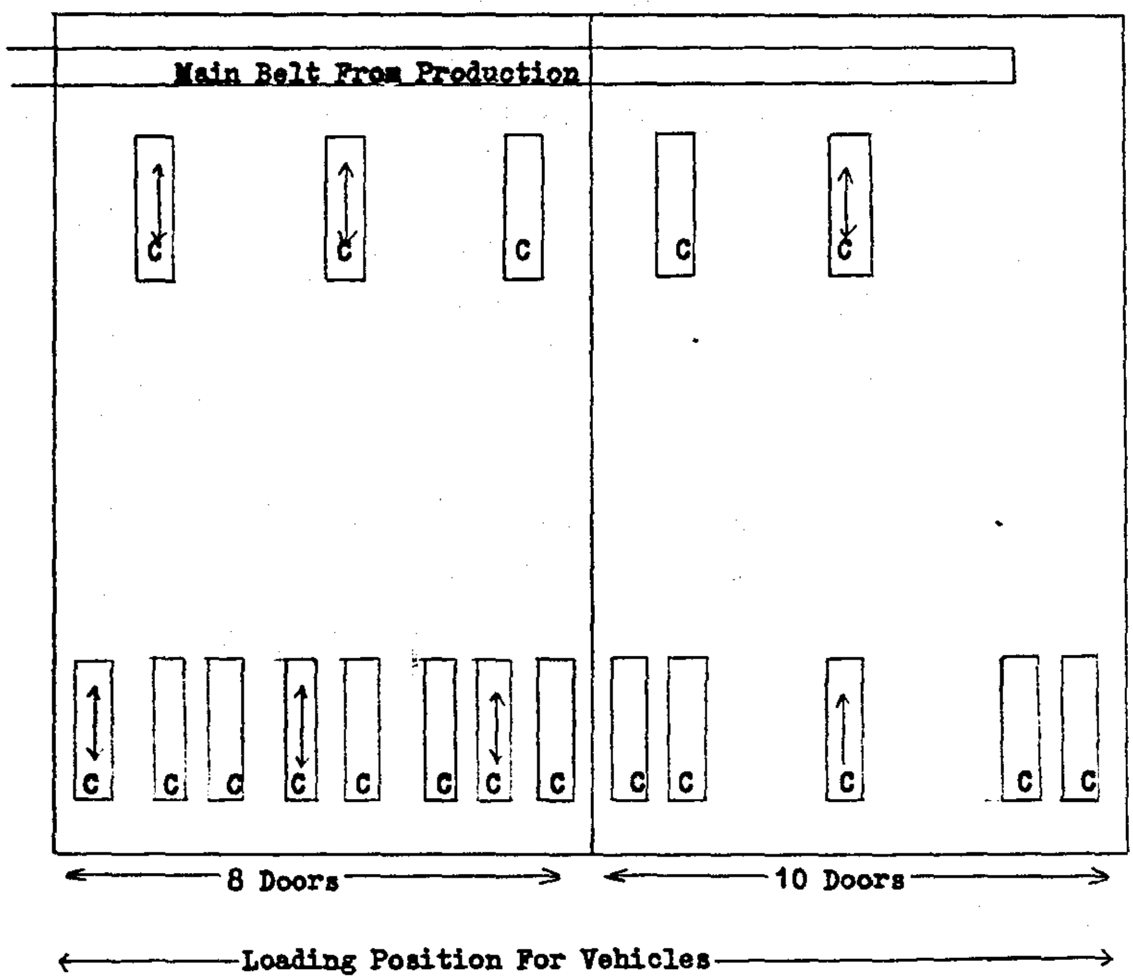
Fig 13. DIAGRAM TO SHOW THE CONVEYOR BELT ARRANGEMENT TO AND FROM THE MEZZANINE FLOORS - 1982 SITUATION



C=Conveyor

(Unless Shown The Conveyor Belts Travel In One Direction Only).

Fig 14. DIAGRAM TO SHOW THE CONVEYOR BELT ARRANGEMENT TO AND FROM THE MEZZANINE FLOOR 1986 SITUATION - SCHEME A.



C=Conveyor

(Unless Shown The Conveyor Belts Travel In One Direction Only).

For load despatch the down conveyors from both mezzanine floors would need adding to. To enable No. 1 warehouse mezzanine floor to adequately cater for the 1986 volumes extra down conveyors are needed so that this floor will be able to cope with loading up to 32 vehicles' loads a shift. No. 2 warehouse mezzanine which at present is hardly used for load despatch would need conveyors constructing, so that it would perform its new role as the Mail Order load assembly and load despatch floor.

However, further capital expenditure would be needed so as to allow the front half of No, 2 warehouse to be able to be fully utilised for its new role. The ground floor would need repairing and the mezzanine floor boarding over before it can regularly be used for load assembly/load despatch. These alterations therefore need to be completed before the proposed system can come into operation.

Movement of Spring Interiors and Divans through the System.

The items pass the production checkpoint in the same manner as at present. High Street products are coded from 0 to 9 according to the shift loading floor they are required for. Mail Order products are coded V to Z for the loading floor they are destined for

On entry into the warehouse the pieces are taken from the conveyor belt which comes from the Production Department and stacked on the appropriate loading floor. The products are stacked manually in piles of the same size and type. At any particular moment in time High Street products should only be being load assembled on one loading floor. The only time when High Street products may go on to two floors is at times of shift changeover.

Once production has finished being stacked on the shift loading floor for High Street distribution at the end of the shift, it will then be ready for loading. On Mail Order the products are ready for loading at the end of the appropriate manufacturing day. On High Street loading takes place on the next shift, while on Mail Order on the next day. Loading teams collect the pieces required in the correct loading sequence and place them directly on to the vehicle. All the picking of the pieces from the stacks on the loading floor and carrying them to the vehicles is done manually. As has already been mentioned all pieces are compatible with manual handling

By the end of the appropriate loading shift, or in the case of Mail Order, appropriate loading day the floor should theoretically be empty and now ready for production to start running on to it on the next but one shift. In practice a loading floor is rarely completely empty after loading has been completed. This is due to cancellations from loads after the items have been produced and excess being sent through from the Production Department. Excess are those items produced over and above the loading requirement but sent to the load assembly floors. These items will then be sent manually to the bulk store areas which occupy the rear half of both warehouse buildings. This clearing of floors after the loading operation has finished will mean that a loading floor will always be empty before production needs to run on to it .

Mail Order items are cleared into the rear of No. 2 warehouse which constitutes the Mail Order stock area. High Street stock is held in the rear portion of No. 1 warehouse, so therefore items left after the loading operation has finished from a particular High Street floor are taken to this area.

Certain items for loading do not come from the Moss production floor. These items are dealt with as follows:-

a). Bulk Stock. These are marked for the appropriate loading floor in the bulk stock area.
High Street products are then placed on to the main conveyor from production at the point where it enters No. 1 warehouse. Mail Order products from stock are placed on the main conveyor from production in No. 2 warehouse before the up conveyors to the mezzanine floor.

b). Sutton Storage Products. These items do not travel on the main conveyor from the Production Department. This helps to reduce the risk of handling damage. These products arrive at the Moss warehouse on inter-site trailers. The Sutton manufactured storage products are off loaded from the inter-site vehicles on to the appropriate loading floor. Those going on to No.1 warehouse mezzanine travel up via one of the three loading conveyors which is powered for both directions of travel. In order to off load the inter-site trailers direct on to the appropriate loading floor, some pre-assembly of storage products at Sutton needs to take place to ensure that all the products for one set of shift's loads are all together on the same trailer.

c). Associate Mail Order Company Products. Certain associate company products will be held in stock in the rear of No.2 warehouse and dealt with as mentioned earlier under items from bulk stock. However, if the products are ordered against production summaries from Sealy and or, Perfecta they can be fed directly on to the Mail Order loading floor by one of the conveyors at the front of No. 2 warehouse.

d). Headboards. These are dealt with in the same way as at present. They are sent from the Sutton Factory on inter-site trailers and then assembled into individual loads in the headboard store on either trolleys or in pallets. When the headboards are required for actual loading, the appropriate trolley or pallet is moved adjacent to the appropriate vehicle. The loaders are then free to select the headboards as required to ensure the maximum cube utilisation of the vehicle

The Bulk Stock Areas.

It has been shown that to create adequate loading floors to cater for the 1986 despatch volumes, it has been necessary to use all the front of both warehouses for the load assembly/load despatch operation. This means that compared with the existing system there is a loss of stacking area for up to 2,000 sets because No. 2 warehouse mezzanine floor is no longer available due to now being the Mail Order loading floor. This therefore leaves the existing warehouse with a stockholding capacity of 9,000 sets. This is composed of 4,500 sets in the rear of each warehouse. This stock is held in post pallets stacked one above the other up to five high and served by reach trucks.

Obviously the figure of a total stock holding of 9,000 sets is a drastic shortfall from the projected need for the stockholding to be around 16,000 sets immediately prior to the main holiday periods in July and September. The cheapest way to raise the stockholding was found to be to use the Barnsey Shed, an old predominantly single storey weaving mill. The Barnsey Shed is shown on the site plan as being vacant and is owned by Silentnight.

Barnsey has a capacity to hold approximately 9,000 sets and this would therefore enable the bulk stocking capacity to be raised to a maximum of 18,000 sets. In order to hold up to 9,000 sets in Barnsey Shed, certain modifications would need to be made, essentially to keep the weather out, and the installation of a sprinkler system. As can be seen from the site plan, The Leeds and Liverpool canal separates Barnsey Shed from the existing Moss site. A link is therefore needed between the two sites to facilitate the movement of stock between the Moss warehouse and Barnsey Shed. The most convenient way to provide this link is by a conveyor, which is seen as being in a bridge over the Leeds and Liverpool canal

Barnsey Shed is seen as being utilised to hold stock immediately prior to the main holiday periods of July and September. It will therefore be utilised for only a small part of the year. It is envisaged that the most effective method to hold stock for these times would be to floor stack the interiors and divans. No storage equipment is therefore needed to handle up to 9,000 sets which would be held in Barnsey.

For all the bulk stocking at Moss the present system of pallets stacked above one another by the use of reach trucks would be maintained.

The Loading Floors.

a). High Street Ground Floors. The layout of the loading floors is shown in Fig.15. Products enter the warehouse on the conveyor at the rear of the loading floor. Adequate gangways as shown exist to enable load assembly and load

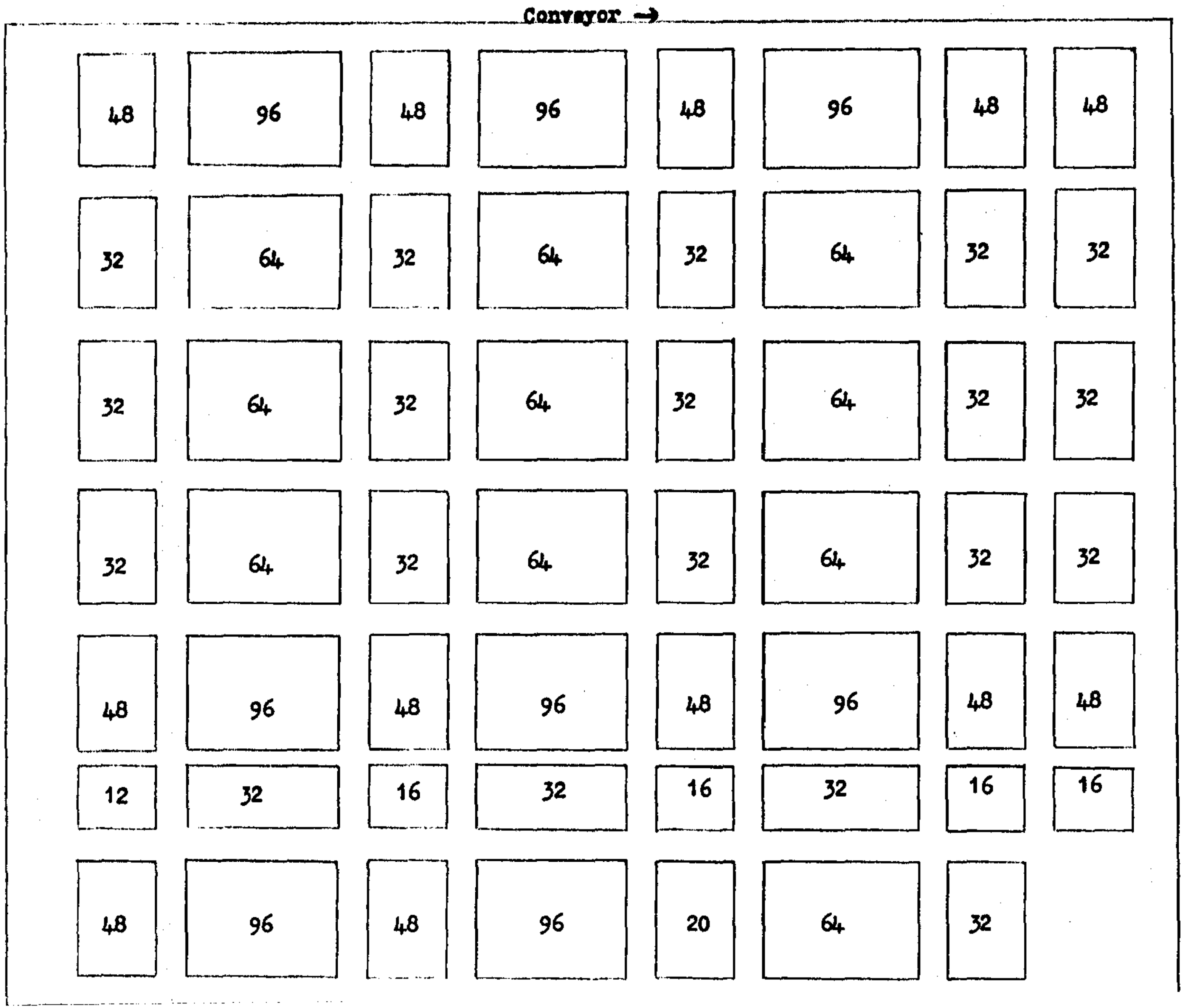


Fig 15
HIGH STREET GROUND FLOOR LAYOUT - SCHEME A.

The Figures Refer To The Number Of Pieces Which It Is Possible To Hold In Each Block.

despatch to take place in an efficient manner. Despatch takes place at the opposite end of the loading floor, from the conveyor from the Production Department

b). High Street Mezzanine. The arrangement of floor stacking is shown in Fig.16. Two up conveyors bring items from the Production Department and where necessary also from the bulk stock area. Sutton storage products are fed up from the opposite end of the loading floor direct from inter-site trailers. Once all the products for a particular Shifts' loads have been assembled they are then ready for loading. As the goods are picked they are carried to one of the down conveyors which feed directly to the back of the vehicles.

c). Mail Order Mezzanine. The floor arrangement is shown in Fig. 17. Two up conveyors lead on to the floor bringing in items direct from the Production Department and the Mail Order bulk stock store. Five conveyors exist at the other end of the loading floor. All Sutton storage products and associate Mail Order products for direct despatch are sent up on to the Mail Order loading floors by the central conveyor. Four down conveyors exist for loading. These are arranged in pairs on opposite sides of the loading floors, being used for loading on alternate days.

The Labour Requirement.

The labour requirement for operating this system is shown in Table 5. This shows that a labour force of 103 is needed which will cost the Company on an annual basis £691,645. These figures were arrived at by examining the total number of pieces it would be practical for one person to handle per shift. The exercise was done in consultation with the Company's Distribution and Work Study Management. It was felt by all concerned that the warehouse Management levels - that is the Head of Department and Shift Supervisors would stay the same as at present. The only change in the labour

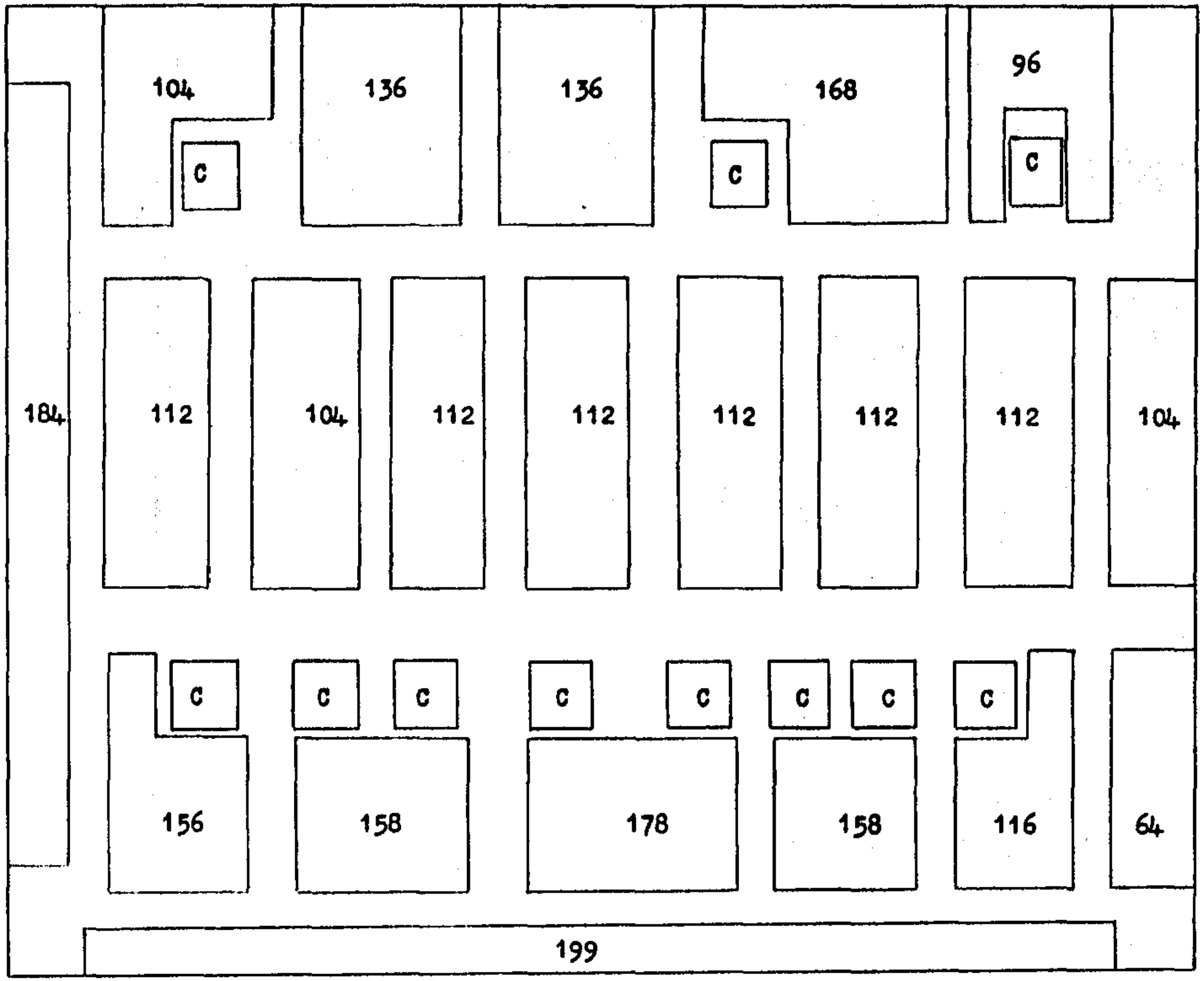


Fig 16

HIGH STREET MEZZANINE FLOOR LAYOUT - SCHEME A.

C=Conveyor

The Figures Refer To The Number Of Pieces Which It Is Possible To Hold In Each Block.

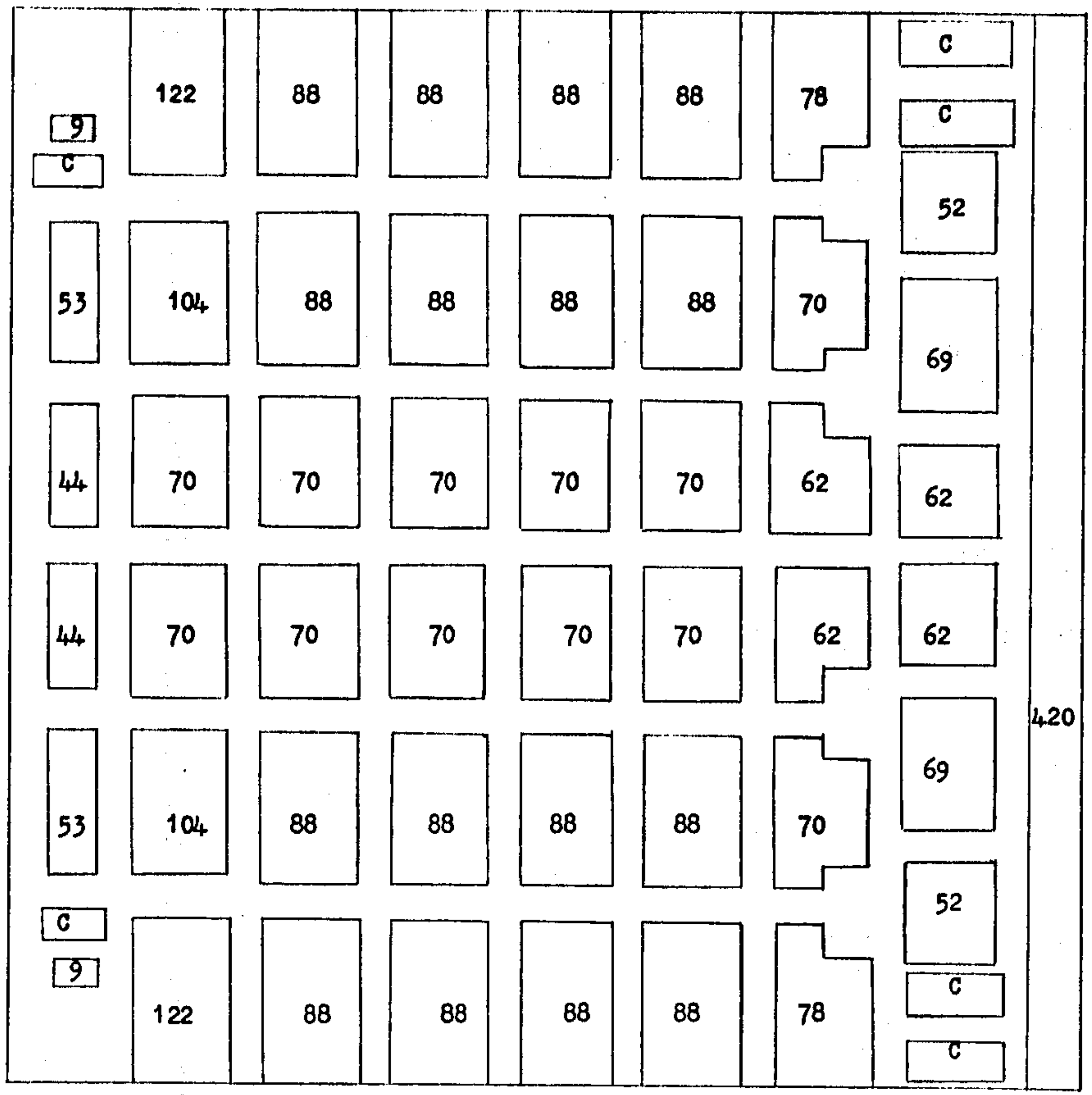


Fig 17. MAIL ORDER MEZZANINE FLOOR LAYOUT - SCHEME A

C=Conveyor

The Figures Refer To The Number Of Pieces Which It Is Possible To Hold In Each Block.

requirement between the various schemes was concerned with the manual labour force directly involved in moving the actual pieces in the warehouse

The Capital Cost. The total capital cost of implementing the aforementioned scheme is £337,380. The details are shown in Table 6.

Implementation Timescale. Fig. 18 shows the estimated time schedule in which it is proposed to complete all the necessary work to enable this warehouse scheme to operate in full. It will be seen from the attached Time Schedule that a period of 43 weeks is judged sufficient.

TABLE 5.

THE LABOUR REQUIREMENT - SCHEME 'A'

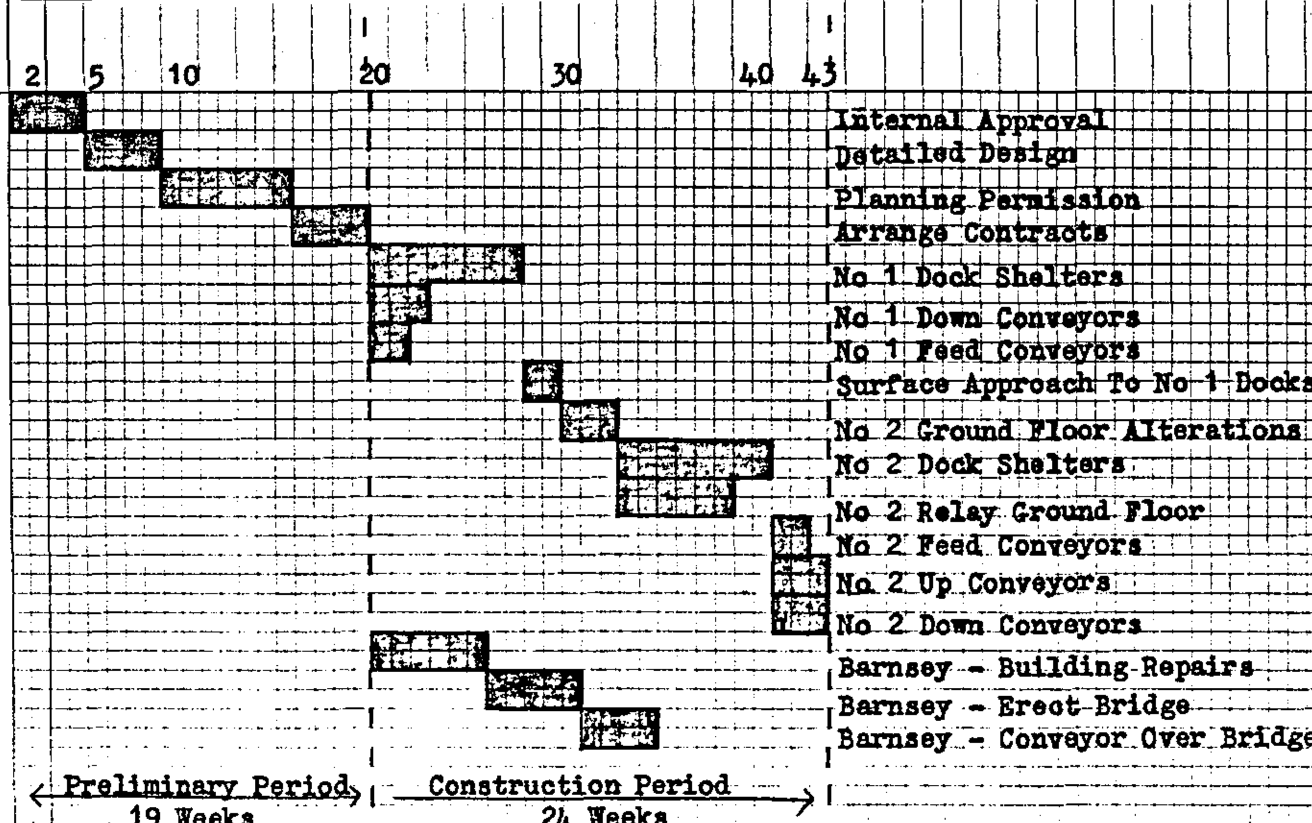
Head of Department	2		
Shift Supervisors	4		
Beltmen	26		
Floor Setters	4		
Fork Lift Operators	5		
Loaders (includes Load Checkers)	52		
Shunters	4		
Returns	2		
Headboards	3		
Cleaners	1		
	103	=	£691,645

TABLE 6.

CAPITAL COST SUMMARY - SCHEME 'A'	£.
Replacing Conveyor from Production Department	87,000
Constructing new up Conveyors to the loading floors Constructing new loading Conveyors.	51,150
Conveyor to Barnsey	10,000
Weather seals and doors on front of No. 1 and No.2 warehouse	44,730.
Repairs to No. 2 warehouse floor	25,500
Repairs to No. 2 mezzanine floor	9,000
Bridge to Barnsey	90,000
Barnsey building adaptations for stock	20,000
	£337,380

Fig 18

IMPLEMENTATION TIMESCALE - SCHEME A



4.2 SCHEME 'B'. CONVEYOR BELT MANUAL SORTATION IN EXISTING BUILDING.

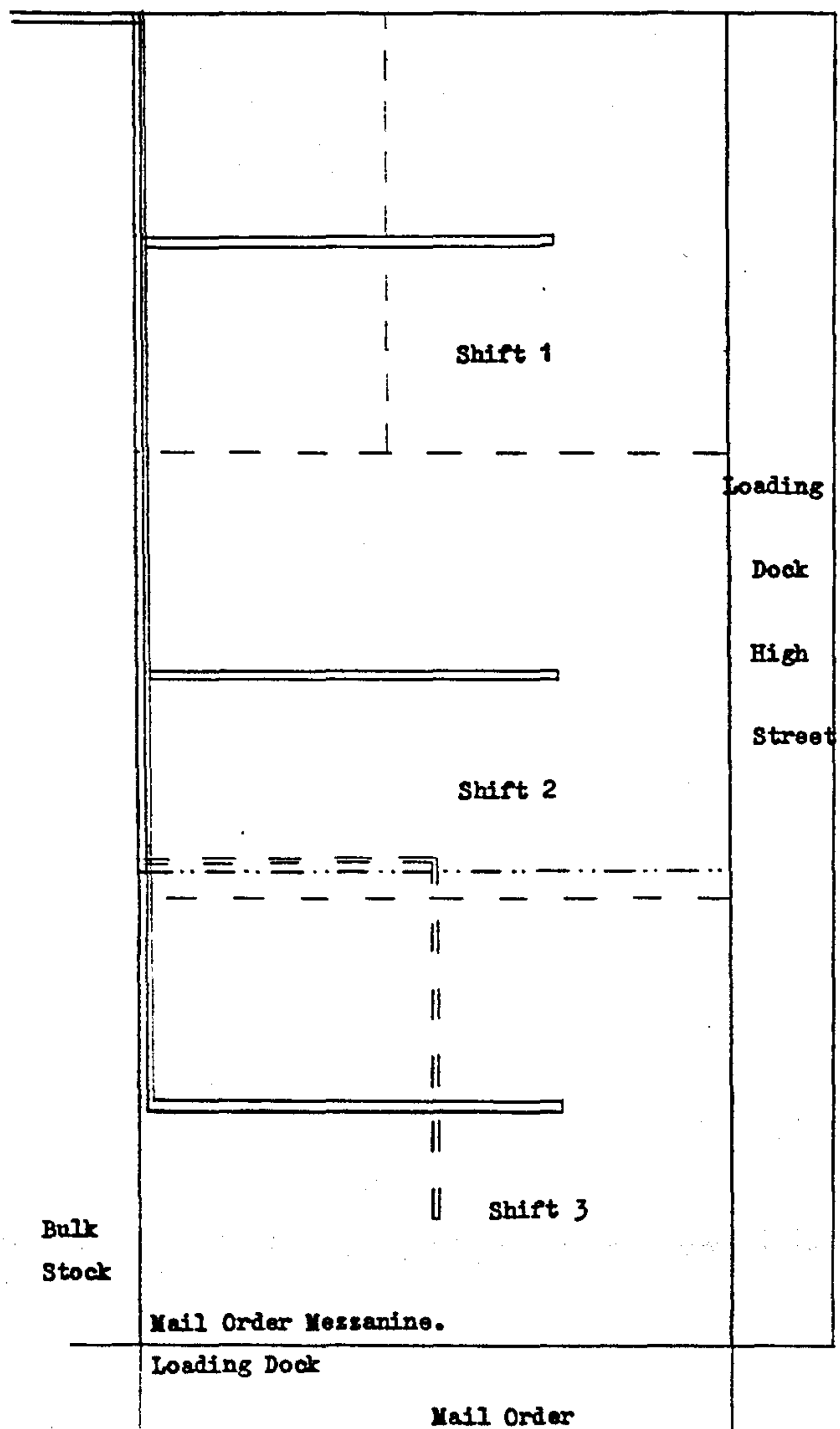
In Scheme 'B' it is proposed to concentrate all the despatch function in No. 2 warehouse. No. 1 warehouse will become concerned with holding stock. The actual working arrangements of the despatch operation are the same in principle as that already described for Scheme 'A'. Three High Street floors and one and a half Mail Order floors are created.

The three High Street floors occupy the ground floor of No. 2 warehouse and load out of the side of the building from newly constructed loading banks. Mail Order load assembly and load despatch will take place on No. 2 mezzanine and loading will be by means of down belts leading to a loading bank on the front of the building, see Fig.19

The ground floor in No. 2 warehouse has sufficient capacity to accommodate three High Street shift loading floors. Each floor would be capable of handling the volumes demanded by a maximum despatch shift of 32 loads. The Mail Order operation, as already mentioned, goes on to No. 2 warehouse mezzanine. This floor has a capacity to hold just over 58 Mail Order loads, that is 3,978 pieces.

The main difference between this system and that in use at the present time, excepting the larger floor areas necessary to cater for the 1986 despatch levels is that the High Street operation now takes place on a three floor system. The immediate advantage over Scheme 'A' is that all High Street loading takes place from one level, the ground floor. This obviously helps to create a more favourable working environment. The three floor High Street system is another contributory factor to this more favourable working environment. It allows one floor to be filled from Production, one to be picked from for loading, while the other is being cleared of any excess stock back to the bulk store. This means that Production can start to run on to a clear floor at the commencement of any Production shift. The three floor system, therefore, creates a time buffer between the production and loading operation.

Fig 19. LOADING FLOOR ARRANGEMENT - SCHEME B.



The use of wider gangways on the floors also allows work to proceed in a more efficient manner. The loading floors are therefore not as congested as under the present system. There will only be a maximum of one shift's set of loads on any particular floor at any one moment in time. This will allow both the load assembly and load despatch operation to operate more efficiently, especially when considered with the fact that the gangways will be wider.

To allow further improvements in efficiency in the load assembly/ load despatch operation, the area to be picked from needs to be reduced. This would increase labour efficiency by:-

a). Reducing the total number of items in an area, so speeding up efficiency.

b). Reducing the walking distance, hence more effectively utilising the labour.

To achieve a smaller load picking area than at present some change is needed in the system which produces the production summaries and the loading sheets. It is necessary to be able to identify products as they leave production for particular groups of loads within a shift. This is essential if the picking areas for distinct groups of loads are to be reduced. At present the loading sheets which identify the products to individual loads are not ready until after production has commenced All that is known when a product is manufactured is to which particular shift's set of loads it belongs to. In order to be able to split a shift's set of loads down it is necessary to have a system in which the loading sheets are available before production commences. The actual number of pieces going to any particular area on a High Street shift loading floor depends on the actual number of loads being produced on that particular shift. The actual number of loads going to an area of the floor depends on the total number of loads being made at the time and is purely a numerical division. It is intended that the split be even within a shift. It was found to be convenient to quarter the loading floors, each area on a maximum despatch day having a requirement to hold 8 loads. Therefore each High Street day would see two Production summaries (one for each shift) and eight warehouse summaries.

The above system therefore needs the loading sheets to be ready before Production commences. This demand obviously alters the present timing arrangements of the routeing and planning operation as related to the manufacturing operation. Such information is needed before the Production Department starts to make. At present this information is unavailable at this time. It is therefore proposed to work a night shift in the Routeing and Planning Department so that the individual load sheets will be available before production starts. This information can then be used to route products to particular quarters of the High Street loading floors.

The Production Department day of 15 hours would stay the same as at present. However, the timings would be altered in which to complete the work as specified by the Production summaries. The Production day would run from 10.00 a.m. the previous day until 6.00 p.m.and from 6.00 p.m. to 10.00 a.m. the following day. Loading would stay on the present shift timings: 6.00 a.m. to 2.00 p.m. and 2.00 p.m. to 10.00 p.m.

Production of shift 1 would start at 10.00 am the previous day and run through till 6.00 p.m.; when the next shift's loads should start and run through till 10.00 a.m. Due to the fact that loading of the first production batch does not start till 6.00 a.m. this gives Production a 4-hours'buffer in which any shortfall could be rectified. (It will be remembered, as outlined earlier,that the Company operates on a two-shift system). There is therefore a period of 4 hours allowed between when production should finish and loading can start. The system stores products for 4 hours only. Therefore ideally, loading should be 4 hours behind production.

The Mail Order production summaries and loading sheets would continue to be produced in the same manner as at present. There is no need to alter the routeing and planning arrangements because all Mail Order loads are made up before production starts. As already stated Mail Order will load out of the front of No, 2 warehouse direct from the mezzanine floor.

To implement the above warehousing arrangements certain modifications will need to be made. The main alteration concerns the conveyors. These are shown in Fig.19 which shows the arrangement of the loading floors. The main conveyor from the Production Department passes round the outside of the bulk stock area in No. 1 warehouse to enter No. 2 warehouse at the ground floor level in the top left-hand corner. The arrangement prior to entry into No. 2 warehouse is advantageous in that all the products from both production and the bulk store are are on the main conveyor as soon as it enters the load assembly/load despatch area. The belt then extends along the rear wall of No. 2 warehouse. The ground floor is divided into three High Street floors. Each floor is divided into two equal halves by conveyors which run at right angles to the main conveyor from the Production Department.

Approximately two-thirds along the warehouse floor an up conveyor leads to the mezzanine floor. When at the mezzanine level this conveyor divides the Mail Order floor into two equal halves. Four down conveyors are provided for the loading operation.

The three conveyors to the individual High Street assembly floors and the Mail Order conveyor are not physically connected to the main conveyor entering from the Production Department. Products are transferred to these conveyors by the labour force employed in the warehouse. The means of transfer between the conveyors is entirely manual.

Capital expenditure would also be needed so as to allow the front half of No. 2 warehouse to be fully utilised for its new role. The ground floor would need repairing and the mezzanine floor boarding over before it can regularly be used for load assembly/load despatch. Loading docks need to be constructed to adequately protect the loading operation from the weather. As can be seen from the diagram showing the conveyor layout, the loading docks extend round two sides of the warehouse. These alterations, therefore, need to be completed before this proposed system can come into operation.

Movement of Spring Interiors and Divans through the System.

The items proceed from the Production Department to pass the production checkpoint at which stage they are coded. Mail Order products are coded from 'V' to 'Z' according to the loading floor they are destined for. High Street products are initially coded '0' to '9' for the shift loading floor they are required for. Once identified they are then lettered either a, b, c, d. according to which particular quarter of the shift loading floor they are required for. This work is done manually at the production checkpoint.

The piece is now able to proceed into the warehouse suitably identified for the appropriate section of the loading floor. On entry into No. 2 warehouse the items proceed down the main conveyor. Once adjacent to the appropriate loading floor the High Street products are manually transferred to the conveyor which runs down the centre of that particular loading floor. These belts for the loading operation are only powered for approximately half their length from the main conveyor. The reason for this is to ensure that no bottlenecks occur adjacent to the main conveyor so necessitating that the main belt is stopped. The other half (that is nearest the loading bank) is left stationary and acts as an overrun for the items entering the despatch floor. Once products are on the floor conveyor they are visually recognised by the beltmen by their coding as destined for a particular quarter of a shift loading floor. From here they are manually taken and stacked on the appropriate section of the loading floor in piles of the same type and size. At any one particular moment in time High Street products should only be being load assembled on one loading floor. The only exception to this is at times of production shift changeover when production will be finishing on one Shift's set of loads and starting on the manufacture of the next.

At the end of the production run all the items for the loads should therefore be assembled. These then stand for 4 hours and are then loaded over the next 8 hours.Loading teams will work in turn from each of the quarters. Those teams working the quarters nearest to the loading bank will walk the products on to the loading bank and place them on to boom conveyors which feed into the rear of the vehicles. The teams working the rear two quarters will use the central conveyor to take pieces down to the loading banks. From here the pieces will travel via boom conveyors into the rear of the vehicles.

Mail Order products entering No. 2 warehouse travel on the main conveyor till they are adjacent to the Mail Order conveyor which leads up to the mezzanine floor. The Mail Order products are identified and then manually transferred to the mezzanine conveyor. Once on the mezzanine floor the products are taken from the belt and manually stocked in piles of the same size and type. There they wait until called off for loading the next day. It will be remembered that Mail Order, unlike High Street, works on a daily basis, not a two shift system. Loading teams collect the pieces required in the correct loading sequence. They are then placed on one of the down conveyors which leads to the vehicle being loaded. Out of the four down conveyors only two will be in use at any one time. The other two will be used on the next loading day.

By the end of the appropriate shift or loading day, depending on whether one is dealing with High Street or Mail Order products, the floor should theoretically be empty. In practice this rarely happens. Provision for the clearance of cancellations and excess stock from the loading floors has been made. At the end of loading on High Street there is an interval of 4 hours before the floor starts filling from Production. This time is allowed to clear the floor of cancellations. Cancellations from the High Street floors can be passed back into No. 1 warehouse which is utilised for bulk stock, through gravity feed conveyors breaching the dividing wall. Mail Order cancellations and excess will be placed on a down conveyor to take the items into No. 1 warehouse

Certain items for loading do not come from the Moss production floor. these items are dealt with as follows:-

a). Bulk Stock.. Products withdrawn from stock are marked for the appropriate loading floor and or section of and then placed on to the main conveyor leading into No. 2 warehouse Once on the belt their movement is exactly the same as that for items from Production.

b). Sutton Storage Products. To reduce the risk of handling

damage Sutton products do not travel on the main conveyor which leads from the Production Department unless they have been held in stock in the bulk store. Sutton storage products will arrive at the despatch warehouse by inter-site transport. Products for High Street despatch are intended to be off-loaded on to the appropriate loading floor and assembled adjacent to the loading positions. Mail Order Sutton Storage products need to be sent on to the mezzanine floor. This is achieved by the use of one or more of the down conveyors which are also reversible. Products are sent up on to the mezzanine floor and load assembled in the appropriate section.
To do this some pre-assembly of storage products at Sutton needs to take place. This would ensure that the inter-site vehicles carry the products for the appropriate sections of a loading floor together. With the new timings for the loading sheets this would now be possible

c). Associate Mail Order Company Products. For those products held in stock the arrangements are identical to that already described for items from the bulk store. However, if the products are ordered against production summaries from Sealy and or Perfecta. They can be fed directly on to the Mail Order loading floors.

d). Headboards. These are arranged as for Sutton storage products. Pre-assembly of headboards will take place at Sutton. On arrival at Moss the headboards go into temporary storage in the headboard store until required for actual loading. They are then moved in the pallets they were packed in at Sutton, to be adjacent to the appropriate loading point. The loaders are then free to select the headboards as required to ensure the maximum cube utilisation of the vehicle.

The Bulk Stock Areas.

No. 2 warehouse has now been given over entirely to the despatch operation. This therefore means a loss of stockholding capacity of 6,500 sets (The present stockholding utilisation possible is No. 2 warehouse). However the whole of No. 1 warehouse now becomes available, giving an increased stockholding capacity of a total of 8,500 sets from the present 4,500 sets. The reason why the capacity in No. 1 warehouse is not doubled is that at the front of No.1 warehouse there are offices which prevent the full use of pallet stacking. A means of further increasing the volume of stock it is possible to hold is required. This is needed in order to cater for the periods prior to the main holidays in July and September. As previously described in Scheme 'A' the cheapest solution is to use Barnsey Shed. The capacity of stock it is possible to hold can now be raised by a further 9,000 sets. This therefore allows a total stockholding of 17,500 sets. Certain modifications are needed to the fabric and structure of Barnsey Shed to enable it to fulfill its new role. Obviously a connection is needed to the Moss site. This is best achieved by a conveyor in a bridge over the Leeds and Liverpool canal.

Barnsey Shed will only be used to hold stock immediately prior to the main holiday periods of July and September. The most cost-effective method to hold stock was therefore judged to be to employ floor stacking. No storage equipment is therefore needed, as all movement of the items is by entirely manual methods,

For all the bulk stocking at Moss, the present system of pallets stacked above one another would be retained.

<u>The Loading Floors.</u>

a). High Street Floors. Fig. 19 shows the floor arrangement of the three High Street floors. Fig. 20 shows the layout of one High Street floor. Products enter the warehouse on the conveyor which runs along the rear of the loading floor. Down the centre of each loading floor runs another conveyor. Once products are transferred on to this central conveyor, they are taken and stacked in the appropriate quarter of the loading floor. Each loading floor comprises four separate summaries:

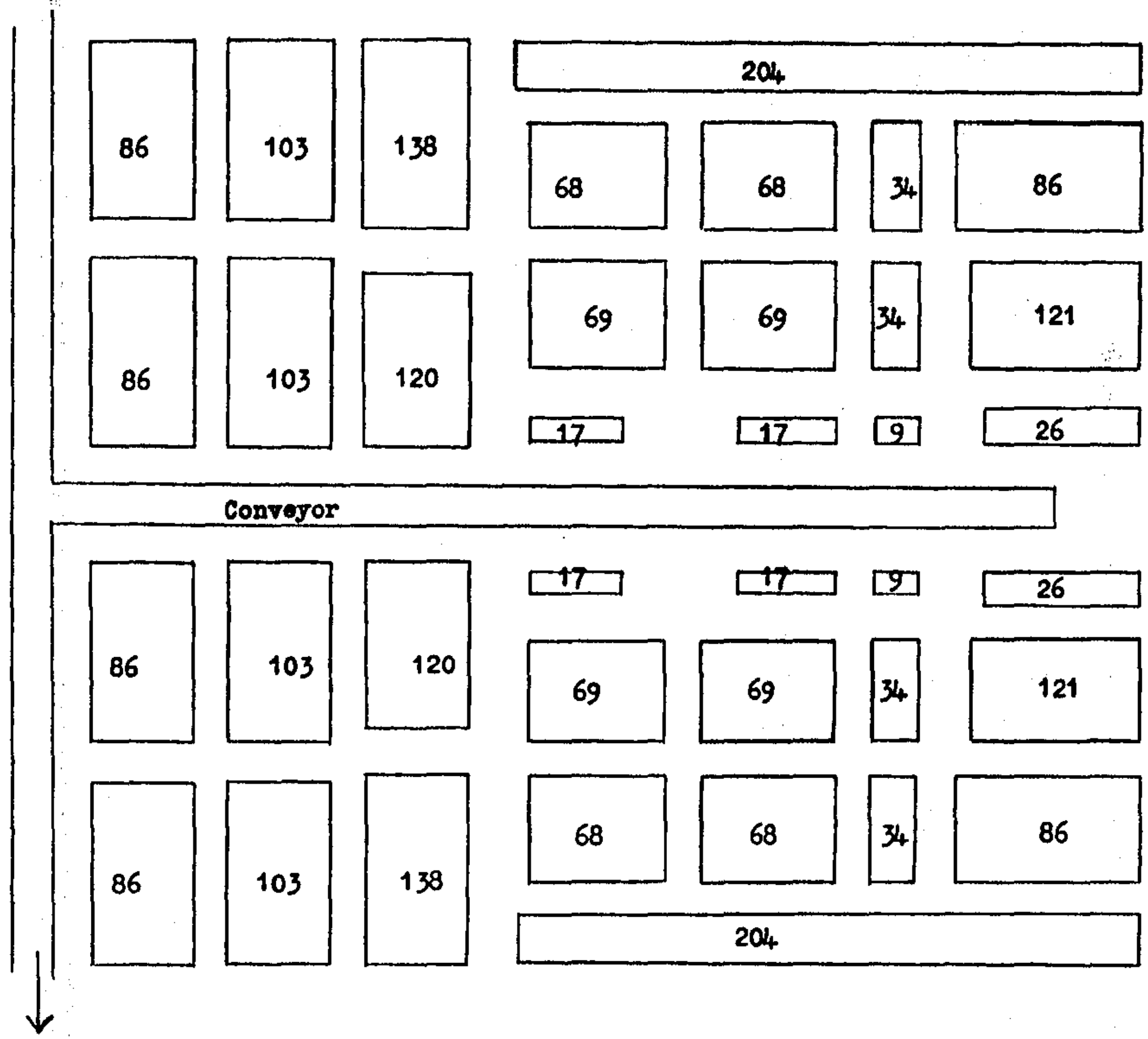


Fig 20. HIGH STREET LOADING FLOOR LAYOUT - SCHEME B

The Figures In The Boxes Refer To The Number Of Pieces Which It Is Possible To Hold On That Section Of The Floor.

thus quartering the floor area. All storage products are held adjacent to the loading bank and grouped into two batches, each composed of the products needed for the two quarters immediately behind it. Each loading summary will refer to 25%.of the total shifts' loading and the teams will load opposite quarters, that is from the front right hand side of the belt and from the rear left hand side of the belt. When these areas of the floor are cleared, the men operating at the rear will move to the forward area and vice versa for the men on the other side of the belt. Those men operating from the rear will use the central conveyor to move the goods to the loading bank, whilst the teams loading from the front section will walk the beds on to the loading bank. Boom conveyors will carry the beds into the boxes.

b). Mail Order Floor. The floor stacking arrangement is shown in Fig.21. One up conveyor leads on to the mezzanine floor and then proceeds to divide it into two equal halves, each half roughly corresponds to a Mail Order loading day. Each half is served by two down conveyors. These conveyors can also be used as up conveyors to enable Sutton storage products and Associate Mail Order Company products to reach the Mail Order load assembly floors. As goods are picked for loading they are carried to the down conveyors which feed directly on to telescopic boom conveyors which take the items into the back of the vehicles.

The Labour Requirement.

The labour requirement for operating this system is shown in Table 7. This shows that a labour force if 83 is needed and on an annual basis this costs £557,345. These figures were arrived at in consultation with the Company's Distribution Management.

The Capital Cost.

The total cost of implementing this scheme is £1,081,490. The details are shown in Table 8.

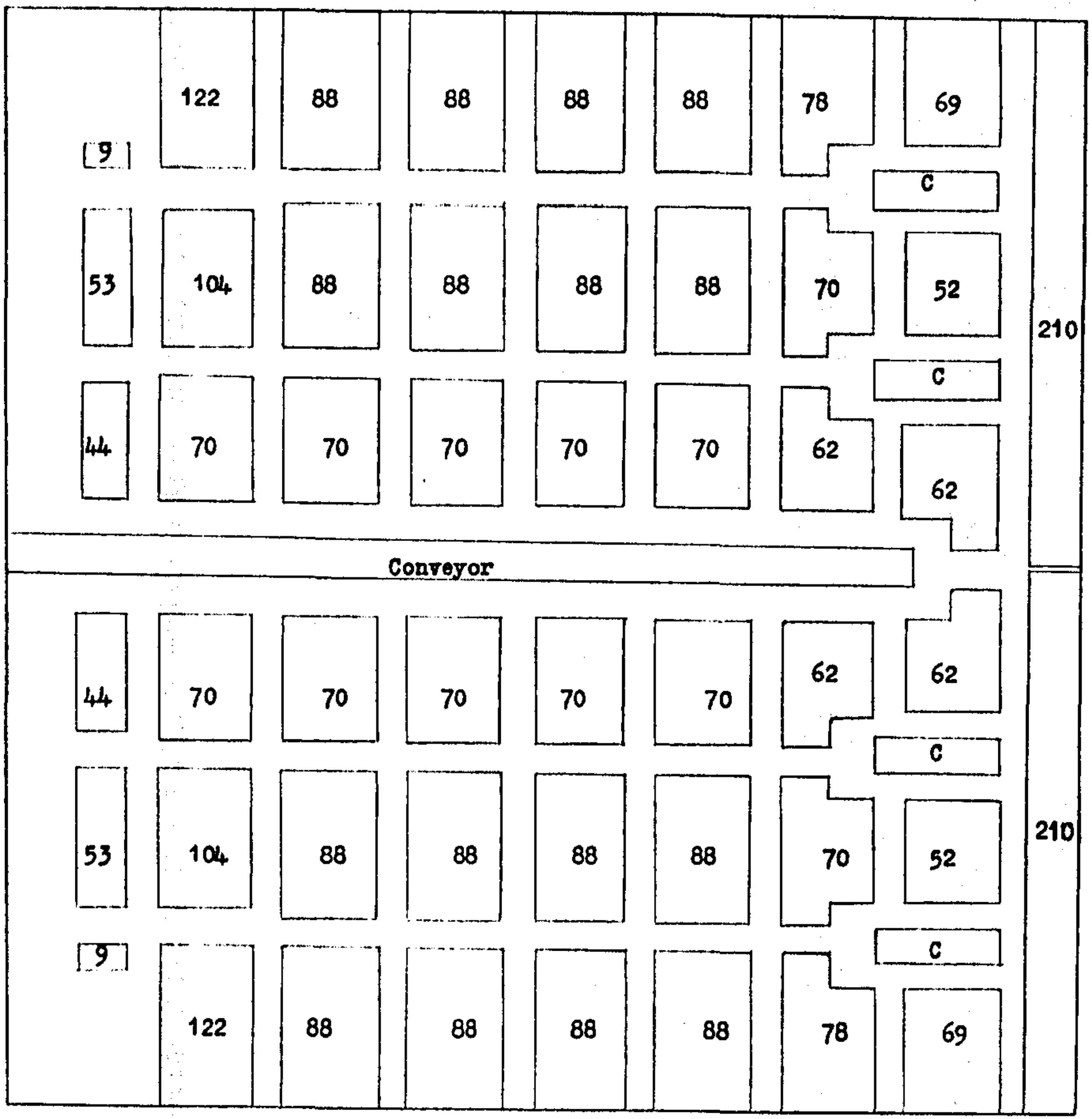


Fig 21. MAIL ORDER LOADING FLOOR LAYOUT - SCHEME B.

C=Conveyor

The Figures Refer To The Number Of Pieces Which It Is Possible To Hold In Each Block.

Implèmentation Timescale.

Fig. 22 shows the estimated timescale in which it is proposed to complete all the necessary work to enable this warehouse scheme to operate in full. This work is projected to take 68 weeks .

TABLE 7.

THE LABOUR REQUIREMENT - SCHEME 'B'

Head of Department	2
Shift Supervisors	4
Belt Men	22
Floor Setters	4
Fork Lift Operators	5
Loaders (includes Checkers)	36
Shunters	4
Returns	2
Headboards	3
Cleaners	1
	83 = £557,345.

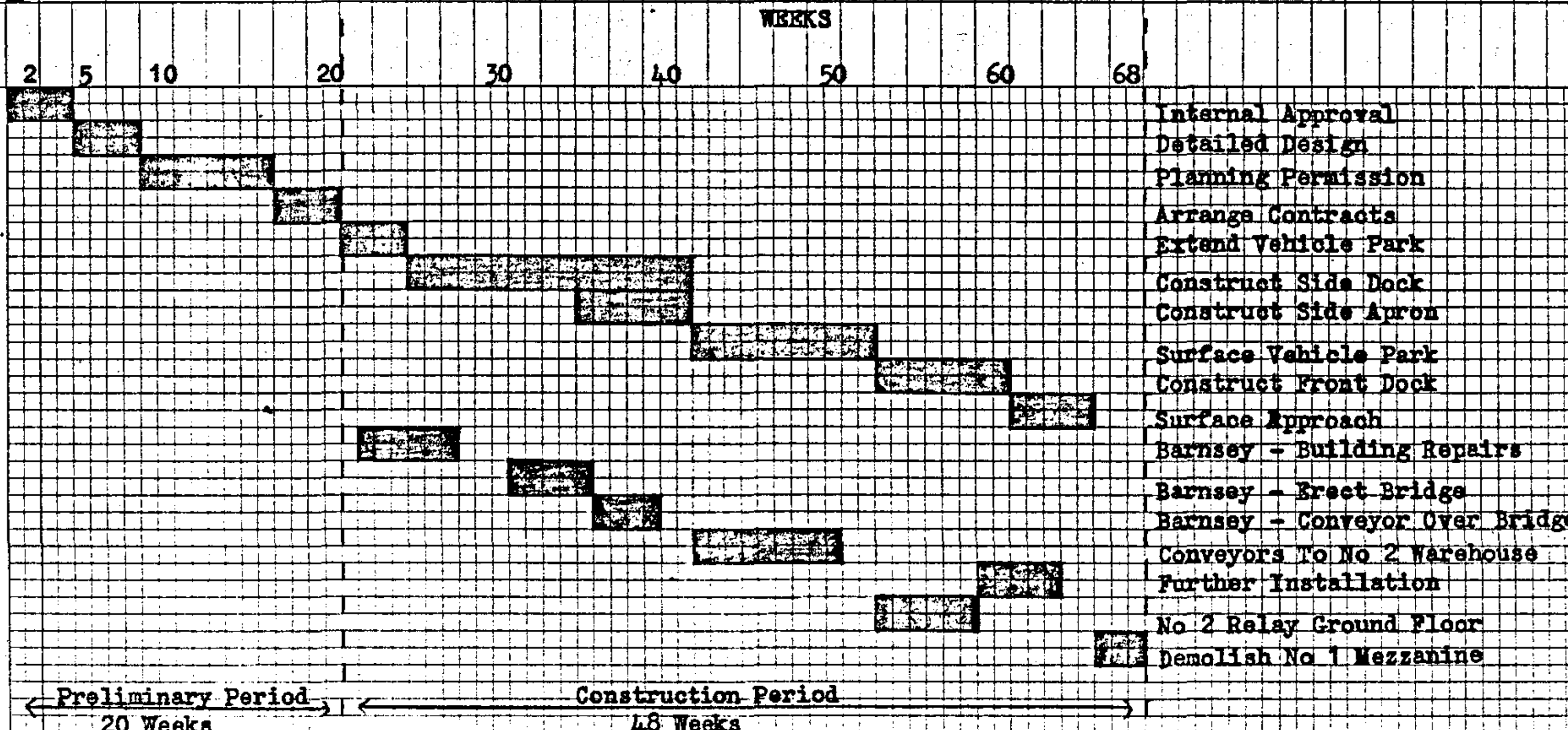
TABLE 8

CAPITAL COST SUMMARY - SCHEME 'B'

	£
Access Roads and Manoeuvring areas surfaced	37,000
Van Park surfaced	290,000
Loading Docks	279,000
Storage Pallets (for No. 1 Warehouse)	22,590
Demolition of No. 1 Mezzanine	17,000
Repair floor beneath No. 2 Mezzanine	25,500
Repairs to No. 2 Mezzanine floor	9,000
Conveyor Package	191,400
Boom Conveyors	100,000
Bridge to Barnsey	90,000
Barnsey Building adaptations for stock	20,000
	£1,081,490

Fig 22

IMPLEMENTATION TIMESCALE - SCHEME B



4.3. SCHEME 'C'. CONVEYOR BELT SORTATION IN EXISTING BUILDING.

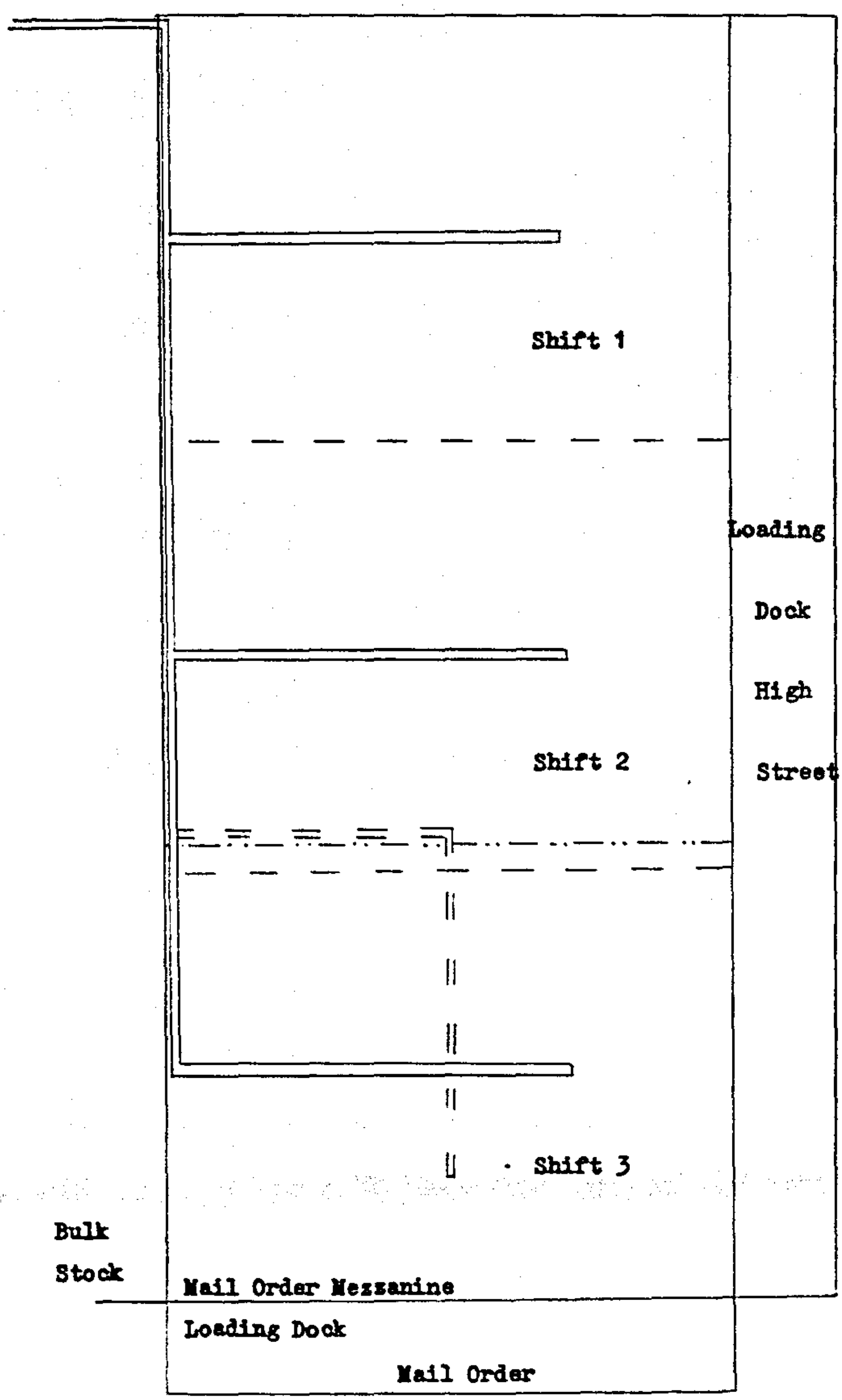
In Scheme 'C' all the despatch function is concentrated in No. 2 warehouse. No. 1 warehouse is therefore solely concerned with the holding of bulk stock. The working arrangements for Scheme 'C' are almost identical to that described in the previous section for Scheme 'B'. The only difference is that an automatic sortation device is used to transfer pieces between the conveyors instead of having a manual transfer.

Three High Street floors and one and a half Mail Order floors are created in No. 2 warehouse. The High Street floors are on the ground floor and load out of the side of the building from newly constructed loading banks. No. 2 warehouse mezzanine is utilised for Mail Order load assembly and despatch. Loading is facilitated by means of down conveyors which lead to a loading bank at the front of the building. See Fig. 23.

No. 2 warehouse ground floor has sufficient capacity to accommodate three High Street shift loading floors, Each High Street floor is capable of handling a maximum despatch shift of 32 loads. The mezzanine floor has a capacity to accommodate 58 Mail Order loads.

The main difference between this system and that in use at the present time, excepting the larger floor areas necessary to cater for the 1986 despatch levels is that the High Street operation now takes place on a three floor system. As with Scheme 'B' the immediate advantage over Scheme 'A' is that all the High Street operation takes place from the ground floor, so helping to create a more favourable working environment. The three floor High Street system is another contributory factor to helping to gain a more favourable working environment. A three floor system on High Street allows one floor to be being filled from Production, one to be picked from for loading, while the other is being cleared of any excess stock to the Bulk Store. This three floor system means that Production can start to run on to a clear floor at the commencement of any Production shift. The three floor system therefore creates a time buffer between Production and the loading operation.

Fig 23. LOADING FLOOR ARRANGEMENT - SCHEME C



The loading floors are laid out with wider gangways and this allows work to proceed in a more efficient manner. The loading floors are therefore not as congested as under the present system. There will only be a maximum of one shift's set of loads on any particular floor at any one moment in time. This will allow both the load assembly and load despatch operation to operate more efficiently, especially when considered with the fact that the gangways will be wider.

To allow further improvements in efficiency in the load assembly/load despatch operation, the area to be picked from needs to be reduced. This would increase labour efficiency by:-

a). Reducing the total number of items in an area, so speeding up efficiency.

b). Reducing the walking distance, hence more effectively utilising the labour.

To achieve a smaller load picking area than at present some change is needed in the system which produces the Production Summaries and the loading sheets. It is necessary to be able to identify products as they leave Production for particular groups of loads within a shift. This is essential if the picking areas for distinct groups of loads are to be reduced. At present the loading sheets which identify the products to individual loads are not ready till after production has commenced. All that is known when a product is manufactured is to which particular shift's set of loads it belongs to. In order to be able to split a shift's set of loads down, it is necessary to have a system in which the loading sheets are available before production commences. The actual number of pieces going to any particular area on a High Street shift loading floor depends on the actual number of loads being produced on that particular shift. The actual number of loads going to an area of the floor depends on the total number of loads being made at the time and is purely a numerical division. It is intended that the split be even within a shift. It was found to be convenient to quarter the loading floors, each area on a maximum despatch day having a requirement to hold 8 loads. Therefore each High Street day would see two Production Summaries (one for each shift) and

and eight warehouse summaries.

The above system therefore needs the loading sheets to be ready before Production commences. This demand obviously alters the present timing arrangement of the routeing and planning operation as related to the manufacturing operation. Such information is needed before the Production Department starts to make. At present this information is unavailable at this time. It is therefore proposed to work a night shift in the Routeing and Planning Department, so that the individual load sheets will be available before production starts. This information can then be used to route products to particular quarters of the High Street loading floors.

The Production Department day would remain at 15 hours. However, the timing arrangements in which to complete the work as specified by the Production Summaries would be altered. The Production day would run from 10.00 a.m. the previous day till 6.00 p.m.and from 6.00 p.m.to 10.00 a.m. the following day. Loading would stay on the present shift timings, 6.00 a.m. to 2.00 p.m. and 2.00 p.m. to 10.00 p.m.

Production of shift 1 would start at 10.00 a.m. the previous day and run through to 6.00 p.m. At 6.00 p.m. production of the next shift's loads would start and run through till 10.00 a.m. Due to the fact that loading of the first production batch does not start till 6.00 a.m. this give the Production Department a 4 hours buffer in which any shortfall could be rectified. (It should be remembered as outlined in earlier sections, that the Company operates a two shift system). There is, therefore, a period of 4 hours allowed between when production should finish and loading can start. The system stores products for 4 hours only. Ideally, loading should, therefore, be 4 hours behind production.

The Mail Order production summaries and loading sheets would continue to be produced in the same manner as at present. There is no need to alter the routeing and planning arrangements because all the Mail Order loads are made up before production starts. As alredy stated Mail Order will load out of the front of No. 2 warehouse direct from the mezzanine floor.

To implement the above warehousing arrangements certain modifications will need to be made. The main alterations concern the conveyors. The conveyor arrangements are shown in Fig.23 which shows the layout of the loading floors. The main conveyor from the Production Department passes round the outside of the Bulk Stock area in No. 1 warehouse. It enters No. 2 warehouse at ground floor level in the top left-hand corner, that is the opposite side of the loading floor from the loading docks. The arrangement prior to entry into No. 2 warehouse is advantageous in that all the products from both Production and the Bulk Store are on the main conveyor as soon as it enters the load assembly/load despatch area in the warehouse. The belt then extends along the rear wall of No. 2 warehouae . The ground floor is divided into three High Street floors. Each of these floors is divided into two equal halves by a secondary conveyor, which runs at right angles to the main conveyor which brings products into No. 2 warehouse.

Approximately two-thirds along the warehouse floor an up conveyor leads to the mezzanine floor. When at the mezzanine level this conveyor divides the Mail Order floor into two equal halves. Each half is provided with two down conveyors, four in all, for the loading operation.

The three conveyors to the individual High Street load assembly/load despatch floors and the Mail Order floor conveyor are connected by automatic transfer devices to the main conveyor from the Production Department. Products are automatically transferred from the main ....conveyor tothe relevant floor conveyor. This system is backed up by automatic tracking devices and an on line computer.

Capital expenditure would also be needed so as to allow the front half of No. 2 warehouse to be fully utilised for its new role. The ground floor would need repairing and the mezzanine floor boarding over before it can be regularly used for Mail Order load assembly/load despatch. Loading docks need to be constructed to adequately protect the loading operation from the weather. As can be seen from the diagram showing the conveyor layout, the loading docks extend round the two sides of the warehouse. These alterations, therefore, need to be completed before this proposed system can come into operation.

Movement of Spring Interiors and Divans through the System.

As each piece is completed in the Production Department a machine readable ident tag is affixed. The completed item then proceeds to the Production checkpoint, at which point a scanner reads the ident tag. The identity of the item is passed to the computer which allocates the item to proceed either to the load assembly area or the bulk stock area. If the item is assigned to a load assembly area, the piece is then marked to show which loading floor it is destined for. Mail Order products are coded 'V' to 'Z'. High Street products are coded '0' to '9' to identify which loading floor they are destined for, and then lettered a, b, c, or d to show which particular quarter of the shift loading floor they are required for.

Once the computer has assigned the item to either bulk stock or load assembly at the Production checkpoint, it tracks its passage throughout the system. As the item passes down the belt its position is monitored until it triggers an automatic transfer when it is sent to either the bulk store or the appropriate area for loading.

If for loading the item is automatically transferred to a secondary belt which directly feeds the loading floor. These belts are powered for approximately the first half of their length from the main conveyor when being used inthe load assembly operation. The reason for this is to ensure that no bottlenecks occur adjacent to the main conveyor, so necessitating that the main belt has to be stopped. That half of the secondary belt furthest away from the main conveyor is left stationary and therefore acts as an overrun for the items entering the despatch floor.

Once products are on the secondary belt they are then visually recognised by the beltmen as destined for a particular part of the loading floor. They do this by using the identification marked on the item as it passed the Production checkpoint. From the secondary belt the items are taken and stacked by the beltmen on the appropriate section of the loading floor in piles of the same size and type . At any one particular moment in time High Street products should only be being load assembled on one loading floor. The only exception to this rule is at times of production shift changeover when production will be finishing making one shift's set of loads and starting on the manufacture of the next.

At the end of the production run all the items for the loads should therefore be assembled. These then stand for 4 hours and are then loaded over the next 8 hours. Loading teams will work in turn from each of the quarters on the High Street floor. Those teams working the quarters nearest to the loading bank will walk the products on to the loading bank from where boom conveyors will feed the items into the vehicles. The items will, of course, be picked from the loading floor in reverse drop order. The teams working from the rear two quarters will use the central conveyor to take the products down to the loading bank. From here the pieces will travel via boom conveyors into the rear of the vehicles.

Mail Order products entering No, 2 warehouse travel on the main conveyor till they are adjacent to the Mail Order conveyor which leads up to the mezzanine floor. The system tracks the Mail Order products till they reach the automatic transfer device which transfers them on to the conveyor which takes them on to the mezzanine floor, Once on the mezzanine floor the products are taken from the belt and manually stacked on the floor in piles of the same size and type. There the products wait until called off for loading the next day. It will be remembered that Mail Order, unlike High Street, works on a daily basis, not a two shift system. Loading teams collect the pieces required in reverse delivery order from the loading floor. They are then placed on one of the down conveyors which leads to the vehicle being loaded. Only two down conveyors at any one time will be in use for loading. The other two are for loading on the next day.

By the end of the appropriate shift, or loading day, depending on whether one is dealing with High Street or Mail Order, the loading floor should theoretically be empty. In practice this does not always happen by the end of the appropriate loading shift.

Provision for the clearance of cancellations and excess stock from the loading floors needs to be made. At the end of loading on High Street there is an interval of 4 hours before the floor starts filling from production for the next shift's loading. This time is allowed to clear the floor of cancellations. Cancellations and excess stock are passed back into No. 1.warehouse by gravity feed conveyors which breach the dividing wall. It will be remembered that No. 1 warehouse is utilised solely to hold bulk stock. Mail Order cancellations and excess from the loading floors will be placed on the down conveyor to take the items into No. 1 warehouse.

Certain items for loading do not come direct from the Moss Production floor. These items are dealt with as follows:

a). Bulk Stock Products withdrawn in the bulk stock area are given a machine readable ident tag. They are also marked to show which loading floor and section of they they are destined for, so that they are visually identifiable to the belt men. Before leaving the bulk store a scanner reads the ident tag and the computer then tracks the pieces movement throughout the system in the same way as that described for items from Production. Once transferred to the appropriate floor conveyor the pieces movement is identical to that as previously described for items entering direct from the Production Department.

b). Sutton Storage Products. To reduce the risk of handling damage, Sutton products do not travel on the main conveyor from the Production Department unless they have been held in stock in the bulk store. Sutton Storage Products will arrive at the despatch warehouse by inter-site transport. Sutton Storage Products for High Street despatch are intended to be off loaded on to the appropriate loading floor and assembled adjacent to the loading positions. Those Suton Storage Products destined for Mail Order loading need to be sent on to the mezzanine floor, These are sent on to the mezzanine floor by reversing one or more of the down conveyors. Products are sent up on to the mezzanine floor and load assembled in the appropriate sections. In order to achieve this some pre-assembly of storage products at Sutton needs to take place. This would ensure that the inter-site vehicle carry the products for the appropriate sections of a loading floor together. With the new timing arrangements for the loading sheets this is now possible.

c). Associate Mail Order Company Products. For those products held in stock, the arrangements are identical to that already described for items from the Bulk Store. However if the products are ordered against Production Summaries from Perfecta and or Sealy, they can be fed directly on to the Mail Order loading floors.

d). Headboards. These are arranged as for Sutton Storage Products. Pre-assembly of headboard loads will take place at Sutton. They are moved to Moss Shed by inter-site transport and go into temporary storage in the headboard store until required for actual loading. From the headboard store they are moved in the pallets they were packed in at Sutton, to be adjacent to the appropriate loading point. The loading team is then free to select the headboards as required to ensure the maximum cube utilisation of the vehicle

The Bulk Stock Areas.

No. 2 warehouse has now been given over entirely to the despatch operation, so is now unable to hold any bulk stock. This, therefore, means a loss of stockholding capacity of 6,500 sets; the present stockholding utilisation possible in No. 2 warehouse. However, all of No. 1 warehouse now becomes available to hold stock. The stockholding capacity in No. 1 warehouse now becomes 8,500 sets, from the current maximum of 4,500 sets. The reason why the capacity of No. 1 warehouse is not doubled is that at the front of the warehouse there are offices which prevent the full use of pallet stacking.

A demand for increased stockholding capacity over and above 8,500 sets is needed. This is in order to cater for the periods prior to the main holidays in July and September. The cheapest solution to gain increased stockholding capacity is to use Barnsey Shed. Barnsey Shed has a capacity to hold up to 9,000 sets. This, therefore, allows a total stockholding volume of 17,500 sets. Certain modifications are needed to the fabric and structure of Barnsey Shed to enable it to fulfill its new role. Obviously a connection is needed to the Moss site, and this is achieved by a conveyor in a bridge over the Leeds and Liverpool canal.

Barnsey Shed will only be used to hold stock immediately prior to the main holiday periods of July and September. The most cost effective method to hold this stock is to employ floor stacking. No storage equipment is therefore needed as all the movement of the items is entirely by manual methods.

For the bulk stocking at Moss in No. 1 warehouse, the present system of pallets stacked above one another would be retained.

The Loading Floors.

a). High Street Floors. Fig. 23 shows the floor arrangement of the three High Street floors while Fig. 24 shows the floor stacking arrangement on one floor only. Products enter the warehouse on the conveyor which runs along the rear of the loading floor. Down the centre of each loading floor runs another conveyor. Once the products are transferred on to this central conveyor they are taken and stacked in the appropriate quarter of the loading floor.

Each loading floor has four separate summaries, thus effectively quartering the floor area. All storage products are held adjacent to the loading bank. They are grouped into two batches, each composed of the products needed for the two quarters immediately behind it. Each loading summary will refer to 25% of the total Shifts loading. The loading teams will load from opposite quarters, that is from the front right hand side of the belt and from the rear left hand side of the belt. When these areas of the floor are cleared the men operating at the rear will move to the forward area and vice-versa for the men on the other side of the belt. Those men operating from the rear will use the central conveyor

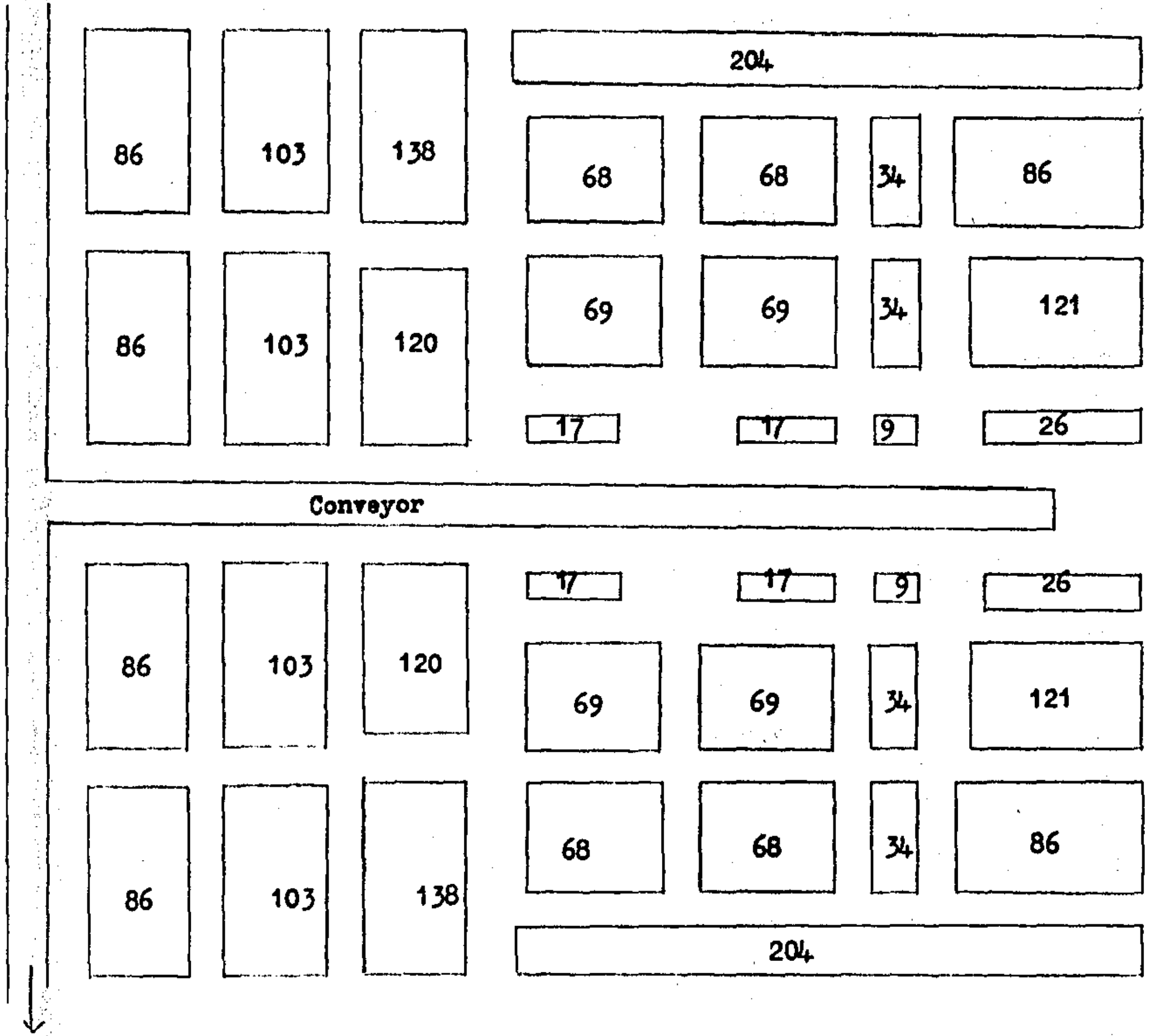


Fig 24. HIGH STREET
LOADING FLOOR LAYOUT - SCHEME C

The Figures In The Boxes Refer To The Number Of Pieces Which It Is Possible To Hold On That Section Of The Floor.

to move the goods to the loading bank, whilst those loading teams working from the front section will walk the beds on to the loading bank. Boom conveyors are used to carry the items into the boxes.

b). Mail Order Floor. The floor stacking arrangements are shown in Fig.25.. One up conveyor brings products on to the mezzanine floor from the Production Department and the bulk store. This conveyor divides the mezzanine floor into two equal halves, Each half roughly corresponds to a Mail Order loading day. Each half is served by two down conveyors. These down conveyors are reversible so as to enable Sutton storage products and Associate Mail Order Company products to directly reach the appropriate loading floor from inter-site and inter-Company vehicles.
As the Mail Order goods are picked from for loading they are carried to the down conveyors which feed directly on to boom conveyors which take the items into the back of the vehicles.

The Labour Requirement.

A labour force of 79 is required for operating this system. This costs £530,485. on an annual basis. The details are shown in Table 9
The labour requirement for this proposed scheme was worked out in co-operation with the Company's Distribution Management.

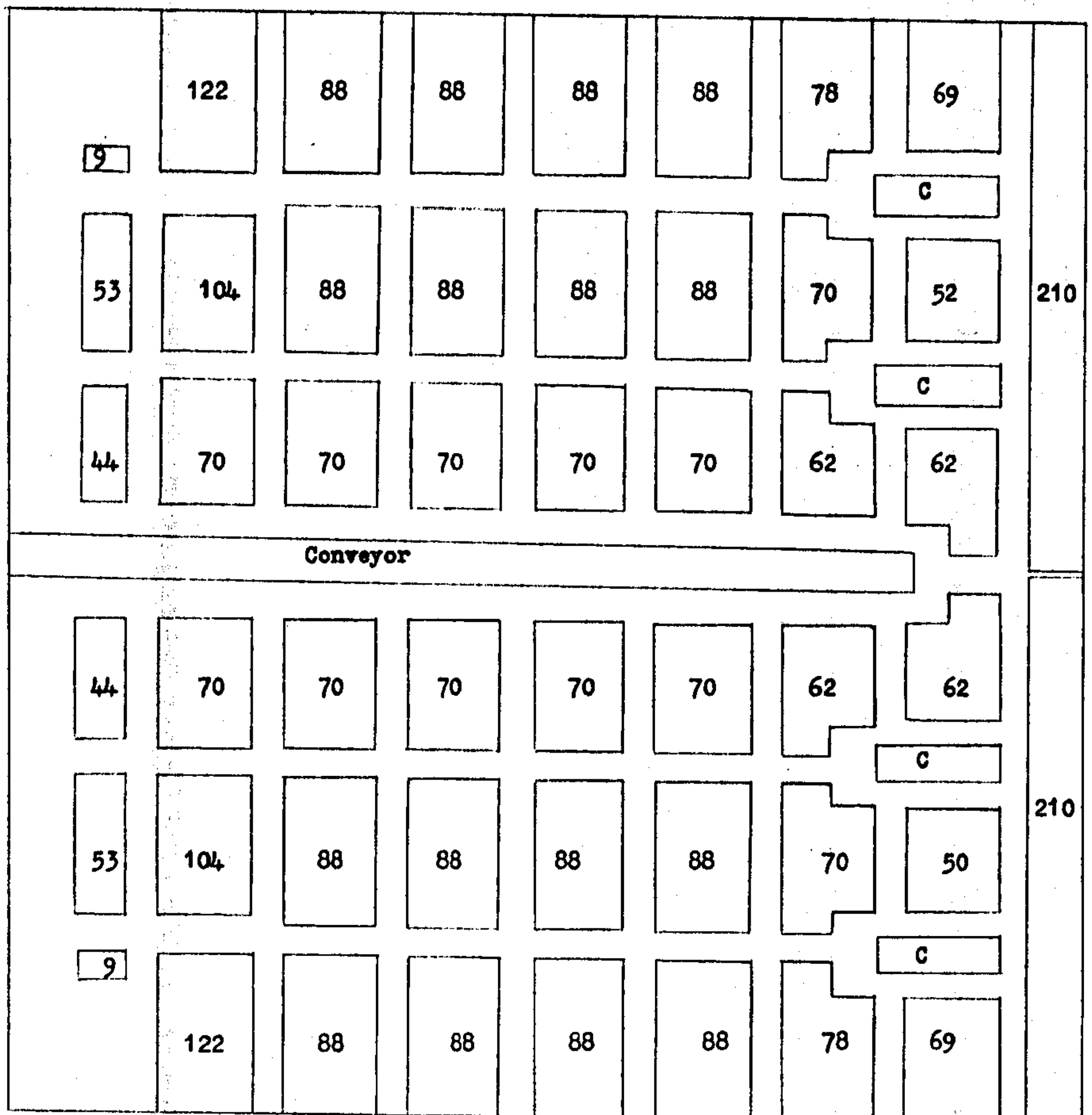
The Capital Cost.

The total cost of implementing this scheme is £1,342,090. The details are shown in Table 10

Implementation Simescale.

Fig. 26 shows the estimated timescale in which it is proposed to complete all the necessary work to enable this warehouse scheme to operate in full. This work is projected to take 68 weeks.

Fig 25. MAIL ORDER LOADING FLOOR LAYOUT - SCHEME C



C=Conveyor

The Figures Refer To The Number Of Pieces Which It Is Possible To Hold In Each Block.

TABLE 9

LABOUR REQUIREMENT - SCHEME 'C'

Head of Department	2
Shift Supervisors	4
Beltmen	18
Floor Setters	4
Fork Lift Operators	5
Loaders (including Checkers)	36
Shunters	4
Returns	2
Headboards.	3
Cleaners.	1
	79 = £530,485.

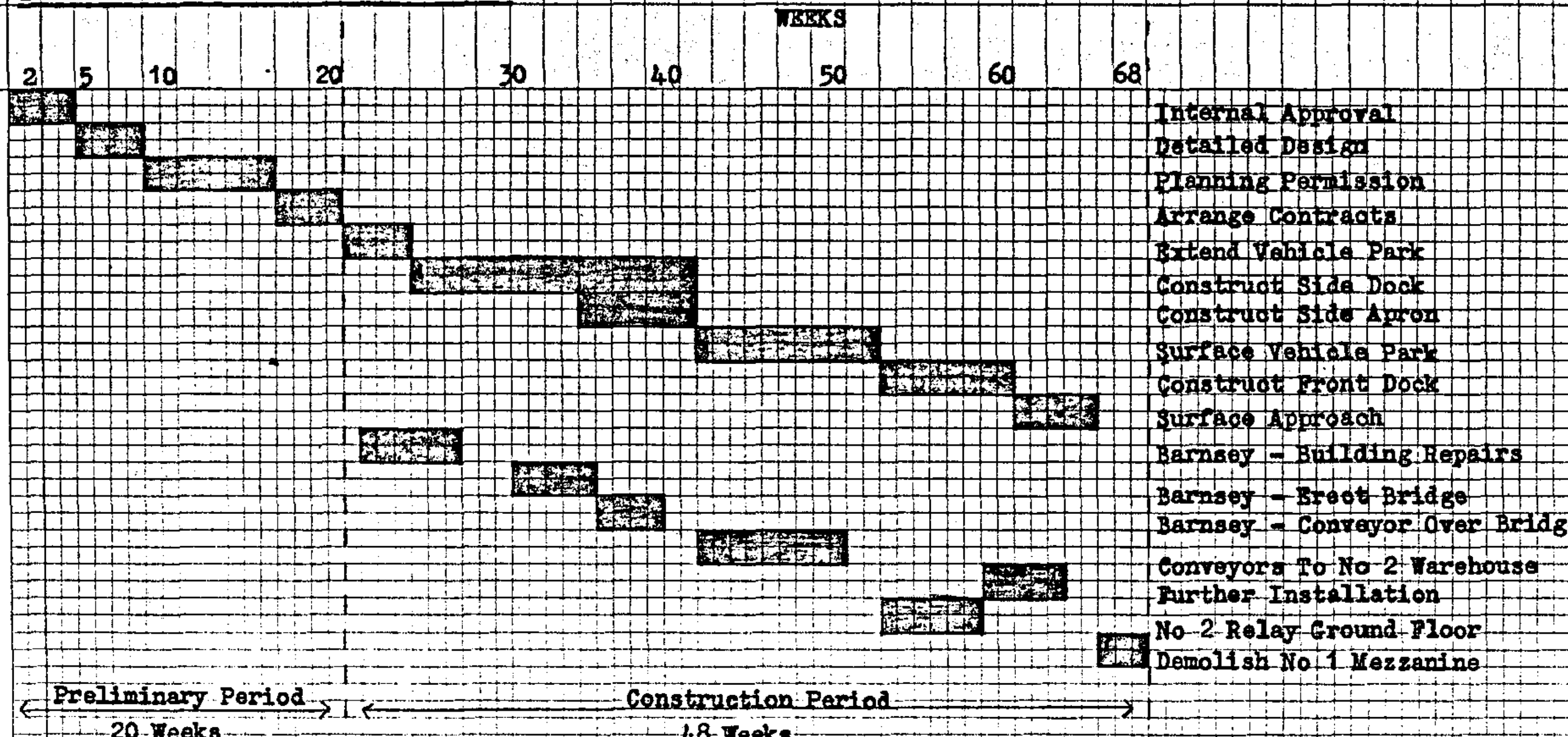
TABLE 10

CAPITAL COST SUMMARY - SCHEME 'C'

	£
Acces Roads and Manoeuvring areas surfaced.	37,000
Vanpark Surfaced	290,000
Loading Docks	279,000
Storage Pallets. (for No. 1 warehouse)	22,590
Demolition of No. 1 Mezzanine	17,000
Repair Floor beneath No. 2 Mezzanine	25,500
Repairs to No. 2 Mezzanine Floor	9,000
Conveyor and Software Package	452,000
Boom Conveyors	100,000
Bridge to Barnsey	90,000
Barnsey Building adaptations for Stock	20,000
	£1,342,090

Fig 26

IMPLEMENTATION TIMESCALE - SCHEME C



4.4. SCHEME 'D'. CONVEYOR BELT SORTATION IN A PURPOSE DESIGNED HIGH STREET DESPATCH BUILDING.

In Scheme 'D' all the loading operation takes place from the ground floor. A new despatch warehouse will be built to cater for the High Street operation. It will be built at a right angle from the side of No. 2 warehouse with vehicle loading positions on either side. The Mail Order despatch facility will remain in No. 2 warehouse. It will be located on the ground floor area underneath the mezzanine floor and will load out of the front of the building. Fig. 27 shows the general arrangement of the loading floors. This scheme will allow No. 1 warehouse to be given over entirely to hold bulk stock. The rear of No. 2 warehouse and the mezzanine will also be available for bulk stock.

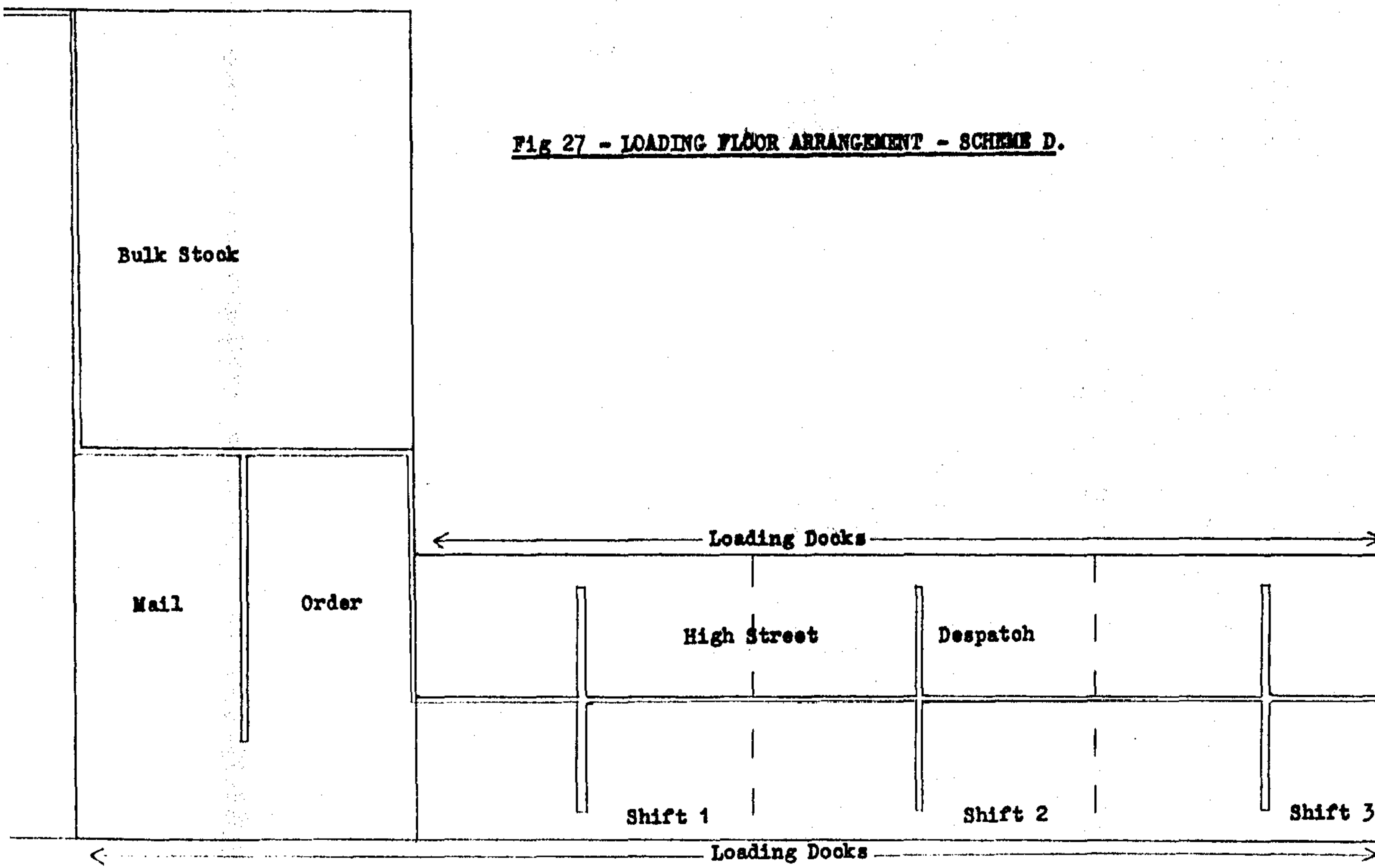
As in all the previously described potentially feasible schemes to cater for the projected 1986 distribution levels, scheme 'D' has three High Street loading floors. Each is capable of handling 32 loads on any one despatch shift. The Mail Order loading floor has a capacity to accommodate approximately 58 loads. Sufficient floor capacity to deal with the projected maximum distribution levels therefore exists within this scheme.

The main difference between this system and the three previously described potentially feasible systems is that all loading takes place from the ground floor. This is obviously an important advantage in creating a favourable working environment. Wider gangways on the loading floors also facilitates a more pleasant working environment. The three floor High Street system is another factor contributing towards creating better working conditions than exists at present. It allows one floor to be being filled from Production, one being picked from for loading, while the third is being cleared of any excess or cancelled items back to the bulk store. The three floor system, therefore, helps to create an effective time buffer between the production and the loading operations.

To allow further improvements in efficiency in the load assembly/ load despatch operation, the area to be picked from needs to be reduced. This would increase labour efficiency by:-

a). Reducing the total number of items in an area, so speeding up efficiency in both load assembly and

Fig 27 - LOADING FLOOR ARRANGEMENT - SCHEME D.



load despatch.

b). Reducing the walking distance, hence more effectively utilising the labour.

To achieve a smaller load picking area than at present a certain degree of change is needed to the present system which produces the production summaries and the loading sheets. It is necessary to be able to identify products as they leave production for particular groups of loads within a shift. This is vital if the picking areas for distinct groups of loada are to be reduced. Under the present system the loading sheets which identify the products to individual loads are not ready till after production has commenced. All that is known when a product is manufactured is to which particular shifts set of loads it belongs to. In order to be able to split a shift's set of loads down in a meaningful manner it is necessary to have a system in which the loading sheets are available before production commences.

The actual number of pieces going to any particular area on a High Street shift loading floor depends on the actual number of loads being produced on that particular shift. The actual number of loads going to an area of the floor depends on the total number of loads being made at the time and is purely a numerical division. It is intended that the split be even within a shift. It was found to be convenient to quarter the loading floors. Each area would therefore have a capacity to hold 8 loads, which means that each High Street loading floor is able to adequately cope with the projected maximum despatch day in 1986 Each High Street day would see two Production summaries (one for each shift) and eight warehouse summaries.

The proposed warehouse system therefore needs the loading sheets to be ready before Production actually commences. This requirement alters the existing timing arrangements of the routeing and planning operation as related to the manufacturing operation. Such information is needed before the Production Department starts to make. At present this information is unavailable before Production starts to make. It is therefore proposed to work a night shift in the Routeing and

Planning Department so that the individual load sheets will be available before production starts to make the items. This information can then be used to route products to particular quarters of the High Street loading floors. The High Street loads on every shift will be quartered and the products then sent to the appropriate quarter for the loads they are required for. The division is purely numerical, but obviously a load is not divisible.

The Production Department day of 15 hours would stay the same as at present. However, the timings would be altered in which to complete the work as specified by the production summaries. The production day would run from 10.00 a.m. till 6.00 p.m. and from 6.00 p.m. to 10.00 a.m. the following day. Loading would stay on the present shift timings, 6.00 a.m. to 2.00 p.m. and 2.00 p.m. to 10.00 p.m.

Production of Shift 1 would start at 10.00 a.m. and run through till 6.00 p.m. when the next shift's loads should start and run through till 10.00 a.m. the following day. Due to the fact that loading of the first production batch does not start till 6.00 a.m. the next day, this gives production a 4 hours buffer in which any shortfall could be rectified. (It will be remembered, as outlined earlier, that the Company operates a two shift system; 6.00 a.m. to 2.00 p.m. and 2.00 p.m. till 10.00 p.m.). There is therefore a period of 4 hours allowed between when production should finish and loading can start. The system stores products for 4 hours only; therefore the loading operation should always be 4 hours behind production.

The Mail Order production summaries and loading sheets would continue to be produced in the same manner as at present. There is, therefore, no need to alter the Mail Order routeing and planning arrangements, because all the Mail Order loads are made up before production starts. As stated earlier, and shown on Fig.27, the Mail Order load assembly and load despatch operation will take place from the ground floor at the front of No. 2 warehouse.

To implement the above warehousing arrangements, certain modifications will need to be made. The conveyor alterations are shown Fig.27 which shows the arrangement of the loading floors. The main conveyor from the Production Department passes round the side of No. 1 warehouse to enter No. 2 warehouse in the top right hand corner. It then passes down No, 2 warehouse till it reaches the edge of the Mail Order load assembly floor at which point it does a right angle turn to run across the rear of the load assembly floor. A secondary belt connected to the main belt by an automatic transfer device divides the Mail Order floor into two equal halves. This enables those products destined for Mail Order load assembly to be diverted to the appropriate warehouse floor.

Once the main belt has passed the Mail Order area it proceeds to enter the new High Street despatch building. The belt runs down the centre of the building and dissects the three High Street loading floors. Each High Street shift loading floor is, therefore, divided into two. To transfer products from the main conveyor leading to the appropriate loading floor, automatic transfer devices are used. These divert the products on to secondary spurs which further divide the shift loading floors. Each High Street shift loading floor is therefore effectively quartered. Each loading quarter is immediately adjacent to the appropriate loading bank.

The largest item of capital expenditure necessary to implement this Scheme is the construction of the High Street despatch warehouse. The van park surface will need altering and improving so as to withstand the constant shunting movement of vehicles around the despatch building. The front of No. 2 warehouse will need to be slightly modified by the provision of dock shelters so as to protect the loading operation from the weather. These alterations are therefore needed in order that this proposed system could be implemented

<u>Movement of Spring Interiors and Divans through the System.</u>

A machine readable ident tag is fixed on to each item as it is completed in the Production Department. At the production checkpoint a scanner reads the information on the ident tag. The computer then assigns the item as either to proceed to the load assembly or the bulk stock area. If assigned to the load assembly area the piece is marked to show the area it is destined for.

Mail Order products are coded 'V' to 'Z'. High Street products are coded '0' to '9' to show which loading floor they are destined for and then lettered a.b.c. or d according to which particular quarter of the shift loading floor they are required for. Once marked and recognised, the computer memorises the position of the piece in the system and tracks its passage throughout the system. As the piece passes down the belt its position is monitored until it triggers an automatic transfer when it is sent to the appropriate area for loading. The identification marked on the item in the productiin checkpoint is then used by the beltmen to identify which side of the secondary belt in the laad assembly area the item is to be stacked in. From this position the items are taken by the belt men and stacked on the appropriate section of the loading floor in piles of the same size and type.

The secondary belts which directly feed the loading floors are only powered for approximately the first half of their length from the main conveyor when being used in the load assembly operation. This is to ensure that no bottlenecks occur adjacent to the main conveyor so necessitating that the main belt is stopped. That half of the secondary belt furthest away from the main conveyor is left stationary and therefore acts as an overrun for items entering the despatch floor. The only difference between the High Street and Main Order areas is the length of the secondary belt. This is simply a function of the size of the load assembly/load despatch floor.

At any one particular moment in time, products should only be being assembled on a maximum of two floors, one being High Street, the other Mail Order. The only exception to this rule is at times of production shift changeover on High Street when production will be finishing one set of shifts loads and starting on the next.

At the end of a High Street production run all the items for that particular shifts loads should be assembled on the appropriate loading floor. These then stand for 4 hours and are then loaded over the next 8 hours. This gap of 4 hours between when production should finish and loading starts gives time to the Production

Department to rectify any shortages. Loading teams then work from the 4 quarters, in turns, clearing one quarter before moving onto the next. The products are walked on to the vehicles and stacked in reverse delivery order .

Mail Order loading is on a daily basis, not a shift system. Products are manually collected from the loading floor and taken to boom conveyors which feed into the rear of the vehicles being loaded.

By the end of the appropriate shift on High Street or the loading day on Mail Order, the appropriate loading floor should be empty. In practice this is often not the case, especially on High Street. Provision for the clearance of cancellations and excess stock from the loading floors has been made. At the end of loading on High Street there is an interval of 4 hours between when loading finishes and production starts to run onto that floor. This time is allowed to clear the floor of cancellations and excess stock. These items are then fed into a vehicle and taken round to No. 1 warehouse and fed into the bulk stock area. Mail Order cancellations are passed into No. 1 warehouse by the use of gravity feed conveyors which breach the dividing wall between the two warehouses.

Certain iitems for loading do not come from the Moss Production floor. These items are dealt with as follows:-

a). Bulk Stock Products withdrawn in the bulk stock area are given an ident tag which is machine readable. They are also marked to show which area of the loading floor they are for. Before leaving the bulk store area a scanner reads the ident tag and the computer then tracks its movement throughout the system in the same way as that described for items from production.

b). Sutton Storage Products. To reduce handling and possible risk of damage, Sutton products do not travel on the conveyor belt. They are intended to be off-loaded at the loading doors and assembled appropiately for the Moss production in the relevant area. Sutton products will arrive at the despatch warehouse by inter-site transport. To off load the products at the appropriate loading doors some pre-assembly needs to take place at Sutton. This would ensure that the inter-site vehicles carry the products for the appropriate sections of the loading floors,together.

c). Associate Mail Order Company Products. For those products held in stock the arrangements are identical to those which have already been described for items from the bulk store. If the items are ordered against production summaries from Sealy and or Perfecta they can be fed direct from inter-Company vehicles on to the appropriate Mail Order loading floor.

d). Headboards. These will be arranged in a similar manner to Sutton Storage products. Pre-assembly of headboards into individual loads will take place at Sutton. On arrival at Moss these headboards go into temporary storage until required for actual loading. They are then moved in the pallets they were packed in at Sutton to be adjacent to the appropriate loading point. The loaders are then free to select the headboards as required to ensure the maximum cube utilisation of the vehicle.

The Bulk Stock Areas.

This scheme frees No. 1 Warehouse from the despatch operation, allowing it all to be used entirely for holding bulk stock. The capacity of No. 1 warehouse therefore becomes 8,500 sets. In No. 2 warehouse pallet stacking would be retained in the rear half of the warehouse. In the front half the ground floor would continue to be used for despatch, as already outlined. However, the mezzanine floor would be available to hold stock. The mezzanine can accommodate up to 2,000 sets, which are floor stacked, while the rear of No. 2 warehouse could hold up to 4,500 sets in pallets. The combined bulk storage capacity of both warehouses is therefore 15,000 sets

For all the bulk stocking, with the obvious exception of the mezzanine floor, the present system of pallets stacked above one another would be retained.

The Loading Floors.

a). High Street Floors. Fig. 27 shows the relative arrangement of three High Street floors, while Fig.28 shows the floor stacking arrangement on one particular floor. Products enter the floor via the conveyor which runs down the centre of the floor; with the obvious exception of those directly off loaded from inter-site vehicles direct on to the despatch floor. Half way down the loading floor are two secondary conveyors which serve the load assembly areas. Products for a particular half of a load assembly floor are automatically transferred from the central conveyor to either of the two secondary conveyors. Once on the secondary conveyor the pieces are manually taken and floor stacked. The beltmen recognise by the coding on the items whether the product is to be stacked to the right or to the left hand side of the floor. This system, therefore, effectively ensures that a High Street loading floor is split into four distinct sections of equal size Due to the reduced size of the picking area loading teams need to comprise of only three men as opposed to previous schemes, all with four men per team. The loading summaries will refer to the distinct quarters. Products will be manually picked and carried to the vehicles and stacked. The loading teams on any one particular shift will work in two areas. They will clear one quarter before moving on to the next.

b). Mail Order Floor. The floor stacking arrangements are shown in Fig. 29. The main conveyor from the Production Department passes along the rear of the Mail Order floor. A secondary conveyor leads off and divides the floor into two equal halves. Each half roughly corresponds to a Mail Order loading day. Products from Mail Order despatch entering from the Production Department are automatically transferred from the main conveyor to the secondary conveyor. From here they are taken and stacked. It is intended that those products for immediate despatch from

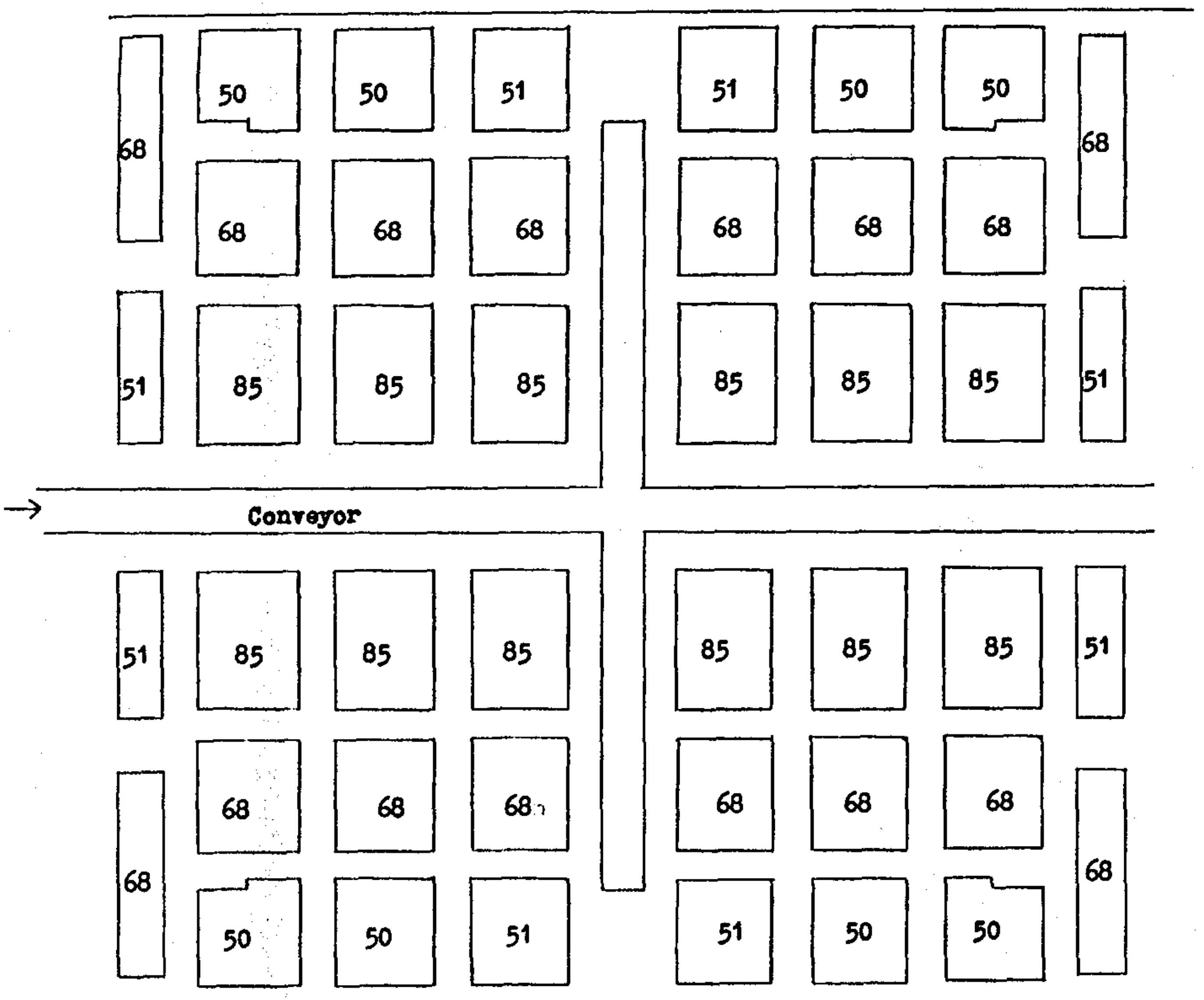


Fig 28. HIGH STREET LOADING FLOOR - SCHEME D

The Figures In The Boxes Refer To The Number Of Pieces Which It Is Possible To Hold On That Section Of The Floor.

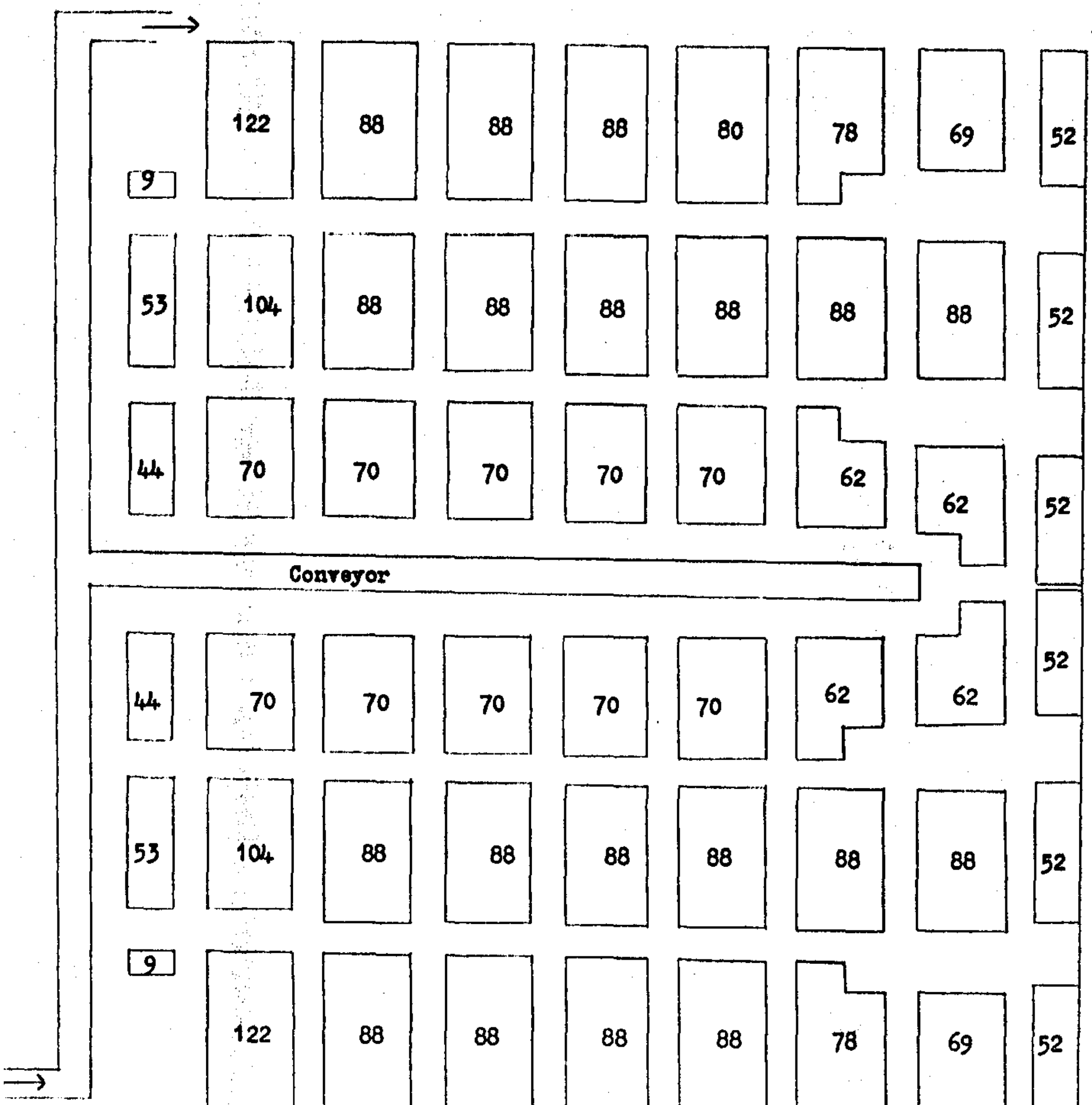


Fig 29. MAIL ORDER
LOADING FLOOR - SCHEME D.

The Figures In The Boxes Refer To The Number Of Pieces Which It Is Possible To Hold

inter-Company and inter-site transport will be off loaded and stacked adjacent to the loading dock. As the goods are picked for loading they are carried to boom conveyors which take the pieces into the vehicle being loaded.

The Labour Requirement.

The labour requirement for operating this system is shown in Table II. This shows that a labour force of 70 is needed. The annual cost of this labour force is £470,050. The details of the labour requirement were worked out in consultation with the Company's Distribution Management.

The Capital Cost.

The total cost of implementing this scheme is £2,411,380. The details are shown in Table 12

Implementation Timescale.

Fig. 30 shows the estimated timescale in which it is proposed to complete all the necessary work to enable this warehouse scheme to operate in full. This work is projected to take 85 weeks.

TABLE 11

THE LABOUR REQUIREMENT - SCHEME 'D'.

Head of Department	2		
Shift Supervisors	4		
Beltmen	18		
Floor Setters	4		
Forklift Operators	5		
Loaders (includes Checkers)	27		
Shunters	4		
Returns	2		
Headboards	3		
Cleaners	1		
	70	=	£470,050

TABLE 12

CAPITAL COST SUMMARY - SCHEME 'D'.	£
Access Roads and Manoeuvring areas surfaced	100,000
Van Park surfaced	510,000
New Buildings	1,204,000
Stoarage Pallets	119,880
Demolition of No. 1 Mezzanine	17,000
Repair floor beneath No. 2 Mezzanine	25,500
Conveyor and Software Package	400,000
Boom Conveyors	35,000
	£2,411,380

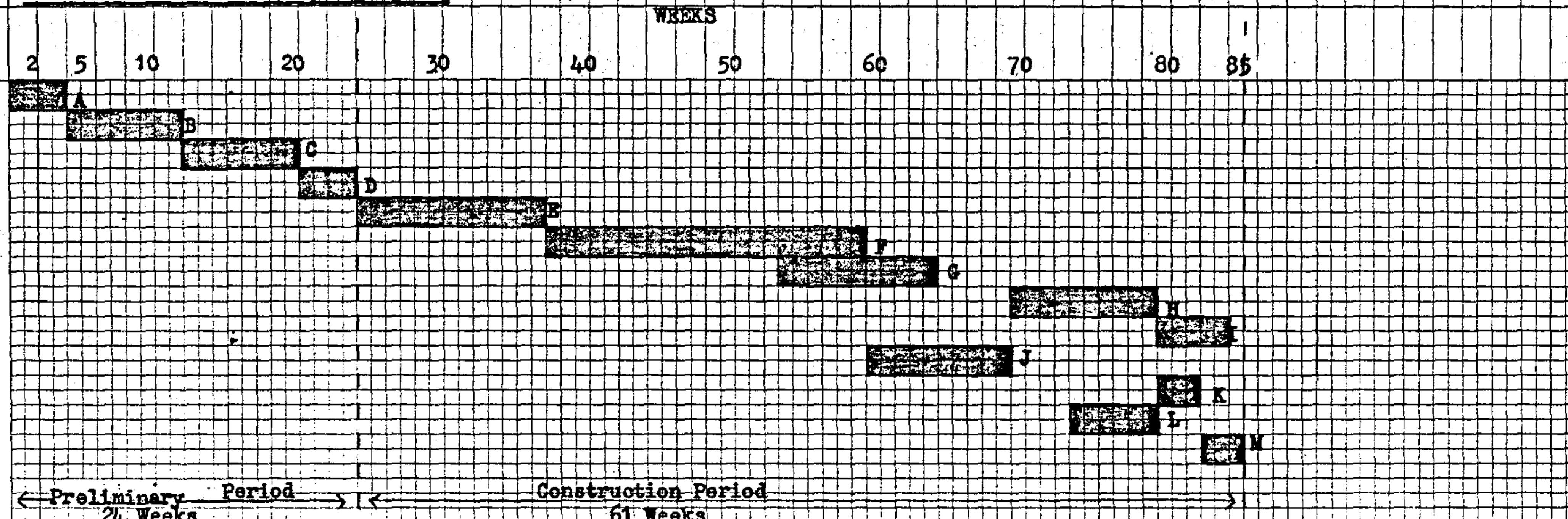
Key For Fig 30

IMPLEMENTATION TIMESCALE - SCHEME D

A=Internal Approval
B=Detailed Design
C=Planning Permission
D=Arrange Contracts
E=Excavate and Surface Vehicle Park
F=Build New Despatch Block
G=Surface Approach To New Block
H=Build Front Dock
I=Surface Approach Road
J=Install Conveyors
K=Further Installation
L=Relay Floor Under No 2 Mezzanine
M=Remove No 1 Mezzanine

Fig 30

IMPLEMENTATION TIMESCALE - SCHEME D.



See Opposite For Key.

4.5. SCHEME 'E'. AUTOMATED STACKER CRANE.

In Scheme 'E' the system proposed can be considered to be fully automated. A new despatch warehouse will be built to cater for all the load assembly operation, that is both High Street and Mail Order, on the site of Barnsey Shed. The despatch warehouse is connected to the main production unit at Moss Shed by a conveyor bridge over the Leeds and Liverpool canal. Also housed on the Moss site is the bulk stock warehouse. Fig. 31 shows the relative arrangement of the new despatch warehouse and the Moss Production Department and the Bulk Stock warehouse. It will be noticed from this plan that all of the warehouse at Moss Shed is now given over to holding bulk stock.

The despatch warehouse will consist of a buffer area served by automated stacker cranes with the individual items held in a high racking structure. Items do not proceed direct from the high racking structure to the individual vehicles for loading. They proceed initially to a load sorting system which consists of eight flat bed conveyor tracks with 90° belt diversions. From the load sorting system the loading team can call pieces off in the required order to best suit the requirements of the individual vehicles being loaded, taking into account reverse drop order and cube maximisation. Fig. 32 shows in more detail the arrangements in the despatch warehouse,

Theoretically the load assembly operation could be carried out by the stacker cranes without the need for the load sorting system described above. The stacker cranes could collect the items in the required order and deliver them on to a conveyor leading direct to the loading bay. However, in practice such a working method would result in a too slow and too inflexible operation to suit the requirements of vehicle loading. The buffer area (the racking structure served by the automated stacker cranes) is, therefore, followed by a load sorting system of a flat bed conveyor type with 90° diversions. The items are called off from the buffer area automatically in inverted drop order sequence and fed into the flat bed conveyor load assembly system. From this system, as already described, they are manually

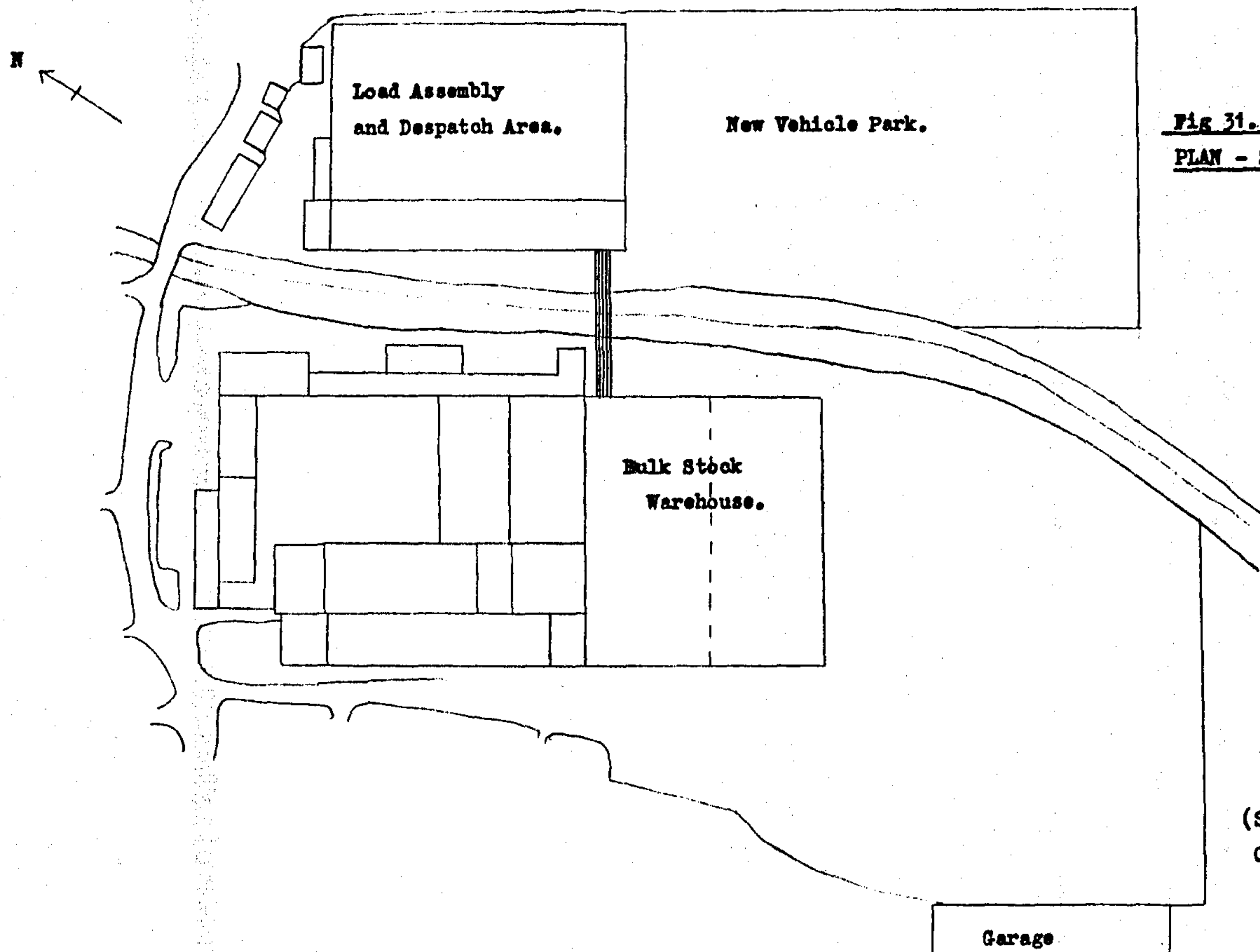


Fig 31. GENERAL SITE PLAN - SCHEME E

(See Fig 5 For Details Of Non Distribution Areas).

called off by the load checker.

The total stockholding capacity in the racking structure is 4,256 pieces (2,128 sets) This is 112% of a maximum production/despatch shift and has been judged sufficient by the Company's Management to be capable of handling a maximum despatch day. A major advantage of the stacker crane system over the previously described schemes is that the items held in the buffer area are not allocated to a particular load up to the moment the load sorting is started. This gives maximum flexibility in the warehouse operation.

The automated stacker crane system has a distinct advantage over the three schemes already described which rely on quartering the High Street loading floors. It does not demand any attention to the production planning and the routeing and planning operations, which would be able to stay as they are. However, if the production planning and routeing and planning operation did take place simultaneously it would create certain distinct advantages ,but this is by no means necessary to ensure the successful operation of this proposed warehouse scheme

To implement this warehousing scheme major alterations must be made and capital expenditure incurred. Obviously a new despatch warehouse needs to be built on the Barnsey site and equipment installed. To link the despatch facilities to the Moss Production Department, as well as to the bulk stock area a conveyor link via a bridge over the Leeds and Liverpool canal needs to be constructed. As all despatch will now take place from the Barnsey site the vehicle park ideally needs moving opposite the loading docks. With No. 1 and No. 2 warehouses at Moss Shed now given over entirely to holding bulk stock, both warehouse buildings will need to be slightly modified. In order to increase their stockholding capacities the mezzanine floors need removing and the floor of No. 2 warehouse repairing so as to allow the full potential height to be used for pallet stacking.

Movement of Spring Interiors and Divans through the System.

The completed products leave the Production Department on a flat bed conveyor. A machine readable ident. tag is put on to each individual item. A scanner placed alongside the conveyor belt between the Production Department and the warehouse reads the information on the ident tag. This information is then passed to the warehouse computer which decides if the individual item is for either load assembly or for the bulk stock area. If the item is for the bulk store it is automatically transferred to a conveyor which will take the item into No. 1 and No. 2 warehouse. If for load assembly the item continues on the main conveyor which crosses the Leeds and Liverpool canal to enter the buffer area in the new warehouse on the Barnsey site. The buffer store consists of 28 racks arranged to form 14 alleys, each one served by an automatic stacker crane . On one alley side the bottom level of racking consists of a driven flat bed conveyor track which is linked to the conveyor feeding into the buffer area of the warehouse by a 90° diversion. The items fed into the warehouse area are thus diverted from the feeding conveyor on to one of the 14 conveyor tracks which form an integral part of the racking structure. The length of the conveyor track on the bottom level of the racking acts as a feed buffer to the stacker crane.

The distribution of the items into the individual alleys is controlled by the warehouse computer to obtain an even throughput to the 14 stacker cranes. It therefore follows that the location of individual items in the system is entirely random. Once the items have been diverted on to the conveyor track inside the racking they are moved on this track up to the opposite end of the rack. Here the individual items are taken over by the stacker crane and placed in a vacant cubicle in the racking. Each item is therefore held indivivually in the racking structure. In order to allow a safe transfer from the conveyor track on to the fork of the stacker crane and from there on to the racking, both the fork of the stacker crane and the racking would be designed in the form of interleafing combs. Once in the racking the item is held there till it is needed for loading.

The warehouse computer continuously compares the stock list of items held in the buffer area with the loading sheets. As soon as all the items required to form a load are in the buffer area, this situation is signalled to the loading area. It will therefore be possible that a certain number of a shifts' loads could be loaded before the Production Department has finished making all the items for that particular shift.

The items are picked from the storage racks by the stacker cranes in inverted drop order and placed on to one of the four levels of the exit conveyor tracks located adjacent to the racking structure . Each level is linked by a flat bed conveyor with one of the four load sorting systems provided between the buffer stock and the loading area. The items leaving the buffer area are conveyed to the outer two conveyor tracks of one sorting system and lined up on these tracks for the final sorting in the most convenient loading sequence. This final sorting is left to the load checker. He calls off the items by keying their product code into the keyboard of the terminal placed next to the loading docks. The items are released in the desired order by the sorting system and sent to the loading belt.

The actual loading of the vehicles must remain a manual operation. To minimise the physical effort of the loading crew, the conveyor proceeding from the load assembly system can, however, be extended in the form of a telescopic belt right into the vehicle. The loading operation can, therefore, be confined to the stacking of the items and the tying of the individual stacks inside the vehicle. Due to the reduction in the amount of manual handling required, the loading teams can be reduced to 3 men. Each individual loading crew would consist of 2 loaders and one load checker. In order to avoid down times in the loading operation due to the need to change the drawbar boxes at the loading bay it is proposed that there will be a total of 8 loading docks.

At the end of the appropriate shift loading it is possible that not all the items produced for loading will have been used. This will be due to the items being cancelled from loads once the loading sheets have been prepared. These items will therefore remain in the racking at the end of their appropriate shift loading time. The computer at the end of the shift will then compare the next shifts loading requirements with those products remaining. If it can use any items, these remain in the buffer store; the relevant items being deleted from the production requirements. Those items which cannot be used are sent out of the system and stacked on to a vehicle and taken to the bulk store warehouse where they then become part of bulk stock.

Certain items for loading do not come direct from the Moss Production floor. These items are dealt with as follows:-

a). Headboards. Since the headboards are not suitable for handling through the automated system, they are handled separately. Pre-assembly of headboards into individual loads will take place at Sutton . They arrive at the despatch warehouse by inter-site transport and are held in a separate warehousing area next to the loading bays, as shown in Fig,32. When required for loading they will be moved in the pallets they were packed in at Sutton to be adjacent to the appropriate loading point. They are then manually added to the loads as required by the loading teams.

b). Sutton Storage Products/Associate Mail Order Company Products. On arrival all the products will be unloaded and kept in the bulk stock area up to the time they are needed for loads. These items, along with the bulk stock withdrawals, would be placed manually on to a conveyor linking into the main conveyor taking Moss production to the load assembly racks. Those items received from outside the Moss site will have to be provided with a product ident tag.

The Bulk Store.

The most suitable set up for this store is seen as utilising the existing No. 1. and No. 2 warehouses These buildings are directly adjacent to the production floor and are already provided with loading docks. These loading docks will be used for unloading the vehicles

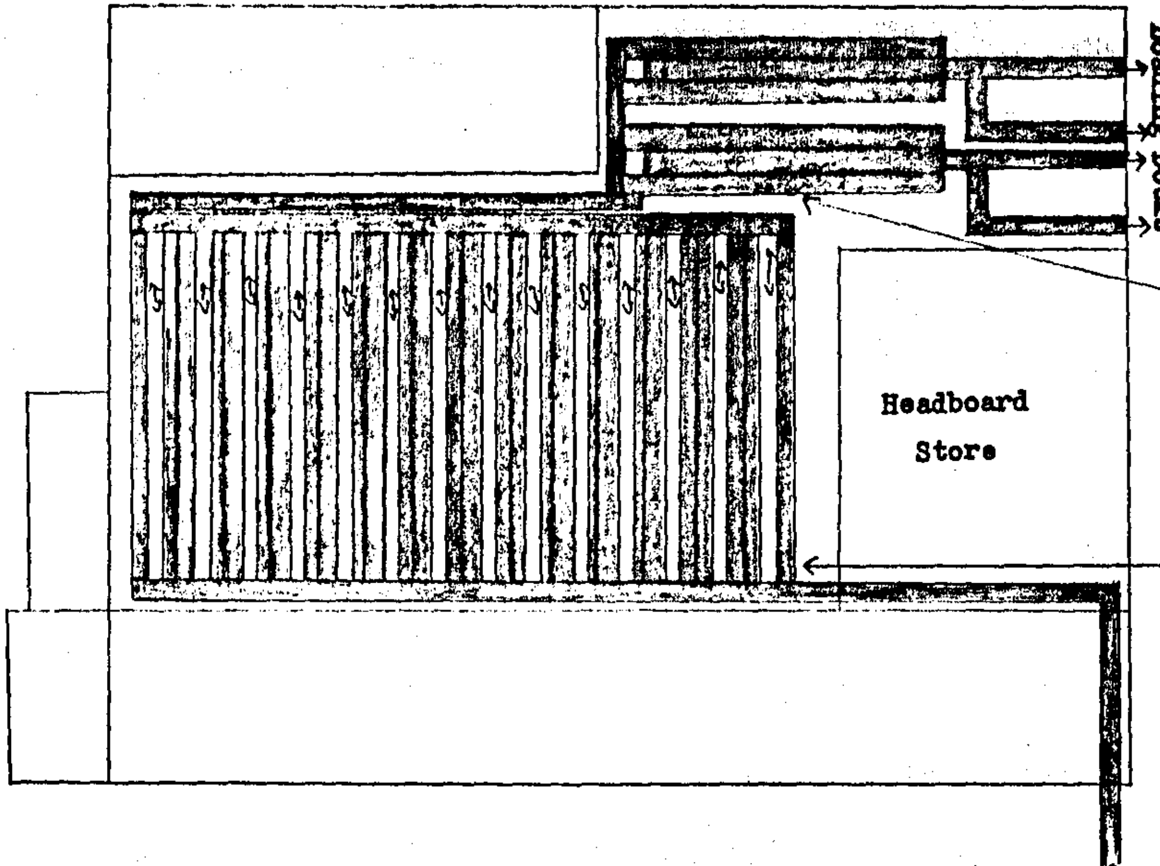


Fig 32 - DESPATCH WAREHOUSE ARRANGEMENTS - SCHEME E

feeding finished products from outside sources into the new centralised distribution facilities.

Products from Sutton and the Associate Mail Order Companies are sorted into pallets while being unloaded from the relevant vehicles.

Goods proceeding from the Moss production floor reach the bulk store on a flat bed conveyor which diverts from the main conveyor between production and the despatch warehouse.Once in the bulk store area the individual items are manually taken off the conveyor and sorted into pallets of idential product specifications. The individual pallets are stacked by means of fork lift trucks.

For each loading shift the bulk store receives a print-out of items needed for load assembly, These items are picked from the bulk store and placed on the outgoing flat bed conveyor which links in with the main conveyor heading for the load assembly area. The movement of the item is then the same as that already described for those items which directly enter the despatch area from the Production Department.

No. 1 and No, 2 warehouse need to be modified in order to be fully effective in their new role as bulk stock warehouses. They will have a combined stockholding capacity of approximately 17,000 sets. For all the bulk stocking the present system of pallets stacked above one another would be retained.

The Labour Requirement.

The labour requirement for operating this system is shown in Table 13. A labour force of 56 is needed, which costs on an annual basis £376,040. The details of the labour force were worked out in collaboration with the Company's Distribution and Technical Management.

The Capital Cost.

The total cost of implementing this scheme is shown in Table 14, and is £4,707,770

Implementation Timescale.

Fig.33 shows the estimated timescale in which it is proposed to complete all the necessary work to enable this warehouse Scheme to operate in full. This work is projected to take 100 weeks.

TABLE 13

THE LABOUR REQUIREMENT - SCHEME 'E'

Head of Department	2		
Shift Supervisors	4		
Beltmen	7		
Forklift Operators	3		
Loaders (including Checkers)	24		
Shunters	4		
Returns	2		
Headboards	3		
Maintenance	4		
Cleaners	1		
Absenteeism	2		
	56	=	£376,040

TABLE 14

CAPITAL COST SUMMARY - SCHEME 'E'	£.
Access Roads and Manoeuvring areas surfaced.	120,000
Van Park surfaced	270,000
Demolish Barnsey	55,000
New Buildings - Barnsey	1,016,000
Storage Pallets (for use in No. 1 and No. 2 warehouse)	207,270
Bridge to Barnsey	90,000
Demolish No. 1 and No. 2 Mezzanine	34,000
Repair floor beneath No. 2 Mezzanine	25,500
Warehouse Equipment Package: (stacker cranes, racking and software)	2,890,000
	£4,707,770

Key For Fig 33.

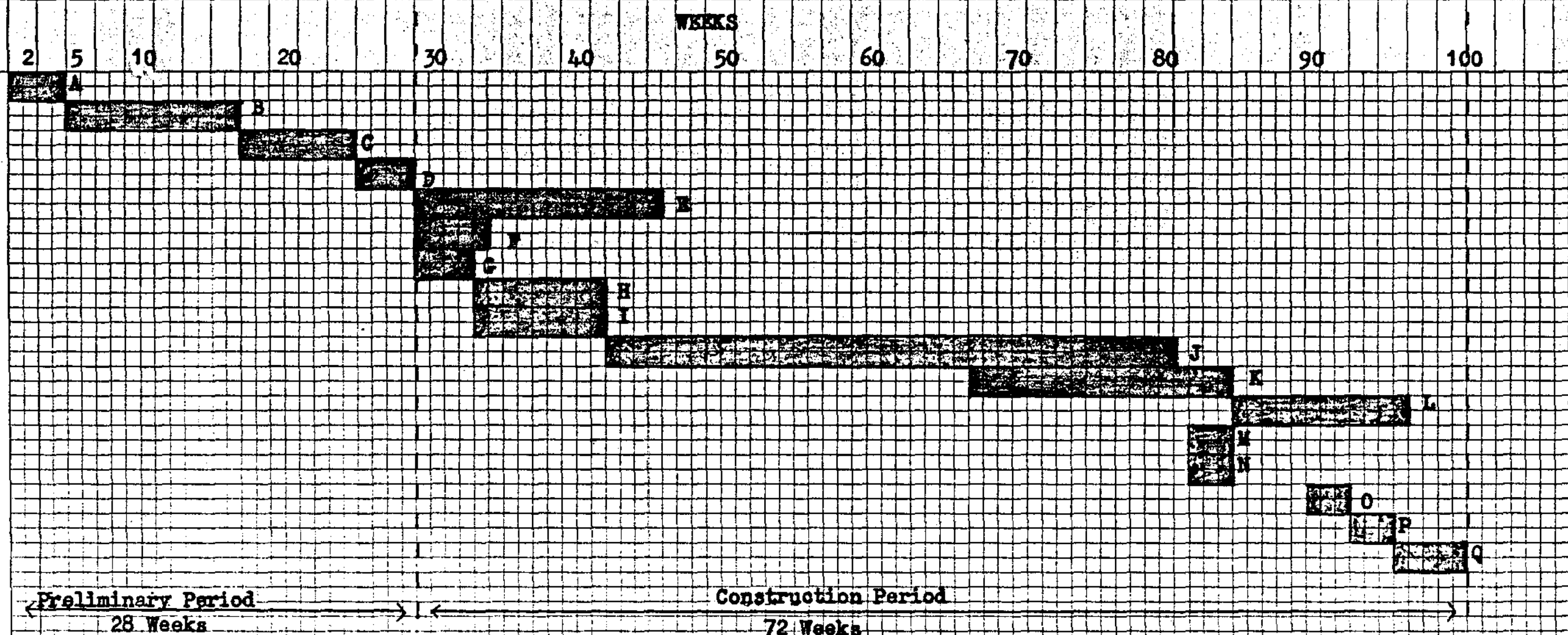
IMPLEMENTATION TIMESCALE - SCHEME E.

A=Internal Approval
B=Detailed Design
C=Planning Permission
D=Arrange Contracts
E=Barnsey - Repairs
F=Barnsey - Erect Bridge
G=Barnsey - New Road
H=Barnsey - Construct Vehicle Park
I=Barnsey - Demolish Shed

J=Barnsey - Erect New Buildings
K=Install Equipment
L=Run In Equipment
M=Fit Conveyor In Bridge
N=Fit Conveyor To Bulk Store
O=Demolish No 1 Mezzanine
P=Demolish No 2 Mezzanine
Q=No 2 Relay Ground Floor

Fig 33.

IMPLEMENTATION TIMESCALE - SCHEME E.



See Opposite For Key.

5. FINANCIAL EVALUATION

FINANCIAL EVALUATION

5.1. INTRODUCTION

Five potential warehousing and load assembly systems have been analysed in the previous chapter and found to be feasible. All five could efficiently deal with 1986 despatch requirements. As has been shown there are major differences between these mutually exclusive alternatives in terms of labour requirement and capital cost.

Obviously the financial viability of these warehouse schemes needs to be judged against each other to find which shows the best return for the capital invested. However, it must also be shown that the proposed warehouse scheme selected as financially most favourable, shows a positive return on the "do nothing" approach. This means comparing the present throughput where the existing system is judged to be working at its maximum capacity (1982) levels with those despatch levels projected for 1986. Also to be taken into account is that, even if the proposed warehouse schemes could be implemented overnight, they would not attain the 1986 volume and profit levels until that year, as the Company forecasts a progressive build up in volume. It has already been made clear that the warehouse schemes are capable of dealing with the 1986 levels, but not more. This particular year has been chosen because the Company's Management see the 1986 despatch volumes as being the maximum production possible in Silentnight's existing factories. If the Company wants to increase its production volume above the 1986 levels, it is envisaged that another manufacturing unit would need to be set up elsewhere in a different part of the country with its own warehousing and distribution system. Therefore, the maximum extra profit that can be generated by any of the schemes can be found by comparing the labour cost differences and the net extra profit per set with the 1986 despatch levels compared with the "do nothing" alternative.

Table 15 shows the additional sets that the proposed warehouse schemes would be able to handle on a weekly basis and the extra profit this would generate up to and including 1986. After 1986 the figure would stay constant. The profit figures included are on a yearly basis which equates to 47.6 distribution weeks. The extra profit is calculated from the Company policy of 12% per set and in 1982 this equated to £8.12.

TABLE 15.

EXTRA SETS THE SYSTEMS COULD HANDLE PER WEEK.

1982	1983	1984	1985	1986
Nil	700	1,450	2,300	3,113

EXTRA PROFIT GENERATED PER YEAR (47.6) DISTRIBUTION WEEKS.

1982	1983	1984	1985	1986
Nil	£270,558	£560,442.	£888,978	£1,203,212

Although figures are included, both for the additional sets per week and extra profit per year for 1983, these figures in practice could be forgotten as all schemes would be in the process of construction, in this year, and therefore not operating at this level, but only at 1982 levels.

However, this table does not give one sufficient information to start a financial evaluation of the various proposed warehouse schemes. The labour cost differences in terms of how many pieces can be moved per man per week must be analysed and then quantified financially for the different levels up to the 1986 despatch volumes. Table 16 compares the number of pieces it is estimated each man could move per week operating under each of the different proposed schemes.

Table 17 analyses the labour requirements of each of the proposed warehouse solutions for each year from 1982 up to and including 1986. The cost of labour is calculated and then compared with the existing system to show a positive or negative value in relation to the 1982 systems' requirements. This information now allows the production of Table 18 which shows the extra net profit generated by each of the different proposed warehouse schemes. The figures can be directly used in the financial evaluation of the different alternative solutions to dealing with the 1986 despatch volumes.

So far attention has been confined to profit levels and labour costs. Obviously these figures will be greatly influenced by the differing capital costs of the various schemes. Table 19 shows a summary of the capital costs of each project. The cost figure is then split into two component parts, plant and equipment and building and structural work. This is because in some of the evaluation techniques used these two cost areas are treated differently for taxation purposes. Table 20 then shows the capital cost in terms of which year the money would be spent.

From the tabulated information now presented there is sufficient material to start the financial evaluation of the various feasible solutions to the mechanisation and the automation of the bedding warehouse.

TABLE 16.

PIECES MOVED PER MAN PER WEEK.

SYSTEM.	SETS/MAN/WEEK.
Existing	126
Scheme 'A'	129
Scheme 'B'	161
Scheme 'C'	169
Scheme 'D'	190
Scheme 'E'	238

TABLE 17.

Labour Cost Differences.

Existing System (1982) = £543,915

Scheme 'A'

Year	Labour	Cost (£).	Comparison with Existing System (£).
1982	79	530,485	+ 13,430
1983	84	564,060	- 20,145
1984	90	604,350	- 60,435
1985	97	651,355	-107,440
1986	103	691,645	-147,730

Scheme 'B'

1982	63	423,045	+120,870
1983	68	456,620	+ 87,295
1984	73	490,195	+ 53,720
1985	78	523,770	+ 20,145
1986	83	557,345	- 13,430

Scheme 'C'

1982	60	402,900	+141,015
1983	65	436,475	+107,440
1984	69	463,335	+ 80,580
1985	74	496,910	+ 47,005
1986	79	530,485	+ 13,430

Scheme 'D'

1982	54	362,610	+181,305
1983	57	382,755	+161,160
1984	61	409,615	+134,300
1985	66	443,190	+100,725
1986	70	470,050	+ 73,865

Scheme 'E'

1982	43	288,745	+255,170
1983	46	308,890	+235,025
1984	49	329,035	+214,880
1985	53	355,895	+188,020
1986	56	376,040	+167,875

TABLE 18.

EXTRA NET PROFIT GENERATED (£).

Scheme 'A'

1982	+ 13,430
1983	+ 250,413
1984	+ 500,007
1985	+ 781,538
1986	+ 1,055,482

Scheme 'B'

1982	+ 120,870
1983	+ 357,853
1984	+ 614,162
1985	+ 909,123
1986	+ 1,189,782

Scheme 'C'

1982	+ 141,015
1983	+ 377,998
1984	+ 641,022
1985	+ 935,983
1986	+ 1,216,642

Scheme 'D'

1982	+ 181,035
1983	+ 431,718
1984	+ 694,742
1985	+ 989,703
1986	+ 1,277,077

Scheme 'E'

1982	+ 255,170
1983	+ 505,583
1984	+ 775,322
1985	+ 1,076,998
1986	+ 1,371,087

TABLE 19.

Summary of Capital Costs (£).

Scheme 'A'	Capital Cost =	337,380:	Plant and Equipment =	189,730
			Building/Structural =	147,650
Scheme 'B'	Capital Cost =	1,081,490:	Plant and Equipment =	313,990
			Building/Structural =	767,500
Scheme 'C'	Capital Cost =	1,342,090:	Plant and Equipment =	574,590
			Building/Structural =	767,500
Scheme 'D'	Capital Cost =	2,411,380:	Plant and Equipment =	554,880
			Building/Structural =	1,856,500
Scheme 'E'	Capital Cost =	4,707,770	Plant and Equipment =	3,097,270
			Building/Structural =	1,610,500

TABLE 20.

Capital Cost as Related to Year Incurred (£)

1982	Nil		
1983	Scheme 'A'	(100%)	337,380
	Scheme 'B'	(100%)	1,081,490
	Scheme 'C'	(100%)	1,342,090
	Scheme 'D'	(60%)	1,446,828
	Scheme 'E'	(50%)	2,353,885
1984	Scheme 'D'	(40%)	964,552
	Scheme 'E'	(50%)	2,353,885

There are many different financial appraisal methods which could be used, which may or may not give differing results. Four main methods were selected as being most suitable. These are:-

a). Payback;

b). Internal Rate of Return;

c). Net Present Value;

d). Net Present Value per £1. Invested;

After the initial results were obtained, more detailed analysis was performed using the Net Present Value method to see what would be the relative effect on the ranking of the different proposed schemes if the 1986 despatch levels were not obtained.

5.2. Payback.

Table 21 applies the Payback method which is calculated on an annual basis. It will be noted that there is no return in 1983 as this is the year which is used for the installation of all the systems. Two of the proposed schemes also have installation running into a second year, 1984. Due to the fact that Scheme 'D' is able to start working in 1984 a small profit is recorded. Scheme 'E' however, takes 2 whole years to build, so does not start to record a profit until 1985. From the information presented all the warehouse schemes have a payback period under 5 years. However, if the solution is to be determined by the criteria of the shortest payback period alone then Scheme 'A' scores, being the only one of the various alternatives with a payback of 2 years or less.

However, there are drawbacks to the use of the Payback method. Payback is defined to be the number of years required to recover the initial investment, and the method recommends that the alternative having the smallest payback is chosen. From this definition it can be seen that payback is not really a profitability concept, but rather it is a time or liquidity concept. Merrett and Sykes go so far as to state that "payback is seriously deficient as a method of profitability appraisal......its sole use should be confined to serving as a crude screening device to eliminate obviously unacceptable projects". Payback ignores the timing of cash flows and their duration, it merely indicates how quickly the initial

TABLE 21.

Payback Method.

Using Cash Flow Figures After Taxation, Allowances Taken Into Account.

		Scheme 'A'	Scheme 'B'	Scheme 'C'	Scheme 'D'	Scheme 'E'
Total Cost		337,380	1,081,490	1,342,090	2,411,380	4,707,770
Net Earnings per Year	1983	nil	nil	nil	nil	nil
	1984	500,007	614,162	641,022	277,897	nil
	1985		1,371,723	1,534,095	1,597,247	2,196,336
	1986				1,576,215	2,490,425
	1987					844,546
Total Earnings to achieve break even.		500,007	1,985,885	2,175,117	3,451,359	5,531,307
Payback Period in Years.		(2)	(3)	(3)	(4)	(5)

(Net Earnings as shown are those generated by that system over and above the present system)

(See Appendix 2)

investment will be repaid. It also ignores the time value of money concept.

To judge the various warehousing solutions by payback alone is obviously not satisfactory. However, it can be used to complement other evaluation techniques. Perhaps its usefulness is best summed up by Sizer when he states "payback is a useful additional item of information, but in isolation is not an adequate measure of profitability". Attention will now be turned to those methods taking into account the time value of money.

5.3. Internal Rate of Return.

The first method to be considered which uses the concept of the time value of money is the Internal Rate of Return. This defined "as the rate of interest which discounts the future cash flows generated by an investment down to the present value which exactly equals the cost of that investment". The rule as to which projects to undertake is "undertake all projects with an internal rate of return greater than, or equal to, the cost of borrowed money". Therefore the internal rate of return can be seen to be the rate of interest which gives a project a zero net present value

Table 22 sets out the internal rate of return for the five mutually exclusive projects over a 4-year timescale. The internal rate of return has been calculated for all the various schemes, except that involving the automated stacker cranes. This is because Scheme 'E' has a negative internal rate of return. The ranking of the various schemes is the same as that shown by the use of the payback method. Scheme 'A' shows up most favourably with a rate of return over 4 years of 179%. This Scheme is certainly the most favourable with this method of analysis; the nearest contender only has an internal rate of return over the same timescale of 64%. Therefore the internal rate of return method and payback method can be seen to produce the same ranking of the various warehouse solutions, that is Scheme 'A' is the financially most favourable and therefore gives the best return for the capital invested.

However, many authorities suggest that the internal rate of return

TABLE 22.

Internal Rate of Return Over 4 Years (£).

Scheme 'A'

Year	Cash Flow	Discount Factor 179%	
1	Nil	1.000	= 0
2	500,007	0.3584	= 179,203
3	940,853	0.1285	= 120,899
4	798,549	0.0460	= 36,733
			336,835

Scheme 'B'

Year	Cash Flow	Discount Factor 64%	
1	Nil	1.000	= 0
2	614,162	0.6098	= 374,516
3	1,371,723	0.3718	= 510,007
4	886,382	0.2267	= 200,943
			1,085,466

Scheme 'C'

Year	Cash Flow	Discount Factor 51%	
1	Nil	1.000	= 0
2	641,022	0.6623	= 424,549
3	1,534,095	0.4386	= 672,854
4	899,275	0.2904	= 261,149
			1,358,552

Scheme 'D'

Year	Cash Flow	Discount Factor 16½%	
1	Nil	1.000	= 0
2	277,897	0.8584	= 238,547
3	1,597,247	0.7369	= 1,177,011
4	1,576,215	0.6325	= 996,956
			2,412,514

Scheme 'E'

Year	Cash Flow
1	Nil
2	Nil
3	2,196,336
4	2,490,425

Cash flow figures below cost, so therefore there will be a negative internal rate of return method is not an ideal method of analysis when used on its own. This is because the rate of return value given is only a relative figure and not an absolute value. Carsberg states the "fundamental shortcoming of the internal rate of return method is that it gives a measure of return relative to the outlay required for the project and ignores the size of the return". There is a general consensus that the net present value method is to be preferred to the internal rate of return method for ranking mutually exclusive projects. Obviously then, the internal rate of return method can only be used as a complementary source of analysis.

5.4. Net Present Value.

The Net Present Value method takes into account the time value of money. It involves calculating the present value of a project's cash flow, both positive (receipts) and negative (outlays). A project has a positive net present value if the present value of its cash inflows exceeds that of it outflows. Optional investment decisions involve accepting projects with positive net present values and rejecting projects with negative net present values using the marginal rate of time preference as the discount rate. In the case of mutually exclusive projects (as is the case in this study) that with the highest positive net present value (if any) should be selected. The present value can, therefore, be seen to represent the firm's prospective increase in wealth from undertaking the project.

Appendix 2 sets out the net present values for the various schemes. Table 23 summarises the information presented to show the net present values for each of the Schemes for a 4-year and a 10-year period. The discount factor has been fixed at 10 % because at the time of writing this was the rate of interest Silentnight would have to pay to borrow money from its Bankers. This figure of 10% has been used as the basic rate throughout all the net present value calculations.

As can be seen, perhaps more clearly from the summary table, Table 23 Scheme 'A' when judged over 4 years gives the highest net present value. Scheme 'E' records a negative value, obviously confirming the results of the earlier considered two methods of analysis. This Scheme must, therefore, be the least financially favourable of the

TABLE 23

Summary of Net Present Values With a 10% Discount Rate (£).

	4 years.	10 years.
Scheme 'A'	+ 1,494,647	+ 3,257,410
Scheme 'B'	+ 1,276,375	+ 3,291,951
Scheme 'C'	+ 1,184,064	+ 3,241,828
Scheme 'D'	+ 433,109	+ 2,655,094
Scheme 'E'	- 807,694	+ 1,559,873

five feasible solutions judged to be capable of dealing with the 1986 despatch levels. The relative ranking of all the schemes is the same as that generated by the payback and internal rate of return method.

However, when comparing the net present value figures when judged over a 10-year period the relative ranking changes between Scheme 'B' and Scheme 'A', Scheme 'B' shows a higher net present value by £34,541, which equates only to a 1.05% difference. Scheme 'A' however, becomes the second most favourable scheme. The remaining Schemes retain their respective ranking positions, that is, third Scheme 'C', fourth Scheme 'D' and fifth and last, Scheme 'E'. All the evidence so far, therefore, points to Scheme 'A', except in one instance, where Scheme 'B' shows up most favourably. The evidence from the use of the net present value method, with a discount rate fixed at 10% is, therefore, not as conclusively in favour of Scheme 'A' as was the payback and internal rate of return method.

5.5. Net Present Value per £1.00 invested.

One further method of financial appraisal still needs to be covered. This is the net present value per £1.00 invested and is shown in Table 24. This shows the return after allowing for the cost of money invested (at 10%). Scheme 'A' shows the highest return, being approximately three times higher that its nearest rival, Scheme'B'

The financial evaluation methods all point to the fact that Scheme 'A' is overwhelmingly the most financially favourable scheme to implement in order to deal with the predicted 1986 despatch volumes. However, all the above calculations do not take into account certain outside variables which may affect the viability of the warehouse schemes. Obviously this investment project is not a high risk study due to the fact that it is essentially a replacement analysis, allowing for growth in the output of the Company. Obviously the reliability of these forecasts of despatch volumes are subjective to a certain extent, being based on the Company's Management's perception of the future.

TABLE 24.

Net Present Value per £1. Invested at a 10% Discount Rate (£)

	4 years.	10 years.
Scheme 'A'	+ 4.43	+ 9.56
Scheme 'B'	+ 1.18	+ 3.04
Scheme 'C'	+ 0.88	+ 2.42
Scheme 'D'	+ 0.18	+ 1.10
Scheme 'E'	- 0.17	+ 0.33

5.6. Effect of Inflation.

Inflation will obviously have a bearing upon the financial viability of the various schemes. Most of the data and information available concerning predictions of inflation is often of a vague nature and often conflicts with that from other sources. However, the Cambridge Economic Review (1982) forecasts inflation for the period 1982-1990 by giving several different rates. The lowest annual level of inflation is given as 6% and the highest as 16½%. It is, therefore, proposed to take these two extremes and apply them to the net present value method. This will, therefore, give some indication of what inflation may be expected to do to the financial viability of the proposed warehousing schemes. In terms of its impact upon the financial ranking, the lower rate of inflation would be expected to have the least impact, and therefore the rate of 6% inflation will be examined first.

Appendix 3 examines the net present value for all the five schemes for a 4-year and 10-year period with a discount factor at 16%. Using the rate of 16% allows for both:-

a). Silentnight's cost of money from its Bankers (10%)

b). The rate of inflation (6%).

Table 25 summarises this information so that the net present values for all the schemes are easily comparable. From this Table it can be seen that over the first 4 years of operation the automated stacker crane system (Scheme 'E') has a negative net present value. All the other schemes show a positive net present value of varying amounts, with Scheme 'A' showing up as the most favourable. Over 10 years the relative ranking remains the same, Scheme 'A' showing the highest positive return.

A low rate of inflation, therefore, has no effect on the relative ranking of these mutually exclusive projects when looked at on a 4-year timescale. Over a 10-year timescale for comparing net present value figures generated by the five schemes, it will be noticed that all five show a positive return varying between £2,584,917 and £561,862. However, when comparing the relative ranking of the schemes over a 10-year period it will be noted that a low rate of inflation

TABLE 25.

Summary of Net Present Values with a 16% Discount Rate (£).

	4 Years	10 Years.
Scheme 'A'	+ 1,304,548	+ 2,584,917
Scheme 'B'	+ 1,035,349	+ 2,498,616
Scheme 'C'	+ 926,839	+ 2,420,540
Scheme 'D'	+ 158,162	+ 1,771,273
Scheme 'E'	- 1,155,237	+ 561,862

has a minor effect compared with that analysis not taking inflation into account. This is, that the most favourable scheme financially is Scheme 'A' and not Scheme 'B' as was shown when just using the time value of borrowed money and ignoring inflation. It can, therefore, be concluded that, with a low rate of inflation over the next decade, Scheme 'A' is the most economically viable scheme to implement of those found to be capable of handling the projected despatch volumes.

The examination of the financial viability of the proposed warehouse schemes with a low rate of inflation has served to confirm previous results. Appendix 4 shows the calculations necessary to get the net present value figures with the predicted higher rate of inflation of 16½% The discount factor in this case is, therefore, 26½% when the predicted level of inflation is added to the assumed cost of borrowed money. Table 26 then summarises the net present value factors as in previous cases for a 4-year and 10-year period. Taking initially the 4-year timescale, two schemes, those most technologically advanced showed a negative value. Only one scheme has a return over £1million , this is the least automated and mechanised project - Scheme 'A'. Between the two conveyor sortation systems in existing buildings that which has manual sortation shows a higher return than that with automatic sortation. Therefore the less automation and mechanisation in the scheme, the more positive the return.

Over a 10-year period the same ranking is held, but only Scheme 'E' shows a negative net present value. The use of a high rate of inflation in the analysis only confirms the existing financial ranking of the various schemes. It, however, throws doubt on the financial viability of the automated stacker crane system with both a high and low rate of inflation. With a high rate of inflation the financial viability of Scheme 'D' is also open to question on a moderately short timescale. Taking inflation into account only serves to emphasise the results shown earlier.

5.7. Effect of Failure to Attain 1986 Despatch Volumes.

All the above financial evaluation has so far assumed that the 1986 despatch volumes as predicted by the Company's Management are

TABLE 26.

Summary of Net Present Values with a 26½% Discount Rate (£).

	4 Years.	10 Years.
Scheme 'A'	+ 1,040,378	+ 1,813,823
Scheme 'B'	+ 699,155	+ 1,582,293
Scheme 'C'	+ 567,626	+ 1,468,940
Scheme 'D'	- 212,702	+ 760,752
Scheme 'E'	- 1,611,622	- 576,914

attained. However certain the Company's Management are of obtaining these forecasts, it is proposed to examine what happens if these results are not obtained and to see which of the proposed warehouse schemes comes out most favourably. This will be examined in two ways. Firstly it will be assumed that no growth in volume takes place above that already achieved. Secondly the schemes will then be evaluated to see what happens if the despatch levels continue to grow till 1984 and then not beyond the predictions for that year.

Appendix 5 shows the calculations necessary to obtain the net present value figures for the various schemes, assuming that despatch levels do not rise above those obtained in 1982. In these calculations the extra profit generated arises from an increase in the number of sets handled per week by each man under each of the proposed schemes. These use labour more efficiently compared with the existing 1982 system, but at an increase in the capital cost of the scheme. These figures were examined earlier in Table 17 and Table 18. Table 27 summarises the net present value figures for the various schemes. It will be noted that all show a negative return. Therefore, if SilentNight does not attain any growth from the 1982 despatch volumes, it would be uneconomic to proceed to alter the existing warehouse arrangements. The Company's Management are, however, quite confident that despatch levels will rise above those obtained in 1982.

What do the net present value figures obtain for a no growth situation say about the relative ranking of the various schemes? It can be seen that they confirm the pattern of ranking previously established. Scheme 'A' shows the smallest negative net present value. This is followed by Scheme 'B', Scheme 'C', then Scheme 'D', and last Scheme 'E', the automated stacker crane system showing the largest negative net present value

If, however, despatch volumes do not reach the predicted levels for 1986, but level off after 1984, what effect will this have on the financial viability of the various proposed warehousing/load assembly solutions? Appendix 6 shows the calculations to achieve the net present values and Table 28 summarises them to ease comparison.

TABLE 27.

Summary of Net Present Values Assuming No Growth from 1982 Despatch Levels (£.)

	4 years.	10 years.
Scheme 'A'	- 175,265	- 146,501
Scheme 'B'	- 433,844	- 196,837
Scheme 'C'	- 540,232	- 271,586
Scheme 'D'	- 1,164,675	- 765,835
Scheme 'E'	- 2,325,241	- 1,814,843

TABLE 28.

Summary of Net Present Values Assuming Despatch Volumes only reach the projected 1984 levels.

	4 years.	10 years.
Scheme 'A'	+ 844,661	+ 1,637,672
Scheme 'B'	+ 600,156	+ 1,611,948
Scheme 'C'	+ 507,845	+ 1,561,830
Scheme 'D'	- 248,155	+ 957,117
Scheme 'E'	-1,504,597	- 177,220

It can easily be seen that Scheme 'A' has the highest net present value, both over a 4-year and a 10-year timescale.

If the despatch volume for 1986 is not obtained then Scheme 'A' comes out most favourably. If due to unforeseen factors the volume does not rise above 1982 levels, then Scheme 'A' costs the least in terms of a negative net present value. Obviously, the Company has already obtained the 1982 levels and is confident that the future growth will be achieved, and therefore to enable it to grow beyond the 1982 volume needs to implement a warehousing scheme capable of dealing with the predicted future level of business. Scheme 'A' does this at the lowest financial risk in terms of outlay and net present value. If volume only grows to 1984, Scheme 'A' gives the highest net present value and is obviously the scheme to implement.

5.8. Conclusion.

Four methods of analysis have been applied to all the five mutually exclusive warehouse schemes which were found to be capable of dealing with the projected 1986 distribution levels. All the methods gave consistent results in terms of ranking of the schemes. This ranking starting with the most favourable scheme was found to be:-

a). Scheme 'A' - Modifying the present system.

b). Scheme 'B' - Conveyor belt manual sortation in Existing Building.

c). Scheme 'C' - Conveyor Belt Sortation in Existing Building

d). Scheme 'D' - Conveyor Belt Sortation in a Purpose Designed High Street Despatch Building.

e). Scheme 'E' - Automated Stacker Crane.

Due to the fact that the net present value method takes into account the time value of money and provides an absolute figure, further analysis was performed using the net present value method. When taking inflation into account, both at a high and low rate prediction, it did not affect the ranking of the projects, only the absolute size of the net present value figures. The schemes were also evaluated under conditions of no growth from current levels and only a small growth in despatch levels to that predicted for 1984. This showed that even if the projected 1986 despatch volumes were

not obtained, the relative ranking of each scheme was not upset.
It can now be concluded that Scheme 'A' is the most viable proposition to implement.

6. CONCLUSION.

6. Conclusion.

Various handling systems have been identified as being compatible with dealing with the warehousing situation at Silentnight. These range from those systems being entirely manual in operation through to a completely automatic system, with manual labour being only involved in the actual loading operation into the vehicles. Many types of warehousing equipment were examined in order to be able to identify these feasible systems.

Problems were encountered in finding suitable handling systems as there is no equipment on the market which is directly applicable to the handling of beds. It became a matter of searching out potentially feasible handling systems and then examining them in greater detail to see if they would be compatible with the demands to be placed on them in the proposed warehousing system. Many potential systems were examined, but the majority proved to be unsuitable for various reasons.

As a general conclusion it can be stated that the lower level of mechanisation, the more financially viable the warehousing solution would be. This is due to the fact that higher levels of mechanisation and of automation do not reduce the labour requirements in sufficient proportions to financially justify their implementation. The majority of the warehousing systems were not compatible with the requirements of the Silentnight operation, as what is essentially required is a specialised load assembly system, not a "conventional" warehouse. Silentnight's products are not picked from a conventional stock situation, but only a buffer stock which exists to bridge the gap between the conflicting demands of the Production and Transport Departments. In a "conventional" warehouse, picking will take place from a storage area of items which have been held in stock, sometimes for a considerable length of time. The bedding industry essentially makes to order, so there is no storage of this kind. The type of warehouse required in this industry is, therefore a load assembly warehouse. The difference between the requirements of the bedding industry and other warehouses in other industries is therefore a functional one.

In the majority of the so termed automatic warehouses, the actual sorting into delivery order is normally manual. The majority of the mechanised and automated warehouses in operation have a manual load assembly function. In essence, such automatic warehouses are essentially automatic storage and retrieval systems. So far there has been little successful automation in the field of load assembly. Where it has been applied has been in the area of small item picking utilising expensive machinery

Automatic and mechanised warehouses can, therefore, be seen as storage and retrieval systems. Products are retrieved out of the storage system and then picked from to form individual loads. At the I.B.M. automated warehouse at Greenock products are automatically retrieved on pallets and sent to a picking station. The required number of items are picked and the pallet then sent back to the storage area. The picking from the pallet is entirely manual. Another example of an automatic storage and retrieval warehouse is the white goods warehouse of the Eastern Electricity Board at Waltham Cross. The items are stored on pallets which are held in racking and served by automated stacker cranes, When an item is required this information is entered into the warehouse computer. The pallet holding the relevant item is then automatically delivered from the racking zone to the picking area. The required number of items are then manually picked from the pallet and taken to a load assembly area where they are manually assembled in the required delivery/drop order for vehicle loading. When the vehicle is ready for loading the items are again manually collected from the load assembly area.

Certain mechanised and automated warehouses do sort products into loads, but not further down into delivery/drop order. Such systems exist within the parcel industry. At Wilkinson's Transport,Nuneaton depot an automatic sortation system exists. This, however only sorts the parcels down to individual loads. There is no need for sortation within the load and this capability does not exist within the system.

These examples show that even a straight transfer of technology between automated warehouses in other industries would not provide the necessary technology to enable a bedding industry warehouse to be successfully automated or mechanised. Automated and mechanised load assembly systems do not exist except for very specialised small parts order picking. This arises due to the fact that the difference between the warehousing required in the bedding industry and other industries where automated and mechanised warehouses exist is basically a functional one. The bedding industry requires a load assembly system, not a storage system.

The conclusion to this study is that various mechanised and automated systems would be applicable in a bedding warehouse. Upon a financial basis, however, only one Scheme could be recommended, that is Scheme 'A', "Modifying the Present System". This, as it happens, is the least mechanised and automated of all the potentially feasible schemes.

Obviously such a warehouse solution in the light of the above discussions seems perfectly plausible as specialised load assembly sortation systems which arrange products into delivery/drop order do not exist except in a few very specialised cases. However, this does not mean that such systems will not be developed in the future and be economic in operation. One needs to stay constantly aware of new and changing methods and examine the latest innovative technology to see if it would be of any potential use.

This study presents no ready made solution to the various handling problems which exist within different industries. All it shows is a methodology of study.

On examining a warehouse operation, the problem needs to be examined as a complete system and related to the environment in which it operates. This means that the systems boundaries must be extended outwards from the actual warehouse operation as far as is required to determine which inter-relationships are significant to the solution of the warehouse/handling "problem" These inter-relationships tie a system together and give it its reason for existence. By using systems analysis the project will be methodically examined by exploring the objectives, assumptions and alternatives as an integral whole.

When examining a warehousing system the most important point is to define the objectives of the study. One must be clear about why the project is being undertaken and what it is hoped to achieve. Once the objects are clearly defined the next step in the study should be to examine the existing system. Even if it is proposed to remove this system completely, it still needs to be used as a base against which to judge potentially improved systems and to measure their respective performances against.

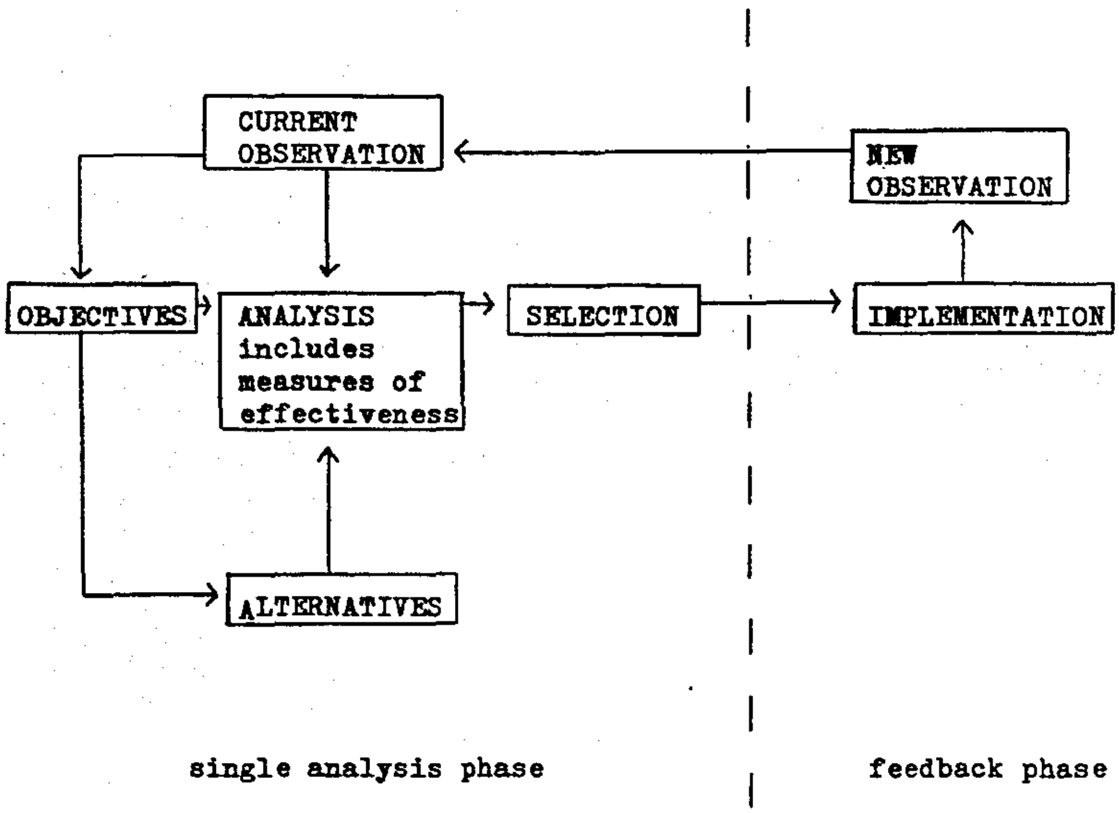
Alternatives need to be generated so that one can be sure that the most effective and efficient solution available at that particular moment in time has been adopted. Many potential systems must be examined to see if they would be feasible in use and if feasible, which would be the most economic to implement. The simplest way to ensure that all potential handling systems are examined is to place all systems on a continuum from entirely manual, through the various levels of mechanisation to full automation. This will ensure that in the examination of potential alternatives all types of technology from the simplest to the most complex will be examined to see if they are appropriate to the warehousing matter in question. Whatever point on the continuum is decided upon as providing the most economic solution at that particular moment in time, when circumstances change in the future it will simply be a matter of upgrading or downgrading technologically the system to suit a changing environment.

When a warehousing system is accepted the environment in which it fits is not static. Change will be taking place all the time which will be altering relationships within the system and externally into the industrial environment in which it fits. The system can, therefore, be seen as dynamic with feedback constantly altering the variables . Fig. 34 shows in a simplified manner the basic stages of system analysis and how dynamic systems analysis affects a single system .

Each warehouse system needs to be judged on its merits. What this study has shown is no ready made answers exist but that a common methodology of study is relevant; this essentially can be seen as a search and evaluate process which is conducted in a systematic manner. The Department of Industry states "Extraneous factors

Fig 34.

DYNAMIC SYSTEM ANALYSIS.



differ so widely in different circumstances that ready made answers to specific handling problems are rarely to be found. The best possible answer to a given problem in one factory may be entirely the wrong answer to an apparently similar problem in another. Each case must be judged on its merits".

In this particular study the result is go for the least mechanised and automated system that will effectively deal with the predicted 1986 volumes. This shows the highest economic return of any of the competing schemes.

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Institute of Physical Distribution Management.

Mannesmann Demag

P. Moorhouse and Sons.

Multipart, (B.L.)

National Association of Warehouse Keepers.

Perfecta.

Rapistan, Lande.

Sealy

S.I. Handling Systems.

Wilkinson Transport.

APPENDIX 1

PROJECTED 1986 DISTRIBUTION LEVELS.

APPENDIX 1.

JANUARY.

Sets/Loading Day.

High Street = 9540

Mail Order = 2707

	M.	T.	W.	Thur.	F.
H.S.	1908	2290	1336	2003	2003
M.O.	677	460	487	460	623
	2585	2750	1823	2463	2626

H.S. Box = 42 sets.

M.O. Box = 34 sets

Number of Loads.

H.S.	46	55	32	48	48
M.O.	20	13	14	13	18
	66	68	46	61	66

Pieces/Loading Day.

(4'6" Storage Products are Counted as Two Pieces).

H.S.

Spring Interiors.	1965	2358	1375	2063	2063
Divans	2218	2662	1553	2329	2328
	46/4183	55/5020	32/2928	48/4392	48/4391

M.O.

Spring Interiors	698	474	502	474	642
Divans	721	490	519	490	662
	20/1419	13/964	14/1021	13/964	18/1304

FEBRUARY.

Sets/Loading Day.

High Street = 8563

Mail Order = 3770

	M.	T.	W.	Thur.	F.
H.S.	1731	2055	1199	1798	1798
M.O.	943	641	678	641	867
	2656	2696	1877	2439	2665

Number of Loads.

	M.	T.	W.	Thur.	F.
H.S.	41	49	29	43	43
M.O.	28	19	20	19	25
	69	68	49	62	68

Pieces/Loading Day.

H.S.

Spring Interiors	1751	2101	1226	1838	1838
Divans	1977	2372	1384	2075	2075
	41/3728	50/4473	29/2610	43/3913	43/3913

M O.

Spring Interiors	972	660	699	660	894
Divans	1003	682	723	682	923
	28/1975	19/1342	20/1422	19/1342	26/1817

MARCH.

Sets/Loading Day.

High Street = 8850

Mail Order = 4085

	M	T	W	Thur.	F
H.S.	1770	2124	1239	1858	1859
M.O.	1021	694	736	694	940
	2791	2818	1975	2552	2799

Number of Loads.

	M	T	W	Thur.	F
H.S.	42	51	30	45	45
M.O.	30	20	21	20	28
	72	71	51	65	73

Pieces/Loading Day.

H.S.

	M	T	W	Thur.	F
Spring Interiors.	1810	2172	1266	1900	1900
Divans	2041	2451	1430	2146	2146
	43/3851	51/4623	30/2696	45/4046	45/4046

M.O.

	M	T	W	Thur.	F
Spring Interiors	1051	716	758	716	968
Divans	1087	739	783	739	1,000
	30/ 2138	20/ 1455	21/ 1541	20/ 1455	28/ 1,968

APRIL

Sets/Loading Day.

High Street = 8087

Mail Order. = 3992

	M	T	W	Thur	F
H.S	1617	1942	1132	1698	1698
M.O.	998	679	718	679	918
	2615	2621	1850	2377	2616

Number of Loads.

	M	T	W	Thur	F
H.S.	39	47	27	41	41
M.O.	29	20	21	20	27
	68	67	48	61	68

Pieces/Loading Day.

H.S.

	M	T	W	Thur	F
Spring Interiors.	1654	1984	1158	1736	1736
Divans	1867	2240	1307	1960	1960
	39/3521	47/4224	27/2465	41/3696	41/3696

M.O.

	M	T	W	Thur	F
Spring Interiors	1028	699	741	699	946
Divans	1062	722	766	722	977
	29/2090	20/1421	21/1507	20/1421	27/1923

MAY.

Set/Loading Day.

High Street = 9280

Mail Order = 3977

	M	T	W	Thur.	F
H.S.	1856	2227	1299	1949	1949
M.O.	994	676	716	676	915
	2850	2903	2015	2625	2864

Number of Loads.

	M	T	W	Thur.	F
H.S.	45	53	31	47	47
M.O.	29	20	21	20	27
	74	73	52	67	74

Pieces/Loading Day.

	M	T	W	Thur.	F
H.S.					
Spring Interiors	1897	2277	1329	1992	1992
Divans	2142	2571	1499	2249	2249
	45/4039	54/4848	31/2828	47/4241	47/4241
M.O.					
Spring Interiors	1025	697	738	697	942
Divans	1059	720	762	720	973
	29/2084	20/1417	21/1500	21/1417	27/1915

JUNE.

Sets/Loading Day.

High Street = 9873

Mail Order = 3315

	M	T.	W	Thur	F
H.S.	1975	2370	1382	2073	2073
M.O.	829	564	596	564	762
	2804	2934	1978	2637	2835

Number of Loads.

H.S.	47	57	33	50	50
M.O.	24	16	17	16	22
	71	73	50	66	72

Pieces/Loading Day.

H.S.

Spring Interiors	2019	2421	1413	2120	2120
Divans	2279	2734	1596	2393	2393
	48/4298	57/5155	33/3009	50/4513	50/4513

M.O.

Spring Interiors	854	581	615	581	785
Divans	882	600	635	600	812
	24/1736	16/1181	17/1250	16/1181	22/1597

JULY.

Sets/Loading Day.

High Street = 9471

Mail Order = 3775

	M	T	W.	Thur	F.
H.S.	1894	2273	1326	1989	1989
M.O.	944	642	680	642	867
	2838	2915	2006	2631	2856

Number of Loads.

	M	T	W.	Thur	F.
H.S.	45	54	32	47	47
M.O.	28	19	20	19	25
	73	73	52	66	72

Pieces/Loading Day.

H.S.					
Spring Interiors	1936	2324	1355	2033	2033
Divans	2186	2632	1530	2295	2295
	45/4122	54/4956	32/2885	47/4328	47/4328
M.O.					
Spring Interiors	972	661	700	661	894
Divans	1004	683	723	683	924
	28/1976	19/1344	20/1423	19/1344	25/1818

AUGUST.

Sets/Loading Day.

High Street = 10,505

Mail Order: = 3704

	M	T	W	Thur	F
H.S.	2101	2521	1471	2206	2206
M.O.	926	630	666	630	852
	3027	3151	2137	2836	3058

Number of Loads.

H.S.	50	60	35	53	53
M.O.	27	18	19	18	25
	77	78	54	71	78

Pieces/Loading Day.

H.S.					
Spring Interiors	2148	2578	1504	2255	2255
Divans	2425	2910	1697	2546	2546
	51/4573	61/5488	35/3201	53/4801	53/4801
M.O.					
Spring Interiors	954	649	687	649	878
Divans	986	670	710	670	907
	27/1940	18/1319	19/1397	18/1319	25/1785

SEPTEMBER.

Sets/Loading Day.

High Street = 10,196

Mail Order = 3864

	M	T	W	Thur	F
H.S.	2039	2447	1428	2141	2141
M.O.	966	657	696	657	888
	3005	3104	2124	2798	3029

Number of Loads.

	M	T	W	Thur	F
H.S.	49	59	34	51	51
M.O.	28	19	20	19	26
	77	78	54	70	77

Pieces/Loading Day.

H.S.

	M	T	W	Thur	F
Spring Interiors	2085	2502	1459	2189	2189
Divans	2353	2824	1648	2471	2471
	49/4438	59/5326	34/3107	52/4660	52/4660

M.O.

	M	T	W	Thur	F
Spring Interiors	996	677	716	677	916
Divans	1028	698	740	698	946
	28/2024	19/1375	20/1456	19/1375	26/1862

OCTOBER

Sets/Loading Day.

High Street = 11,025
Mail Order = 4338

	M.	T.	W.	Thur	F.
H.S.	2205	2646	1543	2315	2316
M.O.	1085	737	781	737	998
	3290	3384	2324	3053	3315

Number of Loads.

H.S.	53	63	37	55	55
M.O.	32	22	23	22	30
	85	85	60	77	85

Pieces/Loading Day.

H.S.

Spring Interiors	2254	2705	1578	2367	2367
Divans	2545	3054	1781	2672	2672
	53/4799	63/5759	37/3359	55/5039	55/5039

M.O.

Spring Interiors	1118	760	805	760	1028
Divans	1155	785	831	785	1062
	32/2273	22/1545	23/1636	22/1545	30/2090

NOVEMBER

Sets/Loading Day.

High Street = 9873
Mail Order = 3276

	M	T	W	T	F
H.S.	1975	2370	1382	2073	2073
M.O.	819	557	590	557	753
	2794	2927	1972	2630	2826

Number of Loads.

H.S.	47	57	33	50	50
M.O.	24	16	17	16	22
	71	73	50	66	72

Pieces/Loading Day.

H.S.					
Spring Interiors	2019	2422	1413	2120	2120
Divans	2277	2734	1595	2394	2394
	47/4296	57/5156	33/3008	50/4514	50/4514
M.O.					
Spring Interiors	844	574	608	574	776
Divans	872	593	627	593	802
	24/1716	16/1167	18/1235	16/1167	22/1578

DECEMBER

Sets/Loading Day.

High Street = 10,712

Mail Order = 2969

	M	T	W	Thur	F
H.S.	2142	2571	1501	2249	2249
M.O.	742	505	534	505	683
	2884	3076	2035	2754	2932

Number of Loads.

H.S.	51	62	36	54	54
M.O.	22	15	16	15	20
	73	77	52	69	74

Pieces/Loading Day.

H.S.

Spring Interiors	2192	2631	1536	2302	2302
Divans	2473	2997	1731	2596	2596
	52/4665	62/5628	36/3266	54/4898	54/4898

M.O.

Spring Interiors	765	520	550	520	704
Divans	790	537	569	537	726
	22/1555	15/1057	16/1119	15/1057	20/1430

APPENDIX 2

NET PRESENT VALUE WITH A 10% DISCOUNT RATE. CASH FLOW

APPENDIX 2.

(All figures rounded to whole numbers)

SCHEME 'A' **Net Present Value with a 10% Discount Rate. Cash Flow.**

Cash Flow

Year	Plant Cost.	Allowances Plant	Building Cost.	Allowances Building	Capital Cost Summation.	Extra Profit	Corporation Tax 52%	Profit/Corp. Tax Summation	Cash Flow	Discount Factor 10%	Net Present Value.	Present Value
1983	-189,730		-147,650		-337,380	Nil			-337,380	1.000		-337,380
1984						500,007		500,007	+500,007	.9091		+454,556
1985		+98,660		+60,655		781,538		781,538	+940,853	.8264		+777,521
1986				+ 3,071		1,055,482	260,004	795,478	+798,549	.7513	+1,494,647	+599,950
1987				+ 3,071		1,055,482	406,400	649,082	+652,153	.6830		+445,420
1988				+ 3,071		1055,482	548,851	506,631	+509,702	.6209		+316,474
1989				+ 3,071		1,055,482	548,851	506,631	+509,702	.5645		+287,727
1990				+ 3,071		1,055,482	548,851	506,631	+509,702	.5132		+261,579
1991				+ 768		1,055,482	548,851	506,631	+507,399	.4665		+236,701
1992				All used		1,055,482	548,851	506,631	+506,631	.4241	+3,257,410	+214,862

SCHEME 'B' Net Present Value with a 10% Discount Rate. Cash Flow.

APPENDIX 2.

(All Figures rounded to whole numbers)

Cash Flow

Year	Plant Cost	Allowances Plant,	Building Cost.	Allowances Building.	Capital Cost Summation	Extra Profit	Corporation Tax	Profit/Corp. Tax Summation.	Cash Flow.	Discount Factor 10%	Net Present Value.	Present Value.
1983	-313,990		-767,500		-1,081.490	Nil			-1,081,490	1.000		-1,081,490
1984						614,162		614,162	+614,162	.9091		+558,335
1985		+163,275		+299,325		909,123		909,123	+1,371,723	.8264		+1,133,591
1986				+ 15,964		1,189,782	-319,364	870,418	+ 886,382	.7513		+ 665,939
1987				+ 15,964		1,189,782	-472,744	717,038	+ 733,002	.6830	+1,276,375	+ 500,640
1988				+ 15,964		1,189,782	-618,687	571,095	+ 587,059	.6209		+ 364,505
1989				+ 15,964		1,189,782	-618,687	571,095	+ 587,059	.5645		+ 331,395
1990				+ 15,964		1,189,782	-618,687	571,095	+ 587,059	.5132		+ 301,279
1991				+ 15,964		1,189,782	-618,687	571,095	+ 587,059	.4665		+ 273,863
1992				+ 3,991		1,189,782	-618,687	571,095	+ 575,086	.4241		+ 243,894
											+3,291,951	

APPENDIX 2.

(All Figures rounded to whole numbers).

SCHEME 'C' Net Present Value with a 10% Discount Rate. Cash Flow.

Cash Flow.

Year	Plant Cost.	Allowances Plant.	Building Cost	Allowances Building	Capital Cost Summation	Extra Profit	Corporation Tax 52%	Profit/Corp. Tax Summation	Cash Flow	Discount Factor 10%	Net Present Value.	Present Value
1983	-574,590		-767,600		-1,342.090	Nil			-1,342,090	1,000		-1,342,090
1984						+641,022		641,022	+ 641,022	.9091		+ 582,753
1985		+298,787		+299,325		+935,983		935,983	+1,534,095	.8264		+1,267,776
1986				+ 15,964		+1,216,642	-333,331	883,311	+ 899.275	.7513		+ 675,625
											+1,184,064	
1987				+ 15,964		+1,216,642	-486,711	729,931	+ 745,895	.6830		+ 509,446
1988				+ 15,964		+1,216,642	-632,654	583,988	+ 599,952	.6209		+ 372,510
1989				+ 15,964		+1,216,642	-632,654	583,988	+ 599.952	.5645		+ 338,673
1990				+ 15,964		+1,216,642	-632,654	583,988	+ 599,952	.5132		+ 307,895
1991				+ 15,964		+1,216,642	-632,654	583,988	+ 599,952	.4665		+ 279,878
1992				+ 3,991		+1,216,642	-632,654	583,988	+ 587,979	.4241		+ 249,362
											+3,241,828	

SCHEME 'D' Net Present Value with a 10% Discount Rate. Cash Flow.

APPENDIX 2

(All Figures rounded to whole numbers).

Cash Flow.

Year	Plant Cost.	Allowance Plant	Building Cost.	Allowances Building.	Capital Cost Summation	Extra Profit	Corporation Tax 52%	Profit/Corp. Tax Summation	Cash Flow	Discount Factor 10%	Net Present Value.	Present Value.
1983	-332,928		-1,113,900		-1,446,828	Nil			-1,446.828	1.000		-1,446,828
1984	-221,952		- 742,600		- 964,552	277,897		277,897	- 686,655	.9091		- 624,238
1985		+173,123		+434,421		989,703		989,703	+1,597,247	.8264		+1,319,965
1986		+115,415		+328,229		1,277,077	-144,506	1,132,571	+1,576,215	.7513	+433,109	+1,184,210
1987				+ 38,615		1,277,077	-514,646	762,431	+ 801,046	.6830		+ 547,114
1988				+ 38,615		1,277,077	-664,080	612,997	+ 651,612	.6209		+ 404,586
1989				+ 38,615		1,277,077	-664,080	612,997	+ 651,612	.5645		+ 367,835
1990				+ 38,615		1,277,077	-664,080	612,997	+ 651,612	.5132		+ 334,407
1991				+ 38,615		1,277,077	-664,080	612,997	+ 651,612	.4665		+ 303,977
1992				+ 9,654		1,277,077	-664,080	612,997	+ 622,651	.4241		+ 264,066
											+2,655,094	

SCHEME 'E' **Net Present Value with a 10% Discount Rate. Cash Flow.**

APPENDIX 2.

(All Figures rounded to whole numbers)

Year	Plant Cost.	Allowances Plant .	Building Cost.	Allowances Building.	Capital Cost Summation.	Extra Profit .	Corporation Tax 52%	Profit/Corp. Tax Summation.	Cash Flow	Discount Factor 10%	Net Present Value	Present Value .
1983	-1,548,635		-805,250		-2,353,885	Nil			-2,353,885	1.000		-2,353,885
1984	-1,548,635		-805,250		-2,353,885	Nil			-2,353,885	.9091		-2,139,917
1985		+805,290		+314,048		1,076,998		1,076,998	+2,196,336	.8264		+1,815,052
1986		+805,290		+314,048		1,371,087		1,371,087	+2,490,425	.7513		+1,871,056
											-807,694	
1987				+ 33,498		1,371,087	-560,039	811,048	+ 844,546	.6830		+ 576,825
1988				+ 33,498		1,371,087	-712,965	658,122	+ 691,620	.6209		+ 429,427
1989				+ 33,498		1,371,087	-712,965	658,122	+ 691,620	.5645		+ 390,419
1990				+ 33,498		1,371,087	-712,965	658,122	+ 691,620	.5132		+ 354,939
1991				+ 33,498		1,371,087	-712,965	658,122	+ 691,620	.4665		+ 322,641
1992				+ 33 ,498		1,371,087	-712,965	658,122	+ 691,620	.4241		+ 293,316
											+1,559,873	

APPENDIX 3

NET PRESENT VALUE WITH A 16% DISCOUNT RATE. CASH FLOW

SCHEME 'A'. APPENDIX 3.

Net Present Value with a 16% Discount Rate ·Cash Flow.

Year	Cash Flow	Discount Factor 16%	N.P.V.	Present Value
1983	-337,380	1.000		-337,380
1984	+500,007	.8621		+431,056
1985	+940,853	.7432		+699,242
1986	+798,549	.6407		+511,630
			+1,304,548	
1987	+652,153	.5523		+360,184
1988	+509,702	.4761		+242,669
1989	+509,702	.4104		+209,182
1990	+509,702	.3538		+180,333
1991	+507,399	.3050		+154,757
1992	+506,631	.2630		+133,244
			+2,584,917	

For details of how the
cash flow column has been
arrived at, see Appendix 2

SCHEME 'B' APPENDIX 3.

Net Present Value with a 16% Discount Rate. Cash Flow.

Year	Cash Flow	Discount Factor 16%	N.P.V.	Present Value
1983	-1,081,490	1.000		- 1,081,490
1984	+ 614,162	.8621		+ 529,469
1985	+1,371,723	.7432		+1,019,465
1986	+ 886,382	.6407		+ 567,905
			+1,035,349	
1987	+ 733,002	.5523		+ 404,837
1988	+ 587,059	.4761		+ 279,499
1989	+ 587,059	.4104		+ 240,929
1990	+ 587,059	.3538		+ 207,701
1991	+ 587,059	.3050		+ 179,053
1992	+ 575,086	.2630		+ 151,248
			+2,498,616	

For details of how the Cash Flow column has been arrived at see Appendix 2

Scheme 'C' Appendix 3.

Net Present Value with a 16% Discount Rate. Cash Flow.

Year	Cash Flow	Discount Factor 16%	N.P.V.	Present Value
1983	-1,342,090	1.000		-1,342,090
1984	+ 641,022	.8621		+ 552,625
1985	+1,534,095	.7432		+1,140.139
1986	+ 899,275	.6407	+926,839	+ 576,165
1987	+ 745.895	.5523		+ 411,958
1988	+ 599,952	.4761		+ 285,637
1989	+ 599,952	.4104		+ 246,220
1990	+ 599,952	.3538		+ 212,263
1991	+ 599,952	.3050		+ 182,985
1992	+ 587,979	.2630		+ 154,638
			+2,420,540	

For details of how the Cash Flow column has been arrived at see Appendix 2

SCHEME 'D' APPENDIX 3

Net Present Value with a 16% Discount Rate. Cash Flow.

Year	Cash Flow	Discount Factor 16%	N.P.V.	Present Value
1983	-1,446,828	1.000		-1,446,828
1984	- 686,655	.8621		-591,965
1985	+1,597,247	.7432		+1,187,074
1986	+1,576,215	.6407	+158,162	+1,009,881
1987	+ 801,046	.5523		+442,418
1988	+ 651,612	.4761		+310,232
1989	+ 651,612	.4104		+267,422
1990	+ 651,612	.3538		+230.540
1991	+ 651,612	.3050		+198,742
1992	+ 622,651	.2630		+163,757
			+1,771,273	

For details of how the Cash Flow column has been arrived at see Appendix 2

SCHEME 'E' APPENDIX 3

Net Present Value with a 16% Discount Rate. Cash Flow.

Year	Cash Flow.	Discount Factor 16%	N.P.V.	Present Value
1983	-2,353,885	1.000		-2,353,885
1984	-2,353,885	.8621		-2,029,284
1985	+2,196.336	.7432		+1,632,317
1986	+2,490,425	.6407		+1,595,615
			-1,155,237	
1987	+ 844,546	.5523		+ 466,443
1988	+ 691,620	.4761		+ 329,280
1989	+ 691,620	.4104		+ 283,841
1990	+ 691,620	.3538		+ 244,695
1991	+ 691,620	.3050		+ 210,944
1992	+ 691,620	.2630		+ 181,896
			+ 561,862	

For details of how the Cash Flow column has been arrived at see Appendix 2

APPENDIX 4

NET PRESENT VALUE WITH A 26½% DISCOUNT RATE. CASH FLOW

SCHEME 'A' APPENDIX 4.

Net Present Value with a 26½% Discount Rate . Cash Flow.

Year	Cash Flow	Discount Factor 26½%	N.P.V	Present Value
1983	-337,380	1.000		-337,380
1984	+500,007	.7905		+395,256
1985	+940,853	.6249		+587,939
1986	+798,549	.4941		+ 394,563
			+1,040,378	
1987	+652,153	.3906		+254,731
1988	+509,702	.3088		+157,396
1989	+509,702	.2441		+124,418
1990	+509,702	.1930		98,372
1991	+507,399	.1526		77,429
1992	+506,631	.1206		61,099
			+1,813,823.	

For details of how the Cash Flow column has been arrived at see Appendix 2

SCHEME 'B' APPENDIX 4.

Net Present Value with a 26½% Discount Rate. Cash Flow.

Year	Cash Flow.	Discount Factor 26½%	N.P.V.	Present Value
1983	-1,081,490	1.000		-1,081,490
1984	+ 614,162	.7905		+ 485,495
1985	+1,371,723	.6249		+ 857,189
1986	+ 886,382	.4941		+ 437,961
			+699,155	
1987	+ 733,002	.3906		+ 286,311
1988	+ 587,059	.3088		+ 181,284
1989	+ 587,059	.2441		+ 143,301
1990	+ 587,059	.1930		+ 113,302
1991	+ 587,059	.1526		+ 89,585
1992	+ 575,086	.1206		+ 69,355
			+1,582,293	

For details of how the Cash Flow column has been arrived at see Appendix 2

SCHEME 'C' APPENDIX 4.

Net Present Value with a 26½. Discount Rate. Cash Flow.

Year	Cash Flow	Discount Factor 26½%	N.P.V	Present Value
1983	-1,342,090	1.000		-1,342,090
1984	+ 641,022	.7905		+ 506,728
1985	+1,534,095	.6249		+ 958,656
1986	+ 899,275	.4941		+ 444,332
			+567,626	
1987	+ 745,895	.3906		+ 291,347
1988	+ 599,952	.3088		+ 185,265
1989	+ 599,952	.2441		+ 146,448
1990	+ 599,952	.1930		+ 115,791
1991	+ 599,952	.1526		+ 91,553
1992	+ 587,979	.1206		+ 70,910
			+1,468,940	

For details of how the
Cash Flow column has been
arrived at see Appendix 2

SCHEME 'D' APPENDIX 4.

Net Present Value with a 26½% Discount Rate. Cash Flow.

Year	Cash Flow	Discount Factor 26½%	N.P.V.	Present Value.
1983	-1,446,828	1.000		-1,446,828
1984	- 686,655	.7905		- 542,801
1985	+1,597,247	.6249		+ 998,119
1986	+1,576,215	.4941		+ 778,808
			-212,702	
1987	+ 801,046	.3906		+ 312,889
1988	+ 651,612	.3088		+ 201,218
1989	+ 651,612	.2441		+ 159,058
1990	+ 651,612	.1930		+ 125,761
1991	+ 651,612	.1526		+ 99,436
1992	+ 622,651	.1206		+ 75,092
			+760,752	

For details of how the Cash Flow column has been arrived at see Appendix 2

SCHEME 'E' APPENDIX 4.

Net Present Value with a 26½% Discount Rate. Cash Flow.

Year	Cash Flow	Discount Factor 26;%	N.P.V.	Present Value
1983	-2,353,885	1.000		-2,353,885
1984	-2,353,885	.7905		-1,860,746
1985	+2,196,336	.6249		+1,372,490
1986	+2,490,425	.4941	-1,611,622	+1,230,519
1987	+ 844,546	.3906		+ 329,879
1988	+ 691,620	.3088		+ 213,572
1989	+ 691,620	.2441		+ 168,824
1990	+ 691,620	.1930		+ 133,483
1991	+ 691,620	.1526		+ 105,541
1992	+ 691,620	.1206	-576,914	+ 83,409

For details of how the
Cash Flow column has been
arrived at see Appendix 2

APPENDIX 5

NET PRESENT VALUE AT 10% ASSUMING NO GROWTH FROM 1982 LEVELS.

Net Present Value at 10% Assuming No Growth from 1982 Levels.

APPENDIX 5

SCHEME 'A'.

Year.	Capital Cost Summation.	Allowances.	Extra Profit.	Corporation Tax 52%	Profit/tax Summary.	Cash Flow	Discount Factor 10%	N.P.V.	Present Value
1983	337,380		Nil			-337,380	1.000		-337,380
1984			13,430		13,430	+ 13,430	.9091		+ 12,209
1985		159,315	13,430		13,430	+172,745	.8264		+142,756
1986		3,071	13,430	- 6,984	6,446	+ 9,517	.7513		+ 7,150
								-175,265	
1987		3,071	13,430	- 6,984	6,446	+ 9,517	.6830		+ 6,500
1988		3,071	13,430	- 6,984	6,446	+ 9,517	.6209		+ 5,909
1989		3,071	13,430	- 6,984	6,446	+ 9,517	.5645		+ 5,372
1990		3,071	13,430	- 6,984	6,446	+ 9,517	.5132		+ 4,884
1991		768	13,430	- 6,984	6,446	+ 7,214	.4665		+ 3,365
1992		All used	13,430	- 6,984	6,446	+ 6,446	.4241		+ 2,734
								-146,501	

Net Present Value at 10% Assuming No Growth from 1982 levels.

APPENDIX 5

SCHEME 'B'

Year	Capital Cost Summation	Allowances	Extra Profit	Corporation Tax 52%	Profit/Tax Summary	Cash Flow	Discount Factor 10%	N.P.V.	Present Value
1983	-1,081,490		Nil			- 1,081,490	1.000		-1,081,490
1984			120,870		120,870	+ 120,870	.9091		+ 109,883
1985		462,600	120,870		120,870	+ 583,470	.8264		+ 482.180
1986		15,964	120,870	62,852	58,018	+ 73,982	.7513		+ 55,583
								-433,844	
1987		15,964	120,870	62.852	58,018	+ 73,982	.6830		+ 50,530
1988		15,964	120,870	62,852	58,018	+ 73,982	.6209		+ 45,935
1989		15,964	120,870	62,852	58,018	+ 73,982	.5645		+ 41,763
1990		15,964	120,870	62,852	58,018	+ 73,982	.5132		+ 37,968
1991		15,964	120,870	62,852	58,018	+ 73,982	.4665		+ 34,513
1992		3,991	120,870	62,852	58,018	+ 62,009	.4241		+ 26,298
								-196,837	

Net Present Value at 10% Assuming No Growth from 1982 levels.

SCHEME 'C'

APPENDIX 5

Year	Capital Cost Summation.	Allowances	Extra Profit	Corporation Tax 52%	Profit/Tax Summary	Cash Flow	Discount Factor 10%	N.P.V.	Present Value
1983	-1,342,090		Nil			-1,342,090	1.000		-1,342,090
1984			141,015		141,015	+ 141,015	.9091		+128,197
1985		598,112	141,015		141,015	+ 739,127	.8264		+610,814
1986		15,964	141,015	73,328	67,687	+ 83,651	.7513		+ 62,847
								-540,232	
1987		15,964	141,015	73,328	67,687	+ 83,651	.6830		+ 57,134
1988		15,964	141,015	73,328	67,687	+ 83,651	.6209		+ 51,939
1989		15,964	141,015	73,328	67,687	+ 83,651	.5645		+ 47,221
1990		15,964	141,015	73,328	67,687	+ 83,651	.5132		+ 42,930
1991		15,964	141,015	73,328	67,687,	+ 83,651	.4665		+ 39,023
1982		3,991	141,015	73,328	67,687	+ 71,678	.4241		+ 30,399
								-271,586	

Net Present Value at 10% Assuming No Growth from 1982 Levels.

SCHEME 'D'

APPENDIX 5.

Year	Capital Cost Summation	Allowances	Extra Profit	Corporation Tax 52%	Profit/Tax Summary	Cash Flow	Discount Factor 10%	N.P.V.	Present Value
1983	-1,446,828		Nil			-1,446,828	1.000		-1,446,828
1984	- 964,552		72,522		72,522	-892,030	.9091		- 810,944
1985		607,544	181,305		181,305	+788,849	.8264		+ 651,905
1986		443,644	181,305	32,711	143,594	+587,238	.7513	-1,164,675	+ 441,192
1987		38,615	181,305	94,279	87,026	+125,641	.6830		+ 85,813
1988		38,615	181,305	94,279	87,026	+125,641	.6209		+ 78,010
1989		38,615	181,305	94,279	87,026	+125,641	.5645		+ 70,924
1990		38,615	181,305	94,279	87,026	+ 125,641	.5132		+ 64,479
1991		38,615	181,305	94,279	87,026	+ 125,641	.4665		+ 58,612
1992		9,654	181,305	94,279	87,026	+ 96,680	.4241		+ 41,002
								-765,835	

Net Present Value at 10% Assuming No Growth from 1982 Levels.

APPENDIX 5.

SCHEME "E"

Year	Capital Cost Summation	Allowances	Extra Profit	Corporation Tax 52%	Profit/Tax Summary	Cash Flow	Discount Factor.10%	N.P.V.	Present Value
1983	-2,353,885		Nil			-2,353,885	1.000		-2,353,885
1984	-2,353,885		Nil			-2,353,885	.9091		-2,139,917
1985		1,119,338	255,170		255,170	+1,374,508	.8264		+1,135,893
1986		1,119,338	255,170		255,170	+1,374,508	.7513		+1,032,668
								-2,325,241	
1987		33,498	255,170	132,688	122,482	+ 155,980	.6830		+ 106,534
1988		33,498	255,170	132,688	122,482	+ 155,980	.6209		+ 96,848
1989		33,498	255,170	132,688	122,482	+ 155,980	.5645		+ 88,015
1990		33,498	255,170	132,688	122,482	+ 155,980	.5132		+ 80,049
1991		33,498	255,170	132,688	122,482	+ 155,980	.4665		+ 72,765
1992		33,498	255,170	132,688	122,482	+ 155,980	.4241		+ 66,151
								-1,814,843	

APPENDIX 6

NET PRESENT VALUE AT 10% WITH DESPATCH VOLUMES ONLY REACHING THE PROJECTED 1984 LEVELS

APPENDIX 6

Net Present Value at 10% with Despatch Volumes only reaching the Projected 1984 Levels.

SCHEME 'A'

Year	Capital Cost Summation.	Allowances	Extra Profit.	Corporation Tax 52%	Profit/Tax Summary	Cash Flow	Discount Factor 10%	N.P.V.	Present Value.
1983	-337,380		Nil			-337,380	1.000		-337,380
1984			500,007		500,007	+500,007	.9091		+454,556
1985		159,315	500,007		500,007	+659,322	.8264		+544,864
1986		3,071	500,007	260,004	240,003	+243,074	.7513		+182,621
1987		3,071	500,007	260,004	240,003	+243,074	.6830	+844,661	+166,020
1988		3,071	500,007	260,004	240,003	+243,074	.6209		+150,925
1989		3,071	500,007	260.004	240.003	+243,074	.5645		+137,215
1990		3,071	500,007	260,004	240,003	+243,074	.5132		+124,746
1991		768	500.007	260,004	240,003	+240,771	.4665		+112,320
1992		---	500,007	260,004	240,003	+240,003	.4241		+101,785
								+1,637,672	

Net Present Value at 10% with Despatch Volumes only reaching the Projected 1984 Levels .

SCHEME 'B'

APPENDIX 6

Year	Capital Cost Summation	Allowances	Extra Profit	Corporation Tax 52%	Profit/Tax Summary	Cash Flow	Discount Factor 10%	N.P.V.	Present Value
1983	-1,081,490		Nil			-1,081,490	1.000		-1,081,490
1984			614,162		614,162	+ 614,162	.9091		+ 558,335
1985		462,600	614,162		614,162	+1,076,762	.8264		+ 889,836
1986		15,964	614,162	319,364	294,798	+ 310,762	.7513	+600,156	+ 233,475
1987		15,964	614,162	319,364	294,798	+ 310,762	.6830		+ 212,250
1988		15,964	614,162	319,364	294,798	+ 310,762	.6209		+ 192,952
1989		15,964	614,162	319,364	294,798	+ 310,762	.5645		+ 175,425
1990		15,964	614,162	319,364	294,798	+ 310,762	.5132		+ 159,483
1991		15,964	614,162	319,364	294,798	+ 310,762	.4665		+ 144,970
1992		3,991	614,162	319,364	294,798	+ 298,789	.4241	+ 1,611,948	+ 126,712

APPENDIX 6.

Net Present Value at 10% with Despatch Volumes only reaching the Projected 1984 Levels.

SCHEME 'C'

Year	Capital Cost Summation	Allowances	Extra Profit	Corporation Tax 52%	Profit/Tax Summary	Cash Flow	Discount Factor 10%	N.P.V.	Present Value
1983	-1,342,090		Nil			-1,342,090	1.000		-1,342,090
1984			641,022		641,022	+ 641,022	.9091		+ 582,753
1985		598,112	641,022		641,022	+1,239,134	.8264		+1,024,020
1986		15,964	641,022	333,331	307,691	+ 323,655	.7513	+507,845	+ 243,162
1987		15,964	641,022	333,331	307,691	+ 323,655	.6830		+ 221,056
1988		15,964	641,022	333,331	307,691	+ 323,655	.6209		+ 200,957
1989		15,964	641,022	333,331	307,691	+ 323,655	.5645		+ 182,703
1990		15,964	641,022	333,331	307,691	+ 323,655	.5132		+ 166,100
1991		15,964	641,022	333,331	307,691	+ 323,655	.4665		+ 150,985
1992		3,991	641,022	333,331	307,691	+ 311,682	.4241		+ 132,184
								+1,561,830	

APPENDIX 6.

Net Present Value at 10% with Despatch Volumes only reaching the Projected 1984 Levels.

SCHEME 'D'

Year	Capital Cost Summation	Allowances	Extra Profit	Corporation Tax 53%	Profit/Tax Summary	Cash Flow	Discount Factor 10%	N.P.V	Present Value
1983	-1,446,828		Nil			-1,446,828	1.000		-1,446,828
1984	- 964,552		277,897		277,897	- 686,655	.9091		- 624,238
1985		607,544	694,742		694,742	+1,302,286	.8264		+1,076,209
1986		443,644	694,742	144,506	550,236	+ 993,880	.7513	-248,155	+ 764,702
1987		38,615	694,742	361,266	333,476	+ 372,091	.6830		+ 254,138
1988		38,615	694,742	361,266	333,476	+ 372,091	.6209		+ 231,031
1989		38,615	694,742	361,266	333,476	+ 372,091	.5645		+ 210,045
1990		38,615	694,742	361,266	333,476	+ 372,091	.5132		+ 190,957
1991		38,615	694,742	361,266	333,476	+ 372,091	.4665		+ 173,580
1992		9,654	694,742	361,266	333,476	+ 343,130	.4241	-956,117	+ 145,521

Net Present Value at 10% with Despatch Volumes only reaching the Projected 1984 Levels.

SCHEME 'E'

Appendix 6.

Year	Capital Cost Summation	Allowances	Extra Profit	Corporation Tax 52%	Profit/Tax Summary	Cash Flow	Discount Factor 10%	N.P.V.	Present Value.
1983	-2,353,885		Nil			-2, 353,885	1.000		-2.353,885
1984	-2,353,885		Nil			-2.353,885	.9091		-2,139,917
1985		1,119,338	755,322		775,322	+1,894,660	.8264		+1,565,747
1986		1,119,338	775,322		775,322	+1,894,660	.7513		+1,423,458
								-1,504,597	
1987		33,498	775,322	403,167	372,155	+ 405,653	.6830		+ 277,061
1988		33,498	775,322	403,167	372,155	+ 405,653	.6209		+ 251,870
1989		33,498	775,322	403,167	372,155	+ 405,653	.5645		+ 228,991
1990		33,498	775,322	403,167	372,155	+ 405,653	.5132		+ 208,181
1991		33,498	775,322	403,167	372,155	+ 405,653	.4665		+ 189,237
1992		33,498	775,322	403,167	372,155	+ 405,653	.4241		+ 172,037
								-177,220	

APPENDIX 7

THE EFFECT OF A CHANGE IN THE LABOUR TURNOVER RATE.

APPENDIX 7. THE EFFECT OF A CHANGE IN THE LABOUR TURNOVER RATE.

In Chapter 1.2 attention was paid to the higher than Company average labour turnover rate in the warehouse with the existing system. The internal and external factors affecting this were discussed and it was shown that the Company's management believe that any of the feasible schemes, (which all create a more favourable working environment) would keep the warehouse labour turnover rates in line with the Company average. When the recession and related unemployment ends there will therefore be a saving by all of the feasible solutions in recruitment and training costs as compared to the existing system.

The existing scheme in the pre-recession period had a turnover of 60% while the Company average was 34%. At present with the recession the warehouse labour turnover rates have fallen in line with the Company average, due to the external factor of the lack of alternative manual employment. However when the recession and related unemployment end it would be assumed that labour turnover in the warehouse would return to pre-recession levels. All the feasible schemes improve internal conditions and it is thought that the implementation of any one of these would have a turnover rate in line with the Company average. If however the old scheme stayed in, labour turnover would go back up to a level 26% higher than the Company average. It is therefore proposed to examine this relative difference in turnover costs between the existing and potentially feasible schemes.

It was stated by the Warehouse Management that it takes approximately one month for a new person to become fully conversant with their job. The question now remains as to how effective that person is during the first month.

The Personnel Department judge a new persons effectiveness to be:

1st week:	25%
2nd week:	50%
3rd week:	75%
4th week:	100%

Throughout this period of time the average effectiveness will be 62.5%, the other 37.5% being the cost to the Company. A monetary value needs to be attached to this figure. The average labour cost per person per annum is £6,715, so for one month it will be £559.58. The cost to the Company for a new employee's first month will be £209.84.

The other cost which needs to be examined is the recruitment cost. Here one is concerned in looking at the avoidable costs of recruitment. Due to the recession the Company recruitment costs for manual labour are of a nominal value due to their being a surplus of suitable labour. However in the past when this was not the case the Company used "blanket" advertisements to recruit manual labour. From the Company records on labour engaged the Warehouse formed 15%. For the purpose of this exercise one is concerned with that percentage above the Company average, so that what is required is 6.5% of the advertisement cost. The Personnel Management state they would place approxiamately 25 "blanket" advertisements in the press each year at a cost of £65 each so giving £1,625 per year. The proportion of this to be allocated to the above average turnover is 6.5% or £105.63 per annum.

The other costs of recruitment are seen to be non-avoidable overheads by the Personnel Department, and therefore no record is kept. Induction for the successful applicant takes place on the first morning of employment and this is taken into account by the 25% "effectiveness" in the first week.

The savings to be calculated for the effect of a reduction in labour turnover by altering from the present system to any of the proposed is:

26% reduction in labour turnover and hence increase in labour effectiveness (21 x £209.84)	£4,406.64
Advertisement cost	£ 105.63
	£4,512.27

(As all previous figures have been rounded to whole numbers it is proposed to do the same here).

This figure of £4,512 is therefore the difference between the higher than average warehouse turnover costs and the Company average. By adopting any one of the suggested warehouse systems with labour turnover at the Company average this can therefore be shown as an area of potential savings.

Table 29 shows the labour cost differences taking into account this saving in recruitment and training costs. Table 30 can now be produced to show the extra profit generated (by combining Table 29 and Table 15). As all the schemes are in the process of construction in 1983, only the extra profit generated from 1984 onwards is shown.

Table 31 shows the discounted cash flow analysis with the discount rate set at 10%. From this data it can be seen that all that has happened has been that the base for the calculations has changed (by the same amount in each case), their relative rankings remain unchanged.

The inclusion of the cost of changes in labour turnover from the existing scheme to the feasible schemes does not affect the ranking of the various schemes, only the actual figure of the net present value. The conclusion to this study therefore remains unchanged.

TABLE 29. (APPENDIX 7).

LABOUR COST DIFFERENCES SHOWING EFFECT OF SAVINGS IN RECRUITMENT AND TRAINING COSTS.

Existing System (1982) = £548,427.

Year	Labour	Cost (£)	Comparison With Existing System (£1)
Scheme 'A'			
1982	79	530,485	+ 17,942
1983	84	564,060	- 15,633
1984	90	604,350	- 55,923
1985	97	651,355	- 102,928
1986	103	691,645	- 143,218
Scheme 'B'			
1982	63	423,045	+ 125,382
1983	68	456,620	+ 91,807
1984	73	490,195	+ 58,232
1985	78	523,770	+ 24,657
1986	83	557,345	- 8,918
Scheme 'C'			
1982	60	402,900	+ 145,527
1983	65	436,475	+ 111,952
1984	69	463,335	+ 85,092
1985	74	496,910	+ 51,517
1986	79	530,485	+ 17,942
Scheme 'D'			
1982	54	362,610	+ 185,817
1983	57	382,755	+ 165,672
1984	61	409,615	+ 138,812
1985	66	443,190	+ 105,237
1986	70	470,050	+ 78,377
Scheme 'E'			
1982	43	288,745	+ 259,682
1983	46	308,890	+ 239,537
1984	49	329,035	+ 219,392
1985	53	355,895	+ 192,532
1986	56	376,040	+ 172,387

TABLE 30. (APPENDIX 7).

EXTRA NET PROFIT GENERATED. (£1).

Scheme 'A'	
1984	+ 504,519
1985	+ 786,050
1986	+ 1,059,994
Scheme 'B'	
1984	+ 618,674
1985	+ 913,635
1986	+ 1,194,294
Scheme 'C'	
1984	+ 645,534
1985	+ 940,495
1986	+ 1,221,154
Scheme 'D'	
1984	+ 699,254
1985	+ 994,215
1986	+ 1,281,589
Scheme 'E'	
1984	+ 779,834
1985	+ 1,081,510
1986	+ 1,375,599

SCHEME 'A' Net Present Value with a 10% Discount Rate. Cash Flow.

Table 31.

(All Figures rounded to whole numbers)

Year	Plant Cost.	Allowances Plant.	Building Cost.	Allowances Building.	Capital Cost Summation.	Extra Profit.	Corporation Tax 52%	Profit/Corp. Tax Summation.	Cash Flow.	Discount Factor 10%	Net Present Value.	Present Value.
1983	-189,730		-147,650		-337,380	NIL			-337,380	1.000		-337,38
1984						504,519		504,519	+504,519	.9091		+458,65
1985		+98,660		+60,655		786,050		786,050	+945,365	.8264		+781,25
1986				+ 3,071		1,059,994	262,350	797,644	+800,715	.7513		+601,57
											+1,504,105	
1987				+ 3,071		1,059,994	408,746	651,248	+654,319	.6830		+446,90
1988				+ 3,071		1,059,994	551,197	508,797	+511,868	.6209		+317,81
1989				+ 3,071		1,059,994	551,197	508,797	+511,868	.5645		+288,94
1990				+ 3,071		1,059,994	551,197	508,797	+511,868	.5132		+262,69
1991				+ 768		1,059,994	551,197	508,797	+509,565	.4665		+237,71
1992				All used		1,059,994	551,197	508,797	+508,797	.4241		+215,78
											+3,273,957	

SCHEME 'B' Net Present Value with a 10% Discount Rate. Cash Flow.

Table 31.

(All Figures rounded to whole numbers)

Year	Plant Cost.	Allowances Plant.	Building Cost.	Allowances Building.	Capital Cost Summation.	Extra Profit.	Corporation Tax 52%	Profit/Corp. Tax Summation.	Cash Flow.	Discount Factor 10%	Net Present Value.	Present Value.
1983	-313,990		-767,500		-1,081,490	NIL			-1,081,490	1.000		-1,081,490
1984						618,674		618,674	+618,674	.9091		+562,437
1985		+163,275		+299,325		913,635		913,635	+1,376,235	.8264		+1,137,321
1986				+ 15,964		1,194,294	321,710	872,584	+888,548	.7513		+667,566
											+1,285,834	
1987				+15,964		1,194,294	475,090	719,204	+735,168	.6830		+502,120
1988				+15,964		1,194,294	621,033	573,261	+589,225	.6209		+365,850
1989				+15,964		1,194,294	621,033	573,261	+589,225	.5645		+332,618
1990				+15,964		1,194,294	621,033	573,261	+589,225	.5132		+302,390
1991				+15,964		1,194,294	621,033	573,261	+589,225	.4665		+274,873
1992				+ 3,991		1,194,294	621,033	573,261	+577,252	.4241		+244,813
											+3,308,898	

SCHEME 'C' Net Present Value with a 10% Discount Rate. Cash Flow.

Table 31.

(All Figures rounded to whole numbers)

Year	Plant Cost.	Allowances Plant.	Building Cost.	Allowances Building.	Capital Cost Summation.	Extra Profit.	Corporation Tax 52%	Profit/Corp. Tax Summation.	Cash Flow.	Discount Factor 10%	Net Present Value.	Present Value.
1983	-574,590		-767,600		-1,342,090	NIL			-1,342,090	1.000		-1,342,09
1984						645,534		645,534	+645,534	.9091		+586,85
1985		+298,787		+299,325		940,495		940,495	+1,538,607	.8264		+1,271,50
1986				+15,964		1,221,154	335,678	885,476	+901,440	.7513		+677,25
											+1,193,522	
1987				+15,964		1,221,154	489,057	732,097	+748,061	.6830		+510,92
1988				+15,964		1,221,154	635,000	586,154	+602,118	.6209		+373,85
1989				+15,964		1,221,154	635,000	586,154	+602,118	.5645		+339,89
1990				+15,964		1,221,154	635,000	586,154	+602,118	.5132		+309,00
1991				+15,964		1,221,154	635,000	586,154	+602,118	.4665		+280,88
1992				+3,991		1,221,154	635,000	586,154	+590,145	.4241		+250,28
											+3,258,374	

SCHEME 'D' Net Present Value with a 10% Discount Rate. Cash Flow.

Table 31.

(All Figures rounded to whole numbers)

Year	Plant Cost	Allowances Plant.	Building Cost	Allowances Building.	Capital Cost Summation.	Extra Profit.	Corporation Tax 52%	Profit/Corp. Tax Summation.	Cash Flow.	Discount Factor 10%	Net Present Value.	Present Value.
1983	-332,928		-1,113,900		-1,446,828	NIL			-1,446,828	1.000		-1,446,828
1984	-221,952		-742,600		-964,552	279,702		279,702	-684,850	.9091		-622,597
1985		+173,123		+434,421		994,215		994,215	+1,601,759	.8264		+1,323,694
1986		+115,415		+328,229		1,281,589	145,445	1,136,144	+1,579,788	.7513		+1,186,895
											+441,164	
1987				+38,615		1,281,589	516,992	764,597	+803,212	.6830		+548,594
1988				+38,615		1,281,589	666,426	615,163	+653,778	.6209		+405,931
1989				+38,615		1,281,589	666,426	615,163	+653,778	.5645		+369,058
1990				+38,615		1,281,589	666,426	615,163	+653,778	.5132		+335,519
1991				+38,615		1,281,589	666,426	615,163	+653,778	.4665		+304,987
1992				+9,654		1,281,589	666,426	615,163	+624,817	.4241		+264,985
											+2,670,238	

HEME 'E' **Net Present Value**
with a 10% Discount Rate. Cash Flow.

Table 31.
(All Figures rounded to whole numbers)

ear	Plant Cost	Allowances Plant	Building Cost.	Allowances Building.	Capital Cost Summation.	Extra Profit.	Corporation Tax 52%	Profit/Corp Tax Summation.	Cash Flow.	Discount Factor 10%	Net Present Value.	Present Value.
83	-1,548,635		-805,250		-2,353,885	NIL			-2,353,885	1.000		-2,353,88
84	-1,548,635		-805,250		-2,353,885	NIL			-2,353,885	.9091		-2,139,91
85		+805,290		+314,048		1,081,510		1,081,510	+2,200,848	.8264		+1,818,781
86		+805,290		+314,048		1,375,559		1,375,559	+2,494,897	.7513		+1,874,41
											-800,605	
87				+33,498		1,375,559	562,385	813,174	+846,672	.6830		+578,277
88				+33,498		1,375,559	715,291	660,268	+693,766	.6209		+403,75
89				+33,498		1,375,559	715,291	660,268	+693,766	.5645		+391,631
90				+33,498		1,375,559	715,291	660,268	+693,766	.5132		+356,041
91				+33,498		1,375,559	715,291	660,268	+693,766	.4665		+323,64
92				+33,498		1,375,559	715,291	660,268	+693,766	.4241		+294,226
											+1,546,971	