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INVESTIGATIONS INTO LONG-TERM PRODUCTIVITY IMPROVEMENTS IN AN AUTOMOTIVE RUBBER CONCERN.

Degree of Master of Philosophy

September 1978

UNIVERSITY OF ASTON IN BIRMINGHAM

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Investigations into long-term productivity improvements in an automotive rubber concern

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The research was to investigate the operations of a group manufacturing and marketing automotive rubber products, principally floor mats. Improvements were to be considered in the short term, realisable within the existing factory, and in the long term, realisable by a move to new premises.

During the course of the project the long term part became an on-going investigation presented as proposals to Dunlop Board for the establishment of a new factory.

Floor mats were batch produced in a functional layout split into a number of rooms using labour intensive technology and machinery little changed since inception in 1950. Poor working conditions were causing increasing difficulty in recruiting personnel.

The proposed linking of the rubber mixing and further processing operations would eliminate unnecessary and physically demanding operations, and also enable the processing of thermoplastic EVA so enlarging the product base. Increased management control over materials and labour, (deteriorated as a result of poor industrial relations) was required. Further automation was possible in certain areas, reducing costs, improving quality and guarding against the dwindling supply of labour. The use of a quick costing method is suggested to improve customer service.

The above and smaller changes would result in an estimated reduction of £130,000 (8%) in the production costs (at 1977 levels) with an implementation cost of £36,000.

A move to new premises would allow a more efficient layout and the autonomous unit mass producing a low technology product would generate low overheads. Semi-automatic mixer feed system and mill accessories would improve working conditions and quality, and reduce labour.

The establishment of such a unit at a cost of £790,000 would reduce total costs from £2.3m to £1.9m (1977 levels), and based on the group's business plan, would give a 78% rate of return on the investment.

Productivity; investment; appraisal; rubber; floor mats.

INDEX

CHAPTER 1

The terms of reference

1.1 Introduction

The Automotive Product Group of Dunlop Ltd., is in the business of supplying rubber goods to the automotive industry and operates from a general rubber goods factory. The group's main product is floor mats for passenger cars and commercial vehicles. The group is the U.K's main supplier of this product, and also exports to Western Europe.

Competitiveness in the floor mat market is based mainly on price, and hence production efficiency is most important. The general rubber goods factory in which the group operates produces a large range of products, mainly to customers' specifications, generating a high level of overheads. The factory building is very old and split into a number of small rooms, most suitable for small production units.

Hence the factory was considered to be unsuitable for the mass production of a low technology product, and it was thought that considerable improvements in the group's operations were possible.

This project was proposed by Mr. K.L. Peet, the Manufacturing Manager of Automotive Products Group, who also became the project's Industrial Supervisor.

The project was divided into short term and long term parts.

1.2 Short term cost reductions

The short term cost reductions were to consist of improvements in the group's current operations within the constraints of the existing factory. The main focus was to be on production, but consideration was to be given to the group's complete operations.

Work for the short term part of the project would aid the long term part. It also afforded the possibility of immediate financial benefits, thus making approval for the project easier to obtain.

1.3 Long term part

The long term part concerned the possibility of the Automotive Group being relocated to a new site in a time span of 2 - 10 years.

The Manufacturing Manager had been interested in the exercise for some time, and would have liked to have done it himself given the time. He was of the opinion that the benefits of a move to a new site would be considerable, and hoped to have his opinion confirmed by an independent researcher.

The possibility of the redevelopment of the Cambridge Street site had often been raised previously, with no outcome, and this part of the project seemed essentially a theoretical exercise.

However, during the course of the research, various factors caused the long term part to become a line exercise, involving the preparation of firm proposals for submission to the Board for an independent Automotive Group operation on a different site.

An evaluation was made of the improvements possible in a factory specifically designed and equipped to produce and sell floor mats, and its economic viability.

CHAPTER 2

Background to the Automotive Products Group

2.1 Dunlop Holdings

Dunlop Holdings is a multinational company in the rubber business. Within the rubber industry its interests are varied, and include plantations in Malaysia and engineering work related to rubber products.

In 1976 the group made profits of £87 million on world-wide sales of £1,289 million, with net assets employed of £675 million, and over 100,000 employees. Its main manufacturing base is within the E.E.C., but it has **further** operations in the Americas, Asia, Australia and Africa.

Despite its diversification, tyres are the most important part of the business, and account for over 60% of turnover.

In 1971 the group formed a union with Pirelli SpA. and the Société International Pirelli. The philosophy behind the union was to allow the geographical nature of the companies, Dunlop being strong in the Commonwealth and North America, Pirelli being strong in Europe and South America, to complement each other. However, shortly after the union Pirelli met severe difficulties which adversely affected Dunlop. This together with the generally depressed state of the rubber industry, and in particular over-capacity in the tyre industry, caused Dunlop to go through a very poor period. Dunlop did not emerge from this bad phase until the latter part of 1974.

The company is now in a healthy condition and has a planned capital expenditure of £246 million for the three years 1977/9.

2.2. Automotive Group

Dunlop Holdings is divided into Dunlop Limited, which includes all member companies operating in the E.E.C., and Dunlop International Limited, which includes the rest. Fig. 2.1 shows the breakdown of Dunlop Limited, and the position of Automotive Products Group within the company, and fig. 2.2 gives the turnovers of the relevant units.

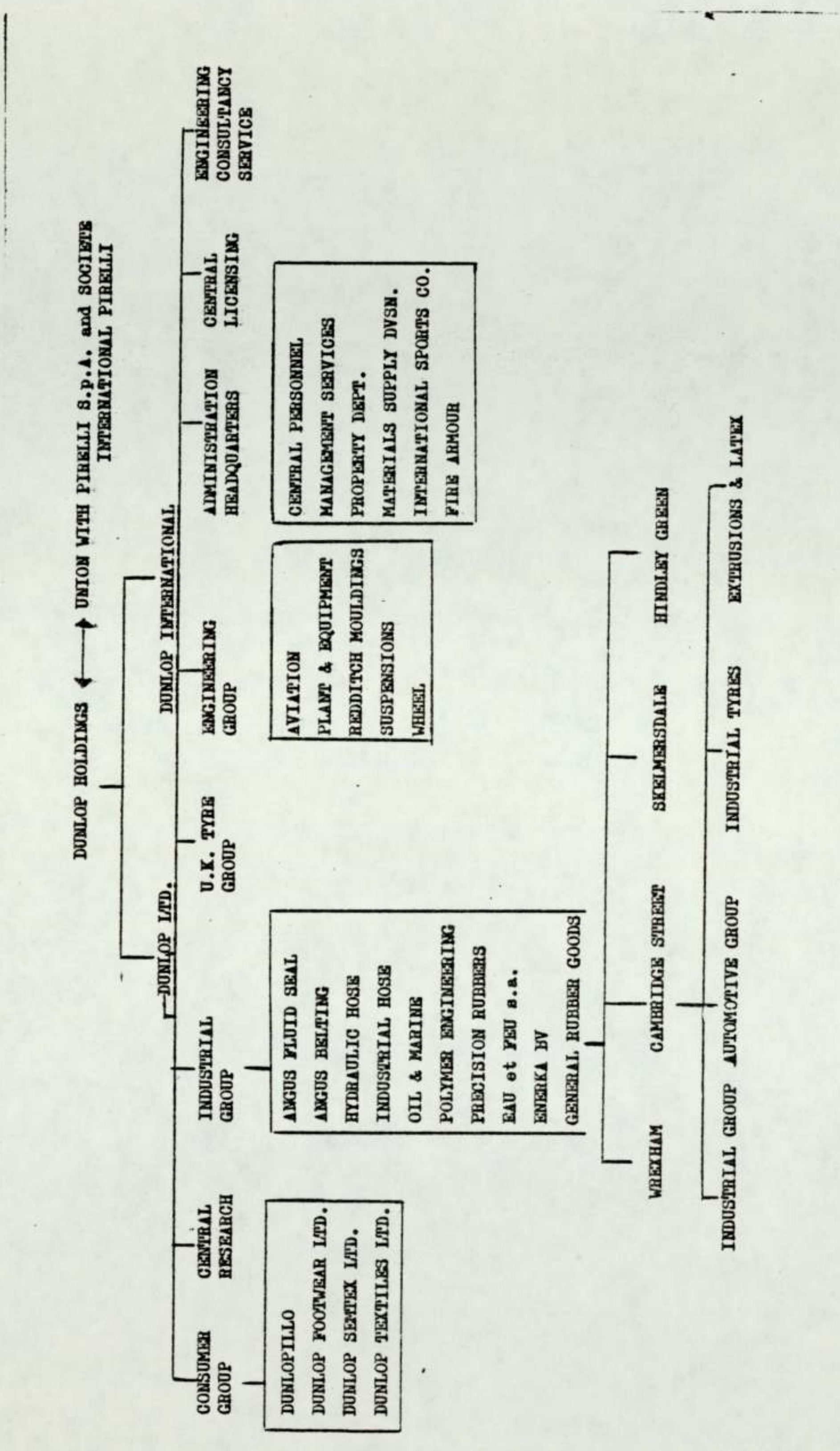


Fig. 2.1 Structure of Dunlop Holdings and the position of Automotive Group

UNIT	TURNOVER 1976 (£ millions)
Dunlop Holdings	1,289
Dunlop Limited	463
Dunlop Industrial Group	133
General Rubber Goods Division	21
Cambridge Street factory	8.6
Automotive Products Group	2.4

Breakdown of 1976 Turnovers

Fig. 2.2

2.3 A History of the Cambridge Street Site, and Automotive Group

The Cambridge Street site's history in the rubber industry dates back to the formation of Charles Mackintosh and Company in 1824. The factory was acquired by Dunlop in 1925. It has always played an important part in the development of the rubber industry. Many rubber products now being the basis of independent divisions, such as belting, flooring and marine life rafts, have originated from Cambridge Street.

A peak of activity was reached during the second world war, when Cambridge Street supplied a variety of products to the armed forces. During these years nearby sites were taken over to meet the required outputs.

Cambridge Street is now made of four product groups: Industrial, supplying rubber goods to industry; Industrial Tyres; Extrusions and Latex; and Automotive. Its involvement in the automotive industry goes back to the 1920's when an assortment of rubber products such as horn bulbs and runner boards were manufactured there.

In 1950 the relocation of the hose, belting and flooring businesses created a need for new products. As the post war increase in car ownership created a strong demand for automotive components, and at Fort Dunlop in Birmingham, the automotive accessories department had good contacts, the rubber automotive flooring business was entered.

The Ohio Rubber Company already supplied vacuum formed rubber mats to the United States auto industry, and Dunlop developed the process from them in 1948 and 1949. Production started in 1950, the mats initially being marketed by the accessories department at Fort Dunlop, and subsequently directly from Cambridge Street. The business was successful until the mid 1960's, when tufted floor coverings swept the market due to their thin carpeted appearance, bright colouring and cheap price. Dunlop's response was the electrostatically flocked rubber car mat, developed at Cambridge Street and produced at Hindley Green.

At Cambridge Street production of floor mats was substantially reduced, until the market for rubber flooring in commercial vehicles replaced that in passenger cars.

It was in 1971 that Automotive Products Group as it now exists was formed, upon the restructuring of the Cambridge Street factory into market-orientated business groups. It then gained control over the marketing of the factory's other automotive products, namely mudwings, Rolls Royce seals and some extrusions.

2.4 Organisational Structure

Fig. 2.3 gives the organisational structure of the General Rubber Goods Division, and of Automotive Products Group.

The division is run by a management committee, responsible to the board at Newcastle headquarters, comprising the factories' general managers, divisional financial and personnel managers, and the director.

Each of the factories is run by a local management committee. The Cambridge Street management committee consists of the four product managers, the various service department managers and the general manager.

The product managers have responsibility for the manufacturing and marketing of their products. The service departments however, respond directly to the general manager, so the product groups are not autonomous units.

Automotive Group has a direct line management structure from the product manager through to the operatives. This manufacturing organisation is coupled to a sales organisation consisting of the sales representatives and a sales administration team. The rest of the group consists of service units.

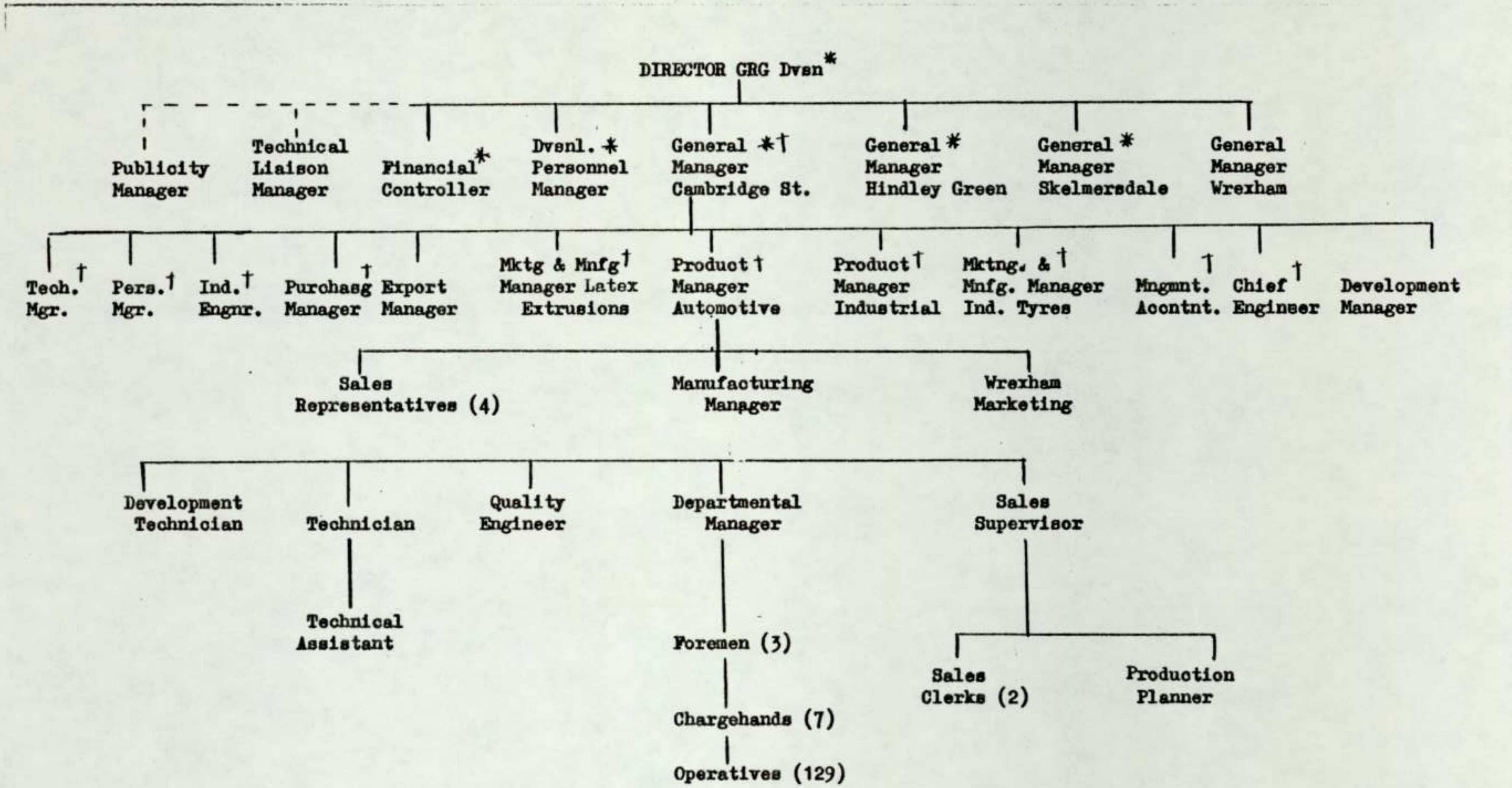
The technician and his assistant were recently transferred from the technical manager to automotive's manufacturing manager, as they were required full-time in the group.

It is of interest that the production planner works under the sales superintendent rather than directly for the manufacturing manager. This was found to be a sensible system, as due to the very low level of finished goods held, production needed to meet immediate sales schedules.

The sales representatives are each assigned to a geographical area, and are concerned primarily with servicing existing customers.

On top of the structure outlined the group draws considerably upon the factory's service departments. One cost accountant is concerned primarily with automotive group, for example.

During 1977 two new appointments were made. The post of departmental manager was filled, having been vacant for a couple of years, and a foreman in charge of calendering was appointed.



* Divisional Management Committee

† Cambridge Street Management Committee

Fig 2.3 Organisational Structure

2.5 Automotive Products sales, markets and business plan

Sales of automotive products 1972 to 1976 are shown in figs. 2.4 and 2.5. The group's business plan is contained in table 6.19, and a complete breakdown of 1976 sales in fig. 2.6.

2.5.1 Floor mats

Rubber flooring for passenger and commercial vehicles are the most important parts of the group's business. Automotive Group's competitors in the U.K. market are Miles Redfern and British Vita. Dunlop has a 78% share of the market, and market shares have remained fairly constant over the 5-year period. There are no imports into the U.K.

Rubber flooring for passenger cars is at the end of its product life cycle, though a continuing demand exists for certain boot mats and car/van variants.

Rubber flooring in commercial vehicles provides most of Automotive Group's business, in particular flooring for van-type vehicles. Growth in this market segment is expected to follow growth in van-type vehicle production, and maintenance of market share.

Export sales to Europe are chiefly to international companies with whom the group has contacts in the U.K. Exports are mainly of assembled mats, in which high labour content enables the U.K.'s favourable labour rates to contribute to competitiveness.

AUTOMOTIVE SALES 1972 - 1976 inclusive (£000's)

YEAR	FLOOR MATS			EXTRUSIONS	MUDWINGS	ROLLS ROYCE DOOR SEALS	TOTAL OTHER AUTO	GRAND TOTAL
	COMMERCIAL VEHICLES	PASSENGER CARS	TOTAL					
1972	282 (23%)	944 (77%)	1226	113	-	-	113	1339
1973	365 (31%)	813 (69%)	1178	42	-	42	84	1262
1974	1087 (55%)	890 (45%)	1977	24	-	63	87	2064
1975	1575 (72%)	613 (28%)	2188	15	56	83	154	2342
1976	1550 (74%)	544 (26%)	2094	37	124	115	276	2370

Fig 2.4

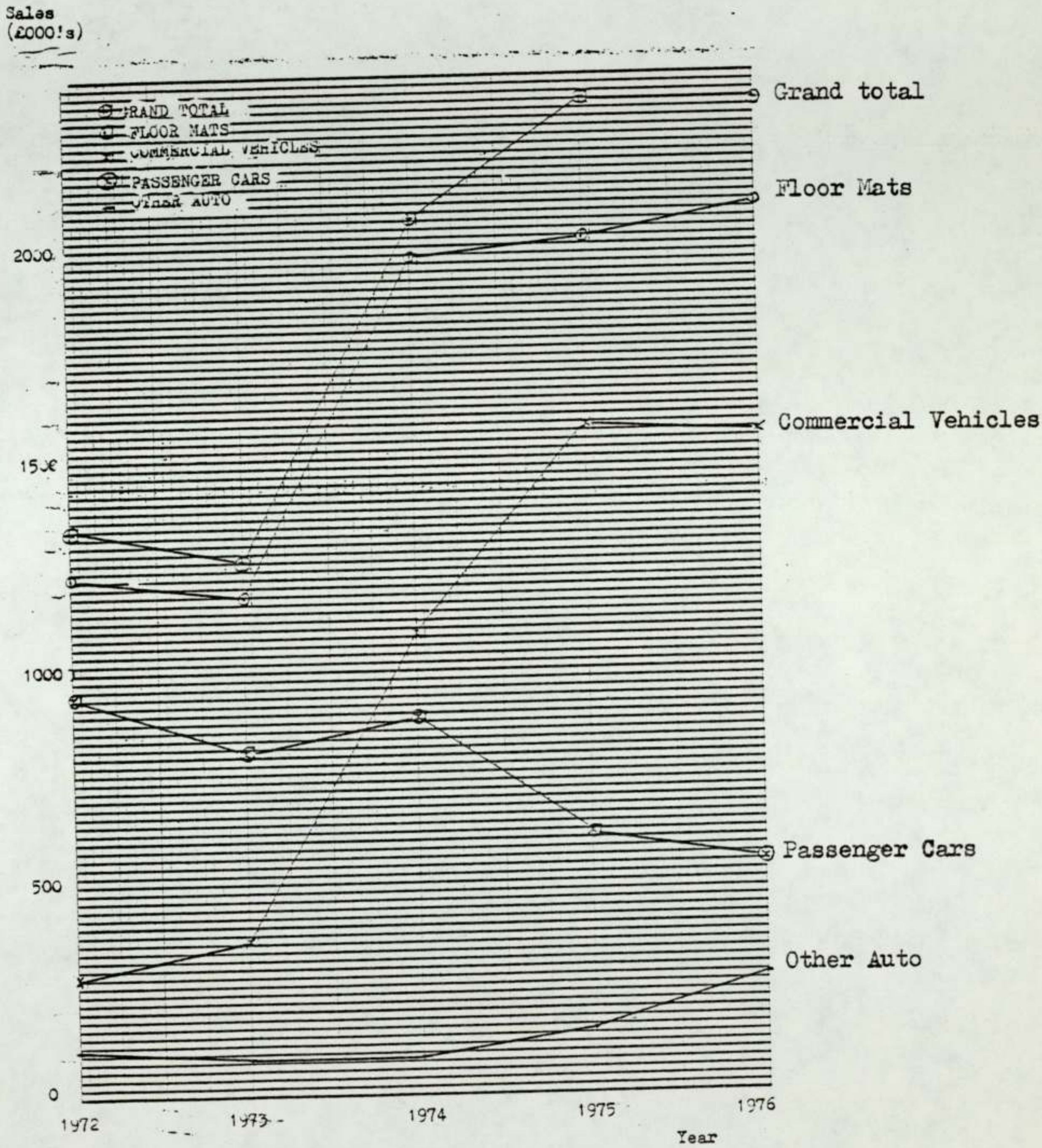


Fig. 2.5 Automotive Sales 1972 - 1976 (incl.)

Automotive Group lack a European representative, and the poor level of customer service has not aided exports.

A Pareto analysis of floor mat sales for the first 16 weeks of 1977 was made. The results are contained in fig. 2.7 and 2.8. 76% of floor mat sales are in 20% of the mats.

2.5.2 Mudwings for commercial vehicles

Rubber mudwings compete with mudwings made of steel and plastic. The share in 1976 of each type is shown in the table below.

Type	Market Share
Rubber	18%
Plastic	70%
Metal	12%

The rubber mudwings are approximately three times the price of metal ones and twice the price of plastic ones. Their selling advantages derive from being flexible and corrosion free. The British Tyre and Rubber Company is the only other U.K. producer of rubber mudwings, and Automotive Group have a 70% share of the market.

The market share of rubber mudwings is expected to grow slowly over the next five years, and a gain over competition in rubber mudwings is anticipated giving a growth of approximately 25% per annum.

2.5.3 Rolls Royce Door Seals

The Rolls Royce door seal was developed in conjunction with Rolls Royce, and Dunlop is their exclusive supplier. The seal is far more expensive than conventional seals, but gives a much better seal with lower door closing pressure.

Interest in the product has recently been expressed by Jaguar Cars. Very little development in the marketing or manufacturing of the seal has followed its introduction.

2.5.4 Air Spoilers for commercial vehicles

All large vehicles on the continent are required by law to be fitted with a valence covering the outside of the wheel and so reducing the water spray. Similar legislation is expected in the U.K. in 1979-80. The manufacture of the spoilers is similar to that of mudwings.

2.5.5. Extrusions

Automotive Group also markets a small number of extrusions to the automotive industry.

FLOOR MATS	HOME Car	HOME Van	HOME Truck	HOME Tractor	HOME Total	EXPORT Car	EXPORT Van	EXPORT Truck	EXPORT Tractor	EXPORT Total	HOME & EXPORT
Ford	153572	617554	239926	-	1011052	35801	221143	199	-	257143	1268195
Leyland	370770	92259	123693	-	586722	-	-	-	-	-	586722
Volvo	-	-	-	-	-			5092		5092	5092
Vauxhall	9624	35254	45865	-	90743	-	-	-	-	-	90743
Chrysler	4179	-	-	-	4179	-	-	-	-	-	4179
London Taxi	27819	-	-	-	27819	-	-	-	-	-	27819
General Motors	3867	-	-	-	3867	-	-	-	-	-	3867
David Brown	-	-	-	1166	1166	-	-	-	-	-	1166
Massey Ferguson	-	-	-	42039	42039	-	-	-	12175	12175	54214
Other	45049	-	-	-	45049	6770	-	-	-	6770	51819
Total (Floor Mats)	614880	745067	409484	43205	1812636	42571	221143	5291	12175	281180	2093816
MUDWINGS					124000						124000
ROLLS ROYCE SEALS					115000						115000
AUTO EXTRUSIONS					37000						37000
TOTAL AUTOMOTIVE					2042796					281180	2369816

Fig. 2.6 Automotive Sales Breakdown 1976 (£'s)

Sales (£)	Cumulative total (£)	Sales (£)	Cumulative total (£)
107398	107398	1735	655604
55093	162491	1510	657114
43575	206066	1491	658605
40237	246303	1468	660073
40121	286424	1441	661514
28393	314817	1393	662907
26534	341351	1333	664240
23683	365034	1325	665565
21625	386659	1325	666890
18982	405641	1324	668214
17779	423420	1263	669477
16022	439442	1244	670721
15668	455110	1192	671913
13990	469100	1191	673104
12834	481934	1145	674249
12550	494484	1132	675381
9638	504122	1116	676497
9300	513422	1045	677542
9029	522451	1010	678552
8380	530831	830	679382
8089	538920	756	680138
8067	546987	688	680826
7608	554595	624	681450
7163	561758	543	681993
6557	568315	507	682500
6118	574433	499	682999
5993	580426	481	683480
5812	586238	480	683960
5613	591851	477	684437
5044	596895	458	684895
4415	601310	448	685343
4400	605710	419	685762
4285	609995	372	686134
3909	613904	328	686462
3849	617753	237	686699
3812	621565	208	686907
3473	625038	193	687100
3445	628483	159	687259
3395	631878	155	687414
3321	635199	140	687554
2627	637826	132	687686
2398	640224	121	687807
2175	642399	105	687912
2024	644423	80	687992
2004	646427	79	688071
1950	648377	48	688119
1881	650258	32	688151
1871	652129	2	688153
1740	653869		

Fig 2.7 Total sales of individual mats in the first 16 weeks of 1977, ranked in order of size, and cumulated.

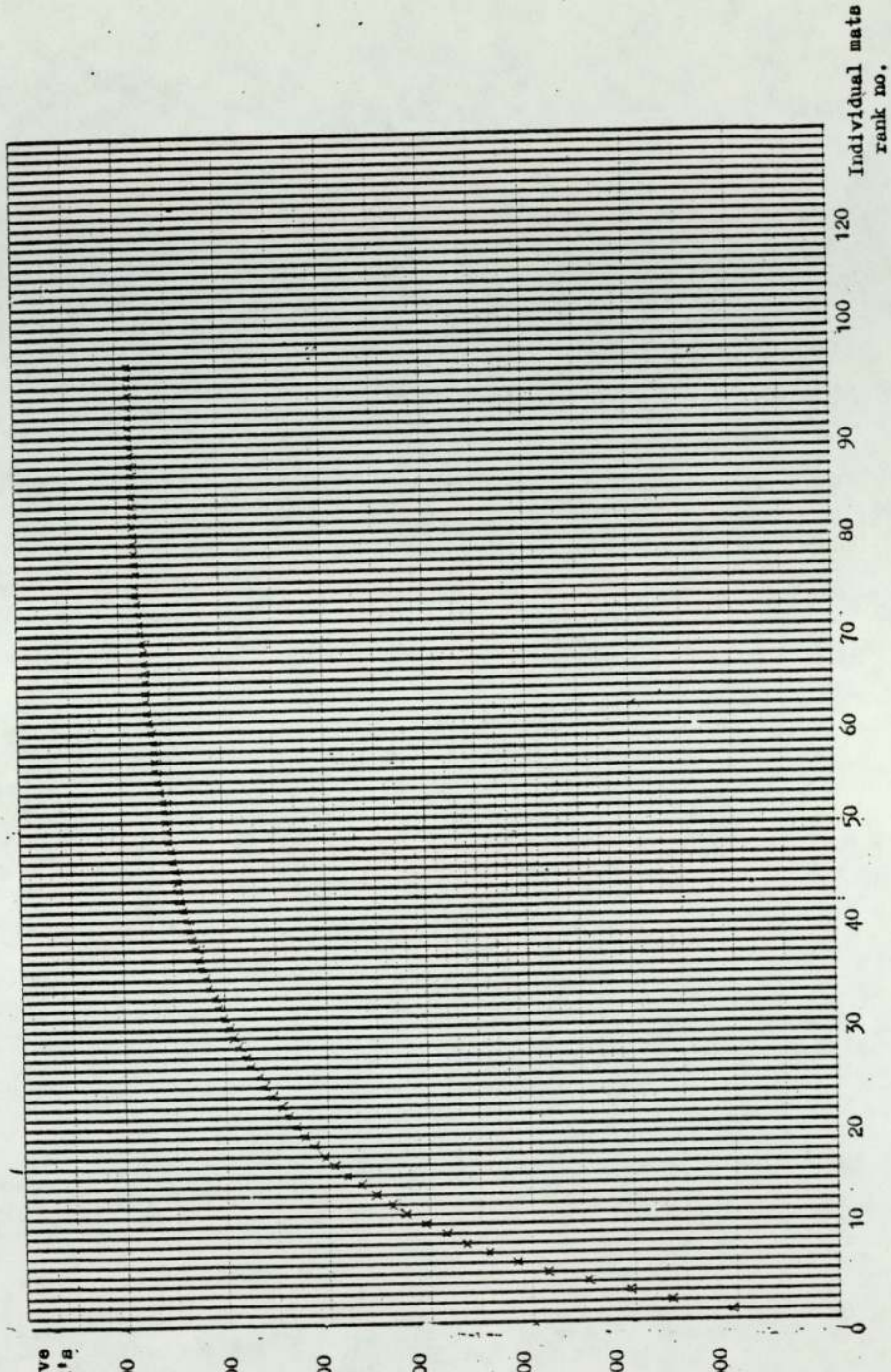


Fig. 2.8 Pareto analysis of Mat Sales during first 16 weeks of 1977

CHAPTER 3

Manufacturing Methods

3.1 Rubber Processing

3.1.1 Introduction

Natural rubber is the only unsaturated high polymer produced by plants. Many different species of trees and shrubs produce latex, the solution from which rubber is obtained, but most rubber is now produced in plantations of the Hevea Brasiliensis tree, which originates from the Amazon. Wickam (a naturalist) planted 70,000 seeds from the Amazon in Kew Gardens, and 2,700 germinated. 2,000 seedlings were sent to Ceylon, and from these 2,000 seedlings all rubber plantation trees have descended.

The microscopic tubes which contain the latex run chiefly in the bark of the tree, and latex is tapped by cutting into the bark. Solid rubber is obtained by coagulating the latex.

The vulcanisation of rubber was discovered in 1839. The application of heat on rubber combined with sulphur results in the cross-linking of the long hydro-carbon chains. Vulcanisation has four main effects:-

(i) It changes rubber from a plastic to a non-plastic material.

(ii) It increases rubber's tensile strength and resistance to abrasion.

(iii) It changes the solubility characteristics

(iv) It causes a stabilisation of the properties of rubber over a wide range of temperatures.

As well as natural rubber, many synthetic rubbers are produced.

3.1.2 Compounding of Rubber

Many ingredients are incorporated into the rubber to give the final compound its required properties.

Plasticizing of the rubber and the addition of peptisers break down the rubber molecules and enable the addition of the other substances. As well as sulphur and other vulcanisers, accelerators, activators and retarders are incorporated. The latter chemicals influence the rate and temperature of vulcanisation, or curing. Reinforcing agents, such as carbon black, are included to increase the strength of the cured rubber. Extenders and fillers are used to increase the bulk of the compound and hence reduce its cost. Other ingredients include protective materials to improve ageing and dyes for colouring.

Plasticizing and dispersion of the other ingredients is achieved by subjecting the rubber to shear strains, and results in the generation of heat. The requirements for rapid mixing of the compound is a large input of work, with efficient cooling to prevent premature vulcanisation. Compounding for industry is carried out on 2-roll mills - a pair of rotating metal rollers which squeeze the rubber between their nip, or in internal mixers, which effectively are 2-roll mills enclosed in a chamber so that work is not only generated at the nip, but also at the interface between the rollers and the chamber.

Recent developments in rubber processing include the use of powdered rubbers.

The powders have a larger surface area, and hence dispersion of ingredients is facilitated. The ideal powder processing line uses a mixer-extruder to continually process the powders, eliminating the batch process of mills and internal mixers.

3.1.3 Moulding of Rubber

After compounding the rubber must be shaped and cured into it's final form. The heating of the rubber initially softens it, to enable it to take the shape of a mould, and then vulcanises it, making the shape permanent.

3.2 Manufacture of Floor Mats

3.2.1 Floor Mat Construction

Floor mats are manufactured to customers' specifications such that they

(i) fit the floor in contour and circumference,

(ii) resist wear and tear,

(iii) are of acceptable appearance,

(iv) in certain cases fulfil sound insulating requirements

The mats are constructed of one or more sheets of rubber compound, which are vacuum moulded to the shape of the floor, and given a surface pattern.

The bulk of the mat is made of a layer of cheap backing compound, single or multi-ply. To this a veneer, a thin surface sheet, may be added, which improves wear and appearance.

Sound insulating mats incorporate a layer of felt or foam to the back of the mat. The insulating layer may be enclosed by a backing skin.

The mat is finished with a periphery trim, internal cut outs, and any extras, such as eyelets, tapes and studs, which may be required.

3.2.2 Floor Mat Compounds

The Group offers a range of compounds of varying quality, price and colour. The compounds have been developed to be of the minimum cost consistent with physical specifications. and processing requirements.

To reduce compound cost the content of natural and synthetic polymers is low, and large quantities of fillers, such as clay and whiting, are incorporated. To reduce moulding time the compounds are very scorchy (rapid vulcanisation).

Fig 3.1 is a list of the main compounds used by floor mats. The department uses approximately 150,000 lbs of compound weekly, 40% of the Mill Department's total output. The mill has a list of about 120 compounds in production.

Floor mat department uses large quantities of a small number of simple compounds.

3.2.3 Manufacturing Process

(i) Introduction

The separate processes involved in floor mat production are compound preparation, calendering of compound into sheets, the cutting of sheets into shaped blanks, the moulding of the blanks and the finishing of the moulded blanks. Fig 3.2 is a flow chart of the manufacturing processes.

Compound	Use
3690	Cheap backing compound
3235	Superior backing compound
6646	Cheap black veneer compound
6649	Superior black veneer compound
3012	Palamino brown compound
CX413) CX546) 3705)	Coloured veneer compounds
6508) 6653)	Sound deadening compounds

Fig 3.1 Floor mat compounds

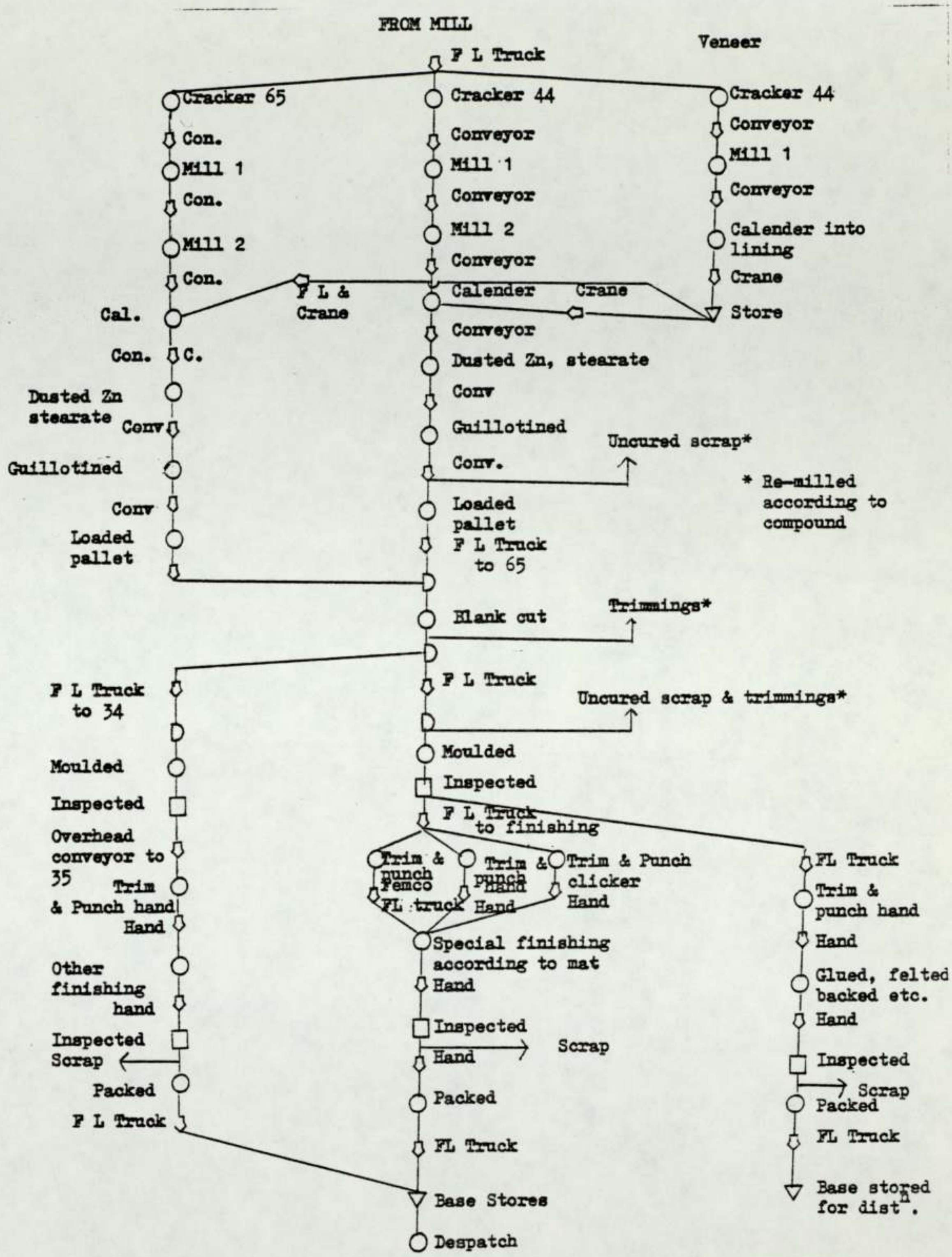


Fig. 3.2 Floor Mat Flow Chart

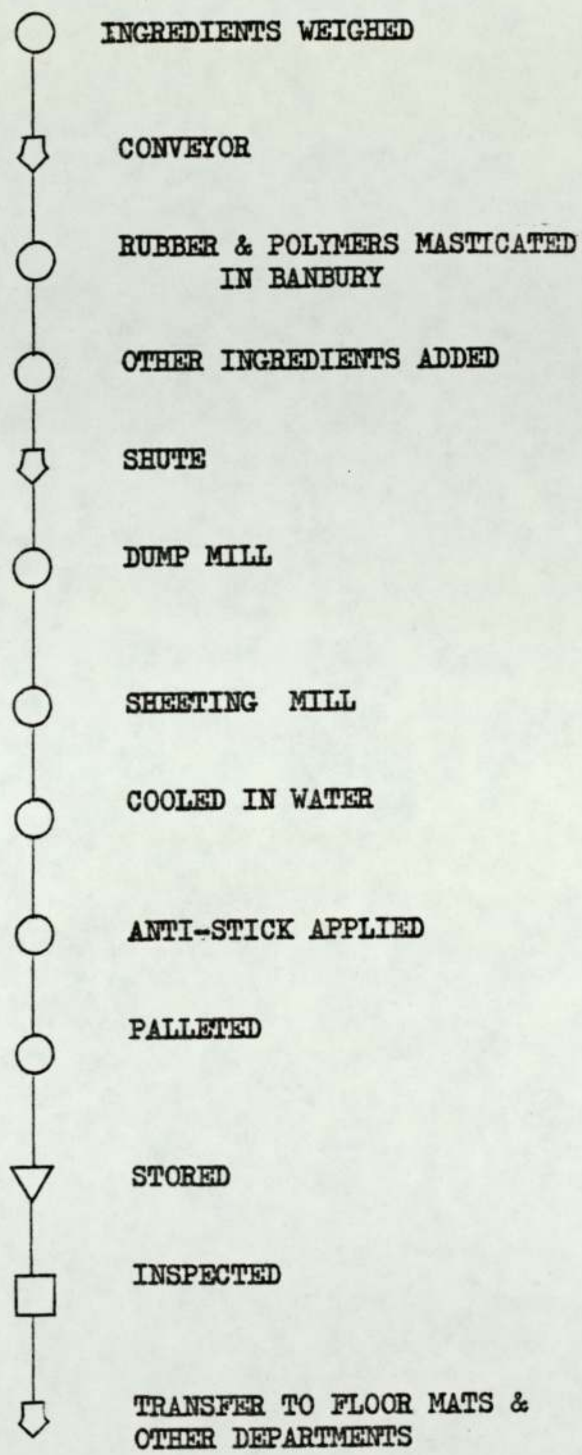


Fig. 3.2 (cont'd)

Mill Department Flow Chart

The plant and equipment used is mainly old and fully depreciated and much of it dates back to the setting up of the operation in 1950.

(ii) a) Compounding

Mixed compounds for the whole factory are prepared from the raw materials in the Mill Department, part of the Industrial Group. The department has two No. 11 Banbury internal mixers, two No. 3 Banbury internal mixers and numerous 2-roll mills. The bulk of compound, including all floor mat compound is mixed in the No. 11 Banburies.

The raw ingredients are weighed and fed into the internal mixers manually, except for the oils which are metered directly into the mixer chamber. Not all ingredients are necessarily added simultaneously, and mixing may take place in multiple stages.

Upon completion of the mixing cycle the compound is discharged onto a 2-roll mill located directly under the mixer chamber. This dump mill rapidly cools the batch, which will have reached a temperature of over 100°C during mixing.

The compound is transferred to a second mill, from where sheets of about 1 yd^2 are cut. The sheets are cooled in water, coated with zinc stearate to prevent sticking, and stacked onto pallets.

A team of 8 men operate the mixing equipment:

2 men preparing and weighing ingredients

1 man feeding and operating the internal mixer

1 man operating the dump mill

1 man operating the sheeting mill

3 men cooling, coating with zinc stearate, stacking and transporting with a forklift truck.

One No. 11 Banbury is "clean", reserved for compounds containing no loose carbon black; the other is "dirty", for compounds containing loose carbon black. Floor mat backing compounds are clean, and the veneer compounds are dirty.

The compound is delivered to floor mats on pallets of batches of 1,500 kg.

(ii) b) Calendering

Floor mat department has two 3-bowl calenders, one 66" wide and one 58" wide. The middle bowl of both calenders is fixed, and adjustment is made to the nips by moving the top and bottom bowls. In practice only the top nip of each calender is used. Adjustment to the calender nip varies the calendered sheet gauge.

Prior to calendering compound must be warmed to a temperature of about 70°C. This is achieved with a cracker mill, a small mill with fluted rollers, and two further mills, connected by conveyors to facilitate the transfer of compound.

40 lb batches of compound are passed twice through the cracker mill and transferred to the first mill, where they are allowed to accumulate until the mill is fully charged. At this stage uncured waste may be added. The compound is blended for 4-5 minutes, cut off the mill in convenient sized rolls or "pigs" and transferred to the second mill. The compound is further blended in the second mill, before being transferred in pigs to the calender.

To calender backing compounds the nip is set to the required gauge, and cutting knives set on the middle bowl to the required sheet width. The calendered sheet is taken off the bottom bowl onto the takeaway conveyor (see fig 3.4 (i)). Edge trimmings are recycled via the second mill.

Veneers are calendered on the 66" calender into cotton linings. Veneer compounds do not pass through the second mill, but are calendered straight from the first mill. The veneer sheet is run out of the linings (see fig. 3.4 (ii) and (iii)) and bonded to the backing sheet by the breast roller.
For two-ply backing sheet, the first ply is run into linings as for veneers.

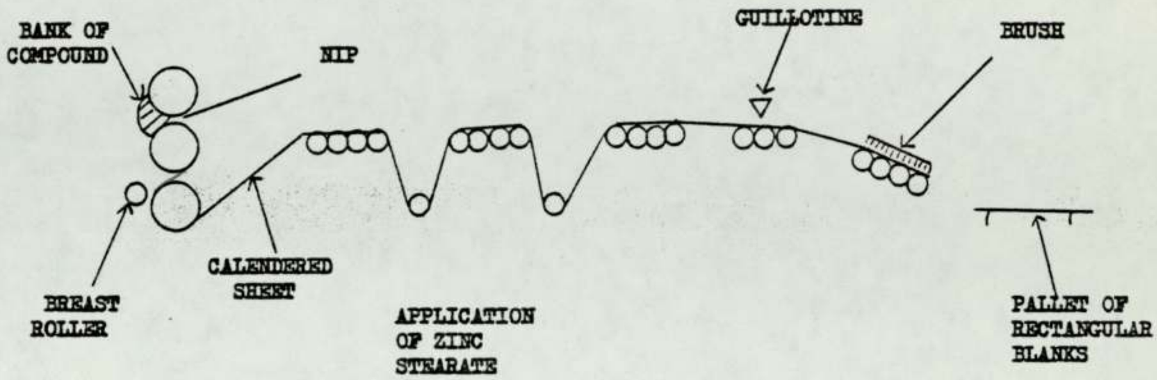


Fig 3.4 (i) 3 Bowl calender and take away conveyor

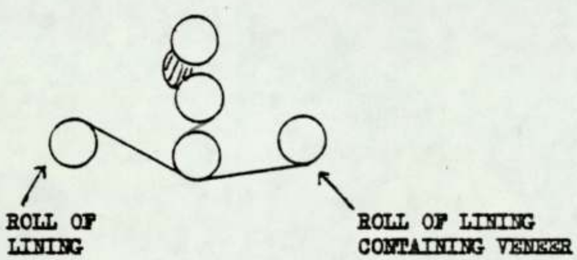


Fig. 3.4 (ii) Calendering of sheet into lining

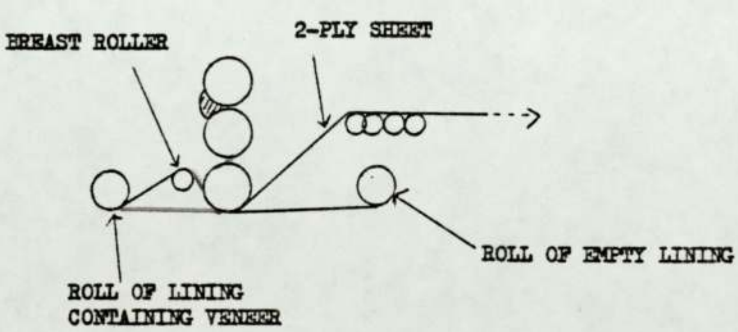


Fig 3.4 (iii) Topping of calendered sheet from a lining giving 2-ply sheet

Fig. 3.4. Calender set-up.

The takeaway conveyor applies zinc stearate to the calender sheet, and guillotines the sheet into rectangles. The rectangular blanks are unloaded from the end of the conveyor onto pallets.

The calender gang is composed of a team of seven men:-

1 man operating the cracker mill

1 man operating the first mill

1 man operating the second mill

1 man feeding the calender

2 men unloading the blanks

1 leading hand

This team is reduced to four men for the calendering of veneers:-

1 man operating the cracker mill

1 man operating the first mill

1 man feeding the calender

1 leading hand

Both calenders are operated during the day shift, and one calender during the night shift.

<u>Blank cutting</u>

(ii) c) The rectangular calendered blanks are periphery trimmed to the shape of the mould. The trimmings are uncured, and can be recalendered.

The palleted blanks are cut to shape manually using a template and a sharpened paint scraper. A number of blanks up to a thickness of two inches can be cut simultaneously.

(ii) d) Moulding

Floor mats are moulded by hand forming an uncured blank to a hot mould fitted with vacuum ports. Vacuum is used to pull the blank onto the pattern and contour of the mould. Vulcanisation of the mats takes place in an autoclave fitted with internal vacuum sources.

The autoclaves are rectangular steam pans fitted with hydraulically operated vertical doors. The curing cycle mechanism is fully automatic.

The moulds are welded onto a trolley composed of three horizontal sections having the facility to close up on entering the pan, and open out on withdrawal, thus exposing all the moulds. The moulds and trolley form a mould train which runs on rails. A hydraulically operated carriage automatically transports the mould train into the autoclave, and removes it upon completion of the moulding cycle. A pair of moulders operate two adjacent autoclaves. The moulds are loaded outside the autoclaves with connections to the external vacuum source. The mould train is then transferred into the autoclave, and the internal vacuum connected. The door closes, and steam pressure is raised to 65 psi. The internal vacuum is cut off when steam pressure reaches 20 psi. The curing cycle totals 7 minutes, 4½ minutes at 65 psi plus the 2½ minutes required to build up and blow down the pressure. After completion of the cycle the mats are stripped off the moulds. In between mouldings the moulds are sprayed with lubricant to prevent sticking.

The blanks are preheated on a hot plate to facilitate forming. Excess sheet over the edge of the moulds is trimmed off, and recalendered if it is uncured.

(ii) e) Finishing

To finish the mats a periphery trim and internal cut outs are made, sound insulating mats are assembled, and miscellaneous extras such as eyes, studs and seat runners are attached.

The majority of finishing is manual, with female labour. Hand knives are used for the periphery trim and internal cut outs; small holes are punched out using a punch and mallet.

A finisher's work station comprises a pallet of moulded mats, a table with a hard rubber surface to work on and keep the tools, and a finished mat stack from where an inspection is made.

A small proportion of the mats are finished mechanically using two Femco beam presses, and two smaller "clicker" presses. The presses are tooled with metal ribbon cutters mounted on boards.

Sound insulating mats are assembled manually. The felts and foams are glued to the back of the mats using latex or other sprayed adhesives. Latex is applied with a pair of rollers through which the felt is passed. The lower roller dips into a tray of latex. The other adhesives are sprayed at a Chemiflow adhesive line with an extraction unit. The periphery trim and cut outs may be made before or after the addition of the sound insulating layer.

During 1977 the technicians developed a new method for the assembly of sound insulating mats. The mat blank, insulating layer and backing skin are assembled by the moulders on the mould. Upon vulcanisation the rubber backing skin bonds to the mat, and the insulating layer is fully contained. The mats are then finished on the beam press. This method offered an improved product at a reduced cost.

(iii) Layout

Floor mats are produced in a number of separate rooms in the Cambridge Street factory. The machinery is located by function, but the size of the rooms necessitates the splitting of the calendering, moulding and finishing areas up into several rooms. Fig. 3.5 is a plan of the Cambridge Street factory. The rooms in red are used by Automotive Group.

(iii) a) Compounding

The Mill Department operates in the basement. Compound is delivered to Auto Group by forklift truck.

(iii) b) Calendering

The 66" calender is located in 44 room (fig. 3.6) and the 58" calender in 64 and 65 rooms (fig. 3.7). Mixed compound and calendered blanks are stored in the areas shown on pallets at floor level, there being no storage rack system.

The pallets of calendered blanks are transferred to 64 room for blank cutting.

(iii) c) Blank Cutting

The blanks are shaped in 64 room (see fig.3.7). Blank cutting trimmings are stored, until recalendered, in the blank cutting area. The templates used for blank cutting are stored in the blank cutting area as well.

The shaped blanks are delivered to the moulding areas on pallets, by forklift truck.

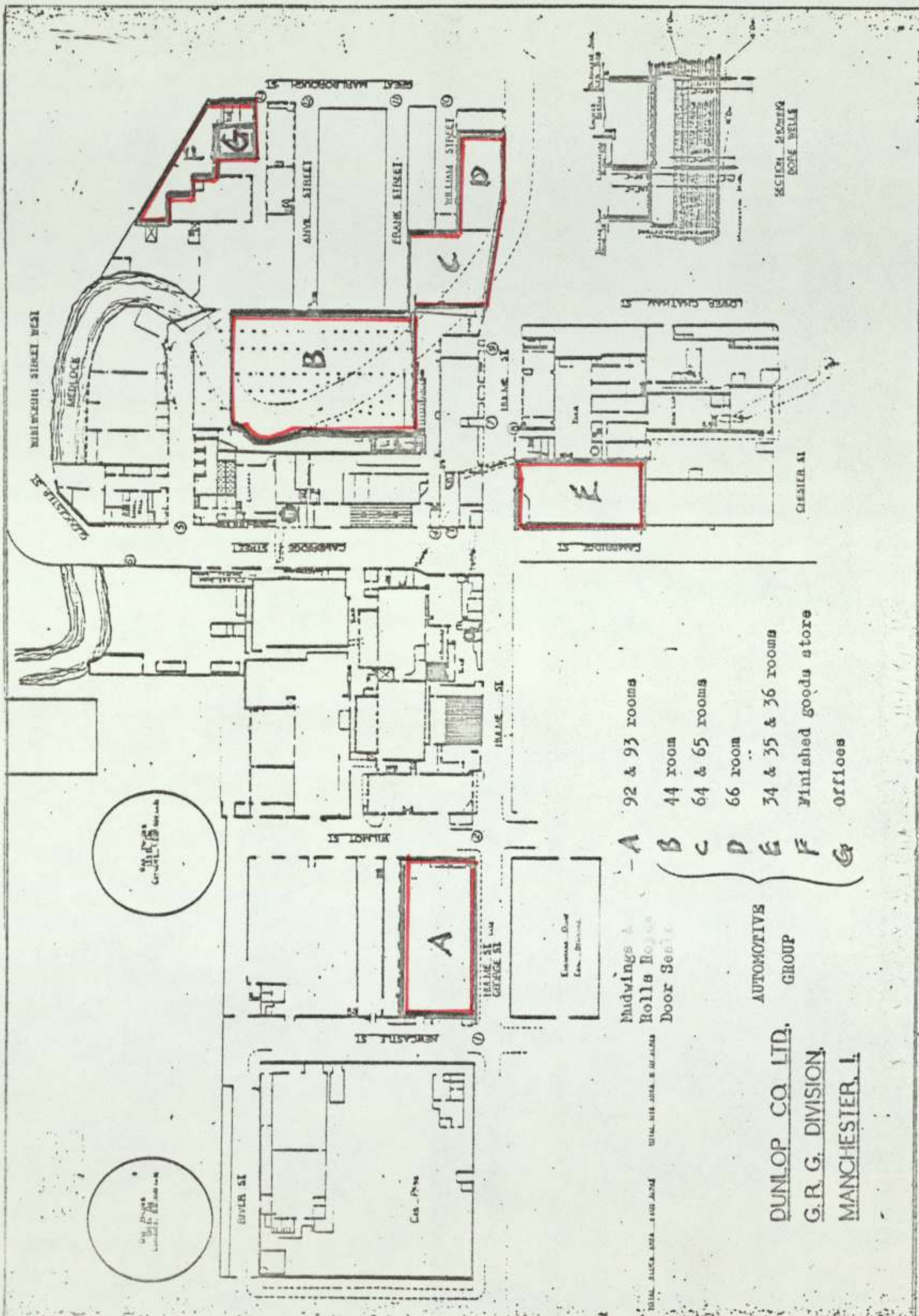


Fig 3.5 THE CAMBRIDGE STREET FACTORY LAYOUT

(iii) d) Moulding

The autoclaves are located in 44 room (fig. 3.6) and 34 room (fig. 3.8).

In 44 room the pallets of blanks for moulding are stored between the mould trains. The moulded blanks are placed on a table in the same area for inspection. The area at the end of the mould trains is used for storage of inspected mats prior to transport to the finishing areas.

In 34 room the autoclaves are closer together, leaving insufficient room for the moulders and the storage of mats, and the blanks are stored across the gangway. Upon moulding they are placed on tables located under the overhead conveyor, from where they are transferred to the general storage area upon inspection. Mats are transported up to room 35 for finishing via the overhead conveyor, or by forklift truck if they outsize the conveyor. Certain mats are transferred direct to the other finishing areas.

(iii) e) Finishing

Hand finishing takes place in 44 room (fig. 3.6), 35 room (fig. 3.8) and 66 room (fig. 3.7). Where possible, mats moulded in 44 room are finished in the 44 room finishing area, and mats moulded in 34 room are finished in the 35 room finishing area.

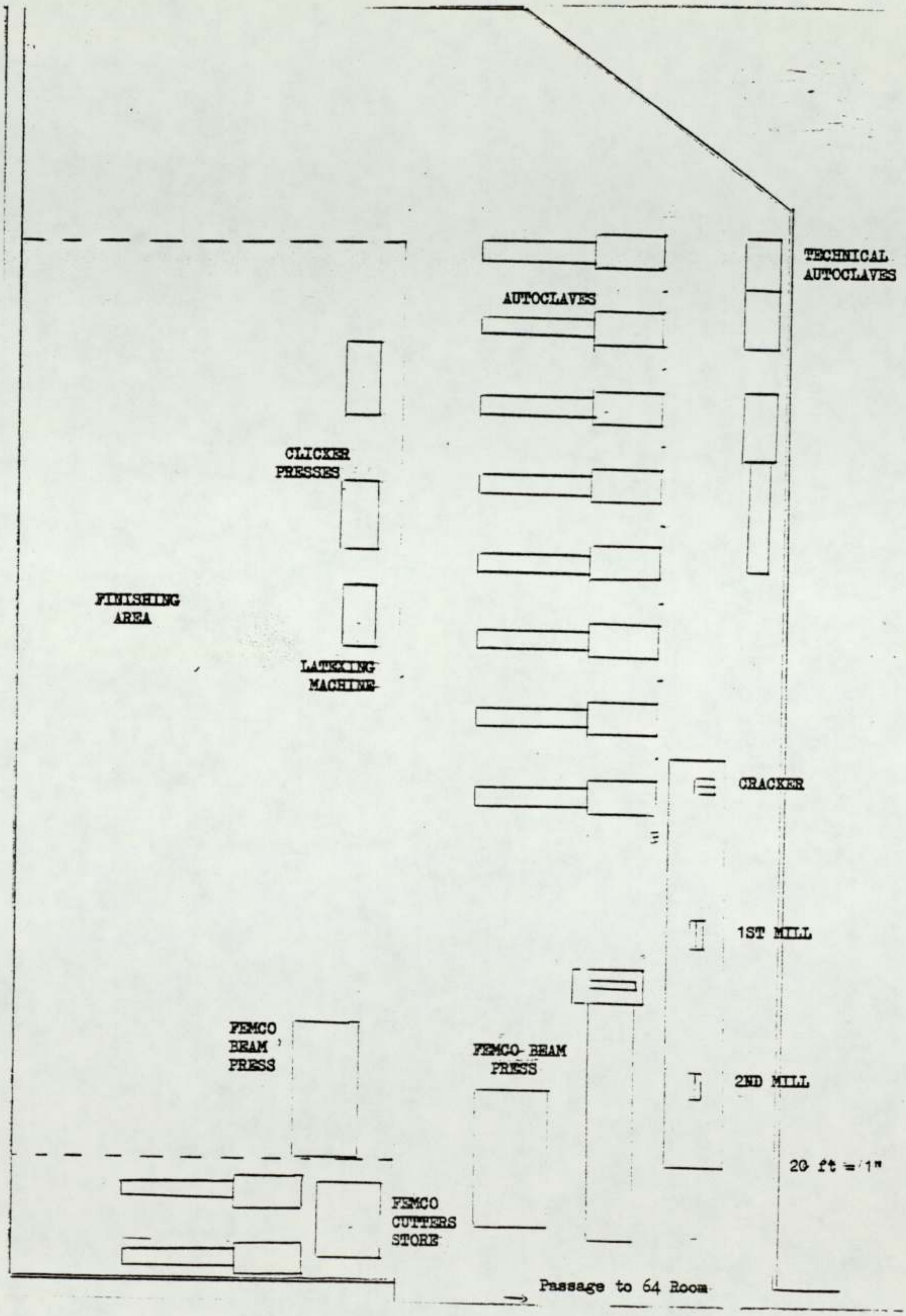


Fig 3.6 44 Room

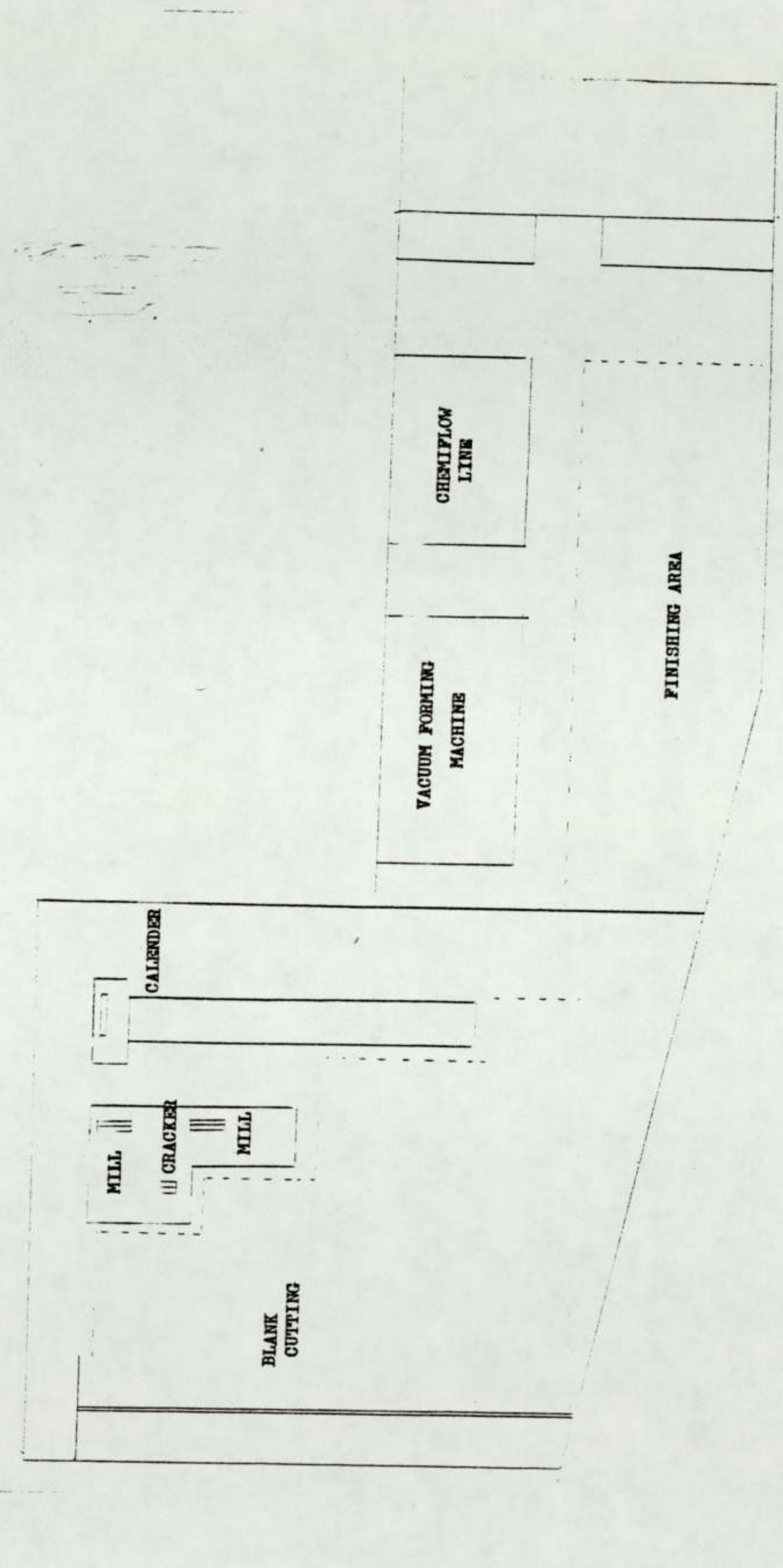
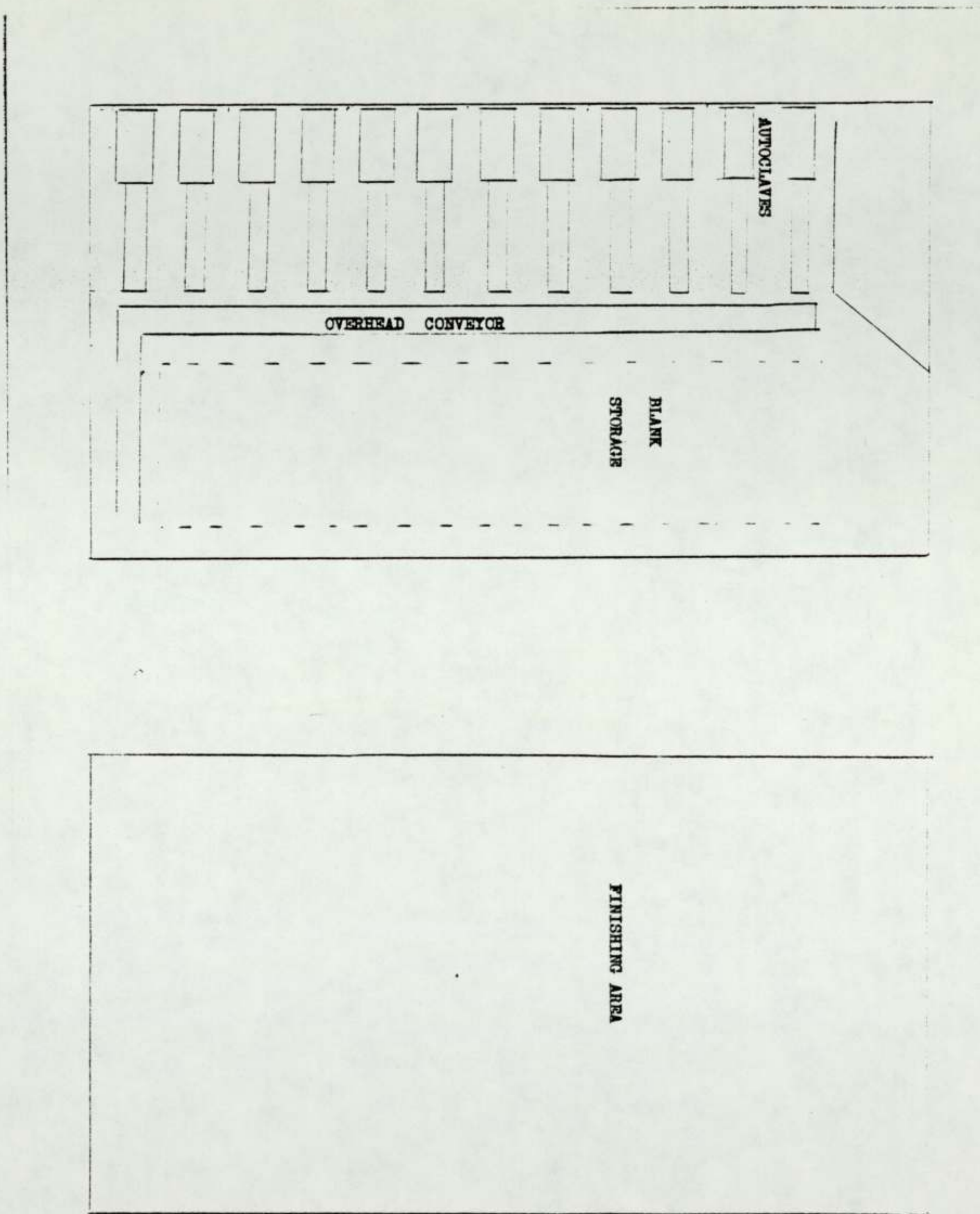


Fig 3.7

64, 65 & 66 rooms



<u>Fig 3.8</u> 34 & 35 rooms

The layouts of the hand finishing areas are flexible and incorporate areas for storage of moulded mats, finished mats and packing.

The Chemiflow adhesive line (extraction unit) is in 66 room, and the latexing rollers in 44 room.

The presses for automated finishing are located in 44 room.

(iii) f) Finished goods store

Packed and labelled mats are transferred to the finished goods store (see fig. 3.5). Deliveries are made via Great Marlborough Street.

(iii) g) Offices

The production foremen and the Departmental Managers have offices off 44 room. The rest of Auto Group staff are located in area G (fig. 3.5). The Product Manager's office is located in the main office block.

(iv) Production Planning

A schedule for each month is received from the customer. This details a firm order for the month, broken down into deliveries, and a tentative order for the following month. The customer guarantees to purchase the firm monthly order, and guarantees the cost of labour and material for the tentative monthly order.

From the schedule, and the finished goods store record, the Sales Supervisor obtains the monthly production requirements. A weekly production requirement is given to the Production Planner.

From the weekly production requirement the Production Planner derives compound requirements, and sends a weekly programme to the Mill Department, which is broken down into daily deliveries. A tentative monthly programme is also sent to the mill.

The calender gangs are given a shift programme, to which the leading hand plans the shift.

The week's mould set-up is compiled by the Production Planner. Moulds are changed by the engineers over the weekend. The mould set-up specifies which moulds are to be placed in which autoclaves, and is derived on the basis of required outputs, and moulding labour content (in standard minute value) of each autoclave. No programme is given to the moulders, who cover the moulds in the autoclaves with the blanks supplied.

The finishing foremen are given weekly programmes by the Sales Supervisor, as each mould can supply several variants of a mat with different finishing.

The packed mats are sent to the finished goods store, and a Stock Transfer Docket is sent to the sales office and the storeroom, detailing the package contents.

Deliveries are planned by the Sales Supervisor. The storekeeper records Stock Transfer Dockets and deliveries, to make a running finished goods inventory.

Other materials apart from compound are required for production.

Sound insulating felts and foams are ordered by the Development technician.

The finishing foremen are responsible for supplies of adhesives, latex, eyes etc. Other items are held in stock in the general store, and ordered by buying department.

(v) Quality Control

(v) a) Mixed compound

Mixed compound from the Mill Department is tested by the laboratory in the Technical Department.

One batch in ten of all floor mat compounds, except for the Palamino brown veneer, is tested for hardness and specific gravity. Every batch of the brown veneer is tested for hardness, specific gravity and colour.

(v) b) Floor mat inspection

(i) Calendering

The leading hand of the calender gang is responsible for calendering sheet to the required gauge and width. No inspection is made on the **calendered blanks prior to moulding.**

A system whereby one of the calender end men inspected the blanks for gauge, width and quantity had previously existed (see **section 4.2.2).**

(ii) Moulding

A 100% inspection of moulded mats is made. The inspection procedure is outlined in fig. 3.9

(iii) Finishing

A 100% inspection of finished mats is made. The inspection procedure is outlined in fig. 3.10

(iv) Weekly reject report

From the inspection sheets received from the inspectors, the quality control engineer compiles a weekly reject report. (fig. 3.11). This gives the number and cause of rejects for each type of mat for the week.

INSPECTION INSTRUCTION FOR FINISHING AREAS

1. CHECK EACH MAT FOR VISUAL FAULTS E.G.

   - LOSS OF VACUUM (POOR DEFINITION)
     BLISTERS
     FOREIGN MATTER (LUMPS IN MAT)
     TEARS OR CUTS
     MISPLACED FELTS
     POOR ADHESION
     POOR TRIMMING
     BAD PUNCH ON CUTOUTS.

2. CHECK ALL CUTOUTS ARE CORRECT AND IN LINE WITH WITNESS LINES MARKS ON THE MAT AND CLEAN WITH CLOTH.

3. AFTER INSPECTION ALL PASSED MATS TO BE PACKED STRAIGHT INTO PALLET OR STACKED AWAITING PACKING.

4. ALL MATS REJECTED TO BE MARKED 'REJECT' AND PLACED IN HOLDING AREA FOR SECOND INSPECTION BY SUPERVISION.

5. IT IS IMPORTANT THAT ALL MOULD NUMBERS, CUSTOMERS' IDENTIFICATION MARKING, ETC. ARE CLEARLY LEGIBLE ON MAT OR CUTTER.

6. AT THE END OF EACH SHIFT, INSPECTION SHEET WILL BE SIGNED BY THE INSPECTOR FOR THE PURPOSE OF COUNT AND QUALITY ON AUDIT INSPECTION CHECK.

....
V. USHER

VU/AEC.
21.11.77.

Fig 3.9

INSPECTION INSTRUCTION FOR MOULDING AREAS

1. CHECK EACH MAT FOR VISUAL FAULTS, E.G.

LOSS OF VACUUM (POOR PATTERN DEFINITION)
BLISTERS
FOREIGN MATTER (LUMP IN MATERIAL)
TEARS OR CUTS
MISPLACED FELTS
POOR ADHESION.

2. ALL PASSED MATS TO BE CLICKED AND PLACED IN BASKET OR ON A PALLET AS STRAIGHT AND NEAT AS POSSIBLE FOR TRANSFER TO FINISHING AREA.

3. ALL REJECT MATS TO BE PLACED IN HOLDING AREA FOR SECOND INSPECTION BY SUPERVISION AND MARKED 'REJECT' WITH CRAYON.

4. ALL MATS TO BE LOGGED ON INSPECTION SHEET. IF REJECTED, REASON FOR REJECTION.

5. SHOULD ANY MOULD PRODUCE THREE OR MORE REJECTS, THIS FACT WILL BE BROUGHT TO THE ATTENTION OF THE MOULDING CHARGEHAND AND QUALITY ENGINEER.

6. AT THE END OF EACH SHIFT, INSPECTION SHEETS WILL BE SIGNED BY THE INSPECTOR FOR THE PURPOSE OF COUNT AND QUALITY ON AUDIT INSPECTION CHECK.

....
V. USHER

VU/AEC.
21.11.77.

Fig 3.10

P LTD. G.R.G. DIVISION

QUALITY CONTROL DEPARTMENT

DEPARTMENT: CAR MAT

WEEKLY REJECT REPORT

1

WEEK ENDING 8: 1.77.

PRODUCT	Number Inspected	Number Passed	Moulding Faults	Faulty Material	Creased	Blisters	[illegible]	[illegible]	Under Cured	Trim	Punch & Cut	Holes	Paint Wash	[illegible]
COMMERCIALS	83	83	.								(			
A23 FRONT														
A23 REAR														
A23 SILL														
A23 FOOTREST	817	789	11	10	2			1	3	1				
A26 FRONT VAN	259	236	7	10			2			2	2			
A26 REAR														
BIB'S PIECES														
POLICE MAT ADULT FRONT														
A26 FRONT	789	672	29	63	6	5	7	1		5	1			
A26 REAR	907	789	32	64	4	5	6		2	4				
A26 3MM [illegible]	1224	1186	8	17	2	5		6						
A26 WHEELARCH	1192	1157	3	23	4			2	3					
ADULT FRONT														
C.V 306 FRONT DELUXE	310	280	3	21		6								
C.V. 306 W/A	962	938	10	8	2	1				3				
SMALL BEDFORD FRONT														
BEDFORD SIDE MAT														
BEDFORD STEP MAT	272	224	24	14						5	5			
RC. [illegible] PIECES														
BOARD MATS														
LARGE [illegible] FRONT	1213	1153	12	37			3	2	1	3	2			
MEDIUM [illegible] FRONT	408	403		3		1			1					
TOTAL	8436	7910	140	270	20	23	18	12	10	23	10			
%			1.65	3.20	.23	.27	.21	.19	.11	.27	.11			

PRODUCT	Wt. in Kgs. Finished Mat	Scrap Quantity	Scrap %	Cum. %	Wt. in Kgs. Passed	Wt. in Kgs. Rejected	% Wt. Reject
COMMERCIALS	1.76	NIL	NIL		146	NIL	NIL
A23 FRONT							
A23 REAR							
A23 SILL							
A23 FOOTREST	.38	28	3.41%		300	11	3.55%
A26 FRONT VAN	5.56	23	8.88%		1312	128	8.88%
A26 REAR							
BIB'S PIECES							
POLICE MAT ADULT FRONT							
A26 FRONT	1.82	117	(14.83%)		1223	213	14.65%
A26 REAR	2.42	118	(13.01%)		1909	286	13.01%
A26 3MM [illegible]	.58	38	3.10%		689	22	3.10%
A26 WHEELARCH	.42	35	2.94%		485	15	2.94%
ADULT FRONT							
C.V 306 FRONT DELUXE	4.62	30	(9.67%)		1296	138	9.62%
C.V. 306 W/A	.735	24	2.41%		689	18	2.54%
SMALL BEDFORD FRONT							
BEDFORD SIDE MAT							
BEDFORD STEP MAT	.87	48	(17.65)		194	42	17.79%
RC. [illegible] PIECES							
BOARD MATS							
LARGE [illegible] FRONT	5.34	60	4.95%		6180	322	4.95%
MEDIUM [illegible] FRONT	3.00	5	1.23%		1209	15	1.23%
TOTAL		526	6.24%		15986	1210	7.28%
%			5.68%				

TOTAL INSPECTED 19,785
TOTAL REJECTED 1,049 = 5.30%

TOTAL WEIGHT IN KGS
PASSED 35,685
REJECTED 2,283 = 6.01%

Mr C N Attenborough
Mr K L Poet
Mr A Richardson
Mr N Russell
Mr H France
Mr B Cassidy
Mr A McGuire
FILE ✓

Vincent Walker

Fig 3.11

(vi) Labour

The following table lists the operatives employed by the floor mat department as at April 1977.

Function	Number
Calendermen	18
Blank cutting	4
Moulders	33
Finishing	44
Servicing and trucking	12
Box lining	1
Pattern maker	1
Sweeper	2
Salvage	1
Chargehands	7
Inspection	11
Total	134

(vii) Costing method and pricing

Costing is handled by the cost accountants in the Accounts Department.

A process sheet for each mat is compiled by the technician, from which the industrial engineers assess the labour content. The cost accountant calculates the cost of the material, including waste, and labour. Variable expenses are added as a percentage of the material plus labour cost to give the Variable Works Cost.

The cost of tooling is covered by the customer, who owns the tools. Hence in response to cost enquiries, piece price and tooling cost is given.

Typically the piece price is the V.W.C. plus 50% giving a gross contribution towards overheads of 33% of the selling price. However, pricing policy and tooling cost policy incorporate marketing considerations.

Each department in the Cambridge Street factory is treated as a cost centre, and Accounts produce quarterly departmental operating statements which evaluate the department's performance against standard (based on V.W.C.)

(viii) Distribution

Distribution is organised on a day-to-day basis by the

Sales Department, using vehicles supplied by the Traffic Department.

All the mats for the Ford Motor Company are delivered to a B.R.S. depot in Birmingham, from where they are delivered to the Ford factories at Southampton, Langley and Dagenham.

(ix) <u>Wages</u>

The hourly wages of the operatives are split into a fixed part and a piece work part, linked to performance (standard 100). There are four operative grades, for which the standard and piece work rates are listed below. (as at October 1977)

Grade	Standard rate (£/hr)	Piece work rate (£/hr)
M2	0.80	0.32
M3	0.85	0.37
M4	0.90	0.42
M5	0.95	0.47

Standard performances are assessed by the Industrial Engineers.

3.3 Manufacture of other Automotive Products

3.3.1 Mudwings

The mudwings and spoilers marketed by Auto Group are manufactured by Fortiflex Department, part of the Industrial Group, in room 92 (see fig 3.5). They are made of sheets of rubber, 4 mm to 6 mm thick, which are moulded to shape in an autoclave.

8" warm fed extruders extrude cylinders of rubber at up to 1,500 lbs/hr. A longitudinal cut is made along the cylinder producing a sheet 30" to 40" wide. The sheet is cut into lengths.

Up to 10,000 lbs of compound per week is used. The compound is warmed prior to extruding on a cracker and mills. The mudwing compound is a better quality compound than floor mat compounds, containing a greater proportion of polymer and carbon black.

The sheets are formed and adhered to metal frames. Surplus sheet is trimmed off the edge, and a beading is added.

The mudwings are cured in a cylindrical autoclave for 25 minutes at 65 p.s.i. Punch outs are made manually after cooling.

Mudwings account for 37% of Fortiflex Department's output, and are manufactured in the same area as the other Fortiflex products, which include rubbish bins. The department employs the following operatives:-

6 men extruding

4 men forming

2 men curing

2 men finishing

1 man inspecting

3.3.2 Rolls Royce Door Seals

The Rolls Royce door seals are manufactured by Cabin Seal Department, part of the Industrial Group, in rooms 92 and 93 (see fig. 3.5).

Compound for the seals is mixed separately on an 84" mill due to the danger of contamination, resulting in paint staining on the door. 450 lbs/week of compound is used, mixed in batches of 150 lbs.

A $1\frac{1}{2}$" warm fed extruder produces blanks through a multi-headed die at 50 lbs/hour. Compound is warmed on a cracker and mill. The extrudate is cut to lengths.

The lengths are cut to shape and assembled in wooden jigs and cured in steam autoclaves. The tubular section of the seal is inflated during vulcanisation to prevent its collapse.

The department employs 3 moulders on a 12-hour day shift, and two moulders on a 12-hour night shift.

3.3.3. Automotive Extrusions

Various extrusions, manufactured by the Extrusions and Latex Group are marketed by Auto Group.

CHAPTER 4

Short term productivity investigations

4.1 Introduction and method of approach

Work in the area of short term productivity improvements within the Cambridge Street factory involved first an understanding of the operation of the manufacturing methods. Areas of interest and possible improvement could then be identified and investigated, and conclusions drawn and recommendations made.

During the course of this part of the research, events at the factory caused an increase in interest in the long term part of the project, and many investigations were not drawn to their full conclusion because of this. Hence cost savings in several areas were evaluated, but formal proposals for the adoption in the factory were not prepared in all cases.

This part of the project involved improvements which could be made within the constraints of the existing factory. Hence no major changes in layout were possible, though the movement of pieces of machinery would have been. Changes in manufacturing methods would also have ramifications in other areas such as industrial relations and administration which would need to be taken into account.

As the short term investigations would obviously aid the more important long term part, it was decided to allocate most time at the beginning of the research to this area.

The investigations carried out have been broken down into the areas of blank preparation, moulding, finishing and general in this chapter.

4.2 Blank preparation

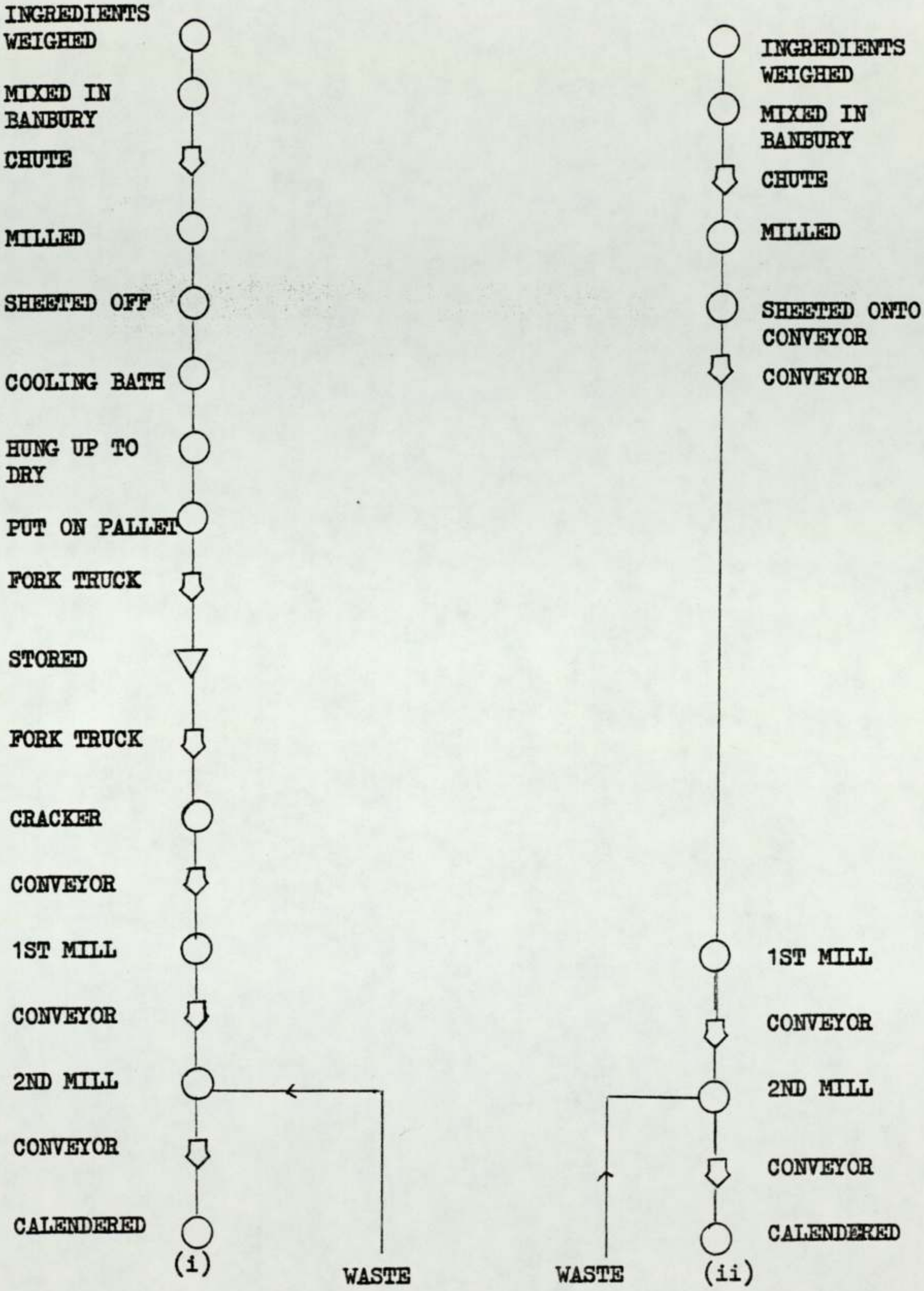
4.2.1 Tandem running

The installation of a conveyor between the 11D Banbury internal mixer in the Mill Dept., and the 44 room calender would enable warm mixed compound to be fed straight from the dump mill of the Banbury to the first mill in 44 room. This tandem system is similar to that used by Pirelli A.G.A. (see Appendix I) and would eliminate the labour required for storing the compound at the Mill Dept., and transferring it to the calender.

Fig. 4.1 is a flow chart comparing the tandem operation with the existing one.

Automotive Group were using a maximum of 200,000 lbs of compound per week, of which 15,000 lbs was veneer compound. As topping compound can be run at 4,000 lbs/hr and veneer at 800 lbs/hr, a maximum of 65 hours of calendering time would be required. The veneer compounds would still be calendered from cold as their calendering rate was too slow to be run on tandem with the mixer. Hence a total of 46 hours would be tandem running.

The effect of the proposals on the running of the mill was discussed with the Mill Manager. The output of the No. 11 Banbury would match the calendering rate on topping, and by running the 11D Banbury on three shifts, and the 11 A Banbury on one shift, the Mill Dept. could operate on tandem with Automotive Group, and still meet the other factory requirements.



<u>Fig 4.1</u> Flow charts for mixing and calendering (i) without tandem running and (ii) with tandem running

The calendering production achieved with three shifts shared between 65 room calender (maximum running speed 54 ft/min) and 44 room calender (maximum running speed 72 ft/min) would be achieved with two shifts on 44 room calender. This was discussed and agreed with the Production Planner. As previously calculated a maximum of 65 hours of calendering would be required per week. The greater productivity achieved by the workers would be compensated by the reduction in operator fatigue resulting from working with warm compound, and in particular the elimination of the cracking operation, considered the physically most demanding job in the factory.

a) <u>Savings in the Mill Dept.</u>

The Mill Manager estimated a saving of £6,000 p.a. in mill labour as a result of tandem running.

b) <u>Running and capital cost of the conveyor</u>

The conveyor would be driven by a 7.5 KW motor. The cost of electricity was £.0181 per KWhr. Hence the yearly cost of electricity for the conveyor used 46 hours per week and 48 weeks per year was £375 (at 80% efficiency).
The engineers produced an estimate of £5,000 for the purchase and installation of the conveyor.

The cost of maintenance on the conveyor was not estimated as it would be offset by reduced maintenance on 65 room calendering equipment and the mill fork lift truck.

c) <u>Cost savings in Automotive Group</u>

<u>Labour</u>

The current calendering labour was two gangs of 7 men (1 cracker man, 2 mill men, 1 feeder, 1 leading hand and 2 end men) and one gang for veneers of 4 men (1 cracker man, 1 mill man, 1 feeder and 1 leading hand). By tandem running, this could be reduced to 2 gangs of 6 men (2 mill men, 1 feeder, 1 leading hand and 2 end men).

During the running of veneers a gang would be reduced to 4 men by the redeployment elsewhere of the 2 end men. The cracker would be operated by one of the mill men.

Hence total labour would be reduced by 4 grade M2 men (the end men) and 2 grade M3 men (the cracker men), approximate average earnings of each being £62 p.w. and £65 p.w. respectively. By losing the end men and replacing them in the new gangs by calender operators the gangs would in effect be strengthened.

So the cost saving was:

Yearly wage M2 man = £62 x 52 = £3224

" " M3 " = £65 x 52 = £3380

Therefore yearly wage savings of 4 M2 and 2 M3 men = £19,656. Plus 9% company pension contribution (£1769) and $10\frac{3}{4}$% company National Insurance contribution (£2113), the total yearly saving was £23,538

The labour would be lost by redeployment followed by natural wastage. Hence a first year saving of £11,769 (half of £23,538) was estimated.

Electricity consumption in 65 room

The calender in 65 room would no longer be used. The total power saved would be as follows:-

1 cracker	97 kW
2 mills	112 kW
1 calender	97 kW
40" press	3.7 kW
total	309.7 kW

Average consumption would be approximately 60% of this due to the machines not being run at maximum speed continuously.

Hence the yearly saving in electricity was (the calender was used on 2 shifts, 80% efficiency assumed)

$$£0.0181 \times 309.7 \times \frac{.6}{.8} \times 80 \times 48 = £16,144$$

Electricity consumption in 44 room without cracker

2 mills	186.5 kW
calender	74.6 kW
2 conveyors	5 kW
guillotine	3.7 kW
total	296.8 kW

Due to higher productivity a consumption of 70% of the maximum was assumed. This equipment would be used 2 shifts instead of 1 with the introduction of tandem running. Hence the increased cost of electricity per year was estimated at

(80% efficiency)

$$£0.0181 \times \frac{.7}{.8} \times 269.8 \times 40 \times 48 = £8,204$$

Cracker 44 room

The cracker would only be used to run veneers (15,000 lbs/wk) at 800 lbs/hr, requiring 18.75 hours. The cracker was currently being run the 40 hour shift, so it would save 21.25 hours. The cracker used 89.5 kW

Assuming a consumption of 60% of the maximum, the yearly saving was calculated as

$$£0.0181 \times \frac{.6}{.8} \times 89.5 \times 21.25 \times 48 = £1,239$$

(80% efficiency)

Total electricity saving

Hence the total yearly saving in electricity was

£1,239 + £16,144 - £8,204

= £9,179

Reduced work-in-progress

An average of 3½ days supply of milled compound was held between the Mill Dept. and Automotive Group. This consisted of a range of compounds of differing value; however the bulk of it would be compound 3235 at £0.11/lb.

This stock could be eliminated with the introduction of tandem running, except for a stock for veneer compounds.

Average stock of non- veneer compounds

$= \frac{3.5}{5} \times 185{,}000 \text{ lbs} = 129{,}500 \text{ lbs}$

Value of stock at £0.11/lb = £14,245

Assuming an annual interest charge of 13%, the yearly cost of this stóck was £1,852

Reduced waste

Semi-cured compound resulting from storage while still warm is unusable. In the period April to July 1976, the total value of such compound received by Automotive Group was £15,759.

Hence a yearly cost of £20,000 was estimated. This would be eliminated upon the introduction of tandem running.

Total savings

The total estimated savings were as follows

	End yr. 1	End year 1 subsequent yrs
Additional running cost of conveyor	(375)	(375)
Savings in Auto. labour	11,769	23,538
Savings in Auto. electricty	9,179	9,179
Reduced wk-in-progress	1,852	1,852
Reduced waste	20,000	20,000
Mill savings	6,000	6,000
TOTAL SAVINGS	48,425	60,194

Cash flow resulting from installing a conveyor from the mill to the 44 room calender

The cash flow resulting from the installation of the conveyor would be:-

Year	£ Cash Flow
0	(5,000)
1	48,425
2	60,194
3	60,194
4	60,194
5	60,194

Hence the payback period would be a fraction of a year, and further benefits in improved industrial relations would also ensue.

Recommendations

It is recommended that a conveyor be installed between the mill and the 44 room calender, at a cost of £5,000, such that the two operations be run on tandem.

4.2.2 Overbooking by the calender gangs

It was an accepted fact that the calender gangs overbooked their production figures to inflate their earnings. In fact, the Production Planner, in compiling the daily work sheets for the calender gangs , actually doubled the quantities of blanks necessary, such that his requirements were fulfilled.

Traditionally the calender gangs were the highest paid operatives in the factory, as their work involved considerable physical effort. However, the differential between them and the other workers had been eroded by wage bargaining. Because of this and the fact that calender labour only represented a small proportion of total labour costs, the Manufacturing Manager tolerated the overbooking.

Previous attempts had been made to check the calender production figures. Inspectors fulfilling the dual role of end man as well had been used, and mechanical counting devices had been installed on the guillotines. Neither system had been successfully implemented.

Establishment of calender gang overbooking

The calender gang's daily work sheets, on which are recorded the days production, are stored by wages department and used to calculate earnings. For each type of blank, figures of the gang's booked production may be obtained by additioning all the appropriate entries in the daily work sheets for any week.

All moulded blanks are inspected, and the results recorded by the Quality Engineer on the weekly reject reports (fig. 3.10). Hence the total number of each type of mat moulded is recorded.

Thus the number of blahks actually moulded may be compared, over a period, with the number of blanks booked by the calender gangs. This comparison was made for a period of 4 consecutive weeks - ending 25.12.76 and the results are contained in fig 4.2.

For each week, the percentage of mats moulded to mats calendered is given. A small discrepancy was expected as detected faulty blanks are returned for recalendering before moulding. However this could only account for a very small quantity of blanks.

The week ending 21.12.76 was not representative as it was the last week before the Christmas shut-down, and so very little compound was calendered, and the normal stock of blanks was run down.

The result of 61% for the 3 weeks ending 18.12.76 indicated the degree of overbooking.

Calendering labour cost

The wages are based on fixed and variable parts. The variable part, on piece work, is directly proportional to the rate of work (performance). The variable part was approximately £1 per hour. By overbooking by a factor of 50%, a worker can increase his hourly earnings by £0.50.

The calender gangs were only on piece work an average of

BLANK	No of mats per blank	Week ending 4.12.76 C	4.12.76 M	11.12.76 C	11.12.76 M	18.12.76 C	18.12.76 M	25.12.76 C	25.12.76 M	TOTALS 3 weeks C	3 weeks M	4 weeks C	4 weeks M
D series tunnel	1	473	156	90	78					563	234	563	234
D series side	2	475	245	90						565	245	565	245
London taxi rear	1	1410	307	102	160					1512	467	1512	467
London taxi luggage	2					111			33	111	0	111	33
Opel 1900 series	4	580	135.5							580	135.5	580	135.5
F.J. Cab	1	2948	683	1029	782	377	409		205	4354	1864	4354.	206.9
70 VB large front	1	950	808	1842	638	2035	1501		617	5197	2947	5197	3564
70 VB medium front	2	170		340	285.5	491	389.5	180	137	1001	675	1181	812
R & D lower	1	900	626	909	997	1955,	1027	271	273	3894	2650	4165	2923
R & D upper	1	668	368	395	343					1063	711	1063	711
MF tractor	2	1290	259.5	907	322.5	414	278		120.5	2731	860	2731	980.5
Bobcat	1	1611	132	587	150		194		68	2198	476	2198	544
CV 306 rear	1	316	141							316	141	316	141
CV 306 deluxe	1	352	338	606	349	644	401		55	1602	1088	1602	1143
CV 306 W/arch	4	523	326.5	560	310	357	373.5		158.75	1440	1010	1440	1165.25
CV 306 Basic	1	124	362							124	362		
T car guard mat	4	350	154	147	179.5	289	198		82	786	622.5	786	704.5
T car one piece	1					129	33			129	33	129	33
LH dash panel	1	3621	2039	3363	1360	3006	1695	300	845	9990	5094	1029.0	5939
RH dash panel	1					150		352	89	502	0	502	89
8 bus rear	1							105	114	0	0	105	114
4 bus rear	1	148	165	145	169	145	191			438	525	438	525
bedford steps	12	330	269	501	241	583	240	140	80	1414	750	1554	830
G cab b/head	4	470	384.75	105		467	209.75		44.5	1042	594.5	1042	639
absorption pad	1	120		207	182	88			88	415	182	415	270
YIT w/arch +2400 S w/arch	4	2500	1490.25	1251	1504	2603	1131.25		488.75	6354	4125.5	6354	4614.25
companion pieces	4	738	392.5	747	298.75	777	367.25	131	92.75	2262	1058.5	2393	1151.25
AEC tunnel	1	238		120	140					358	140	358	140
AEC rectangle	1			150	73		60			150	133	150	133
A20 front	1	1140	140	1040	1067	1874	983		281	4055	2190	4055	2471
A20 b/head	4	201			62	428	243		63	629	305	629	368

Fig 4.2

BLANK	No of mats per blank	Week ending 4.12.76 C	M	11.12.76 C	M	18.12.76 C	M	25.12.76 C	M	TOTALS 3 weeks C	M	4 weeks C	M
A20 P/rear	2	300		444		446			131	1190	0	1190	131
A20 S/rear	1	1138	276	1383	1189		1024			2521	2491	2521	2491
A20 W/arch	4	418		615	425.75	887	455.5		174	1980	881.25	1980	1055.25
footrest	6	320	53.33	120	273	300	194		18	740	520.33	740	538.33
YIT front	1	548	115	1258	753	1271	781	365	248	3077	1649	3442	1897
YIT crumb	1	621	314	675	248	1650	972		232	2946	1534	2946	1766
diane L floor	1	271			341					271	341	271	341
A23 front	4	153			71					153	71	153	71
6 cyl front	1	180		365	305					545	305	545	305
cavalier G mat	2			104		493	264		30.5	597	264	597	294.5
commercial	1					120			42	120	0	120	42
arrow L floor	1					142			63	142	0	142	63
A28 van front	1					109			178	109	0	109	178
TOTALS		26357	10673	20257	13297	22341	13615	1844	5051	68955	37585	70799	42636
Moulded/Calendered x 100%		40.5%		65.6%		60.9%		273.9%		54.5%		60.2%	

Fig 4.2 (cont'd)

approximately 80% of the time, as during breakdowns and the grinding of scrap , they were put on fixed earnings.

The yearly cost of excess calender wages for a gang of 7 men working 40 hours per week and 48 weeks per year would be £5376. The total cost for the 18 men would thus be $\frac{18}{7} \times 5376$ = £13,824

Checking systems

a) Inspection

Inspectors at the end of the calender conveyor could easily verify the number of blanks produced. However, at a cost of £5,000 (including fringe benefits) to the group, an inspector could save a maximum of £5,376 of overbooking.

On top of the poor maximum possible saving, by experience it was found that the inspectors, in constant contact with the gangs, tended to side with the gangs rather than with the management, resulting in poor inspection.

b) The use of job tickets

Each batch of blanks should have attached to it a job ticket. At the current time this ticket was only being used to identify the type of blank, and in fact at the time of this investigation the job tickets were not being used at all as the department had run out of them.

If the job tickets were properly filled in they could form the basis for a system of checking the calender production without special inspectors.

All mats after moulding are inspected and counted prior to finishing. This number, passed and rejected, should equal the calender production less any blanks detected as faulty prior to moulding. These rejected blanks are included in calender gangs output as they can result from poor quality compound. Provided these rejected blanks were stored and counted prior to being reprocessed then an exact figure for the calender gangs production could be obtained.

Hence if the job tickets were properly filled in as follows, calender gang production could be controlled.

For veneers part A and the relevant section of part C of the job ticket (see fig. 4.3) would be completed by the gang. The quantity in the batch (the length of the roll) and the job ticket number would be entered on the daily work sheet, and part A of the job ticket detached and kept by the gang as a record. Parts B and C would be attached to the roll.

Once topped, part B and the relevant part of part C would be completed. The batch quantity and the job ticket number would be entered on the daily work sheet. Part B of the ticket would be kept by the gangs.

For non-veneered blanks part A would be discarded.

The batch would have part C attached to it when moulded, and

C

JOB Nº 10837

QUALITY

DESCRIPTION

CALENDERED BY | DATE

TOPPED BY | DATE

CUT BY | DATE

No. OF BLANKS

B

JOB Nº 10837

TOPPED BY

DESCRIPTION

No. OF BLANKS DATE

A

JOB Nº 10837

CALENDERED BY

DESCRIPTION

YARDS DATE

ccw 27572

Fig. 4.3 Job ticket

hence the gang producing it could be identified, and the number they booked known. This number would be compared by the moulding inspector with the total number moulded plus the number rejected prior to moulding.

The only cost in re-introducing the job tickets would be that of the job tickets themselves, which would be small.

However it would be impossible to introduce a scheme resulting in a reduction in calender gang earnings. The calender gangs are only a small part of the total labour cost but wield total power in their ability to bring production to a stop. At the time of the investigation difficult relations were being experienced with the gangs who were on a go-slow.

The other benefits of the job ticket scheme would be facilitated production planning and improved management control over production.

Recommendations

It is recommended that the proper use of the job tickets, as described, be implemented, with the £13,800 calender earnings resulting from overbooking included in their wages by increased rates. In this way the not easily quantifiable benefits of facilitated production planning and better management control over production would be realised, at no cost.

4.2.3 <u>Misusage of compound</u>

During the period April to June 1977 the Departmental Operating Statement, produced by the management accountant, showed a loss on compound for Floor Mats of £49,030 (see fig. 4.4). The statement compares each department's actual performance with its standard performance based on the Variable Works Cost of its total sales. Hence during this period Floor Mats had used £49,030 more compound than it should have done to produce the goods it sold, had it been operating consistently with the process sheets from which the VWC is derived.

<u>Analysis of the cause of the Dept. Operating Statement loss</u>

Using the Pareto analysis carried out previously, the 23 largest running mats, accounting for 79% of total turnover, were identified. Provided that these mats were not weighted about the mean in price, then these mats would account for 79% of the total in quantity, and hence 79% of the total compound usage.

<u>Higher rejects than as process</u>

The VWC includes an allowance for reject moulded and finished mats. An actual reject percentage greater than the allowance would hence increase the actual cost of the goods sold over the standard cost.

Using the following formula, the actual cost of the extra rejects was calculated (see fig 4.5) for the 23 mats' sales to 28.5.77

	Period	To-date
Working Days	56	115
Activity		

Department	Car Mats 2014
Period	April/May/June

DEPARTMENTAL OPERATING STATEMENT

	MATERIAL				LABOUR		VARIABLES		TOTAL
	Compound	Waste	Direct	Other	Direct	Transfer	Direct	Transfer	
Opening Stock	63113	6185	617	9034	12453	5852	15193	9024	121471
Closing Stock	37763	6746	625	8310	11223	3907	12583	7149	88306
Stock Movement	25350	(561)	(8)	724	1230	1945	2610	1875	33165
Input									
Materials Ex Stores			–	49656					49686
Labour – Wages Paid					81557				81557
Variable Expenses							82161		82161
Transfers In – Ex. C.St. Depts.	175003		4426			13594		20730	213753
– Ex. H. Green									
– Ex. Skelmersdale							145		145
Waste Adjustment	(22441)	22441							
Total Cost of Input	177912	21880	4418	50410	82787	15539	84916	22605	460467
Output									
Deliveries to F.G.S. & Customers	122055	28875	6810	43812	71223	13315	86892	20297	393279
Transfers Out – To C.St. Depts.									
– To Hindley Green									
– To Skelmersdale									
Total Cost of Output	122055	28875	6810	43812	71223	13315	86892	20297	393279
Variance From Standard	(55857)	6995	2392	(6598)	(11564)	(2224)	1976	(2308)	(67188)
To-Date Adjustments									
To-Date Variance from Standard	(49030)	(1524)	4181	(1316)	(21363)	(1937)	3171	(1108)	(81586)

Fig 4.4

$$E = \sum_{\text{all mats}} \frac{d\,(VWC)}{1 + x} \quad \frac{T}{S}$$

where d = difference between actual rejects and process rejects

x = rejects according to process

T = sales of each mat

S = mat selling price

This formula is derived in appendix (II)

MAT	Process No.	(x')(to 29.5.77) Actual reject %	(x) Process Reject %	(d) Excess Actual Over Process %	Sales to 28.5.77 (T)	VWC	(S) Selling Price (£)	Excess cost of Production over Process Cost (£)
Y-I-T Front (A Series Y-I-T)	87	4.81	3	1.81	£83,581 + £53.372	£5.5738	10.07	1332
Y-I-T wheelarch	56	7.44	6	1.44	£41,022 + £27,213	£0.6307	2.22	263
4 cyl dash insulator LH (A Series dash panel)	60	4.27	6	-1.73	£19,685 + £29,180	£1.8684	2.60	-573
" RH	58	10.59	7	3.59	£37,290	£2.7824	4.30	810
Lge Transit Frt. (2400, 70 VB)	52	4.09	5	-0.91	£25,789 + £31,677	£2.6071	2.83	-459
CV 306 Deluxe Frt.	105	7.68	9	-1.32	£24,733	£3.2736	3.84	-255
FJ Cab	45	2.56	4	-1.44	£24,816	£3.1685	3.84	-284
ADO 28 Van Frt. (ADO 73)	63	8.00	6	2.00	£29,726	£3.1262	3.09	567
ADO 20 Rear	59	7.67	7	0.67	£12,521	£1.9026	1.69	88
" Front	49	9.47	8	1.47	£14,443	£1.4072	1.67	166
" W/A	35 & 36	2.58	3	-0.42	£18,101	£0.2446	2.29 prs	-16
Cavalier Guard Mat Set	142	1.1	3	-1.9	£7,275	£1.8114	2.99 "	-162
Bedford Stepmat	37	2.97	3	-0.03	£21,295	£0.4110	1.21 "	-42
Rover centre floor	19	6.1	6	0.1	£11,072	£2.8563	2.675	11
Rover sides	130	6.51	4	2.51	£10,060	£1.1707	2.765 "	206
Companion piece	53	6.36	5	1.36	£6,008	£0.7723	0.89	68
Small transit w/a	57	6.23	6	0.23	£18,078	£0.4716	1.72	11
Escort rear (Brenda)	77	8.93	7	1.93	£31,153	£1.8508	2.43	428
R & D Lower	88	7.22	4	3.22	£52,589	£2.4393	3.86	1029
" Upper	94	9.3	7	2.3	£39,514	£8.4079	12.75	555
Transit med. Frt.	100	4.64	4	0.64	£23,270	£1.3899	2.32	86
Rover O/T Frts.	93 & 96	2.16	5	2.84	£11,545	£0.6155	1.66 "	-232
M. Ferguson	143	4.76	5	-0.24	£12,550	£4.4109	5.00	-25
TOTAL					£717,558			3610

Fig 4.5

Use of more compound and different compounds than according to process

If mats are manufactured from more expensive compounds than according to process, then this will result in higher compound costs, as would the use of a greater quantity of compound.

From the sales and selling price, the number of each mat sold in 1977 to 28.5.77 was calculated. Including an allowance for rejects and cured waste, the total compound usage is contained in fig. 4.6

From the knowledge of the make-up of each mat, the theoretical total usage for the chosen mats could then be calculated (see fig. 4.7)

The actual usage of compound in that period was then obtained from the Production Planners records. By multiplying this by 0.793 for each compound, the quantity of each type of compound estimated as actually used to manufacture the 23 chosen mats was obtained. (see fig. 4.8). By knowing the cost of each type of compound, the cost of the compounds actually used could be compared with the cost of the compounds which should have been used.

The results showed that a deficit of £57,314 in compound costs for the 23 chosen mats resulted from

a) the use of 3235 and 6649 compounds in place of the cheaper 3690 and 3691 compounds specified in process and

b) the discrepancy between the total amount of compound used by weight according to process, and that actually used of 8%.

Process No.	Composition (% by wt.)	Weight Trimmed Mat	Weight shaped blank (trimming on mould)	weight calendered blank	Cured waste (x'')	Dimensions cal. blank (x mm^{-1})	No. sold	Weight sold (w) (kg)	wt. produced = $w(1 + x')(1 + x'')$
87	5.16% 6649; 94.84% 3690/waste	6.78 kg	8.67 kg (8.31 kg)	10.4 kg	23%	3.05 x 1372 x 1473	13600	92208	118871
56	89% 3754; 11% 6649	.545	.76	3.98	39%	1.52 x 940 x 1676	30737	16752	25018
60	90% 3754; 10% 6649	1.27	1.88 (1.68)	3.45	32%	1.52 x 762 x 1778	18794	23868	32851
58	89% 3754; 11% 6649	1.5	2.23 (2.09)	3.45	39%	1.52 x 762 x 1778	8672	13008	19996
52	94% 3690; 6% 6649 (+ .08kg extruded cord)	5.4	6.44	8.17	19%	2.41 x 1372 x 1473	20306	109652	135823
105	100% 3752; cork	4.21	4.75	6.25	13%	2.29 x 1295 x 1422	6441	27117	32995
45	4% 6649; 19% 3754; 77% 3691/waste	7.67	9.3	11.67	21%	5.08 x 787 x 1980	6463	49572	61518
63	54% 3754; 46% 3691/waste	5.56	7.4 (6.3)	8.9	13%	3.05 x 1041 x 1778	9620	53487	65276
59	13% C6646; 87% C3690	2.42	5.26	6.25	9%	1.52 x 1346 x 1829	7409	11930	21042
49	14% 6646; 86% 3752	1.82	2.24	3.0	23%	1.52 x 838 x 1524	8649	15741	21194
35/36	89% C3690; 11% C6646	.43	.56	3.06	30%	1.52 x 991 x 1194	7904 prs	6797	9065
142	61% 3235; 59% 3691/w; 40% 3235; 60% 3691/w	2.06	2.06 (2.71)	7.19	37%	4.06 x 610 x 1930	2433 "	3455 5012	11727
37	100% 3690/waste	.87	3.97 (→4 mats)	11.8 (12 mats)	16%	3.05 x 1118 x 2032	17599 "	30622	36577
19	3012	4.48	5.89 (5.43)	6.6	21%	3.05 x 686 x 1829	4139	18543	23805
130	3012	1.99	2.38	13.58 (4 mats)	20%	3.05 x 1118 x 2438	3638 "	14480	18507
53	89% 3754; 11% 6649	.34	.5	3.45 (1 mat + 1 dsh-ins)	47%	1.52 x 762 x 1778	6751	2295	3589
57	89% 3754; 11% 6649	.52	.68	3.98 (4 mats)	31%	1.52 x 940 x 1676	10510	5465	7606
77	3752	2.48	3.25 (3.0)	3.56	21%	1.52 x 876 x 1727	12820	31794	41906
88	95% 3690/waste; 5% 6649	4.6	5.45 (5.38)	7.53	17%	3.04 x 762 x 1930	13624	62670	78619
94	95% 3690; 5% 6649	8.64	15 (10.02)	15.58	16%	3.04 x 1397 x 2184	3099	26776	33949
75	93% 3690; 1% 6649 (+ cord 0.045kg)	2.98	3.34	9.0	12%	2.41 x 1372 x 1626	10030	29889	35030
100	3690/waste	1.69	1.69	8.74 (4 mats)	19%	2.29 x 1372 x 1626	6955 "	23507	28577
143	90% 3690; 10% 6649	3.83	5.55 (5.06)	12.92 (2 mats)	31%	3.8 x 1270 x 1620	2510	9613	13193
									876734

Fig. 4.6

MAT	COMPOUND 3690	3235	6646	6649	3012	3691	TOTALS
Y-I-T Front	112928			5944			
" W/A		22266		2752			
4 cyl. dash ins. LH		29566		3285			
RH		17796		2200			
Lge Transit Front	127673			8149			
CV 306 Deluxe Front		32995					
FJ Cab		11688		2461		47369	
ADO 28 Van Front		35249				30026	
ADO 20 Rear	18307		2736				
" Front		18227	2967				
" W/A	8067		997				
Cavalier Guard Mat Set		4691				7036	
Bedford Stepmat	36577						
Rover Centre Floor					23806		
Rover sides					18507		
Companion piece		3194		395			
Small transit w/a		6769		837			
Escort Rear (Brenda)		41906					
R & D Lower	74688			3931			
R & D Upper	32251			1698			
Transit med. frt.	32578			2452			
Rover O/T Fronts	28577						
M. Ferguson	11874			1319			
TOTALS	483520	224347	6700	35423	42312	84431	876734
% of total	55%	25%	1%	4%	5%	10%	
Correction for waste	66625	56094	1675	8856	-	-	
Quantity used (process)	416895	280441	8375	44279	42312	84431	878733

<u>Compound Waste</u>

Waste			
3691	max	80%	general
3690	max	50%	general
3235	max	50%	own
6646	max	5%	own
6649	max	5%	own
3012	max	50%	own

Correction for waste: 3691 and 3690 will both contain other compounds. Assuming 25% of compound returned as waste, then 25% of 3235, 6646, 6649 will go into 3690 and 3691.

<u>Note</u>: Compounds 3754 and 3752 have been replaced by 3235. Compound 3691 (Cork) is ground crumb and general waste.

<u>Fig. 4.7</u>

	C O M P O U N D						
	3690	3235	6646	6649	3012	3691	TOTAL
Quantity used by process (k)	416895	280441	8375	44279	42312	85229	876734
Price (£/k)	.2117	.2493	.2745	.4962	.3393		
Cost of process qty. (£)	88257	69914	2299	21971	14357		197040
Qty. used to 28.5.77 (k)	164395	868075	5665	105775	44771		1195491
Cost of qty. * used to 28.5.77 (£)	27598	171614	1233	41621	12046		256992
Variance from process (£)	60659	(101700)	1066	(19650)	2311		(57314)

Fig. 4.8 Material cost actually compared to costs incurred by process

	3690	3235	6646	6649
Qty. ordered from Mill Dept. (k)	218141	1026757	7256	133150
Qty. received from Mill Dept. (k)	161260	868076	5665	113470
% qty. received of qty. ordered	74%	85%	78%	85%

Fig. 4.9 Comparison of amounts of compound ordered and received from the Mill Dept.

Conclusion

The loss caused by higher reject rates than according to process gave rise to an increased compound usage of £3,610. Also total compound usage was approximately 8% higher than process.

However, the major cause of the excess compound costs was the replacement of cheaper compounds with more expensive ones. There were two reasons why this should have been.

The first was that the Mill Dept. preferred to supply the more expensive compounds (see fig. 4.9). Floor Mat Dept. ran out of the cheaper compounds on occasion and then had no option but to replace them with the more expensive ones in stock.

The second was that compound 3235 was much easier to process for the calender men than compound 3690, and so the gangs frequently used it instead of 3690.

The management in fact recognised that it would be unreasonable to expect the gangs to use 3690 in all the mats for which it is the process compound, and that the process sheets for some of the mats should be changed accordingly.

Thus part of the projected £98,000 years misusgae of compound, say £49,000, could be eliminated by increased control over the calender gangs and supplies from the Mill Dept. and that the rest should be accounted for by the changing of process sheets.

Recommendations

It is recommended that increased attention be given to checking day-to-day deliveries from the mill dept to redress any slackness on their behalf.

Furthermore the awarding of increased calender wage rates recommended in the previous section should also be tied in with increased control over their usage of compound, resulting in a saving of £49,000 p.a. The process compound for certain mats should be changed to account for the remaining £49,000 misusage.

4.2.4 Automated blank cutting

Introduction

The Rotary Cutting Machine, manufactured by Rotaforme of Oldham, was developed by Rotaforme in conjunction with Dunlop for the automation of blank cutting. Dunlop, however, lost interest in the project, and Rotaforme went on to successfully market the machine, mainly for cutting rolls of carpet.

It was decided to look into the possibility of using a Rotary cutter on the end of the calender line to cut blanks.

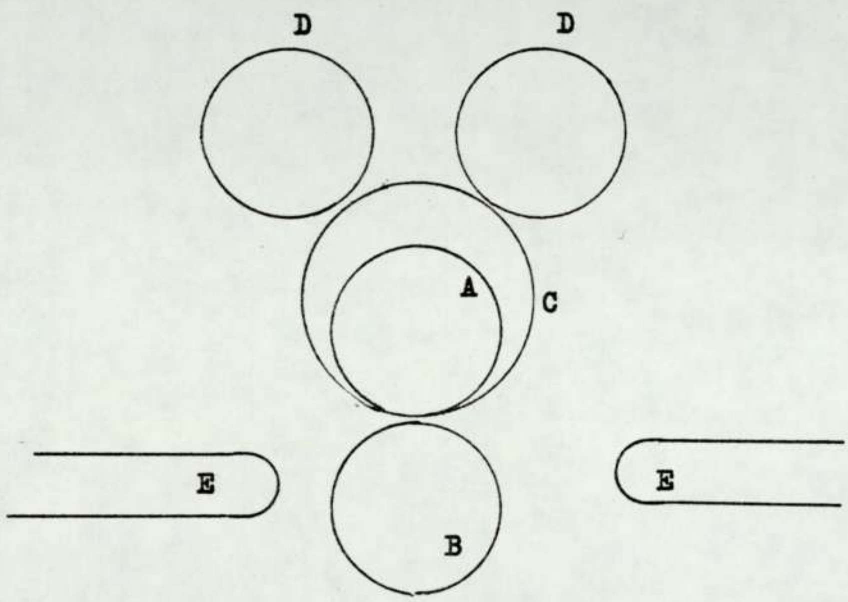
A visit was made to Rotaforme and samples of calendered rubber sheets were successfully cut at the factory.

Fig. 4.10 is a diagram of the machine. The attraction of the machine for blank cutting is that is can take drums of different diameters and widths, and hence can cut blanks of different lengths and widths.

As the cutter would be installed on the end of the calender line, replacing the guillotine, it would cut blanks from sheet still warm, and under tension in the conveyor. Hence the blanks would contract after cutting.

A sanction had previously been raised for the installation of cooling drums on one of the calender conveyors, which would reduce the sheet temperature to about 40°C.

An experiment was conducted to determine the extent of the



A Fixed axis roller

B Vertically adjustable pressure roller with plastic sleeve

C Cutting roller (tool)

D Adjustable supports for roller C

E Input and output tables (conveyors)

Fig. 4.10 The Rotaforme Rotary blank cutter shrinkage resulting from cooling. The shrinkage resulting from tension relaxation would be constant, and hence easy to allow for in tooling design.

The laboratory mills and calender were used to calender sheets of compound 3690, which were measured for shrinkage upon cooling. The calendering was carried out by the Car Mat assistant technician.

The results of the experiment are contained in the table below.

Calender bowl temperature	Compound temp. when blank cut	size of hot blank (mm)	size of blank at 20°C (mm)
50°C	40°C	1 x 280 x 1000	1 x 280 x 960
60°C	50°C	1.3 x 280 x 1000	1.3 x 280 x 957
70°C	50°C	2 x 280 x 1007	2 x 280 x 986
75°C	50°C	1.9 x 280 x 1000	1.9 x 280 x 968

Due to the difficulties experienced in conducting the experiment further tests were not made, although these would have obviously been desirable. However, the experiment indicated that shrinkage from a temperature of 40°C - 50°C was small (under 5%) and hence could be allowed for by designing the cutters with a small margin of error for shrinkage. The templates from which the blanks were cut manually had a similar margin as the blanks at the bottom of a pile shrink slightly as the top ones are removed.

A visit was subsequently made to Cambridge Street by the owner of Rotaforme and their chief engineer, who looked at the shapes required and decided that appropriate cutting tools could be made.

The cost of the cutting tools would be dependent on size, with an average, for the mats shown, of £400. The changing of the cutting tools is a rapid operation, and could be completed during the changing of veneer linings.

Estimate of cost saving resulting from the use of a Rotary Cutter

A quotation of £15,000 was received from Rotaforme for a 70" Rotary Cutter.

As 75% of Floor Mat turnover comes from the 20 largest selling mats, (see Pareto) 75% of blank cutting could be automated with the use of 20 cutting tools (assuming these 20 mats are not weighted about the mean in price). Hence the requirement of 4 blank cutters would be reduced to 1.

Two end men are required to stack the blanks accurately for the blank cutters. With the Rotary Cutter the same care in blank stacking would not be necessary, and so only 1 end man would be required for 75% of each of the two topping shifts, a saving of 1.5 men. As the end men are on occasion redeployed within the department, the savings of fractions of men is cost-wise sensible.

The total labour saving would be 4.5 men at approximately £4,000/man, a saving of £18,000 p.a. The first years savings would be about half of this as the machine would be progressively introduced.

The Rotary Cutter uses a 3 kW motor, equal to that of the guillotine, and so no extra energy costs would result from its introduction.

The total investment would be £15,000 for the Rotary Cutter, plus 20 x £400 = £8,000 for tooling, a total of £23,000.

The £23,000 investment would be recouped within 2 years.

Recommendations

It is recommended that the cooling drums, for which a sanction has already been raised, be installed on the 44 room calender, and that the Rotary blank cutter be installed on the end of the calender conveyor.

The 66 room calender would provide the rectangular blanks for manual blank cutting of the 25% of the blanks not automated.

4.2.5 Reducing the cost of compound

Raw material

The raw materials contained in the compounds account for approximately 40% of the total VWC, and hence consideration was given to the possibility of reducing this cost.

The gauge of the mats was specified by the customers, and hence no saving was possible there.

During previous cost reduction exercises, the quality of the Floor Mat compounds had been reduced such that any further saving in this area was impossible.

Reduced waste

The moulding of a blank which is punctured results in loss of vacuum at the puncture, which causes poor surface definition of the mould's pattern. The detection of punctured blanks prior to moulding would thus reduce cured mat rejects. However, only a very small puncture is necessary, which may not be visible to the naked eye.

The problems were discussed with the engineers and technicians but no practical solution was found.

4.2.6 The use of a four bowl calender

With a four bowl calender it is possible to calender both sheets of a 2-ply sheet simultaneously (ref. 1) eliminating the use of linings for veneers. The Aga Pirelli factory uses such a calender (see Appendix I).

The use of a four bowl calender does not result in any labour saving, as each sheet is in effect calendered separately; however its use eliminates the downtime necessary for the changing of veneer linings.

The average downtime per hour with a 3-bowl calender is 3 x 2½ minutes, as a lining will take about 20 minutes to top. With the 4-bowl, assuming a run of 1 hour, then a downtime of 2 minutes per hour would be required to change sheet width and gauge once.

Hence downtime would be reduced by 5½ minutes per hour, equivalent to an increase in productivity of 9%.

As the production requirements can be fulfilled with the existing calenders, the increase in productivity would not result in a saving as the calender gangs are specialised skilled labour and could not be redeployed elsewhere. Hence the 4-bowl calender would not result in a labour saving.

A quote for a four bowl calender of £200,000 was obtained from Iddon Brothers. The salvage value of the group's 2 existing calenders was zero. Hence the £200,000 net cost of the 4-bowl could not be justified by any significant saving.

4.3 Moulding

4.3.1 Autoclave design and lengthening of mould trains

Autoclaves for the moulding of floor mats must be designed by the criteria of labour utilisation, machine utilisation and steam consumption.

Steam consumption is proportional to the volume of the vessel and hence the efficiency with which the moulds are packed in the autoclave. The present pans use 2.1m^3 per transit mould, the Aga type pan uses 2.1m^3 and a single mould oyster pan - 2 m^3. The present pans could contain an extra mould by the lengthening of the mould train, reducing the volume required per mould to 1.6 m^3.

Considering machine utilisation, the pan is unproductive during the time taken for the moulds to be unloaded and reloaded. The interest charge per hour on a £30,000 pan (at 10% p.a.) is £0.82. As the pan depreciates this charge reduces accordingly, and is zero for the fully depreciated pans currently in use.

The moulding labour is unproductive when it has no moulds to unload and load. The cost of labour is approximately £4,000 per man, or £128,000 p.a. for the 32 moulders.

The Pirelli-Aga autoclaves were designed on the basis that the labour utilisation was the most important factor. The size of the mould trains was such that the time taken for it to be unloaded and reloaded equaled the curing cycle. In this way a team of moulders could operate 2 adjacent autoclaves with no idle time.

Their mould trains are 5.5 m long, and each double-ended autoclave cures two such trains simultaneously. Their cure cycle is twelve minutes.

In practice they found that a team of 5 female moulders could load an autoclave in considerably less than 12 minutes, and so they did not achieve the 100% labour utilisation hoped for.

The mould trains on the Automotive Group's autoclaves are 5 m long, and the curing cycle is 7 minutes. The time taken to unload and reload a mould train is dependent on the size and difficulty of the moulds involved, and varies between 2 - 10 minutes and in some special cases, over.

With such variation it would not be practical to try and match exactly the load and unload time to the curing cycle.

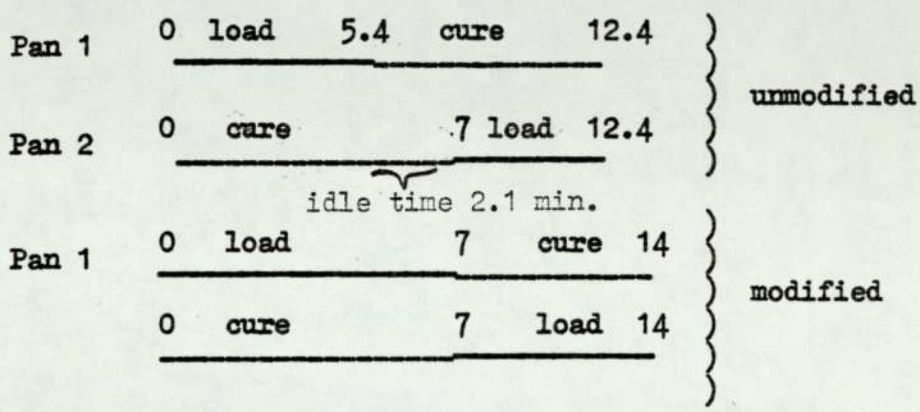
Lengthening of mould trains

The mould trains could easily be extended to a length of 6.5 m, without modifying the pan vessel, an increase of 30%. This extension would enable mould configurations at present falling below 7 minutes for loading and unloading to be added to increase the load and unload time. This would eliminate some under-utilisation of labour currently occuring and reduce steam consumption. The extension would cost £850 per pan.

Labour saving

As the moulders vary in ability and speed, calculations involving labour savings cannot be exact. The following example illustrates the magnitude of the potential savings.

The lengthening of a mould train previously requiring 5.4 mins. to load and unload would take 7 mins. to load and unload. A pair of moulders operating two adjacent autoclaves would have been idle for 2.1 mins. in the total 12.4 mins. load, unload and cure cycle. With the pans modified, the total cycle would be 14 mins. with no labour idle time.



In 14 minutes the 2 moulders would produce $\frac{7}{5.4}$ times the previous production in 12.4 minutes, an increase in productivity of

$$\frac{7}{5.4} \times \frac{12.4}{14} = 1.15 \text{ ,or } 15\%$$

As the moulders' earnings are split into roughly two halves, the first being fixed and the second proportional to performance, only half the increased productivity would give rise to cost savings. Hence the labour cost saving would be 7.5%.

Assuming 2 autoclaves were modified, the labour saving would be 7.5% of 4 moulders average earnings:- .075 x 16000 = £1200 p.a. (as the pan would be worked on both shifts.)

Reduced steam consumption

The autoclaves, when used unmodified, require an average of 400 lbs/hr of steam. Hence a pair of autoclaves, used on two 40 hour shifts, 48 weeks per year, would consume 1.54×10^6 lbs of steam per year. This would cost £2690 p.a. with steam at £1.75/1000 lbs (fuel plus labour costs).

By increasing the capacity of the autoclaves by a factor of 1.3, the saving in steam cost would be

$$£\left(2690 - \frac{2690}{1.3}\right) = £620$$

Total savings

The total savings would be £620 + £1200 = £1820 p.a.

However the labour savings were calculated using an example which gave the maximum possible saving. Due to variations in moulders ability, and the possibility of the two pans getting out of phase, this maximum would rarely be achieved.

If a saving of 30% of this maximum is achieved, the total yearly saving would be £360 + £620 = £980

Thus the pay back (not discounted) period would be under 2 years.

Cash Flow

The modification, costing £1700, and considering only the steam cost saving gives the following cash flow, discounting at 30% the £620 yearly savings.

Year	Cash flow discounted at 30%	
0	(1700)	
1		477
2		367
3		282
4		217
5		167
6		128
7		98
8		76
9		58
10		45
	(1700)	1915

Hence, based on the steam saving alone the modification gives a return of over 30% on the investment.

Conclusion

Incorporating the labour savings the £1700 investment would have a pay back period of under two years. Considering only the steam savings, which are definite, the return on the investment is over 30%.

Recommendations

It is recommended that an adjacent pair of autoclaves have their mould trains extended by 1.5 m at a cost of £1700, and that the use of these autoclaves be subsequently monitored.

Provided no unforseen difficulties arise, further pairs of autoclaves should subsequently be modified.

4.3.2 Variation of moulding cycle time with mat gauge

All mats were moulded on a standard cycle of 7 minutes, except for the new Volvo assembly mat which was moulded on a 9½ minute cycle. However, it seemed likely that the time required to cure a mat would be dependent on the thickness of the mat. It was decided that an experimental investigation into this relationship should be carried out.

A survey of the distribution of the gauge of mats moulded in 1977 to 28:5:77 was made, and is contained in fig. 4.11. It was based on the 23 largest running mats, representing 79% of the total.

The experiment to determine cure time dependence on gauge was performed by the group's technician. Calendered sheet of compound 3235 of gauge 1.5 mm to 4.5 mm were cured in a hot air oven over a range of times from 2 minutes to 15 minutes. Hence for each gauge of mat a range of cure times was performed. The resulting samples were then tested for permanent set (at 100% elongation) tensile strength and modulus (at 100% elongation). These tests were the standard tests for cure.

From the results the technician estimated the following cure times, as illustrated in fig. 4.12.

Gauge (mm)	Cure time (min)
1.5	4
2.25	6
3	8
4.5	9
6	12

MAT THICKNESS (mm)	NO. OF MOULDINGS (% of total)	
1.52	64,805	(39%)
2.29 and 2.41	43,732	(27%)
3.05	46,458	(28%)
3.8 and 4.06	3,727	(2%)
5.08	6,463	(4%)
TOTAL	165,185	(100%)

FIG 4.11

Distribution of mat gauges, based on the 23 largest running mats

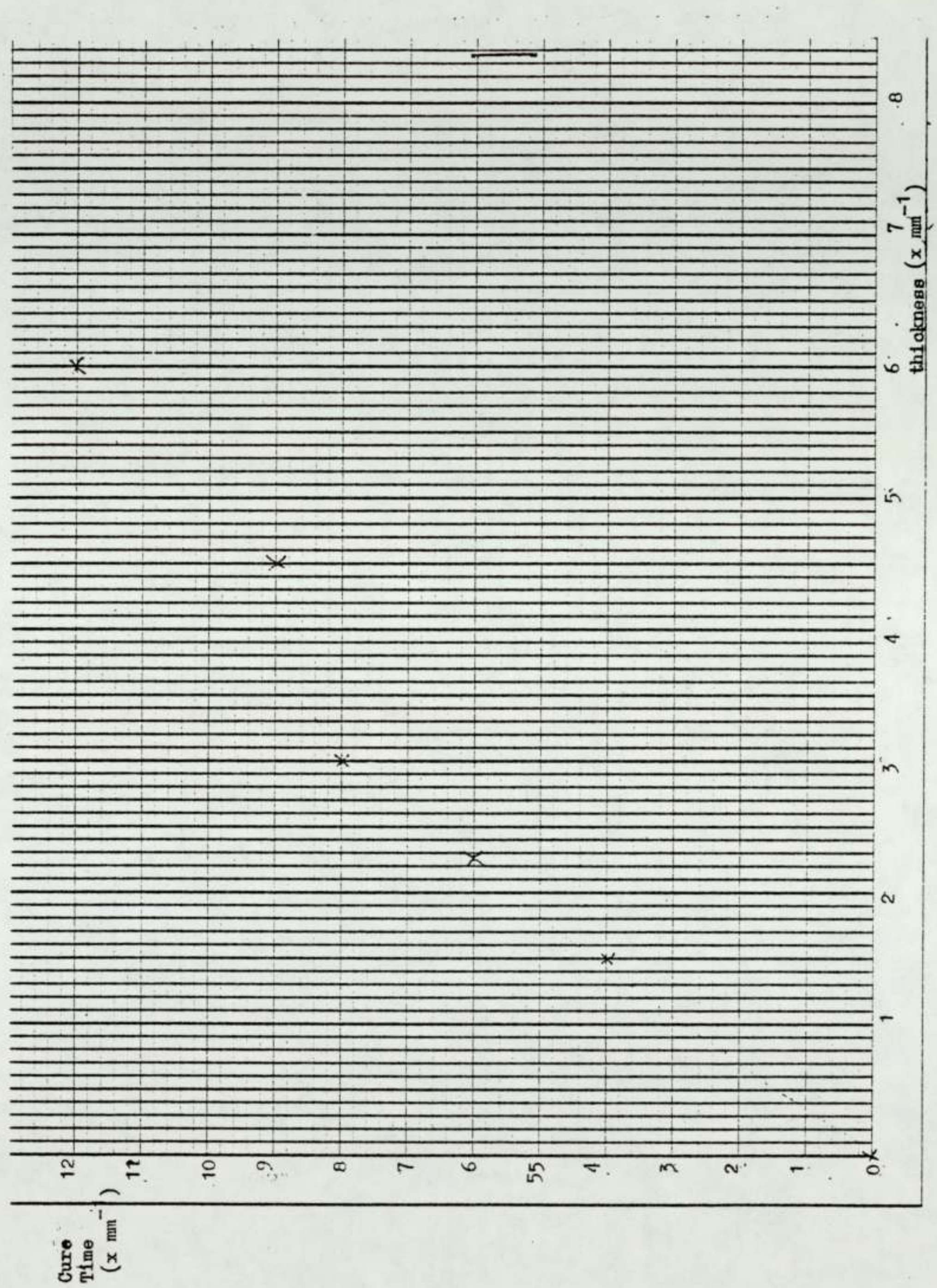


Fig. 4.12 Cure time against mat thickness

The technician qualified the results to the extent that the cure took place in a hot air oven rather than in a steam autoclave. The results nevertheless showed that a similar range of cure times would exist in a steam autoclave.

In practice, the thick mats achieve sufficient strength even if they are not fully cured throughout, which is why all the mats were adequately cured in the standard 7 minute cycle.

The curing of mats of gauge 1.5 mm and 2.25 mm in a 5 minute cycle would reduce steam consumption. These mats could be allocated to a set of autoclaves programmed to the shorter cycle.

Saving in steam

The mats of gauges 1.52 mm, 2.29 mm and 2.41 mm represent 66% of the total by number (see fig. 4.11). However, these mats are in general smaller in area as well, and it was estimated that they would represent only 33% of the total in area, and hence in steam usage.

The total cost of steam for the 16 pans used 2 shifts per week, 48 weeks per year was

$$\frac{£1.75}{1000} \times 400 \times 40 \times 2 \times 48 \times 16 = £43,008$$

The steam used in the pans goes approximately 75% in filling the pans and 25% in running them. The reduction of the curing cycle from 7 to 5 minutes would not reduce the number of fillings, and so would only save on the running cost.

The total saving would be

$$£43{,}008 \times .33 \times .25 \left(1 - \frac{5}{7}\right) = £1014$$

Increase in production

The moulding of the mats on a 5 minute cycle would increase productivity of these mats. However, as the group has excess moulding capacity this would not be of benefit.

Conclusion

The saving in steam of £1014 would result from the moulding of all mats of 1.5 to 2.41 mm on a cycle of 5 minutes.

However the allocation of these mats to special assigned pans would complicate the Production Planner's job. The moulds are allocated to pans such that each pan has a minimum moulding labour content, to ensure the moulders' piece work performance, and the additional allocation constraint of gauge would reduce the permutations available.

Recommendations

It is recommended that no change be made to the current 7 minute standard curing cycle.

4.3.3 Conversion of the pans to double-ended pans

The conversion of the pans to double-enders with two mould trains, enabling one mould train to be loaded while the other cures, would increase the output of each pan by a factor of 1.6. The current output achieved on 16 pans could be achieved on 10 double-ended pans. The cost of the conversion is £3250 per pan.

The conversion results in a slight decrease of area, but no decrease in steam consumption.

Area per pan	=	408 ft^2
Area per double-pan	=	604 ft^2
=> Area per 16 pans	=	6528 ft^2
=> Area 10 double-pans	=	6040 ft^2
=> Area saved	=	488 ft^2

This would result in a cost saving in rent and rates (at £1.92/ft^2) of £937.

Conclusion

The conversion of 10 pans to double-enders would cost £32,500 and yield a cost saving of £937 and so the conversion is not viable.

Recommendations

It is recommended that no pans are converted to double-enders.

4.3.4 Other improvement ideas in the moulding area

Several other possibilities for improving the moulding operation were considered.

An increase in temperature and hence pressure of the steam would result in more rapid cure. This was not realisable as the steam was supplied from central factory boilers which could not be adjusted to suit the Floor Mat department.

The attachment of a cutter round the periphery of the moulds would enable the moulders to trim off excess sheet, and hence eliminate the blank cutting operation. However, during the time taken for the moulder to form the blank to the mould, and then trim off the excess, the trimmings, in contact with the hot mould could be partially cured and hence not recalenderable. To determine whether this scheme was possible an experimental mould would need to be fitted with the periphery cutters.

The steam from the autoclaves is just blown away upon completion of the cure, with no attempt made to extract any heat from it. This steam is contaminated after contact with the rubber, and hence special pipes would be required in a heat exchange unit to resist corrosion.

4.4 Finishing

4.4.1 Increased automation in finishing

One of the principal differences between the manufacturing methods of Pirelli Aga (see appendix I) and of Automotive Group, was the almost total automation of the Aga finishing operation by the use of double-ended presses. It should be noted, however, that the Aga mats were moulded on the "assumed shape" principle, whereby the flexible mat is allowed to form itself to the car floor, and hence the moulded shape is much flatter. Automotive Group mould the mat to the exact shape of the car floor, and hence the mats can be very contoured, resulting in increased difficulty in automating the finishing.

The Femco cutting machines used at Cambridge Street are large double-ended roller presses. The moulded blanks are located onto the cutter by means of studs. The cutter and mat are manually pushed under the cutting board. The cutting board descends onto the mat hydraulically and the roller passes twice over the board.

The machine is operated by two men as considerable effort is required to slide the mat and cutter under the cutting board.

Only a small proportion of mats were finished in this way. The advantages over hand finishing were in cutting heavy duty mats, making complicated cut-outs in a single operation, and in giving a consistently good quality finish.

Comparison of hand and Femco finishing rates

The standard hour value of the Ford Tranist Large mat on the Femco was 25.81 for all conditions of the mat, compared to 26 to 30 for manual finishing.

The motor (3.7 kW) on the Femco runs for 6 seconds per cycle, giving an hourly cost of electricity (at £1.81/kWhr and 80% efficiency) of:-

$$\frac{3.7}{.8} \quad x \quad 25.81 \quad x \quad \frac{6}{3600} \quad p \quad = \quad .20 \text{ p}$$

This cost was negligible compared to the labour costs.

Hence for the rates achieved on the above mat, the benefits of an improved finish need to be weighed against the slightly slower rate.

The Rollerpress

A number of firms constructed rollerpresses similar to the Edwards Rollerpress (see fig. 4.13). The price of the machines was dependent upon the width of the rollers as illustrated by the Cundell price list:

30" - £2,400

41" - £2,750

54" - £3,600

60" - £6,545

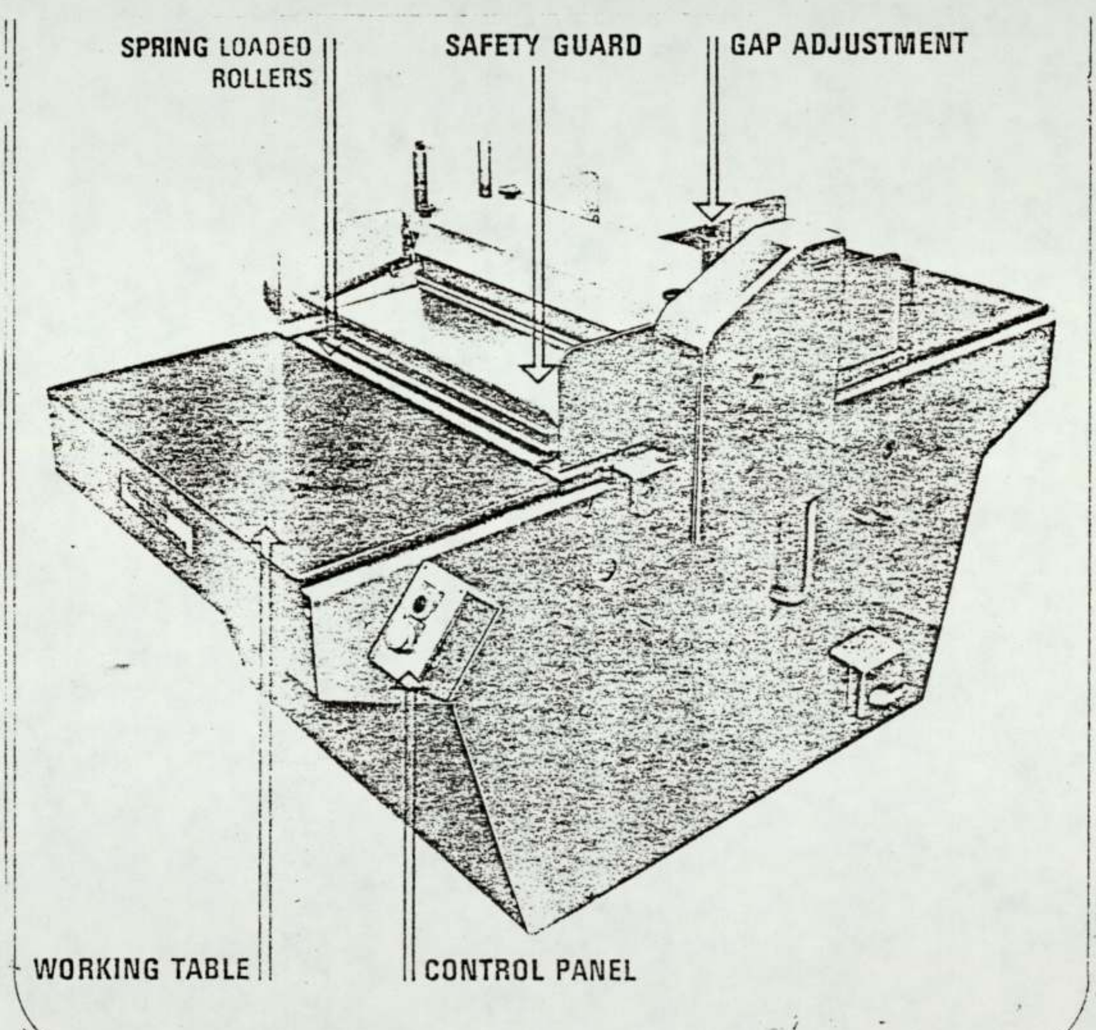


Fig. 4.13 THE ROLLERPRESS

The advantages over the Femco were a smaller overall machine size, the elimination of physical effort in introducing the mat under the roller, which is drawn in automatically, and that the mat passes only once under the roller, and is unloaded and reloaded the other side. The latter two points were thought to give rise to improved rates.

A meeting was held with a representative from Cundell and Norther Press-Knife Co. Ltd., manufacturers of ribbon cutters for rollerpresses, and no technical problem was foreseen in cutting flat and slightly contoured mats.

The possibility of cutting highly contoured mats with a 3-D cutter in conjunction with a female cutting board was discussed. This type of system could only cut horizontal surfaces, and any sloping surfaces would have to be cut separately.

Recommendations

It is recommended that a 60" rollerpress be purchased at a cost of £6,545. The machine should be tooled for some of the mats and the suitability of the machine be established. Precise cost savings could then be established, and the use of rollerpresses extended, if the savings justified it.

4.4.2 T-square for stepmat

The rear stepmat for the CV 306 bus (British Leyland) was cut to shape from continuously vulcanised fluted sheet, purchased from the C.V. Department. The rolls were cut by hand into 3 unit blanks, which were cut into 3 stepmats on the clicker press.

During 1976 a high proportion of mats were returned due to the fluting being skew to the edge of the mat. During November 1976 1000 units at £.23, totalling £230 were returned.

This problem was not financially important, but it was decided to investigate it as it would give direct contact with shop floor operatives, which would be useful in subsequent project work.

Due to the blanks being placed fluted side down on the cutter, neither the fluting nor the cutter could be aligned, and as the blanks were hand cut from rolls, the cut edge was not at right-angles to the fluting and could not be used as a guide. The longitudinal edge was not straight.

The problem could be solved by cutting the blanks such that the cut was perpendicular to the fluting, enabling this edge to be aligned with a guide on the cutter.

A T-square was designed such that a lip along its base fitted into the fluting. The T-square was manufactured by the draughtsmen, and the cost (£12) covered by tooling. The length of the T-square fixed the lengths of the blanks, and the amount of scrap was reduced by cutting the blanks 4" shorter than previously. This resulted in a reduction of material cost of 8% as the number of blanks obtained from a standard roll of 37.5 ft was increased from 11 to 12.

Savings

In 1977 £938 of stepmats were sold. As from the adoption of the T-squarein March 1977 no rejects were returned.

A saving also resulted from the 8% material saving.

4.5 General

4.5.1 Investigation into work-in-progress and finished goods levels

During the early 70's after the Dunlop-Pirelli merger, a period of financial stress was experienced, resulting partly from the merger and partly from the generally depressed state of the rubber industry. The cash flow was poor to the extent that measures had to be taken to ensure payment of wages and salaries. These measures included the minimisation of work-in-progress levels and finished goods stocks.

In the years '75, '76 and '77 Dunlop's financial position improved considerably. However, no official relaxation of the minimisation of stocks had been made.

It was decided to investigate the actual influence on production efficiency of the very low work-in-progress and finished goods levels.

Stock levels and stock turnover ratio

The work-in-progress levels and finished goods stocks during 1976 for the Floor Mat department were:

Date	work-in-progress (£)	finished goods (£)
opening 1976	73,101	35,531 (at 24.1.76)
26.3.76	59,590	22,559
22.6.76	54,208	10,479
24.9.76	66,726	26,261
23.12.76	52,996	6,885
average	61,324	20,343

The total average stock level was £81,667. The turnover of floor mats in 1976 was £1.9 m, giving a total stock turnover ratio of just over 23 (ref. 2).

<u>The influence of stock levels on production</u>

4.5.1 (i) <u>Calendering</u>

Calendering output needed to keep the moulders supplied with blanks. As no proper stock of calendered blanks was kept, the calender production was directly linked to moulding output.

The vast majority of blanks were veneered mats, which were calendered with veneer from linings. The linings were of two lengths; 150 yards and 300 yards, the longer linings being used for the narrower and thinner gauge mats.

Once the lining was emptied, calender production stopped and a full lining was fitted, a process taking 2 - 3 minutes. This created a natural break in calendering during which both gauge and width of sheet could be altered. Hence there was no benefit in calendering a particular blank for greater runs than the duration of one lining.

Therefore increased calendered blanks stocks to uncouple calendering production from moulding would not increase calendering efficiency.

(ii) <u>Blank cutting</u>

The manual blank cutting method required no down time in changing blank shape. Hence no benefit would result from longer production runs possible with a buffer store of shaped blanks.

(iii) Moulding

Mould changes were made at the weekend with no interference with production output. Increased stocking of moulded mats would necessitate fewer mould changes, but the cost of mould changes was small. Floor mats also had surplus autoclaves, and frequently mould changes were avoided by keeping moulds on all the autoclaves.

(iv) Finishing

No downtime came from changing mats with manual finishing. The changing of cutters on the Femco required only a matter of a minute. As the Femco was used for only a small number of mats, very little cutter changing was required.

Hence no significant benefits would arise on finishing from increased finished goods levels.

(v) Batch size

The size of the batches of blanks was dictated by the length of the calender linings. To reduce downtime these were made as long as possible, given the maximum lining weight which could be handled. Only the mixing and calendering operations were batch processes.

Conclusion

The efficiency of the floor mat manufacturing operation would not have been significantly improved by the increase in stock levels. The levels then obtained were sufficient to ensure constant supply of work to all the functions.

Recommendations

It is recommended that no change be made to the present policy of minimising work-in-progress and finished goods.

4.5.2 Mat rough costing method

Introduction

The normal procedure for handling cost enquiries is for firstly the floor mat technician to draw up a process sheet for the mat. This is then sent to the cost accountant who will send it to the engineers for a tooling cost estimate and to the industrial engineers for a labour estimate. The cost accountant then works out the material costs and produces a final VWC. The cost sheet is then returned to the sales office who make a quote to the customer for the mat.

This procedure, though comprehensive, is very lengthy, and delays of up to 3 months can occur between the receipt of an enquiry to the return of an offer.

During visits to France with the Product Manager, several enquiries were received which subsequently took a long time to return, and this could only have reduced the chances of successfully obtaining the business.

As first quotes in any case, formed only the basis of negotiations, a quick rough costing method which would enable an immediate reply to an enquiry would be of benefit to the group.

Method of approach

It was decided that the rough costing method should eliminate the lengthy processes of the standard method, i.e., the sending of the enquiry around several departments. Hence a system which could be based solely on the technicians process sheet was sought.

As the floor mats manufactured and previously costed fell into several distinct categories whose mats would all be related, a system could be compiled making use of the existing costs of a range of standard mats.

Hence the floor mat technician was requested to supply a list of mats, with technical specifications, which could be used as standards. The cost sheets for these mats were then obtained from the cost accountant, which broke the VWC down into the constituent parts of the material and labour costs. This information is contained in fig. 4.14

Various ratios were then calculated, such as compound cost over mat volume. Certain of these ratios came out roughly as constants, and hence these constants could be used to estimate costs for mats.

The final rough costing method

The technician firstly estimates the cut blank area, and the gauge of the mat to be costed. He then specifies whether it will be a veneer or a plain rubber mat, whether it would have an insulating layer, and the number of layers of latex or glue required in assembling the mat. The VWC of the mat can then be estimated as follows:-

COST BREAKDOWN

PRODUCT	COMPOSITION	COMPOUND(S) x GAUGE	FINISHING	MOULD AREA	LABOUR				COMPOUND	LATEX	OTHER MATERIALS
					OTHER	BLANK CUTTING	MOULDING	FINISHING			
Brenda Rear	Solid rubber mat	3235 0.090"	Hand trimmed periphery + cut out	14.9 ft^2	.068	.0897	.2787 .4955	.1271	.8632 (.886)		
Large Transit Front	Hytone Mat	6649 0.008" 3690 0.087" (overall) 0.095"	Machine cut (Femco)	17.3 ft^2	.1316	.1084	.2840 .5331	.1407	1.3884 (.2719)		
R & D Upper 1	Hytone mat with Autoair felt insulation + rubber block	6649 0.008" 3690 0.112" (overall) 0.120" Autoair felt = 18 mm thick	Hand trimmed periphery + punch & cut. Stick on rubber block. Stick down felt insulation	26.3 ft^2	.2811	.1762	.4705 1.1545	.5078	2.8714 (.4559)	.4738	2.8655
Volvo long cab	Hytone mat with Jute felt insulation + skin rubber backing (Moulded composite)	6649 0.010" 3235 0.115" (mat) 0.125" Skin backing 3235 0.035" Jute felt 10 mm thick	Machine trim (Femco)	14.3 ft^2	.1458	.1560	.3635 .6247	.1052	1.4016 (.2064)	.640	1.0632
4' bus rear	Hytone mat	6649 0.008" 3690 0.087" 0.095"	Hand trim periphery and several cut-outs	21. 8 ft^2	.1636	.1217	.2986 .6307	.2104	1.6206 (.1855)		
"G" cab bulkhead	Solid rubber mat	3690 0.090"	Machine cut Beam press	2.86 ft^2	.0207	.0205	.0453 .1006	.0348	.1975 (.0555)		

Fig. 4.14

(i) Cost of compound

a) Solid rubber mat £.7 per ft^2 per inch gauge

b) Veneer mat £.8 per ft^2 per inch gauge

(ii) Other material (where applicable)

a) Insulating layer £.08 / ft^2

b) Latex or glue (per layer) £.02 / ft^2

c) The cost of any other material, such as rubber blocks must be estimated.

(iii) Labour

a) Mill labour £.08/ft^2/inch gauge

b) Calendering and blank cutting labour £.007/ft^2

c) Moulding labour £.017/ft^2 except for the Volvo assembly type mat at £.025/ft^2

d) Finishing labour £.009/ft^2

(Note: calendering, blank cutting, moulding and finishing labour total £.033/ft^2 or £.041/ft^2 for Volvo type mat).

(iv) Variables

Variable costs = total labour x 1.21

The VWC then is the sum of (i), (ii), (iii) and (iv)

Accuracy

Several mats were costed in this way and the cost compared to the VWC calculated with the standard procedure. An accuracy of ± 10% was obtained. The accuracy of ± 10% would be adequate to initiate negotiations on supplies of mats and hence would eliminate the long response time.

Recommendations

It is recommended that a full statistical testing, based on a large sample of existing mats, be carried out, and that confidence limits for the method be established.

If these limits prove acceptable then it is recommended that the system be adopted for answering queries.

If the confidence limits prove unacceptable then it is recommended that modifications be made to the method until sufficient accuracy is achieved, and that the modified method be then adopted.

4.6 Conclusion and recommendations

The investigations carried out into the operations of the group generally gave rise to a picture of an operation in which costs had been already reduced to a minimum, subject to the limitations imposed by the site.

The lack of control over materials and labour had resulted from a gradual degeneration over several years, linked to industrial disputes. This situation had not been aided by the fact that the group did not have autonomy over its own union negotiations, the personnel and industrial engineering departments being involved.

The following cost savings are recommended:-

a) The installation of a conveyor from the Mill Dept. to the 44 room calender at a cost of £5,000, with a saving of £48,400 in the first year and £60,200 in subsequent years.

b) The introduction of the proper use of the job tickets to eliminate calender overbooking. Increased control should be exercised over mill deliveries and the calender gangs use of compound, with wage concessions if necessary, to reduce the misusage of compound to £49,000 p.a., a saving of £49,000 p.a.

c) The installation of the Rotary Blank cutter at a cost of £23,000, including tooling, resulting in a saving of £9,000 in the first year and £18,000 in subsequent years.

d) The lengthening of an adjacent pair of autoclave mould trains at a cost of £1,700 with a saving of £980 p.a.

e) The purchase of a 60" Rollerpress at a cost of £6,545.

f) The final testing and adoption of the rough costing method.

To implement all the above recommendations, the total cost would be £36,245, with quantified savings of £107,380 in the first year and £128,180 in subsequent years (at 1977 levels of production).

Unquantified savings include:- improved industrial relations in the calendering area as a result of tandem running and improved wage rates; improved response time to cost enquiries giving better service to new and existing customers; the possibility of an improved finishing operation by increased automation.

CHAPTER 5

Long Term Investigation

5.1.1 The reasons for the investigation

Automotive Products Group holds a 78% share of the U.K. market for automotive rubber flooring, and a 20% share of the European one. Competitiveness in these markets is based chiefly on price and flexibility in delivery.

The group's price competitiveness derives from a supply of cheap and willing labour, chiefly first generation immigrants. Due to the increased expectations of labour in terms of wages and working conditions, the high physical fatigue factor in many of the jobs in the group and the poor level of cleanliness, lighting, ambient temperature and odours all contribute to increasing difficulty in the recruitment and keeping of operatives.

The group manufactures in a multi-product factory, the rest of which produces mainly custom designed products, generating high overheads. The division of the Cambridge Street site into a number of small rooms suitable for small production units does not allow the development of an efficient layout for a mass producing group.

Hence as the labour costs of the group are forced to rise, its poor performance in layout and high overheads will cause the group to lose its competitive edge.

Hence to maintain its share of the U.K. market, and to obtain growth in the European one, the group must improve its operations. In the previous chapter, the improvements realisable in the Cambridge Street site were discussed, and a cost saving of 8% in the VWC estimated as the maximum achievable.

It was thus decided to investigate further improvements achievable at a new site, where total freedom in the conception of the manufacturing and marketing operation exists.

5.1.2 First developments in the possibility of a move

The possibility of a move first arose out of contact between the Manchester Corporation and the Director of G.R.G. Division. The Corporation informed Dunlop and other industrial concerns in the city area that vacant buildings and sites were available, and that financial assistance would be offered to aid any redevelopment (see ref.3) The corporation, in expectation of government legislation to encourage the redevelopment of inner cities, had in fact allocated a fund for this purpose. Furthermore, general government incentives to industrial development existed, not specifically related to inner cities (see ref.4 to 9).

Automotive Group had previously stated that if investment was not received, then the group would become uncompetitive, and the group would need to be run down. Hence, in light of the Corporation's move, the group was asked to produce an outline of an independent automotive operation. As this was closely related to the work in this project, the author was asked to investigate and prepare the outline, indicating the number of employees and the floor area involved etc. In this way the research project became linked with on-going considerations in the development of the Cambridge Street factory.

5.1.3 Further developments and the arrival of the module concept

No immediate feedback followed the circulation of the outline described in the preceding section. The next impetus in the long term developments came from the Newcastle Board of the Dunlop Industrial Group. Following a London Board directive that 700 employees was the maximum manageable unit size (Cambridge Street has 900), and the recent government moves to encourage the redevelopment of industry in city centres, the Newcastle Board allocated funds for the redevelopment of Cambridge Street.

To reduce the size of the unit required the splitting up of the operation. Thus the Director proposed the creation of a number of units, based between new sites and perhaps Cambridge Street. These units would be a natural extension of the factory's product group structure (see chapter 2), and were termed "modules".

The Product Managers were asked to produce plans for independent operations of their product groups, deriving the capital investment required.

5.1.4 The preparation of proposals

The author was asked to investigate and prepare the proposals for the Automotive Module. The proposals would be used to present the module to senior management and the board, and in writing the proposals the expectations and requirements of the readers needed to be considered (ref 4).

The proposals would need to completely define the module in terms of the products involved, the manufacturing methods, the number of employees and the factory size. Marketing information on the products would be required, and the employees would need to be fitted into an organisational structure.

An outline of the capital investment and a forecasted return on the investment, analysing the viability of the module, would be essential to enable the management to consider it.

Hence the management would have a complete description of the module, as well as a financial analysis of its operation, on which an investment decision could be made.

An interim set of proposals were also required so that negotiations could be begun with the Manchester Corporation concerning sites, and so that the Newcastle Board could get a first estimate of the proposed capital requirement.

These initial proposals were produced within two weeks of the undertaking of the module proposals. They also formed a useful reference point for the writing of the more detailed and exact final proposals, and facilitated discussion concerning the module with other people.

5.1.5 The module proposals and corporate strategy

Effective long term corporate strategy has become increasingly difficult to devise over the past few years. A period marked by economic fluctuations from boom to slump, inflation to deflation, coupled with a proliferation of government legislation influencing business, have resulted in a rapidly changing and unpredictable business environment. (ref. 11, 12, 13).

The time horizon in a corporate strategy has of necessity been shortened. There is now therefore a trend (ref 14) towards the consideration of specific business development projects rather than more general corporate strategies.

A large corporation can delegate the generation of business projects to its constituent units, which are then adopted or otherwise to further the corporation's business.

In this way the Cambridge Street redevelopment and the module proposals, being specific projects capable of implementation in the short term, can be examined as part of the overall Dunlop strategy, and can form an important part in the implementation of that strategy.

5.2.1 The products involved in the Automotive Products Module

Automotive Group manufacture and market floor mats, and also market mudwings, Rolls Royce Door Seals, and some extrusions, the latter three products being manufactured by other product groups.

The marketing of all the above products by Automotive Group has several advantages. It eliminates duplication of representative's work from different product groups servicing the same customer. Furthermore, by marketing several products, the group increases its total market presence, with each product reinforcing contacts for the other products (ref 15)

These benefits should be extended to the module, and as the technology for the manufacture of the other products is simple, it was decided to include them in the module's production. This would also have the benefit of eliminating the conflict which arises in Cambridge Street due to the discrepancy of interests between Automotive Group and the manufacturers of the other products.

The extrusions marketed by Automotive Group generate only a very small turnover. However, the equipment required for their manufacture is specialised, and the sales generated could not justify the inclusion of this equipment.

Dunlop Iberica manufactures automotive sound packages from EVA, a thermoplastic. The mixing and calendering of EVA is identical to that of rubber floor mat compounds, except that it is carried out at a higher temperature. To mould the sound packages, EVA blanks are warmed on hot plates and vacuum formed on cooled moulds. The processing of EVA could thus easily be included in the module. The group's contacts in the automotive industry would facilitate the marketing of the product, and therefore EVA was included in the modules product mix. EVA was not processed at Cambridge Street as a tandem process between mixer and calender is required for its production to be viable.

5.2.2 The business plan and market sheet

Automotive Group's existing 10 year plan (1977 to 1986) was extended for one year. Furthermore the extrusions were removed from the plan to give the modules 10 year forecast (see fig. 5.1) Air spoilers are a sister product to mudwings with the same manufacturing process. The thermoform panels are a recent development of the group, manufactured on an existing thermoforming machine.

Based on the group's existing sales, a market sheet for the module was derived (fig. 5.2)

The PYE motorstat (ref 16) was used to find the total U.K. anc European output of passenger cars and commercial vehicles for 1977. The total markets for the products concerned were obtained by multiplying the piece price for each unit by the number of units produced. Thus the group's market shares were derived by dividing 1977 sales by the total markets.

The market sheet, though only rough, illustrates the importance of the European market, particularly for passenger cars, to the group's future expansion.

AUTOMOTIVE PRODUCTS GROUP - BUSINESS PLAN (at 1977 prices) (£000's)

		1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987
FLOOR MATS												
HOME	Passenger Cars	557	594	200	200	100	100	100	100	100	100	100
	Trucks	1118	1329	1400	1500	1550	1550	1600	1650	1650	1700	1700
	Sound Package	0	0	500	600	700	700	850	900	1000	1000	1000
EXPORT	Trucks	328	447	800	1001	1000	1200	1200	1350	1400	1400	1450
	Sound Package	0	0	80	100	120	120	150	150	150	150	150
TOTAL FLOOR MATS		2003	2370	2980	3401	3470	3670	3900	4150	4300	4350	4400
	Rolls Royce Seals	145	120	120	120	120	120	120	120	120	120	120
	Mudwings	200	250	400	450	500	500	600	600	650	650	650
	Thermoform Panels	40	40	40	40	40	40	40	40	40	40	40
	Air Spoilers	50	50	250	300	350	400	400	500	500	500	500
TOTAL OTHER AUTO		435	460	810	910	1010	1060	1160	1260	1310	1310	1310
GRAND TOTAL		2438	2830	3790	4311	4480	4730	5060	5410	5610	5660	5710

Fig. 5.1

Market Sheet

	1977 Total Market (£)	1977 Dunlop Share (£)	%
1. Rubber Flooring Passenger Cars			
U.K.	610,000	480,000	79
Europe	4,590,000	-	-
Commercial Vehicles			
U.K.	1,530,000	1,200,000	78
Europe	2,100,000	420,000	20
2. Mudwings			
U.K.	1,270,000	200,000	16
3. Rolls Royce Door Seals	145,000	145,000	100

FIG. 5.2

Market Sheet

5.3 Module manufacturing methods

5.3.1 Formulation of compound supply method for the module

The module would need a supply of compound for all its products, and it was necessary to identify the most efficient method of meeting this need. Fig. 5.3 gives the forecasted module compound usage. This was derived assuming usage proportional to product turnovers, and existing compound usages to meet 1977 turnovers. The EVA compound requirements were derived from the average cost of an EVA sound package, its average weight and the forecasted turnover.

The traditional compounding method used at Cambridge Street, of an internal mixer feeding mills was the most common in the rubber industry, However, more recent developments in rubber processing technology had been made, particularly in the processing of powdered rubbers and in the use of alternative equipment to mills in handling an internal mixer discharge. It was also necessary to consider buying in mixed compound, both from within and without the Dunlop group.

In tackling this problem the knowledge gained during a visit to the Rubberex '77 exhibition was extremely useful. It was also necessary to draw from many other sources of information, including experts from within Dunlop and the manufacturers of rubber processing machinery.

The floor mat department technician was able to supply essential information on the technical properties of the compounds concerned.

Year	Compound calendered on tandem	Batched-off compound	EVA	Rolls Royce Seals
78	3348	622	0	10
79	3384	962	910	10
80	3825	1055	1100	10
81	3744	1136	1290	10
82	4032	1224	1290	10
83	4050	1290	1570	10
84	4380	1407	1650	10
85	4440	1463	1810	10
86	4500	1470	1810	10
87	4570	1478	1810	10

Fig. 5.3 Forecasted compound usages (000k)

The advice obtained from the different sources varied enormously and was often contradictory, and it was necessary to analyse the reasoning behind the advice to ascertain its relevance to the problem under consideration.

Finally a number of technically possible mixing alternatives were arrived at.

The sources and information obtained were as follows:-

a) Rubber machinery manufacturers

Contacts had been made at the Rubberex '77 (ref 17) with manufacturers of rubber processing machinery, and further contacts were made through the trade journals (e.g., Plastics & Rubber Weekly). Representatives from the companies were met and the range, function, performance and cost of the available machinery established (ref 18).

b) Dunlop Research Centre

A visit was made to the Reseach Centre to discuss the problem with their compounding expert, Mr. D. Norbury.

The research centre was in fact more concerned with the physical properties of compounds than the technology of mixing them, but useful information was nevertheless obtained.

Powdered rubbers were discussed. It was felt that the premium paid for powdering rubbers was not justified by the subsequent benefits. The main benefit is a reduction in mixing time, but this varies between compounds.

The continuous mixing of powdered rubbers was still in its infancy, and large capacity machines had yet to be developed. These type of machines were already in use in the plastics industry, where dispersion problems did not exist to the same extent as in rubber.

The different makes of internal mixers were discussed, and the Shaw Intermix was favoured over the Bridge Banbury for improved cooling and easier servicing.

c) <u>Dunlop Hose Division</u>

A visit was made to the Dunlop Hose Division where the use of powdered rubbers was discussed with the factory's senior engineers, Mr. C. Evans and Mr. D. Cavanagh.

The Dunlop Hose Division was in fact the only part of Dunlop using powdered rubbers, and their engineers were considered experts on the subject.

Three different methods of compounding powdered rubbers were outlined. The use of conventional rubber processing machinery; the use of high speed powder mixers feeding compactors and mills; the continuous mixing of powdered rubbers in mixer-extruders.

The first method was in use by the Hose Division who claimed that the reduction in mixing cycle times and energy consumption more than offset the increased raw material cost.

The second method uses a compactor, a funnel-shaped extruder which compresses mixed powders.

The third method was in development and the Hose Division worked in conjunction with Farrel-Bridge on their MVX mixer extruder.

The in-house grinding of baled rubbers into powdered rubbers was also discussed. The term powdered rubbers covers powder grain diameters from 8 mm to 1 mm., the former correctly termed granular rubber. The Hose Division were experimenting with the different sizes to identify that most economically favourable.

Being the only users within Dunlop of powdered rubbers, the Hose Division would have liked support in their choice.

It was suggested that the use of a roller-die could replace the calenders. The roller-die is a 2-roll calender placed directly on the end of an extruder, thus eliminating the labour required to feed a calender.

d) Cambridge Street Technical Department

Advice was also sought from the Cambridge Street technical department. It was suggested that a dump extruder could be used to handle the internal mixer discharge, thus eliminating mill labour.

e) Fort Dunlop

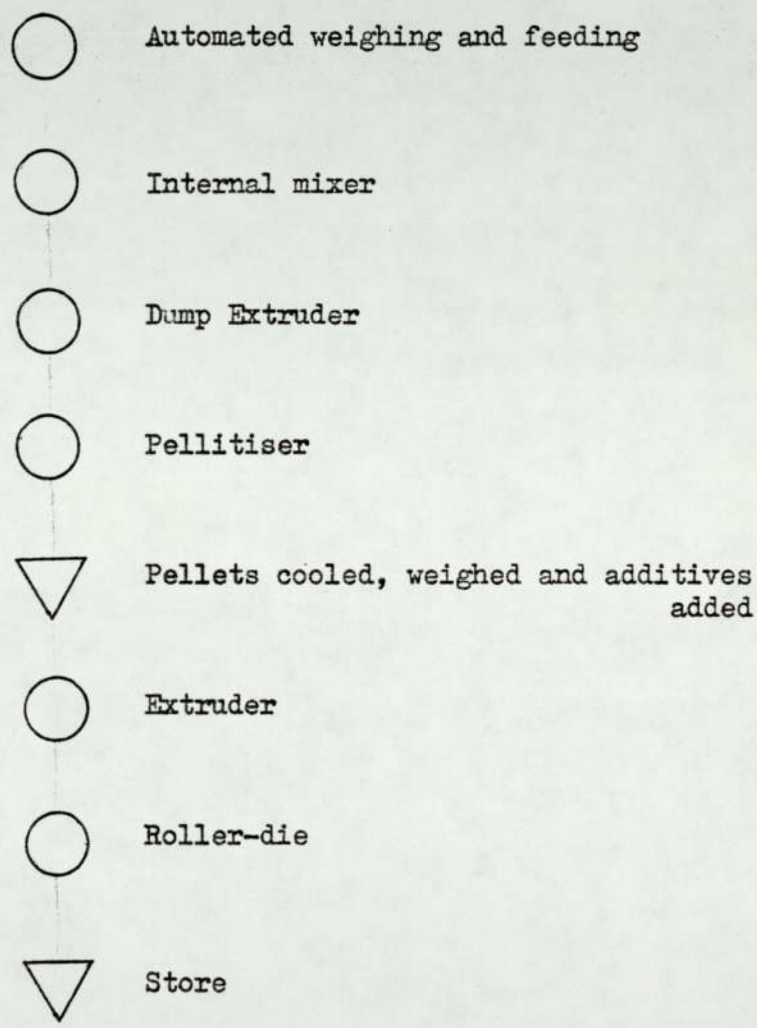
Fort Dunlop, in the manufacture of tyres, used vast quantities of rubber. A visit was made there to discuss rubber compounding for the Automotive Module with Mr. M. Peakman, the Fort Dunlop compounding specialist.

A new mixing unit had been set up at Fort Dunlop, and this was visited. The unit (see fig. 5.4) was semi-continuous, making use of a dump extruder, and a roller-die. It was suggested that such a mixing unit was far too complex for the module's requirements, and that the use of a dump extruder would result in problems with the fast curing of car mat compounds.

As the dump extruder requires a constant stock of compound to work on, its feed hopper must always contain some compound. Hence a batch from an internal mixer must take at least as long to feed into the extruder reserve as is taken for the mixer to discharge the next batch.

Part of the batch therefore remains at discharge temperature (about 120°C) for at least as long as the mixing cycle, plus the time to pass through the extruder. A Pirelli factory had installed a dump extruder and just managed to process a compound curing in 10-12 minutes. Hence problems of curing could be expected in floor mat compound with a 4 minute cure. To avoid this the compound would have to be made slower curing, reducing moulding output, or the curatives would have to be added, after the compound had passed through the dump extruder, requiring 2 stage mixing, or the mixing speed would have to be reduced until the discharge was of a sufficiently low temperature not to cure.

It was suggested that as a single stage mixing process was suitable for floor mat compounds, the use of an internal mixer feeding dump mills which immediately cool the compound, could not be improved



<u>Fig. 5.4</u> West Mill at Fort Dunlop

upon, and would offer most flexibility. The use of stockblenders on the mills enables one operator to handle two mills, and improves the consistency of the output.

Two mills subsequent to the mixer enable a buffer stock to be built up between the mixer and the calender, necessary for tandem running. In the case of a mixer breakdown conventional warming of premixed compound could be reverted to.

f) The Dunlop Angus Industrial Group mixing report

This report was written from within the group and analysed the state of mixing throughout the group. The new technologies for compounding were also discussed (ref 19).

The main conclusions of the report were that there was a general overcapacity in mixing within the group and that the existing mixing capacity was split into too many small and inefficient mixing units, as opposed to a few central large mixing units.

The report would obviously influence any decision concerning new mixing equipment for Cambridge Street modules.

List of processing options

After all the sources had been consulted and the information received appraisal, the following list of processing options was produced.

a) An internal mixer feeding 2 mills with stockblenders on a tandem with the calender

In this system the feeding of the mixer is semi-automated. The consultants T.A. Shore designed the feeding system, costing £65,000 which is described in appendix 3. The system has the advantages of reducing labour, and keeping all the powders enclosed, hence tidying up the working area and improving working conditions. The latter is particularly important if the mixing is to be on tandem, and adjacent to the calendering. An alternative system of feeding using vacuum equipment was found more expensive.

A trial mixing session was carried out at Francis Shaw on their laboratory K3 intermix. Ten 27 litre batches of ingredients for compounds 3235 (backing compound) and 6649 (veneer compound) were prepared by Cambridge Street technical department and transferred to Francis Shaw. The batches were mixed and passed through a mill, and samples taken, so as to establish the ideal mixing speeds and cycle times.

It was established that mixing cycles of 3 minutes on a speed of 33 r.p.m. were sufficient. The samples tested by the Car Mat technicians gave a better mix than the compound received from the Mill Department at Cambridge Street.

It was decided to base cost calculations on a 5 minute mixing cycle, to make allowance for industrial relations problems.

A batch-off unit would be included to cool and store compound for the cold feed extruders and the veneers.

The stockblenders were incorporated onto the mills to improve milling consistency, and to enable one man to operate both mills.

A flow chart of this system is in fig. 5.5

b) An internal mixer feeding a dump extruder and slabber-mill through to the calender

In this set-up the mixer discharge is fed into a dump extruder which produces"chops" of compound which pass through a slabber mill, forming a continuous sheet for feeding the calender.

Although it was doubtful that this system would work, due to the problems of compound curing inside the extruder,it was included so as to evaluate its potential cost saving.

The same feeding system is used as in (a). Fig. 5.5. contains a flow chart of this system.

A warming mill would be required for uncured scrap.

c) The use of powdered rubbers in system (a)

A cycle reduction of 25% was estimated to result from the use of powdered (2 mm) rubbers. This was estimated bearing in mind the low polymer content of floor mat compounds. A premium of 7p/k for powdered rubbers was used.

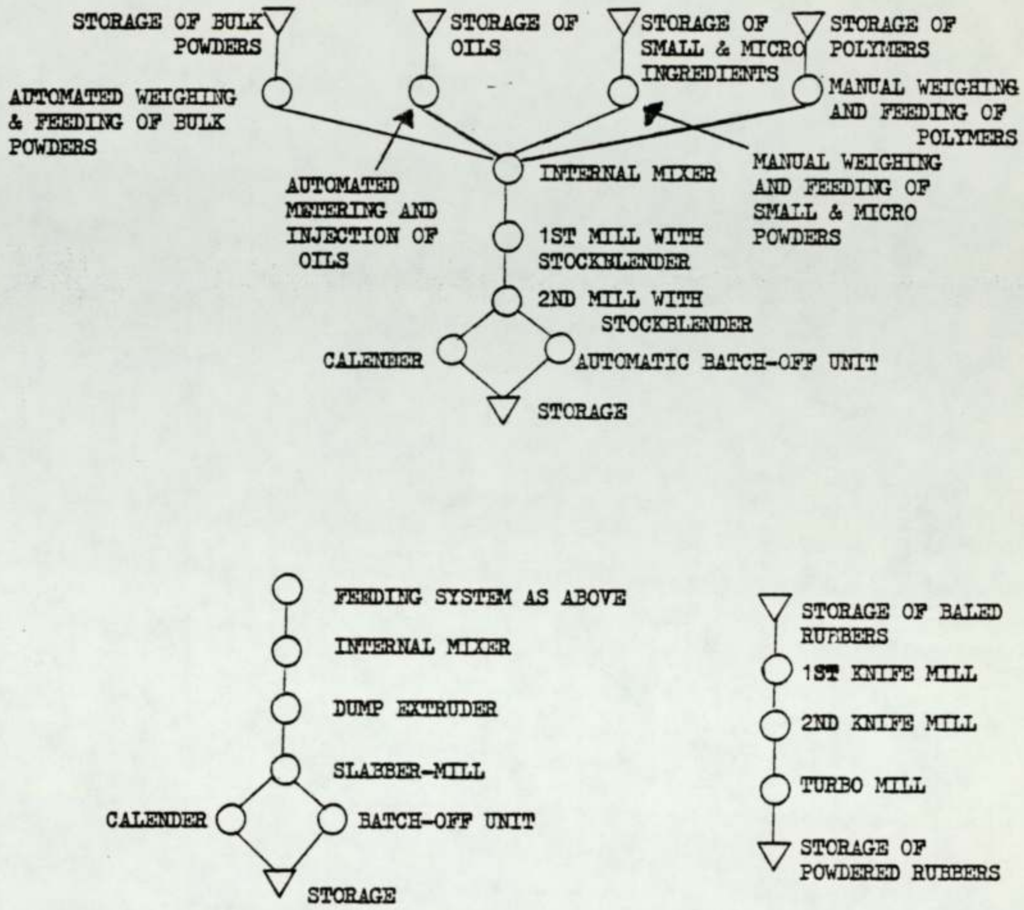


Fig. 5.5 Flow charts for processing methods

The cost of feeding equipment was higher as the powdered rubbers needed storing and feeding.

d) The in-house grinding of rubbers to produce powdered rubbers to feed system (a)

Brookside Size Reduction Ltd. were consulted on the grinding of baled rubbers.

Three steps are required to reduce efficiently bales into 2 mm powders. A first knife mill chops the bales into nuggets of 50 mm, which can be reduced to granules of 8 mm in a second knife mill. The final powdering is carried out in a turbo (very high speed) mill.

A set-up producing 400 k/hr of powdered polymer, which would meet the ten year plan, would cost £120,000, require 2 operators and consume 150 kW.

Fig 5.5. contains a flow chart for this method of grinding baled rubbers.

e) The buying in of mixed compound

On costs for buying in mixed compound were obtained from the Cambridge Street buying department. The cost was 30% to 40% above the Cambridge Street variable works cost.

f) Transferring mixed compound from Cambridge Street

This system involved feeding the calenders at the module from compound mixed in the Cambridge Street Mill Department.

g) Transferring mixed compound from a new central G.R.G. mixing unit

In this system it was assumed that the new mixing unit would mix as efficiently as that proposed for the module.

Further processing methods finally judged as not feasible were:

a) <u>The use of a mixer extruder to process powdered rubbers</u>

Three manufacturers of mixer extruders were contacted: Farrel-Bridge, Troester and Werner and Pfleiderer. All the machines were still in development stages and none could meet the capacity requirements of the module.

b) <u>The use of a roller-die to replace the calenders</u>

The roller-die was originally designed to produce thick gauge sheets for shoe soles. The necessity of constantly varying gauge and width of sheet for floor mats rendered the roller-die unsuitable. The roller-die would not be capable of calendering the thin veneer sheets.

c) <u>The use of a dump extruder to feed the calenders as well as produce the extrudate for mudwings</u>

This initially attractive option, eliminating the need of an expensive piece of equipment,(the extruder for mudwings) was not technically possible.

To prevent build up of temperature a dump extruder works against a very low nozzle pressure, whereas high nozzle pressure is required to properly define the shape of an extrudate.

Costing of the mixing alternatives

To compare the costs of the mixing alternatives previously outlined, only direct labour and power were considered, assuming that other variable costs (lighting, maintenance etc.) and overhead costs (administration, rent etc.) would be equal for all the methods.

The production of calendered sheet was used as a basis for comparison, though the module would require also cooled and stored compound.

a) An internal mixer feeding 2 mills with stockblenders, on tandem with the calender

The following equipment would be required:-

Item	Cost (£)	Power Consumption (kW/hr)	Labour
Feeding equipment	65,000	-	2
K6 internal mixer	145,000	500	
84" mill with stockblender	51,000	100	1
"	51,000	100	
Conveyors	10,000	10	
Calender, anti-stick, cooling and blank cutting line	25,000	110	2
TOTAL	347,000	820	5

The K6 has a capacity of 112 litres, giving a batch weight of

179k (S.G. 1.6). Based on a 5 minute mixing cycle an output of 2148 k/hr would be achieved. The net output with 20% downtime would be 1718 k/hr.

Cost per kilo:

5 men at £2.08/hr	=	£10.40/hr
820 x .8 kW at £.02/kWhr	=	£13.12/hr
Total	=	£23.52/hr
⇒cost per kilo	=	£.0137

b) An internal mixer feeding a dump extruder and slabber mill through to the calender

The following equipment would be required:-

Item	Capital Cost (£)	Power (kW/hr)	Labour (men)
Feeding equipment	65,000		
K6 internal mixer	145,000	500	2
Dump extruder, slabber mill	100,500	140	
Calender, and end line	25,000	120	1
Warming mill	42,000	100	1
Total	377,500	860	4

The output would be 1718 k/hr as in (a). The cost per kilo would be:

4 men at £2.08/hr	=	£8.32/hr
.8 x 860 kW at £.02/kWhr	=	£13.76/hr
Total	=	£22.08/hr

⇒cost per kilo = £.0129

c) <u>The use of powdered rubbers in system (a)</u>

The cost of feeding equipment is increased by £20,000 as the powder rubber feeding is automated. This results in a reduction of 1 man.

The premium for the powdered rubber is 7p/k. A cycle reduction of 25% was assumed to result from the use of powdered rubbers in system (a).

The output on a mixing cycle of 3.75 min., 20% downtime and 179 k batches would be

$$179 \times \frac{60}{3.75} \times .8 \text{ k/hr} = 2291 \text{ k/hr}$$

The cost per kilo would be:

4 men at £2.08/hr	=	£8.32/hr
.8 x 820 kW at £.02/kWhr	=	£13.12/hr
Total cost	=	£21.44/hr
⇒cost per kilo	=	£.00936

The premium for powdered rubbers = £.07 x .25/k = £.0175/k

Thus the total cost = £.0269/k

d) The in-house grinding of rubbers to feed system (c)

The capital cost = £140,000 for the grinding equipment

Cost of powdered rubber:

2 men at £2.08/hr	=	£4.16/hr
150 kW at £.02/kWhr	=	£3 /hr
Total	=	£7.16/hr

The output of the powdering system would be 400 k/hr thus the cost of powdering the rubber is £.0179/k.

Hence the in-house grinding of rubbers compares favourably with the buying of powdered rubbers (£.07/k)

The cost of processing the powdered rubber would be as in (c). i.e., £.00936/k. With a 25% polymer content and in-house grinding an on-cost of £.00448/k is incurred.

The total cost of calendered compound is £.0138/k

e) Transferring mixed compound from Cambridge Street

The mill room at Cambridge Street is less efficient than that proposed for the module, and hence the mixing costs would be greater.

The following equipment would be required:

Item	Cost (£)	Power (kW/hr)	Labour
Feeding			2
Mixing		500	1
Mill		100	1
Mill		100	1
Cooling		10	3
Stacking, storing			
Total mill		710	8
Cracker	40,000	100	1
Mill	40,000	100	1
Mill	40,000	100	1
Calender and end line	25,000	110	2
Conveyors	10,000	10	
Total calendering	155,000	420	5

(i) <u>Milling and calendering costs</u>

The output of the mill room, with 227 k batches, 11 minute mixing cycle and 20% down time is 990 k/hr.

8 men at £2.08	=	£16.64
.8 x 710 x £.02/kWhr	=	£11.36
total		£28.00

⇒mill cost = £.0283/k

5 men at £2.08	=	£10.40
£.8 x 420 at £.02	=	£ 6.72
total	=	£17.12

Cost = £.0095 (at 1800 k/hr)

The total cost of milling and calendering is:-

£.0095/k + £.0238/k = £.0378/k

(ii) Storage and transport costs

A buffer stock of mixed compound would be required in the case of bought-in compound. On the basis of a stock of 1 weeks supply 70,000 k would be required. This would consist of 7000 k veneers at £.4962/k and 63000 k other at £.2493/k, giving a total value of £19,179.

At 10% interest this would cost £1918 p.a.
Furthermore a storage area of 2240 ft^2 at £1.80/ft^2 rent and rates p.a. would cost £4032 p.a. (For 1986 compound requirements, 16 ft^2/pallet and 680 k/pallet).

The cost of transport from Cambridge Street to a factory within the Manchester area was estimated by the traffic offices at £175/week.

Thus the total cost of storage and transport per annum = £12,082
This equals £.0038/k for 70,000 k/week, 46 weeks per year.
Thus the total cost of calendered compound equals:
£.0378/k + £.0038/k = £.0416 k

f) The buying-in of mixed compound

The following table shows the on-cost of buying in mixed compound assuming a cost of 35% above the Cambridge Street VWC.

Compound	1977 VWC (£/k)	1977 bought-in premium = VWC x .35(£/k)	1977 forecasted usage (000k)	bought-in on-cost (£)
6649	.4962	.1737	156	27,000
3235	.2493	.0873	1000	87,000
3690	.2117	.0741	1490	110,000
3702	.5077	.1777	200	36,000
3012	.3393	.1187	149	18,000
3691	.20	.07	300	21,000
6646	.2745	.0961	30	3,000
Total			3325	302,000

This compound would need to be calendered with the following equipment

Item	Cost (£)	Power kW/hr	Labour
Cracker	40,000	100	1
Mill	40,000	100	1
Mill	40,000	100	1
Calender end line	25,000	110	2
Conveyor	10,000	10	
Total	155,000	420	5

Stockblenders could not reduce the milling labour as the compound needs constant attention when cold.

As at Cambridge Street, an output of 1800 k/hr including downtime could be achieved.

5 men at £2.08	=	£10.40
420 x .8 x £.02	=	£6.72
Total	=	£17.12

⇒ cost = £.0095/k

The bought-in on-cost is $\frac{£302 \times 10^3}{3325 \times 10^3}$ = £.0908

⇒ total cost per kilo = £.1003/k

Plus storage and transport costs = £.0038/k (see (e))

total cost - £.1041/k

g) Transferring mixed compound from a new central G.R.G. mixing unit

The fictitious mixing unit in this method was based on the proposed module mixing unit.

The following equipment would be used:

Item	Cost (£)	Power (kW/hr)	Labour
Feeder	65,000		2
K6 intermix	145,000	500	
84" mill plus stockblender	51,000	100	1
"	51,000	100	
Conveyor	10,000	10	
Batch-off unit	32,000	10	1
Cracker	40,000	100	1
1st Mill	40,000	100	1
2nd Mill	40,000	100	1
Calender and end-line	25,000	110	2
Conveyors	10,000	10	
Total	509,000	1140	9

The output would be 1718 k/hr as in (a)

9 men at £2.08/hr	=	£18.72
.8 x.1140 kW x £.02/kWhr	=	£18.24
		£36.96

=>cost per kilo = £.0215

Storage and transport costs as in (e) of £.0038/k would also be incurred

=>total cost = £.025/k

Discussion of results

The results are summarised in fig. 5.6 and the cost of producing the forecasted calendered outputs (not including veneers) for years 1978 - 1982 is shown. The difference in cost for each method compared to method (a) is shown in the second column in each case.

Financially, method (b) is not viable, with a very long pay back period. This method using a dump extruder, would need to be experimentally tested. The large value of the compound materials, compared to the labour and energy costs, make the loss in flexibility of this method, and its risk of curing compound a poor proposition.

Both methods (c) and (d) for processing powdered rubber involve a greater capital outlay, and produce more expensive compound, so neither is viable.

Of the methods involving transferring compound to the module both (f) and (g) are obviously not viable. Method (e) saves £192,000 capital expenditure over method (a) but method (a) pays that back within three years.

It must also be emphasised that the loss of the tandem operation by transferring compound has other detrimental effects.

The importance of the reduction of labour fatigue in the calendering area resulting from the tandem operation is great, and this would improve industrial relations. The tandem operation also results in full control over the supply of compound, as previously discussed.

METHOD	(a)	(b)	(b-a)	(c)	(c-a)	(d)	(d-a)	(e)	(e-a)	(f)	(f-a)	(g)	(g-a)
Capital(£)	347,000	377,500	30,500	367,000	20,000	487,000	140,000	155,000	(192,000)	155,000	(192,000)	509,000	(162,000)
Output (k/hr)	1718	1718		2291		2291		990		1800		1718	
Cost £/k	.0137	.0129		.0269		.0138		.0416		.1041		.025	
Cost of producing calendered output (not veneers) for years -(£)													
1978	45,900	43,200	(2700)	90,100	44,200	46,200	300	139,300	93,400	348,500	302,600	83,700	37,800
1979	46,400	43,700	(2700)	91.000	44,600	46,700	300	140,800	94,400	352,300	305,900	84,600	38,200
1980	52,400	49,300	(3200)	102,900	50,500	52,800	400	159,100	106,700	398,200	345,800	95,600	43,200
1981	51,300	48,300	(3000)	100,700	49,400	51,700	400	155,800	104,500	389,800	338,500	93,600	42,300
1982	55,200	52,000	(3800)	108,500	53,300	55,600	400	167,700	112,500	419,700	364,500	100,800	45,600

(i)

Year	Calendered (not veneer) (k000's)	Value (£) at £.2493/k
1978	3348	834,700
1979	3384	843,600
1980	3825	953,600
1981	3744	933,400
1982	4032	1,005,200

(ii)

(i) Comparison of cost of producing calendered compound (not veneered) for forecasted outputs., 1978 - 1982

(ii) Forecasted calendered outputs (not veneer) 1978 - 1982 and average value of material content of output

Fig 5.6

Recommendations

It is recommended that the module have its own mixing facilities with automated feeding, and a tandem operation with the calender.

Fig. 5.7 is a flow chart of the recommended method.

Note:-

A detailed report was prepared (appendix IV) which compared the costs of supplying all the compounds (not just the calendered) to the module by the following methods:-

(i) The installation of new mixing facilities at the module

(ii) The transfer of mixed compound from Cambridge Street

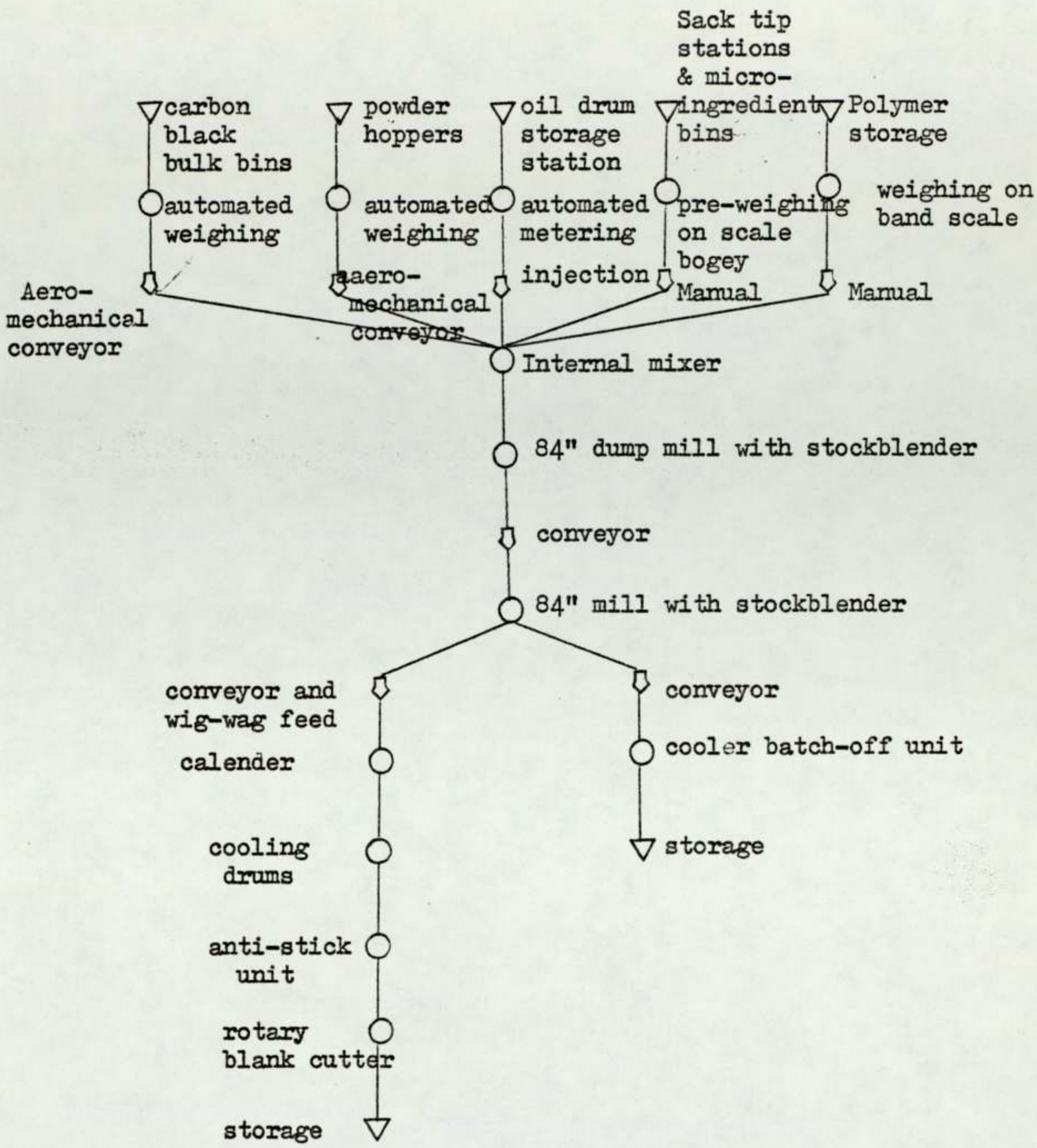
(iii) The transfer of mixed compound from a new central G.R.G. mixing unit.

(iv) The transfer of mixed compound from Skelmersdale

(v) The buying-in of mixed compound from outside the Dunlop group

(vi) The transfer of an existing mixer from Cambridge Street

This report was based on the work previously described, but did not contain the alternative technologies to the standard processing of baled rubbers with internal mixers and mills. It was orientated towards the options under consideration at the time by the senior management of the factory.



<u>Fig. 5.7</u> Flow chart for the proposed automotive products module mixing facilities

5.3.2 Formulation of the rest of the processing method

In this section only changes from the Cambridge Street operation are discussed.

Calendering and blank cutting

The possibility of using a four bowl calender was rejected in section 4.2.6.

Discussions were held with the maintenance engineer on the calenders' conditions. The cost of reconditioning the 66 room calender was estimated at £6600 and the 44 room calender at £21,400. These calenders would then be transferrable to a new site. The cost of new 3-bowl calenders is far in excess of the reconditioning costs.

Based on a ratio of 150,000 lbs/week of compound per £2m turnover in calendered products, and a calendering rate of 4,000 lbs/hr on topping and 800 lbs/hr on veneers, 82.5 hours per week would be required to meet the 1979 forecasted output. Hence as from 1979 two shifts on one calender would not suffice, and it is recommended that both calenders be reconditioned and transferred to the module.

It is also recommended that the 44 room mills and cracker, required at the module for calendering veneers be reconditioned at a cost of £11,500 (estimated by the maintenance engineer) and transferred to the new site.

The automation of blank cutting was discussed in section 4.2.4.

It is recommended that a rotary blank cutter be installed at the module on the 44 room calender end line, on which the cooling drums would also be installed. The cost of the blank cutter plus tooling is £23,000.

Extruding blanks for mudwings and Rolls Royce door Seals

The use of cold feed extruders would eliminate the labour required for warming compound for warm feed extruders. Cold feed extruders also give rise to a better extrudate as the compound is extruded at a more constant temperature than in warm feed extruders. The variation of compound temperature in warm feed extruders arises from the variation in warming of the compound by the operatives.

Samples of Rolls Royce door seal compound, and mudwing compound were sent to Troester, manufacturers of cold feed extruders, who reported that no problem would arise in cold feed extruding the two compounds.

Quotes for an 8" cold feed extruder for mudwings and a 1½" cold feed extruder for Rolls Royce door seals were obtained at £76,800 and £12,280 from Farrel-Bridge, with a combined delivery and installation charge of £1,000.

The use of these cold feed extruders was discussed with the departmental manager in charge of Rolls Royce seals and mudwings. He agreed the benefits of cold feed extrusion.

It is recommended that the module be equipped with two cold feed extruders as described above, for manufacturing mudwings and Rolls Royce seals.

Moulding

The cost of reconditioning and reval·ving the pans was estimated at £3,500 per pan by the engineers.

Based on the ratio of 16 pans per £2m floor mat turnover, all 23 pans would be required to meet the 1982 turnover forecast. Hence it is recommended that all 23 pans be reconditioned at a cost of £80,500, and transferred to the module.

It is also recommended that 10 of these pans have their mould trains extended, (as discussed in section 4.3.1) at a cost of £8,500. The total cost of reconditioning and modifying the pans would thus be £89,000.

Finishing

The automation of finishing using rollerpresses was discussed in section 4.4.1. Two 60" rollerpresses, if installed at the module would enable experimentation to be carried out on automated finishing.

It is thus recommended that two 60" rollerpresses be installed at the module at a cost of £13,090.

Storage and transport equipment

A quote for storage racks for raw materials, work-in-progress, and finished goods was obtained at £5,000.

It is recommended that the storage racks be installed at the module.

5.3.3 Summary of the recommended processing method

Fig. 5.8 is a flow chart of the recommended module processing method.

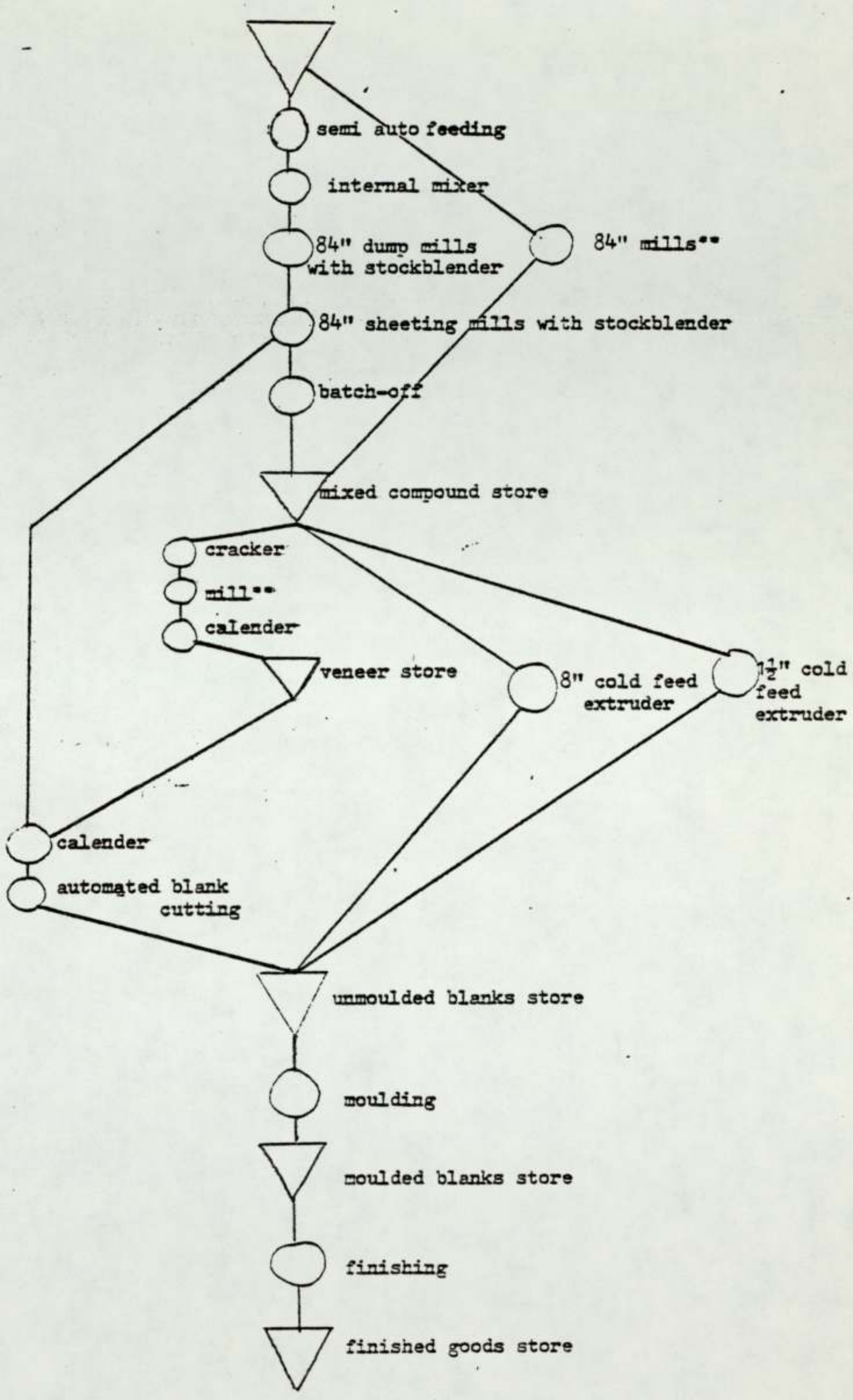
The recommended method is a vertically integrated operation, which carries the following advantages:-

(i) A cost saving in labour and energy over a non-vertically integrated operation buying in compound.

(ii) The ability to process EVA on the tandem basis, thus enlarging the module's produce base.

(iii) The elimination of the most physically demanding job in the Cambridge Street factory; the warming of cold mixed compound for calendering. This will be of importance in the field of industrial relations.

(iv) No dependence on outside supplies of compound. The module will have total control over the supply of compound which is important to a business supplying the automotive industry, where flexibility in schedules in an important selling factor.



** denotes same piece of equipment

Fig 5.8. Production flow chart

5.3.4 Floor area requirements for the module

A detailed breakdown of the manufacturing and storage areas used for floor mats, mudwings and Rolls Royce door seals was made from factory plans and shop floor measurements (see fig. 5.7).

The areas required to meet the 1977 level of turnover in a new factory with the manufacturing methods recommended in the previous sections are shown in fig. 5.7. These areas were calculated bearing in mind changes in manufacturing methods from the Cambridge Street operation, and any overcapacity existing at Cambridge Street.

The areas required to meet the 1986 level of turnover in the new factory are also listed in fig. 5.9. It was assumed that no significant changes (to floor areas) would take place within the floor mats, mudwings and Rolls Royce door seals product mixes. Hence variable areas, such as finishing, were assumed to be proportional to turnover. No change in machine linked areas was made unless further machines were required to meet capacity.

The areas for the moulding of the new product EVA were compiled in conjunction with the technician. A 700 ft^2 moulding station would be required to meet £400,000 turnover. As EVA mats would be of similar price to rubber mats, calendering and finishing areas were assumed to bear the same ratio to turnover as floor mats.

The storage areas incorporated the use of multi-layer storage. The area for finished goods was increased from Cambridge Street due to the shortage of space there.

FUNCTION	PRESENT AREA		NEW FACTORY AREA 1977		NEW FACTORY AREA 1986	
		Sub Totals		Sub Totals		Sub Totals
Endwings						
Extruding	3200		1540		1540	
Finishing and Inspection	2330		1451		4715	
Moulding and Curing	1720	7250	1075	4066	3494	9749
Rolls Royce Door Seals						
Extruding	1500		710		710	
Moulding and Curing	1600	3100	1600	2310	1600	2310
Calendering						
Car mats and EVA	6740	6470	7500	7500	7500	7500
Blank cutting						
Floor mats and EVA	2060	2060	520	520	1120	1120
Moulding						
Floor mats	11640		11638		13160	
EVA	0	11640	0	11638	2100	15260
Finishing						
Floor mats	23410		18370		29390	
EVA	0	23410	0	18370	10510	39900
Thermoform Panels	2000	2000	2000	2000	2000	2000
Compounding						
Feeding and internal mixer	-		2500		2500	
Small powder weigh station			300		300	
Dump mill, 2nd mill and batch-off		-	1830	4630	1830	4630
Storage						
Raw materials			3048		5000	
Mixed compound	1970		1970		4650	
Blanks	2180		1860		4000	
Finished goods	4000	8150	7200	14078	17100	30660
TOTAL PRODUCTION		64080		65112		11329
Offices and laboratory			6000		6000	
Canteen, recreation rooms, V.C.'s			5000	11000	5000	11000
TOTAL				76112		124129

Fig 5.9 - Floor areas

The non-production areas were estimated. It was assumed no increase in staffing levels would be required to meet the 1986 forecast.

5.3.5 Layout

Fig 5.10 (a) shows a layout enabling expansion to meet the 10 year business plan. The layout has been broken down into individual areas for each function. The shape of the areas takes into account the machinery they contain. For example the calendering area contains two calenders and take-away conveyors side by side, and the floor mat moulding area contains two rows of 13 autoclaves.

The layout has been devised to meet the following criteria:

(i) The minimisation of transport of work-in-progress

(ii) The grouping of the mixing and calendering operations to enable tandem running

(iii) The separation of the heavy engineering functions from the offices, canteen and recreation areas to prevent the former interfering with the working of the latter.

(iv) The grouping of the moulding areas to facilitate steam connections

(v) The grouping of the finishing areas.

The boiler would be housed with the other service machines outside the factory area as is usually the practice.

Each of the areas makes allowance for passages.

Fig 5.10 (b) shows the flow of work through the factory for the different products. The layout is similar to that used in the Pirelli-Aga factory, with raw materials entering the factory at one end, and finished goods leaving the other. Hence road access would be required at both ends.

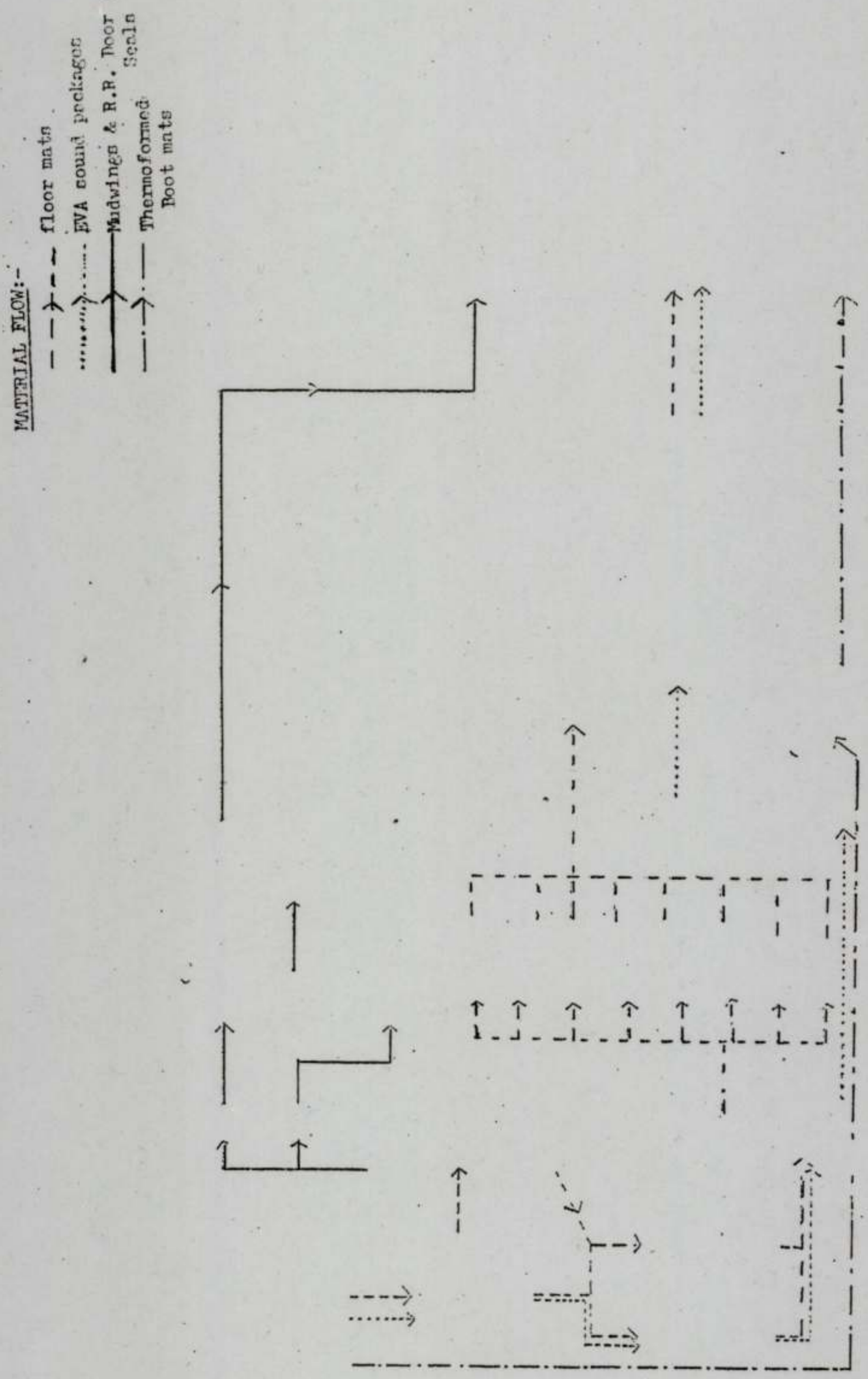


Fig. 5.10 (b) Material flow (Fold back for fig, 5.10 (a)).

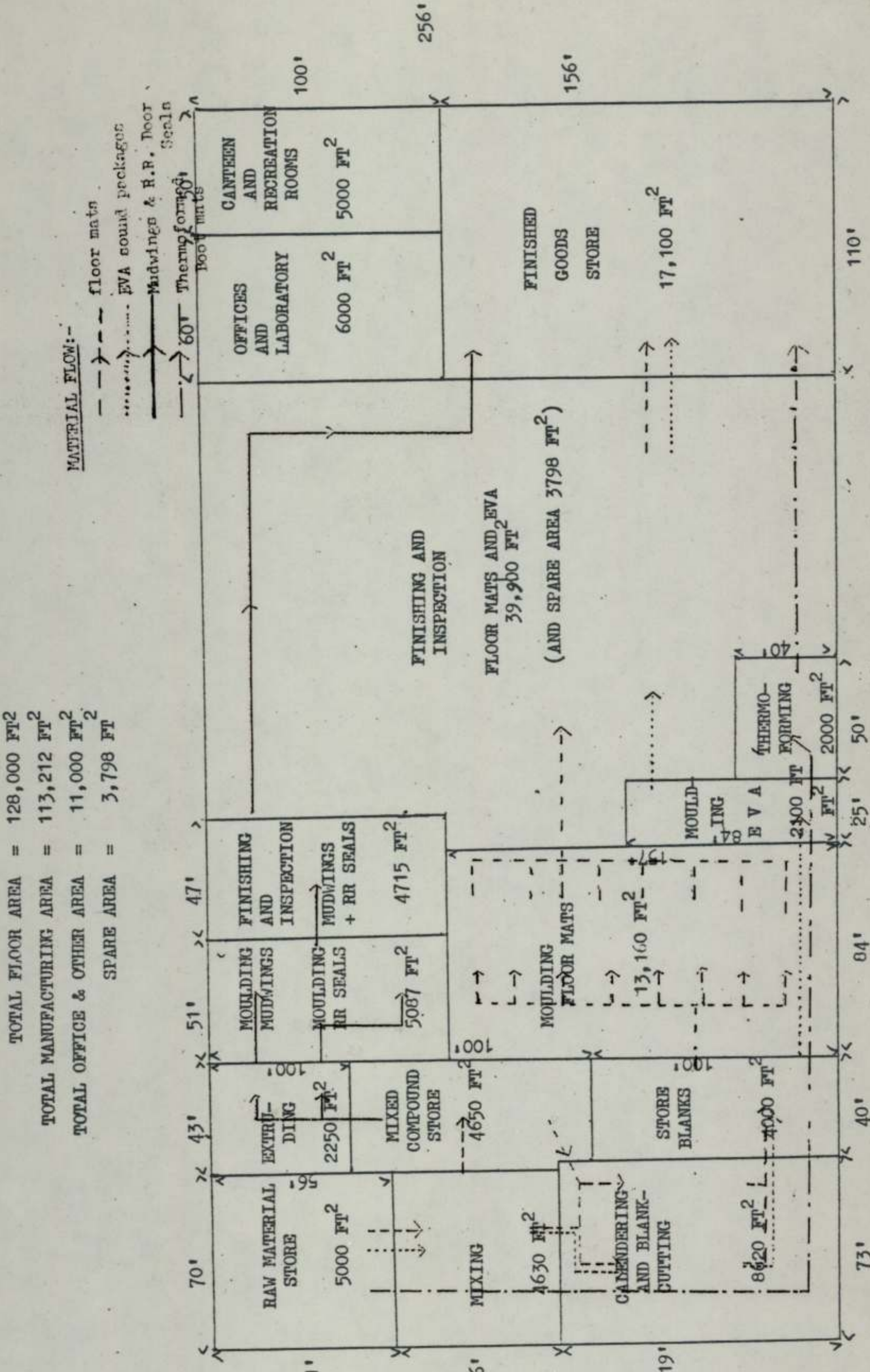


Fig. 5.10 (b) Material flow (Fold back for fig, 5.10 (a)).

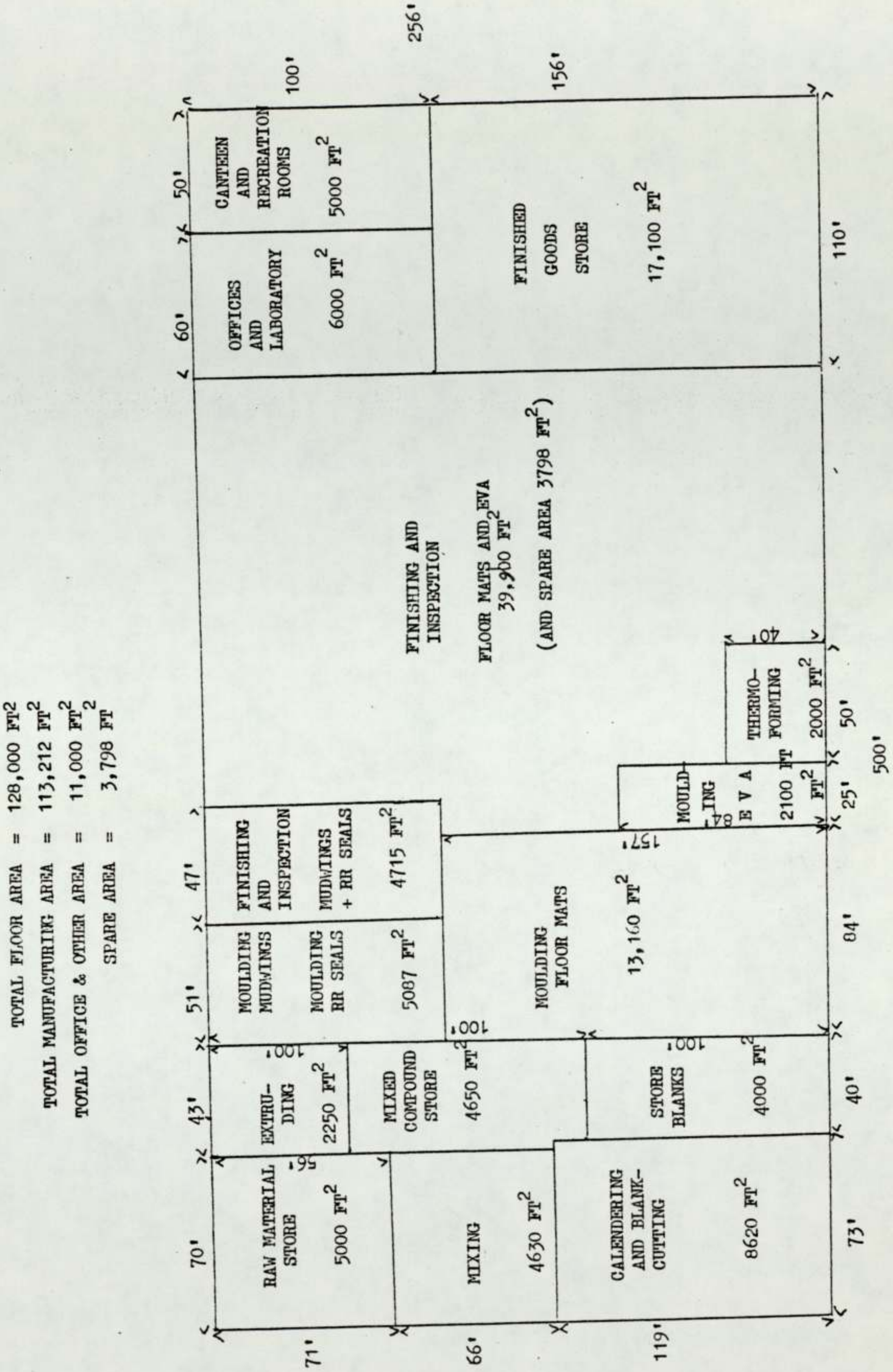


Fig. 5.10 (a) Layout for automotive module to accomodate the 1987 plan

On a move to a new site, the layout would have to conform to the size and shape of the building, and hence the above layout is only intended as a guide.

5.3.6 Module operative requirements

Fig 5.11 gives the operatives required for the proposed manufacturing operation to meet the 1977 level of turnover.

In the mixing and calendering functions the day shift is for running on tandem, and the night shift for the production of batched-off compound for veneers and mudwings. The operative levels are as discussed in section 5.3.1

The moulding, finishing and inspection labour requirements are unchanged from Cambridge Street, as no change in the processing methods has been made.

At Cambridge Street four moulding chargehands are required, one on each moulding area on each shift. The moulding areas would be combined at the module, and thus only two moulding chargehands would be required.

Similarly of the three finishing chargehands at Cambridge Street, one for each of the three finishing areas, only 2 would be required at the module for the combined area.

At Cambridge Street the engineering services for the four product groups are supplied centrally, and the number of hours of each type of engineer used each week by the floor mat department was obtained from Industrial Engineers records. These were averaged over several weeks, and divided by 40 hours to give the man requirements of each type of engineer. This requirement was then increased to cater for the mudwing and Rolls Royce Door Seal operations. As the engineers can fulfil several of the disciplines, fluctuations in demand for each type could be catered for.

	Days	Nights	Totals (day & night)
feeding and mixing	1	1	
micro ingredient weighing and materials trucking	1	1	
mills	1	1	
calender	1	1	
endman	1		
blank cutter and trucking	1		
batch-off and trucking		1	
cracker		1	
mill		1	
$1\frac{1}{2}$" cold feed extruder	1		
8" cold feed extruder	1		
TOTAL	8	7	15
moulding car mats	16	15	
moulding car mats inspection	2	2	
moulding mudwings	3		
moulding and finishing Rolls Royce seals	3 (12) hrs	2 (12) hrs	
finishing mudwings	2		
inspection mudwings and Rolls Royce seals	1		
finishing car mats	46		
inspection car mats	6		
packing car mats	3		
trucking, finishing and moulding	1		
TOTAL	83	19	102

FIG. 5.11 OPERATIVES

	Days	Nights	Totals (day & night)
Chargehands			
mixing, calendering and extruding	1	1	
moulding	1	1	
finishing	2		
TOTAL	4	2	6
general cleanining etc.	6		6
electricians	1	1	
pipefitter	1		
maintenance	1	1	
machine shop	1		
pump and boiler men	1	1	
TOTAL	5	3	8
			137

FIG 5.11 (cont'd)

5.3.7 Administrative staff and organisational structure

The proposed module manufactures a small range of products with specialised technology and sells to a narrow market. The unit should give rise to lower production costs than a less specialised unit, and furthermore should generate lower overheads.

The staffing requirements(fig 5.12) and the organisational structure (fig 5.13) reflect this. The administration is based on the group's existing staff and management, supplemented where necessary to supply services centralised at Cambridge Street.

The additional staff is headed by an accountant.

Certain job titles were modified in the module due to the unit being autonomous. Thus the Product Manager becomes a General Manager, the Manufacturing Manager a Works Manager, and the Departmental Manager a Production Manager. The heading of the additional administration unit by the accountant reduces the number of staff otherwise reporting to the General Manager. The appointment of a Field Sales Manager, a post not existant at Cambridge Street has the same effect.

The engineering department is headed by an Engineering Supervisor who can thus report to the Production Manager.

Function		Totals
General Manager	1	
Works Manager	1	
Production Manager	1	
		3
Foremen	3	
Quality Engineer	1	
		4
Sales Supervisor	1	
Sales Clerks	2	
Planner	1	
		4
Field Sales Manager	1	
Sales Representatives	2	
European Representative	1	
Engineering Representative	1	
		5
Accountant(administrative supervisor)	1	
Buyer	1	
Storeman	1	
Wages	1	
Cost Accountant/Industrial Engineer	1	
Personnel and Training	1	
Canteen	3	
Security (days and nights)	2	
		11
Mould Design, Engineering Supervisor	1	
		1
Technical and Development Supervisor	1	
Technician	1	
Development Technician	1	
		3
Secretaries	3	
		3
TOTAL STAFF		34

Fig. 5.12 Staff requirement

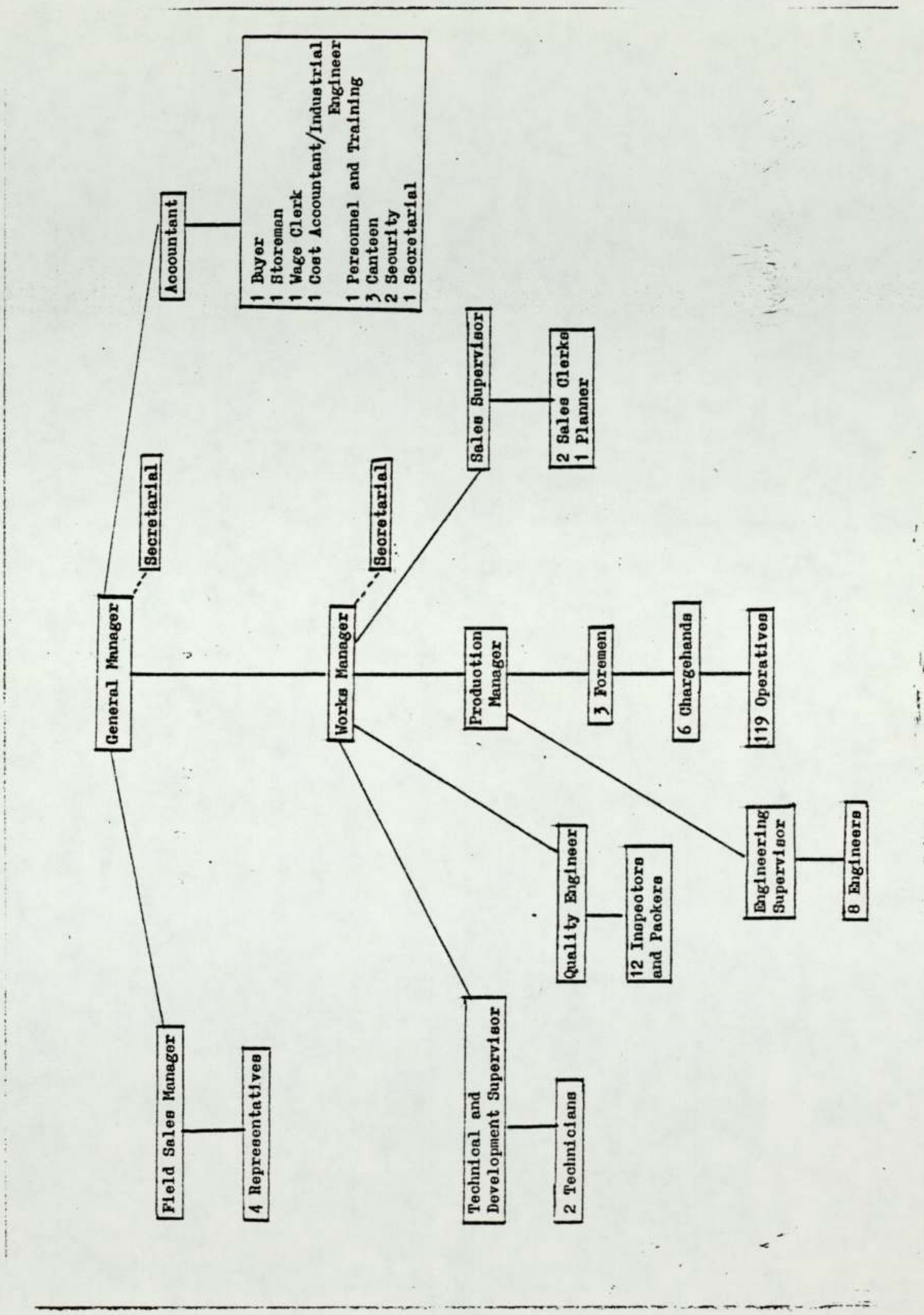


Fig. 5.13 Organsational structure

5.4 Capital cost of the module

Estimates for the delivery and installation of the new equipment were obtained from the manufacturers. The costs of reconditioning and transferring existing equipment from Cambridge Street, to the module (in the Manchester city area) were obtained from the Cambridge Street engineers. A quote for 2 boilers to meet the module steam requirements was obtained. The engineers gave an estimate for the cost of supplying the other services of power, compressed air, vacuum and hydraulics. The engineers and technicians also supplied estimates for the cost of engineering equipment (for maintenance etc.) and laboratory equipment (for compound testing and development).

As estimate for the cost of office furniture was also made. This was based on the staff level (see previous section) and allowed for the fitting out of the offices with new furniture. Existing furniture could have been transferred from Cambridge Street, but totally new furniture would have the benefit of contributing to a feeling amongst the staff of starting up a new concern, hence increasing motivation.

Fig 5.14 gives a breakdown of the £777,000 capital cost of the module.

A.) New Equipment

ITEM	COST/£
Semi-automated mixer feed system and raw material storage	65,000
Francis Shaw K6 intermix, with Sturdigear drive (33, 16½ r.p.m.)	108,500
Intermix stillage	14,500
Intermix drive (670 kW/335 kW)	22,000
2 x 84" mills with stockblenders	102,000
Automatic compact batch-off unit with wig-wag stacker	32,000
8" cold feed extruder	76,800
1½" cold feed extruder	12,280
Conveyors	15,000
Rotary blank cutter and tooling	23,000
1 x 60" Rollerpresses	6,545
Storage equipment (racks)	5,000
	482,625

B.) Delivery, installation and commissioning of new equipment

Mixing equipment installation and commissioning 11½% contract value and	40,000
delivery 1½% contract value	5,000
Delivery and installation and commissioning of cold feed extruders	1,000
Delivery and installation of rotary blank cutter and 2 x 60" roller presses	500
	46,500

Fig 5.14 - Capital cost of the module (cont. overleaf)

C.) Tranfer and reconditioning of existing equipment

ITEM	COST/£
58" x 28" calender, dismantle, overhaul, install	6,600
66" x 28" calender	21,400
44 room mills and cracker	11,500
Ten steam pans	8,500
install steam pans	5,000
Mudwings and Rolls Royce autoclave, install	400
Press 85 room, dismantle, install	800
Femco cutters, dismantle, install	500
Transport of above and other miscellaneous equipment (moulds, finishing tables, tools, glueing equipment etc.)	10,000
	54,700
D.) Installation of Services	
2 x 7,000 lbs/hr gas/oil boilers	38,000
transfer of 1 vacuum pump	500
transfer of 1 hydraulic pump	500
compressor for air	10,000
power - new substation	40,000
main connections	20,000
other connections	20,000
	129,000
E.) Office furniture and equipment	35,000
Laboratory and engineering equipment	30,000
	65,000
Total capital requirements, excluding building costs	777,155

Fig 5.14 (cont'd) Capital cost of the module

5.5 Analysis of the proposed module

The previous sections have defined the module, designed to manufacture as efficiently as possible the products concerned. The profitability of the investment is obviously of prime importance in the investment decision (see ref.(20)). Hence it was necessary to establish the expected return on the investment.

Forecasted profits at the module could be compared with forecasted profits for continued operations at Cambridge Street, and the increased profit thus identified with the investment.

An investigation was previously carried out (Chapter 4) to establish the improvements which could be achieved on the automotive operations within the constraints of the existing factory.

Therefore it was decided to compare the module with Cambridge Street as it existed, and also with the improved Cambridge Street as described in Chapter 4.

5.5.1 Costing of the module

Results for the first 6 months in 1977 at Cambridge Street for floor mats, mudwings and Rolls Royce door seals were extended to give the 1977 year's Automotive Products operating statement, which formed the basis for comparison.

It was decided that to attempt to build up the module's costs from scratch, by calculating all the costs incurred by the recommended machinery, labour, staff and processing methods to produce the required output was unnecessarily complicated when an existing model i.e., Cambridge Street could be used.

Thus the Cambridge Street operating statement was assumed to be a first rough approximation to the proposed module's operating statement. Then the effect of differences between the model, Cambridge Street, and the module, on the operating statement were evaluated, and these changes incorporated into the first rough approximation to give the modules operating performance.

Module variable works cost

a) Manufacturing labour and engineering labour

The Management Accountant estimated the wage bill for the modules proposed manufacturing and engineering labour, based on current (1977) Cambridge Street labour costs. Fringe benefits for Company National Insurance Contributions, Company Pensions Contributions and sick and holiday pay were included (see fig. 5.15)

b) Services

The allocation of service charges (power, heat, steam, maintenance materials and other miscellaneous services) for Cambridge Street was obtained.

The cost of services for the module was estimated as the full floor mat allocation plus 44% of the Cabin Seal allocation and 37% of the Fortiflex allocation. Rolls Royce door seals accounted for 44% of the Cabin Seal output and Mudwings accounted for 37% of the Fortiflex output in the first 6 months of 1977.

Changes in processing methods, particularly tandem mixing and calendering would result in decreased power usage. Furthermore any new equipment would result in decreased maintenance costs. It was decided not to include estimates of these factors, as being impossible to calculate exactly, they would be open to discussion and criticism in the final proposals.

c) Material

The breakdown of the material usage at Cambridge Street for January to June 1977 was obtained. The module material usage was based on this with the following modifications:-

The total amount of waste for Floor Mats, which includes rejects, trimming waste and reject compound, was reduced from £128,000 to £100,000. This reduced waste of £28,000 is to be compared with the reduced waste of £20,000 incorporated into the savings resulting from tandem running at Cambridge Street. The extra £8,000 saving would result partly from the improved mixing of the new internal mixer, and from the use of stockblenders on the new mills giving a more systematic post internal mixer mixing.

The excess cost resulting from using compound not per process (see section 4.2.3) was halved from £49,000 for January to June to £49,000 for the whole year.

These two changes were considered conservative estimates of benefits arising from better mixing conditions and material control in the module.

(Note: The bought material variance arose from the cost of rubber being below plan)

From the above estimates for labour, services and material the module's VWC, as shown in fig. 5.16 was built up.

Module constant costs

The proposed staff structure was used by the Management Accountant to estimate the staff salaries and other expenses (see fig. 5.15) These costs were based on existing costs at Cambridge Street.

These and the other constant costs which would be incurred at the module are contained in fig. 5.17.

As no indication of the possible location of the module existed, the cost of distribution was unchanged from Cambridge Street.

The Divisional charge was likewise unchanged.

	No.	Hours per week	Rate per hour	Cost per week	Cost p.a.
OPERATIVES					
Preparation	15	600	1.42	852	40,000
Car Mats	102	4080	1.44	5875	273,000
Chargehands	6	240	1.50	360	17,000
Cleaners	6	240	1.30	312	15,000
Engineers	8	320	1.60	512	24,000
Wages	137				369,000
National Ins	10.75%				40,000
Co. Pensions	7.2%				27,000
Sick Pay	1.5%				6,000
Holiday Pay	14.0%				52,000
STAFF					
Production	7				29,000
Engineers	1				4,000
Sales	9				35,000
Services	17				66,000
	34				134,000
National Ins.					14,000
Co. Pensions					10,000
Travelling Exp.					20,000
Car Scheme (6)					15,000

Fig. 5.15 - Operative & Staff Costs

Direct Labour	345,000	(preparation, production, chargehands, cleaners)
Variables	24,000	engineers
	125,000	fringe benefits
	194,000	services
Material	519,000	compound car mats
	100,000	compound waste car mats
	20,000	direct material car mats
	175,000	other material car mats
	18,000	compound cabin seals including waste
	52,000	compound mudwings including waste
	7,000	direct and other, cabin seals and mudwings
total material	891,000	
less BMV(i)	142,000	
	749,000	
TOTAL VWC	1,437,000	

(i) Bought material variance

Fig 5.16 A.P.M. Variable Works Cost

The following table and notes give a breakdown of the fixed costs incurred by the module.

Distribution	£94,000	
Divisional	£58,000	
Factory	£35,000	Salaries sales (viii)
	£99,000	Salaries (other)
	£24,000	National Insurance and company pensions
	£20,000	Travelling Expenses
	£15,000	Car Scheme
	£26,566	Power, heat, steam, offices, canteen
	£7,800	Insurance
	£77,720	Depreciation
	£180,000	Rent and Rates
	£20,000	Sundries
	£505,086	Total factory constants
TOTAL:	£657,086	

Fig. 5.17 A.P.M. Constants

The cost of services for the offices and canteen were as the appropriate allocations at Cambridge Street. The insurance bill was estimated at 26% of the total factory insurance bill. (Automotive Group accounts for 26% of the factory turnover). An estimate of £20,000 was made for sundries based on expenses such as telephone, stationery, canteen subsidy etc. at Cambridge Street.

From the North West Development Association average rents and rates for the Manchester City area were obtained. These were £1.20/ft^2 for rent and £.60/ft^2 for rates.

The floor area requirements (see section 5.3.4) were discussed with the General Manager, who suggested that an area of 100,000 ft^2 be considered. This area allowed for expansion over the 1977 levels, but did not allow for expansion to the forecasted 1986 levels.

The cost of rent and rates for a 100,000 ft^2 factory would be £180,000

Depreciation was included at 10% of the total capital investment in accordance with Dunlop accounting standards.

5.5.2 Module operating statement

The operating statement for the module, on 1977 levels of production, was built up from the VWC and the constant cost. This is contained in fig. 5.18 along with the Cambridge Street operating statement.

The operating margin of £132,000 for the Cambridge Street operation is improved to £458,000 for the module. The breakdown of the £326,000 difference is given in fig. 5.19.

The independent autonomous module incurs much lower overheads than Automotive Group is charged with at Cambridge Street. This supports the view that the group is out of place in the Cambridge Street factory, being the only mass producing unit amongst a number of high overhead low volume units.

The bulk of the rest of the saving is generated by the vertical integration of the unit. This results in reduced material costs (the estimate of this saving was conservative) and a saving in direct labour, giving rise also to reduced variable costs.

Further improvements at the module, but not included in the cost build-up should come from reduced maintenance costs due to the inclusion of new equipment and the refurbishment of the old, and improved industrial relations. The latter is an important consideration, considerable difficulties being experienced at Cambridge Street in this field. Again the tandem operation makes a contribution in the field, reducing the labour fatigue in the calendering operation.

	as exists Cambridge Street (£000's)	Module (£000's)
T/O	2552	2552
VWC	(1684)	(1437)
<u>Gross Contribution</u>	868	1115
% to T/O	34%	44%
distribution	(94)	(94)
divisional constants	(58)	(58)
factory and sales constants	(584)	(506)
<u>Operating Margin</u>	132	458
% to T/O	5%	18%
% to ANFE	23%	37%
<u>Funds Employed</u>		
average fixed assets	87	738
stocks	263	263
debtors	647	647
creditors	(414)	(414)
ANFE	583	1234

Fig. 5.18 Automotive Products Group
Operating Statement

	Module	Cambridge Street	Difference
Operating Margin	448,000	132,000	316,000
Accounted for by Factory Constants			
including sales, excluding rent	385,000	584,000	199,000
rent	120,000	-	(120,000)
Variable Costs			
waste	100,000	128,000	28,000
wrong compound	49,000	98,000	49,000
direct labour	345,000	436,000	91,000
variables	343,000	422,000	79,000
			326.000

Fig. 5.19 Breakdown in difference of operating margin at module and Cambridge Street

The semi-automated feeding system with the enclosing of the powders also improves the cleanliness of the mixing area. Generally the factory should be far cleaner, lighter and more agreeable than Cambridge Street.

In this area the opportunity to introduce a good colour scheme in the painting of the building (ref 21) and good lighting conditions (ref 22) would make an important but not easily quantifiable contribution in both the production and office areas.

5.5.3 Module forecasted operating statement

By assuming a move to a new factory completed by the end of 1977, then 1978 was a convenient fictitious starting date for the module. The forecasted business plan 1978 to 1987 (fig. 5.1) thus gave a ten year output plan on which to base forecasted performances and profits.

The module was to be compared with Cambridge Street as it existed, and with Cambridge Street as modified in Chapter 4. As the existing operation in Cambridge Street could not process EVA, forecasted operations for the module both with and without EVA were calculated, such that the benefits of the sales of EVA, and those resulting from improved module operations, could be separately identified.

a) Funds employed

In calculating the forecasted funds employed (see fig. 5.20) it was assumed that stock, debtor and creditor levels would be proportional to turnover.

The value of the fixed assets was the average of the values at the beginning and end of each year. It was assumed that no investment would take place after the initial outlay in all cases.

b) Constants

Constant costs were split into "fixed" constants and"variable" constants. "Fixed" constants, such as salaries, depreciation, rent, were assumed to remain unaltered over the 10 years

YEAR	T/O	STOCKS	DEBTOR CREDITORS	AVERAGE FIXED ASSETS	AVERAGE NET FUNDS EMPLOYED
77	2550	263	233	87	583
78	2830	292	259	76	627
79	3210	331	294	65	690
80	3610	372	331	54	757
81	3660	377	336	43	756
82	3910	403	358	32	793
83	4060	418	372	21	811
84	4360	449	400	10	859
85	4460	460	409	0	869
86	4510	465	413	0	878
87	4560	470	418	0	888

Fig. 5.20 (a)

Cambridge Street funds employed (no EVA, £000's)

YEAR	T/O	STOCKS	DEBTORS - CREDITORS	FIXED ASSETS				AVERAGE NET FUNDS EMPLOYED
				BEGINNING	END	DEPT	AVERAGE	
77	2550	263	233					
78	2830	292	259	777	699.3	77.7	738	1289
79	3790	390	347	699.3	621.6	77.7	661	1398
80	4311	444	395	621.6	543.9	77.7	583	1422
81	4480	461	411	543.9	466.2	77.7	505	1377
82	4730	487	434	466.2	388.5	77.7	427	1348
83	5060	521	464	388.5	310.8	77.7	350	1335
84	5410	557	496	310.8	233.1	77.7	272	1325
85	5610	578	514	233.1	155.4	77.7	194	1286
86	5660	583	519	155.4	77.7	77.7	117	1219
87	5710	588	523	77.7	0	77.7	39	1150

Fig. 5.20 (b) Module funds employed with EVA

YEAR	T/O	STOCKS	DEBTORS - CREDITORS	AVERAGE FIXED ASSETS	AVERAGE NET FUNDS EMPLOYED
77	2550	263	233		
78	2830	292	259	738	1289
79	3210	331	294	661	1286
80	3610	372	331	583	1286
81	3660	377	336	505	1218
82	3910	403	358	427	1188
83	4060	418	372	350	1140
84	4360	449	400	272	1121
85	4460	460	409	194	1063
86	4510	465	413	117	995
87	4560	470	418	39	927

Fig 5.20 (c) Module funds employed
(No EVA, £000's)

YEAR	T/O	STOCKS	DEBTORS - CREDITORS	NEW AVERAGE FIXED ASSETS				AVERAGE NET FUNDS EMPLOYED
				BEGINNING	END	DEPT	TOTAL AVERAGE FIXED ASSETS	
78	2830	292	259	36	32.4	34	110	661
79	3790	390	347	32.4	28.8	31	96	833
80	4311	444	395	28.8	25.2	27	81	920
81	4480	461	411	25.2	21.6	23	66	938
82	4730	487	434	21.6	18	20	52	973
83	5060	521	464	18	14.4	16	37	1022
84	5410	557	496	14.4	10.8	13	23	1076
85	5610	578	514	10.8	7.2	9	9	1101
86	5660	583	519	7.2	3.6	5	5	1107
87	5710	588	523	3.6	0	2	2	1113

Fig. 5.20 (d) The improved Cambridge Street, funds employed (£000's)

(at 1977 prices) and the "variable" constants, such as selling and travelling expenses, telephone bill, were assumed to be directly proportional to turnover. Fig. 5.21 contains the resulting forecasted constant expenses.

c) Variable works costs and distribution

Both VWC and distribution costs were calculated on a directly proportional basis to turnover.

Forecasted operating statement

The forecasted operating statements for the module with EVA (Fig. 5.22 (i)), without EVA (Fig. 5.22 (ii)) and for Cambridge Street unmodified, without EVA (Fig. 5.22 (iii)) and for modified Cambridge Street (Fig. 5.22 (iv)) were thus built up.

Return on the investment

The increased revenue generated at the module over that generated at Cambridge Street was calculated (Fig. 5.23). To obtain these figures, the depreciation included in the constant costs was added back in each case, and the increased capital expenditure included as an outflow in year 0 (1977).

Discussion of results

The return on the investment was calculated leaving out many considerations. The move to a new site would obviously have a disruptive effect on the group's operations. The forecasted sales

P.T.O.
209

AUTOMOTIVE PRODUCTS MODULE CONSTANTS (£000's)

YEAR	T/O WITH EVA	FIXED CONSTANTS	VARIABLE CONSTANTS	TOTAL WITH EVA	T/O NO EVA	VARIABLE CONSTANT	TOTAL NO EVA
77	2550	479	81	560	2550	81	560
78	2830	479	90	569	2830	90	569
79	3790	479	121	600	3210	102	581
80	4310	479	137	616	3610	115	594
81	4480	479	143	622	3660	116	595
82	4730	479	150	629	3910	124	603
83	5060	479	161	640	4060	129	608
84	5410	479	172	651	4360	139	618
85	5610	479	178	657	4460	142	621
86	5660	479	180	659	4510	143	622
87	5710	479	182	661	4560	145	624

CAMBRIDGE STREET CONSTANTS

YEAR	T/O	FIXED CONSTANTS	VARIABLE CONSTANTS	TOTAL. C.ST. as is
77	2550	544	98	642
78	2830	544	109	653
79	3210	544	123	667
80	3610	544	139	683
81	3660	544	141	685
82	3910	544	150	694
83	4060	544	156	700
84	4360	544	167	711
85	4460	544	171	715
86	4510	544	173	717
87	4560	544	175	719

IMPROVED CAMBRIDGE STREET (Constants)

T/O including EVA	"F" Constants	"V" Constants	TOTAL
2550	548	98	646
2830	548	109	657
3790	548	146	694
4310	548	166	714
4480	548	172	720
4730	548	182	730
5060	548	194	742
5410	548	208	756
5610	548	215	763
5660	548	217	765
5710	548	219	767

Fig. 5.21 Constants Module and Cambridge Street

YEAR	T/O	VWC	GROSS CONTRI-BUTION	DISTRI-BUTION	CONSTANTS	OPERA-TING MARGIN	% to T/O	AVERAGE NET FUNDS EMPLOYED	OPERATING MARGIN % TO ANFE
(i) WITH EVA									
78	2830	1593	1237	104	569	564	20	1289	44
79	3790	2134	1656	140	600	916	24	1398	66
80	4310	2427	1883	159	616	1108	26	1422	78
81	4480	2522	1958	165	622	1171	26	1377	85
82	4730	2663	2067	174	629	1264	27	1348	94
83	5060	2849	2211	186	640	1385	27	1335	104
84	5410	3046	2364	199	651	1514	28	1325	114
85	5610	3158	2452	206	657	1589	28	1286	124
86	5660	3187	2473	208	659	1606	28	1219	132
87	5710	3215	2495	210	661	1623	28	1150	141
(ii) WITHOUT EVA									
78	2830	1593	1237	104	569	564	20	1289	44
79	3210	1807	1403	118	581	704	22	1286	55
80	3610	2032	1578	133	594	851	24	1286	66
81	3660	2061	1599	135	595	869	24	1218	71
82	3910	2201	1709	144	603	962	25	1188	81
83	4060	2285	1775	149	608	1018	25	1140	89
84	4360	2455	1905	160	618	1127	26	1121	101
85	4460	2511	1949	164	621	1164	26	1063	110
86	4510	2539	1971	166	622	1183	26	995	119
87	4560	2567	1993	168	624	1201	26	927	130

Fig. 5.22 (a) Automotive Products Module forecasted operating statements 1978 to 1987 (£000's)

(i) with EVA

(ii) without EVA

YEAR	T/O	VWC	GROSS CONTRI-BUTION	DISTRI-BUTION	CONSTANTS	OPERATING MARGIN	% TO T/O	AVERAGE NET FUNDS EMPLOYED	OPERATING % TO ANFE
(i) Without EVA									
78	2830	1869	961	104	653	203	7%	627	33%
79	3210	2119	1091	118	667	306	10%	690	44%
80	3610	2383	1227	133	683	411	11%	757	54%
81	3660	2416	1244	135	685	424	12%	756	56%
82	3910	2581	1329	144	694	491	13%	793	62%
83	4060	2680	1380	149	700	531	13%	811	66%
84	4360	2878	1482	160	711	611	14%	859	71%
85	4460	2944	1516	164	715	637	14%	869	73%
86	4510	2977	1533	166	717	650	14%	879	74%
87	4560	3010	1550	168	719	663	15%	888	74%
(ii) With EVA									
78	2830	1725	1105	104	657	344	12%	661	52%
79	3790	2310	1480	140	694	646	17%	833	78%
80	4310	2628	1682	159	714	809	19%	920	88%
81	4480	2732	1748	165	720	863	19%	938	92%
82	4730	2884	1846	174	730	942	20%	973	97%
83	5060	3085	1975	186	742	1047	21%	1022	102%
84	5410	3299	2111	199	756	1156	21%	1076	107%
85	5610	3421	2189	206	763	1220	22%	1101	111%
86	5660	3451	2209	208	765	1236	22%	1107	112%
87	5710	3481	2229	210	767	1252	22%	1113	112%

Fig. 5.22 (b)

Cambridge Street forecasted operating statements
1978 to 1987 (i) without EVA
(ii) with EVA

YEAR	MODULE (NO EVA) AGAINST C. ST.	MODULE (WITH EVA) AGAINST C. ST.	MODULE AGAINST IMPROVED C. ST.
1977 (0)	(777)	(777)	(741)
1978 (1)	428	428	283
1979 (2)	465	677	333
1980 (3)	507	764	362
1981 (4)	512	814	371
1982 (5)	438	840	385
1983 (6)	454	921	401
1984 (7)	583	970	421
1985 (8)	605	1030	443
1986 (9)	611	1034	444
1987 (10)	616	1038	445

Fig. 5.23 - Increased revenue of the Module over Cambridge St.

(£000's)

YEAR	a	a-h	a-i	b	b-h	b-i	c	c-h	c-i	d	d-h	d-i	e	e-h	e-i	f	f-h	f-i	g	g-h	g-i	h	h-i	i
0 (1977)	(777)	(741)	(777)	(627)	(591)	(627)	(777)	(741)	(777)	(382)	(326)	(382)	(396)	(360)	(396)	(396)	(360)	(396)	(396)	(360)	(396)	(36)	(36)	-
1	642	283	428	640	281	426	642	283	428	607	248	393	566	207	352	538	179	324	285	(74)	71	359	145	214
2	994	333	677	992	331	675	994	333	677	746	85	429	701	40	384	671	10	354	394	(267)	77	661	344	317
3	1186	362	764	1184	360	762	1186	362	764	889	65	467	837	13	415	803	(21)	381	490	(334)	68	824	402	422
4	1249	371	814	1247	369	812	1249	371	814	907	29	472	855	(23)	420	821	(57)	386	508	(370)	73	878	443	435
5	1342	385	840	1339	383	837	1342	385	840	997	40	495	941	(16)	439	905	(52)	403	568	(389)	66	957	455	502
6	1463	401	921	1460	399	918	1463	401	921	1053	(9)	511	996	(66)	454	959	(103)	417	615	(447)	73	1062	520	542
7	1592	421	970	1589	419	967	1592	421	970	1159	(12)	537	1096	(75)	474	1056	(115)	434	684	(487)	62	1171	549	622
8	1667	443	1030	1664	441	1027	1667	443	1030	1195	(29)	558	1131	(93)	494	1100	(124)	463	711	(513)	74	1224	592	632
9	1684	444	1034	1651	442	1031	1684	444	1034	1214	(26)	564	1149	(91)	499	1108	(132)	458	724	(516)	74	1240	590	650
10	1701	445	1038	1698	443	1035	1701	445	1038	1231	(25)	568	1165	(91)	502	1124	(132)	461	734	(522)	71	1256	593	663

Fig. 5.24 Comparison of different forms of the module (£000's)

have not taken into account that the module could sell at lower prices than Cambridge Street, and hence gain a larger market share. Furthermore, the Cambridge Street operation could not meet the existing business plan without investment.

Considerations such as these were omitted, due to the difficulty in evaluating them exactly. It was decided that they would best be used to qualify the results during presentations to senior management.

.5.4 Comparison of different forms of the module

During the course of the research, it became apparent that Dunlop may be interested in installing one of Cambridge Street's existing internal mixers at the Automotive Module. As previously discussed the management was also considering the possibility of transferring compound to the module from other mixing units. The following alternatives were all possible forms of the module.

a) The Automotive Module with new mixing facilities as described in the proposals.

b) The replacement of the new internal mixer in the proposals by a No. 11 Banbury from Cambridge Street.

c) The Automotive Module being part of a new central mixing unit, supplying to the other modules.

d) Compound transferred to the Automotive Module from a new central mixing unit.

e) Compound transferred to the Automotive Module from Skelmersdale.

f) Compound transferred to the Automotive Module from Cambridge Street.

g) Compound bought in by the Automotive Module from outside the Dunlop Group

h) Automotive Group remaining on its present site with the short term improvements incorporated.

i) Automotive Group remaining on its present site.

The capital investment for the alternatives is as follows:

a) As the proposed module £777,000

b) The K6 intermix costs £164,000 including installation. Against this the transfer of the No. 11 Banbury would cost £14,000, so the net saving in (a) is £150,000. The total capital investment is therefore £627,000.

c) It has been assumed that other mixing facilities could be included in the module without influencing its performance. Hence the investment is as in (a) for the Automotive part of such a module.

d) Omitting the mixing from the module decreases the required investment by £381,500. However, the new mixing unit elsewhere would require £353,000 investment, and thus the total investment would be £748,500.

e) The investment at the module would be £395,500

f) Investment as in (e)

g) Investment as in (e)

h) Investment - £36,000

i) No investment

Alternatives (d) (e) (f) (g) and (i) could not process EVA.

The on-costs incurred in supplying the module with its total compound requirements, calendered and batched-off, over the costs of method (a) were calculated in appendix 4. Only direct labour and power were considered, assuming that other variable costs (lighting, maintenance etc.,) and overhead costs would be equal for the different methods. Whether such costs be incurred at the module or elsewhere within the Industrial Group makes no difference to the performance of the group as a whole.

The appropriate on-costs calculated in appendix 4 were added on to the forecasted module operating statements (Fig. 5.18). In each case the depreciation of £77,700 included in the forecasted operating statements was removed to give the funds generated.

For alternative (h) the forecasted revenue was as in table 5.11 (iv) with the depreciation of 15 up to year 8 (1985), and subsequently 4, added back in.

For the final alternative, effectively doing nothing, the funds generated were obtained by removing the £11,000 depreciation charge from the Cambridge Street forecasted operating statement (fig. 5.18) up to year 8 (1985) when Cambridge Street was fully written off.

For each alternative the increase in revenue over alternative (h) and alternative (i) was calculated.

Fig. 5.24 contains the above results. The first column in each case is the yearly revenue for that alternative, and the second column the increase in yearly revenue over alternative (h) and the third column the increase in revenue over alternative (i).

Fig. 5.24 clearly illustrates the importance of the module incorporating its own mixing facilities. From fig. 5.24 alternatives (a), (b), (c) and (h) can be seen to be the most attractive. These all have a tandem operation between mixing and calendering and enable the production of EVA.

5.5.5 Discounted rates of return

(i) The discounted rate of return on the increased investment of £741,000 of (a) over (h) is 45%

(ii) The discounted rate of return on the increased investment of £591,000 of (b) over (h) is 56%

(iii) The discounted rate of return on the increased investment of £777,000 of (a) over (i) is 78%

Therefore very high rates of return are achieved on the module, compared with remaining at Cambridge Street, whether Cambridge Street is improved (as recommended in Chapter 4) or not.

The cost of implementing the module would be partly recovered in the form of Government Development Grants. (ref 17 to 22 incl)

Provided the module moved to one of the government classified Development Areas, then the cost of the move would be partly recovered in the form of Government Development Grants (ref 17 to 22 incl.)

5.6 Conclusions

The module described in this chapter was designed to manufacture and market as efficiently as possible the automotive products from Cambridge Street. The analysis of the module showed that the investment required to implement it gave a very healthy rate of return.

Furthermore non-financial benefits, in the way of improved industrial relations, would result from the implementing of the module, and the smaller autonomous unit would permit the development of a family type atmosphere in the operation.

5.7 Recommendations

It is recommended that the module as described in this chapter be established to manufacture the products floor mats, EVA sound packages, mudwings and Rolls Royce Door Seals.

If possible, a No.11 Banbury should be transferred from Cambridge Street to the module, giving a total module investment of £627,000.

If a No.11 Banbury is not available, then it is recommended that a new K6 Intermix be purchased, giving a total module investment of £777,000.

CHAPTER 6

Recommendations, implementation and further work

6.1 Short term investigation

6.1.1 Recommendations

In Chapter 4, areas in which improvements could be made within the constraints of the Cambridge Street factory were identified, and where possible the cost savings were quantified.

Based on these cost savings, the following sanctions should be raised for the finance required to implement the short term improvements.

A sanction for £5,000 to install a conveyor between the mill department and the 44 room calender to enable the two operations to be run on tandem.

A sanction for £23,000 for the purchase and installation of the Rotary Blank Cutter, and for the purchase of the required tooling.

A sanction for £1,700 for the lengthening of a pair of adjacent mould trains to increase the capacity of the pans.

A sanction for £6,545 for a 60" Rollerpress for automated finishing.

Furthermore, at no cost, the correct use of the job tickets should be implemented to eliminate calender overbooking. Increased control should be exercised over the mill deliveries and the calender gangs' use of compound, with wage concessions if necessary, to improve the control of materials in the production process.

Also at no extra cost, the rough costing method should be statistically tested, modified if necessary, and the final method used for immediate quotations on cost enquiries.

6.1.2 Implementation

The total cost of implementing the above recommendations is £36,245, with quantified savings in the first year of £107,380, and £128,180 in subsequent years (at 1977 levels of production). This reduces the 1977 VWC of £1,684,000 (based on the period January/June 1977) by 6.4% in the first year and 8% in subsequent years. The group's operating margin would be improved from £132,000 (5% of turnover) to £239,380 (9.4% of turnover) in the first year and £260,180 (13% of turnover) in subsequent years.

Once implemented, the projects would require monitoring to ascertain that they run to plan. Any deviations from the recommendations will result in a change in the savings achieved, and such deviations must be identified, and if possible, rectified.

6.1.3 Work remaining to be done

As described in section 6.1.1 the rough costing method requires further statistical testing and possible modification prior to implementation.

Once a Rollerpress has been installed the labour rates achievable on it must be ascertained. The cost saving resulting from its use could then be identified. If appropriate, the use of rollerpresses should be extended in the finishing area.

In implementing the use of job tickets and increasing material control in the compound preparation and calendering areas certain concessions on wages willbe necessary. Thereafter, the area must be regularly monitored to maintain full control.

A mould should be equipped by the engineers with a peripheral cutter,. to enable the trimming of blanks on the mould. If this system is successful, it should be adopted on mats not tooled for by the Rotary Blank Cutter.

6.2 Long term investigation

6.2.1 Recommendations

It is recommended that the proposed automotive module be implemented at a new site at a cost of £777,000 (or £627,000 if a No. 11 Banbury is available from Cambridge Street)

6.2.2 Implementation and work remaining to be done

Prior to the implementation of the above recommendation much work remains to be done.

A site must be selected. If the site has an existing building then a layout needs to be designed for that building. If the site is greenfield, then a building plan can be selected which would enable a layout as discussed in the previous chapter to be used. The building and its site will have to conform to legal and physical restrictions.

Negotiations with the relevant authorities regarding grants (ref 4-9) must be completed.

Once a site, building and layout were finalised, then the transfer of the automotive operations must be effected with the minimum disruption to operations. Here the possibility of using Aga-Pirelli as a short term supplier must be considered.

The purchase of all new equipment and the reconditioning and transfer of existing equipment must be planned. Here techniques such as CPA can be used.

The finishing equipment, with little machinery, could be moved without causing disruption.

As a result of excess moulding capacity, eight autoclaves would be transferred to the new site, and a moulding operation established there. Half of the remaining pans would then be transferred to the new site, thus allowing the whole moulding operation to be carried out on these. The remaining pans could then be transferred,

The transfer of the manual blank cutting operation would cause no problem.

In moving calendering facilities, the finding of alternate supplies would be necessary. The use of a single calender on 3 shifts during the transfer of the other would meet most requirements, except that the smaller calender is unable to produce the wider sheets.

If a new mixer was purchased for the module then it could be installed with the feeding equipment at the new site while compound was being supplied from Cambridge Street. The transfer of an internal mixer from Cambridge Street to the module would require an alternate compound source, preferably from within Dunlop.

Obviously throughout the transfer considerably extra personnel, particularly engineers, would be required. Here the benefits of using specialist moving companies (ref 23) must be considered.

Prior to transfer, negotiations would be required with the group's employees to arrange their transfer, and to implement the proposed module manning levels.

If the module is not fully autonomous, then effective transport and communication links with the administration would have to be established.

6.3 Conclusion

The investigations carried out have shown that certain improvements can be made to the Cambridge Street automotive operation within the constraints of the existing factory. However the moving of the operation to a new site and the establishment of an autonomous unit permit significant further improvements to be made.

In light of the threats facing the group, it is recommended that the autonomous operation be implemented.

Appendix 1

Visit to A.G.A., s.P.a., Milan - 18th/19th February 1977, with Mr. K.L. Peet

Persons seen: Sgr. P. Gavazzi, General Manager

Sgr. Modanini, Works Manager

Sgr. Italia

Sgr. Galmarini

A.G.A. Pirelli produce automotive rubber mats by the same process as Automotive Group, G.R.G. As their turnover in rubber mats is roughly equal to Auto Group's it was decided that a vist there would be useful.

First, a discussion was held with Sgrs. Gavazzi and Modanini, during which an outline of their business was given.

A.G.A. has 194 employees, of which 171 are operatives; of the operatives, 22 are male and 149 female.

Their product mix is: 62% Automotive rubber mats
14% Industrial flooring
6.5% Technical rubber sheeting
11% Rubber mix
5% Protective mats

for a total turnover of 308,000 million Lira (£2½m)

The industrial flooring is continuously vulcanised, and used for airports, buses, public buildings etc. The rubber mats are split roughly equally between passenger vehicles, where they are losing market share to low cost textile carpets, and industrial vehicles, where the market is expanding. The sales are heavily dependent on Fiat.

Both Sgr. Gavazzi and Sgr. Modanini expressed a willingness to help further if possible. Sgr. Modanini showed particular interest in the M. Phil project, and hoped to be able to read it on completion.

Production of Vacuum Moulded Mats

Sgr. Modanini gave a guided tour of the factory. Attached is a flow chart of the production process (Fig. 1).

(i) Materials Store

The raw materials are stored on pallets in high scaffolding. The access to all materials is very good. Powders used in large quantities are stored in silos connected by tube conveyors to the Banburys.

Mixed compound, in the form of calendered sheets, is stored for sale.

Cured scrap is sent to a nearby reclaim plant, from whom they buy back reclaim. 30% reclaim is used in their mix. Cured ground scrap, crumb, is used for flooring and sheets, not for vacuum moulded mats. (Auto Group used crumb in some of their mixes.)

Apart from the powders in the silos, transport to and from the stores is by forklift truck.

(ii) Banburys

Two Banburys, one for dirty compound (loose carbon black) and one for clean compound are used.

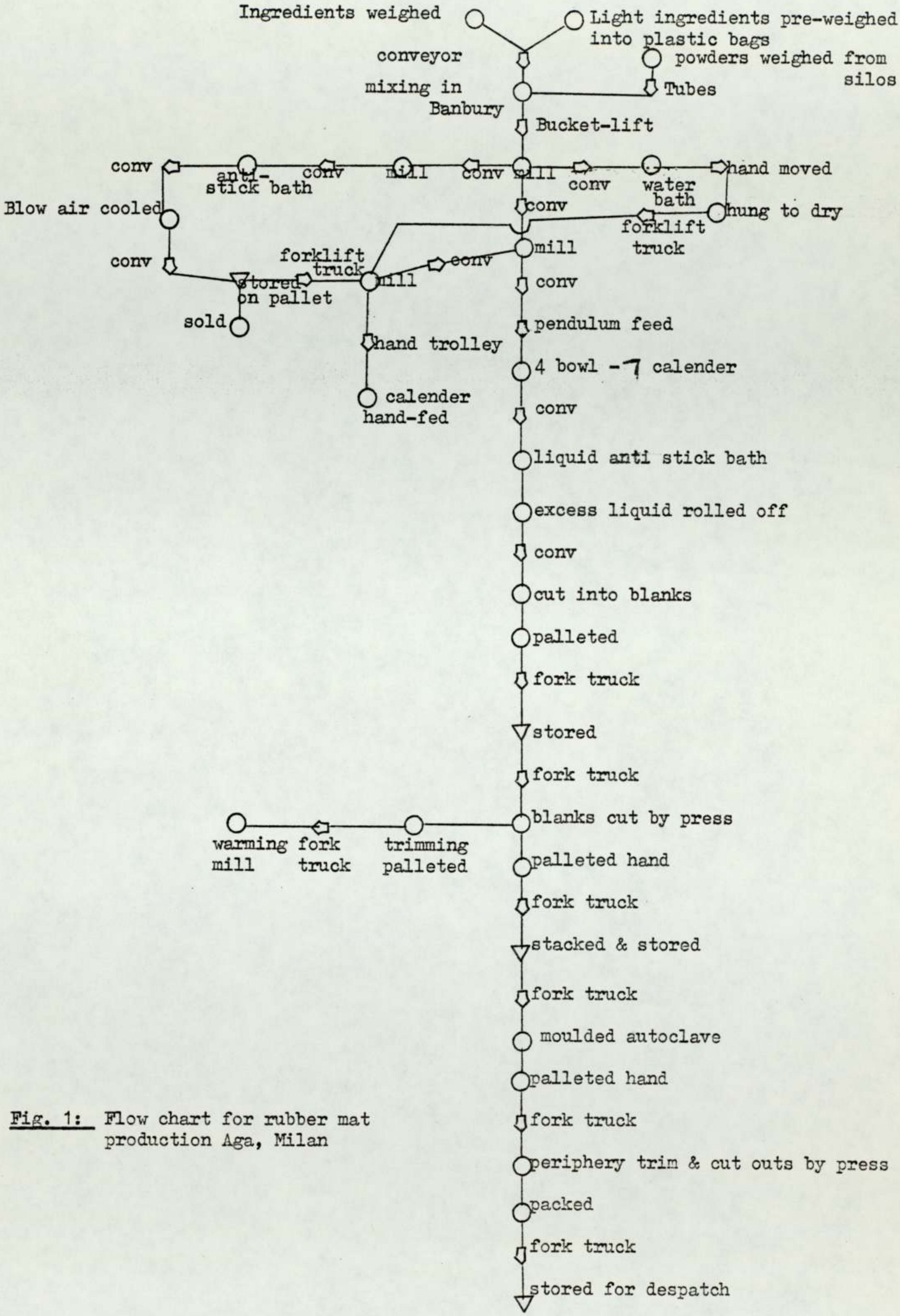


__Fig. 1:__ Flow chart for rubber mat production Aga, Milan

Small quantity ingredients are pre-weighed into plastic bags, which go into the mix. The rest of the ingredients, apart from the powders from the silos, are weighed at the Banbury. The batch size is 180 - 220 Kg, with a cycle time of five minutes, giving an output of 2,000 Kg/hr. 72 batches are produced in a 7½ hour shift. The dirty Banbury is used on two shifts, the clean Banbury on one.

The mixing chambers of the Banburys are underground, and the mix is tipped into a mill by an elavator-bucket. The mix from the mill is fed off in three ways:

(a) Into a cooling bath, then hung up to dry

(b) Into a second mill, from where it is fed off in long strips through a cooling and anti-stick bath, then past a bank of air fans to dry and complete cooling. The strips are then stacked and stored, and used for feeding the calender, or sold for feeding extruders.

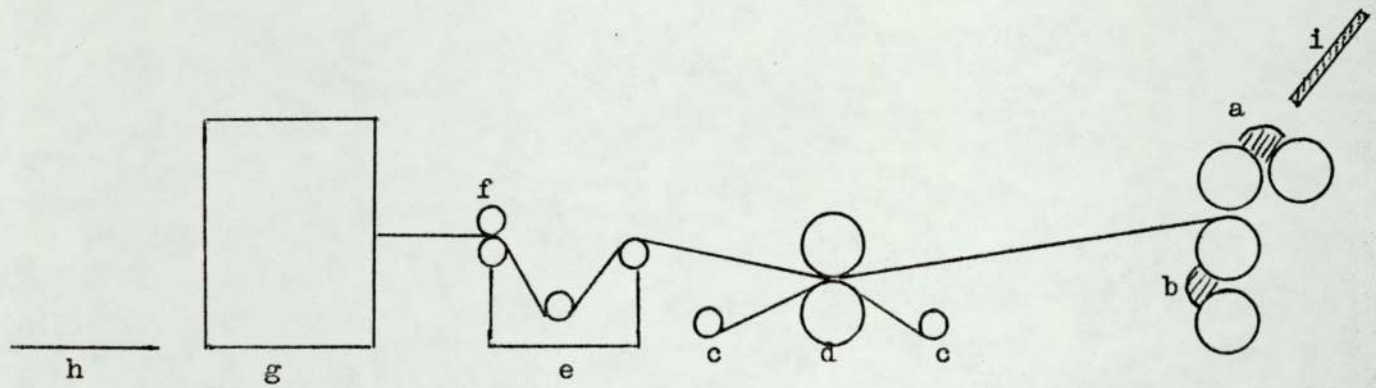
(c) Straight to the calender, with which the Banbury can be run in tandem via an overhead conveyor.

The Banburys are operated by 3 - 6 men, depending on how the mix is fed off.

(iii) <u>Calendering</u>

A single calender is run for 1½ shifts and supplies calendered sheet for all of A.G.A.'s operations, as well as for sale. It is a 4-bowl inverted 'L' calender, permitting 2-ply sheet to be calendered in a single operation. If the sheet is topped from a lining, then this is done by two separate rollers after calendering of the base sheet (Fig. 2.)

The pre-calender warming mill is fed simultaneously directly



a. Main nip
b. Second nip (2-ply)
c. Liner rollers
d. Nip if liner used
e. Liquid anti-stick tank
f. Rollers to remove excess anti-stick
g. Automated blank cutter
h. Blanks stacked
i. Pendulum feed

Fig. 2. Aga calenders and blank cutting set-up

from the Banbury by conveyor, and from another mill which itself warms cold mixed compound sheets. 4" wide strips from the mill are fed into the calender by a conveyor which ends in a pendulum feeder. The strip is cut off the mill continuously by fixed knives. Much heavy work is avoided using these knives, and by joining mills and calender by conveyors.

The calendered sheet passes through an anti-stick bath, and then into an automotive blank cutter, which palletises the blanks. The stacked blanks are stored in an adjacent scaffolding for 2 - 3 days prior to moulding. The blanks are still hot when stacked, but there is no problem of curing while stacked.

(iv) Blank cutting

The blanks are cut to approximate mould shape, with a double-ended press 5 - 6 blanks are placed on the base plate, the cutter is placed on top and the base plate is then slid under the press where the blanks are cut. Four women work the single blank cutter, two at each end. The cycle time is about 80 seconds.

Trimmings are palleted and fed back to the warming mill.

The shaped blanks are stored in the same scaffolding as the unshaped blanks.

(v) Moulding

Mats are moulded in ten double-ended autoclaves. An adjacent pair of autoclaves are operated by a team of five women. One autoclave is loaded and unloaded while the other is curing. Each completes 36 curings in an eight hour shift. (Fig. 3).

Cured mats are stripped off the moulds, which are then sprayed with anti-stick. The moulds are then covered with the blanks which are sprayed with cold water to shrink any blisters. The autoclave closes, moulds and re-opens in an automatic cycle. Steam temperature is 151°C.

A.G.A. make their own moulds. The edge of the mould is designed on a different principle from our moulds (Fig. 4).

Mats are transported to and from the autoclaves by forklift truck.

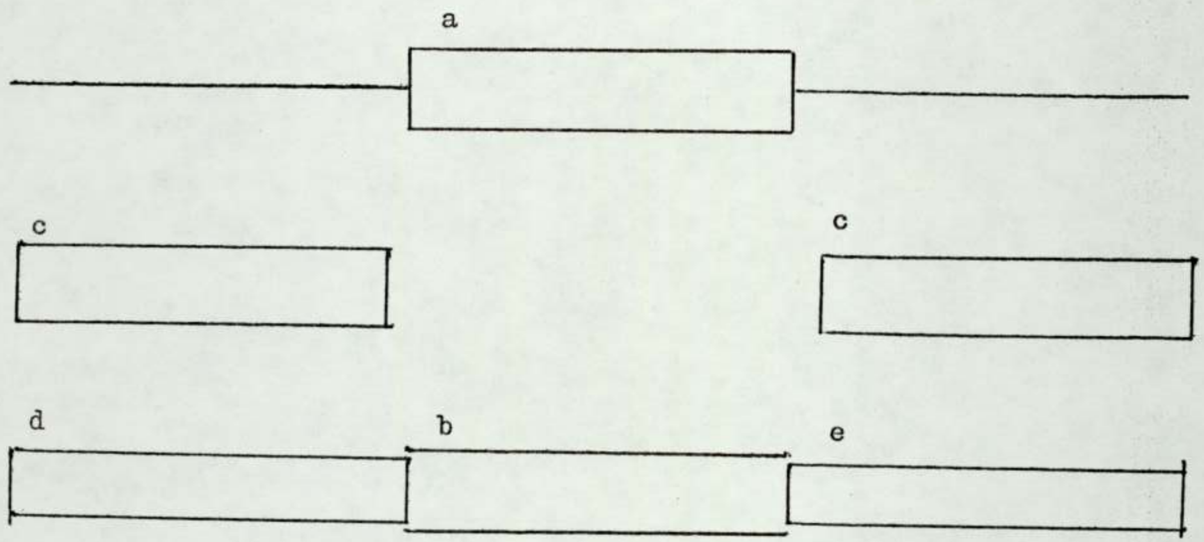
(vi) Finishing

Finishing is with double-ended presses, operated by two women each end. A rate of 200 - 1,000 mats per shift per 2 women is achieved. The mats are designed with the assumed shape principle, i.e., the mat is moulded flatter than the shape on which it will lie.

The boards carrying the ribbon finishing cutters have cut-outs in them to allow any contoured areas to hang below the cutter.

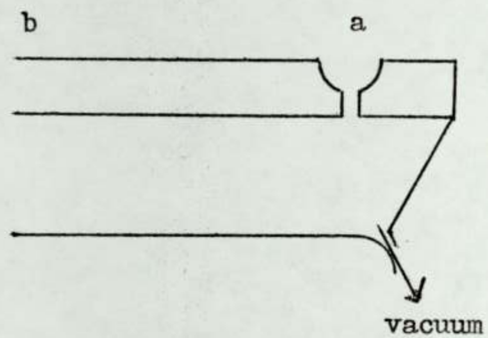
Layout (fig 5 & 6)

Production takes place in a single workspace. Raw materials are received by road at one end of the factory, and finished



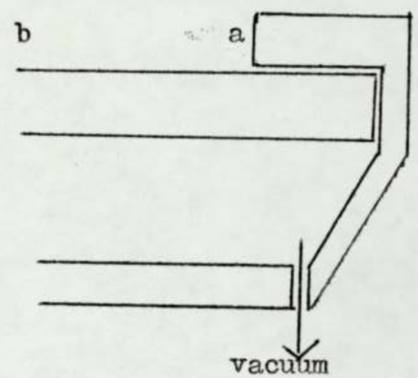
a. Autoclave curing
b. Autoclave being loaded
c. Working surfaces
d. Moulds
e. Fork truck passages

Fig. 3 Aga autoclaves



a. Source of suction
b. Moulded surface

I Dunlop mould



a. Source of suction
b. Moulded surface

II Aga mould

<u>Fig. 4</u> Mould edge design

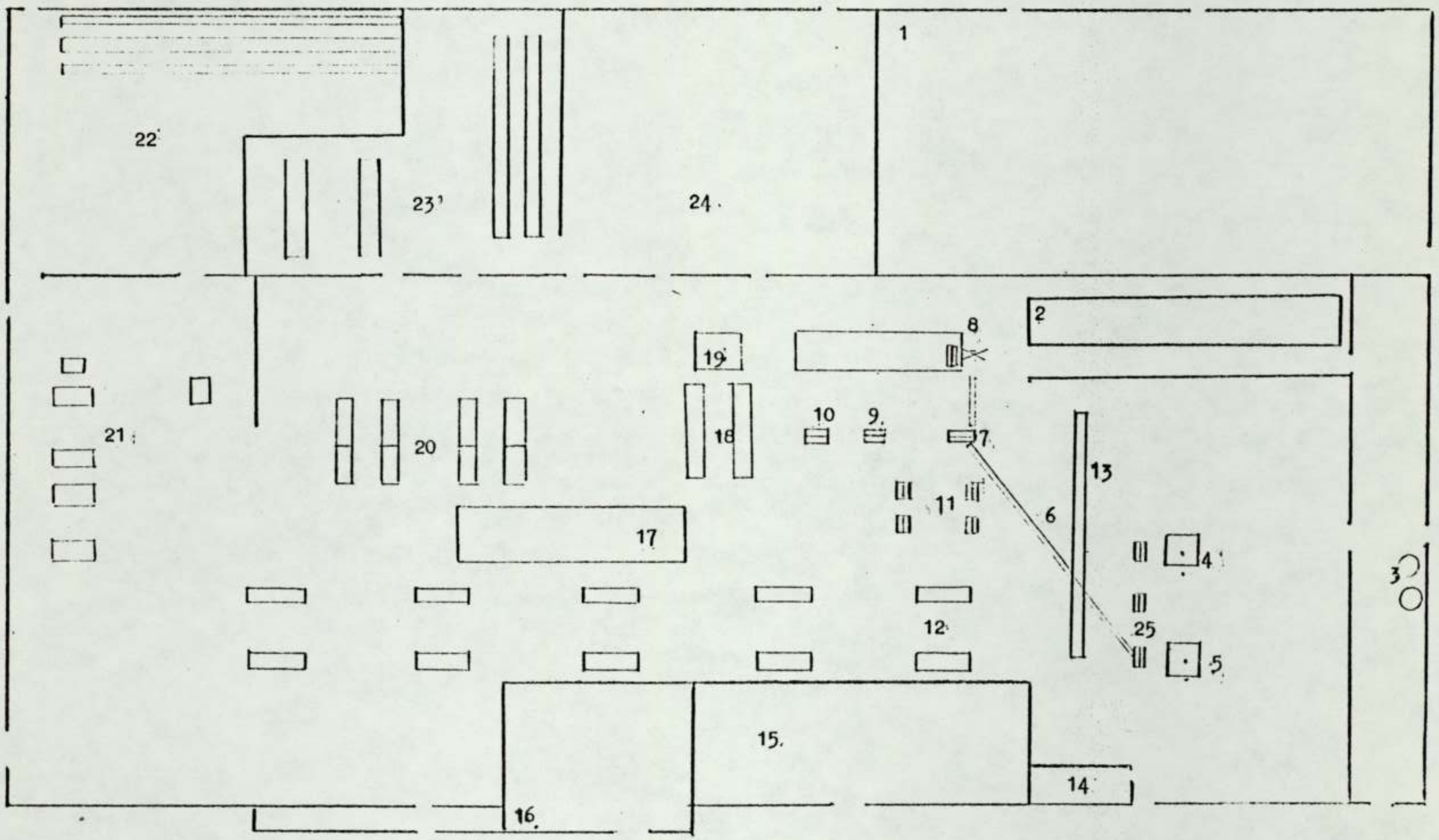


Fig 5 Factory Layout Aga (scale 1:600) (For key see over)

KEY FOR FIG. 5

1. Raw materials store
2. Continuous vulcanisation machines
3. Silos
4. Colour Banbury
5. Black Banbury
6. Banbury - calender conveyor
7. 84" mill
8. Inverted L calender, pendulum feed
9. 60" warming mill
10. 60" warming mill for uncured scrap
11. Compound sheeting mills (42")
12. Autoclaves
13. Air cooler with wig-wag stacker
14. Electrical centre
15. Offices (main office block is outside factory)
16. Boilers
17. Compression moulds
18. Scaffolding for blank storage
19. Blank cutting press
20. Single ended autoclaves
21. Finishing presses
22. Finished goods and fork truck store
23. Mould stores
24. Technical area
25. 84" dumping mills

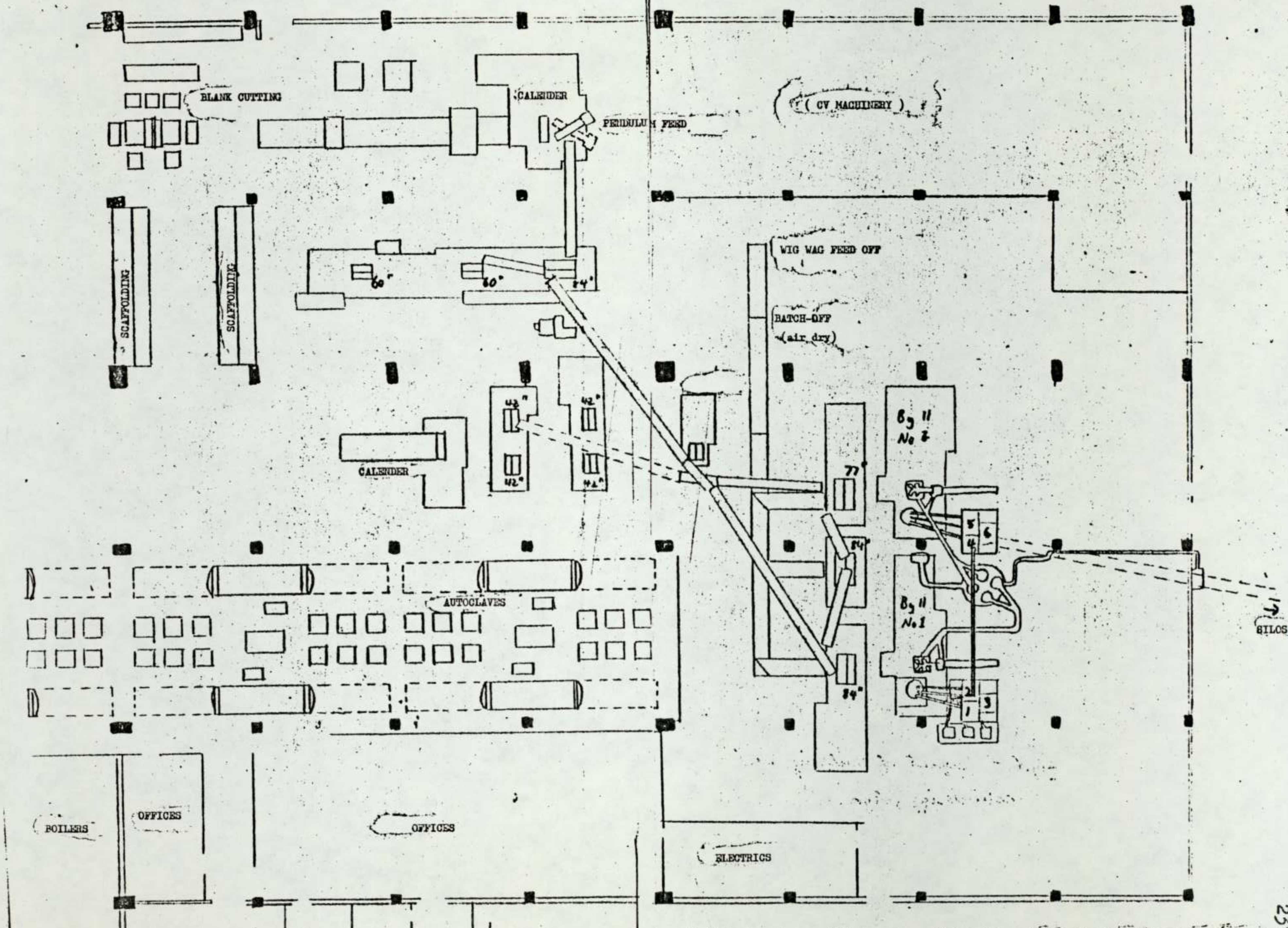


Fig. 6 Aga Banburys, Calender, Blank Cutting,

goods are stored and despatched at the other end.

Machinery is located by function. There is considerable wasted space, and forklift truck passageways are wide.

Transport is by conveyor, until the blanks have been palleted, from which point forklift trucks are used.

Stock and work-in-progress

Mats are produced to monthly schedules. Particular orders vary from 150 to 7,000 mats per month. The large series moulds are permanent.

No particular attention seemed to be given to the size of work-in-progress, which found its own level depending upon the month's orders.

Raw materials may be stocked for pricing reasons.

Appendix II

<u>Derivation of formula to calculate cost of higher than process rejects</u>

x = rejects according to process

x^1 = actual recorded rejects

d = $x' - x$

VWC = variable works cost

T = turnover of each type of mat

S = mat selling price

C = variable works cost excluding reject allowance

The VWC of a mat included a reject allowance

i.e., $VWC = C(1 + x)$

$$\Rightarrow C = \frac{VWC}{1+x}$$

If the actual reject is higher than that allowed for, the cost is

$$VWC^1 = C(1 + x^1)$$

$$\Rightarrow VWC^1 - VWC = C(1 + x^1) - C(1 + x) = C(x^1 - x) = dC$$

$$= \frac{d\ VWC}{1 + x}$$

Thus the total excess cost for all mats is (E)

$$E = \sum_{\text{all mats}} \frac{d\ (VWC)}{1 + x} \cdot \frac{T}{S}$$

Appendix III

Semi-automated mixer feeder system

Tascol **T.A.SHORE Company Ltd**
ENGINEERS

14 Covedale Road – Sherwood – Nottingham – NG5 3H
Telephones: (0602) 201044 – (0602) 262014 Telex: 377542

Our Ref. TAS/MH/CE 1st August, 1977.

Dunlop Manufacturing Ltd.,
General Rubber Goods Div.,
60 Cambridge Street
Manchester

for the attention of Mr. Green, Auto Dept.

Dear Sirs,

Further to the visit of our Mr. W. H. Bonser, we are pleased to quote as follows, in accordance with the items shown on our schematic drawing M2/0107/75 enclosed:-

CARBON BLACK WEIGH STATION

Bulk bins by Dunlop
3 - Screw feeders with braked motors
3 - Surge hoppers over screw feeders
3 - Level switches
3 - Bulk bin stands 1½ metres high
1 - Auto Scale with flexible hopper and pneumatic slide outlet
1 - Aero-Mechanical conveyor
1 - Chute to mixer

POWDERS STORAGE AND WEIGH STATION

1 - 20 ton Whiting storage hopper with pipe connection to tanker and air filter — 2 ½ in diam.
1 - 20 ton storage hopper for dry, fine , powdered Clay with pipe connection to tanker and air filter
1 - Sack tip unit for China Clay
Bulk bin for rubber crumb by Dunlop
4 - Screw feeders for Whiting
Clay
Rubber crumb
China Clay
1 - Auto Scale with flexible hopper and pneumatic slide outlet
1 - Aero-Mechanical Conveyor
1 - Chute to mixer

POLYMER WEIGHING

1 - Band Scale, 3½ metres centre, complete with dial indicator, manual weighing.

OIL STORAGE AND METERING

3 - Drum emptying station 600 litre capacity each. Complete with level switch, stop valve, filter and re-circulating pump. Not heated. As M3/0111/08
3 - Oil metering stations, each comprising stop valve, filter metering head for 50 c.c. increments, diaphragm valve with solenoid pilot valve. As M3/2005/24.
1 - Surge tank with level switch
1 - Pump to mixer
1 - Injector

SMALL POWDERS

5 - Sack tip stations each with 20 cu.ft. storage hoppers and scoop outlets. Connection for your exhaust. Floor standing.
12 - Bins for micro ingredients approx. 1 cu.ft. capacity. Floor standing.
1 - Scale Bogey complete with Avery Scale 0-3/3-6 kg capacity type 1108 CJC
1 - 5 metre length of track

CONTROLS

1 - Automatic Control Panel for:-

Pre-selecting weights of solids
" the volumes of oils
in 50 c.c. increments
Automatically sequencing the mixer cycle
Starting and stopping the mixer auxiliaries by pushbutton
Giving alarm for auxiliaries failure

Complete with starters for all TASCOL supplied equipment
Complete with Temperature Recorder and Burrell Timer
Mimic diagram on facia

TASCOL price - £64,835 Ex Works

Terms of payment:
5% with Order
5% on presentation of installation design
40% 5 months after Order
45% Monthly account
5% After 6 months

Delivery: 6 months

B.E.A.M.A. to apply

We shall be pleased to prepare a general arrangement drawing upon receipt of your building drawing.

Trusting the foregoing meets with your approval but should there be any further information you require, please do not hesitate to contact us.

Yours faithfully,
T. A. SHORE CO. LTD.

T. Alan Shore
Managing Director

Encs. Panel Photo

Drg.No.	M3/0111/08	Drum emptying
"	M3/2005/24	Oil metering station
"	M1/2006/5	Typical only - Carbon Black weigh station
"	M2/0107/75	Schematic Diagram

Appendix IV

Mixing costs for the Automotive Products Module

This report compares the cost of supplying mixed compound to the Automotive Products Module by the following methods:-

i) The installation of new mixing facilities at the module.

ii) The transfer of mixed compound from Cambridge Street.

iii) The transfer of mixed compound from a new central G.R.G. mixing unit.

iv) The transfer of mixed compound from Skelmersdale.

v) The buying-in of mixed compound from outside the Dunlop Group.

vi) The transfer of an existing mixer from Cambridge Street to the module.

Table I summarises the results.

Only direct labour and power have been used in comparing the different set-ups, making the assumption that other variable costs (lighting, maintenance etc.) and overhead costs (administration, rent etc.) will be equal for the different methods.

The cost of labour at Skelmersdale is 18% higher than at Cambridge Street. The cost of labour at the module has been assumed to be 9% above that of Cambridge Street.

The cost of production of calendered sheet and batched-off compound have been considered separately as mixing on tandem with calendering enables savings to be made.

The production of EVA thermoforming sound packages is dependent on the module having its own mixing facilities, as EVA requires a high calendering temperature which could not practically be achieved with warming mills. Hence the contribution from the forecasted EVA turnover would be lost if the module does not have its own mixing facilities.

1) MIXING AT THE AUTOMOTIVE MODULE

a) Production of calendered sheet

Mixing at the module enables the bulk of the floor mat compound to be calendered on tandem with the mixer. This eliminates labour and power required to cool and store the compound after mixing, and to reheat the compound prior to calendering.

The proposed mixing and calendering unit would comprise the following equipment:-

ITEM	COST (£)	POWER KW/HR.	LABOUR
Semi-automated mixer feeding equipment	65,000		1
K6 intermix and stillage	145,000	500	1
84" dump mill with stockblender	51,000	100)	1
84" sheeting mill with stock-blender	51,000	100)	
Calender		110	2
Conveyors	15,000	10	
Batch-off unit	32,000	10	
Delivery and installation	45,000		
TOTAL	404,000	830	5

In the following calculation power for the batch-off unit has been excluded as it is not involved in calendering. The dump and sheeting mills require only one man as they have stockblenders. The man handling the feeding equipment will also do any trucking required.

The K6 intermix, capacity 112 litres, with compound of specific gravity 1.6 will discharge 179K batches. Based on a 5 minute mixing cycle with no premastication of polymers, and 20% downtime, the output is 1718 K/hr.

Cost per kilo of calendered compound:-

5 men at £2.27/hr	=	£11.35/hr
820 KW x .8 (downtime) at £.02/KW hr	=	£13.12/hr
Total	=	£24.47

Therefore cost	=	£.0142/K

Plus a fixed annual rent of £5040 for the area of 2800 ft^2 required for mixing at £1.80/ft^2/annum.

b) Cooled and stacked compound for veneers and cold feed extrusion

The investment for this has been covered in part a)

Only one mill is required after mixing, and compound from the mill is fed into the automatic anti-tack, cooling and stacking unit. The trucking of stacked compound is done by the feeder-trucker.

Hence the total of 3 men and 620 KW are required for an output of 1718 K/hr.

3 men at £2.27/hr	=	£6.81/hr
620 KW .8 x £.02/KWhr	=	£9.92/hr
Cost of batched compound	=	£16.73/hr
Cost per kilo	=	£.0097

2) TRANSFER OF MIXED COMPOUND FROM CAMBRIDGE STREET

Cambridge Street mill is less automated than the proposed module unit. The module will require a cracker and 2 mills for feeding the calender. The mills cannot be fitted with stockblenders, as cracked compound will not immediately lap up, and hence each mill will require an operator.

Mixing and calendering costs

The following equipment would be required:-

ITEM	COST(£)	POWER KW/HR.	LABOUR
Mixer feeding			2
Mixing	(Existing equipment)	500	1
Dump Mill		100	1
Sheeting Mill		100	1
Cooling		10)	
Stacking and store		)	3
TOTAL MILL		710	8

ITEM	COST(£)	POWER KW/HR.	LABOUR
TOTAL MILL B/F...		710	8
Cracker)	transfer and	100	1
1st. Mill)	recondition	100	1
2nd. Mill)	12,500	100	1
calender		110	2
conveyors	10,000	10	
TOTAL CALENDERING	22,500	420	5
T O T A L	22,500	1130	13

a) Mixing Costs

The mill produces batches of 227 K, giving, with an 11 minute cycle and 20% downtime, an output of 990 K/hr.

8 men at £2,08/man	=	£16.64
710 Kw x .8 (downtime) at £.02/Kwhr	=	£11.36
Total		£28.00

Cost = £.0283/K

b) Calendering costs

The calender can produce up to 1800 K/hr

5 men at £2.27	=	£11.35
420 x .8 (downtime) at £.02/Kwhr	=	£ 6.72
Total		£18.07

Cost = £.0100/K

c) Storage and Transport Costs

A stock of 1 week's supply, (70,000 K 1977) of mixed compound will be required in the case of transferred compound.

Storage space: Allowance for storage space for future expansion must be made. 1986 forecasted compound usage will require 2240 ft^2 of space for 1 week's stock (allowing 680 K/pallet and 16 ft^2/pallet).
Rent and rates for storage space at £1.80/ft^2 = £4032 p.a.

Transport costs: Transport of 70,000 K compound from Cambridge Street to the module (within Manchester) would cost £175 per week = £.0025/K

Value of stock

7,000 K Veneers at £.4962/K	=	£3,473
63,000 K at £.2493/K	=	£15,706
Total stock value	=	£19,179
Interest cost at 10% p.a.	=	£1,918
Cost (70,000 K/week, 46 weeks p.a.)		£.0006/K

Hence the total cost of calendered sheet is:

Mixing cost	=	£.0283/K
Calendered cost	=	£.0100/K
Transport cost	=	£.0025/K
Interest cost of stock		£.0006/K
Total		£.0414/K

Plus a fixed annual cost of £4,032

The cost of compound for veneers and cold feed extrusion is;

Mixing cost	=	£.0283/K
Transport cost	=	£.0025/K
Stock	=	£.0006/K
Total		£.0314/K

3) TRANSFER OF MIXED COMPOUND FROM A NEW CENTRAL G.R.G. MIXING UNIT

A new central mixing unit could supply all the modules. In this exercise it has been assumed that this unit would perform identically to the proposed automotive module unit.

Mixing costs (see table overleaf) Output = 1718/Khr (as (i))

3 men at £2.27 / hr = £6.81

620 KW/hr x .8 x £.02/hr = £9.92

Total = £16.73

ITEM	COST(£)	POWER KW/HR.	LABOUR
Semi-automated mixer feeding	65,000		1
K6 intermix and stillage	145,000	500	1
84" dump mill with stock blender	51,000	100	1
Conveyors	15,000	10	
Batch-off unit	32,000	10	
Delivery and installation	45,000		
T O T A L	353,000	620	3
Module calendering (as in ii)	22,500	420	5

Cost = £.0097

Calendering costs

As in (2) £.0100/K

Storage and transport

As in (2)

Hence the total cost of calendered compound is:-

Mixing cost	=	£.0097/K
Calendering cost	=	£.0100/K
Interest cost of stock	=	£.0006/K
Transport cost	=	£.0025/K
Total cost	=	£.0228/K

And the total cost of mixed compound for veneers and cold feed extrusions is as above less the calendering cost, i.e., £.0128/K Plus a fixed annual rent of £5040 for mixing and £4032 for storage, giving a total annual fixed cost of £9072.

4) TRANSFER OF MIXED COMPOUND FROM SKELMERSDALE

Skelmersdale mixing is no more efficiently manned than Cambridge Street, and they have a very poor mixer feeding system. However, the mixer is operated on shorter cycle times. It is assumed in this exercise that car mat compound would be mixed on a 7 minute cycle giving an output of 1557 K/hr. (227 K batches, 20% downtime).
Labour and power requirements are as for Cambridge Street. (2)

8 men at £2.45	=	£19.6 /hr
710 Kw at £.02/Kwhr x .8 (downtime)	=	£11.36/hr
Total cost	=	£30.96/hr

Mixing cost = £.0200/K

The transport cost for 70,000 K of compound per week from Skelmersdale to Manchester is estimated at £270 per week or £.0039/K

Hence the total cost of calendered compound is:-

Mixing cost	=	£.0200/K
Calendering cost	=	£.0100/K (as in (2))
Transport cost	=	£.0039/K
Interest on stock	=	£.0006/K (as in (2))
Total cost	=	£.0345/K

Plus a fixed annual rent of £4032. Capital investment £22,500 as in (2). The cost of compound for veneers and cold feed extrusion is as above less the calendering costs, i.e., £.0245/K.

5) BUYING-IN MIXED COMPOUND FROM OUTSIDE THE DUNLOP GROUP

A typical cost for bought-in compound is 10p/kilo on top of the material value. From experience in buying-in compound, during times of mixing difficulties, the buyers at Cambridge Street estimate an average increase of 30% to 40% over the VWC. The increase results from less effective purchase of raw materials plus distribution and profit allowance.

The table below analyses the on-cost resulting from buying in from outside the group. An increase of 35% on the VWC has been used. Total 1977 compound usage has been considered, excluding EVA compound.

Compound	1977 VWC	Bought in Minimum = 1977 VWC x.35	1977 Forecasted usage(K000's)	Bought in On Cost (£)
6649	.4962	.1737	156	27,000
3235	.2493	.0873	1000	87,000
3690	.2117	.0741	1490	110,000
3702	.5077	.1777	200	36,000
3012	.3393	.1187	149	18,000
3691	.20	.07	300	21,000
6649	.2745	.0961	30	3,000
TOTALS			3325	302,000

6) MIXING AT THE MODULE WITH THE USE OF ONE OF CAMBRIDGE STREET's NO. 11 BANBURY'S

One of Cambridge Street's No. 11 Banbury's could be installed at the Module, with the feeding and downstream processing equipment specified for the K6 intermix.

The Banbury would not be as efficient as a new Intermix, and so a mixing cycle of 6 1/2 minutes has been assumed. This gives an output of 1676K/hr. (227 K batches, 20% downtime).

a) Calendered sheet

Labour and power requirements are as for (1)

820 Kw x .8 x £.02/Kwhr	=	£13.12/hr
5 men at £2.27/hr	=	£11.35/hr
Total		£24.47/hr

Cost = £.0146/K

b) Batched-off compound

Again labour and power requirements are as for (1)

3 men at £2.27/hr	=	£6.81 /hr
620 Kw x .8 x £.02/Kwhr		£9.92/hr
Total		£16.73/hr

Cost = £.010/K

c) Capital investment

Semi automated mixer feed system	=	£65,000
Transfer and installation of Banbury	=	£14,000
84" dump mill with stockblender	=	£51,000
84" sheeting mill with stockblender	=	£51,000
Conveyors	=	£15,000
Batch-off unit	=	£32,000
Delivery &installation of new equipment	=	£26,000
TOTAL	=	£254,000

Plus a fixed annual rental of £5,040 as in (1)

	Method (i)					Method (ii)			Method (iii)			Method (iv)			Method(v)	Method (vi)				
	CALEN-DERED .0142/K	BATCH-OFF 0097/K	TOTAL (+5040 FIXED)	EVA .0142/K	TOTAL WITH EVA	CALEND-ERED .0414/K	BATCH-OFF .0314/K	TOTAL (+ 4030 FIXED)	CALEND-ERED .0228/K	BATCHED-OFF .0128/K	TOTAL (+ 9070 FIXED)	CALEND-ERED .0345/K	BATCH - OFF .0245/K	TOTAL (+ 4030)	TOTAL	CALEND-ERED .0146/K	BATCH-OFF .010/K	TOTAL (PLUS 5040)	EVA .0146/K	TOTAL WITH EVA
0			(404,000)					(22,500)			(375,500)			(22,500)	(0)			(254,000)		(254,000)
1	47,540	6030	58610	0	54873	138610	19530	162170	76330	7960	93360	115510	15240	134780	357000	48880	6220	60140	0	60140
2	48050	8980	62070	12920	74990	140100	29000	173210	77160	11050	98080	116750	22690	143470	388000	49410	9260	63710	13290	77000
3	54320	10230	69590	15620	85210	158360	33130	195520	87210	13500	109780	131960	25850	161840	439000	55850	10550	71440	16060	87500
4	53170	11020	69230	18320	87550	155000	35670	194700	85360	14540	108970	129170	27830	161030	439000	54660	11360	71060	18830	89090
5	57250	11870	74160	18320	92480	166930	38430	209390	91930	15670	116670	139100	29990	173120	472000	58870	12240	76150	18830	94980
6	57510	12510	75060	22290	97350	167670	40510	212210	92340	16510	117920	139730	31610	175370	481000	59130	12900	77070	22920	99990
7	62200	13650	80890	23430	104320	181330	44180	229540	99860	18010	126940	151110	34470	189610	521000	63950	14070	83060	24090	107150
8	63050	14190	82280	25700	107980	183820	45940	223790	101250	18730	129030	153180	35840	193050	531000	64820	14630	84490	26430	110920
9	63900	14260	83200	25700	108900	186300	46160	236490	102600	18820	130490	155250	36020	195300	537000	65700	14700	85440	26430	111870
10	64900	14340	84280	25700	109980	189200	46410	239640	104200	18920	132190	157670	36210	197910	545000	66720	14780	86540	26430	112970

TABLE 1 Cost of tandem calendered, batched-off and EVA forecasted compound usage (direct labour and power only)

YEAR	Compound to be Calculated on Tandem (K000's)	Batched-off Compound (000K)	EVA (000K)	R.R. Seals (000K)
78	3348	.622	0	10
79	3384	962	910	10
80	3825	1055	1100	10
81	3744	1136	1290	10
82	4032	1224	1290	10
83	4050	1290	1570	10
84	4380	1407	1650	10
85	4440	1463	1810	10
86	4500	1470	1810	10
87	4570	1478	1810	10

TABLE 2: Forecasted compound usage 1978-1987.
Veneer compound is included in batched-off compound.

YEAR	Method (ii)	Method (iii)	Method (iv)	Method (v)	Method (vi) (with EVA)
0	(381,500)	(28,500)	(381,500)	(0)	(150,000)
1	103560	34750	76170	357000	1530
2	111140	36010	81400	388000	2010
3	125930	40190	92250	439000	2290
4	125470	39740	91800	439000	2340
5	135230	42510	98960	472000	2500
6	137150	42860	100310	481000	2640
7	148650	46050	108720	521000	2830
8	141510	46750	110770	531000	2940
9	153290	47290	112100	537000	2970
10	155360	47910	113630	545000	2990

TABLE III Compound supply on - cost over module proposals (method (i)), and saving in capital investment (year 0). (£)

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