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[illegible] OF A CULTURE FACTORY IN A DEVELOPING COUNTRY

by

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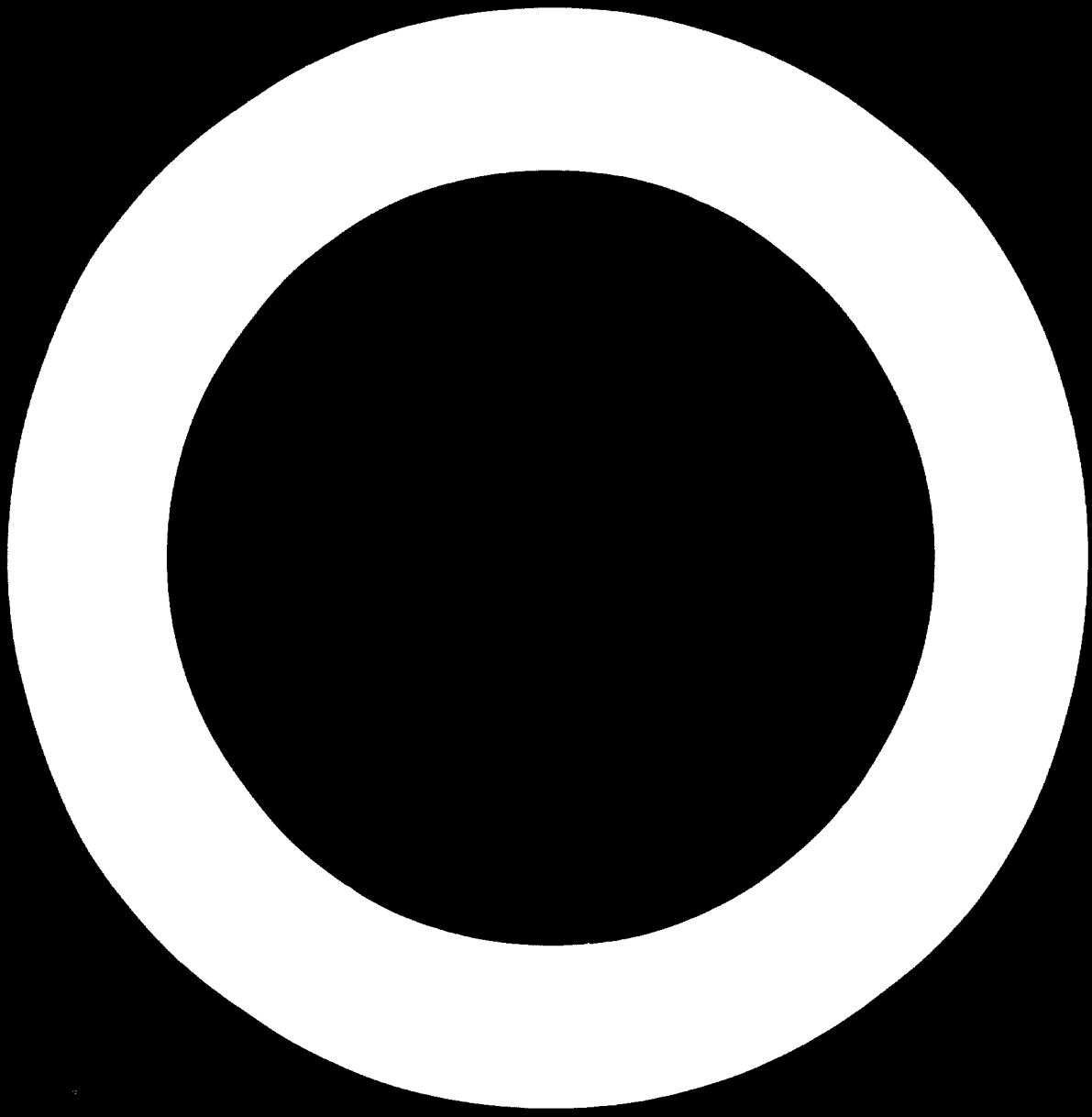


PART I

INTRODUCTION

In view of the preference shown for the textile industry in the process of industrialising developing countries, it would seem pertinent to formulate some guidelines on the establishment of small or medium-sized knitwear operations in such countries.

Knitting and knitted fabrics are competing in many fields with weaving and woven fabrics, the advantage being that knitting units can be started on a small scale and thus initial costs can be kept low. The relation between labour requirements, capital investment and output is very favourable. The knitting industry offers employment at a relatively low rate of per capita investment. The nature of the work is not complicated, so that the training of semi-skilled labour is comparatively easy.

The first section of the paper is concerned with an evaluation of the problems most likely to be encountered, and the second section offers a description of the various sectors within the plant. Hand-knitting looms and crochet are not included as they are handicrafts. The second section also provides fundamental technical data on the various types of machines, processes and fabrics.

MARKET RESEARCH

Prior to setting up a knitwear factory, detailed market research studies should be carried out to establish the population's most urgent requirements. Comparative consumer studies relating to countries with similar climatic and social conditions can also provide a basis for the assessment of the market. It should also be remembered that in the developing countries fashion changes are very rapid. People tend to abandon their traditional clothes in favour of European styles and the growing urban populations adapt their clothing habits to their new environment.

Whereas certain standard knitted garments can be manufactured to replace imports, others remain a distinct risk. Fortunately, the knitwear industry is less susceptible to sudden changes of this nature. The machines are flexible; similar fabrics in wool, cotton or synthetic fibres can be produced on the same machines, and within certain limitations, yarn counts and gauges can be changed on the very same machines.

Experience and the proper interpretation of market trends will help one to assess market requirements as business expands. However, prior to starting a knitwear factory, the industrial engineer must ascertain which articles were imported previously so as to ensure that there is a market which justifies domestic production. Potential investors from industrialized countries should pay due consideration to governmental regulations pertaining to joint ventures. The various aspects with regard to the import of capital, transfer of profits, etc. should also be closely examined.

PROFITABILITY

Throughout the initial period production costs will be higher than those of established enterprises. New knitting factories in developing countries must be granted some form of protection. At the same time consumers have to be protected against exorbitant retail prices.

To ensure normal prices from the very beginning, a portion of the necessary development costs could be borne by the Government. Building plots, and in some cases the buildings themselves, can be made available free of charge and for the purchase of equipment, low interest loans may be granted.

Foreign specialists are needed to train local technicians, but they have to be paid at higher rates. The Government could help to

meet these expenses by providing, through international aid organisations or bilateral arrangements, foreign expertise. Government aid could also be given to finance local training schemes. Tax rebates should only be granted when the new factory has been in operation for some time and is already running at a profit. A more effective form of aid, however, is the granting of facilities to import machinery, spare parts and yarn duty-free.

WORKSHOP LOCATION

The site must be open-ended to provide for possible extension. There must be a constant supply of electricity unaffected by peak-hour loads or drought, and water should be available in sufficient quantities for the ancillary departments. Knitwear production generally presents no transport problems. When selecting a factory site, however, the availability of labour is more important than location close to consumer centres or sources of raw materials.

LABOUR FORCE, EXPERTS AND TRAINING SCHEMES

In comparison with European conditions, the initial rate of productivity will be low. An acceptable level of production can only be reached after two or three years.

The training of technicians and semi-skilled labour presents a particular problem. Fortunately, many developing countries have good vocational schools. Some of these schools have knitting departments and offer young people a chance to improve their skills whilst apprenticed to capable craftsmen in local factories. In areas where such facilities are not available, apprentices can be sent to trade schools abroad.

Foreign specialists who are recruited to assist in the initial stages must have local graduates as counterparts, so that in the course of time the latter can take over. It is interesting to note that the difference in wages paid to semi-skilled and skilled labour is much greater in developing countries than in industrialised countries. Care must be taken to ensure that initial training is carried out on simple machines to facilitate familiarisation.

Operatives should not be employed in fully automated shops unless they have been fully trained as mechanics and are conversant with the operation of the individual pieces of equipment.

Small workshops need only one expert mechanic-cum-foreman. Larger factories require one such person to train new workers in addition to an overseer on each shift. Even when one is fortunate enough to obtain sufficient skilled labour, one has to cope with such factors as hot weather and absenteeism, which are common occurrences in developing countries.

CAPITALIZATION

The financial requirements must be very carefully calculated. The exact cost of the fixed assets, such as buildings and machinery (see quotations made by various suppliers), must be added together, including the installation costs and ancillary appliances. Provision should also be made for departments not specifically dealt with in the scope of the study, i.e. equipment for the supply of basic utilities, such as cleaning and purification plants or transformers. In larger plants, welfare facilities for the workers have to be provided and duly included in the assessment of the starting capital.

Working capital depends on the manner in which the business is conducted. If the enterprise is to job work only, receiving batches of yarn from its customers and being paid upon delivery of the goods, it should suffice to make provisions for the running-in period and the value of one month's sales.

If the enterprise works on its own account, against firm orders only, it should have sufficient capital to maintain a three months' stock of any yarn that has to be imported, a two months' stock for counts that can be purchased locally, plus one month's work in process. If the yarn is dyed locally, provisions must be made for an adequate stock of yarn at the dye-house.

An enterprise that sells from stock should have sufficient capital to finance a two months' stock of finished goods. Special care should be taken to ensure that all ancillary departments, such as the dyeing or finishing sections, have sufficient intermediate stocks.

CHOICE OF MACHINERY

Knitting machines are comparatively flexible. Various kinds of yarns and patterns can be used and the yarn count can be changed. Servicing is simple.

Automation is only advisable in countries where labour costs are high and the market justifies setting up many machines in one factory, for long runs on the same fabric. High-speed machines also require skilled operatives and formers, and are best avoided in the initial period. Equipment should be sturdy and trouble-free and it is imperative that the machines be simple to operate. The individual production stages must be carefully planned to avoid bottlenecks or idle machinery.

A twelve months' stock of spare parts should be available. It is also advisable to obtain the supplier's guarantee that spare parts will continue to be available in the future. With regard to the depreciation of machinery and the repayment of loans, a period of ten years is considered adequate.

THE ECONOMICS OF SCALE

Automatic knitting machines are independent units, whose productivity does not vary provided operation is continuous. At the simplest level, the machines can be tended by members of the family on a part-time basis. The yarn can be purchased on cones, and the owner can restrict himself to job work only and return the knitted fabrics to the original suppliers of the yarn. If he decides to work on his own account, it is advisable to trade directly with a few selected customers. Unlike the products of other cottage industries, knitted fabrics can rarely be sold directly to the public, as overlock sewing machines are usually required before the garments can be made up.

Ten-unit workshops should include winding machines to make the unit independent of other winding services. The hypothetical

projects in the second section of this study are based on this type of shop. In workshops of this size the owner-manager acts as his own foreman and has paid operatives to tend the machines. The number of operatives should stand in reasonable relationship to the number of machines, the owner's family can help if necessary and the owner can be expected to do his own accounting, buying and selling.

The owner can also embark upon steaming and calendering. However, if he has no finishing mill to support him he must use coloured yarns only, and finish his own articles. He can concentrate on job work and or working on his own account, and sell his fabrics in bulk to wholesalers or garment makers. The latter can then send the products, if necessary, to the finishing mill for further treatment.

The above remarks do not apply to warp knitting and Cotton machines. Production in this case is an integrated and much more sophisticated process, which includes winders and ancillary equipment for making borders, finishing and steaming. Cotton machines also require the services of an expert supervisor whose employment can only be justified when a large number of machines is in operation.

The situation is similar with warp-knitting machines. They cannot be operated on a small scale. They require an air-conditioned operational environment and stringent supervision. Their products can only be finished in properly equipped finishing plants, and production has to be on a large scale.

The third category is a factory working on industrial lines with foremen supervising departments containing at least 30 - 50 machines. These factories usually have their own dyeing facilities and a garment making plant is often attached.

No particular problems are encountered when expanding from the single machine to the ten-machine stage. It is simply a process of the owner having the space, training a suitable operative and buying one machine after the other. Expansion beyond this stage, however, is governed by three factors: the enterprise's actual earnings, the availability of technical assistance and the current market situation.

The factory-type of plant can be planned as such and built as an individual enterprise, or it can be developed from the workshop stage. When expanding, on this scale, certain organisational changes must be made. Clear marketing principles must be formulated and decisions taken as to brand names, and production carefully planned. The all too numerous cases of successful small-scale owner-managed enterprises getting into difficulties when seeking to expand are indicative of the complications involved.

Industrial plants should be open-ended. Basic re-organisation is generally not necessary when expanding at this level.

PRODUCTION COSTS

Pre-investment studies are necessary to ensure that manufacturing costs will make profitable operation possible.

The most important factor affecting the maintenance of competitive prices is the continuity of production. Stoppages should be avoided.

The lines of production should not be changed too frequently. It is best if the machines run continuously as long as there is a demand for a given article.

Wages in developing countries are invariably lower than those in industrialised nations. Hence one could argue that productivity can be permitted to be lower, which means that the man-hours per article and the proportion of labour per machine may well exceed the levels customary in countries with established industries. As long as wage levels allow the use of labour-intensive operations, prices will remain competitive. Improvements in production techniques should pave the way for a rise in productivity, permitting an increase in wages without the imposition of higher prices.

OTHER PREREQUISITES FOR PRODUCTION

Raw material of an acceptable standard, if not available locally, will have to be imported. A reliable supply of electricity and steam

must be available. A boiler can be installed or a link provided with a public source of steam. If there is no suitable dyeing plant in the vicinity, either a special dye-house must be built, or production must be based on dyed yarns. The fabrics produced on flat-bed or circular knitting machines using dyed yarns have to be calendered; both hosiery and fully fashioned knitwear have to be steamed. This equipment is simple and should be included (see Part III).

Spare parts must be readily available and adequate provisions made for their importation. If difficulties are encountered, a suitable licence agreement could provide the answer.

Fabrics produced on warp-knitting or Raschel machines require sophisticated finishing facilities which are only justified in large factories. If such facilities are not available, this type of fabric should not be produced. Whereas full fashioned knitwear and hosiery can be made up on the premises, other types of knitted goods require the services of garment- and sport makers, or further processing.

The proper utilization of waste poses a problem in areas where there are no waste spinning plants to reprocess the material. This affects the market price of waste, which has to be used for secondary purposes, i.e. wiping down machinery and polishing.

Some of the largest knitting mills using synthetic filament yarns have their own texturising equipment. However, in view of the specialised nature of the work, most knitters buy ready textured yarns from their suppliers.

[redacted]

In the knitting industry, integration is not as simple as it seems. If fabrics are produced that only require dyeing, steaming and calendering, it would seem reasonable to add these departments to the knitting mill and to consider the profitability of including garment making. One superintendent could act as overseer for both sections, and a single boiler could produce steam for both the finishing and pressing of the garments, thus reducing production costs.

However attractive the above proposition might appear, flexibility is reduced. Integration on this scale should only be considered if the garment-maker can restrict himself to the limited variety of fabrics or yarns on the knitting machines. If this is not the case, he is better advised to buy on the open market and thus be in a better position to meet any changes in demand.

Integration is best suited to plants producing standard articles. However, care must be taken to ensure that the capacities of the fabric-producing and garment-making sections complement each other.

Another possible combination is that of knitter and wholesaler. The knitter can concentrate on improving productivity, and the wholesaler is assured of a continuous supply of standard fabrics. The system, however, is advisable only if the runs are long enough for the knitter and he is not expected to meet short-term deadlines or supply small quantities.

A sophisticated finishing mill should only be merged with a knitting mill where the production of the knitting mill is sufficient to occupy fully the finishing mill. If this prerequisite is not met, there should be an alternate supply of fabrics for the finishing mill from other sources.

Another proposition would be to combine a knitting mill with a weaving mill in a case where both produce fabrics that require a similar type of finishing. This would ensure the optimum utilization of the finishing department's resources. Caution should be exercised when planning to integrate warp knitting and shirt making, because a wide range of fabrics is required for shirt production and there are seasonal fluctuations.

QUALITY CONTROL

In many developing countries there is considerable consumer resistance to new domestic products. People have learnt that many

of these new articles are more expensive than, and inferior to the previously imported articles. Admittedly, quality is difficult to maintain with inexperienced labour, though stringent quality control does help to alleviate the situation.

Foremen must carry out continuous checks on the equipment and impress on the labour force the importance of high quality products. Incoming yarn must be examined on arrival and sub-standard material rejected. One should not economise falsely and buy low-grade yarn. Outgoing fabric should be checked to ensure that specifications are met. Fabrics which fail to come up to standard can be stored for sale as seconds.

RAW MATERIALS

The main raw material for a knitting mill, yarn, is readily obtainable on the world market. Special spare parts for the machines, however, should be purchased from the original suppliers of the equipment. Parts such as needles are best obtained from specialists. Simple components could be replaced locally by a reliable machine-shop which has the great advantage of offering rapid service.

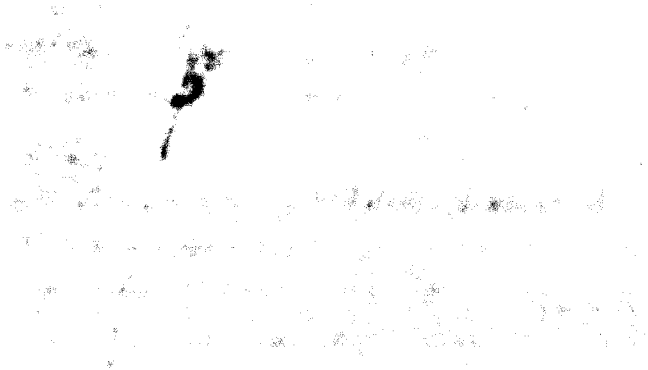
It is imperative that a knitting mill be at liberty to purchase from the supplier considered most suitable. To keep pace with market trends and maintain standards, a reliable supply of suitable raw material should be available. It is also important that the yarn used for brand goods should have exactly the same count, twist and quality irrespective of its origin, otherwise the machines must be stopped and the fabrics changed.

Most suppliers of man-made fibres have reasonable quantities of both coloured and white yarns in stock, but if a medium-sized enterprise is forced to buy dyed cotton and woollen yarns from spinners located at some distance from the plant, it might find prices prohibitive and delivery terms unsuitable. Therefore, most knitters make a practice of buying grey cotton or woollen yarns. Until production justifies the inclusion of a dyeing plant, dyeing can be carried out on a commission basis by local dyers. The knitting mill, of course, must have sufficient winding equipment to deal with the quantities involved.

[redacted]

The development of a large-scale industry involves an entirely different approach. Prior to building a new factory and investing capital to the order of US$ 5 - 10 million, it is advisable to appoint a firm of consultants to carry out a detailed feasibility study. The cost of such a study may range from US$ 30 - 40,000.

Training also presents its problems. In large-scale factories the worker usually performs a limited number of highly specialised tasks and his training can, therefore, be completed in a relatively short time. In a small-scale factory, however, he is required to perform several tasks, and consequently he needs a longer training period.



PART II

INTRODUCTION

For the reader's convenience the names of the suppliers whose catalogues were used are quoted, and interested parties can obtain any additional information directly from them. Mention should also be made of the number of textbooks available in many countries, and particular attention is drawn to the authoritative work written by M. Spencer, B.Sc., F.T.I., F.S.T., Senior Lecturer in knitting technology, entitled "Knitting", (Pitman, London).

The second section of this study provides detailed descriptions of the machinery to be used at each stage and some examples of hypothetical projects. The technical data provided in this section were compiled with the help of experts from the Vienna School of Textiles and include information from catalogues and details supplied by a variety of prominent knitting machine manufacturers in different countries. The author would hasten to point out that there is no preference or discrimination intended; the list is not exhaustive, the selection is limited to those firms who supplied data.

Prices quoted within the context of this report are in United States dollars, ex-works, based on quotations received from several machine makers in September 1980. The examples quoted refer to small-scale plants and when planning larger units, the figures given need only be increased proportionally. It must also be borne in mind that this study and the data supplied refer solely to knitting. Ancillary or supplementary machines are mentioned within the framework of the main study merely for the sake of the record.

Once a decision to build a plant and produce certain fabrics has been taken, the study can be consulted to see what types of machinery are available and who supplies them. The next step would be to draw

up in conjunction with the suppliers a plan for the actual factory, on the basis of the most suitable examples given in this study. A lay-out diagram, including the floor-space requirements, is included for each stage and production data are based on a 90 hour, two-shift working week. Attention is drawn to the fact that though knitting machines vary from one manufacturer to another, each basic type is fundamentally the same.

CIRCULAR KNITTING MACHINES FOR OUTERWEAR

The distinct advantage of circular knitting machines is that one can dispose with all preparatory operations such as warping and sizing; the yarn need only be wound onto packages. As there is no warp, the question of minimum lengths in one colour or pattern no longer arises. As changes in structure and colour are both simple and quick, these machines can be run for protracted periods without any stoppages, and productivity is high.

Due to the comparatively low yarn tension, softly twisted yarns can be used to produce articles which are both bulky and soft. The major disadvantage of a circular machine, however, is that the widths and gauges cannot be changed, and thus the range of yarns that can be used on each machine is limited.

There are three basic types of machines:

(a) simple machines with a limited selection of patterns, but capable of high speeds;

(b) machines suitable for medium-sized patterns. The pattern possibilities can be increased with the aid of various attachments and the needle selection is set by hand;

(c) machines using a Jacquard mechanism with either punch cards, film or electronic controls for the knitting of large patterns.

The machines may also be classified according to the number of beds:

(a) single jersey machines with one bed of needles;

(b) double jersey machines with two beds of needles;

(c) purl machines with two beds of needles, but only in one row.

All the machines mentioned above can be adjusted to continuous bulk production or the production of fitted lengths. Fabrics are finished in circular or tubular form and sold to the trade or makers-up. Other fabrics are produced in specific lengths, thus eliminating cutting and waste, and facilitating the making-up.

Machines for the production of outerwear usually have a diameter of thirty to thirty-three inches and the finished cloth is approximately 155 cm wide.

Gauges vary widely between five and twenty-four needles per inch, and the machine's capacity depends upon the number of threads being fed into the beds of needles (multi-feeders). A great variety of yarns is available. They are drawn off cones and when continuous lengths in plain or one-colour patterns are being produced, grey yarns can be used and the cloth subsequently sent to the finishers for dyeing and steaming. Cloth made from dyed yarns is passed through a steaming calender on the premises, while other types of fabric are sent to the finishing sector to be fulled or shrunk prior to steaming. Cloth produced in fitted lengths is usually steamed on-plant before being made up into garments, and the garments are re-steamed when finished.

In this section, data were supplied by the following companies:

The Bentley Engineering Co. Ltd., Leicester, United Kingdom;
Georges Leboeuf et Cie., 10 Troyes, France;
Mayer und Co., Maschinenfabrik, 7477 Tailfingen/Württemberg, F.R.G.;
Franz Morat, Stuttgart, F.R.G.;
Nishio Knitting Machine Works Ltd., Osaka, Japan;
C. Terrot Söhne, Maschinenfabrik, 7 Stuttgart, Bad Cannstatt, F.R.G.;
Wildmann Jacquard Division, North American Rockwell, Reading, Pennsylvania, U.S.A.;
Wildt-Meller-Bromley, Leicester, U.K.

Theoretical Layouts

LAYOUT A1

Machinery: 6 double jersey circular knitting machines
18 needles per inch, 24 feeders
diameter: 30 inches

Power: approx. 2 kW/h per machine

Type of production: outerwear fabrics, plain

Material: blend of 45 per cent virgin wool and
55 per cent polyester
30/1 metric count, yarn purchased ready-dyed
on cones

Output:	90% efficiency approx. 700 m per machine, totalling 4,200 m or 1,620 kg for six machines
Yarn requirements per running metre: (155 cm wide)	approx. 375 g
Waste:	negligible
Other equipment:	1 winder in the yarn store to re-spool yarn residue on cones
Finishing procedure:	steam treatment on tenter frames, the actual finishing being done in an ancillary plant, whereafter the fabric is sold by the yard.
Staff requirements:	2 semi-skilled operatives per shift, knitting duties only
Approximate costs involved:	6 machines: US$ 66,000

LAYOUT A2

Machinery:	6 double jersey Jacquard circular knitting machines, 20 needles per inch, 24 feeders diameter: 30 inches.
Power:	approx. 2.2 kW h per machine.
Type of production:	outerwear fabrics, three-colour Jacquard cloth.
Material:	bright, polyester fibre, 135 denier 50/1 metric count, yarn purchased ready-dyed on cones
Output:	90% efficiency approx. 550 m per machine, totalling 3,300 m or 990 kg for six machines
Yarn requirements per running metre: (155 cm wide)	approx. 300 g
Waste:	negligible
Other equipment:	1 winder in the yarn store to re-spool yarn residue on cones

Finishing procedure:	performed in ancillary plant and sold thereafter by the yard
Staff requirements:	2 semi-skilled operatives per shift, knitting duties only
Average costs involved:	6 machines: US$ 108,000

LAYOUT A3

Machinery:	6 double jersey transfer Jacquard circular knitting machines 16 needles per inch, 24 feeders diameter: 33 inches
Power:	approx. 2.2 kW h per machine
Type of production:	ribbed cotton cloth for jackets
Material:	combed, singed and mercerized cotton 60/2 metric count, grey yarn purchased on cones
Output:	90% efficiency approx. 800 m per machine, totalling 4,800 m or 1,800 kg for six machines
Yarn requirements per running metre: (180 cm wide)	approx. 300 g
Waste:	negligible
Other equipment:	1 winder in the yarn store to re-spool yarn residue on cones
Finishing procedure:	washing, dyeing, drying and steaming performed in ancillary plant and the cloth then sold by the yard to the makers-up
Staff requirements:	2 semi-skilled operatives per shift, knitting duties only
Approximate costs involved:	6 machines: US$ 138,000

LAYOUT A4

Machinery:	10 circular knitting machines with one bed of needles each 26 needles per French inch (27.8 mm) 8 feeders diameter: 20 French inches
Power:	1 kW/h per machine
Type of production:	single jersey
Material:	worsted wool 30/1 metric count, grey yarn purchased on cones
Output:	80% efficiency approx. 300 m per machine, totalling 3,000 m or 930 kg for ten machines
Yarn requirements per running metre: (180 cm wide)	approx. 310 g
Waste:	negligible
Other equipment:	1 winder in the yarn store to re-spool yarn residue on cones
Finishing procedure:	washing, dyeing, a certain amount of fulling, drying, shearing and steaming. The width of the fabric is reduced to 140/150 cm after fulling. Finishing is carried out in an ancillary plant and the cloth then sold by the yard
Staff requirements:	2 semi-skilled operatives per shift, knitting duties only
Approximate costs involved:	10 machines: US$ 80,000

LAYOUT A5

Machinery:	8 double jersey Jacquard circular knitting machines for fitted lengths 14 needles per inch, 24 feeders diameter: 33 inches

Power:	2.2 kW/h per machine
Type of production:	long-sleeved pullover lengths in cloqué knit ending in 2/2 rib
Material:	acrylic yarn 34/2 metric count, purchased ready-dyed on cones
Output:	90% efficiency approx. 375 m per machine, totalling 3,000 m or 2,040 kg (1,500 items, average length 65 cm) for eight machines
Yarn requirements per pullover:	approx. 540 g
Waste:	negligible
Other equipment:	1 winder in the yarn store to re-spool yarn residue on cones steam facilities overlock sewing machine, linking machine, lockstitch machine, plain lockstitch machine, buttonhole and button sewing machines for making up
Finishing procedure:	steaming calender and garment making on the premises
Staff requirements:	2 semi-skilled operatives per shift, knitting duties only
Approximate costs involved:	8 machines: US$ 192,000

Similar garments can also be knitted on flat-bed knitting machines. The pattern possibilities are greater on re-setting, but the output is lower. The gauge is restricted (14 needles per inch max.) and compares unfavourably with that of circular knitting machines (24 needles per inch).

CIRCULAR KNITTING MACHINES FOR UNDERWEAR

The various circular knitting machines are distinguished by the number of needles and their setting.

1. Circular knitting machines with one bed of needles;
2. Circular knitting machines with two beds of needles;
   (a) where the dial needle slots and cylinder needle slots are staggered (rib machines);
   (b) where the dial needle slots and cylinder needle slots are set in a straight line (interlock machines).

Both types of machines are mainly used for the production of tubular fabrics with diameters ranging from 12 to 24 inches. This makes for savings when the garments are made up. Even larger machines with a diameter of 30 inches can be used for the production of underwear fabrics (160 cm wide).

A further distinction can be made between:

(a) machines for the production of running lengths; and
(b) machines for the production of fitted lengths with or without attachments for fully-fashioned welt.

Depending on the machines used, patterning scope is very wide, ranging from plain to ajour. There are almost no limits to the materials that can be used, or the fibres that can be blended and their respective counts. Finishing in this sector mostly consists of dyeing or piece bleaching in addition to steaming. Making-up presents no particular difficulties and can usually be included in the production line.

Underwear fabric can be produced on both circular knitting and warp-knitting machines depending on the yarn count. Circular knitting machines use slightly coarser yarns.

In this section, data were supplied by the following companies:

The Bentley Engineering Co. Ltd., Leicester, U.K.;
Georges Lebocey et Cie., [illegible]es, France;
Mayer und Cie., Maschinenfabrik, 7477 Tailfingen, Württemberg, F.R.G.;

C. Terrot und Söhne, Maschinenfabrik, 7 Stuttgart, Bad Cannstatt, F.R.G.;
TRW Division, North American Rockwell, Reading, Pennsylvania, U.S.A.;
Wildt-Meller-Bromley Ltd., Leicester, U.K.

Theoretical Layouts

LAYOUT B1

Machinery:	8 CMS rib machines
	20 needles per inch, one feeder per inch
	diameter: 10 - 20 inches
Power:	approx. 1.5 kW/h per machine
Type of production:	men's sleeveless vests ranging from 10 to 20 inches depending on the machine
Material:	medium quality cotton yarn
	32/1 metric count, wound onto cones on the premises
Output:	85% efficiency
	approx. 2,200 m per machine, totalling 17,600 m or 2,800 kg (22 - 30,000 vests)
Yarn requirements	
per garment:	160 g
Waste:	approx. 5%
Other equipment:	shelving to accommodate 8 - 10 days production and a vertical conveyor in the yarn store, as well as a humidifier to maintain a constant atmospheric humidity of approx. 65%
	1 small winder with twelve spindles in the winding shop
	The knitting section should comprise the following models:
	1 10" knitting machine
	2 12" " "
	2 14" " "
	2 16" " "
	1 18" " "
	1 20" " "

An additional 72" machine (14 gauge) should be installed to produce 6,000 bands daily.

Provision should be made for ample passage way between the machines, to allow a small trolley to pass. Adequate rack and shelving systems should be installed for the temporary storage of fabric rolls before they are sent to the inspection department.

Power lines are to be laid below ground and in addition to humidifiers, the area must be equipped with a compressed air unit (Gryvacone, type WCW 100) for the oil pump and de-fluffing machines.

The finished rolls of fabric are subjected to mechanical inspection, using the "Visiteuse type V" manufactured by Ateliers Heliot-Tryes of France.

Finishing procedure: prior to being made up, the fabric must be bleached, either on the premises or in a dyeing mill. Thereafter the fabric is cleaned, checked and ironed. Steam facilities are thus necessary.

Fabrication department: the fabric is stacked, marked out and cut. The shoulders are seamed, the neck bands are sewn on, followed by the right and left armhole bands, all of which are then stitched. The lower hem is completed and finally the label is sewn on.

Power requirements:

10 knitting machines	1.5 kW/h	= 15.0 kW/h
1 winder	1 kW/h	= 1.0 kW/h
1 compressed air unit	5.5 kW/h	= 5.5 kW/h
1 inspection machine	0.5 kW/h	= 0.5 kW/h
	Total	22.0 kW/h

Three-phase 220/380 V, 50 cycles

Light is provided by fluorescent tubes, 5-600 lux/sq.m

Staff requirements: The following recommendations are based on a standard European eight-hour shift, including making-up but excluding finishing:

Winding: 1 skilled operative

Knitting: 4 operatives, semi-skilled

Inspection: 1 skilled female hand

Cutting and preparing: 5 skilled hands, 2 unskilled labourers for handling purposes

Making-up: 14 skilled female workers, 4 unskilled labourers

Cleaning, checking, ironing and packing: 3 skilled female hands, 2 unskilled labourers for handling purposes

Storage of finished goods: 1 foreman aided by 4 unskilled labourers

Approximate costs

Machinery: Depending on gauges and diameters, prices per machine vary between US$ 6,200 and US$ 9,700

LAYOUT B2

Machinery: 8 transfer Jacquard circular knitting machines for fitted lengths
14 needles per inch, 12 feeders
diameter: 15 inches

Power: 1.1 kW/h per machine

Type of production: fitted lengths for ladies' chemise, patterned with ribbed welt. Half-cardigan with 2/2 ribs

Material: blend of 67% cotton and 33% viscose
60/1 metric count, grey, purchased on cones

Output: 90% efficiency
approx. 2,100 m per machine, totalling 16,800 m or 1,680 kg (20,800 chemise lengths) for 8 machines

Yarn requirements

Per running metre: approx. 100 g
(100 cm wide)

Waste:	5%
Other equipment:	1 winder in the yarn store adequate steam for pressing lockstitch machine, overlock machine and chainstitch machine for making up
Finishing procedure:	effluent activity restricted to washing, bleaching or dyeing, drying and steaming
Staff requirements:	2 operatives per shift, knitting duties only
Approximate costs	
Involved:	8 circular knitting machines: approx. US$ 80,000

LAYOUT B1

Machinery:	8 fine rib circular knitting machines with Jacquard attachment 15 needles per inch, 12 feeders, diameter: 18 inches
Power:	1.5 kW/h per machine
Type of production:	ladies' underwear rib Jacquard eyelet structure
Material:	polyamide staple fibre 20/1 metric count or possibly polyacrylic yarn 34/1 metric count, both purchased on cones
Output:	90% efficiency (a) polyamide approx. 1,300 m per machine totalling 10,400 m or 1,300 kg for 8 machines (b) polyacrylic approx. 1,300 m per machine totalling 10,400 m or 1,560 kg for 8 machines
Yarn requirements per running metre: (180 cm wide)	approx. 170 g and 150 g respectively
Waste:	5%
Other equipment:	1 winder in the yarn store adequate steam for pressing lockstitch machine, overlock machine, chain stitch machine for making-up

Finishing procedure:	off-plant activity entailing washing, bleaching or dyeing, drying and steaming
Staff requirements:	2 semi-skilled operatives per shift, knitting duties only
Approximate costs involved:	8 circular knitting machines approx. US$ 72,000

LAYOUT 14

Machinery:	8 interlock circular knitting machines 28 needles per inch, 24 feeders diameter: 16 inches
Power:	approx. 1.1 kW/h per machine
Type of production:	running lengths for underwear plain interlock
Material:	combed cotton 28/1 English count, grey yarn (40/1 metric count) purchased on cones
Output:	90% efficiency approx. 2,200 m per machine, totalling 17,600 m or 2,800 kg for eight machines
Yarn requirements per running metre: (85 cm wide)	160 g
Waste:	negligible
Other equipment:	1 winder in the yarn store adequate steam for pressing lockstitch machine, overlock machine, chain stitch machine for making-up
Finishing procedure:	washing, bleaching or dyeing, drying and steaming
Staff requirements:	2 operatives per shift, knitting duties only
Approximate costs involved:	8 circular knitting machines: US$ 64,000

LAYOUT B5

Machinery: 8 interlock circular knitting machines
super-multi-feed FRIN/SN
gauge: 20 needles per inch
diameter: 16 - 22 inches

Power: 1.5 to 2 HP

Type of production: men's underwear - vests and pants
interlock fabric, continuous knit

Material: cotton
34/1 English count, 56/1 metric,
quality 34/35 CPI purchased on cones

Output: 90% efficiency
approx. 200 m per machine, totalling
1,600 m and 256 kg for 8 machines (8-hour day)

Yarn requirements: any surplus material over and above the requirement of 1,440 yards, enough for 200 dozen garments, plus the material cut away when making up the garments can be used for gussets, neck bindings and other edgings

Waste: negligible

Other equipment: 1 winder in the yarn store to re-wind spoilt cones
The eight machines in the knitting area should be set up with a 4-foot passageway down the centre and room enough for an operator to pass round each machine. Racks and benches should be arranged at a convenient distance to avoid damage to yarns during handling; knitted fabric rolls taken from the machines need to be weighed, ticketed and stored in a properly conditioned store room

Finishing procedure: as for B4

Making-up: as for B4

Staff requirements: a semi-skilled mechanic can usually service 30 machines, and an operative can manage

120 to 144 feeds on 24-feed machines, and 144 to 180 feeds on 36-feed machines. Unskilled labour can be used for miscellaneous tasks, and it is customary to have an apprentice assigned to the mechanic

Approximate costs involved:

For the suggested machines (1 16" dia., 3 18" dia. 3 20" dia. and 1 22" dia.): £ 25,000

CIRCULAR KNITTING MACHINES FOR HOSIERY

The machines can be classified as follows:

1. Single-cylinder circular knitting machines, alternatively circular jersey machines.
2. Rib circular knitting machines where the dial is mainly used for knitting the rib welt (the length is knitted using the cylinder).
3. Double-cylinder circular knitting machines, alternatively purl machines, to knit 1/1 rib welts, broad ribs and/or purl stitch structure.

The patterning scope of the above three basic types can be extended by the use of additional appliances such as plating, reverse plating and colour changing attachments and other fittings for Jacquard effects, trick patterns and warp designs.

The technical classification can be supplemented by a further division according to the articles produced which determine the cylinder diameter.

Cylinder diameters of 3 3/4 to 4 inches are used for:

1. (a) ladies' stockings, fine and seamless;
   (b) ladies' stockings, reciprocated heel and reciprocated looped toe;
   (c) ladies' stockings, reciprocated heel and tailored toe;
   (d) ladies' stockings, reciprocated heel and closed toe;
   (e) ladies' stockings, seamless, reciprocated heel and toe;
   (f) ladies' socks, reciprocated heel and reciprocated looped toe;
   (g) ladies' ankle socks, reciprocated heel and reciprocated looped toe;
   (h) ladies' half-hose, reciprocated heel and reciprocated looped toe;
   (i) ladies' sports hose, reciprocated heel and reciprocated looped toe;
   (j) ladies' tights, reciprocated heel and reciprocated looped toe.

Cylinder diameters of 3 3/4 to 5 inches are used for:

2. (a) gent's socks, reciprocated heel and reciprocated looped toe;

(b) gents' ankle socks, reciprocated heel and reciprocated looped toe;

(c) gents' half-hose reciprocated heel and reciprocated looped toe,

(d) gents' sports hose, reciprocated heel and reciprocated looped toe.

Cylinder diameters of 2½ to 3½ inches are used for:

3. (a) childrens' socks, reciprocated heel and reciprocated looped toe;

(b) childrens' half-hose, reciprocated heel and reciprocated looped toe;

(c) childrens' sports hose, reciprocated heel and reciprocated looped toe;

(d) childrens' tights, reciprocated heel and reciprocated looped toe.

Light-weight sheer stockings in cotton or textured synthetic yarns are knitted in grey on simple single- or double-cylinder machines and the gauge is 12-16 needles per inch. Light- to medium-weight ankle socks, socks and half-hose can be produced on all three types of machine. The machines are more expensive, however, owing to the patterning units that have to be included to keep pace with fashion trends. Materials used vary from textured synthetic filament yarns, high-grade cotton to wool yarns. The gauges vary from 12 to 20 needles per inch, whereas ladies' stockings require gauges of 20 to 24 needles per inch.

Heavy-weight socks and sports hose can be knitted on all three machines listed at the beginning of this section, where the gauges range from 4 to 8 needles per inch. The most suitable materials would be high-grade cotton and wool yarns, and a terry attachment can be fitted for knitting soles, soles, toes, or whole socks. Very coarse-gauged single-cylinder circular knitting machines are used for the extremely heavy variety of socks; gauges vary from 2½ to 4 needles per inch and the most suitable material is good quality wool yarn that can be fulled. The diameter of these machines is usually 5 inches.

Finishing will consist of batch-dyeing and boarding, but dyed yarns can be used. Making-up requires a linking machine and a very fine overlock machine. The majority of the machines are fitted with an attachment for a full fashioned welt so that it is not necessary to separate the individual stockings. Elastic thread is automatically inserted into the welts of the various types of socks. The number of feeders which is dependent on the type of machine and patterning, ranges from two to three, but can be as high as eight.

In this section, data were supplied by the following companies:

The Bentley Engineering Co. Ltd., Leicester, United Kingdom;
Gottlieb Eppinger KG, Maschinenfabrik, 7306 Denkendorf bei Stuttgart, F.R.G.;
Bruno Sangiacomo, 25100 Brescia, Italy;
Schubert & Salzer, Ingolstadt, F.R.G.;
TRW Division, North American Rockwell, Reading, Pennsylvania, U.S.A.

Theoretical Layouts

LAYOUT C1

Machinery:	10 single-cylinder circular knitting machines, 34 needles per inch, 8 feeders, diameter: 3 3/4 inches.
Power:	0.5 kW/h per machine
Type of production:	ladies' stockings, fine plain welt knit.
Material:	polyamide fibre, 20 denier, purchased grey on cones.
Output:	80 % efficiency approx. 13.5 kg per machine, totalling 135 kg or 1,400 dozen stockings for ten machines.
Yarn requirements per pair:	approx. 10 g
Waste:	5 %
Other equipment:	Adequate shelving for yarn storage, 1 special overlock sewing machine , adequate supply of steam.

Finishing:	On-plant activity, with the dyeing, boarding, pairing and folding being done in a separate department.
Staff requirements:	2 semi-skilled operatives per shift, knitting duties only.
Appropriate costs involved:	10 circular knitting machines: US$ 35,000

LAYOUT 02

Machinery:	10 double-cylinder circular knitting machines 14 needles per inch, 3 feeders diameter: 4½ inches.
Power:	0.7 kW/h per machine
Type of production:	men's half hose purl, Jacquard pattern
Material:	combed, singed and mercerised cotton 40/2 English count, grey yarn purchased on cones
Output:	80 % efficiency 53.5 kg per machine, totalling 535 kg or 800 dozen for ten machines.
Yarn requirements per pair:	approx. 55 g
Waste:	5 per cent
Other equipment:	Adequate shelving for yarn storage 1 double chain-stitch machine
Finishing:	dyeing, steaming, pairing and packing, necessitating an adequate supply of steam.
Staff requirements:	2 semi-skilled operatives per shift, knitting duties only
Approximate costs involved:	10 circular knitting machines: US$ 40,000

WARP-KNITTING MACHINES

Unlike other sectors in the knitting industry, warp knitting cannot be run on a small scale. The employment of a master-technician is necessary, the working premises must be air-conditioned and the layout must include a warping section. A finishing mill complete with the most modern machines should be on hand.

Warp-knitting represents one of the latest developments in the knitting industry. With the introduction of the new man-made fibres and the technological innovations of the last few years, it is now possible to produce an extensive range of high-grade fabrics, eminently suitable as outerwear and underwear or for technical uses. The fabrics thus produced are either entirely new or they replace articles that were previously woven or produced on other knitting machines.

Plants using warp knitting machines have to include appropriate winding and warping equipment. However, unlike in weaving, sizing is not necessary as the warp is subject to little strain.

Basically there are two types of warp knitting machines:

(a) Raschel machines;

(b) standard warp-knitting machines.

The range of these machines can be extended considerably by using special attachments. It must be pointed out, however, that the finishing of most of the fabrics produced on such machines is beyond the scope of the average knitting mill. Finishing procedure entails piece-dyeing and steaming, synthetics have to undergo heat-treatment on tenter frames and, depending on their final application, numerous other kinds of finishing processes may be required.

WARP-KNITTING ON RASCHEL MACHINES

Single Raschel machines have one needle bar and a number of guide bars and additional attachments depending on the type of production. The basic version is available in gauges from 28 to 56 (14 to 28 NPI), and the working widths range from 50 to 190 inches. The rate of

production is dependent on the gauge set, material used and pattern desired, and the yarn is processed at speeds of up to 1,000 courses per minute. Using 8 guide bars and possibly a chopper bar to increase the vertical and horizontal rigidity of the fabrics, this type of machine can be used to knit various bags, gauze, mosquito nets, shoe linings, package and hair nets, fishnet fabrics, and technical articles.

On Raschel machines designed for the knitting of curtain materials, the gauges range from 14 to 28 needles per inch and the working widths vary from 105 to 244 inches. The rate of production which is governed by the number of guide bars from plain or lightly patterned curtain material in fine or coarse net to plush curtaining.

Special Raschel machines have been developped for the production of foundation garments and underwear, bathing costumes, patterned and plain elastic materials and various ribbonings. These machines are equipped with automatic tension control for the elastic material feeders, and gauges vary from 24-48, even 64 (12-24 or 32 NPI) with working widths from 105 to 124 inches. The guide bars may number 4, 5, 6 or 8 and the rate of production varies accordingly from 600-1,000 courses per minute.

Highly versatile multi-bar Raschel units are also used for the production of lace ribbons, laces plain and patterned curtains, and outwear with the chopper bar and wool fringe effect. As a rule, three basic guide bars and as many as 27 pattern guide bars are used: the gauges on these machines range from 28 to 48 (18 to 24 NPI) and working widths from 75 to 124 inches. The rate of production varies from 400 to 700 courses per minute. Special Raschel machines are also available for the production of cords, braids, fishnet stockings, packaging nets, carpets, mats, etc.

In this section, data were supplied by the following company:

Karl Mayer Textilmaschinenfabrik G.m.b.H., 6053 Obertshausen über Offenbach-Main/4, F.R.G.

Theoretical Layouts

LAYOUT D1

Machinery: 4 Raschel machines with 6 guide bars and 1 chopper bar
gauge: 36 (18 NPI)
working width: 75 inches

Power: approx. 4 kW/h per machine

Type of production: ladies' outerwear fabrics for tropical climates

Material: textured polyester fibre
135/1 denier, grey, purchased on cones.

Output: 90 % efficiency
approx. 900 m per machine, totalling 3,600 m or 580 kg for four machines.

Yar requirements per running metre: approx. 160 g

Waste: 5 per cent

Other equipment: 1 winder in the yarn to re-spool residue on cones

Making up: sold by the yard or made up in an ancillary plant.

Finishing: an ancillary plant activity comprising dyeing and heat treatment on tenter frames.

Staff requirements: 4 semi-skilled operatives per shift, knitting duties only.

Approximate costs involved: 4 Raschel machines US $24,000 and an additional US 4,000 may be needed for the various attachments.

LAYOUT D2

Machinery: 4 Raschel machines with 3 guide bars, 20 pattern guide bars and a chopper bar.
gauge: 36 (18 NPI)
working width: 105 inches.

Power:	approx. 3.5 kW/h per machine
Type of production:	lace fabric for ladies outerwear
Material:	textured polyamide and polyester yarns: either 70/1 denier or 135/1 denier, purchased grey or white on cones.
Output:	90 % efficiency approx. 1,000 m per machine, totalling 4,000 m or 520-640 kg, for four machines.
Yarn requirements per running metre:	approx. 130 g of 70/1 denier polyamide, 140 g of 135/1 denier polyamide and 160 g of 135/1 polyester yarns.
Waste:	5 % efficiency
Other equipment:	1 winder in the yarn store to re-spool residue on cones.
Making up:	sold by the yard or made up in an ancillary plant.
Finishing:	an ancillary-plant activity comprising dyeing and heat-treatment on tenter frames.
Staff-requirements:	4 semi-skilled operatives per shift, knitting duties only.
Approximate costs involved:	4 Raschel machines US$ 56,000 and an additional US$ 8,000 may be needed for the various attachments.

STANDARD WARP-KNITTING MACHINES

Single warp-knitting machines are built with one needle bar and 2, 3 or 4 guide bars for the warp threads. These machines are obtainable with gauges of 12 to 36 needles per inch and working widths ranging from 84 to 168, even 260 inches. They are used for the production of plain, patterned or open-worked fabrics, elasticated or otherwise for gentlemen's shirts, ladies' blouses, children's wear, casual wear and working clothes. Knitted foundation layers for laminated or bonded fabrics and lining fabrics can also be produced on these machines. The patterning possibilities can be extended

by the addition of certain attachments. The rate of production, dependent as always on such factors as gauge, number of guide bars and the pattern selected, varies from 400 to 1,000 courses per minute.

A second class of warp-knitting machines with 8, 12 or even 18 guide bars and a rate of production that ranges from 400 to 800 courses per minute is available. Gauges vary from 14 to 26 needles per inch and working widths range from 84 to 168 inches. The fabrics produced are used for lad ies' underwear, foundation garments, dresses, blouses, bathing costumes and beachwear as well as for furnishings, umbrella fabrics, etc.

There is another type of automatic warp-knitting machine with two needle bars opposite each other and two guide bars. This double warp loom is obtainable in gauges of 26 to 34 needles per inch with a working width of 84 inches and a rate of production touching 900 courses per minute. It is suitable for the production of glove fabrics, imitation leather fabrics, outerwear in synthetic yarns and cotton, curtains and covers.

In this section, data were supplied by the following company: Karl Mayer Textilmaschinen-Fabrik G.m.b.H., 6053 Obertshausen, F.R.G. VEB Wirkmaschinenbau, Limbach-Oberfrohna, German Democratic Republic.

Theoretical layouts

LAYOUT N1

Machinery: 4 warp-knitting machines with 2 guide bars
32 needles per inch
working width: 84 inches.

Power: 2,4 kW/h per machine

Type of production: gentlemen's shirts

Material: polyamide
70 denier, grey yarn purchased on cones

[redacted]: 80 % efficiency
approx. 2,000 m per machine, totalling
8,000 m or 660 kg on four machines

Yarn requirements

[redacted] entry: approx. 82 g

[redacted]: 3 %

Other equipment: 1 winder in the yarn store to re-spool
receive on cones.

[redacted] up: sold by the yard to shirtmakers or made up
in an ancillary plant.

Finishing: an ancillary-plant activity, entailing dyeing
and heat treatment on tenter frames.

[redacted] requirements: 4 semi-skilled operatives per shift, knitting
duties only.

Approximate costs: 4 warp-knitting machines approx. US $ 22,000
and an extra US $ 4,000 might be needed for
additional attachments.

[redacted]

[redacted]: 4 warp-knitting machines with 3 guide bars
20 needles per inch
working width: 163 inches.

Power: 3.3 kW/h per machine

Type of production: fabric for working clothes

Material: bright, texturised polyester
133/30/1 denier, purchased on cones.

[redacted]: 80 % efficiency
approx. 2,200 m per machine, totalling
8,800 m or 7,900 kg on four machines

Yarn required

[redacted] running entry: 900 g

[redacted]: 3 %

Other equipment: yarn storage space.

[redacted]: sold by the yard or made up in ancillary plant.

[redacted]: ancillary-plant activity comprising dyeing, printing and heat treatment.

[redacted]: 4 semi-skilled operatives per shift, knitting duties only.

Average costs involved: 4 warp-knitting machines approx. US$ 40,000 plus an additional US$ 2,000 for attachments.

[illegible]

The yarns used on flat-bed knitting machines are coarse and medium counts. The raw material is pure wool or blends of wool and other fibres. The fabric produced on these machines is ideal for outerwear garments such as ladies' dresses, children's wear and pullovers. It is common practice to include a garment-making section in the plant, and the fabric passes through a steaming calender prior to being made up.

Flat-bed knitting machines usually have a gauge varying between 3 to 16 needles per inch. Details are restricted to the following basic types:

(a) Machines producing plain cloth which can only operate with circular knitting machines when racking or the ability to change from 2/2 ribs to plain is required. Their working width of 180 cm generally permits the production of a finished fabric 95 cm wide;

(b) Machines with stitch transfer and Jacquard attachment, which offer a wide variety of patterns, including "intarsias". Fabrics can be produced in exact lengths to specific garment requirements with the requisite 2/2 welts. With a working width of 180 cm the finished fabric is 155 cm wide or several narrower widths run off side by side;

(c) Machines with attachments for widening and narrowing, which produce semi-fashioned fabrics. The maximum working width of 90 cm permits the production of parts, the widths of which can be adjusted to the measurements of the final garment;

(d) Purl machines which offer a great variety of structures, including loose ones which are used for garments and scarves where free stretch is required both lengthwise and breadthwise. With a looser structure, a working width of 170 cm suffices to produce 155 cm of finished cloth, and the machines themselves are equipped with narrowing and widening attachments.

A typical factory layout has been given for each of these machines. It is also common practice to have a narrow width machine (working width 40 cm) operating as a supplementary machine producing multi-coloured borders with Jacquard trimming. Each of the four layouts refers to different yarns, structures and applications. Production is based on a 90 per cent efficiency factor, 10 per cent being allowed for stoppages as opposed to the customary 5 per cent in Europe.

Over and above the staff requirements cited, a knitting technician is required. If there are less than 30 to 40 flat-bed knitting units, it should be pointed out that the work of the knitting technician or owner is merely a part-time occupation.

In this section, data were supplied by the following companies:

H. Stoll & Co., Strickmaschinenfabrik, 7410 Reutlingen, F.R.G.;
VEB Elite-Diamant, 9030 Karl-Marx-Stadt, German Democratic Republic;
Wildt-Meller-Bromley Ltd., Leicester, United Kingdom.

Theoretical Layouts

LAYOUT F1

Machinery: 6 flat-bed knitting machines with high and low butt needles.
10 needles per inch.
working width: 130 cm.

Power: 0.5 kW/h per machine.

Type of production: ladies' short-sleeved pullovers with 2/2 welt,
average size: 12 or medium.

Material: pure worsted wool
28/2 metric count, purchased ready-dyed in hanks and wound onto cones on the premises.

Output: 90 % efficiency
approx. 145 m per machine, totalling approx. 870 m or 630 kg (1230 pullovers) for six machines.

Yarn requirements per garment:	approx. 500 g, net weight 400 g
Waste:	20 %
Other equipment:	1 winder in the yarn store cutting machine, lockstitch sewing machine overlock machine linking and seaming machines for making up.
Finishing:	steaming calender and cloth press as well as steamer for garments when finished, necessitating an adequate supply of steam. Fabric inspection facilities, storage space and shipping amenities.
Staff requirements:	2 semi-skilled operatives, knitting duties only.
Approximate costs involved:	6 flat-bed knitting machines: approx. US$ 27,000

LAYOUT F2

Machinery:	6 flat-bed knitting machines with stitch transfer and Jacquard attachment.
Power:	0.5 kW/h per machine
Type of production:	men's long-sleeved cardigans, average size 12 or medium.
Material:	lambswool 1/2 metric count, purcahsed ready-dyed in hanks and wound onto cones on the premises.
Output:	90% efficiency approx. 330 m per machine, totalling 1,980 m or 1,680 kg (1,440 garments) for six machines.
Yarn requirements per garment:	1,100 g per garment, net weight 850 g
Waste:	25 %
Other equipment:	as for F1, with the addition of a button sewing machine and a button hole machine in the making-up department.

Staff requirements:	2 semi-skilled operatives per shift, knitting duties only.
Approximate costs involved:	6 flat-bed knitting machines: approx. US$ 57,000

LAYOUT F3:

Machinery:	6 flat-bed knitting machines with attachments for widening and narrowing 12 needles per inch. working width: 90 cm.
Power:	0.5 kW/h per machine
Type of production:	full fashioned, long-sleeved ladies' dresses in double jersey, average size: 12, or medium
Material:	worsted yarn, virgin wool 40/2 metric count, dyed hanks wound onto cones on the premises.
Output:	90% efficiency approx. 30 kg per machine, totalling 180 kg (enough garment parts for 300 dresses) for six machines.
Yarn requirements per garment:	approx. 600 g
Waste:	negligible
Other equipment:	as for F1
Staff requirements:	2 semi-skilled operatives per shift, knitting duties only.
Approximate costs involved:	6 flat-bed knitting machines: approx. US$ 78,000

LAYOUT F4

Machinery:	6 purl machines with Jacquard attachment 8 needles per inch working width: 170 cm
Power:	0.5 kW/h per machine

Type of production:	ladies' garments in purl fabric with plain Jacquard patterns.
Material:	acrylic yarn 16/2 metric count, spun-dyed and purchased on cones.
Output:	approx. 500 m per machine, totalling 3,000 m or 1,920 kg (1,300 garments) for six machines
Yarn requirements per garment:	approx. 170 g net weight 150 g
Waste:	approx. 10%
Other equipment:	As for F1, except for the steaming and calendering facilities. On being made up, the garments have to be washed, thus provisions should be made for on-plant washing and drying. In view of the fact that babies' wear is often embroidered, an embroidery machine should be included in the making-up department.
Staff requirements:	2 semi-skilled operatives per shift, knitting duties only.
Approximate costs involved:	6 flat-bed knitting machines: approx. US$ 48,000

COTTON'S PATENT FRAMES

Originally used to produce full-fashioned stockings for ladies, now discarded in favour of seam-free stockings, Cotton machines are currently used for the production of full-fashioned garments with a 2/2 rib border or welt suitable for outerwear of all kinds. They are highly economical as the shaped sections require a minimum of cuttings, and the waste is negligible. Only best quality yarns should be run on these machines, and preference has been given to cashmere or lambswool for the production of twin-sets. However, with the introduction of new blend yarns of wool and synthetics, production has turned towards ladies' dresses and other garments.

When stockings were produced on these machines, the most common material was nylon or other synthetics, and some natural silk. The working width of the needle bars ranged from 18 to 20 inches, and the most popular gauge was 51 to 56. Today, however, with the increasing variety of garments there has been a corresponding increase in the machines' range. Gauges currently vary from 48 to 52, and the working width of the needle bars is 21 inches for sleeves and as much as 38 or 45 inches for body widths. The patterning scope can be extended with the aid of various attachments, such as lace, "intarsia," cable and striping attachments, to include geometric, asymetric and fancy patterns.

A Cotton frame comprises several working head so that a number of garment blanks are produced at the same time, and the sizes of the machines vary from 4 to 20 such divisions. Whereas it is now common practice to have a single needle bed in each division, a rib machine with two needle beds is being developed. Cotton's Patent Frames are sophisticated pieces of equipment requiring the full-time services of a knitting technician and a mechanic. It should be adequately housed and proper factory services should be available. Thus, in presenting two hypothetical factories - one producing full-fashioned cardigans, the other full-fashioned dresses - the lay-outs suggested make allowances for much larger units than the minima quoted for flat-bed and circular knitting units.

Despite its size, a factory using Cotton's Patent Frames is far less dependent on the support of other industries because the garment making procedure is limited solely to linking. Afterwards the garments are steamed on individual frames and the ready-to-wear article is finished.

In this section, technical data were supplied by the following companies:

William Cotton Limited, Loughborough, United Kingdom;
Georges Leboeuf & Cie, 10 Troyes, France;
Schubert & Salzer AG, D8070 Ingolstadt, F.R.G.

Theoretical Layouts

LAYOUT C1

Machinery: 6 Cotton's Patent Frames, comprising:
4 machines with 12 divisions, gauge 21,
width of needle bars: 22 inches (body width)
2 machines with 16 divisions, gauge 21,
width of needle bars: 20½ inches (sleeves).

Power: 10,000 kW per week for the whole factory.

Type of production: ladies' long-sleeved, full-fashioned raglan cardigans. Average size: 12, or medium

Material: Lambswool
15/1 metric count, purchased ready-dyed and wound onto cones on the premises.

Output: 80 % efficiency
approx. 810 kg of yarn (4,500 cardigans) for all six machines

Yarn requirements
per garment: approx. 180 g

Waste: negligible

Other equipment: 1 winder in the winding section
2 flat-bed knitting machines to knit ribbed borders, cuffs and necks (see F1).

	linking machines, button-hole machines, button sewing machines and lockstitch sewing machines for making-up.
Finishing:	laundering and drying facilities as well as an adequate supply of steam for the steaming box.
Staff requirements:	one knitting technician per shift, 100 employees for the whole factory working two shifts.
Approximate costs involved:	six Cotton's Patent Frames US$ 130,000

LAYOUT G2

Machinery and equipment:	8 Cotton's Patent Frames, comprising: 6 machines with 16 divisions gauge 21, width of needle-bars: 31 inches (body width) 2 machines with 20 divisions, gauge 21, width of needle bars: 20¼ inches (sleeves)
Power:	12,000 kW per week for the whole factory
Type of production:	ladies long-sleeved, "intarsia" patterned full fashioned dresses in single jersey. Average size: 12 (medium).
Material:	lambswool 14/1 metric count, purchased ready-dyed and wound onto cones on the premises.
Output:	80 % efficiency approx. 1,800 kg of yarn (3,000 dresses) for all six machines
Yarn requirements per garment:	approx. 600 g
Waste:	negligible
Other equipment:	As for G1
Staff requirements:	120 employees for the whole factory working two shifts.

Approximate costs involved:	8 Cotton's Patent Frames: US$ 590,000

LAYOUT G)

Machinery:	8 Cotton's Patent Frames, comprising: 4 machines with 16 heads, gauge 21, width of each head: 30 inches (body width) 2 machines with 16 heads, gauge 21, width of each head: 36 inches (body width) 2 machines with 20 heads, gauge 21, width of each head: 22 inches (sleeve width)
Power:	12,000 kW per week for the whole factory
Type of production:	men's long-sleeved full-fashioned V-neck pullovers, single jersey in cable-stitch design in various sizes. Average size: 42 (medium).
Material:	worsted yarn, virgin wool 28/2 metric count, purchased ready-dyed on cones.
Output:	80 % efficiency approx. 2,700 kg (6,000 pullovers) for eight machines.
Yarn requirements per garment:	approx. 450 g approx. 450 g
Waste:	negligible
Other equipment:	1 winder in the yarn store 2 flat-bed knitting machines to knit welts, cuffs and V-neck borders in rib structure. Sewing machine, linking machine, overlock machine for making-up.
Finishing:	ironing facilities.
Staff requirements:	120 employees for the whole factory working two shifts.
Average costs involved:	8 Cotton's Patent Frames: US$ 480,000

LAYOUT 04 (by courtesy of Messrs. Schmber and Salser, F.R.G)

Machinery and equipment: 3 Cotton's Patent Frames, comprising:
2 Cotton machines type SM with 12 heads, gauge 24.
1 Cotton machine type JPO with 12 heads, gauge 24.

Power: 5,100 kW per week and 1,100 kg of steam in the same period.

Type of production:
1. ladies long-sleeved raglan jumpers, plain with inturned tubular welt (SM frame);
2. ladies' long-sleeved raglan jumpers, partly patterned frontwith bow (JPO frame for front, SM frame for back and sleeves);
3. ladies' jumpers with long insert sleeves and fully-patterned front, 1/1 rib welt (JPO frame for front, SM frame for back and sleeves).

Material:
1.and 2. Polyester (Trevira-Schapira) 135 denier
3. a blend of acetate (Chavalor-Rhodia) 90/2 denier and rayon 200 denier, all purchasedon cones

Output: 85 % efficiency
approx. 672 kg (2.880 jumpers) for all three machines comprising:
1. 260 kg or 1,240 jumper parts
2. 216 kg or 890 jumper parts
3. 196 kg or 750 jumper parts

Yarn requirements per garments:
1. approx. 220 g
2. approx. 242 g
3. approx. 210 g

Waste: negligible

Other equipment: 1 flat-bed knitting machine, gauge 14 and the needle bed 180 cm.

	4 double-chain stitch sewing machines without cutting device, 1 3-thread overlock machine, 5 circular linking machines (gauge 18/20), setting equipment and 2 lockstitch sewing machines for making-up.
Finishing:	steam press facilities and hand irons.
Requisite finishing time per garment:	1. 23.85 minutes 2. 26.29 minutes 3. 37.75 minutes
Staff requirements:	1 technicians for Cotton's Patent Frames 55 operatives for various machines 1 designer 1 pattern maker 1 supervisor for the sewing department.
Approximate costs involved:	3 Cotton's Patent Frames machines: US$ 300,000

[redacted] BASED ON LAYOUT 84 - by courtesy of
Messrs. Schubert & Salzer

Running time and rate of production per frame:

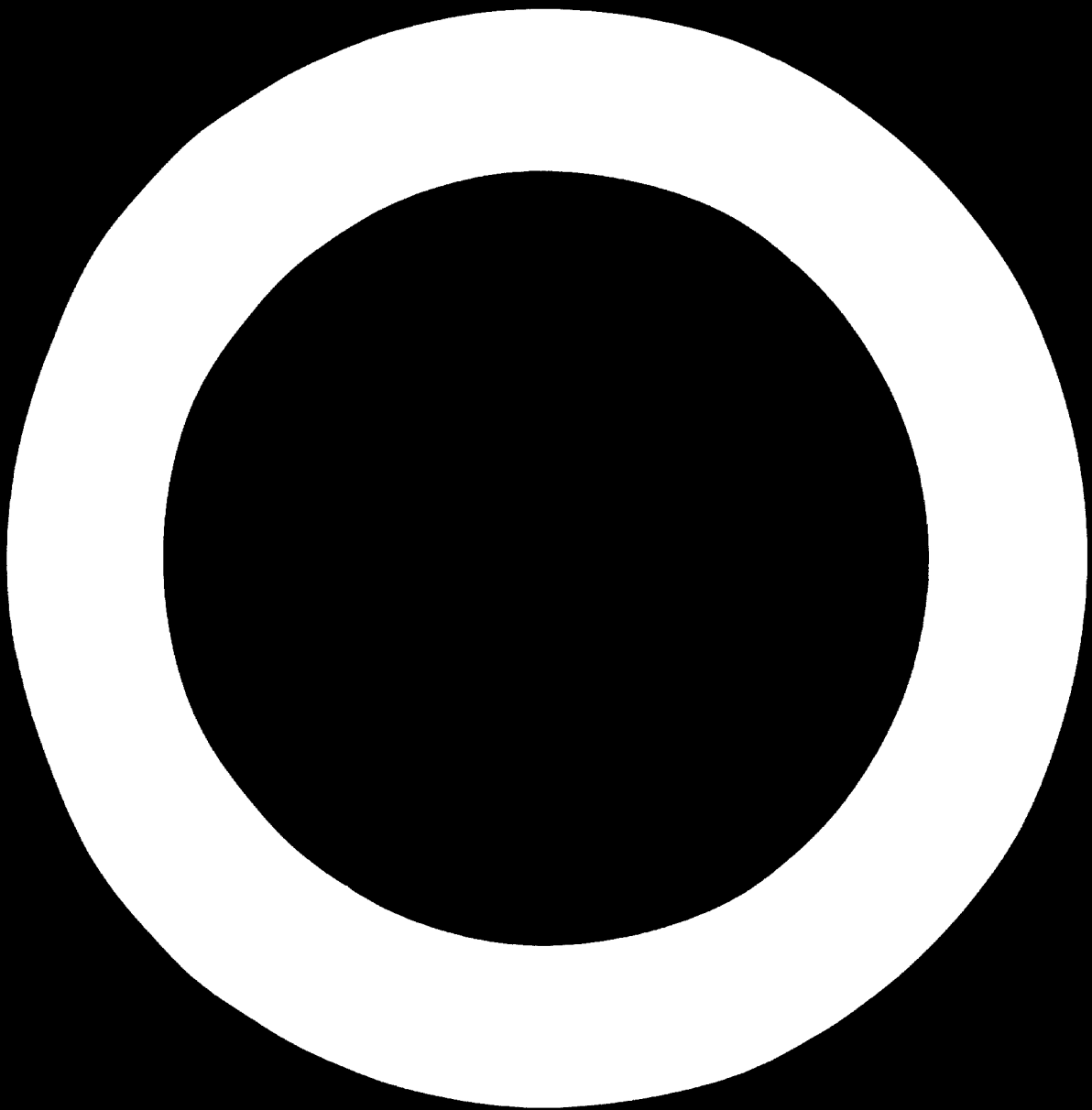
Item (i)	front	10.20 minutes	
	back	10.20 minutes	
	sleeve	10.80 minutes	
	sleeve	10.80 minutes	
		42.00 minutes	
	Stoppages incurred due to starting and finishing one		
	front and back	2.00 minutes	
	sleeve	2.00 minutes	
		4.00 minutes	
	Total running		
	time approx.:	46.00 minutes	
	Rate of production of one frame:	12 complete jumpers	
		in 46 minutes	
Item (ii)	front	22.00 minutes	(JPO frame)
	back	11.40 minutes	(SH frame)
	sleeve	12.40 minutes	(SH frame)
	sleeve	12.40 minutes	(SH frame)
		58.20 minutes	
	Stoppages due to reasons quoted above:		
	front and back	2.00 minutes	
	sleeves	2.00 minutes	
		4.00 minutes	
	Total running		
	time approx.:	62.00 minutes	
	Rate of production:	12 complete jumpers in 62 minutes	

Item (iii)	front	60.00 minutes (JPO frame)
	back	8.05 minutes (NP frame)
	sleeve	8.40 minutes (SH frame)
	sleeve	8.40 minutes (SH frame)
		69.55 minutes
	Stoppages as above:	4 minutes
	Total running time approx.:	74 minutes for 12 complete jumpers.

[redacted]

Sequence	Time (minutes)
Item (i)	
Knitting, front	[illegible]
Knitting, back	[illegible]
Knitting, sleeve	[illegible]
Knitting, sleeve	[illegible]
Closing, side seams	[illegible]
Closing, neck seam	[illegible]
(for later fixing)	
Mounting on [illegible]	
1st operative	[illegible]
2nd operative	[illegible]
Cutting, neck	[illegible]
Linking, neck welt	[illegible]
Cutting, zip fastener	[illegible]
Sewing, zip fastener	[illegible]
Hand sewing (fixing of threads, etc.)	[illegible]
Ironing in press	[illegible]
Ironing by hand (collar)	[illegible]
Inspection	[illegible]
Packing six hours	[illegible]
Knitting, rib welts	[illegible]
Pre rate sending	[illegible]
Total working time	[illegible]
Item (ii)	
Knitting, front	1.00
Knitting, back	[illegible]
Knitting, sleeve	[illegible]
Knitting, sleeve	[illegible]
Closing, side seams	[illegible]
Closing, neck seam	[illegible]
(for later fixing)	

Knitting on TRICOMAT	
1st operative	0.20
2nd operative	0.20
Cutting, neck	0.50
Linking, neck welt	1.50
Cutting, zip fastener	0.10
Sewing, zip fastener	1.50
Knitting, rib welts	0.25
Knitting, bow	0.25
Embossing (fixing of threads, sewing on bow, etc.)	1.00
Ironing in press	1.00
Ironing by hand roller)	0.50
Inspection	1.00
Packing into bags	0.50
Pro rata sending	1.00
Total working time:	[illegible]
Item (iii)	
Knitting, 1 x 1 welt	
bodice	0.25
sleeves	0.25
Knitting, rib welts	0.50
Transfer of 1 x 1 welt	
Bodice	1.50
Sleeves	1.50
Knitting, front	1.50
Knitting, back	0.75
Knitting, sleeve	0.50
Knitting, sleeve	0.75
Closing, side seams	1.50
Linking, insertion of sleeves	3.50
Closing of neck seam (for later fixing)	0.20
Fixing on TRICOMAT	
1st operative	0.20
2nd operative	0.20



Cutting, neck	0.50
Linking, neck welt	3.50
Cutting, zip fastener	0.30
Sewing, buttons and button holes	4.00
Other sewing operations	4.00
Ironing in press	1.00
Ironing by hand	0.50
Inspection	3.00
Packing into bags	0.50
Pro rata mending	1.00
	17.75 minutes

The following computations are based on conditions prevailing in the Federal Republic of Germany (Autumn 1969), the figures will vary from country to country.

Computation

Item (1)

1. Cost of raw materials	DM 6.40	
+ 20 % overheads	DM 1.28	DM 7.68
2. Production costs		
Wages	DM 1.70	
+ 100 % production overheads	DM 1.70	DM 3.40
Total production costs:		DM11.08
3. Management and sales organisation expenses (related to production costs)		
10 % management overheads	DM 1.11	
15 % sales overheads	DM 1.67	DM 2.78
Cost price:		DM13.86

Item (ii)

1.	Cost of raw materials	DM 7.00	
	+ 20% overheads	DM 1.40	DM 8.40
2.	Production costs		
	Wages	DM 1.90	
	+ 1000 % production overheads	DM 1.90	DM 3.80
	Total production costs:		DM12.20
3.	Management and sales organization expenses (related to production costs)		
	10 % management overheads	DM 1.22	
	15 % sales overheads	DM 1.83	DM 3.05
	Cost price:		DM15.25

Item (iii)

1.	Cost of raw materials	DM 6.95	
	+ 20% overheads	DM 1.39	DM 8.34
2.	Production costs		
	Wages	DM 2.80	
	+ 100 % production overheads	DM 2.80	DM 5.60
	Total production costs:		DM13.94
3.	Management and sales organization expenses (related to production costs)		
	10 % management overheads	DM 1.39	
	15 % overheads	DM 2.08	DM. 3.47
	Cost price:		DM 17.41

The yearly production, calculated on the basis of 48 90-hour weeks would, therefore, be of the following order:

Item (i)	52,500 jumpers
Item (ii)	40,000 jumpers
Item (iii)	42,000 jumpers
Grand total:	134,500 jumpers

Costs would be accordingly:

Item (i)	DM 750,000
Item (ii)	DM 600,000
Item (iii)	DM 750,000
Total:	DM2,100,000

Selling prices should not be lower than:

First choice quality (95 per cent of total production)

Item (i)	DM 15.00
Item (ii)	DM 19.00
Item (iii)	DM 25.00

Seconds (5 per cent of total production)

Item (i)	DM 10.00
Item (ii)	DM 13.00
Item (iii)	DM 17.00

Total sales income

Item (i)	DM 770,000
Item (ii)	DM 740,000
Item (iii)	DM1,000,000
Total sales:	DM2,510,000
Less total production costs:	DM2,100,000
	DM4,100,000

MISCELLANEOUS

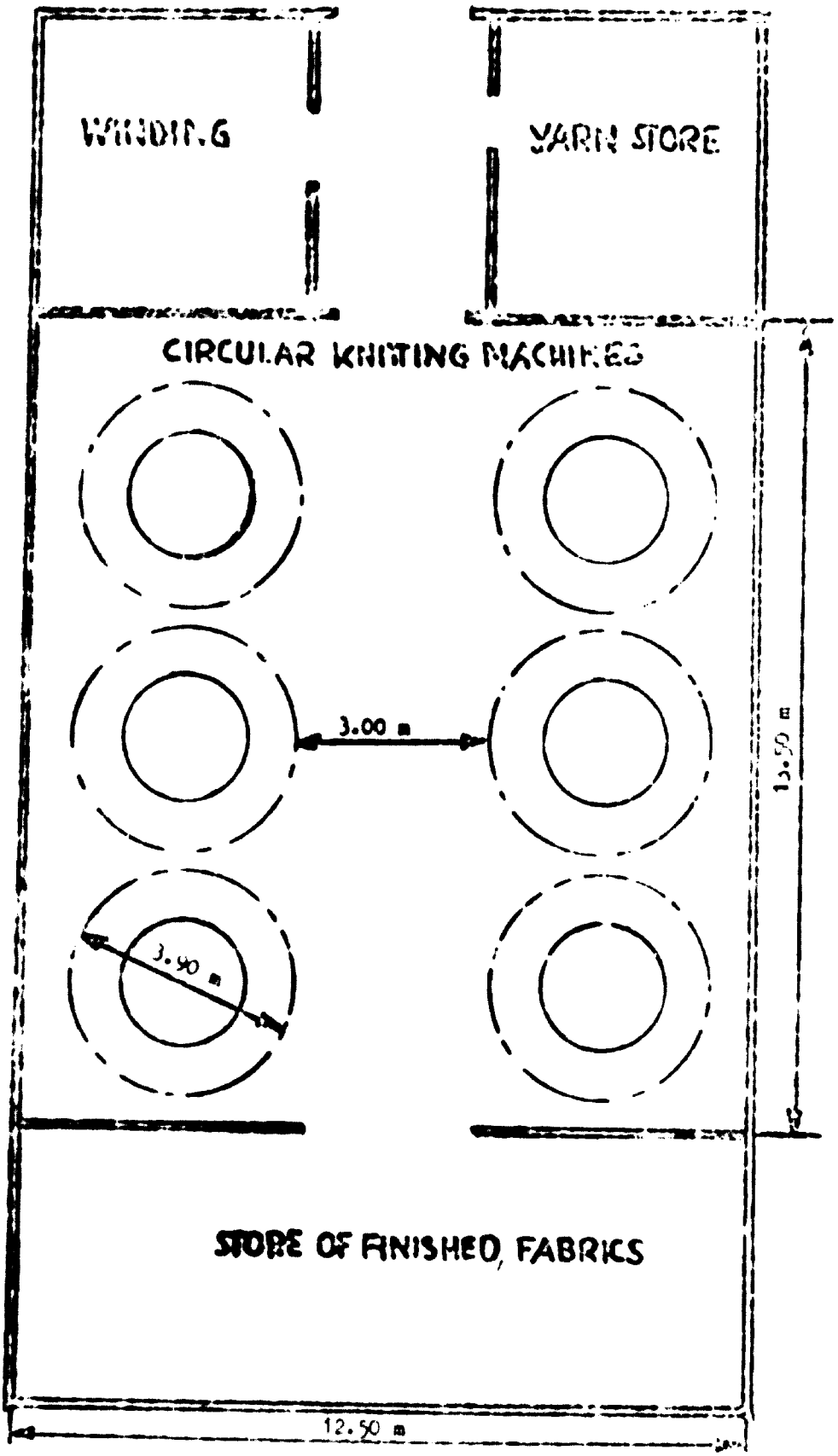
In addition to the range of fabrics directly utilized by the clothing industry, knitting machines are also used for the production of diverse technical articles. While appreciating their importance, layouts, however, have not been presented for these particular lines as they can be produced on the various types of machines already described.

Packaging material and netting are typical examples of technical articles produced on knitting machines. Special Raschel machines have been designed for the production of fishing nets made from twisted synthetic yarn. A finer-gauged Raschel machine has been developed to

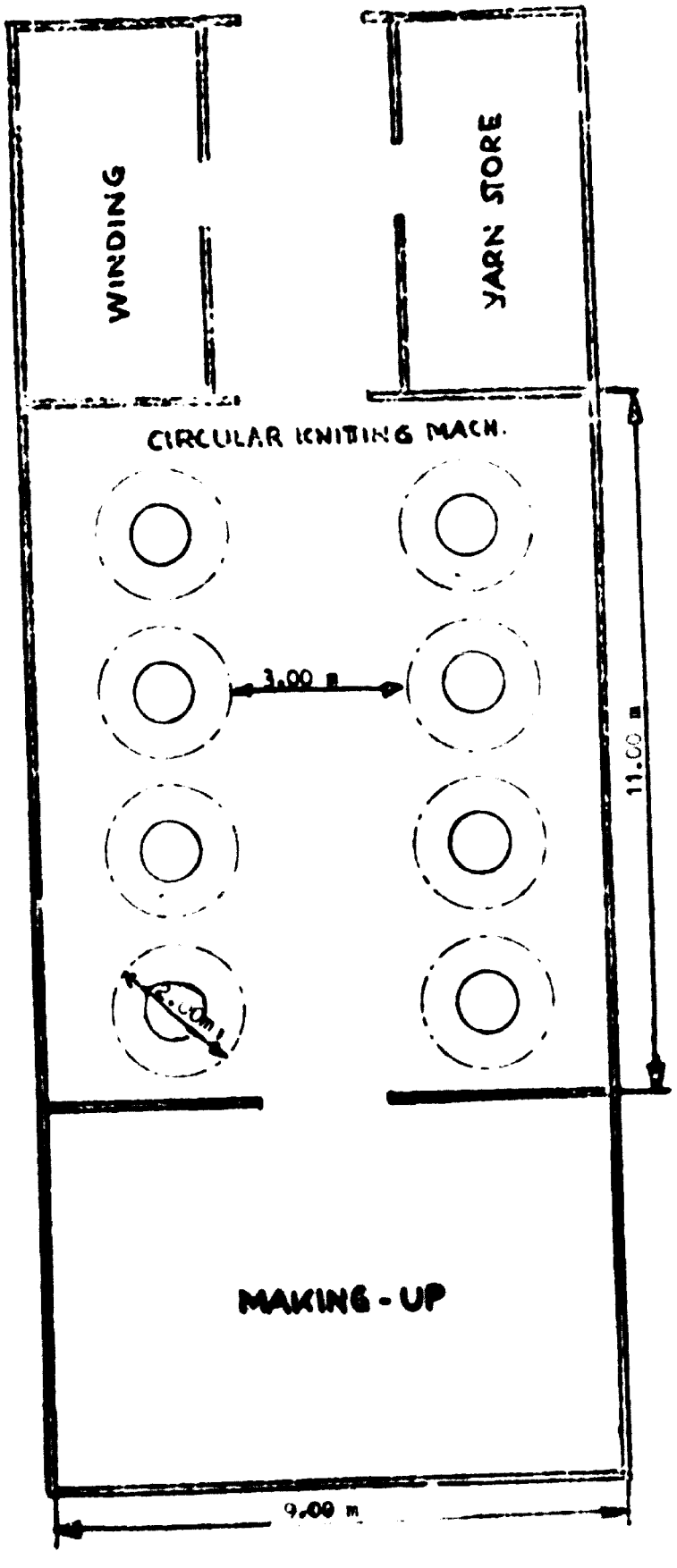
produce mosquito netting, using fine cotton or synthetic yarns. Supplementary warping and steaming machines are needed.

Another innovation has been the development of a new appliance permitting the superimposition of a second, coloured thread with a different warp onto a fine net fabric produced on a Raschel machine, thus creating an embroidered effect. The resultant fabric has countless uses.

LAYOUT: CIRCULAR KNITTING OUTERWEAR, EXAMPLE A



LAYOUT: CIRCULAR KNITTING UNDERWEAR, EXAMPLE 1



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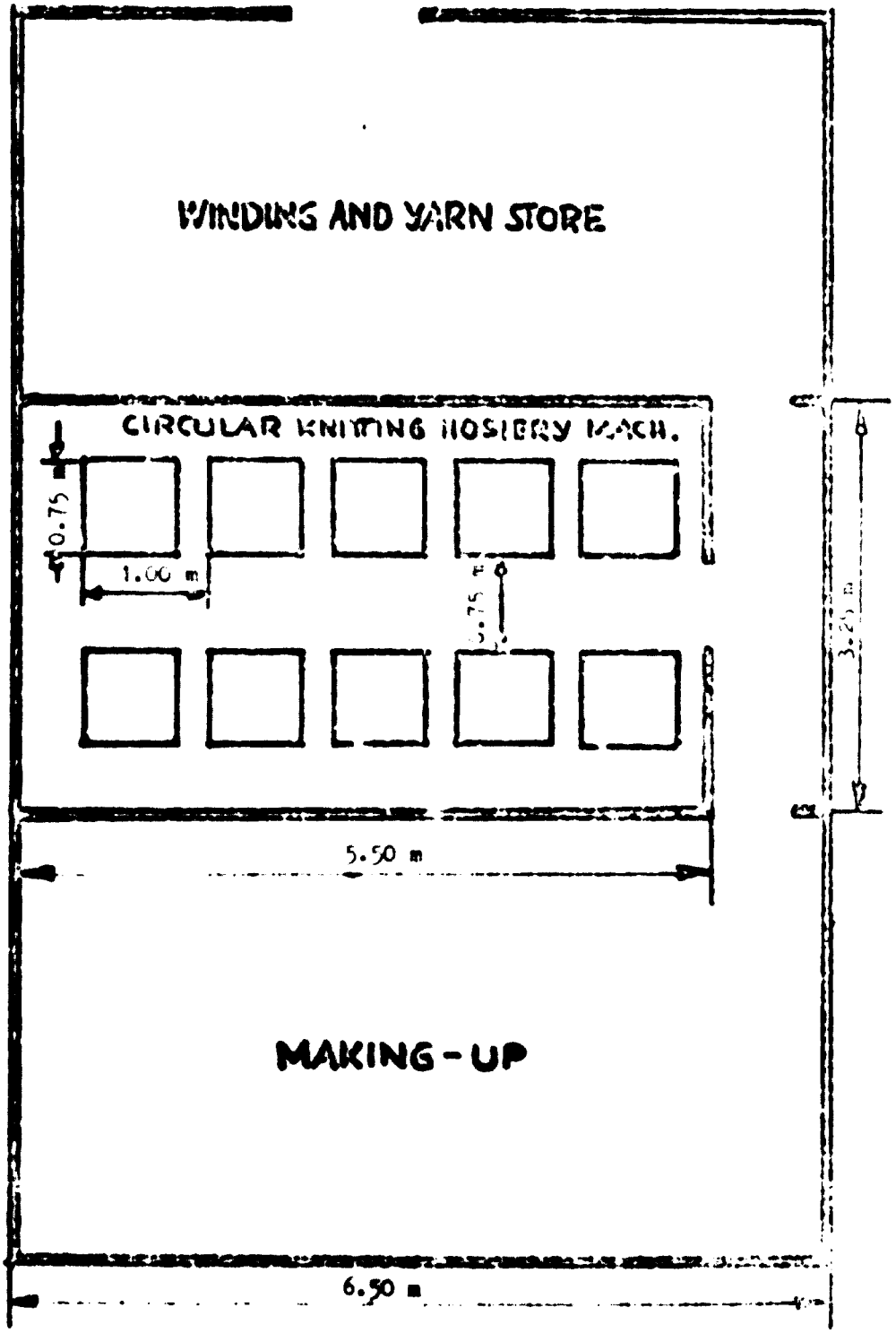
LAYOUT: CIRCULAR KNITTING HOSIERY, EXAMPLE „C"



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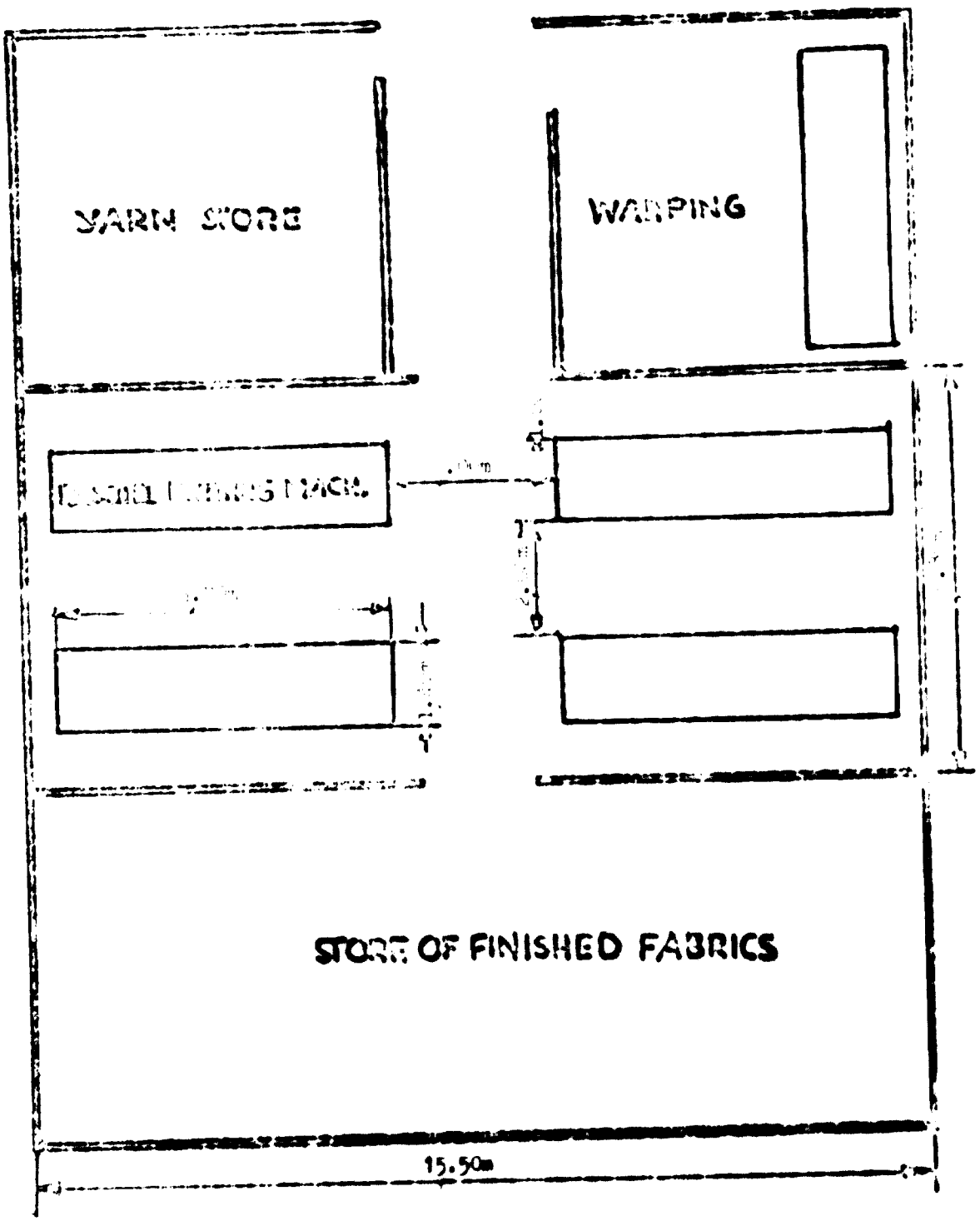
LAYOUT : [illegible] D



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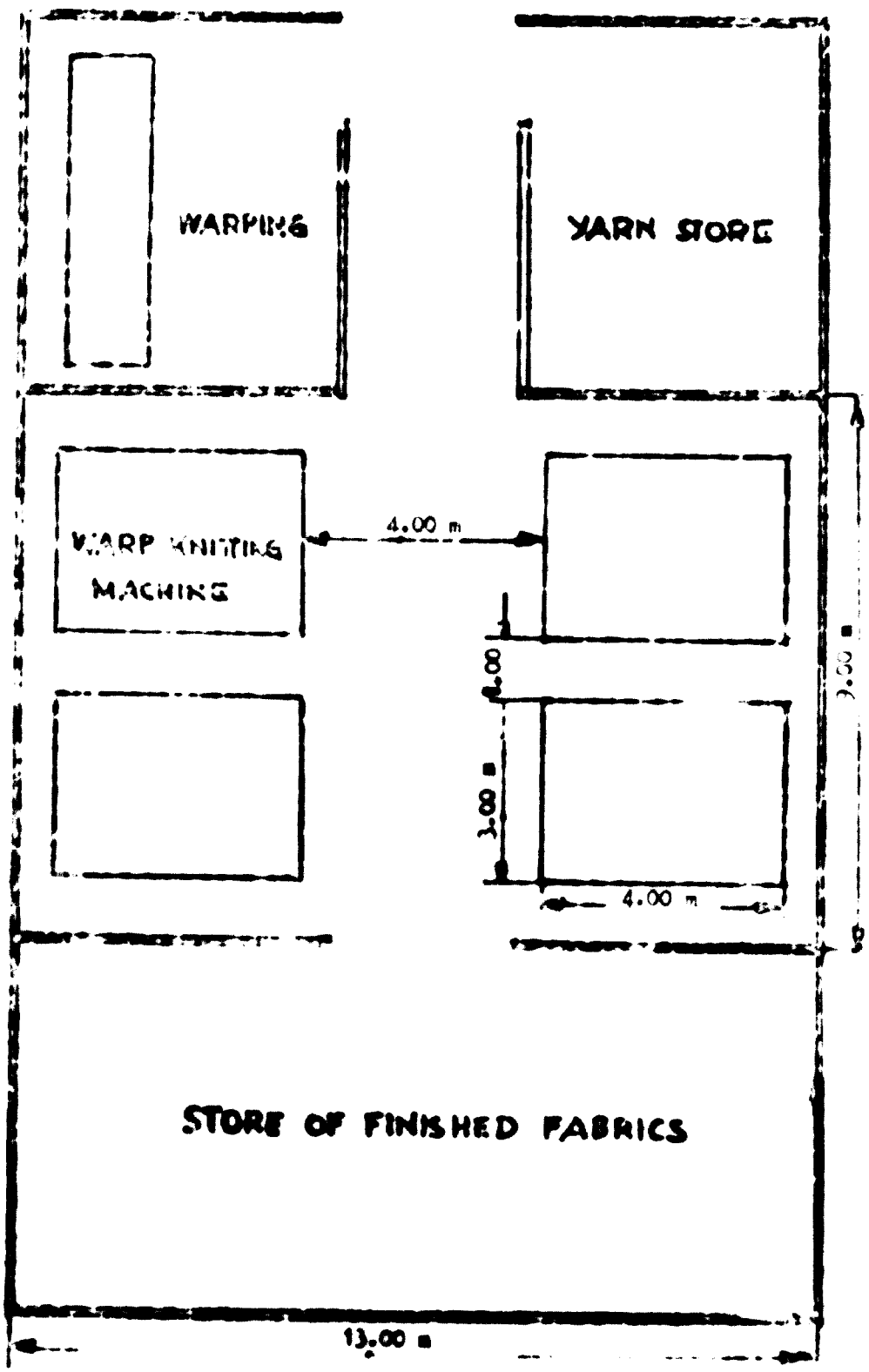
LAYOUT : WARP KNITTING EXAMPLE E



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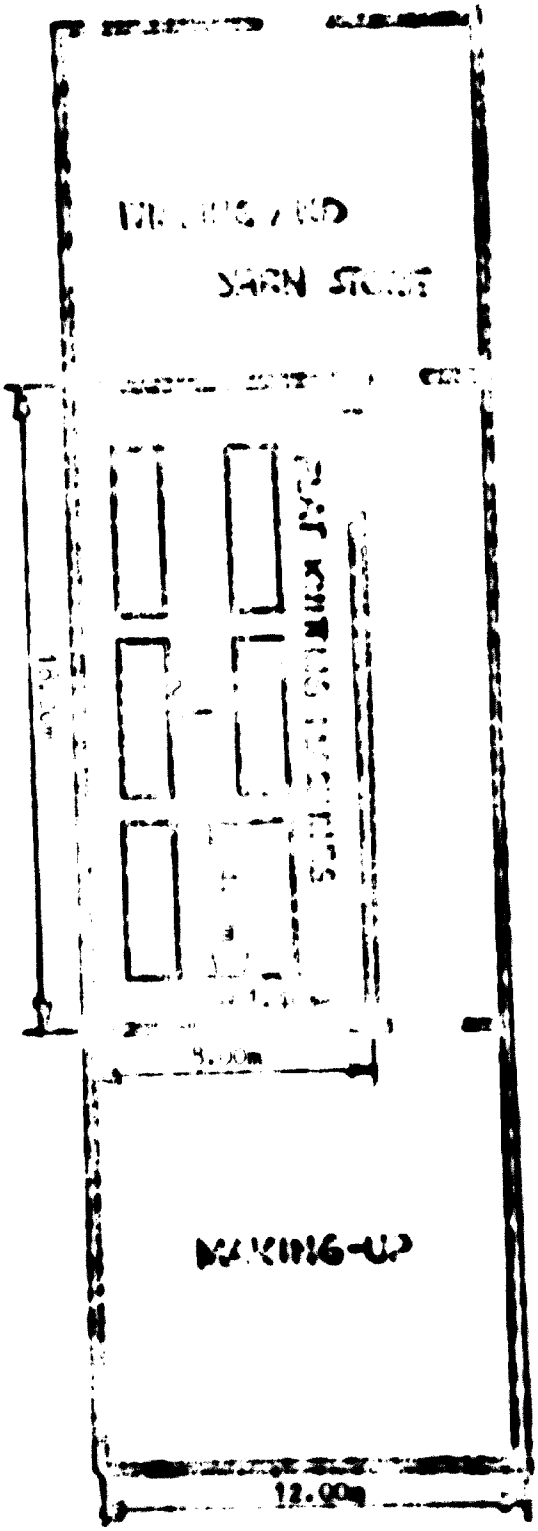
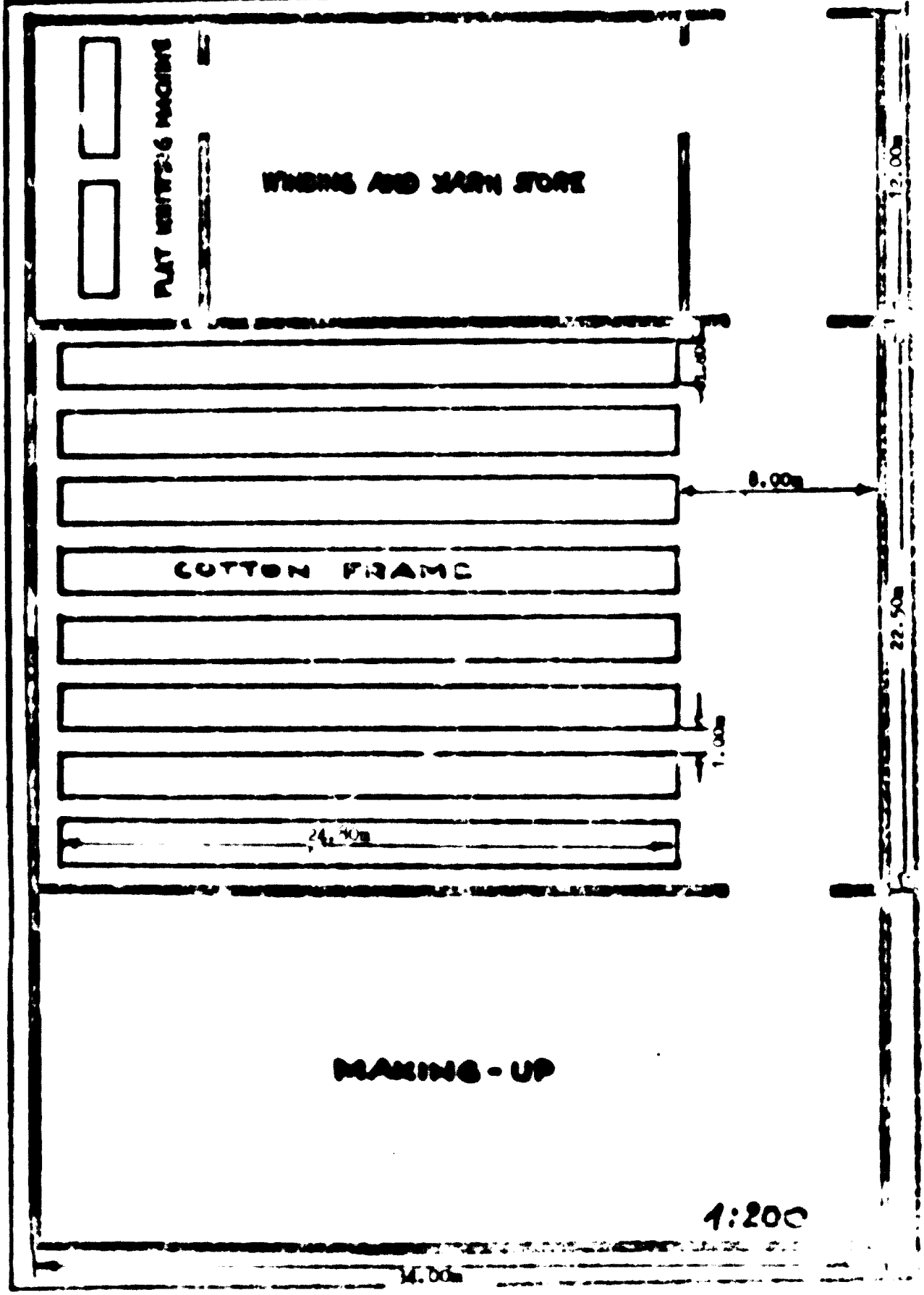
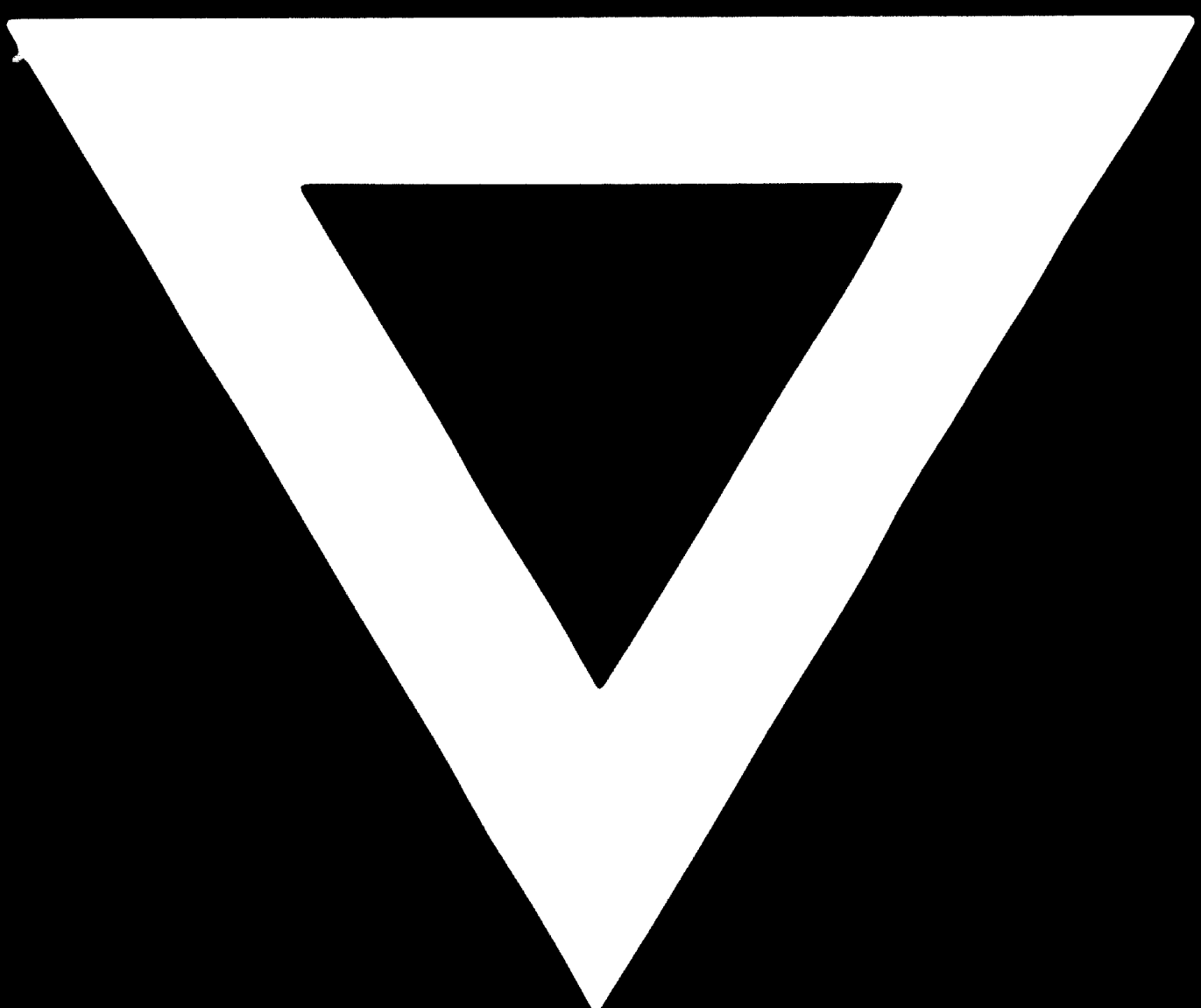

SARN STREET
12.00m

LAYOUT : COTTON FRAME, EXAMPLE G





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