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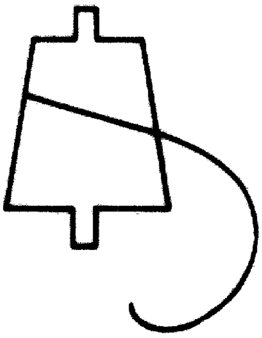

Technological and Economic Aspects of Establishing Textile Industries in Developing Countries

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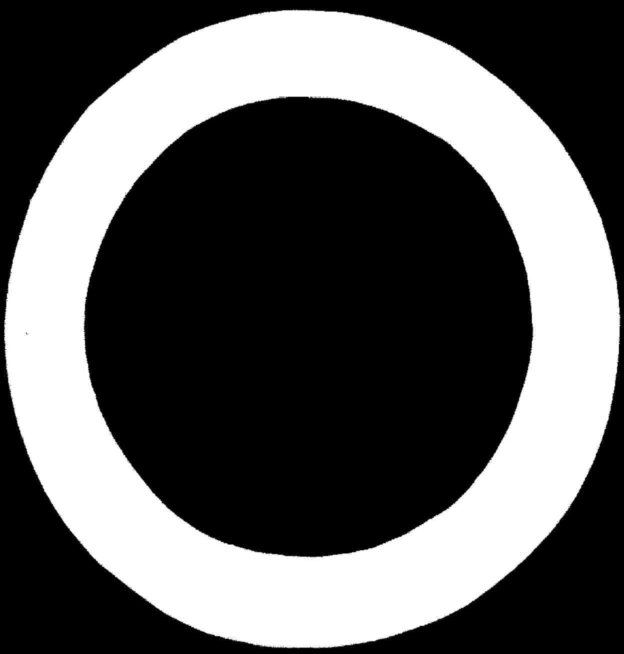

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TECHNOLOGICAL AND ECONOMIC ASPECTS OF ESTABLISHING TEXTILE INDUSTRIES IN DEVELOPING COUNTRIES

UNITED NATIONS INDUSTRIAL DEVELOPMENT ORGANIZATION
VIENNA, 1967

UNITED NATIONS
NEW YORK

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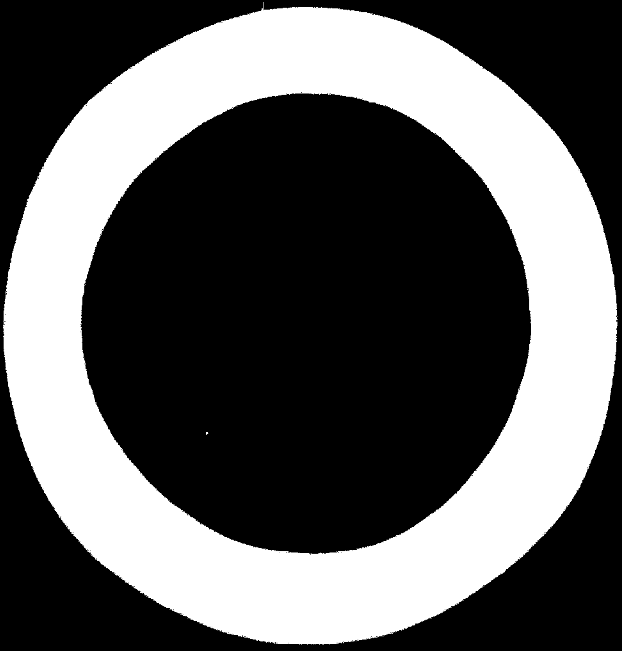

Preface

This manual is based on a working paper[1] submitted by the Centre for Industrial Development to the first United Nations Interregional Workshop on Textile Industries in Developing Countries, held in Lodz, Poland, from 6 to 27 September 1965.

This working paper was revised and supplemented by the United Nations Industrial Development Organization, which, in accordance with General Assembly Resolution 2089 (XX) and Economic and Social Council Resolution 1194 (XLI), superseded the Centre for Industrial Development. It contains information on raw materials, textile products and processes, new production and administrative methods and other matters relevant to the successful development of textile industries in developing countries. Reference to the aforementioned matters is based on consultations with acknowledged authorities in the textile industry field; it is not however to be construed as specific endorsement of any product or process by the United Nations Industrial Development Organization.

We wish to express our gratitude to Mr. Victor Saxl, United Nations technical assistance expert, for his valuable assistance and advice in preparing this document.

It is hoped that the manual will serve as a useful guide to those who bear the responsibility of policy decisions concerning the textile industry in developing countries.

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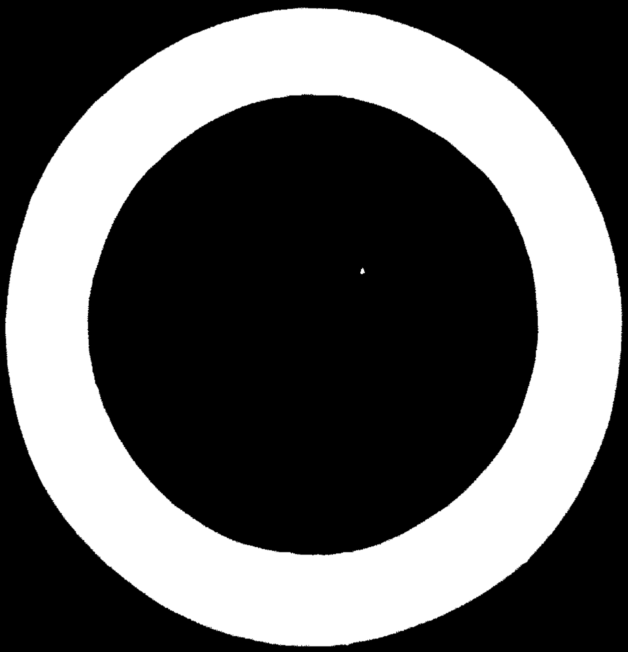
[1] "Textile Industries in Developing Countries" prepared for the Centre for Industrial Development by Mr. Victor Saxl, July 1965.



Introduction

The textile industry, catering to a basic human need, is one of the oldest manufacturing industries, and usually it is one of the first to be established in a country in the process of industrialization. For this very reason it is much more important to the developing than to the industrialized countries, both as a source of income and a source of employment. The textile industry of the developing countries employs nearly 25 per cent more people than does the textile industry of the industrialized countries, and in terms of value added in manufacturing it is about three times as significant to the developing countries as to the industrialized countries.

The textile industry is often regarded as a purely traditional and static, rather than dynamic, industry, and labour intensive rather than capital intensive. This image of the industry was true until about fifteen years ago when, after over half a century of technological stagnation, a dynamic progress began to change the picture. Since then, the production capacity of the machinery has increased dramatically; advanced automation is now being applied at all stages of fibre and fabric processing; an entirely new range of raw materials has been developed whose share of the total fibre supply is already one third and increasing fast; new production methods have been developed which, in their very concept, deviate from the traditional textile processes.

This rapidly changing pattern of products and processes, the growing international competition and the difficulties in the utilization of existing production capacities characterize the situation in countries with traditional textile industries and influence the prospects of building up a viable textile industry in others where production is lagging behind consumption.

In developing countries with old-established textile industries, there is an urgent need to modernize existing plants and to improve the efficiency of operations by introducing mill control systems, repair and maintenance programmes and proper labour-training schemes. International technical assistance programmes may be engaged when planning and implementing these actions, but it is important that they be supported by a consistent government policy which provides suitable incentives for the entrepreneurs. Such government measures may range from fiscal and credit incentives and suitable tariff and price policies to the determination of replacement rates for machinery.

Proper machinery selection is one of the key problems in the development of textile industry. The machinery must suit the twofold requirements of most developing countries: it should be up to date to allow for competitive production, and on the other hand it should not provide unnecessary savings in labour force at the expense of higher capital costs. An effort should be made to choose from the modern technological alternatives a level that strikes a balance between fixed costs based on depreciation and variable costs based essentially on wages.

In many developing countries the production of textiles has taken place on the basis of small units rather than large mills. Reasons for this may have been lack of a large home market, lack of sufficient funds at a particular time and the hope that small units, in aggregate, would employ more labour at a given level of technology than a larger plant producing the same output. It is generally assumed that economies of scale in the textile industry are not as important as in many other industries and therefore a policy of concentrating production in small units does not necessarily result in serious cost disadvantages. This assumption is not valid. In the cotton industry, the economies of scale are quite marked in the smaller-size mills from 2,000 to 10,000 spindles, becoming progressively reduced up to mill capacity of 20,000 spindles, after which no further economies of scale will be obtained from a larger size. The economies of scale vary significantly, not only in relation to the scale of production, but also according to the type of cloth produced. The finer the yarn and the closer the weave, the greater are the advantages of a larger scale of output. In a non-integrated mill the scale of output and capital intensity required for economical operation is probably still higher. It may be possible to combine a highly capital-intensive spinning mill, operating on a large scale, with several small-scale, labour-intensive weaving units. These units could be established either on a national scale with suitable government incentives or on a sub-regional basis in co-operation with appropriate planning organizations in areas where national markets are too small.

The availability of local raw materials has often provided the main incentive for the development of textile industry. It is important to ascertain, however, whether the available raw materials fully correspond to the types of products to be manufactured. Using raw materials of too high quality would be squandering the resources, and using raw materials of too low quality for the products manufactured would result in technical problems, uneconomical production and low quality and products. A further result of an inappropriate use of raw materials is the often very restricted range of products in the textile industry of many developing countries. The scope may be widened by introducing blends of natural and man-made fibres. The United Nations and its specialized agencies are in a position to provide expert assistance to study this question of the use of raw materials and suggest measures to be taken to improve the situation.

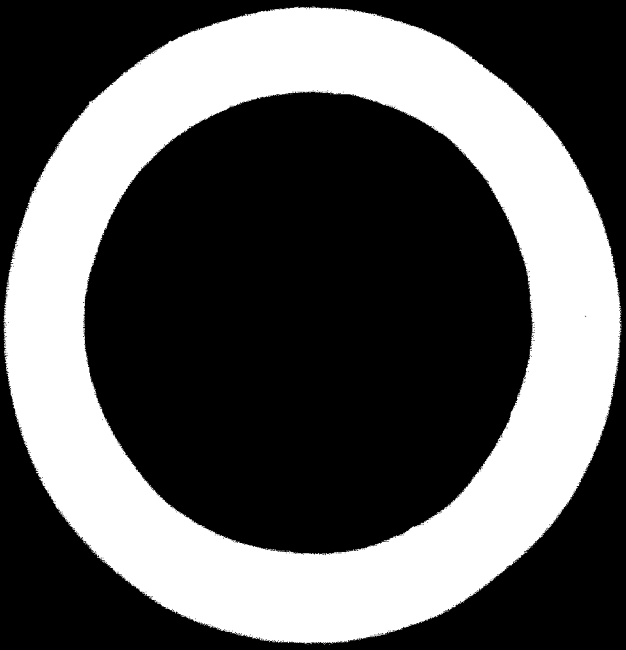
For several years there has been a consistently growing and world-wide trend in the use of blends of natural and man-made fibres. The correct blending of regenerated cellulosic fibres increases the range of yarn counts obtainable from a given type of cotton, facilitates production and improves the performance characteristics of the end product. The growing standard of living results in a demand for easy-care properties of the garments, and these demands can often be met by the end use of synthetic fibres - either in pure form or in blends with natural fibres. The consumer's preference is thus clearly shifting towards the use of non-traditional materials. To ensure the viability and further growth of the textile industry in developing countries. the use of man-made fibres should be considered from the very beginning.

The production of synthetic and regenerated cellulosic fibres involves distinct economies of scale, and the minimum economical scale may well be too large to justify production in most developing countries unless the production is planned to satisfy the requirements of several countries in the region. The feasibility of establishing man-made fibres production either on a national or sub-regional basis should be clarified by the Governments in connexion with the general planning of the textile industry.

The increasing complexity of machinery and fabrics produced has tended to increase the skills required at supervisory staff and top management levels. Management inadequacy is the largest single cause of the poor performance of the textile industry in developing countries. A recent study by the Economic Commission for Latin America (ECLA) of the cotton industry in Brazil revealed that only one third of the over-all operational deficiency was due to obsolete equipment. Two thirds were due to the fact that the unit output of operating machinery was not equal to recognized standards. Administrative reforms, improved production flows, better layouts and more efficient use of raw materials would thus improve the productivity more than modernization of equipment alone. Questions related to the training of manpower deserve, therefore, special attention when planning or modernizing textile industries in developing countries.

In a modern spinning and weaving mill less than one quarter of the labour force needs to be composed of skilled workers. Furthermore, operative skills and even the skills of intermediate management, such as shop foreman and maintenance workers are relatively easy to acquire. This is true not only in mills equipped with conventional machinery but also where automation has been applied to a high degree. The main scope for official action is, therefore, in the training of management and supervisory staff. The alternatives seem to be either to rely on the instruction given in industrialized countries or to set up regional or sub-regional training institutes for the textile industry, possibly with the assistance of the United Nations, its specialized agencies and regional commissions. The establishment of training centres on a national basis would probably be economically sound in relatively few cases. A work force of 10,000 people is considered necessary before a technical school is worthwhile, and a special textile department attached to a university, with an annual throughput of 10-15 technologists, would require a minimum of 50,000 employees in the textile industry in order to be justified. In most developing countries the size of the textile industry is well below these figures.

To co-ordinate the actions by the Government on one hand and private industry on the other, in their efforts to increase the productivity of the textile industry, the establishment of National Textile Development Councils, or similar bodies, could be considered. Both the Government and the industry could be represented in these councils and their functions could be to collect and disseminate statistical information on production, productivity, sales, trade, prices and the establishing of production and quality standards and specifications. They could also prepare forecasts of market requirements and trade trends and work out long-term plans for the development of the textile industry.



Chapter 1. ASSESSMENT OF NEEDS AND FORMULATION OF POLICIES AT NATIONAL LEVEL

Promotion

The growth of industries in developing countries is usually not spontaneous. Many problems have to be confronted, among them lack of capital, a limited consumer market, shortage of raw materials and scarcity of skilled labour. These and other formidable obstacles are enough to deter prospective industrialists.

Governments however look further: they have an interest in the continuous development of industry, as a means of utilizing the nation's raw materials, employing labour and saving foreign exchange spent on imports.

Some countries may wish to establish state-owned mills, or they may participate in joint ventures or encourage industrialists to produce on their own with some degree of help. In the case of the textile industry, it is generally not a matter of starting a completely new industry for which a Government offers incentives to prospective manufacturers, but of developing a rudimentary industry and improving its techniques so that more sophisticated goods may be produced locally.

In any of these circumstances the Government may be a prime mover in initiating and promoting development by means of credit grants, tax advantages and duty reductions or exemptions for machinery and locally unavailable raw materials. In some countries the Government creates special autonomous or semi-autonomous agencies to promote essential industries. They are equipped to investigate the feasibility of a project, make a detailed market analysis and examine all submitted plans in order to ascertain their attractiveness to the country's economy and to the industrialists. Among the well-known government agencies or autonomous government organizations promoting and often financing new industries or plants, one must mention the Nacional Financiera S.A. of Mexico which greatly influences Mexican industrial activities, the Development Corporation of Chile (Corporación de Fomento) and the Venezuelan Development Corporation (CVF) which spearheaded an industrialization programme that became government policy in 1959. The Venezuelan Development Corporation has played an important role in the programming and development of Venezuela's textile industry, having invested since 1959 approximately $30 million in the textile industry alone.

A good industry development programme should include an estimate of present and future consumption for the period covered by the plan, taking into account increases due to population growth and purchasing power which may bring about possible price reductions. Recommendations should be made on desirable and advisable products for local manufacture. Export possibilities should be explored. Co-operation between government agencies and the private sector is of the utmost importance. Proper canalizing of investments is encouraged so as to avoid a situation where too many factories wish to produce similar types of goods merely because a few have found a good market for these products.

Some countries therefore grant credits and other facilities only to those enterprises that co-operate in implementing the over-all development plan, although it is often difficult to steer clear of pitfalls in the highly substitutive market of textiles. The need for programming has been recognized in several Latin American countries, notably Venezuela, Mexico and Brazil. In Venezuela, where there was an import substitution problem, a programme was worked out jointly by the private sector and the Government whereby the number of spindles increased from 94,000 in 1958 to 280,000 by the middle of 1965. First a selection was made of products that could be manufactured economically within the country, and those items were protected by high import tariffs. Next a programme was established for the improvement of domestic cotton, and technical assistance by the Government was given free of charge wherever it was requested or found necessary. Standards of quality and production were set forth and large-scale training programmes devised for workers and technical personnel, as well as for managers who were informed of the newest administrative procedures.

In 1958 Venezuela's textile industry supplied 35 per cent of the apparent consumption of textile goods; by 1964 this had risen to 85 per cent.

Financing and fiscal policy

Credit facilities

Industrial credits may be granted through private, autonomous or semi-autonomous government agencies, development corporations, or government affiliated banks. Development corporations have played an important role in financing the industrialization of many Latin American countries. In Venezuela, as mentioned above, a substantial textile industry has been developed by joint private efforts and government promotion, with credits granted up to 50 per cent of the total investment at an annual interest rate of only 6 per cent for a period of ten years.

Each project was evaluated and the Venezuelan Development Corporation was given guarantees by the loan recipient consisting of machinery, and in some cases buildings. The Corporation does not interfere in the operations of the enterprise except in cases of economic difficulties or where the manufacturers themselves solicit assistance.

Another method of encouraging the establishment of new industries is the so-called system of "lease agreement of fixed assets" by which the industrialist has the right to purchase the plant after a certain time: this system gives a start to those who have the capability of initiating a viable project, but have limited financial resources. Naturally, considerable risks are involved for the financing institutions, and strict supervision must be exercised on every new project.

International finance agencies

A Government often seeks the co-operation of international financing institutions in promoting and financing projects: for instance the Inter-American Development Bank, the Export-Import Bank, the International Finance Corporation and similar international banking institutions. Furthermore, some Governments offer investment guarantees under specific conditions; for example, those guarantees granted under the United States Agency for International Development (AID), an economic assistance programme specifying that in return for loans granted, 51 per cent of ownership will be retained by United States investors and equipment will be purchased in the United States.

Fiscal policy

A Government's fiscal policy is of primary importance in the success or failure of efforts to promote industry. Incentives should not be limited to direct government assistance but should be such as to encourage individuals, states, towns and municipalities to co-operate in these efforts. Among the effective inducements commly granted by Governments are:

(a) Tax exemptions for a specific number of years, thus attracting domestic and international investment capital: this powerful incentive has been successful in the industrialization programmes of many countries and territories;

(b) Duty-free import of equipment in countries where duties or import surcharges are usually levied;

(c) Favourable exchange rate for the import of capital goods such as machinery and raw materials;

(d) Free or low-cost land placed at the disposal of new industries by states and municipalities, thus developing industrial zones in areas best suited for the purpose. This point is of particular interest to Governments wishing to decentralize industrial establishments which too often tend to concentrate in already densely industrialized zones, causing an imbalance in the country's total industrialization programme.

Nature of industry

Government-owned or mixed

The nature of the industries to be established may be of far-reaching significance to the country's future development and the Government should therefore take clear-cut decisions as to which of them are to be privately owned, or government-owned, or under mixed ownership. In some countries there is preference for government-owned industries whereas other countries may have any one of the three types mentioned.

In many developing countries some primary industries, such as the exploitation of mineral wealth and oil, may be kept in the hands of the State, leaving a large territory free for either mixed or entirely private ownership. Mixed interests may be established when a Government wishes to participate in some activity requiring very large capital, or when the product is essential to a country's economy. In the textile industry there is only a limited need for such government participation and in fact only in very few countries - apart from those within the socialist orbit - are textile mills state-owned. There are cases, as for example Turkey and Iran, where a part of the textile industry is state-owned and freely competes with privately-owned enterprises.

Integrated or non-integrated industries

This aspect is being dealt with in more detail in another chapter, but here it should be mentioned that in promoting a textile enterprise the Government may be motivated by certain economic needs and may be desirous of assisting the establishment of non-integrated mills to fill specific requirements such as supplying intermediate products, for instance delivering yarns to knitters and weavers who lack their own spinning facilities, or rendering to mills that need them such services as commission-twisting, commission-texturizing, commission-dyeing and finishing, the last being of importance particularly to smaller weavers. A finished plant, equipped with first-class modern facilities, would be ensured of full utilization of capacity, at low cost to consumers.

Measures to ensure efficient operation and utilization of factors of production

The Governments of developing countries that participate in establishing the textile industry through credit, promotion or any other facility while having regard for the reasonable protection of the new industry, should nevertheless insist that it operate efficiently and without an undue proliferation of costs. This protection and this insistence might be expressed in the following measures:

Tariff policy

The Government should accord the industry sufficient protection from imported goods that it can develop satisfactorily without undue competition. The establishment of a meaningful tariff policy is one of the most difficult problems because of the desire on the one hand to protect the industry to ensure its sound development without on the other hand coddling it. Theoretically the approach is sound, but it does not always work satisfactorily, especially in countries where there are no foreign exchange restrictions. The difficulty often lies in the so-called "close-outs", large quantities of goods which, in highly-industrialized countries, are disposed of at the end of the season at prices often slashed by 50 per cent. If these goods are imported in large quantities they can greatly harm the local industry. In considering situations of this kind, it may be decided to impose quantitative restrictions in conjunction with tariffs. This is clearly illustrated in the experience of Venezuela.

Education of workers

The training of labour to ensure efficient mill operations is vitally necessary to the industrialization process. In many countries the factories themselves have training centres for their labour force, but wherever this does not exist or is not in continuous existence, the Government should concern itself with labour education. Again citing the example of Venezuela, mention must be made of the National Institution of Educational Co-operation to the upkeep of which manufacturers and workers alike contribute and which trains labour within the factories or in separate workshops or classes: a training that greatly helps to make operators industry-minded.

Technical assistance

Wherever it is desired or necessary, the Government can encourage better production and higher productivity through technical assistance which should be given not on the industry level alone but also to growers and producers of raw materials so that with a continuing supply of raw materials of suitable quality assumed, the efficient operation of industry is reinforced.

Intensity of equipment utilization

The Government should be concerned with the intensity of the utilization of equipment, especially in cases where substantial government credits have been granted and where a proliferation of investments can occur. New textile equipment, semi-automatic or automatic, producing at high production speeds, is very expensive, and plants with such equipment should work in three shifts in order to operate economically.

Supervision of production and efficiency

In countries where the Government has decided to protect the textile industry it must ensure that the industry operates efficiently and that production costs, as well as the costs of the finished goods, are as low as possible. This control is advisable especially in countries where only one plant of a certain type exists; when the quality and price of yarn for example depend on one expensively installed man-made fibre plant, and yet the establishment of a second plant would not be economical. Even in cases where two or more plants exist it might happen that competition is not vigorous, or instances occur where firms instead of competing, parcel up the market or fix prices, keeping them artificially high. To avoid such developments, the Government should watch the market situation and see to it that qualities and prices are right, giving a fair return to the manufacturer and at the same time ensuring the lowest possible prices to the consumer.

Standards

The Government should encourage the establishment of standards to ensure the proper quality of raw material, intermediate products and finished items.

Price regulations and quality controls

Some price regulation and quality control may be necessary when developing and protecting an infant industry. In various developing countries, where industries are growing under similar conditions, it was found important to conclude detailed agreements whereby the industry bound itself to adhere to price regulations, not to alter the quality of goods produced, and not to change delivery or payment conditions in order to make sure that customers would not be at a disadvantage when purchasing locally made textiles.

Strict enforcement of these agreements is imperative. Such steps have helped to maintain favourable price conditions for consumers even when necessary protection is conferred on the manufacturing industry.

Relative merits of domestic manufacture and imports of textiles in developing countries

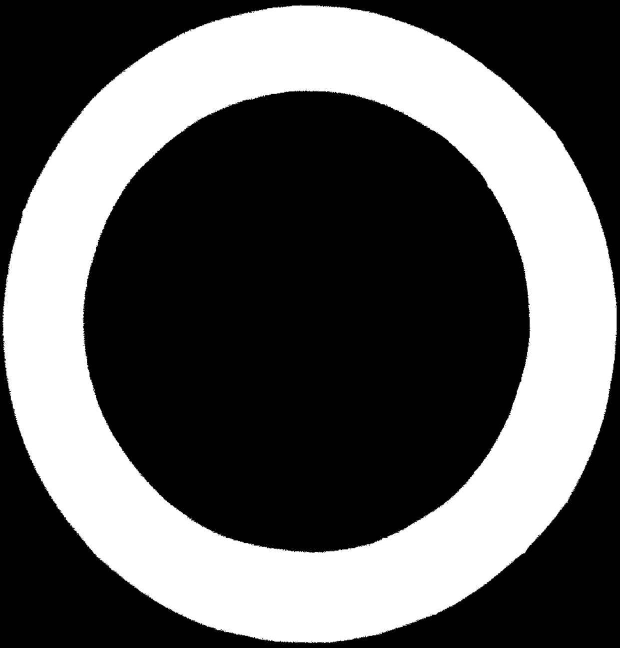
The conditions under which it is thought better to import certain types of fabrics rather than to produce them within the country will depend very much upon the economic position of each country. Decisions will certainly be influenced by aspects of employment and labour, the availability of foreign exchange and factors of international trade relations.

The first concern should be to stimulate production of general goods that can be economically produced within the country: in other words, whenever possible developing countries should concentrate on articles of mass production comparatively simple to produce and leave to the more industrialized countries the manufacturing techniques or special skills. A second consideration would be to eliminate from production programmes goods made of special fibres that can be better supplied by countries where production of the raw material is a traditional occupation: for example, silk. The old silk-growing countries have the possibility of producing small quantities of many types of cloth for such highly specialized articles as brocades, complicated Jacquard patterns or tie silks. Other fabrics in the same category are luxury fabrics such as cashmere, alpaca, vicuna and others which require special skills in spinning, weaving and finishing.

The question arises, naturally, about the convenience of importing these luxury articles into the developing countries, and here, of course, the market situation and the availability of foreign exchange will be of great importance. Care should be taken that these specialized and expensive materials do not interfere with the marketing of locally made products, especially as in many countries there is a marked preference for imported goods even though some imports sold at high prices may be inferior in quality to some domestic manufactures.

Unquestionably, consideration on regional or international levels must take place. Interregional planning should foresee greater specialization of textile products in different parts of the region, so that the production of larger quantities of special types of goods can be encouraged where it seems most indicated and most economical.

The general picture of foreign trade should not be neglected in development plans. The case may be cited of a country which, having no textile industry to speak of, decided to build one up. Previously, this country had imported textiles from another region, exporting in return its agricultural products to the same region. But when the textile mills were established and the purchases of textiles ceased, the partner-in-trade was not able to continue buying agricultural products because of lack of foreign exchange. The situation was disturbing to both countries, and the case proves the value of planning from many aspects when industrialization is under way.



Chapter II. ASSESSMENT OF NEEDS AND FORMULATION OF OPTIMUM POLICIES AT MILL LEVEL

Establishing new plants

The assessment of needs and determination of optimum policies at mill level depend upon a number of factors. An all-important one concerns the policies prevailing in the region where the new mill is to be established: whether it is a free market area, or a common market area. Next, the matter of supplies: are the needed raw materials procurable and accessible? The availability of capital and whether or not an employable labour force exists will influence the recommendations of industrialists and regional planning commissions.

Capital availability is of first importance and the rate of turnover of capital must be considered because it will be influenced by the type of product manufactured. A factory producing staple goods will have smaller stocks of grey and finished goods and will probably have to give shorter credit terms to customers but with a smaller profit margin. On the other hand, manufacturers of high-styled products may have to concede more liberal credit terms but will have a much higher profit margin. It is important to mention the needs of capital as it often happens in developing countries that the textile industry is under-capitalized and suffers from this difficulty, especially in times of slack market sales or export problems.

Other considerations have reference to the economic situation within the country and must be explored on a national level, after a thorough market survey, clarifying some of the following questions:

(a) Which products are not yet being manufactured, or are manufactured in less than sufficient quantities, and why?

(b) What is the import situation, and what are the customs tariffs levied on these items?

(c) What are the selling prices of these goods and what would they cost, under normal conditions, if manufactured?

(d) Should the factory plan to produce a few widely consumed goods, or should it establish itself as a specialized mill, producing diversified or fancy products?

To these questions there are often no clear-cut answers, and each decision has to be made according to the individual case.

Obviously, a mill planned for diversified production would have to be equipped for much greater flexibility than one specializing in the manufacture of a small number of products. However, it sometimes happens that a mill which generally manufactures standardized products wishes to produce a certain number of fancy goods. In this case, it might be advisable to create a separate department with different workloads and separate supervision, so that one type of production does not adversely affect the other.

Further aspects, such as the choice of production systems from those available, for example for woven or knit goods,as well as considerations of economies of scale, or the application of alternative technologies must be determined and clearly delineated.

Modernizing a plant

However, it may not always be necessary to think about establishing a new plant. Very often, the problem is to modernize a mill, reorganizing and possibly amplifying in order to produce more fabrics, with greater possibilities of diversity, and to effect an over-all improvement in mill efficiency.

Amplifying the mill is comparatively simple, since the management usually has a clear idea whether it should produce more of the same type of goods or to diversify: machinery is then acquired accordingly.

One modern planning trend is the construction of unit plants. A completely equipped balanced spinning plant of a determined number of spindles is often constructed. Adjacent to the existing building, sufficient space may be left for constructing additional buildings of a similar size, when and if such a need arises. Then the walls separating the unit can be removed and the factory can thus operate as one larger, more efficient plant, with lower unit cost.

But even where such provisions are not taken, amplification programmes are possible and feasible, so long as there is sufficient space that the additional installations are not cramped. Care must be taken to avoid a situation where, instead of having an improved position, the firm finds itself battling against a shortage of space, especially storage space for intermediate products, thereby making material handling more difficult.

The co-ordination between production and distribution is one of the more important aspects which must be considered by every progressive mill.

Modernization or new plant

The decision to modernize mills or to build anew is one that today faces textiles manufacture industry in the United States. The surge of technological developments in machinery, fibres and finishes in recent years has transformed it from the static to the dynamic. The industry that once launched the Industrial Revolution is in the mainstream of a second revolution, triggered by automation, computers, market research-analysis and professional management.

The overriding change is that the industry has shifted from an emphasis on labour to an emphasis on machinery. In short, it has become "capital intensive". Realizing the impossibility of competing with the products of low-wage countries (where some wages are so low as 16 cents per hour), it has resolved to forge ahead by judicious use of capital and technology.

Springs Cotton Mills in Fort Mill, South Carolina, recently made an analysis of the problem and found that the renovating of an old mill constitutes up to 80 per cent of the cost of constructing a new mill, assuming that the two mills will have comparable machinery.

The expenditures needed to create the modern automated plants are staggering, Springs Mills emphasized. For example, plants like the Beaunit unit at Clinton, North Carolina, and the new Dan River plant in Benton, Alabama, cost between $40,000 to $50,000 for each job created. The Jefferson Mills plant in Jefferson, Georgia, will have an outlay of $100,000 per job, a total of $5 million to create 50 jobs.

In spite of the enormous outlay, new mill construction will continue for some time for several reasons:

(a) The increasing age and obsolescence of old mills which make up a large percentage of the industry's productive capacity;

(b) The increasing cost of rebuilding and repairing old mills to make them suitable for running the latest machinery under the best operating conditions;

(c) A growing awareness that new plants of superior design reduce labour costs: for example, by eliminating the need for sweepers and helpers to haul material from one place to another.

In the last two years, the Springs organization has modernized three older plants and built three new plants. Two more plants are currently under construction and nearing completion. A typical experience was the modernization of an older multi-storied cotton plant in Chester, South Carolina. It took five months to do the job compared with twelve months to build a new plant. Cost of the change-over was less than half compared with the $10 million that a new plant would have cost.

The old plant did have some key things in its favour: the management was strong and experienced; the existing machines were adaptable to the new operation; the buildings were structurally sound and laid out in such a way as to ensure reasonably straightforward production, convenient handling of raw materials and practical air-conditioning and refrigeration arrangements.

The plant is now in operation, and though the renovated structure cannot match a new plant in efficiency, the efficiency achieved per dollar spent has outstripped that of a new plant; and the goods delivered match those of a new plant in quality. The Springs management feel that they have a good polyester blend plant that will remain competitive for some fifteen years.

Numerous problems and riddles remain to be solved, for example:

(a) Sales and profits in American textile mills rose strongly in the decade 1955-1965; yet while some profit margins run as high as 7.5 per cent, others are as low as 1.2 per cent. Some mills have become efficient, others have not;

(b) Skilled labour supply is shrinking, and labour turnover is high;

(c) Automation or even semi-automation of mills must be made feasible in economic terms. There must also be an upgrading of work force skills to handle new and complex equipment.

In the drive toward new plants and automation, production lines must remain flexible in order to meet changing market demands for fibres, blends, yarn numbers, twists, fabric constructions, widths and fabric finishes.

Improving operations at mill level

It may happen that due to circumstances beyond the control of management a mill can no longer operate successfully and profitably. Reorganization, purchase of new equipment, production streamlining, and changes in sales policy may help to solve much of the difficulty.

It might be interesting to mention some of the main problems, psychological, technological and organizational, that were encountered during the reorganization of a spinning mill, in a Latin American country. The psychological problems involved convincing the labour unions and plant technicians of the need for a change. This was achieved by lectures and visits to other plants, the establishment of a study group and the co-ordination of the results of the studies with the proposed changes. The assistance was recruited of consulting engineers responsible for programming.

Next, it was necessary to determine which yarns could be most economically produced in the light of existing conditions within the plant, what possibilities existed for improving blends and reducing the number of yarn counts, and what changes were to be made in the spinning process.

The third problem was to create conditions which would result in improved production factors. New air-conditioning was installed, the lighting was improved, the machinery layout was changed, work-loads were studied and a change in wage policy was initiated. Another aspect was the reduction of the number of ends down by better raw material blending and spinning controls. A mill control laboratory with strict quality controls was installed, material handling and positioning was simplified, the size of cans was increased and new roving frames with larger bobbin sizes were installed. Waste was reduced by strict waste control procedures.

The problems relating to redistribution of labour were reduced by a better selection of production staff and the retraining of workers.

Above all, it is important to make manufacturers and factory managers understand that a climate of productivity has to be created which must permeate every single phase of mill operations.

In fact, the individual mill manager is responsible to some degree not only for the productivity level at his own mill, but for that in similar mills in the whole country which increases or decreases with the understanding of problems relating to productivity.

Deciding on a new textile mill in developing countries

Survey and planning

In investigating the feasibility of establishing a primary textile plant (spinning and weaving) in a developing country, the following considerations are suggested:

1. The extent of the market

There should be a distinct need for a basic product which is now imported or is simply absent from the market. Then, by means of population figures, per capita income available for textile products, local customs, and existence of other industries (modern or otherwise), the market for fabrics should be estimated in metres.

2. Type of production

Based on the market study, climate and seasons, it will become evident what basic fabrics should be produced. They will fall into the following broad categories:

(a) Staple fabrics such as sheeting, poplins, batistes and drills;

(b) Fancy woven fabrics, usually yarn-dyed and requiring dobbie-looms and possibly Jacquard looms;

(c) Prints on a variety of basic fabrics in the simple three or four colour range and in more elaborate materials using eight or ten colours;

(d) Industrial fabrics for uses in industry, such as canvas, tyre cord, beltings and plush fabrics;

(e) Floor coverings and tapestry requiring special weaving and finishing equipment such as tufting and Jacquard;

(f) Marginal products such as bedspreads, towellings.

3. Type of plant

Once the market requirements as to type of goods, price range and volume are determined, a decision must be made as to whether an integrated plant (spinning, weaving and finishing) is desirable; or, if the size of the market suggests that it might be preferable to separate spinning and weaving from finishing. Each plan has its advantages and disadvantages. Usually in relatively small markets integration is preferred. In the United States both exist: integration to reduce costs of staple fabrics and commission weaving and commission finishing on fancy fabrics and prints. At this point it is desirable to decide whether costs will permit production for export and what types of products can be exported to other markets.

4. Type of machinery

Obviously the products to be produced and the basic fibres to be employed will govern the type of spinning and weaving machinery to be purchased. The finishing plant should be very flexible and capable of handling all fibres, especially blends, which are the order of the day and will continue to grow in importance. The latest and most modern machinery should be investigated even if at just a glance it seems unnecessary to bring such machinery to a country at an early stage of industrial development. With the great advances in textile technology in recent years, the economical aspects of transferring old equipment to new markets have to be considered and evaluated very carefully. Countries develop rapidly, and inefficient machinery fast becomes displaced.

5. Sufficient capital

Financing should cover the advantageous purchase of basic machinery and raw materials without undue recourse to borrowing at high interest rate.

6. Working capital

Capital should cover needs with limited use of credit, in the foreknowledge that profits normally come only after an extended period, sometimes as long as four years, especially in areas where extensive training is needed for labour. This is characteristic of an integrated textile plant in a developing country.

7. Ample labour market

Unskilled and some skilled labour should be available. At the outset, skilled specialists can be brought in to train local personnel.

8. Executives

Those who fulfil managerial capacities should be well-versed technically and expert in merchandising and finance. They must be aware of the fact that they can expect little subordinate assistance for the first years. This vital subordinate help must be trained by the executives and, if possible, drawn from the local market.

9. Raw material

It need be determined to what extent raw materials are available locally or can be imported at reasonable prices.

10. Duty

Measures should be taken to protect the new industry against foreign competition from industries well developed and with amortized equipment.

11. Location of plant

On deciding where the plant is to be established the following factors must be considered:

(a) The availability of labour, unskilled and skilled;

(b) The climate and altitude and their effects on types of buildings and machinery: humidification and chemical reactions;

(c) The availability and type of water;

(d) The availability of electricity and the cost of running a plant plus steam; and whether the plant will be required to supply its own power;

(e) Accessibility to the market and to the home office, which is vital for controls and service to customers. The available transport and means of communication must be carefully studied;

(f) Local tax assessments.

No study can be complete without detailed and careful research intu sales channels, types of customers (cutters, wholesalers, retailers) customers' likes and dislikes, regional preferences, and colour trends. In a market previously unexposed to western type of merchandising there may be initial resistance, but judicious sales techniques and advertising will create the proper public reception. In short, distribution of the products must be so arranged that maximum coverage is being practised from the start.

Utilization of new, rebuilt or second-hand machinery

The urge to acquire new equipment in textile mills may not be due solely to the necessity of replacing the old: it may be thought desirable to exchange a machine, even though it is not old, for another piece of equipment that produces materials of better quality. The need for more automated or higher-speed machines using larger bobbins, packages or cans, facilitating material handling and economizing on subsequent processes, is not to be ignored. Another reason is the wish to acquire a unit which is more versatile and more efficient. To amplify these aspects:

(a) A machine is obsolete when it requires costly maintenance, operates at slow speeds and produces deficiently;

(b) It may be that a more efficient process has been developed, in which case equipment involved in the former process, though not old, must be declared technologically obsolete;

(c) The machine to be replaced might be operating in a similar way to the new model, but lacks new devices or accessories that permit better over-all end result and higher workloads: for instance auto-levellers, stop-motions and pneumatic waste removal;

(d) It might be considered desirable to acquire machines with higher speeds and drafts, permitting higher production and elimination of one or more processes (for example, roving frames), or automatic machines permitting simpler operations, and substantial increase in workloads.

Change-over, new equipment or second-hand equipment

Technological advances induce, even oblige, the textile manufacturer to improve his products and produce them more economically, in order to compete. The questions are: Should he buy new equipment, rebuild existing machinery or should he acquire second-hand machinery which would serve the purpose?

In general, rebuilding one's own equipment is much cheaper than buying new machines. Another possibility would be to purchase good secondhand equipment that is not actually obsolete. It may be that a factory in a highly industrialized country replaces a machine which, though not technologically the "last word" is still in good operating condition. Such a machine would be suitable for use in a developing country in certain circumstances, as for example when it might be expedient to buy a good secondhand auxiliary machinery for completing a production line or improving some products. However, any secondhand equipment should be thoroughly inspected before it is acquired.

The decision to buy a new or second-hand machine or to rebuild an old one will depend not only on the manufacturers themselves but on local conditions: Is foreign exchange available and what customs duties or taxes would have to be paid? In a small country with limited consumption it may not be advisable to purchase a high production machine which may be idle part of the time.

In every case careful calculations must establish the per unit cost of the new process, that is the total new production, direct and indirect labour, electricity, depreciation and other manufacturing costs for the department as well as interest on the invested capital.

Generally in the more industrialized countries the investment should pay for itself in two or three years - in five years for more expensive machinery. But this estimate varies from country to country and at times from factory to factory. It is clear that in countries with higher labour and raw material costs, it is more important to increase workloads and reduce waste than in areas where labour and raw materials are cheap.

One must also consider the availability of spare parts and accessories before making final decisions.

Experience has shown that there were successful transfers of entire textile mills from highly developed countries to developing ones. Each case has to be considered individually from all angles.

New equipment

When all considerations have been weighed and it has been found that new equipment must be purchased, it is important to secure offers from as many different manufacturers as possible. Formerly, the choice depended largely on the personal preference of a factory owner, but today, more scientific methods are used to evaluate both offers and performance of industrial equipment.

Often, trial equipment is placed at the disposal of a possible customer, who thus is able to test and compare the new machines methodically within his own plant and to avoid purchasing equipment that does not completely satisfy the need or tie in efficiently with the preceding and subsequent processes. The dimensions of the machine, too, must fit into the shop layout.

Workloads within the department also should be calculated. If it is found uneconomical to buy at high cost a superspeed machine that will be in operation only a few hours daily, a slower machine at much lower cost will be considered adequate. Naturally, future requirements and expansion plans must also be taken into consideration.

When trial equipment from various manufacturers is installed, sufficient time should be taken to observe the performance of each machine under actual mill conditions. Examples of the studies to be made in the proper evaluation of equipment are these made in the case of a ringspinning machine:

(a) Checking on machine performance: physical production per day or per week; the simplicity of making changes as in speeds, drafts, and twist, and the time needed; maintenance; cleaning; lubrication; observations of ends down; waste; efficiency; number of machines that can be assigned per worker under normal operating conditions.

(b) Checks on yarn count and quality: resistance and elongation variation within bobbins and between bobbins; yarn count and its variation within and between bobbins; yarn appearance; evenness.

Tests have to be made under controlled conditions and equal preparation of the roving must be exacted for proper comparison of results.

Degree of machinery specialization

In setting up a mill, a most important decision is whether it should manufacture only a few types of standard goods or produce a large number of highly specialized fancy products. In each case the mill has to be planned differently with a different internal organization and sales set-up. Cases exist of mills established to manufacture standard products. When they began to diversify they lost their ability to produce staple products efficiently, and yet were unable to produce satisfactory fancy goods because the mill work force lacked the specialized technical know-how and the capacity to create attractive designs, properly finished. The same thing can be said of a mill which, though it was primarily planned to produce fancy types of goods, suddenly switched to the production of staple goods. This mill's production costs were so high that it could not compete against mills especially designed to produce similar staple goods.

This naturally does not mean that a mill should be inflexible. All changes in production plan should, however, be well thought out so that neither its existing operations nor its cost structure suffer.

Another weighty decision would be the degree of machinery specialization: that is, how versatile should the machines be, in order to satisfy the requirements of that mill, and its market demands.

Generally speaking, the more versatile the machines, the greater the probability that some aspect of production, especially the production rate, must be sacrificed. If, for instance, a spinning frame is geared principally to the production of certain types of yarns, such as cotton, the same frame will have to be adjusted for the spinning of blends or other raw materials which may have to run at slower speeds.

In the weaving department, shuttleless looms are generally more limited in scope and in the types of fabrics that can be woven in comparison to the shuttle looms.

There is no clear-cut answer for recommendations for machinery specialization, and each case will have to be investigated on its own merit according to the type of goods the factory wishes to produce and how far it wishes to diversify.

Chapter III. RAW MATERIALS

Cotton

Criteria for selection of cotton for best utilization and performance

Technological advances in the construction and manufacturing of textile fabrics call for continuous improvement of criteria applied to the selection of raw materials.

Cotton, which is a fibre of the vegetable hair type, is subject to a great many interrelated variables such as environment, production practices, seed variety and ginning practices, all of which have a certain effect on the physical and mechanical properties of the fibre. Selecting from these highly variable cottons the types most suited to a specific production programme requires a full understanding of the basic functions here briefly outlined and discussed:

(a) Finished product performance: The yarn count, fabric construction, type of finish and desired appearance as well as strength and other physical requirements of the end product are of utmost importance in selecting the right type of fibre.

(b) Processing facilities: The available mechanical and chemical cleaning equipment influences the selection of the grade of cotton; and the high speeds and high drafts of modern spinning equipment will justify the use of longer, stronger cottons than those used on older machines.

(c) Continuous supply: Frequently neglected, but of great importance in ensuring mill efficiency and that the quality of the product should be evenly maintained at a high level, especially in small cotton producing countries, is the matter of continuous supply. To avoid serious difficulties blends should be planned using types of cotton that are most likely to be available in uninterrupted supply. Sometimes it is advisable to sacrifice some other consideration in favour of this.

(d) Standardization: Many mills are forced to produce a variety of different constructions and yarn-counts, each of which might call for a separate optimum blend. From a cost and efficiency point of view, however, it is necessary to arrive at some kind of compromise, either by dropping certain styles from the manufacturing programme or by using standard blends that will exceed minimum requirements in some of the counts or styles manufactured from them.

(e) Cost: When the cost of cotton is considered in a textile mill, it should be discussed in terms of the formula:

$$C = \frac{C_1 \times W_c}{W_y} - C_{ws} + C_{mw}$$

C:	cost of raw material
C_1:	cost of cotton, landed
W_c:	weight of cotton
W_y:	weight of yarn
C_{ws}:	cost of waste salvaged
C_{mw}:	manufacturing cost of waste

This figure represents very closely the cost of cotton per pound of yarn, and it is this figure, rather than the landed price of the raw cotton, that should be used to establish the most economical type of cotton that will satisfy the concepts 1 to 4 given above.

(f) Grade: The grade of cotton as defined by colour, leaf and preparation is of minor importance as regards the mechanical characteristics of yarn and fabrics: it is much more closely related to the complex of cost, waste and appearance. However, grade is also a limiting factor for yarn count since it is known that interference from residual non-lint content will always be higher from low-grade cotton.

(g) Length: The length and length frequency distribution are the main limiting factors for maximum yarn counts, and at the same time they determine optimum and lowest twist. The longer and more uniform the staple, the finer the count that can be spun and the lower the twist that may be used.

Uniformity of the staple length is highly desirable in modern processing as, for instance, a high short fibre content has an adverse effect on spinning performance. On the other hand, long fibres will more easily nep or tangle and therefore may have to be processed at slower machine speeds in opening and carding.

(h) Strength: Fibre strength is of course correlated to yarn and fabric properties, but only taken together with length does it become an important factor in predetermining the performance of a fibre in manufacturing and utilization.

(i) Fineness: Fibre fineness, as measured by today's airflow instruments (Micronaire), represents a compound indication of fibre diameter and cell wall thickness. Thin-walled (immature) fibres are less desirable, but for most practical purposes, large diameter thin-walled fibres and small diameter thick-walled fibres perform in very similar ways, and of course, are identified by the same Micronaire reading. Fibres of low Micronaire reading tend to nepping and tangling in processing, but give finer counts of better uniformity because of the higher number of fibres per cross-sectional area. As blending of cottons of different Micronaire values is easily accomplished, close raw stock control and evaluation will result in improved yarn appearance, dyeability or cloth and processing performance, as well as yarn and fabric properties.

Certain aspects of cotton policy

Some cotton producing countries grow a rather limited range of cotton in type, grade and staple length. Usually these are lower grades and shorter staple cottons; better-grade longer cottons have to be imported for specific end uses such as sewing thread and fine types of poplins and batistes. The quantities imported may depend not only on purely technical aspects such as definite needs for a specific end use but upon the availability of foreign exchange. Such fibre imports ought not be allowed to endanger the sales of locally grown cotton.

It may be that in some countries, for instance Peru and Egypt, excellent locally grown cotton qualities are available, but lower cotton grades are in short supply. It can then happen that the finer grades are employed to spin a yarn used in materials for whose end use lower grade cotton yarn would be perfectly adequate.

It would be [illegible] and that fine cottons be used only in fabrics that [illegible] high qualities of [illegible], while importing cheap cotton for the lower grade goods; this would release a large quantity of high-grade domestic cotton for export.

The pre-blending of cotton

An important step in the preparation of cotton blends is pre-blending, as practised by many mills in the United States and other parts of the world; it was, in fact, impressive to observe a pre-blending operation in [illegible] mill that assured this progressive factory of a very uniform cotton blend.

The general practice in the United States is to pre-[illegible] which are selected for end use according to staple length, Micronaire reading, and at times, according to Pressley, fibre strength. Eight to twenty bales are usually laid out at a time, in the opening room, thus ensuring a satisfactory blend. The advantage of pre-blending can be summed up in several points:

(a) A better distribution of qualities is obtained;

(b) Cheaper qualities of cotton can be used; that is to say one can blend shorter and longer staple cottons and cheaper grades as well as cottons of slightly lower Micronaire reading, within the type of cotton, which might be of cheaper quality, so that the resultant blend will be more economical and still sufficient for the end use;

(c) The pre-blending operation can be separate from the spinning mill, housed in a building of cheaper construction, which does not have to be air-conditioned, so that there is a saving in building cost as compared with regular mill space;

(d) The picker room in the spinning mill itself can be built with fewer opening machines, which means that savings in machinery cost can be achieved.

On the other hand, there are some disadvantages to pre-blending which should also be mentioned:

(a) There is more handling, as the cotton bales have to be transported to the pre-blending mill; the cotton has to be baled and stored in an intermediate storage place;

(b) There might be some possible fibre damage due to the double blending operation; however, the fewer opening points in the opening room proper tends to diminish this possibility.

Summing up, there is no doubt that pre-blending is of greatest interest in connexion with the preparation of cotton for spinning and should be considered in detail, especially where larger-scale operations are involved, as more uniform and often cheaper blends can be processed.

Section of cottons - importance of cotton testing for selecting and blending

From figure 1 one can see the influence of different fibre properties on the quality of yarn and cloth, and these factors will have an important bearing on the selection of cottons appropriate to their end use.

Cotton is a variable raw material. It differs by variety and according to the area where it was grown. Even cotton from the same region may differ in quality from year to year, due to a change in climatic conditions. Every major spinner should have a fibre laboratory to test the cotton properties thus enabling him to predict and judge the performance of the fibres during processing and also to foresee any possible difficulties in the spinning as well as with the finished product. Needless to say, no raw cotton purchase should be made except on the basis of tests performed in the buyer's fibre laboratory.

[illegible] main object in selecting cotton or preparing the blend is to manufacture a suitable end product at the most economical price. The cotton quality alone may not always be the determining factor for purchase or utilization: price and availability are also to be considered. Various factors may influence a decision to purchase cotton of a certain type, for example:

(a) Due to market conditions the high price of some cottons may induce a mill to purchase similar types from another region at a more attractive quotation;

(b) In countries where raw material is expensive and labour cheap the factory will select the lowest possible qualities for a certain end use in order to reduce costs;

(c) In countries where labour is expensive, the mill would be inclined to buy a better quality of raw material in order to be able to spin at higher speeds, thus obtaining a higher productivity with lower manufacturing costs.

Cotton development and improvement programmes

In countries where poor qualities of cotton are produced, industrialists and cotton-growers should make a joint all-out effort to improve them, and if necessary they should establish a cotton development programme for the most needed types, as well as plan for the production of those cottons required by the industry at large. Such programmes have already been successful in a number of countries, as for example Venezuela where a Cotton Development Fund was established, a semi-autonomous organization that includes cotton-growers, ginners, textile industrialists and government authorities concerned with the co-ordination of agricultural and industrial development. The Fund assists growers in their cultivation plan• and in measures taken against insect damage, plant disease and weeds; it recommends appropriate fertilizers, checks ginning practices and has established cotton classing. Finally, it is helping to draw up plans for overall requirements in growing the different types of cotton now being utilized in the industry, especially with reference to the sharp increase in blends with synthetics, so as to achieve a major integration of cotton-growing with textile manufacturing.

Summing up, one may say that the selection of the right cotton quality and the preparation of proper blends based on fibre controls are among the most important of a mill's operations.

Wool

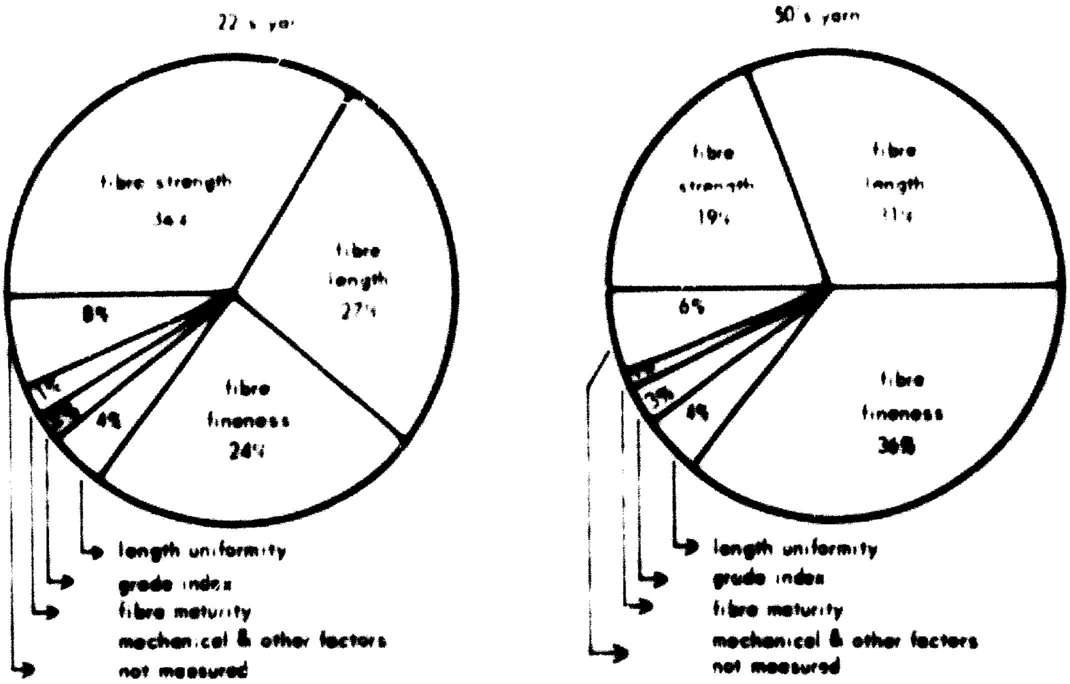
The selection of proper wool qualities

Modern production methods in woollen and worsted spinning require raw materials of better quality than were hitherto necessary. Higher speeds and drafts in spinning make this mandatory. Besides, the demand for improved wool quality is increasing with the trend toward finer and lighter-weight fabrics.

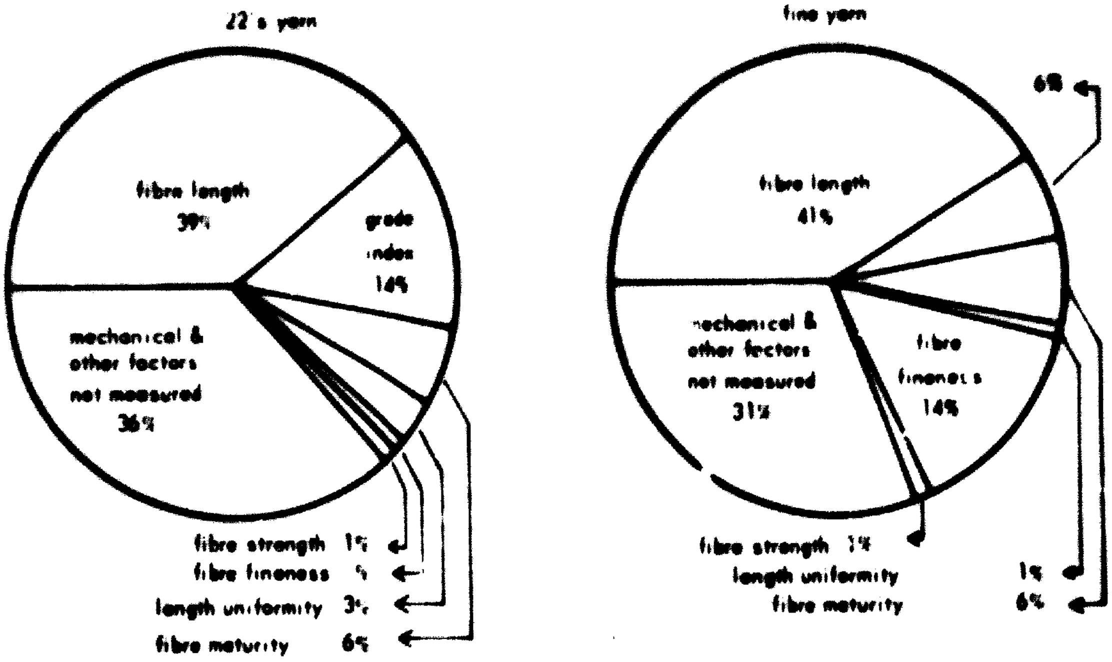
Figure 1

Cotton fibre properties that affect yarn quality a/

Yarn strength



Yarn appearance



a/ *Textile Industries*, December 1954; based on a paper presented by John W. Wright of the United States Department of Agriculture at the 4th Canadian Textile Seminar at Kingston, Ontario.

The fineness of the wool, its length and uniformity of staple are of prime importance in indicating spinnability. Further properties, such as crimp and loftiness, are also of significance in determining its suitability for a required end use.

Research in wool properties has gone a long way in helping the conscientious manufacturer select the quality of the wool he needs for his products. Instruments have been developed by which an expert may easily establish the primary qualities mentioned above, as well as such important criteria as yield in scouring and noilage during combing. Other properties, however, cannot be measured by instruments, but must be judged by expert examination: these include "springiness","loftiness" and bulk.

Some aspects of wool policy

As in the case of cotton, it often happens that a wool-growing country produces only certain types of wool suitable for a few specific end uses, as for example hand or machine knitting, or carpets; or the coarser wools suitable for some types of woven cloth. These same wools may lack the essential qualities needed for the production of fabrics used domestically or for which there is a foreign market. Naturally, wool growers become alarmed when local spinners import special types of foreign wools, especially where there is a surplus of home grown raw materials. It is important to study such matters carefully in order to determine which qualities of wool are really needed and which may be imported without endangering the domestic wool market. It is sometimes advisable to import some qualities, finer ones to improve blends and end products, but even coarser ones, so that cheaper fabrics may be manufactured from the lower grade imported wools, thus leaving the fine domestic wools for export - should this be found economically justifiable.

Fell-mongering

Fell-mongering, or the removal of wool from skins, has been practised for ages and such wool is lower in quality and generally damaged by the mechanical or chemical process used. Usually it is for low-grade woollen fabrics where certain desirable properties of wool are not of considerable importance.

In Australia a new fell-mongering process has been developed and is now used routinely, that preserves the quality of wool to a great degree, so that it serves a larger number of end uses. This process utilizes the bacterial population normally present on sheepskin to digest the skin without damaging the wool without requiring the addition of any bacterial culture. No loss in colour in the wool results from the treatment and fibre damage is exceptionally small.

Since wool is an expensive raw material, it might be interesting in countries where mutton is being consumed in great quantities, to introduce this improved method of fell-mongering which would yield skin wool of better quality for domestic use or for export.

Criteria of selection of wool qualities and blending[2]

The proper selection of wool qualities and blending is a science and an art acquired by long experience. It will crucially affect the end-use properties of yarns and fabrics as well as their cost.

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[2] N.A. Thompson and J.F. Mathews, "Selection and Blending of Wool in Relation to End Use", International Wool Secretariat; presented in draft form at the Textile Workshop in Lodz, Poland, 1965.

Wool quality

All wool, irrespective of origin, is divided into two main categories: Crossbred and Merino. Both are composed of a range of grades or quality numbers applicable to all wools, as follows:

Crossbred	Merino
28's	60's
32's	64's
36's	66's
40's	70's
44's	80's
46's	90's
48's	100's
50's	
52's	
54's	
56's	
58's	

The quality numbers are arranged in ascending order of fineness, the 28's Crossbred being the coarsest and 100's Merino the finest; these standards are based on the experience and custom of many generations of wool men. In recent years the practice of measuring the diameter of wool fibres in microns with the help of various instruments and relating these measurements to wool quality numbers has been increasing throughout the wool industries of the world. However, it has not yet been universally accepted for determining raw wool qualities, being used usually as a basis for determining the quality of wool and tops prior to purchase.

W.J. Onions in his book *Wool: An Introduction to its Properties, Varieties, Uses and Production* indicates a summary of quality classification of wools used in apparel, and warns that "no agreed international standard of comparative qualities exists, but the Commonwealth Economic Committee has published this table as an approximate guide". (Table 1.)

The same author gives a table of United States official standards for grades of wool and wool tops (in microns) but emphasizes that these grades should not be confused with Bradford qualities, which use similar numerical designations but for which no official fineness standards exist. (Table 2.)

Table 1

Quality classifications of wools used in general[a]

United Kingdom Bradford quality groups	United States Boston quality groups	United States Blood groups	France	Germany	Argentina	Uruguay
Merino						
80's	80's	Very fine XXX	Merino supérieure 125-130	AAA	-	-
70's	70's	-	Merino supérieure 115	-	Fine supra	Fine supra
64/70's	64's	Fine XX	Merino 110	AA	Fine supra	Fine supra
64's	60/64's	Fine medium X	Merino 105 (Prime merino)	A	Merino	Merino
60/64's	60's	High 1/2 blood	Merino 100 (Prime croisée)	A/B	Merino/Prime	Prime merino
60's	58/60's	High 1/2 blood	Prime croisée	-	Prime	Prime cruza
Fine crossbred						
58/60's	56/58's	1/2 blood	-	B	Prime/Cruza	Prime cruza B
58's	56's	1/2 blood	Croisée I	-	Cruza (fina) I	-
56/58's	50/56's	-	Croisée I/II	B/C1	Cruza (fina) I/II	-
56's	50's	3/8 blood	-	-	Cruza (fina) II	-
Medium crossbred						
50/56's	46/50's	3/8 blood	Croisée II/III	C1	Cruza (mediana) II/III	-
50's	46's	High 1/4 blood	Croisée III	C2	Cruza (mediana) III	-
48/50's	44/46's	1/4 blood	Croisée III/IV	D1	Cruza (mediana) III/IV	As for Argentina
Coarse crossbred						
48's	-	-	Croisée IV	D1/D2	Cruza (gruesa) IV	-
46's	44's	Low 1/4 blood	Croisée V	D2/E1	Cruza (gruesa) V	-
40/46's	40/44's	Common	Croisée VI	E1/E2	Cruza (gruesa) VI	-
36's	36's	Braid	Croisée VIII	F1	-	-

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[a] W.A. Thompson and J.F. Matthews, Selection and Blending of Wool in Relation to End Use, International Wool Secretariat, presented in draft form at the Textile Workshop in Lodz, Poland 1965.

Table 2

Relationship between wool quality numbers and micron diameter measurements[a]

Grades	80's	70's	64's	62's	60's	58's	56's	54's	50's	48's	46's	44's	40's	36's
Average diameter range														
Minimum	18.1	19.6	21.1	22.6	24.1	25.6	27.1	28.6	30.1	31.8	33.5	35.2	37.1	39.0
Maximum	19.5	21.0	22.5	24.0	25.5	27.0	28.5	30.0	33.4	35.1	33.4	35.1	37.0	41.2
Diameter distribution (percentages)														
10 to 25 (Mn.)	91	83												
10 to 30 (Mn.)			92	86	80	72	62	54	44					
10 to 40 (Mn.)										75	68	62	54	44
Above 25.1 (Mn.)	9	17												
Above 30.1 (Mn.)	1	3	8	14	20	28	38	45	56					
Above 40.1 (Mn.)										25	32	38	46	56
Above 50.1 (Mn.)						1	1	2	2					
Above 60.1 (Mn.)										1	1	2	3	4
Minimum number of fibres to be measured	400		600		800		1000			1200				

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a/ W.A. Thompson and J.F. Matthews, Selection and Blending of Wool in Relation to End Use, International Wool Secretariat, presented in draft form at the Textile Workshop in Lodz, Poland [illegible].

Purpose of various blends[1]

The object of wool blending is to mix thoroughly two or more lots of wool so as to produce an end product at a given price: we are concerned not only with blends of wools but with blends that mix wools and other textile fibres. In either case the aim is to achieve improvements or variations in aesthetics, performance and cost. Some components of these three factors are:

(a) Aesthetics -
Appearance: colour, lustre, surface texture, cover and drape;
Hand and touch: liveliness, fullness, firmness, loftiness, dryness, smoothness, softness.

(b) Performance -
Function (according to end use): wrinkle resistance, warmth and comfort, durability, fastness;
Processing: workability in tailoring.

(c) Cost -
Fibre quality and composition of blend;
Processing: spinnability and weavability; dyeing and finishing.

Certainly, aesthetics are an important factor for deciding on blends, since a customer's choice in purchasing a certain textile product is largely based on its appealing qualities. Fibres of different types, grades or lustre can be blended in such a way as to produce modifications on the surface appearance of the fabric as well as on its effect to the hand and touch.

Procedures for wool blending differ according to whether the blend is destined for processing in the worsted or the woollen sectors of the industry, and it is therefore necessary to consider separately the blend requirements of each sector.

The blending of wools for the worsted industry

The organization of this section of the industry requires that the blend or blends of wool must be combed and formed into a top for further processing on the worsted system. It follows that the blending must take place prior to this stage being reached, and indeed the different "lots" of wool which go into a blend are layered after sorting has taken place and before the actual top-making operations begin.

Detailed standards for various qualities of the tops have been established, including fineness, length, neps count, content of vegetable matter, black hair, oil content, and evenness. These properties form a guideline for estimating qualities of tops, whether they were produced in one's own mill or purchased elsewhere.

Although the top-maker has considerable leeway in his selection of wool for blending, the end product must always conform as closely as possible to the requirements of the top-user. The smooth, clear-cut appearance of worsted fabrics, in which yarn and weave structure are accentuated, demand a high degree of skill, judgement and experience in the selection and blending of wools for top-making and for subsequent processing.

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[1] Werner Von Bergen, Wool Handbook, Vol. I, 3rd enlarged edition (Interscience Publishers, 1939).

The blending of wools for the woollen sector

In the woollen sector, on the other hand, a blend of wool is a less critical matter, the selection being made according to the requirements of the end use. The blend is prepared and subsequently mixed. Further processing operations, right through to spinning, leave the fibres arranged almost at random and the wool is not combed at any stage of processing - indeed noils from the worsted combings are widely used as a basic raw material in the woollen sector.

The woollen sector can generally use any type and quality of wools. It most frequently takes shorter wools than the worsted sector and even uses those wools unsuitable for worsted, including wastes from top-making.

Wool blended with synthetics

The practice of blending wool with other fibres, especially with synthetics, has been increasing rapidly in the past decade, and a substantial portion of woollen and worsted goods are made not only of blends with natural fibres such as cotton, silk and fine hair (such as cashmere, mohair and camel hair) and cellulosic fibres (such as viscose and acetate) as in the past; in fact the main increase was registered in blends with non-cellulosic fibres.

Blends may be used to improve the functional performance of fabrics: for example, the use of acrylics or polyester fibres in blends with wool contributes to increased pleat and crease retention and minimizes fabric wrinkling. Small amounts of synthetic fibres such as nylon may be added to raw stock to improve spinning performance and strength. In other applications staple fibres with varying dye affinities can be blended so that cross-dye effects can be obtained during piece-dyeing or over-dyeing. In addition, fibres with inherent differences in shrinkage may be blended to give increased loft or modified fabric surface texture which are the result of the relaxation of fibre and yarn incurred during the finishing process.

In addition, less expensive fibres can be substituted either for styling purposes or for the sake of economy.

Regardless of the reason for blending, it is certain that this practice no longer conveys the image of a cheaper imitation as was formerly the case, and suitable blends which improve end-use properties are firmly established in the woollen industry.

Man-made fibres

The share of man-made fibres in the total world fibre production is nearly one third, and it is increasing rapidly. The production of synthetic fibres has shown the highest growth rate at 25 per cent compound interest annually. The corresponding figure for regenerated cellulosic fibres is 5 per cent and for the natural fibres, cotton and wool, the annual growth rate is only about 2 per cent.

It is inevitable that the world requirement for textile fibres will continue to rise steeply both because of population growth, and - even more - because of the rising standard of living.

Whether the growth rates will be maintained at present levels is a matter for speculation, but few would have forecast in 1900 that the textile fibre requirement would rise fourfold by 1960 due to a doubling of the world population and a doubling of the consumption of textiles per head in these 60 years. As a further example of the dramatic change in the usage of textile fibres during this century, one may mention that as late as 1920, only cotton and wool were of any importance for apparel wear; yet by 1940 the regenerated cellulosics equalled the wool output, and by 1964 the synthetic fibres alone had caught up with wool and had passed the 1900 total world output of textile fibres.

The increased use of man-made fibres has not been accidental nor has it been imposed upon the consumer solely by skillful advertising. Man-made fibres have been accepted because of their genuine value to the consumer. They offer wearing performances which are often superior to those obtained with natural fibres; regular quality which, unlike cotton and wool, is unaffected by climatic conditions; and stability in price which, since their introduction, has had a steadily declining trend. Man-made fibres can also be produced in countless variations of denier, length, shrinkage, strength, elongation, colour, and crimp, at practically no extra cost, and are thus much more versatile than natural fibres. The full commerical exploitation of this versatility has only recently begun. So far, fibre processing methods have remained, in principle, relatively unchanged. Naturally the operations have been automated and made more sophisticated, but such radically new methods as bulking, two conversion, tufting and foam backing are still relatively little used. One reason for this may be the basic conservatism of the human being: since he has been accustomed to fabrics made of spun yarns for several thousand years, he continues to demand the same wearing qualities from fabrics made of man-made fibres. This leads to the actually absurd practice of chopping up parallel fibres into a tangled mess only to - through a laborious process - make them parallel again in the form of a spun yarn.

The emphasis in man-made fibres production today is, for these reasons, on staple fibres. Two thirds of the synthetic fibres produced are supplied in staple fibre form and one third as filament yarns. This ratio, however, is gradually changing and the filament yarn usage will definitely increase with the increasing production of textured yarns of various types.

Certain important man-made fibres fall into the following groups:

- Man-made fibres
  - Regenerated fibres
    - Cellulosic
      - Viscose rayon
      - Polynosic
      - Acetate
      - Triacetate
    - Protein
      - Fibres derived from vegetable and animal proteins.
    - Unorganic
      - Glass fibres
      - Metal fibres
  - Synthetic fibres
    - Polyaddition
      - Polyurethane
    - Polycondensation
      - Polyester
      - Polyamide
    - Polymeration
      - Polyacrylonitrile
      - Polypropylene
      - Polyvinylchloride
      - Polyvinylalcohol
      - Polyethy-

The most important groups in the above fibre chart are the regenerated cellulosic fibres, polyamides, polyesters, polyacrylics and, more recently, polypropylene and polyurethane fibres. The regenerated cellulosics represent the biggest single group among the man-made fibres. Among the synethetic fibres, the big three - polyamides, polyesters and polyacrylics - account for over 90 per cent of all synthetics.

Based on present fibre trends and rates of increase in population and rise in the standard of living it has been forecast that by the year 2000, half of all textile fibres will be man-made. The following tabulation compares the situation in 1965 with the estimated situation in 2000:

	1965 %	2000 %
Cotton	63	44
Wool	8	6
Regenerated cellulosics	18	20
Synthetics	11	30
	100	100

This forecast is justifible on the grounds that the increasing demand for textile fibres will have to be met largely by man-made fibres because of the shortage of land suitable for vast increases in the production of cotton and wool. Furthermore, man-made products are no longer to be considered as artificial substitutes for the natural products they replace. It is now widely recognized that a fibre derived from a "natural" source, a plant or an animal, is not for this reason necessarily better, in terms of textile properties or value for money than one devised by the scientist to meet particular requirements.

Regenerated cellulosic fibres

The basic raw material for these fibres is natural cellulose. Preserving the original molecule chain as far as possible the cellulose is dissolved and then regenerated in a continuous filament form which is subsequently cut into predetermined staple lengths. The regenerated cellulosic fibres are generally characterized by a high moisture absorption which results in the swelling of the fibres and thus facilitates dyestuff absorption, but on the other hand it also renders them sensitive to tension and abrasion in the wet state and leads to often excessive shrinkage of the fabrics.

There are four major types in this group: regular viscose rayon, polynosics, acetate fibres and triacetate fibres.

1. Viscose rayon and modified rayons

Viscose rayon is the oldest commercial man-made fibre. It has been produced since the beginning of this century and is the second largest group of textile raw materials after cotton. It is, like most man-made fibres, very versatile and can be produced in countless variations to suit any particular end use. Being a cellulosic material, many of its properties are rather similar to those of cotton. Its main weaknesses are high water absorption and subsequent swelling which leads to dimensional instability of fabrics. These weaknesses can be offset either by chemical treatments or by modifying the fibre itself during the manufacturing process. It is used mostly in blends with both natural fibres and synthetics. In blends with cotton it lends evenness to the yarn because of its even staple length, and in blends with the synthetic fibres it reduces the tendency to static electricity, which is one of the main problems related to the use of synthetic fibres.

A very popular blend with cotton, widely used particularly in the knitting trade, is one third viscose rayon and two thirds cotton. This improves the appearance and the mechanical properties of the yarn without significantly reducing the dimensional stability of the fabric. It has also been shown that the resistance to wear of woven fabrics, such as sheetings, is improved through the blending of viscose rayon with cotton.

The main weaknesses of the regular viscose rayon fibre, its swelling in water and subsequent low wet strength and poor dimensional stability, have led to the development of modified rayon fibres. These can be divided into two main groups: High Wet Modulus fibres (HWM) which were developed in the United States by modifying the manufacturing methods of super cord; and the polynosic fibres, developed by the Japanese during the Second World War. The following is a short comparison between these two groups and regular viscose rayon.

(a) The degree of polymerization of the modified fibres, that is, the number of units in the chain molecules is twice or even three times higher than that of ordinary viscose rayon. This has, among other things, a bearing on the tensile strength of the fibres. The tensile strength of both HWM and polynosic fibres is high;

(b) The elongation at break of both HWM fibres and polynosics is lower than that of ordinary viscose rayon. The load-elongation properties of these fibres greatly resemble those of cotton;

(c) There is a correlation between the modulus, that is, the elongation of a fibre under low stresses, particularly in the wet state, and the dimensional stability of the fabric. Both the HWM fibres and the polynosics are superior to regular rayon in this respect. The polynosics have a higher wet modulus than the HWM fibres;

(d) In blends with cotton, resistance to alkaline treatments is important. The polynosics are in this respect better than the HWM fabrics. A blend of cotton and polynosic fibres can even be mercerized, a treatment which would reduce the strength of HWM fibres and cause regular rayon to disintegrate.

It is difficult to predict which rayon type will dominate in the future. The bulk production at present is in the regular rayon staple which combines versatility with low price, but development work continues, and there is increasing interest in composition fibres which would combine hithero incompatible properties such as pleasant handle and high tensile strength.

The main physical properties of regular and modified rayons are:*

	Regular rayon	HWM fibres	Polynosic fibres
Tenacity, gr./den.: dry	2.0-2.7	4.5-5.0	3.7-4.2
Tenacity, gr./den.: wet	1.0-1.6	3.0-3.5	2.5-2.7
Elongation at break : dry	15-23 per cent	15-17 per cent	8-10 per cent
Elongation at break : wet	20-30 per cent	19-20 per cent	8.5-11 per cent
Moisture regain	13 per cent	10 per cent	7 per cent
Effect of heat	Does not melt; weakened at 150°C.; disintegrated at 180-200°C.		

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*These figures are approximate.

2. Acetate and triacetate

The basic structure of acetate and triacetate fibres is the cellulose chain to which acetyl groups have been added. The fibres contain 40-60 per cent natural cellulose and possess some of the typical characteristics of cellulosic fibres, but to a lesser degree. They show a tendency to swell in water, which facilitates the absorption of dyestuffs, but also renders the fibres sensitive to tension and abrasion in the wet state and results in dimensional instability of the fabrics. In this respect, the acetate and triacetate fibres may be regarded as semi-synthetic. Their properties lie between those of pure regenerated cellulosic fibres and those of true synthetic fibres, such as polyamides and polyesters.

In apparel wear and home furnishings acetate and triacetate fibres are used mostly in filament form. Their main industrial application is cigarette filters.

The acetate fibres are very sensitive to heat.

Some physical properties of acetate and triacetate fibres are:

	Acetate	Triacetate
Tenacity, gr./den.: dry	1.3-1.5	1.2-1.5
Tenacity, gr./den.: wet	0.6-1.1	0.8-1.0
Elongation at break : dry	23-34 per cent	22-28 per cent
Elongation at break : wet	30-45 per cent	30-40 per cent
Moisture regain	6-6.5 per cent	3.2-4.0 per cent
Effect of heat	Weakened at 100°C.; softens at 180°C.	Softens at 230°C.

Synthetic fibres

1. Polyamide

The polyamides are the largest single group (50-60 per cent) among the synthetic fibres. They were also the first to be manufactured on a large commercial scale. The outstanding physical properties of nylon 66 - the original, and still most widely used type of polyamide - are the high strength/weight ratio, high breaking elongation, recovery from deformation, high abrasion resistance and an excellent flex life.

The biggest users of nylon are the tyre cord, carpet and hosiery industries.

The load/elongation characteristics of nylon staple make it particularly suitable for blending with wool to improve the fabric's resistance to wear.

Some physical properties of polyamide fibres are:

Tenacity, gr./den.: dry	4.5-6.2
Tenacity, gr./den.: wet	4.0-5.6
Elongation at break : dry	24-40 per cent
Elongation at break : wet	28-42 per cent
Moisture regain	3.5-5 per cent
Effect of heat	Softens at 140-225°C., depending on the type.

2. Polyester

The polyester fibres are characterized by high tensile strength and abrasion resistance, excellent appearance retention, easy-care properties, good dimensional stability and very good resistance to acids. Some of the disadvantages of this group are low moisture absorption resulting in static electricity and a tendency to pilling, that is the formation of [illegible] In spite of these weaknesses, however, the polyester fibres probably have the best balance of performance characteristics of any natural or man-made fibre produced today. This is also reflected in the high growth rate of the polyester group. It is higher than that of any other fibre group, man-made or natural.

The largest single volume of polyester blend fabrics is in polyester/cellulosic blends. The blend proportion is usually 67/33 polyester/cellulosic or 50/50 polyester/cellulosic. The latter blend seems to have a big potential in fabrics for permanent press garments.

In blends with wool the polyester content is usually [illegible] or [illegible] per cent. It improves the appearance of the fabric and its shape retention and its thermo-plasticity make it possible to impart permanent pleats into the fabric.

In filament yarn form, the polyester fibres are used in industrial outlets such as fishing nets and, lately, tyre cord.

Some physical properties of polyester fibres are:

Tenacity, gr./den.: dry	4.4-5.5
Tenacity, gr./den.: wet	4.4-5.5
Elongation at break : dry	15-25 per cent
Elongation at break : wet	15-25 per cent
Effect of heat	Softens at 220°C.

3. Polyacrylic

The acrylic fibres have a remarkable resistance to the degrading action of sunlight, making them particularly suitable for end uses where the fabrics are exposed to weathering.

In apparel fabrics, acrylic fibres are used mostly in knit-wear. They have a warm, pleasant handle, good wrinkle resistance and ability to be heat set. The moisture region of the acrylics is higher than that of other synthetics thus making the handle of acrylic fabrics more pleasant to the skin.

Some physical properties of acrylic fibres are:

Tenacity, gr./den.: dry	2.0-3.5
Tenacity, gr./den.: wet	1.6-3.1
Elongation at break : dry	20-40 per cent
Elongation at break : wet	20-40 per cent
Moisture regain	1.0-2.5 per cent
Effect of heat	Sticks at 230-240°C.

4. Polyurethane

Polyurethane elastomeric fibres are one of the recent, significant man-made fibre developments. Their commercial production started in 1960 and they are finding increasing application in woven and knitted apparel textiles where stretch properties are required.

The inherent properties of polyurethane fibre enable it to be easily stretched like rubber with an almost 100 per cent recovery. Its other textile properties, such as tensile strength, resistance to light, dye affinity and initial modulus of elasticity are superior to those of natural rubber.

Some of the main physical properties of the fibre are:

Tenacity	0.6-1.0 gr./den.
Elongation at break:	550-800 per cent
Elastic recovery:	97-98 per cent recovery when elongated 100 per cent

Resistance to light:	Polyurethane may be made resistant to ultraviolet rays by using a special agent during manufacture
Resistance to heat:	Melting point 200–220 °C.
Specific gravity:	1.0 (polyester 1.38 and polyamide 1.4)
Dye affinity:	Good
Resistance to chemicals:	Resistance to acids, alkalies and other chemicals other than chlorides.

The main applications of polyurethane fibres are in foundation garments, swimwear, blouses, slacks, socks and lingerie. The fibre may be used either in bare form together with other yarns, or in a corespun form where it is covered by staple fibres. The degree of elasticity may be varied during core-spinning to suit the particular end-use requirements.

The high price of polyurethane fibres has somewhat limited their use but this disadvantage is partly offset by the fact that in most cases a polyurethane fibre content of only 6–10 per cent in the fabric is sufficient to give the desired elastic properties.

5. Polypropylene

This fibre is used extensively in industrial application such as filter cloth, fishing nets, laundry bags, dye nets, sewing thread, cords, ropes and twine. An important area of development is its use in carpets in textured filament form.

Certain physical and chemical properties of polypropylene fibre are:

(a) Specific gravity: Its specific gravity of [illegible] makes polypropylene the lightest of all existing fibres. This property makes it suitable for many textile and industrial applications such as light garments, ropes and floating fish nets;

(b) Tensile strength: Polypropylene is as strong as nylon, 4.5–9 gr./den. and does not lose its strength when wet. This makes the fibre very suitable for many wet industrial applications;

(c) Moisture regain: The moisture regain of polypropylene is nil, both in air and in water. This property gives polypropylene its quick-drying and wash-and-wear properties and its outstanding dimensional stability. The same property, however, results in poor dyeability of the fibre and makes pure or high percentage polypropylene fabrics unsuitable for undergarments. Polypropylene fibre can be blended with cotton or viscose rayon to improve the strength and dimensional stability of the fabric;

(d) Abrasion resistance: The flex abrasion resistance of polypropylene is as high as that of nylon; when rubbed on a flat plane it loses its strength at heavy loads, but shows almost no change at low loads. This property makes polypropylene an ideal material for carpets.

(e) Light stability: The resistance of polypropylene to the degrading action of ultraviolet rays is not good, but it can be improved by the use of special additives during the manufacture.

Processing of man-made fibres

As a general rule, man-made fibres, especially filament yarns, need far more skilled and careful handling than yarns spun from natural fibres. Broken filaments, non-uniform stretching, mistakes in mixing different deniers or twists, and similar mishaps lead to expensive waste and loss of capacity as the faults can be detected only after dyeing and finishing.

With natural fibres different lots vary in colour and uptake of dyestuffs, and therefore the mills make every effort to blend them into big uniform lots before use. Man-made fibre producers also make every effort to sell a uniform product, but in spite of this the problem has not been solved. Differences in raw materials, and difficulties in fully controlling production conditions lead to variation in final fibre properties such as the shade obtained during the dyeing process. It is therefore recommended that as producers cannot guarantee absolute uniformity, different lots from such producers must be processed separately. Frequent errors also arise when workers open bales or cases without noticing the producers' warnings against mixed processing. The purchasing department of a mill should consider such factors, not only cheap prices, if they want the most economical production. Bales or cases of man-made fibres should be stored in proper warehouses, as far as possible to avoid excess heat and humidity. Water leakage into warehouses affects the finish on the fibre, and even after redrying the same performance during processing cannot be expected. The physical characteristics of viscose fibres are especially affected by high humidity in the processing department, while synthetic fibres in dry condition are highly charged with static electricity. It is therefore recommended that the man-made fibres processing department be properly air-conditioned to maintain the correct humidity.

During the simultaneous processing of natural fibres and man-made fibres in the same mill without blending, precautions have to be taken to ensure that there is no mixing of wastes, which are valuable materials. Machinery has to be well maintained and kept clean, otherwise it may stain the filaments; or changes in the friction between moving parts may lead to tension differences. Since the molecular density influences the dye uptake, a stretched section will take up less dye. Overstretched filaments will regain their original length after wet processing or heat treatment, resulting in bars or streaks in the fabric. With proper attention to these factors, production will be more efficient, with less end-breaks.

Spinning of staple fibres

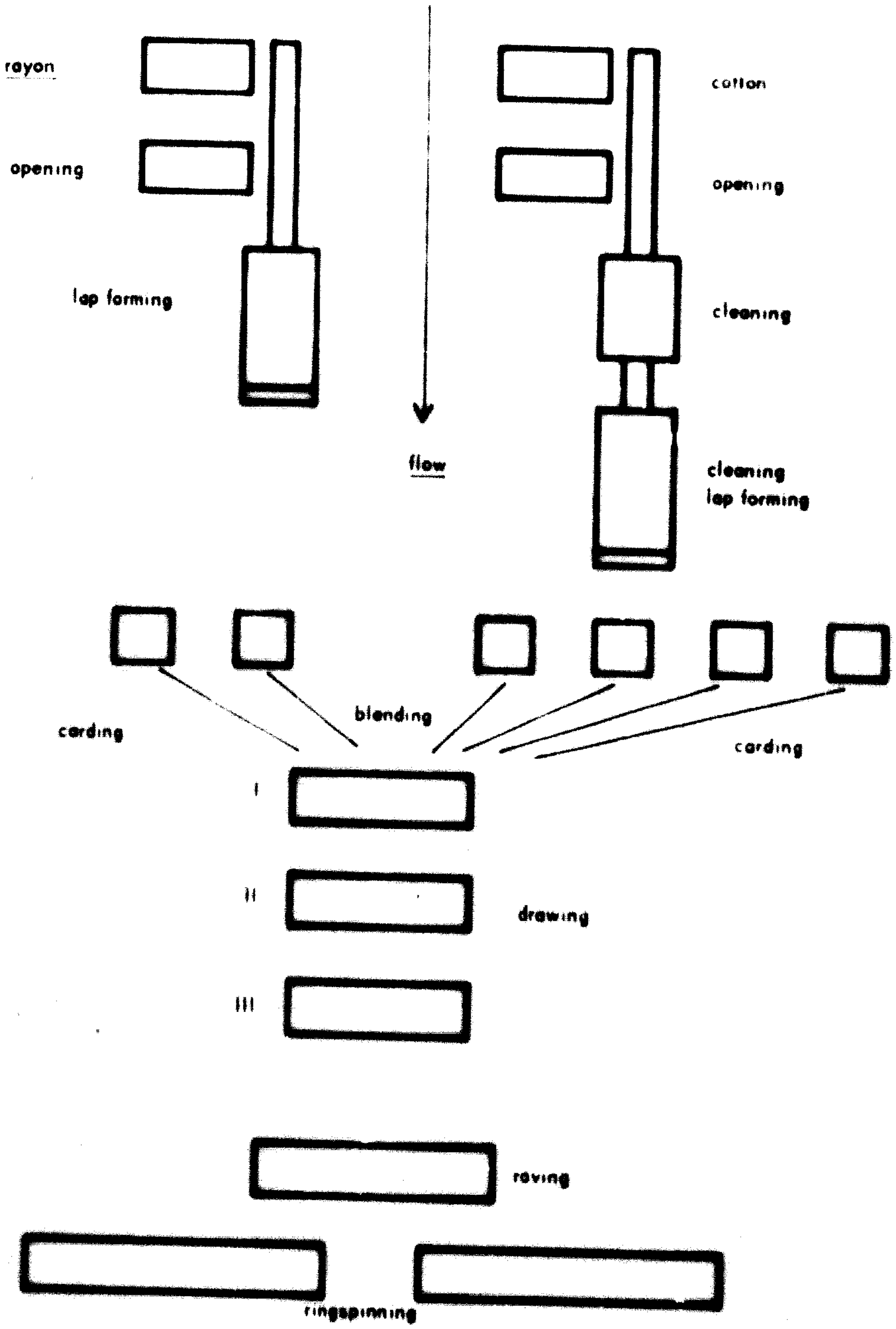
Most of the man-made staple fibres are spun by the "cotton spinning" and "worsted spinning" systems, sometimes even with wool or jute spinning machinery. In worsted spinning, the use of blends of synthetic staple fibre (for example, polyester) with wool is common, whereas viscose staple or pure synthetic staple is processed on the cotton system. Combing of man-made fibres is required only in special cases or if blends with dye tops are difficult to spin. All machinery built since the Second World War can generally be used for processing man-made fibres. It may be necessary to change the wiring of cards, cylinders on frames, needle bars in intersecting and gill boxes, but the basic machines can be used if they have been maintained in good condition. Processing details are provided by machinery makers and fibre producers.

Spinning by the cotton system

As far as possible big fibre lots should be blended to avoid differences in dyeing. Hard beating on openers or cleaners of the Crighton type should be avoided. Simple assemblies with needle conveyors (hopper feeder) and a beater of the "Kirschner" type are quite adequate for opening and formation of laps. Metallic or semi-flexible wiring of cards is preferable, especially for processing synthetics, like polyester or polyamide. Licker-in speeds should not be too high, and bulk development leads to the use of higher strand counts. Modern high-speed cards have been used to process such fibres successfully. Two stages on drawframes and one on a high-draft speed frame are usually sufficient to prepare roving for ringspinning. Roving twist has to be much lower than with cotton, because the longer and smoother fibres develop more adhesion. This leads automatically to higher production on the speed frame. Breaks and development of dust are higher with cotton, and for good drafting the pressure on the top rollers should not be too low. Spring-loaded devices are to be recommended. The blending of the fabrics can be accomplished in different ways, one of them being blending at the draw-frame. In this case, each component is prepared in proportion and a blend, for example, of 33 per cent rayon and 67 per cent cotton, is made by delivering two strands of rayon staple and four strands of cotton to the mixing drawframe, followed by other drawframes for good fibre distribution. More intimate mixing can be achieved by simultaneously carding both components, preceded by use of mixing bins, the sandwich method, blender feeding to a conveyor belt, special mixing machines or by combination of different laps on a second beater unit. In all these cases precautions have to be taken, such as correct weight proportions and prevention of the tendency to demix. High efficiency can be obtained in ring-spinning with end-breaks of about 30/1000 spindle hours. The twist has to be low with man-made fibres, about 135 per metre (3.5 turns per inch). High-draft systems are useful, but draft higher than 20 with synthetic staple and 30 with rayon, should not be used without control on yarn uniformity. A mill interested in a quality product must use an electronic yarn evenness-tester, which can reveal much information at all steps during production. Figure 11 shows a schematic flow diagram of a cotton/rayon spinning process.

Figure II

Flow of cotton rayon blend spinning process a/



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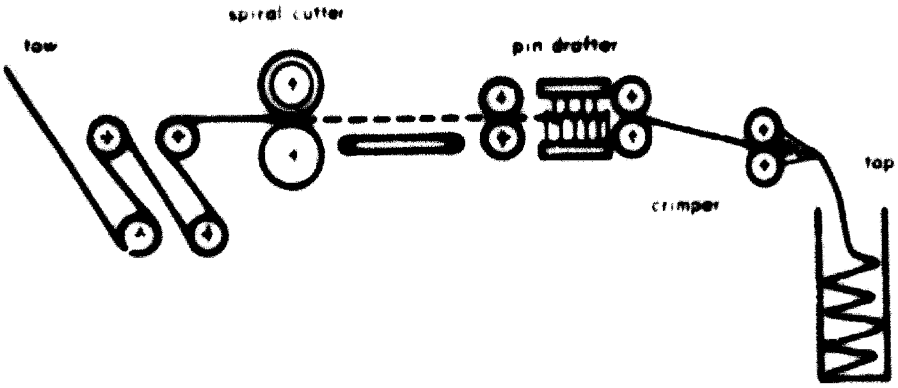
a/ E/CN.11/I & NR/MFI/L.11

Spinning by the worsted system

In principle it is possible to process man-made fibres with all existing worsted systems, but it should be remembered that certain variations are necessary. Thus, for example the Nobel combing machine needs a different amount of finish for intimate working. Blending is normally done after the preparation of each component of a top. Fibre denier and staple length of the wool and man-made fibre components should be selected in proper relation to one another, to get a good fibre distribution in the yarn and uniform, easy drafting. In many countries where 55/45 polyester/wool blends are in wide use, the technique of "converters" has become common in worsted mills. Figure III shows the principle of such a device.

Figure III

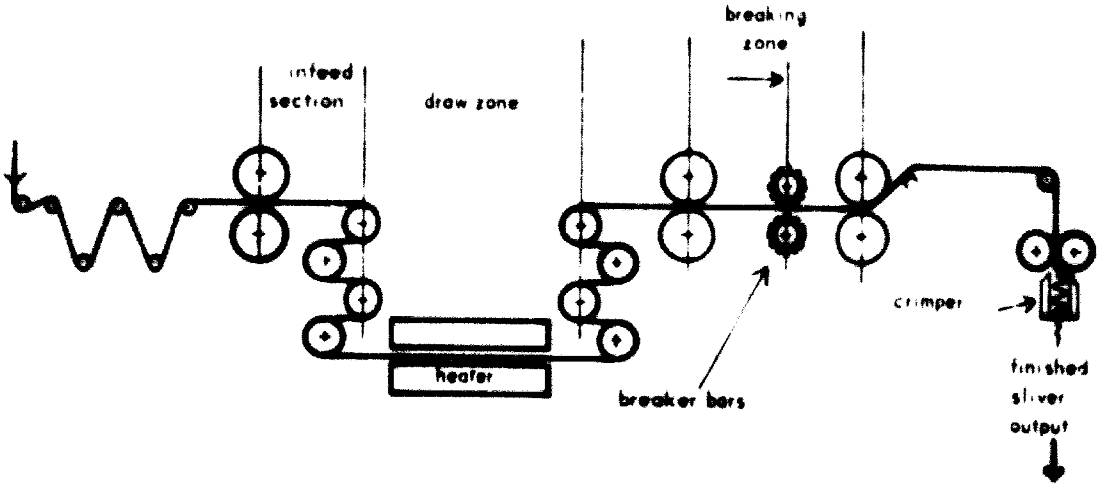
Tow-to-top converter (schematic diagram) a/



The fibre producer sells crimped tow, and the machine directly transforms it into a draftable strand without the usual intermediate step of total disorientation of fibres. A cutting or more exactly a pressure separation device of spiral type, forms the fibres which are directly drafted in an intersecting head. The fibres are made of irregular length by a special device and this leads to easier separation of single fibres during drafting later on. Other systems obtain a similar effect by over-stretching a continuous cable. The Turbostapler, which has given good results with acrylic tows, is an example of such a method (Figure IV).

Figure IV

Turbo-stapler converter (schematic diagram) a/



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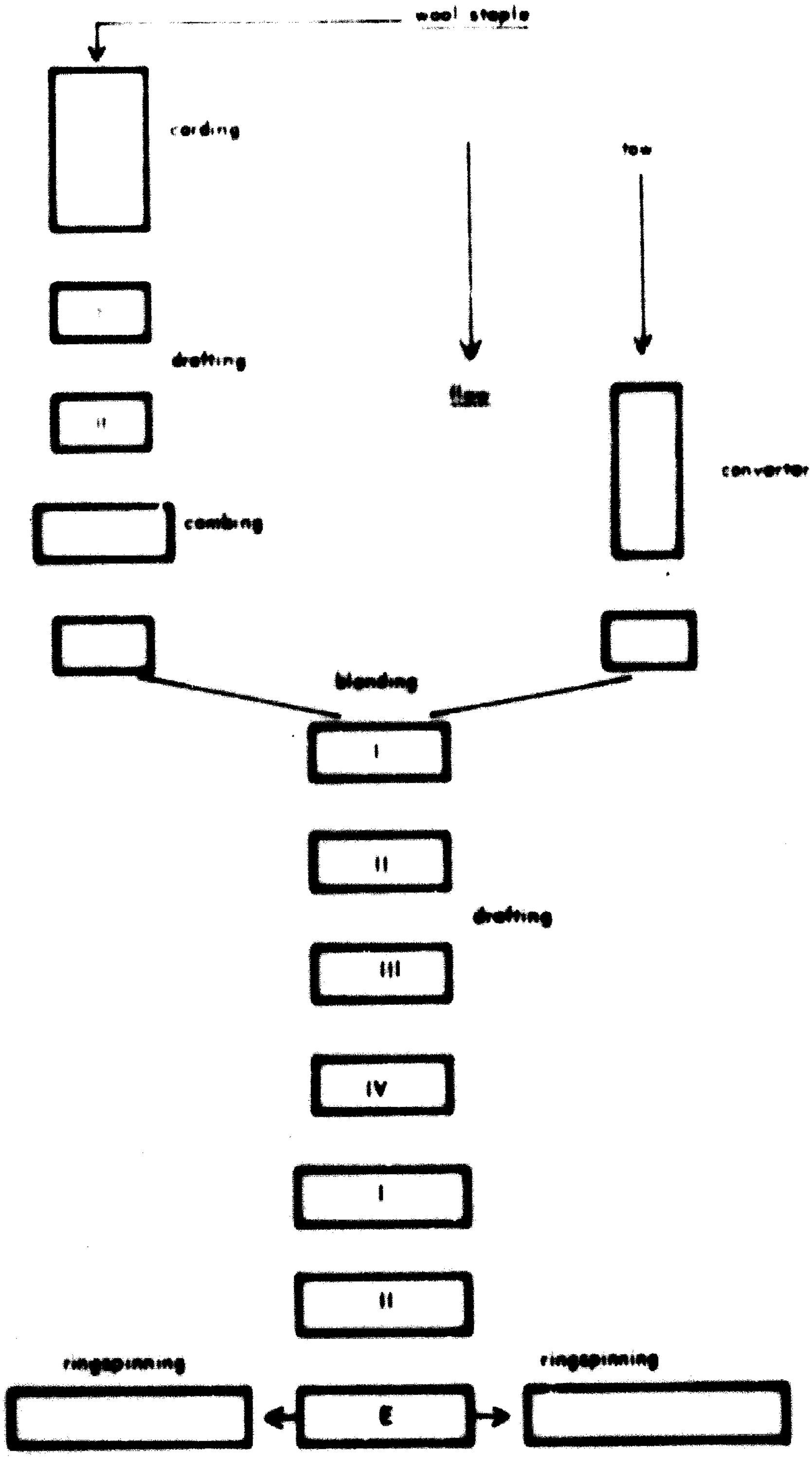
The high capacity of such devices, which can process about 50 kg./hour, results in high savings by reducing worsted roller cards, intersecting and wool-combing machines. After the intersecting treatment, the strands can be mixed with wool top and processed as usual on a set of pin-drafters. There are varying opinions about the relative advantages of using an ordinary gill box and a roving frame in preparation for ringspinning. Figure V shows the flow chart of a modern worsted spinning process for blends. The use of synthetic fibres with higher tension in ringspinning, which means higher spindle speed and higher production, together with the use of rings with a bigger diameter, accommodating larger bobbins, has the effect of saving work on doffing. Special bulk effects can be produced, for example, by mixing overstretched strands with heat-relaxed strands from a Turbo-stapler. In later processing, the non-relaxed component of the yarn shrinks under the influence of heat, and the already relaxed fibres are forced to form waves, leading to bulk yarn. Development of such innovations continues, and the latest information can be had only from makers of machinery and fibre producers.

Figure V

Flow of worsted spinning process that includes tow-to-top convertor [a]



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Twisting of yarns

All kinds of equipment can be used, including ring-twisters, up-twisters and "double-twist machines". Working with man-made fibres requires control of tension to prevent non-uniform stretch and control of high friction to prevent melting of synthetic fibres and avoiding end-breaks. Otherwise, the finished fabrics will show small dark dyed balls of molten polymer which will degrade the product severely. The particles of titanium dioxide in fibres cut grooves in yarn guides. The use of super hard ceramic parts is therefore recommended.

Slashing of spun yarns

Single spun yarns have to be slashed like cotton yarn to run better on the looms. Rayon staple can be treated in a similar way to cotton in air drying or drum drying units. Since viscose yarn is very sensitive to tension and is swollen by hot size solutions, tension should be avoided in the impregnation zone and overstretching should be prevented in the drying zone. The sizing of synthetic fibres requires the use of special recipes, as the usual sizing agents do not adhere to such fibres. Drying cans should have a cover of a natural which prevents adhesion, such as Teflone or Hostaflone.

Warping and winding of filament yarns

The rules already mentioned are even more necessary for filament yarns, especially when they have a low twist. Grooves, stain, deposits of finish or dust create tension differences, displacement of filaments into loops or filament breakage, which can cause neps during further processing. Bobbins in the warp creel must be well adjusted to the thread guides and tension devices must be clean and uniform. The use of photo-electric nep detectors is costly but is very effective in allowing a higher warping speed and avoids idle time due to stoppages in winding or knitting. Raw workers who have had no experience with fine silk-like filaments have to be intensively trained before they can work on quality production. The rules are the same for winding of filament yarn.

Weaving of man-made fibre yarns

As different sectors of the textile industry use looms of common design, cotton-type spun yarns are usually processed on high-speed cotton looms, worsted yarn on broad wool looms and filament yarn on silk looms with all the necessary refinements for fine fabrics. They can all be used for man-made yarns and blends provided they are maintained in good condition. Rough guides, rough eyes or reeds, etc., or any parts coming in contact with the yarn will cause damage to the delicate filaments and should therefore be avoided. Similarly, perforated tin rolls will cut holes into the fabrics and tension rollers may cause damage also. Fabrics made from synthetic yarns require heat-setting and there is a change in width in this process. The number of ends and picks on the loom has therefore to be chosen correctly for the desired cloth density and dimensions of the finished products.

Knitting

Man-made fibres develop less dust than cotton and the knitting efficiency is invariably high. Since there are a variety of types and principles in knitting (such as seamless hosiery, cotton hosiery, circular knitting, flat knitting, warp and Raschel knitting) only selected highlights are noted in this paper.

The production of fine filament yarn has led to the introduction of fine gauge machines which are only able to work with such yarns; for example, ladies' hosiery is produced almost continuously to a nearly final product. The same applies to fine-gauge multi-bar warp knitting machines. In this case, the tension of the yarn must be low and must be controlled, about .15 grams per denier. Only a specialist in knitting is able to determine the exact nature of machinery needed for an expanding industry or for adaptation of an existing mill for made fibres. The use of synthetic fibres frequently necessitates heat-setting, for which special machinery must be employed.

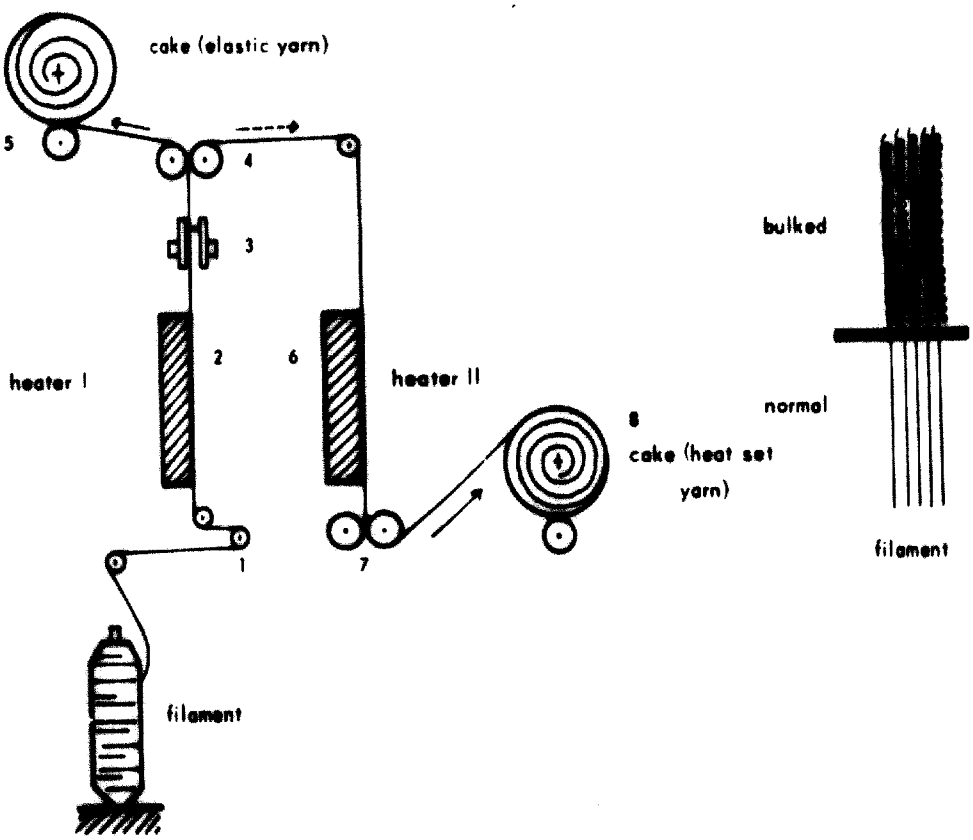
Warp-knitted shirts from nylon, ladies' nylon hosiery, texturized nylon socks, acrylic knitted wear, texturized polyester, women's outerwear, and artificial fur are common products of the man-made fibre knitting industry.

Texturizing filament yarns

The desire to impart bulk and elasticity to filament yarns with straight and parallel capillaries has led to a number of different developments in the texturizing of filament yarns. Two examples are quoted below. The modern "false-twist process" (see figure VI) developed from old ideas and from the famous Swiss "Heberlein" patent is briefly described here.

Figure VI

Texturizing: false twist method (schematic diagram) a/



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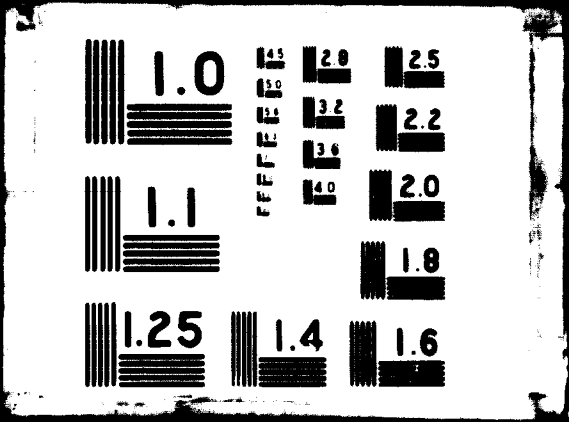


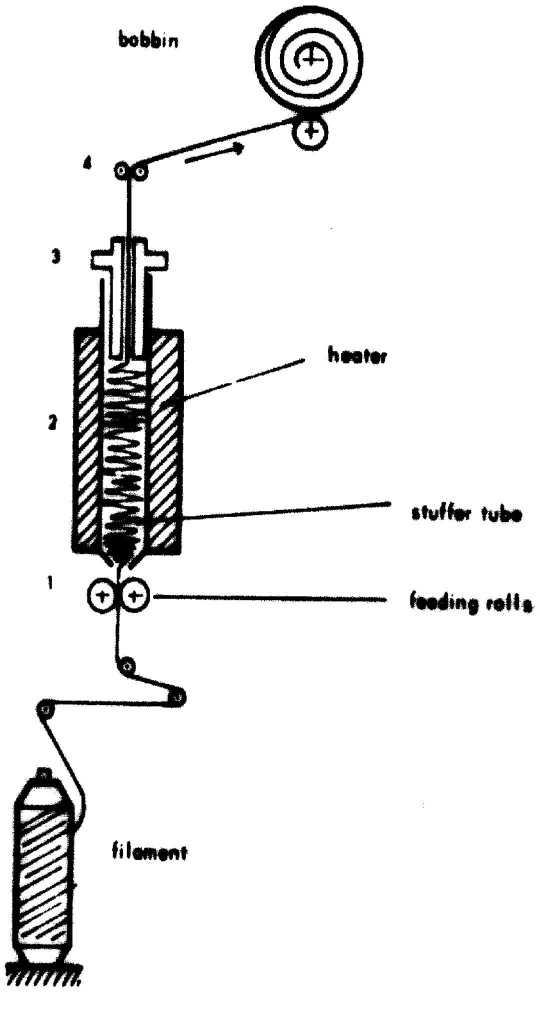
When a filament yarn is twisted up to 3,000 turns per metre, the capillaries on the outside are stretched and lie in spiral form. After heating and reversed twisting to "zero twist" the filaments retain their spiral form, which is the equilibrium state after heat setting. This process may be undertaken in three "classic" processing steps. The false-twist machine can perform this procedure continuously on a device which consists principally of an inlet (1), a heater (2), a small rotating spindle (that is, a hollow tube with a horizontal bar of sapphire) (3), a controlled outlet device (4), and a winding machine (5). In this process the running yarn actually touches the heater and the spindle continuously imparts a twist, while the yarn as it leaves the spindle is again untwisted. Although the wound yarn at (5) does not appear to have been changed very much, it develops a high crimp of about 50 per cent when heated or boiled at a later stage. Such yarns have a very high elasticity and are the secret of the "one-size-for-all" nylon sock. If bulk but no elasticity is required, a second step is added. Between stages (4) and (7) the yarn touches a second heater (6) which would normally impart high shrinkage properties, but the very small difference in the speeds of (4) and (7) does not permit this. Hence the spiral leads to a bulky separation of the capillaries and this is the final stage in internal balance. This yarn is called "set yarn" and is widely used for ladies' outerwear such as sweaters. In woven fabrics such yarn gives a superior feel and better covering qualities.

To obtain high productivity, a spindle speed of 300,000 r.p.m. has been developed by using the drive of a small steel spindle coupled by magnetic force to larger driving rollers. In this way bearing friction is eliminated. A number of firms are building such machines, although the details differ in certain aspects.

Another patented process uses the stuffer box principle (figure VII).

Figure VII

The Banlon process (schematic diagram)a/



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In this process the yarn is fed continuously by two rollers (1) to a small heated tube (2) but prevented from leaving the tube by a piston (3). This leads to the regular formation of zig-zag folder layers, which are set by heat. The yarn is drawn from the chamber by rollers (4) and wound; later it develops a crimp like that of medium "set yarn".

In practice, such yarns are mainly knitted before the crimp is developed and it requires expert knowledge to choose a loose-knitting construction, which after shrinkage in boiling water or steam develops the required dimensions.

The temperature of the heaters in all types of texturizing machines has to be controlled within a narrow limit of about ± 1.5°C to avoid differential dyeing uptake at later stages.

Dyeing and finishing

The difference in the chemical activity, molecular density and structure of the different types of man-made fibres has led to the introduction to new classes of dyestuffs and auxiliary substances. Furthermore new dyeing processes and equipment have had to be developed. This whole aspect is subject to continuing development and here remarks are confined only to the principles and machinery required for treating man-made fibres in yarn and fabric form.

The dyeing of rayon is similar to that of cotton, but the sensitivity of the viscose fibres to alkalies and the problem of fibres swelling has to be taken into account.

The behaviour of synthetic fibres varies with type. The chemical nature of polyamide fibres makes them easily dyed. Acrylic fibres vary according to the copolymer used and require different classes of dyestuffs. Polyester fibres are generally dyed with dispersion dyes; to obtain the desired effect within a reasonable time three different methods are used: (a) dyeing under pressure in closed apparatus to obtain dyeing temperatures of about 125°C.; (b) adding "carrier" substances to the dyebath which have a swelling effect on the fibres and allow the structure to be opened for easier access by the dyestuff molecules; and (c) the Thermosol process, whereby the fabric is impregnated with dyestuff and heated to high temperatures in a drying unit. The dyestuff migrates to the interior of the filaments within seconds. In the dyeing of polyester fibres, significant differences arise from the irregular density and crystallinity. While certain dyestuffs give excellent wash and light fastness, they may also reveal small differences in the filament yarn arising from tension or temperature variations. Others of the same class provide full uniformity throughout the fabric. When dyeing yarn on bobbins attention has to be paid to the shrinkage rate of the yarn, since the liquid flow may be inhibited if the bobbins are wound too hard. The affinity of polypropylene for the common dyestuffs in a waterbath is lower than that of other fibres and strenuous efforts are being made to include compounds which will increase dyeability, essential for apparel end-use.

The development of H-T (high-temperature) dyeing apparatus from fibre-stage to fibre-stage is a result of synthetic fibre processing. A further process required is "heat-setting", which may be undertaken in different states but is used prior to fabric dyeing. Quick heating to near the melting point relaxes internal tensions and the fabric takes on a flat, permanent shape which nevertheless includes the waves formed by crossing or mesh-forming threads. In this way, during the subsequent dyeing and washing processes, the fabric remains stable and does not become wrinkled. To obtain high quality products, effective heat-setting units are required. Tenter frames are commonly used to give an even temperature across the fabric and also precise temperature control, but these are expensive (normal drying units are constructed to take off humidity and cannot be run at such a high temperature). Nylon hosiery requires shaping on electrically heated forms. The printing of all types of man-made fibre fabrics is possible with heat-setting and dyestuff migration. A recent development is the application of colour pastes to fabrics which exhibit direct affinity for them.

Finishing to obtain crease resistance, softness, stiffness or dimensional stability requires to be modified for each type of man-made fibre, especially viscose and acetate. In the case of polynosic fibres, the fibre producer has reduce the alkali sensitivity of the cellulose fibre to such a degree that it can be mercerized together with cotton to improve the appearance of the fabric. One of the most widely discussed new developments in the finishing of man-made fibres is the "permanent press" or "durable press" process for ready-made garments. This process stems from "wash-and-wear" finishing of cotton with resins, which at higher concentrations lower the tenacity and abrasion-resistance of the fabric. None the less, a 50 per cent blend of polyester fibre is a satisfactory compensation and fabrics can now be prepared with the compound, tailored and then fixed to a permanent shape by pressing at high temperature or at low temperature followed by oven curing to obtain the cross-linking effect in the cotton simultaneous with a heat setting effect in the polyester component. This is clearly preferable to the process in which the fabric is heat-set in a flat stage and then processed to acquire durable non-iron qualities. The first success with trousers and shirts was revolutionary, although there are still a number of problems to be overcome (for example, colouring, storage and handling of resin-treated fabric before curing or tumbler-drying is only common in the United States). This development demonstrates the necessity for very close and local contact between finisher and garment-maker because long storage and transport is not possible. Another development which is leading to permanent changes in textiles is the "stretch" concept giving greater comfort in clothing. This has been furnished in various ways, including special finishing of the fabric, the use of textured yarns and also the use of elastomerics. Each of these is having a major effect on the finishing industry.

Special processes

1. Non-wovens

For man-made fibres new processes have been developed to produce non-woven fabrics. They consist of layers of carding web of conventional or special web types, which are bonded by various means. In the "needle-felt" process, a long row of hook needles fixed on a moving bar quickly stitches through a continuous transported fleece, thus "sewing" together the layers substituting a bundle of fibres for a thread.

Another method is to blend fibres with a small quantity of thermo-elastic fibres which, when melting in the subsequent heating process, bind all the fibres together. Impregnation with a liquid can also be used; this flows to the contact points of the fibres and is then hardened by heating or chemical reaction. Such fabrics are already being used for interlacing and as a base for coated fabrics. Further uses are under examination.

There are several common factors involved in these manufacturing systems: they are economical and require minimum labour input; they do involve a capital investment which, although relatively high, is much lower than that for conventional textile manufacturing methods.

The future of this young growing industry offers considerable scope, although the development has been much slower than generally anticipated. However, it has its potential and its future depends on the improvement of existing fabrics and the development of new ones through research. The biggest advantage to industry is that a variety of products can be manufactured very economically.

2. Laminated fabrics

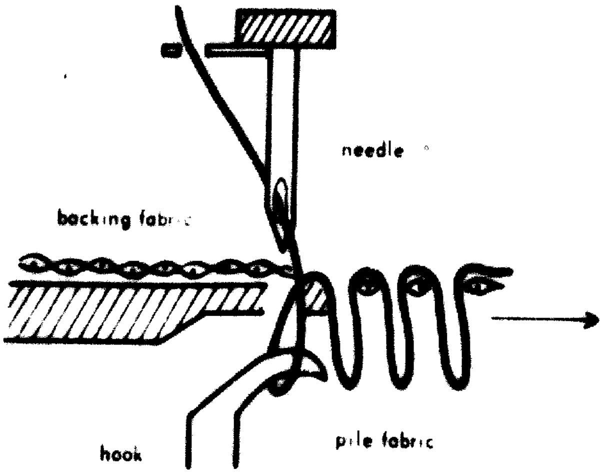
New textile fabrics based on lamination with polyurethane foam are under development. Methods such as binding by melting or sticking can be used to manufacture products which provide a light-weight insulating layer (foam) with a stabilizing external textile such as knitted acrylic jersey. Air permeability can be achieved by appropriate methods.

3. Tufting

The increasing use of carpets by low income earners has led to rapid progress in "tufting". The technique uses a light basic fabric on which a long row of needles with a large eye sews parallel rows of texturized nylon, acrylic or polypropylene filaments (see figure VIII). Each stitch is held by

Figure VIII

Tufting process a/



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a device to form a loop. If these are uncut, the result is a loop pile, but they can also be cut to provide a cut pile surface, or patterned by automatic alternation of these two processes. The productivity of a tufting machine is much higher than that of a carpet-weaving loom. A rubber foam backing on the reverse side holds the filaments and at the same time gives better adhesion to the floor and a second smooth layer.

4. Sewing-knitting technology

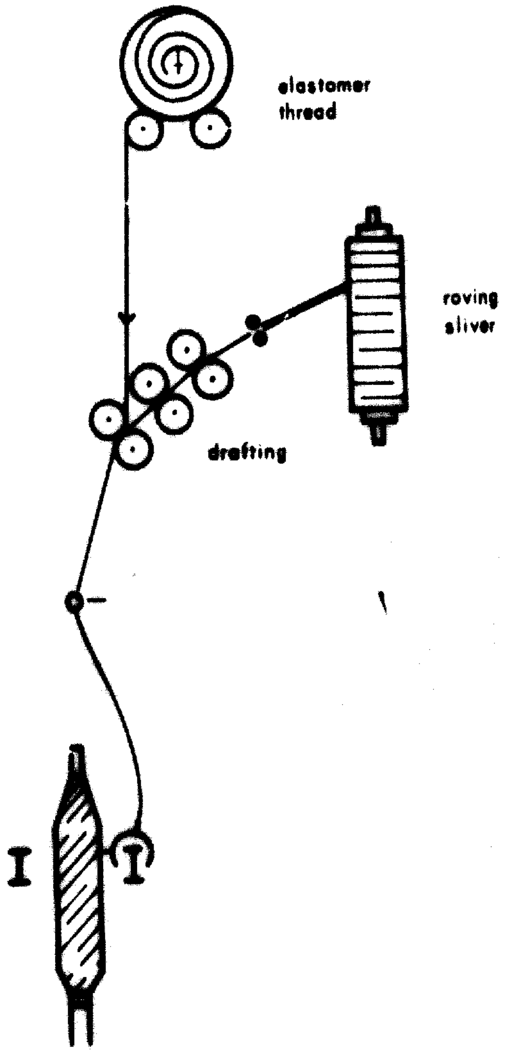
In East Germany and Czechoslovakia a new type of fabric-making machine has been developed using a warp system onto which a parallel system of about 20 or more threads is laid crosswise. A row of needles with fine threads binds the two systems into a stable fabric. The appearance is not yet very impressive but the production rate is very high and a United States firm has taken out licences for further development.

5. Corespinning

Stretch fabrics can be made by corespinning, which uses a continuous elastomeric filament delivered under controlled tension to a normal ring-spinning/drafting system. The filament passes only the end rollers and the spun fibres form a covering layer around the elastomeric core (see figure IX).

Figure IX

Corespinning a/



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The result is a yarn with the appearance and performance of fibres such as polyester/wool but with the elastic performance of an elastomer. Further development is required on certain aspects such as tension, percentage, dyeing, weaving construction and finish conditions in order that the fabric will seem tensionless in its normal state but become elastic when stretched. Naturally the garment maker needs to know how to handle such a fabric.

These few examples illustrate that the textile industry is developing in new directions with the support of man-made fibres and that continuous observation of the trends is necessary to form a policy.

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Chapter IV. TEXTILE PROCESSES AND PRODUCTS

Yarn production: Cotton system spinning

Cotton spinning has made remarkable advances since the Second World War. Several steps denote the main stages of progress, starting in the early fifties with the introduction of high-draft, large-package roving frames, high-draft large-package high-speed spinning frames, large receptacles, and pneumatic suction devices.

The next step was the introduction of higher production cards, high-speed drawing frames and more modern combing room equipment. The spinning room was equipped with pneumatic cleaning devices and the larger packages produced made material handling easier and presented economies in the subsequent processes. These developments were followed by super-draft spinning frames, first constructed in Japan, which promoted the spinning of drawframes slivers directly on spinning frames. This system was introduced in several mills especially for finer yarn counts.

Finally, a further step was the partial and progressive automation of the spinning. Practically all manufacturers have developed some methods which reduce material handling. Some of the machine builders have introduced a spinning system which feeds the cards automatically and the carded slivers are manually transported to the drawing room.

Ohher manufacturers continue with the automatic processes to the first or second drawing step from where the sliver is transported either to the roving frame or directly to a super-draft spinning frame. Some firms have extended this operation to doffing the bobbins automatically and positioning them directly on the automatic winders. There they are automatically wound and only the finished packages have to be transported manually.

All these developments represent enormous steps forward. Progress made in the past fifteen years in cotton spinning and allied processes is accepted as being greater than that of the previous fifty years.

The question is now how best to apply the most modern technologies to the needs of the developing countries. It will be important to decide what influence they have on capital investment; on versatility of production; and on labour employed. Unquestionably, the automatic system is very expensive, requiring careful maintenance and highly skilled operators. Its versatility is limited in a certain respect, as it would not produce economically the smaller lots often needed in developing countries for certain types of fabrics. Also the labour employed drops to a minimum. The old technique needed a comparatively high amount of labour, which varied in Latin Americen countries from four to eleven persons per thousand spindles. But some European mills now employ fewer than 1 1/2 operators per thousand spindles.

The new automated mill will require between 1/2 and 1 person per thousand spindles, and what was said in other chapters must be repeated: great consideration should be given to abundant factors against scarce factors in each country. This does not mean, naturally, that in establishing new plents modern techniques should not be considered, especially when they result in the manufacture of better quality, more uniform goods at cheaper prices that will benefit large segments of the consumer public.

New trends

There is, however, a new trend discernible in cotton spinning caused by the advent of automation in spinning, automatic doffing and automatic winding, which is a slight reversal from previous developments: smaller gauge frames are being built, spinning bobbins produced are slightly smaller and spindle speeds are increasing.

Proper operating conditions

An important point is the proper housing for spinning mills. It is imperative to have adequate buildings, a functional layout and proper temperatures and humidities in the spinning rooms. Without these, no spinning mill can operate efficiently.

Cleaning operations, suction cleaning for ends down, overhead cleaning, travelling cleaners and all types of cleaning are of great importance and contribute to the efficient operation of a spinning mill.

Progress of cotton spinning technology

Table 3 shows the progress of cotton spinning technology in the decades following the Second World War, progressive improvements that took place in 1950, 1960, 1963 and some of the partially automated spinning systems.

Table 3

Development of spinning technologies

Type of process	Pre-World War II	Technology mid 1950	Technology 1960	Technology 1963	(a) Automatic Rieter	(b) Automatic CAS	(c) Systemized Whitin	(d) NAS Nitobo
Opener-picker	2-process unit	One-process picker	One-process picker with automatic doffing Pneumatic lap control	Mechanical blending	Carousel-opener Automatic mixer	Opening Mixing	Multi-bale pluckers	Pluckers
Cards	Low production Small cans Flexible wire Manual stripping	Higher production Larger cans Metallic clothing Pneumatic stripping	Rigid flats with slower flat speed	High production Crush rollers Large cans Vacuum cleaning system	Direct card feeding	Direct card feeding	Aerodynamic card	Direct feed of cards
					Automatic transfer	Automatic transfer	Manual transport to drawframe	Automatic delivery
Drawing frames	Low drafts Low speeds Several passages	High draft Larger cans Higher speeds 2 passages	Improved drafting system Higher speeds Suction waste device Large cans	Very high speeds 1-2 head machines Very large cans Sliver evening device Automatic change of cans	Delivery directly to servo-control Drawframe with automatic can change	Ribbon lapper Drawing frame with auto-leveller		First draw-frame with autoleveller Second draw-frame
Roving frames	Low drafts Small bobbins Low speeds 2-3 passages	Higher drafts Higher speeds Larger bobbins Single operation	High drafts High speeds Large bobbins Suction cleaner Stop-motion	Very large bobbins Fixed flyer	Manual transfer to roving	No roving Manual transfer to spinning	Manual transfer to roving	No roving frame
Ring frame	Low draft Small package Small rings Low speeds Manual doffing	High draft Large package Pneumatic suction Higher speeds Travelling cleaners	Higher speeds Automatic doffer	Very high speeds Nylon travellers Automatic doffing improved	Manual transfer to ring frame	Superdraft spinning Automatic doffer	Manual transfer to ring-spinning Automatic doffer	Manual transfer to ring-spinning Automatic doffer
Cone-winders	Non-automatic	Non-automatic	Semi-automatic	Improved semi-automatic	Manual transfer to automatic coner	Direct transfer to automatic coner	Direct transfer to automatic coner	No coner

The main short automated spinning processes*

Practically all the larger cotton spinning equipment builders have developed or are developing some kind of automated or partially automated cotton spinning system. In the mid sixties, the processes being used by the various textile firms were, in brief outline:

Ingolstadt system: The opening and mixing are still conventional, up to and including the opener range. There is no scutcher; instead, the flock is fed directly from high-performance cards through filling trunks and a pneumatic-mechanical circular duct. There is a parallel arrangement of four high-performance cards with a channel sliver guide, and slivers fed into an autoleveller. The slivers are coiled into cans 32 inches in diameter, and they are transported manually to a high-performance drawframe. The second passage has automatic loading of transport trucks which transport them to the slubber, after which they are transported manually to the ringspinning machine which is equipped with an autodoffer.

Rieter system: In the carousel opener, six bales are broken down to flock by means of rotating plucking elements. Two to four of these openers work in conjunction with a drawbox, one per opener, and these are situated over a collecting conveyor belt. This conveys the stock to a single cylinder cleaner, and further to an automatic mixing unit. Then follows again a single cylinder cleaner, and with less clean cotton, a horizontal opener with a hopper-feeder. The connecting flock-feeder with pneumatic conduit and reserve chutes (that is, the Aerofeed system) leads to the high-performance cards. There follows automatic conveyance of the card slivers (without cans) to the servo-control drawframe, equipped with an automatic can-changing arrangement. Next, the drawn sliver is transported to the roving frames and manually transported to the ringspinning machines and the cops are manually doffed.

Saco-Lowell system: Each bale-plucker works from five bales with four bale-pluckers feeding a common hopper-feeder. A circular pneumatic duct conveys the flocks to filling trunks, serving a group of eight cards arranged parallel. Card ribbons are superimposed to form a sandwich, drafted in a high-speed drawframe and coiled into cans, 24 inches and 40 inches in diameter. Full cans are changed automatically. Manual transport follows to the Versamatic autoleveller, then to the Rovematic slubber, and to the Spinomatic ringspinner. The cops are doffed by an autodoffer, after which they are transported by conveyor belts to a circular magazine where they are automatically tied on and wound into cheeses, without manual intervention.

Platt system: Six to eight bales are fed to automatically-operated plucking machines, several of which may be worked parallel. Flocks are passed into an air current and led to an airflow cleaner. Further cleaning machines may follow if needed. A hopper-feeder supplies a circular duct, from which filling trunks, with a shaker device, serve the cards. The slivers from four high-performance cards are led over a sliver table to the high-performance drawframe with one delivery and an automatic can change. The bulk of the slivers is monitored before it is fed into the drawframe and variations are corrected by an appropriate adjustment of the card speed. If a sliver is missing, the drawframe draft is changed. The cans are transported manually to the slubber, where two slivers are fed to each spinning unit. Positively guided rollers control the sliver infeed. There is no second drawframe passage. Large slubber packages are taken manually to the ringspinner, which operates with an autodoffer.

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* This chapter is based on "Spinning, Prominent Shortened and Automated Spinning Processes", International Textile Bulletin, April 1964.

SACM system: In the Flocomat cyclical blender, twenty to thirty bales are opened in flocks over two, four, six or eight plucking machines. A pneumatic conveying system takes the open flocks, cleaned by horizontal beaters, to mixing hopper-feeders with weighing arrangements, one for each plucking unit, coupled with a high-performance card. Manual transport follows in cans 20 inches in diameter for coiled slivers to two high-performance drawframe passages; then to a ringspinner with manual doffing.

Marzoli system: The opening and blending methods are still conventional up to and including the opener range, but without a lapping machine. There is a pneumatic transfer duct to the starting machine. The distribution lap is fed by suction: high-performance cards, up to ten in number, working parallel, can be supplied by a card feeder. The excess stock is returned periodically and automatically into the distribution duct, stopping the blowroom machinery at the same time. The lap weight is automatically regulated at the card infeed. The maximum output of a Transautomat installation, with a blowroom range, and twenty cards of type C arranged side by side in two groups of ten units each, amounts to 450 kilograms per hour.

Whitin system: The bales are opened on multi-bale-pluckers of which several can be worked parallel. They are cleaned in Axi-Flo and in further openers, if need be. The raw material is then led into a circular duct with filling trunks for each card. Up to twelve cards can be formed into a group. Work is in progress to develop an automatic can-changer for the card. The cans are transported manually to the drawframes, fed at the second passage and transported to the slubber where they are doffed still manually. The packages are deposited in section creels for feeding in bulk to the ring-spinner on the Audomac system by which cop-doffing, tube-creeling and space-cleaning are united in one automatic process. The Audomac system also takes cops to the winding machines and brings back empty tubes. The full cones are taken manually from the winders.

Toyoda system: The methods of opening and mixing are conventional, up to and including the opener range. There are no scutchers; instead the flock is fed directly to a coupled group of three high-performance cards. Three card webs are combined into wide slivers and passed to the first auto-drawframe which is equipped with an automatic can-changer. Then eight sliver strands are delivered together to the second auto-drawframe, equipped with an autoleveller. The full cans are loaded automatically on a can-carrier; they are then **manually** transported to a high-performance slubber with semi-automatic doffing, and thence to the ringspinner which operates with an autodoffer. Cops are doffed automatically in the circular magazine of a winder and tied on automatically, and cheeses are produced without manual intervention.

Cas system: The opening and mixing are conventional up to and including the opener. There is no lapping-machine; instead, the cards are fed by means of a circular pneumatic duct and filling-trunks directly above the multi-cards, with six to eight cards forming one group. The card slivers are passed from the sliver-conveyor through the sliver-reversing drawframe with an automatic can-changer, thereby reversing the direction of sliver travel. Then ten sliver strands together are delivered continuously to the super-auto-drawframe (with an autoleveller). This drawframe is also equipped with an automatic can-changer. The cans are carried manually to a sliver-to-yarn ringspinning frame, operating with an automatic doffer. The doffed cops are fed automatically and continuously by an auto-cop-feeder for rewinding.

Das system: The cotton, which is opened and cleaned through a Model D bale-plucker, a Model D blender, a superior cleaner, a Model [illegible] opener and an injection feeder, is fed through the pneumatic conveyor duct into a Model D card-feeder, and then conveyed into a cotton web-former on each card. Eight cards are arranged parallel to form a group through a branch duct. Webs are combined into wide slivers, led off in sandwich form in a sliver channel to the drawframe (equipped with an autoleveller) and placed into cans with a can-changer. Then the cans are removed by hand to the roving frame, with an autodoffer. This frame is the high-speed Model [illegible] (1200-1400 r.p.m.) with large packages (20 inches by 5 1/2 to 6 1/2 inches). The roving packages are automatically transferred to the ringspinning frames which operate with an autodoffer. Then the cops are automatically transferred to automatic winders, where the cheeses are produced without manual operation.

Nas system: The bales are opened on pluckers, delivered to the hopper-feeder, an inclined cleaner, and a second hopper-feeder and opener. The raw material is collected by means of trunks and feeder units and further delivered through pneumatic ducts leading into branches with trunks for each card; six to eight cards form one group, and they have a pneumatic waste-collecting device. The card slivers are delivered over the sliver table to an autoleveller. Uniform feeding is effected by means of a card sliver accumulator on each card.

There is an automatic can change on the first drawframe, with cans set in a row. All feed cans are automatically changed in the second passage with pneumatic starting of new slivers and return of the empty cans to the first passage. The cans are then automatically ejected from the second passage into a can bin. Tubes for all spindles of the ringframes are brought up by the Audomac crane system. An Audomac also performs automatic doffing, creeling of tubes and transport of doffed cops for rewinding. The cops are transported to the bobbin loading station and fed automatically to the winders by a conveyor system.

A capital-intensive industry

The textile industry is gradually changing from a labour-intensive to a capital-intensive industry. United States experts have calculated that in the year 1900 a textile plant had to make an investment of about $1,300 per working post. Nowadays for ultra-modern automated mills, the expenditure may be as much as $30,000 to $40,000 per working post.

In the special study published by the Organization for Economic Co-operation and Development (OECD) under the title, Modern Cotton Industry: A Capital-Intensive Industry, a cost comparison is made between a new mill as recommended in the year 1963/64 and a mill built and installed in 1945. The figures prove that the cotton industry has developed into a capital-intensive industry requiring in 1963/64 an investment in machinery, auxiliary equipment and buildings of $18,000 per working post. Details of the plant, the number of machines, the investment, the operating costs, the pay-back period and a number of other items of interest were tabulated and they are reproduced in table 4.

Table 4

Comparison between a modern mill (1963-1964) and a mill built and installed in 1945*

(Plant to produce 1,260,000 kg. per year of 34's Nm yarn)

A. Production

	Modern mill	1945 mill[a/]
Shifts operated	3	1
Hours per week[b/]	112.5 hrs.	42.5 hrs.
Production per hour	232 kg.	615 kg.
Production per week	26,122 kg.	26,122 kg.
Area	3,250 sq.m.	7,500 sq.m.

B. Numbers and types of machinery required

	Modern mill	1945 mill
Blowroom (scutchers)	2	6
Cards	16	112
Drawframes (deliveries)	8	240
Speed frames (spindles)	384	2,520
Ring frames (spindles)	9,504	36,000

C. Investment[c/]

	Modern mill	1945 mill
Machinery	$ 756,000 - 58%	
Ancillary equipment	$ 266,000 - 20%	
Building	$ 294,000 - 22%	
Total	$ 1,316,000 -100%	
Investment per spindle	$ 138.5	
Investment per employee	$ 18,300	

D. Labour

	Modern mill	1945 mill
Total employees	72	176
Total production workers[d/]	64	168
H.O.K.	9.2	27.4
Direct workers per 1,000 spindles per shift	1.72	3.4
Labour cost per week (excluding administration)	$ 2,400	$ 5,540
Labour cost per 100 kg.	$ 9.19	$ 21.21

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*Source: Modern Cotton Industry (A Capital-Intensive Industry). Report by the Special Committee for Textiles (OECD, 1965).

Table 4 (continued)

E. Annual operating costs

	Modern mill	1945 mill
Labour costs[e]		
Direct labour	$ 90,700	$ 271,600
Supervision and ancillary	$ 27,800	
Administration	$ 33,600	$ 33,600
	$ 152,100 - 37%	$ 305,200 - 78%
Power costs[f]	$ 56,000 - 14%	$ 44,800 - 11.5%
Other items[g]	$ 33,600 - 8%	$ 42,000 - 10.5%
Total operating costs	$ 241,700	$ 392,000
Thus the annual saving for the modern mill is:	$ 150,300	
Depreciation[h]		
Machinery (10%)	$ 75,600	
Ancillary equipment (10%)	$ 26,600	
Building (5%)	$ 14,700	
	$ 116,900 - 29%	
Interest on capital (6%)[i]	$ 47,600 - 12%	
Annual totals	$ 406,200 -100%	$ 392,000 - 100%

F. Pay-back period

	Modern mill	1945 mill
Annual saving for modern mill (see section E)	$ 150,300	
Simple pay-back period	8.8 years	
Pay-back period after interest and taxation	9.1 years	
Cost of 1964 mill (machinery only)	$ 756,000	
Simple pay-back period	5 years	
Pay-back period after interest and taxation	5.8 years	

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[a] The 1945 mill is assumed to have been equipped with new machinery of the latest design available in 1945.

[b] It is assumed that the 1945 mill will be run on a single-shift basis of 42.5 hours per week. The operation of such a mill on a two or three-shift basis without the installation of new machinery and re-deployment of labour would be uneconomic owing to the wage bonus which must be paid for shift working. The modern mill is shown operating on a three-shift basis (i.e., 3 x 37.5 = 11.5 hours).

[c] The figure shown for machinery is based on present-day CIF prices and includes erection. No account has been taken of import duties or local taxes. Ancillary equipment covers air conditioning, electrical equipment and auxiliary services.

Table 4 (continued)

d/ The figures for production workers for the 1945 mill are based on "Man-power Consumption in Some Lancashire Cotton Spinning Mills 1946 to 1956" published by the British Cotton Industry Research Association in June 1958 and show the level for the best 25 per cent of Lancashire mills at the time of the survey. The level shown is therefore probably better than the average of the European industry as a whole in 1945.
The H.O.K. figures shown for the modern plant have been compiled by the Technical Economy Department of TMM (Research) Limited, based on actual work studies. It is possible that under the most favourable conditions the labour loads shown for the modern mill could be exceeded, but the figures may be taken to represent good modern practice.

e/ Wage levels for both ordinary one-shift and three-shift operations are representative of present-day practice in the United Kingdom.

f/ Power costs are based on the following:

	Modern mill	1945 mill
kW/hours	703	925
Hours per year	5,512.5	2,082.5
Cost per unit	1.25 pence	2.00 pence

g/ "Other items" include consumable mill stores, insurance, legal fees, trade subscriptions, rates, stationery, telephone, transport, etc. Both mills are assumed to be members of a larger group in which certain services (including sales, research, etc.) would be centrally administered. The cost of these central services is not shown.

h/ Machinery and ancillary equipment have been amortized over ten years on a "straight line" basis: buildings have been amortized over twenty years.

i/ The figure shown ($ 47,600) represents the average annual sum payable assuming that the total investment ($ 1,316,000) is repaid over ten years (in the case of machinery and ancillary equipment) and over twenty years (in the case of buildings) and calculating the interest at 6 per cent on the declining balance.

Spinning with conventional equipment

It is possible to achieve high efficiency with conventional spinning equipment: this has been proved by the outstanding performances of many mills in Europe, and especially in the United States where productivity is the highest in the world. This is achieved by functional layout of plant and machinery, careful selection of raw materials, proper mill controls, and by processing a single product in large quantities.

Although American production figures would be difficult to achieve, some European mills have made great advances in productivity, and it might be of interest to analyse some technical details, presented in table 5, of one such enterprise, the Lauffenmuehle Spinning Mill in Tiengen, Germany which has a labour complement of only 1.45 operators per 1000 spindles and produces an average of 7.45 kilograms per man hour based on their average yarn count of 30's, or 13.10 kilograms per man hour based on a yarn count of 20's of cotton yarn of the best quality. It is thus among the top mills in efficiency, based on a survey of some 500 cotton spinning plants in countries of the European Economic Community.

Table 5

The Lauffenmuehle Spinning Mill

A. Principal specifications

Number of spindles	38,400
Average yarn count	30's
Number of workers and employees	
Per shift	55-58
Per 1000 spindles	1-45
Total	125
Superintendent	1
Overseer, opening-carding	1
Overseer, combing, drawing, roving	1
Overseer, spinning (for 3 shifts)	2
Production	
Per hour, total 30's yarn, average kg.	480
Per hour, 30's gr./spindle hour	12.6
Per hour, 20's gr./spindle hour	28.2
Per worker kg. per man-hour 30's	7.45
Per worker kg. per man-hour 20's	13.10
Actual efficiency 1 year	98.2%
Power consumption	
Whole mill, kW.	1,550
For light, kW.	100
For air conditioning, kW.	235
Per kg. of 30's yarn, kW.	3.24

Shift times are 6 a.m. to 2 p.m., 2 p.m. to 11 p.m. and 11 p.m. to 6 a.m., with a "normal" (day) shift from 7 a.m. to 11 a.m. and 1 p.m. to 5 p.m. The first three handle production; the "normal" shift takes care of such jobs as opening bales, baling waste, grinding top rolls, lubricating, cleaning, and maintenance jobs of all kinds.

B. Draft organization

		Mix	
	Green[a]	Blue[b]	Brown[c]
Carded yarns			
Picker lap wt., oz./yd.	13	13	-
Card sliver, grain	69	69	-
Drawing sliver[d], grain	79	79	-
Drawing sliver[e], grain	95	45	-
Roving, hank Ne	0.9	1.2	-
Yarn, count Ne	12-30	20-40	-
Combed yarns			
Picker lap wt., oz./yd.	-	13	13
Card sliver, grain	-	56	56
Sliver lap, grain	-	778	778
Ribbon lap, grain	-	875	875
Comber sliver, grain	-	60	56
Drawing sliver[d], grain	-	69	56
Drawing sliver[e], grain	-	69	56
Roving, hank Ne	-	1.2 and 1.8	1.8 and 2.3
Yarn, count Ne	-	20-50	40-75

Table 5, (continued)

C. Equipment

Opening:

Two opening and picking lines:

First line: Whitin Axi-Flo cleaner, zig-zag opener, porcupine opener, 3-way distributor, 2 pickers;

Second line: Mono-cylinder cleaner, zig-zag opener, porcupine opener, 3-way distributor, 2 pickers.

Carding:

133 cards, with single coilers for 20" x 42" cans.

Combing:

2 sliver lap machines, 2 ribbon lap machines, and 12 combers with suction waste removal.

Drawing:

2 high-speed frames with 4 deliveries each, for combed yarns; 24 standard frames with 4 deliveries each, for carded yarns (the standard frames could today be replaced with 2-delivery high speed frames).

Roving:

16 roving frames with 76 spindles each: total, 1216 spindles.

In carded-yarn section, 7 cards per line, with 2 drawing frames and 1 roving frame. These units are balanced at a production of about 70 pounds per hour.

Spinning:

There are 96 Rieter Model G-4 frames, each with 400 spindles: total, 36,400 spindles. The frames are 3" gauage, 9.5" lift, with 1 3/4" and 1 7/8" rings.

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[a] Up to 1 1/16" staple, GM.

[b] Up to 1 1/8" staple, GM.

[c] 1 7/16" Karnak.

[d] Breaker.

[e] Finisher.

Yarn production: Wool processes[4]

Scouring

In 1963, at the Textile Exhibition in Hanover, some interesting developments in wool-scouring machinery were displayed which, while they have not as yet had major acceptance in scouring plants, have pointed to new trends. One of the machines sends an aqueous detergent liquid moving through the wool rather than mmoving the wool through the liquid, as is the rule. This was not entirely an innovation as the CSIRO in Austrialia built the first successful machine on the solvent jet scour principle some time ago. A British system also recommends aqueous detergent liquid instead of a solvent.

The French Charpentier system is basically a jet scour system where two endless belts of woven nylon carry the greasy wool between them and transport it through the detergent liquid.

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[4] Victor Saxl, "Report on visit to the Textile Exhibition in Hanover, Germany, 1963".

In the Federal Republic of Germany a new wool transport system is being used that can be fitted to existing bowls to replace the rake motion. In each bowl there are five perforated drums mounted off centre; each drum dips **alternately** into the liquid and then rises above the surface. During the drum movement, liquid flows through the perforations to the hollow interior, carrying the wool onto the drum surface and holding it there as the drum rotates, thereby transporting the wool in the bowl.

Combing

In the field of combing, progress has been made, but no basic changes have **occurred** in the past ten years. Worsted cards are being built wider, with improved types of card clothing, better burr removal and higher doffer comb speed. In fact it is reported that some of these cards operate at speeds of around eighty metres per minute. High-speed intersectors, some with auto-levellers, are being used instead of the slow intersecting gill boxes. Rectilinear combs are wider and faster and produce up to twenty kilograms of tops per hour, depending upon the fineness and quality of the wool. Stop-motions on high speed gills and combs are standard equipment.

The French or rectilinear comb has captured a substantial part of the market previously dominated by the circular or Noble comb. This comb produces oil-combed top from longer types of wool as well as mohair, alpaca, camel hair and **coarse** hair. One of the important reasons is that the Bradford system was replaced to a large degree - especially in the United States - by the American Worsted Spinning System, which uses dry-combed tops from rectilinear combs.

With the introduction of high-speed gills and autolevellers a better and more even type of top is being produced, which in turn makes it possible to produce good worsted yarn with a reduced number of drawing operations.

Worsted spinning systems

In pre-war days there existed two different worsted spinning systems. One was the Bradford system, used to advantage for longer types of wools and for long, coarse and special fibres, among them mohair, goat hair, and alpaca. It uses wool combed on circular combs, especially on the Noble comb with a grease content of more than 2 per cent.

The second system was the French system suitable for shorter types of wools and wool tops of less regular staple, combed on rectilinear combs and with an oil content of around 1 per cent.

Later, these systems were joined by the so-called American system, which in fact is a modified cotton system using a roving frame, producing roving with a light twist as the last operation before spinning.

The Bradford system

Many years ago, the Bradford system was the most important spinning system in the world. Originally suitable only for long wools, it was gradually perfected and now can be used also for medium long wools and shorter wools.

The fibres are controlled by twist. The pre-war system consisted of five to nine operations depending upon the stock quality and the yarn count to be spun.

Many changes occurred in the 19[illegible]'s especially with the introduction of high speed gills, such as pin-drafters, gill-reducers and super-intersectors. These machines have very high speeds (up to 100 metres per minute) and deliver the slivers into a can. The introduction of the Haper autoleveller marked an important step forward. This [illegible] device measures sliver thickness and automatically and continually varies the draft of the gills to correct variations in sliver thickness, in order to reduce or eliminate long-term variations. Other autolevelling devices operate electronically.

New roving frames have been introduced with substantially higher drafts.

The yarn produced on the Bradford system is smoother, less harry and fuzzy than yarn produced on the French or the American systems and it can be worked under less rigid operating conditions.

A new type of Bradford system has been developed by the British firm **of Prince-Smith & Stells:** the Haper continental system. It consists of three drawing operations: one high speed gill with the Haper autoleveller, an autoleveller drawbox, a finisher (roving frame) with Ambler superdraft which can be adjusted successfully for drafts up to more than 100. Tops with an oil content from 0.5 per cent to 1 1/2 per cent (depending on whether they are dry-combed and oil-combed) can be used, and uniform staple is recommended to ensure the production of even yarns. Twisted rovings, and recently untwisted ones, can be used.

It should be mentinned that the superdraft system enables the spinner to produce a large variety of yarn counts from one or two roving weights.

<u>The new Bradford spinning system consists of the following steps:</u>

			Ambler system
(a)	High-speed gill[a]	High-speed gill[a]	Speedogill[a]
(b)	High-speed gill	High-speed gill	Drawbox with autoleveller
(c)	High-speed gill	Roving frame	Finisher with Ambler draft
(d)	Roving frame	-	Ringspinning
(e)	Ringspinning	Ringspinning	With Ambler superdraft.

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[a] One or more gilling processes can be equipped with autolevellers.

The French system

The French system uses open roving, without twist, for all drawing operations.

Before the war the French system was known as the **porcupine** spinning **system,** because six to eight drawings were made on so-called porcupine spinning frames, which permitted drafts only up to 4.5. Thus a slow reduction of the sliver could be obtained.

In the early 1950's, this system was improved by the introduction of high speed gills and so called "open gill boxes" (gills with one field of fallers), and the drawing steps were reduced to five or six. Despite these improvements, the French spinning system could not hold its own especially in the United States, where it was completely replaced by the American **system.** Since then the French spinning equipment manufacturers have fought back and have introduced a high-speed finisher, permitting substantially higher drafts and high speeds in order to compete against the other systems in the number of drawing steps and in production rate. The modern French spinning system consists of four steps:

(a) High-speed gilling with autoleveller;
(b) High-speed gilling;
(c) High-speed gilling (this step is sometimes eliminated especially for lower count yarn, synthetics or synthetic blends or very regular tops);
(d) High-draft finisher;
(e) Ringspinning.

The French spinning system is widely used in Europe, Latin America and in other parts of the world where it produces lofty and fine yarn of short and often weak wools. It is less employed for spinning blends or synthetic yarns, when a roving frame that imparts twist is used instead of the high-speed finisher.

The American system

The American system uses tops of low oil content. The tops are dry-combed and contain 1-1.5 per cent of oil. Twist is inserted in the roving frame, but it is softer than that used on the Bradford system.

The American system, originally a modified cotton system, has been vastly improved for longer staple length, which can process fibres from two inches to about six or seven inches.

The modern American worsted spinning system consists of the following steps:

(a) Pin-drafter or gill-reducer usually with autolevelling device;
(b) Pin-drafter or gill-reducer;
(c) Pin-drafter or gill-reducer (this step can be eliminated for synthetics, some blends and very even top);
(d) Roving frame;
(e) Ringspinning.

The American system is being used to great advantage for wools which are not very long and have a reguler staple diagram, for blends of wools with man-made fibres and for man-made fibres alone. The American system has become the most widely used worsted spinning system in the United States because of lower production costs especially for medium counts, as well as low maintenance costs.

Spinning of high bulk yarns

High-bulk yarns find an important niche in modern worsted systems. These yarns are generally spun on the American or the Bradford system and only rarely on the French system.

The yarns have found wide acceptance because of their lofty appearance, agreeable hand, warmth, and easy washability. They are used chiefly in knitted outerwear.

Yarns of special qualities can be produced by blending man-made fibres with high and low shrinkage components in the same yarn. When the material made from these yarns is treated with steam or boiling water, the high-shrinkage fibres shrink and the diameter of the yarn increases and gives the yarn its lofty and bulky appearance.

Blends of synthetic fibres with wool can also be processed on the Turbo-stapler. The slivers produced usually have a fibre length of 6 to 9 inches.

These are the usual steps for processing high-bulk yarn:
(a) Turbo-stapler;
(b) Turbo-fibre-setter;
(c) Breaker;
(d) Three pin-drafter operations or one high-speed gill with autoleveller, followed by a high-speed gill or reducer;

(e) Roving frame;
(f) Ringspinning.

The production of the Turbo-stapler, which stretches and [illegible] the tow is about 50 kilograms per hour. Other machines are geared to [illegible] The fibre-setter sets the fibres under steam pressure.

The breaker reduces the fibres from a staple length of [illegible] to a maximum length of about 6 1/2 inches.

Several mills use one or two additional gilling operations before drawing to ensure proper blending of the **fibres**. These gilling operations are made prior to the drawing operations.

Usually high-draft roving frames and high-draft spinning frames suitable for worsted yarns are used for these operations. Several mills use a slightly modified Bradford system with a Bradford roving frame and a Bradford type spinning frame.

Future trends in worsted spinning

Changes in all three worsted systems have been phenomenal over the last fifteen years, and this period of changes and improvements **continues. Higher** processing speeds, even fewer drawing operations and doublings and higher drafts are still being developed. Evenness testers have provided a tool to reveal whether sliver or yarn evenness suffers through higher speeds and **drafts and fewer doublings.**

Even yarns can be produced on the short system if operating conditions are carefully controlled. The raw material and the quality of the tops must be watched closely. Tops with few neps and good evenness will cause few difficulties in processing and produce a satisfactory yarn with fewer doublings.

Top-makers are co-operating with spinners to produce even tops with low nep counts. Top-breaking machines have also contributed to the manufacture of even tops with more even staple **diagrams.** Some mills, including combing mills, are using these machines.

Maintenance cost too is an important consideration.

Spinners have reduced steps and doublings to meet the particular requirements of the user. Yarns for hand knitting may not have to be perfectly even. Yarns for machine knitting must be very even, while for weaving they must be of excellent evenness.

Wools can naturally be spun to greatest advantage on the worsted system because the natural fibre length is preserved, and the yarn retains more desirable qualitites.

Carded yarns system

No recent radical changes can be noted in the carded yarns processes and the basic construction of equipment has changed very little. The cards are being built wider (250 centimetres) and they operate faster. At least one firm offers a card equipped with an electronic web control attachment.

Delivery speeds of 26-30 metres per minute and more are possible. The mules are gradually being replaced by ringspinning frames. The production capacity of a ringspindle is at least twice that of the mule spindle. Almost all recently built ringspinning frames have a special type of attachment atop the spindles (for example, a spindle crown) for the reduction of spinning tension with or without balloon. This device makes it possible to increase spindle speeds by some 30 per cent.

The average carded yarn count in most Latin American countries is Nr. [illegible] metric and it is calculated that with good types of wool one can operate with spindle speeds of about 6400 r.p.m. and at 80 per cent efficiency. At about 330 turns per metre, production can reach more than 130 grams per spindle hour.

Another important new feature is the extra-large or giant packages with which the new spinning frames are equipped.

The Chapon spinning system is used to a small degree in various countries of Europe, South America and elsewhere. The roving from a woollen card is placed on a spinning frame where only twist is inserted and no draft takes place. The yarn is usually wound on filling cops. This type of spinning is used mainly for waste yarn or yarns made of short wools with low twist such as is used for blankets and felts.

Semi-worsted spinning system

The semi-worsted spinning system, producing yarn which has an appearance similar to worsted yarn but is spun without the combing process, is being used in some European countries. It has grown in importance due to improved equipment for the production of such yarns.

The preliminary processes consist of carding and gilling. The card sliver is gilled, usually in two operations, the last one on a gill with an autolevelling device. A special type of spinning frame produces a yarn which is quite even and suitable for carpet yarn, hand-knitting yarn, woven felts and other end uses. Due to the gilling processes involved the fibre length used for the semi-worsted spinning must be longer than that used for the carded system.

Tow-to-top processing machines

were spun on the conventional worsted system, that is, staple fibres were carded, gill-combed and finished, as a normal wool top would be in order to make the fibres parallel and overlap them so as to produce an even sliver. The purpose was achieved, but a number of defects originated in the process itself, due to faults caused by the preparatory machinery, human error and overhandling. By lessening the number of handlings, the tow-to-top conversion system was a great step forward.

This system has expanded tremendously especially for non-cellulosic filaments, nylon, acrylics as well as polyesters. Blends too are extensively processed in this way.

By now the various tow-to-top conversion systems have almost eliminated the conventional carding and combing of long-staple synthetics.

The shortened drawing operations now used in spinning in conjunction with the tow-to-top system, which demands a higher uniformity of the top, makes this rapid conversion system a very acceptable one. Although many spinners have incorporated the tow-to-top conversion system in their operations, the commission converter has gained ground in some countries, particularly with fibre producers. The tow-to-top system should actually be an integral part of the spinning operation, as it gives the spinner the possibility of meeting certain requirements, such as a specific staple length or a certain bulk produced by blending stretched heat-set fibres with stretched unset fibres. Substantial bulk is then developed during the steaming or dyeing process. Tow-to-top conversion systems can be classified according to the method used for separating the filaments either as stretch-breaking or as cutting. The best known stretch-breaking machine is the American-built Turbo-stapler, especially suited for acrylics. Among well-known tow converters are the Pacific converter, the Rieter, the Courtaulds and the Tematex Machine.

The tow should be of very uniform quality with filaments not wedded to each other. The subsequent step, after preparing the sliver, should be by a gill or draw breaker that would break filaments not broken or cut during the prior conversion operation.

Wools and other fibres can be blended with synthetic slivers on some of these machines too. Recent improvements permit the production of short staple, suitable for spinning on modified cotton systems. It is sometimes difficult to choose between converters and stretch-breaking machines. The stretch-breaking technique is more delicate than the cutting, and it requires greater care in the drawing and spinning operations.

The choice must depend on the type of yarn to be produced, and on its end use.

Stretch yarns

Stretch fabrics

A little more than a decade ago, the only stretch fabrics used were for ladies' foundation garments, swimwear and some other limited uses with the stretch imparted by natural rubber yarns. In the early fifties, techniques were developed and described in a separate chapter, whereby thermoplastic filaments, mainly polyamid and polyester, could be bulked and/or crimped, thus giving stretch properties to these yarns. Without texturized filaments, stretch fabric properties would not have been possible, nor would stretch pants, skirts, socks, sweaters and other articles of clothing.

The development of elastomeric polyurethane fibres gave a strong impetus to this new trend. Today many of the large synthetic fibre firms are producing these yarns, marketed under the name of Spandex, Lycra, Vyrene, Spanzelle and others. They can be used as direct substitutes for natural rubber yarns in foundation garments or in swimwear fabrics, while fabrics for leisure wear, containing a small percentage of elastomeric fibres, have improved elastic properties. There are many additional end uses where these new fibres create their own product. Corespun yarns have only recently begun to grow in importance. The types of fabrics made from natural, elastomeric and texturized yarns are shown in figures X, XI, XII.

Figure X

Stretch fabrics: Covered natural rubber yarn[a]

(Fabrics made from naturally extensible yarns. Rubber is always processed as covered yarns, that is with "S" or "Z" covering of rigid yarn, such as viscose, cotton and nylon.)

Woven fabric

(Weft yarn; one-way stretch)

Satins
Lenos
Batiste

Corsetry
Swimwear

Stretch 40%–80%

Woven narrow fabrics

(Warp yarn)

For pant tops etc.

Stretch 80%–240%

Raschel knitted fabric

(Warp yarn; two-way stretch)

Power nets

Corsetry

Stretch,
warpwise: 60%–150%
widthwise: 20%–60%

Bobbinets

(Two-way stretch)

Corsetry
Surgical hose

warpwise: av. 50%
widthwise: av. 40%

Weft-knitted

(Two-way stretch)

Surgical hose
Swimwear

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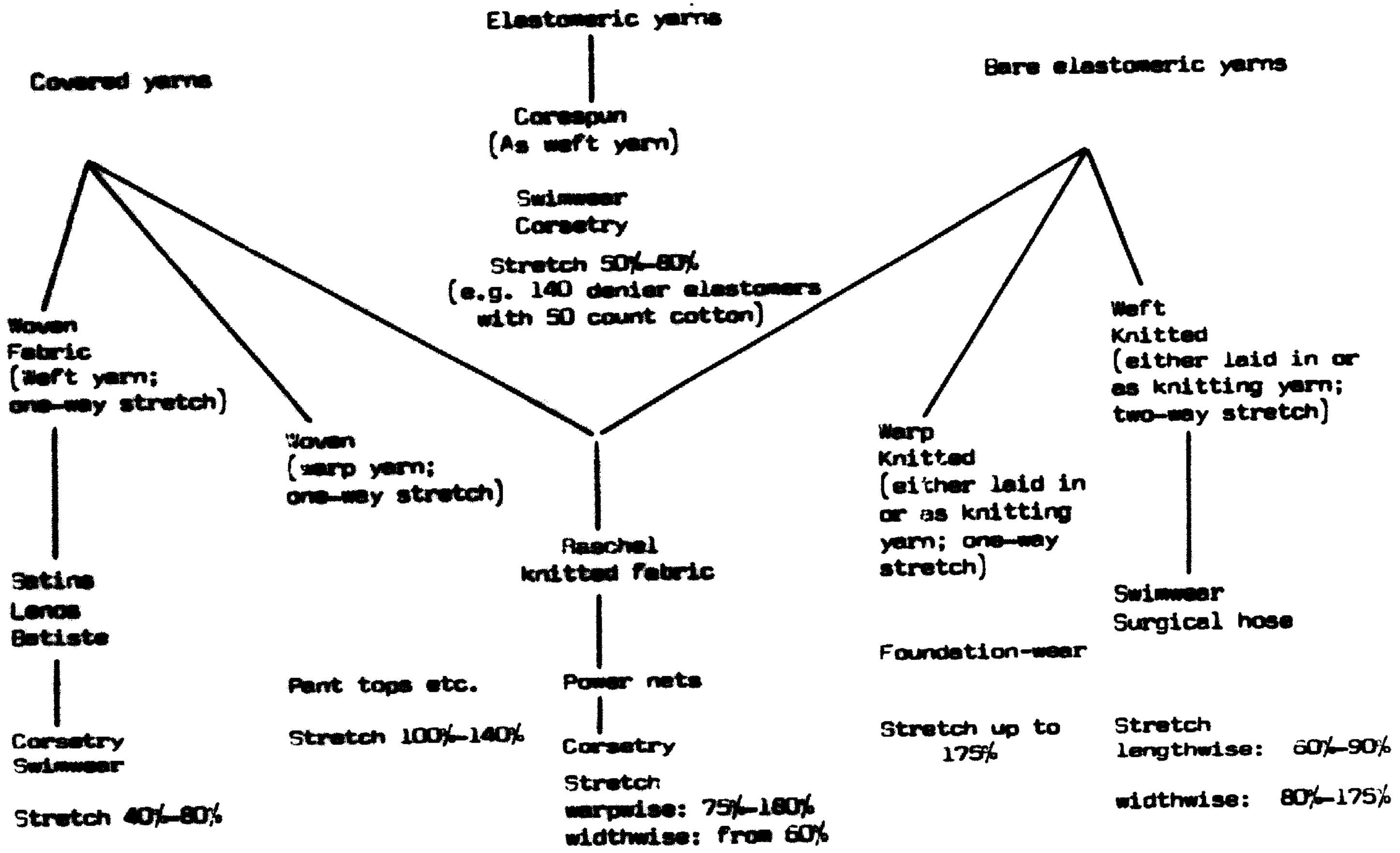
[a] Source: Textile Institute and Industry, September 1964.

Figure XI

Stretch fabrics: Fabrics made from extensible synthetic (elastomeric) yarn[a]



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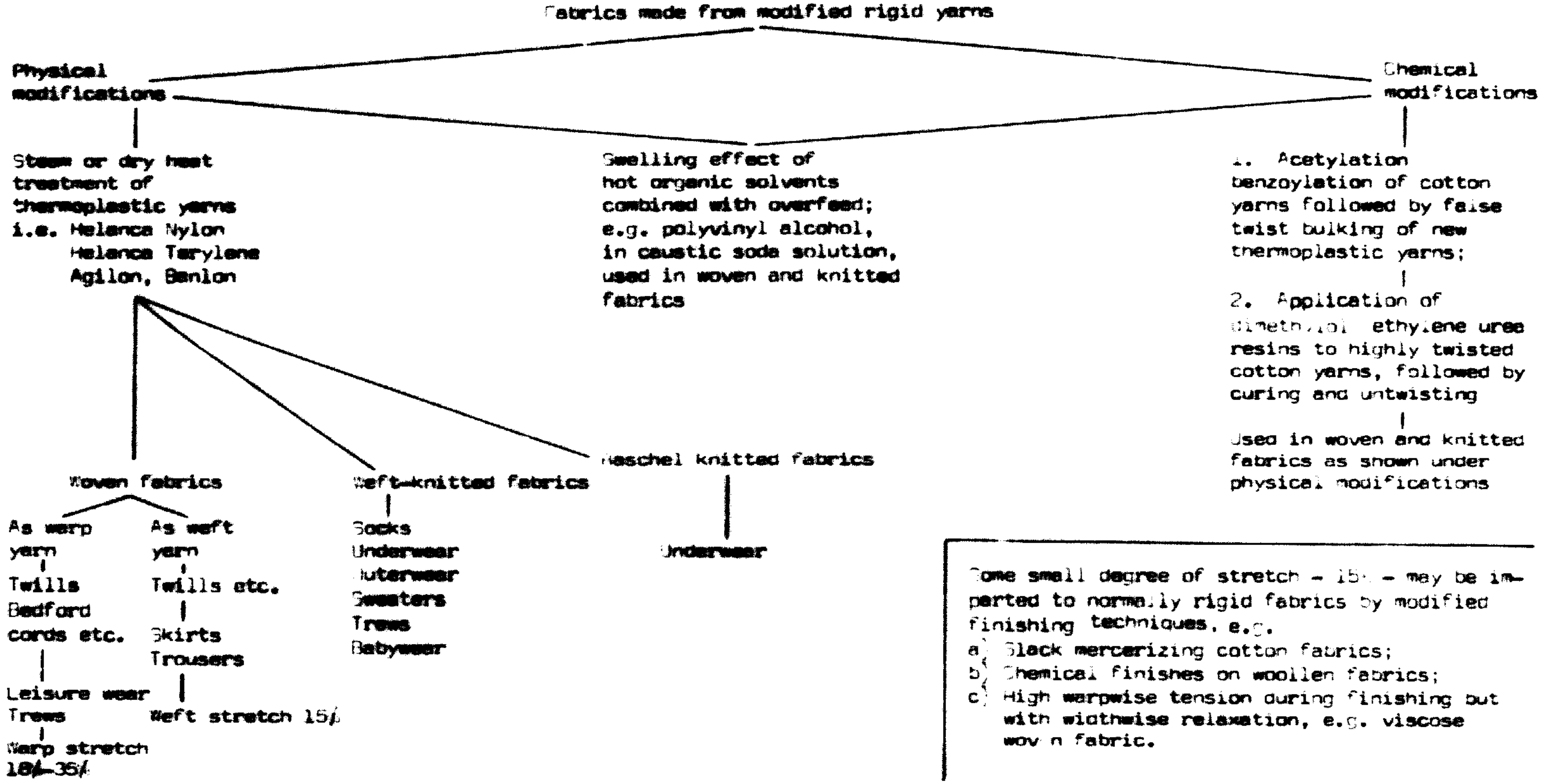
[a] Source: Textile Institute and Industry, September 1964

Figure XII

Stretch fabrics: Texturized yarns[a/]



Some small degree of stretch - 15% - may be imparted to normally rigid fabrics by modified finishing techniques, e.g.

a) Slack mercerizing cotton fabrics;
b) Chemical finishes on woollen fabrics;
c) High warpwise tension during finishing but with widthwise relaxation, e.g. viscose woven fabric.

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a/ Source: Textile Institute and Industry, September 1964.

Natural rubber is affected by a number of factors, such as sunlight, perspiration and gas fumes, and is always used as a covered yarn; this means that a natural rubber core is covered with one set of covering yarns with S-twist and an outer cover with Z-twist. Filament or yarns of all types can be used as rigid covering.

Elastomeric fibres as shown in figure XI may be used as covered yarns, as in the case of natural rubber, or, since they are unaffected by natural agents such as sunlight and perspiration, may be used in certain fabrics as bare yarns.

Texturizing

Processes have been developed whereby a change in appearance and texture and an increase in the bulk and stretch characteristics of filament yarns may be obtained by putting a permanent crimp, loop, coil or curl into normal continuous filaments. These yarns, known under the generic name of "texturized yarns" may be either of the stretch, modified stretch or bulk type. Texturized yarns offer one of the most promising areas for the future of filaments of the cellulosic type such as acetate and triacetate and non-cellulosic filaments, mainly polyamides and polyesters.

Texturized yarns have won an important position in the market. Synthetic filaments are most suitable for texturizing, as they can be heat-set, which may be done by hot air, saturated steam or hot water. For the same yarn count, these yarns have considerably greater bulk than comparable spun-fibre yarns.

These processes have made possible a great number of new end uses in fields where formerly spun yarns were used, for instance in many knitted goods, such as underwear, swimwear, and men's and women's hosiery, in rugs and carpets and in woven upholstery fabrics.

The basic principle of all texturizing processes lies in the marked deformation of the yarn followed by immediate heat-setting, which causes a considerable increase in the volume of the endless filament. At the same time the elasticity of the textured thread may be increased to a controlled degree, as in most stretch yarns.

The texturizing process depends upon the denier of the filament and the end use. For handling monofilament yarns the Agilon or crinkle system is being used. With multifilament yarns of 20 to 500 denier, bulking is brought about by the classical twisting process (Helanca), the false twist process (Fluflon) and the pressure crimping processes.

Bulked yarns such as Ban-Lons or Taslan show various degrees of stretch, depending upon the method and condition of bulking. However, bulk is permanent, irrespectively of whether the yarn is in a relaxed or extended condition.

Stretch yarns are those with high elongation, rapid recovery and permanent crimp retention.

The principle method by which stretch yarns are produced is the false twist method in which the yarns are twisted, heat-set and untwisted, in one process. One special type, Agilon, is produced by running a continuous filament yarn through a heat zone and then around a knife edge, a procedure which deforms the filaments into a series of spirals and imparts elastic, voluminous, non-torque characteristics.

The high-bulk yarns are produced by the texturizing method which consists of pushing the filaments through a heated crimp box; in making Taslan, bulk is imparted by feeding the yarn through an air jet at a faster rate than it is drawn off by take-up rolls on the far side of the jet.

The equipment for stretch yarns and bulk yarns has been perfected, and the new machines operate at speed of up to 400,000 r.p.m.

The advantages of texturized yarns over natural fibre yarns are derived from the low weight of the finished article, despite large volume; their freedom from the undesirable pilling effect; the good stability of form imparted by thermo-setting; the ease of care in washing and ironing - a characteristic of all finished goods made from synthetic yarns. The physiological properties in clothing, of both woven and knitted texturized yarns, such as their permeability to air, heat retentiveness and ability to absorb and transfer moisture are similar to those of finished woollen articles.

Another texturizing process is the so-called crinkle-process which consists of knitting unbulked filaments on a fine gauge machine, setting the fabric so produced by pressure steam, then unravelling it and reknitting on coarser machines. This process, used for some time for welts in ladies' stockings, is now used only for outerwear.

Unquestionably, texturized yarns have captured an important place in many fields of the textile industry. Their use for knitting has increased tremendously, displacing a substantial amount of spun yarns, even in such fields as lace manufacturing. Their use for stretch woven fabrics is on the rise also.

For these reasons texturized yarns merit the special attention of textile men all over the world.

Corespun yarns

Corespinning can be accomplished on any conventional spinning frame including the cotton, the worsted and the woollen systems. The procedure involves the spinning of a staple sheath around a core of elastic thread under tension. On the cotton system, sheaths of combed cotton or combed cotton blended with man-made fibres or with other natural fibres can be processed.

On the worsted system, much longer staple lengths can be used, including wool and wool blends. Corespinning can also be done on the woollen system and generally with wool only.

The weaving of corespun filling stretch fabrics has been much easier and simpler than was at first expected. Weft prepared on filling spinning frames can be used. Unifil equipment as well as various types of quill winding equipment are utilized with greater simplicity and ease of operation.

Spandex corespun yarns made on any of the three conventional systems can be processed with suitable tensioning on various types of knitting equipment. Double-knit fabrics with good elastic properties are popular for swimwear, outerwear, ski-wear and many other types of garments.

Cotton stretch yarns

In general, two methods are being developed for the production of texturized, highly stretchable cotton yarns, based upon the principle of setting the crimp in the yarn by the use of crosslinking agents. These methods may be referred to as (a) crimped-crosslinked, back-twisted, and (b) crimped-crosslinked, false-twisted. In the first method, highly twisted plied yarns are treated with a solution of a crosslinking agent, dried, cured, then back-twisted. In the second method, conventional plied yarns are impregnated with a solution of a crosslinking agent and then passed through a false-twisting machine at such a rate and temperature as to cause a reaction between the cellulose and the crosslinking agent.

Considerable interest has been shown in crimped-crosslinked yarn, and it is expected that such yarns will become commercially available soon. Since the quality and over-all properties of the yarn produced by the false-twist and back-twist methods are similar, the cost of production will become a major factor in commercialization. At present it appears that crimped-crosslinked yarn can be produced at a lower cost using the back-twist method. In general, the end uses for fabrics made from crimped-crosslinked will be different from those made by slack mercerization of woven goods.

A third principle for imparting stretch and bulk to cotton is also being explored. Certain chemical modifications of cotton impart plastic flow properties which permit heat-forming. Such thermoplastic yarns can be crimped by false-twisting, stuffer box, back-twisting and related techniques. These chemical modifications apparently impart thermoplastic properties by breaking or disrupting normal bonding forces within the fibre and inserting new bonds by heat-setting.

Automatic winding equipment

In the past five years winding has advanced from its traditional position as a costly necessity, contributing substantially to the quality of the yarn. Newly designed automatic winding-machines are producing larger, more knot-free and slub-free packages at much higher speeds. At the same time, labour requirements have been greatly reduced. This has certainly influenced the preceding spinning operation, subsequent material handling and further steps.

It must be stated that at present a fully automatic winder does not exist as a mill operating unit. Bobbins have to be placed manually on supply spindles, but it may not be long before spinning bobbins can be conveyed to the winder automatically. The yarn will be cleared and delivered on a suitably wound package to the next process without the use of direct labour. Fully automatic laboratory models are undergoing tests. One type is attachec directly to the spinning frame and becomes a part of that unit. Another type is separate, but provides fully automatic handling of material.

Until automatic winders were introduced, the only way to reduce winding costs was to re-equip the spinning section with large-package spinning frames. Now a more attractive alternative is available. In fact the trend in spinning seems to be reversing itself, and slightly smaller packages are being spun, at very much higher spindle speeds, on new ringspinning frames.

The ability of the automatic winder to handle smaller bobbins must be achieved without any substantial increase in cost or loss of efficiency. Approximately two thirds of an operator's work on present-day automatic coners is spent on preparing and feeding the bobbins into the winder. Automatic loading attachments have recently been developed for this purpose.

Yarn clearing

One of the most important functions of the automatic winder is the removal of imperfections in the yarn. The amount of yarn clearing should be determined without consideration of cost increase or reduction in machinery efficiency.

Winding must be considered as a filtering process between spinning and weaving or knitting, the yarn quality being governed by the requirements of the market. To achieve this exact standard of clearing one has to use electronic, photo-electric or other means, and indeed the full advantage of such clearing can be attained only in connection with an automatic winder.

Types of winders

Automatic winders can be grouped into three major categories: those with a stationary knotter for each end; those with travelling knotters; and third, the rotary type, with stationary knotter and travelling spindles.

Among the stationary knotter types the best known is the winder called Uniconer, manufactured by the Leesona Corporation of Warwick, Rhode Island, the United States. It has a rotating magazine for each spindle and runs at speeds of up to 1100 metres per minute. On the Uniconer new supply bobbins are automatically indexed and tied in; yarn defects are automatically detected and removed, and the running bobbin is retied. Defective bobbins are rejected and taken to the end of the machine. The package is automatically stopped and lifted when it reaches full size.

The Autoconer, built by Schlafhorst, is an example of the travelling knotter type of automatic winder. There are ten spindles per knotter, and the knotter patrols constantly. Speeds are up to 1100 metres per minute.

A rotary type of winder is produced by Ateliers de Construction Gilbos, Belgium; by Foster-Müller of Germany and the United States; by Abbott in the United States; and others.

Automatic winders have to fulfil three basic objectives:

(a) To produce large cones or cheeses of yarn of maximum uniformity;
(b) To inspect all yarns during the winding operation in order to reduce yarn imperfections to a minimum;
(c) To achieve the two above objectives at low cost.

Weaving

Developments in weaving techniques since the Second World War

For centuries the machine used for mixing warp and filling to produce cloth has been called a loom. The evolution of technology in this area has been so drastic that today even the machine producing woven fabrics is referred to usually as a "weaving machine" rather than as a loom.

The war years 1938-1945 showed no development in textile machinery; this was true of all items not directly essential to the war effort. Research, however, was not at a complete standstill, even though it was carried on mostly in the minds of engineers engaged in the industry. After the end of the war, there was a new industrial revolution, aided directly or indirectly by capital expenditures that could only be afforded on a governmental level.

Table 6 shows the development of looms or weaving machines between 1935 and the present.

Speeds were previously limited to 190 picks per minute. These have increased fantastically, and on looms where filling is inserted pneumatically or by water-jet 440 picks per minute are possible. The versatility of the looms has improved, and they are more accurately built. Some looms have the filling winder on the loom itsllf, such as the Unifil and the automatic battery filling arrangement. Last but not least, there are the various types of shuttleless looms, as shown in table 7, illustrating the impact made by progress in this type of loom.

Table 6

Progress in weaving technology

Decade	Speeds (in picks/min.)	Weft inserted by:	Versatility	Precision	Observations
1935 – 1945	190 max. even in latest models	Shuttle	Narrow range: looms capable of only fixed fabrics	Generally requiring a semi-skilled technician	
1945 – 1950	Up to 212 on "plain" looms	Shuttle and mechanical carrier a/	Evolving	Standards of settings are being introduced	
1950 – 1960	To 440 (double widths)	Shuttle, rapier (others pending) Filling wound on the loom (Unifil) Automatic battery filling	Multicolour and multipurpose	Skilled technicians required	Almost 80% of all cloth is plain woven fabric (the sheeting family); and while the loom of the past century has not the speed or automatic properties of today's machines, it is still capable of quality production.
1960 onward	Constantly increasing speeds	Shuttle rapier gripper water jet needle pneumatic	Idem.	Loom fixing becomes a profession	

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a/ This mechanical carrier known as a "bullet" was introduced by Warner-Swasey, United States.

Table 7

Shuttleless or bobbinless types of looms and their main technical data[a]

Firm	P. Balbé Ridameya, Barcelona-6, Spain	Dornier GmbH Lindau, Germany	Draper Corp. Hopedale, USA Licensee: Georg Fischer, Brugg, Switzerland	Elitex, Prague Distributors: Kovo, Prague 7, ČSSR	Elitex, Prague, Distributors: Kovo, Prague 7, ČSSR
Machine designation	Shuttleless weaving machine	Gripper weaving machine Model GWM (weft mixer) Model GWB (4-colour machine)	Shuttleless weaving machine Model DSL	Jet weaving machine Models P 105, 125 pneumatic	Jet weaving machine Models H 105, 125 hydraulic
Suitable yarns	Carded yarns, bast fibre yarns, man-made spuns, glass yarns	Cotton yarns, worsteds, man-made spuns	Cotton yarns, man-made spuns	Cotton yarns, man-made spuns	Man-made filament yarns, man-made spuns (must be hydroscopic)
Range of yarn counts (appr. figure)	Metric counts 0.25-40 tex 4000-25	Metric counts 5-150 tex 200-6.7	Metric counts 4-120 tex 250-8.4	Metric counts 30-50 tex 33.3-20	10 to 120/2 den. tex 1.1-6.7
Especially suited for following fabrics	Upholstery fabrics, repp-type fabrics, jute and glass fibre fabrics, heavy fabrics	Light to medium-weight fabrics	Light to medium-weight fabrics	Lightweight plain weave or twill fabrics	Lightweight plain weave or twill fabrics
Max. weight per m²	700 g. (25 ozs.)	400 g. (14 1/4 ozs.)	16.5-400 g. (1/2 - 14 1/4 ozs.)	200 g. (7 ozs.)	200 g. (7 ozs.)
Range of picks spacing per cm. (depending on weave and yarn count)	1-30	5-80	4-70	5-90	5-95
Possible number of weft colours or types of yarn	6	6	1	1	1
Weft sequence	Pick and pick, however always two consecutive picks per shed	GWM: Picks inserted in pairs GWB: Pick and pick any order	None	None	None
Side weft is inserted	Right	From both sides	Right	Left	Left

Shedding mechanism	Dobby up to 24 heald frames Jacquard machine	Outside cam up to 10 heald frames, dobby up to 20 heald frames Jacquard machine	Inside cam up to 8 heald frames	Inside cam up to 6 heald frames	Inside cam up to 6 heald frames
Height of shed					
minimum	100 mm.	40 mm.	20 mm.	36 mm.	36 mm.
maximum	200 mm.		35 mm.	55 mm.	55 mm.
Useful widths available	Twin machines each with 2 independent reed widths of 200 to 285 cm.	100, 130, 160, 180, 200 cm.	110, 120, 130, 140, 150, 160, 170 cm.	106, 125 cm.	106, 125 cm.
Possible variations in weaving width	Up to 30 cm.	Up to 50 cm.	Up to 33 cm.	-	-
Selvedge		Hairpin tuck on each side		Leno selvedges on both sides	Leno selvedges on both sides
left hand	Normal selvedge		Leno selvedge		
right hand	Loops hanging free		Normal selvedge		
Weft insertion principle	Flexible rapier on one side, which draws out a weft yarn loop in the shed	Rigid rapier on both sides, transferring a weft yarn loop in centre of shed	Flexible rapier on both sides, transferring weft yarn loop in centre of shed	Compressed air jet	Water jet
Guide parts in the shed	None	None	None	None	None
Maximum warp beam diameter	1000 mm.	700 mm.	800 mm.	700 mm.	700 mm.
Weft insertion rate in m/min.	360-570 m.	420 m.	420 m.	400 m.	490 m.
Remarks	Double picks are always inserted in each shed Pneumatic warp let-off motion	In spite of the rigid rapiers normal space requirements, as machine rows are staggered. Extremely good selvedge Further details see bulletins 3/63, 4/63	In 1964 Georg Fischer acquired the license: a completely new design is expected at the beginning of 1966 Further details see bulletins 1/61, 4/63	Three-step setting range for 300, 350, 400 r.p.m. Compressed air supplied by a compressor Electric weft stop motion Further details see bulletins 2/62, 3/64	Three-step setting range for 300, 350, 400 r.p.m. Electric weft stop motion Further details see bulletins 2/62, 3/64

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e/ International Textile Bulletin: Weaving, March 1964.

Table 2 (cont'd.)

Firm	Elitex, Prague Distributors: Kovo, Prague 7, CSSR	Gösken J., Dülken, Germany	IMER Maquinaria, Textil del Norte, Barcelona, Spain Fatex, Lyons 3, France	Lanacek Ltd., Zug, Switzerland (Crompton & Knowless Ltd., Worcester, USA) Dewatex, Lambersart, France A. Engels, Velbert, Germany SMIT, Schio, Vebloio, S.P.A., Turin, Italy	Mackie & Sons Ltd., Belfast, N. Ireland	Prince Motors Ltd., Textile Machinery Dept., Tokyo, Japan
Machine designation	Gripper weaving machine Model Novostav	Shuttleless gripper weaving machine Model GM	Shuttleless weaving machine Patent Ancet-Sayolle	Gripper weaving machine Model LK 1	Shuttleless weaving machine Model Unemack	Jet weaving Machine
Suitable yarns	Cotton yarns, woollen and worsted yarns, bast fibre yarns, man-made spuns and filaments	Cotton yarns, woollen and worsted yarns, man-made spuns and filaments	All yarns, including glass fibre yarns	Cotton yarns, woollen and worsted yarns, man-made spuns	Bast fibre yarns, hard fibre yarns, paper yarns, glass fibre yarns	Synthetic yarns and filaments
Range of yarn counts (approx. figure)	Metric counts 10–150 tex 100–6.7	Metric counts 1–70 tex 1000–14.3	Unlimited	Metric counts 1–20 or 60/2 tex 1000–50	Jute, hemp, flax yarns without restriction, sisal yarns up to metric count 0.8 tex 1250	10 to 120/2 den. tex 1.1–6.7
Specially suited for following fabrics	Light to medium-weight fabrics	Medium to heavy-weight fabrics	Virtually all fabrics	Medium to heavy fabrics, blankets	Bast fibres, hard fibre, glass and paper yarn fabrics	Light weight fabrics
Max. weight per m^2	100–350 g. (3 1/2 – 12 1/2 ozs.)	150–750 g. (5 1/2 – 27 ozs.)	600 g. (2 1/2 ozs.)	Up to 750 g. (27 ozs.)	700 g. (25 ozs.)	200 g. (7 ozs.)
Range of pick spacing per cm. (depending on weave and yarn count)	4.5–240	3.5–60	1.3–60	3.5–65	1–8	5–40
Possible number of weft colours or types of yarn	4	8	8	8	2	[illegible]
Weft sequence	Pick and pick	Pick and pick	Pick and pick	Pick and pick	Pick and pick (1A/1B)	None
Side weft is inserted	From both sides	Right	Left	Left	Both sides	Right
Shedding mechanism	Inside cam up to 6 heald frames, dobby up to 15 heald frames Jacquard machine	Outside cam up to 2 heald frames, dobby up to 20 shafts Jacquard machine	Cam dobby up to 3 shafts, dobby up to 21 heald frames Jacquard machine	Outside cam up to 8 heald frames, dobby up to 25 heald frames Jacquard machine	4 special cams with rocking shed	Outside cam up to 8 heald frames

Height of shed						
minimum	80 mm.	40 mm.	20 mm.	100 mm.	Rocking shed	35 mm.
maximum	110 mm.	65 mm.	30 mm.	200 mm.		55 mm.
Useful widths available	165, 215 cm.	150, 175, 190 220 cm.	60–180 cm.	Up to 375 cm.	76, 96, 124, 150, 214 cm.	105 cm. 165 cm.
Possible variations in weaving width	165 cm. model: every 2 cm. from 135 cm. 215 cm. model: every 2 cm. from 185 cm.	Up to 30 cm.	Any variation	Up to 25%	Up to 30%	–
Selvedge left hand right hand	Leno selvedges on both sides	Leno selvedges on both sides	By means of supplementary threads on both sides	Tucked side Leno or with supplementary threads	Hairpin tucks on both sides or with double picks: left: normal selvedge right: leno selvedge	Leno selvedges on both sides
Weft insertion principle	Pneumatic, both sides alternately	Rigid rapiers on both sides, transferring weft loop in center of shed	Rigid rapier on one side	Flexible rapiers on both sides, transferring weft in center of shed	Rigid rapiers on both sides, which draw the weft through the shed from the opposite side	Water jet
Guide parts in the shed	Guiding bars	None	None	Guide pins	None	None
Maximum warp beam diameter	750 mm.	800 mm.	1000 mm.	760 mm.	910 mm.	700 mm.
Weft insertion rate in m/min.	345–430 m.	225–250 m.	190 m.	350–440 m.	Up to 300 m.	550 m.
Remarks	Three-step setting range 165 cm. reed width 180, 200, 210 r.p.m. 215 cm. reed width 175, 190, 200 r.p.m. Pneumatic weft insertion Compressed air produced on weaving machine Further details see bulletin 4/64	"Hunt warp let-off Automatic pick-finding motion with driven dobby Further details see bulletin 4/63	Stepless starting Possibility of processing completely different yarn counts at same time Further details see bulletins 3/59, 4/63	"Hunt let-off motion When weaving backwards, all devices run backwards in unison Stepless starting Further details see bulletins 4/59, 1/63, 2/63, 4/63, 4/64	No sley. Only plain weave and twills up to 4 shafts can be processed Further details see bulletin 4/63	–

Table 7 (cont'd)

Firm	Roscher F. Ogh., Bamberg, Germany	SACM, Société Alsacienne de Construct. Mecaniques S.A., Mulhouse, France	Snoeck S.A., Ensival-Verviers, Belgium	Sulzer Bros Ltd., Winterthur, Switzerland	VEB Webstuhlbau, Grossenhain, Saxony, Distributors: Invest-Export, Berlin W.8, GDR Licensee: G. Hattersley & Sons Ltd., Keighley, England
Machine designation	Shuttleless weaving machine Gripcomat	Flying gripper weaving machine Type MAV 3 different models	Alco shuttleless gripper weaving machine	Gripper shuttle weaving machine 20 different models	Gripper shuttle weaving machine Model 4405
Suitable yarns	Cotton yarns, woollen and worsted yarns, coarse yarns, man-made spuns and filaments	Cotton yarns, woollen and worsted yarns, man-made spuns and filaments	Cotton yarns, woollen and worsted yarns, man-made spuns	Cotton yarns, woollen and worsted yarns, man-made spuns and filament yarns	Woollen yarns, man-made spuns
Range of yarn counts (appr. figure)	Metric counts 0.8–150 tex 1250–6.7	Metric counts 5–300 tex 200–3.4	Metric counts 1–40 or 80/2 tex 1000–25	Metric counts 3–160 tex 333–6.3	Metric counts 1.6–16 tex 625–63
Specially suited for following fabrics	Virtually all fabrics	Light to medium-weight fabrics	Medium to heavy fabrics, blankets, double pick insertion	Virtually all fabrics	Medium to heavy fabrics, blankets
Max. weight per m²	800 g. (28 1/2 ozs.)	Up to 400 g. (14 1/2 ozs.)	Up to 750 g. (27 ozs.)	Cotton fabrics 40–350 g. (1 1/2–12 1/2 ozs.) Worsted fabrics 80–350 g. (3–12 1/2 ozs.) Woollen fabrics 100–610 g.	Woollen fabrics up to 360 g. (12 1/2 ozs.) Blanket cloths up to 700 g. (25 ozs.)
Range of pick spacing per cm. (depending on weave and yarn count)	3–160	5–80	2.5–40	4–96	5–30
Possible number of weft colours or types of yarn	16	4	8	1.2 or 4 depending on model	2 x 6
Weft sequence	Pick and pick	Pick and pick	Pick and pick	Pick and pick	Pick and pick
Side weft is inserted	Both sides	Right	Left	Left	Both sides

Shedding mechanism	Inside cam up to 5 heald frames, outside cam up to 12 heald frames, dobby up to 25 shafts Jacquard machine	Outside cam up to 6 heald frames, dobby up to 12 heald frames Jacquard machine	Dobby up to 24 heald frames	Outside cam up to 10 heald frames, dobby up to 18 heald frames	Outside cam up to 8 heald frames, dobby up to 20 heald frames Extra heald frames for the selvedges
Height of shed					
minimum	50 mm.	65 mm.	100 mm.	16–20	20 mm.
maximum			200 mm.		25 mm.
Useful widths available	110–180 cm. at intervals of 10 cm.	180 cm.	190, 217, 246 cm.	216, 279, 330 cm.	180, 220 cm.
Possible variations in weaving widths	Up to 30 cm.	Up to 40 cm.	Up to 25	75 to 330 cm. Weaving several widths side by side possible	Up to 40 cm.
Selvedge left hand right hand	Tucked selvedges	Special leno selvedges with 3 nylon threads	Tucked selvedge, leno or supplementary threads on both sides	Tucked or leno selvedge	Special tucked selvedges, Neumann system
Weft insertion principle	Rigid rapiers on both sides, transferring weft loop in center of shed	Rigid rapiers on both sides, weft end transfer in center of shed	Flexible rapiers on both sides, transferring weft end in center of shed	From one side by gripper shuttle	From both sides by means of flying shuttle
Guide parts in the shed	None	Guide track in reed	Guide pins	Guide teeth	Safety bars slightly projecting into shed
Maximum warp beam diameter	700 mm.	800 mm.	760 mm.	800 mm.	700 mm.
Weft insertion rate in m/min.	Up to 300 m.	400 m.	320–350 m.	Between 500 m. and 700 m. depending on model	310–350 m.
Remarks	Infinitely variable speed regulation Possibility of inserting double picks with different colours of yarn Further details see bulletin 4/64	Stepless start Electric weft stop motion Novel warp beam let-off Further details see bulletins 1/63, 4/63	"Hunt" warp let-off Stepless starting Fancy twists can also be used in the weft Further details see bulletin 4/63	Further details see bulletins 1/59, 2/61, 4/63, 3/64 Certain discrepancies are unavoidable, since arbitrary figures had to be chosen from 20 different models	Stepless speed regulation Warp let-off gear with compensation tension Further details see bulletins 2/63, 4/63

In future we shall talk more about "pirnless" looms than about shuttleless looms, because some of the grippers or weft-transferring devices resemble a shuttle. Of the thirty-odd shuttleless looms displayed there, two thirds were rapier looms and one third were gripper shuttle looms. In this field the Sulzer Brothers of Switzerland, the pioneers of shuttleless weaving machines, displayed looms on an experimental basis with up to 360 picks per minute. Sulzer Brothers is also the firm chiefly responsible for propagating the wide loom, up to 330 centimetres and wider. These looms weave three pieces of cotton cloth simultaneously, one metre or more wide. When one realizes that the shuttle motion constitutes the biggest source of mechanical difficulties on looms, one can readily appreciate the variety of advantages offered by shuttleless looms, though there are definite fields for the application of high-speed shuttle looms, which continue in favour in many developing countries. But in general, the contest between the two types of loom is being won by the shuttleless construction, especially for the simpler types of fabrics.

In the woollen field, the old mechanical looms still used in many countries are being replaced by automatic looms and this trend was encouraged by the introduction of automatic filling changers, including the electronically controlled loom produced by Crompton & Knowles called the "[illegible]" loom.

The introduction of modern automatic looms has led to a complete revolution in workloads in weave rooms. Formerly 20 looms were considered an optimum workload; this was increased to 40 looms and later even to as many as 60 or 96 looms, depending upon the types of cloth and the loom stoppages observed.

At present, studies and observations of warp breakages, gilling breakages and mechanical stops are being performed in order to establish equitable workloads in weave rooms. As a rule of thumb it is understood that a weaver can attend to between forty and fifty loom stoppages per hour, depending on the type of fabric produced. In some countries so-called "bench marks" are set which assign a certain number of looms to each weaver, this number being based on time studies establishing that a worker can attend to that many loom stops per hour.

An important point still neglected in many parts of the world is the control of temperature and humidity in the weave room. Remarkable increases in efficiency are obtained through proper attention to the comfort of the weavers.

Most important in the operation of these sophisticated looms is the need for properly trained weavers and meticulous mechanics.

Unifil attachments for looms

An important development in weaving, constituting a transition between conventional weaving and semi-automatic weaving, was the introduction of Unifil, a winding attachment on the looms. It can be used on most types of looms and can wind one or more colours directly on the loom itself. This unit has brought substantial advantages to the weave room:

(a) Reduction in costs by the elimination of a separate winding operation;
(b) Saving in storage space since none is needed for filling;
(c) Automatic rewinding, with large packages brought to the looms;
(d) Uniform yarn tension; this is of particular importance in weaving fine cloth, weaving of filaments and especially for stretch yarns;
(e) Simple maintenance.

On the other hand, Unifil has the disadvantages that its efficiency is low especially on finer counts; and it is expensive.

Originally produced only by Leesona Corporation in Providence, Rhode Island, devices similar to Unifil are being produced also in Italy.

Shuttleless looms

One step forward in the evolution of weaving machines was the advent of means of interlacing the weft with the warp without the use of a shuttle.

As is the case in many types of equipment, new inventions and new processes do not render the existing one obsolete overnight.

Table 7 shows the different types of shuttleless looms now being constructed and their present status.

The outstanding advantages are:

(a) Savings in repair parts. In conventional shuttle looms, it is the shuttle with its required transfer motion that constitutes over half of the spare parts costs;
(b) Labour-saving in battery fillers;
(c) Higher efficiency as downtime due to stops stemming from shuttle use are eliminated.

The limitations of shuttleless looms - at least of some types - can be summed up:

(a) They are generally less versatile than the newest types of shuttle looms, which permit the production of many types of constructions and the use of spun as well as filament yarns;
(b) Selvages are untidy, since the filling yarn does not reenter the "shed" at each opening as would be the case where the filling is carried by a shuttle from a large package. New procedures and processes are now being employed to alleviate the situation, such as selvage tucking motion, Leno motion, or selvage trimming after weaving;
(c) These operations, no matter how successful, add to the cost of the product.

Knitting machines

Flat frame

V-bed machines use both latch needles and bearded needles. This feature makes the machine ideal for producing outerwear materials and the garments may be fashioned as knitting proceeds. Fabrics may be knitted in flat form, using one or both beds of needles, and in circular form, if first one bed is used and then the other.

Usually garment sections are made from dyed yarns, and after seaming, only light pressing is required.

Full-fashioned outerwear and underwear are produced on this machine.

Links-links

This equipment is composed of two flat beds and needles which have latches on both ends to produce the special type of fabric, plain or patterned, associated with links-links appearance. The machine is used either for full-fashioned or for cut garments and the fabrics produced are generally in slightly coarser yarns for use in sports outerwear.

Circular frame knitting

The second category of knitted fabrics are those made on circular machines which may be classed:

(a) Plain web machines with cylinder needles only;
(b) Interlock and double jersey machines, using dial and cylinder needles;
(c) Pattern fabric machines using pattern wheels or a Jacquard mechanism.

Plain web machines are the simplest type of circular knitting machines. Since the fabric ladders easily, they are used only for cheaper products.

Interlock machines use two sets of needles, the cylinder needles being placed vertically around the machines, while the dial needles are set radially above and spaced equally between the cylinder needles. In this way it is possible to produce ribbed fabrics that can be used for underwear or outerwear. Double jersey machines have a similar needle arrangement but they are usually coarser in gauge and are therefore mainly used for outerwear fabrics.

Various attachments can be obtained to increase the pattern possibilities of the machines, and the Jacquard mechanism usually operates through drums containing extractable pins or studs which may be positioned as required according to a pre-determined pattern.

The productivity of circular machines is varied, higher figures being obtained on the plain types with multi-feeders, and lower quantities from the more complicated mechanisms of Jacquards.

Originally most fabrics were finished in circular or tubular form, but with the advent of man-made fibres and also due to demand it is now standard practice for these fabrics to be slit and finished on an open width tenter frame. In this way control can be obtained over finished fabric characteristics and it is also easier to apply various types of finishes now in demand.

Warp knitting

While circular knitting machines and flat knitting machines are fed with yarn from cones, warp knitting and Raschel machines are normally fed with warped yarn from beams. This means that a separate warping process is necessary. There are two different ways of warping: direct or indirect. In the direct operation yarn is wound on sectional beams and several sectional beams are then mounted on a common mandrel, so that several sectional beams correspond to the over-all width of the knitting machine. Generally, one yarn beam is required for each guide bar. Jersey, charmeuse and weave-knit fabrics are produced on two-bar machines. However, there are many fabrics that require three or four guide bars and consequently, three or more sets of beams.

The indirect method of warping is used normally by smaller firms who operate a limited number of warp knitting machines. Here the packages are creeled, and bands or sections are wound on to a warp reel of large diameter. After the required length has been run out, the yarn ends are moved over so that another band can be warped adjacent to the first one, and so on until the required width for knitting is reached.

There are two types of machines in use at present: one works with the bearded needle, and the other with the compound needle. Speeds of knitting now achieve 1200 courses per minute, which amounts to an average production of about thirty metres of fabric per hour.

Warp knitting has been confined mainly to continuous filament yarns. However, with the advent of the various man-made blends, the tendency to increase their application resulted in the production of coarser gauge machines, that is, 18 gauge and 14 gauge, and it is possible that even lower gauges can be used for the production of fabrics for suitings.

In addition, there appears to be a current interest in fabrics produced on 4 to 12-bar, multi-bar machines, where two bars are used for the base fabrics and the remainder for producing patterns.

Another type of bearded needle warp-knitting machine is the Simplex machine with two needle bars. Here, both sets of warp threads are knitted on one bar. The guide bar then swings through to the other side of the machine and performs a similar operation, so that the fabric produced has two loop sides, as opposed to normal fabrics, which have a loop side and a reverse side. These machines knit mainly nylon yarns and viscose continuous filament, for gloves, shoe linings and other such uses.

Raschel knitting

This is a very specialized section of the knitting industry that has grown tremendously, especially since the advent of bulked and crimped yarns which are being used for it in great quantities. Raschel machines are very versatile, are built with one or two needle bars for the production of single face or double face fabrics. The construction ranges from light tulle fabric and curtain material to the heaviest upholstery fabrics and carpets.

The Raschel machines are built in many different types, such as:

(a) Curtain Raschels with one needle bar and 4 to 14 guide bars. The basic fabric constructed is marquisette;
(b) Raschel machines for knitting lace, with one needle bar and 18 to 30 guide bars, for producing lace edgings and over-all patterned lace fabrics as used in ladies underwear, scarves, mantillas, and curtains;
(c) A rubber yarn machine with a needle bar (latch needles), and 4 guide bars, used for the production of corset fabrics;
(d) Machines for knitting fishnet fabrics;
(e) A universal Raschel machine with two needle bars and 4 to 8 guide bars, for the production of underwear fabrics, dusters, blankets, sacking, package nets, and outerwear fabrics;
(f) Warp loom machines with one needle bar and 4 guide bars, used for the production of patterned fabrics and ladies' outerwear;
(g) Double warp looms with two needle bars and two guide bars, for glove fabrics and imitation leather fabrics;
(h) Crocheting machines with one needle bar and up to 12 guide bars for production of edgings for underwear and patterned ladies outerwear.

There is no question that Raschel machines, because of their versatility, have acquired an important position on the market, and by now there are some five brands, mostly built in Germany.

Recent trends in knitting equipment

The 47th Knitting Arts Exhibition held in Atlantic City, New Jersey, in May 1965 was the most comprehensive display of knitting equipment ever brought together and it underlined the increasing importance of this branch in the textile industry as a whole as it spreads into areas until recently dominated by weaving. Knitting machines have always been versatile; today, automation and refinement of equipment are giving the industry diversity and potential, extending into the fashion field, that did not exist before. The new yarns made of man-made fibres have accelerated knitting development. Synthetic yarns are more even and stronger than yarn made of natural fibres, and this is a big advantage on fast-running knitting machines. The popular texturized and stretch yarns are ideally suited for knitting.

Socks and hosiery have always been knitted; however, the elaborate patterns now used in ladies' hosiery have brought a strong new impulse towards versatility in technology. The demand for bright multi-coloured designs in men's socks has induced machinery manufacturers to perfect Jacquard machines, and a great variety of big Jacquard machines have a patterning scope that would have been considered impossible only a few years ago. Certain circular knitting machines are now offered in very fine gauges to bring out light and yet compact fabrics. Many machines are equipped for welt and draw thread, giving circular knitting machines possibilities formerly obtainable only on flat knitting machines. The number of feeders have increased on all the new methods. Speed has increased also; indeed, on warp knitting machines it could hardly be increased further, since no yarns known today could be processed at higher speeds.

Raschel knits have invaded fields formerly held by weaving, and Spandex fibres have opened this section of the knitting industry to new markets. Fabric for outerwear is being produced on Raschel machines, and further increase in this field can be expected.

Full fashioned machines have been perfected and a variety of Jacquard designs can be made on such machines. The ladies' stockings formerly produced exclusively on full fashion machines have disappeared from the market, as seamless hose is made on circular knitting machines. The fully automatic motor-driven flat knitting machine has kept its place in the industry. Although such machines produce less than circular knitting machines, they still offer certain advantages: they change more easily from one pattern to another, and they are able to produce shaped cloth sections, eliminating cutting and waste.

Great things may be expected for knitting equipment in the future, and this branch of the industry can be expected to invade markets still dominated by traditional weaving.

Stitch-sewing and stitch-bonding

The original principle behind stitch-sewing was to produce lower grade goods. Machines are now being developed and improved in order to produce more sophisticated fabrics, and the methods of stitch-sewing and stitch-bonding, explored and developed in Eastern Germany, have begun to arouse special interest in western countries.

The Mali machines, of which there are three types, Malimo, Malimat and Malipol, are the principal representatives. The Malimo employs the principle of weft insertion across warp threads, which are then sewn together by needles passing the thread through. The guide bars move horizontally across the machine or over two needles in the form of a horizontal figure 8 and the yarn for both warp and sewing is supplied from warps carried on simple bearings at the front of the machine. The yarn is loaded onto creels on each side of the machine and then passed to carriers which draw yarn from both sides of the creel at each passage. Solid or open mesh fabrics can be produced at rates of between 100 and 150 metres per hour.

The Malimo fabrics are being used for the cheaper kinds of dress wear, sports coats and upholstery fabrics; recently such fabrics as knit imitations used for cardigans and artificial furs are being produced by this method.

The principle of the Malimat machine is similar to that of the Malimo, except that a sheet of wadding or web of cotton or wool, or other fibre, is fed to the sewing elements. Because of high output, the end use of fabric of this type would appear to be for laminating with polyvinylchloride (PVC) for industrial uses, shoe-linings, insulation and other types of coated fabrics, filters and packaging materials.

In this category can be classed also a Czechoslovak stitch-bonding machine, which produces fabric by knitting the warp yarn through the fibre web. The principle is first to puncture the threads with a special needle and then to knit the warp threads into a fresh stitch. This operation is suitable for cotton or woollen webs and for a great number of end uses.

The Malipol machine employs a system of sewing pile yarn through a cloth which has already been woven or knitted, the yarn forming the loop being laid across sinkers to control height or length. The resultant fabric is used among other things for towelling, beachwear, and drapes.

Finer gauges, wider widths, higher production speeds, increasingly subtle fabrics and continuous processing potentials are being developed by the new Mali knit-stitch and knit-bond technology.

Flocking

The history of flocking spans fifty years or more. Even electrostatic flocking, about which most of the current interest is centred was originated commercially more than thirty years ago. During this time the flocking industry has failed to make any significant gains, although potential applications for its products have become more numerous.

In postwar Europe far-sighted machinery manufacturers began to develop electrostatic ranges of new design. Simultaneously, Germany's Farbenfabriken Bayer pioneered research aimed at synthesizing new adhesive molecules. The success of this work, together with advances in flock cutting and finishing, launched electrostatic flocking in Europe by the early 1950's.

In the past five years, many textile firms and carpet producers have invested in new equipment and have instituted fabric-developing programmes.

These developments did not rely only on the newer electrostatic flocking techniques. The old beater-bar process was ideally suited to producing the suede-like surface and its accompanying soft hand. These effects are in fact the distinguishing characteristics of mechanically flocked materials. In mechanical flocking the fibres (flocks) fall onto a moving adhesive coated backing to assume oblique, vertical and horizontal positions in the viscous adhesive bed. In the following step, rotating beater bars strike the fabric, or an endless belt carries the fabric forcefully at high speed. This action tends to stand the individual flocks on end. The distribution of vertically oriented fibres, however, is not high.

In contrast, in electrostatically flocked material, the distribution of vertically oriented fibres is extremely high, and the yield is a bristle-like pile of uniform height. In the process, the cut fibres (flock) first acquire a positive charge as they enter the electrostatic field. After alignment into a vertical position, they are impelled downward at high velocity toward a negatively charged field, where they impinge individually on an adhesive-coated backing material.

The electrostatic process also affords greater fibre densities than mechanical flocking - on the order of 275,000 to 300,000 fibres per square inch and higher, as against about 30,000 fibres per square inch. Much longer fibres can also be used - requiring higher voltages, however - to extend fabric range and scope.

In the past, flocked materials have found many and diverse uses, but the over-all market remained small. Today, improved electrostatic flocking and the availability of permanent adhesives signal deeper penetration into traditional markets and the promise of new ones. Virtually endless possibilities exist for creating products, since numerous materials lend themselves to electrostatic flocking, including foams, paper, cellophane, aluminium, plastics, and textiles. All of these and many others can be flocked with natural and synthetic fibres, requiring, of course, suitable adhesives and bonding technologies. In the final analysis, the success of flocked materials will depend on a favourable cost/performance ration and on innovations in design.

Modern dyeing and finishing methods for cottons and synthetics

The present day textile market requires fabrics that are impeccably dyed and appropriately finished, and many new techniques have been developed.

Dyeing

A new group of dyestuffs, constituting an altogether new dyeing principle, has found rapid acceptance throughout the industry: reactive dyes. These do not act by absorption, as have all dyestuffs hitherto known, but by chemical union between the molecules of the cellulose and the molecules of the dyeing chemicals.

This method renders products with good fastness to light and washing. The colours appear brilliant and alive. The technique can be used for all classes of cellulose fabrics, not only for solid-colour dyeing but also for prints.

One disadvantage of the reactive dyes is their low resistance to chlorine.

Another important new dyeing technique is the so-called "Thermosol" method which is comparatively simple and economical and has excellent uniformity and solidity. The material, which has been previously de-sized and bleached, is impregnated with the dyestuff on a foulard and then dried and "thermosolated" at a temperature of 200 to 210 degrees Celsius, for thirty seconds. The resulting colours remain uniform, even on striped cloths, coarse threads, different yarn counts or comb marks.

Thermosol dyeing can be applied successfully on cellulosic fibre fabrics with the reactive dyestuffs and on polyester and polyester/cotton blends, with dyestuffs consisting of a blend of "dispersed" and reactive dyes.

Another advantage of this process is that the Thermosol process and the heat-setting are carried out in one single operation.

Finishing

The appearance of synthetic fabrics with special and desirable end use properties unequalled by natural fibres has compelled manufacturers of cotton, wool and other natural fibre cloth to devise methods of imparting to their product qualities that will compete successfully with artificial fibre textiles. Today, natural fibres can be made into flame-resistant, rot-resistant, stain-proof fabrics with permanent impermeability as well as the crease-resistant and wash-and-wear properties that are more and more in demand and which have been perfected to a high degree.

The first such fabrics were produced with a resin of urea formaldehyde, but this process carried with it a loss in strength of the cloth and high chlorine retention. Nevertheless it is still being amply used today for cloth not bleached by chlorine or produced of highly resistant yarn.

The next step was to use a large number of resins with different characteristics to achieve wash-and-wear properties in the treated material.

What is the difference between crease-resistant and wash-and-wear finishes? The essential difference is that crease-resistant cloth in a dry state will recuperate its original aspect within three minutes after it has been creased. This finish is being given cloths meant for outerwear that should appear continually neat such as trousers and slacks, skirts, jackets and so on. Wash-and-wear properties are those which recuperate the proper aspect while in a humid state, as they are gently dried. This finish is ideal for cloth used for men's shirts, ladies' dresses, and children's wear, as such garments can be washed and dried with little or no ironing.

It is now also practicable to impart both wash-and-wear and crease-resistant finishes to the same length of cotton cloth if these qualities are desired.

Many years of research were necessary to produce resins that do not damage the strength of the fabrics, retain only a minimum of chlorine or can be cross-linked with cellulose in a reaction process, as in a sulfonium product (Cotonova, Belfast, Teb-X-cel). In order to guarantee the correct performance of cloth it should be submitted to a series of exacting tests.

A new type of finish, the so-called "permanent press" will be discussed in a separate chapter. In recent years the company that patented the "Sanforized" process announced the introduction of new equipment which will mechanically eliminate the loss of strength caused by resins in preshrinking. Such advances serve to maintain the leading position of cotton in the textile market, in the face of more exacting requirements in fabric performance brought about by the competition of synthetics with great advantages in end use properties.

Progress in wool finishing 5/

Considerable improvement has been achieved in the past ten years in the finishing process of woollen goods. Some of the new methods should minimize the less desirable features of woollen materials, for example their susceptibility to moths and carpet beetles and low mildew resistance. Furthermore, some finishes impart to woollen fabrics desirable properties otherwise attainable only through mixes with synthetic fibres.

Of the new finishes, the furthest advanced commercially are the methods for mothproofing and for producing permanent creases and pleats. Most wool carpets are now made permanently resistant to moths and carpet beetles and a reasonable quantity of knitwear, upholstery fabrics and blankets are also treated. Very little woven apparel fabric is mothproofed however.

Interest in permanent creasing and pleating of woollen garments was greatly stimulated a few years ago by the introduction of blends of wool with synthetic fibres. Such fabrics can be given permanent creases or pleats by steaming techniques very similar to those used conventionally for pressing trousers or pleating skirts. A challenge was thus presented to wool interests to devise, and introduce on a large scale, methods for producing similar effects in "all-wool" garments.

The first industrial process for producing these effects was the Si-Ro-Set process, and this is still the most convenient method. The principle of permanent creasing or pleating is that the woollen material, while held in the required form, is given a permanent set by the simultaneous application of heat, water and a chemical reducing agent.

An alternative method to the Si-Ro-Set process is a technique known as "pre-sensitizing". Here, the reducing agent is applied to the fabric in the mill and the permanent creases or pleats are then produced, after the garment has been made, by adding water just before steam ironing.

Flat-setting was first used industrially as part of the "Sironizing" process. In this case, it was carried out on shrink-proofed wool fabrics to give the cloth the ability to retain a smooth appearance after washing. In Australia, this is still the main use for flat-setting. This certainly is a very effective way of crebbing and can be used to simplify and shorten finishing routines. Some European mills now flat-set fabrics straight from the loom, then scour, tenter and give them a light blow. This produces fabrics that are quite acceptable for many uses and with further streamlining of the process, production costs can no doubt be significantly lowered.

5/ J.R. McPhee. "The Application of New Wool Finishes". Textile Institute and Industry, November 1963.

Processing to overcome felting-shrinkage has advanced greatly over the past ten to fifteen years, although even now perhaps only 10 to 20 per cent of wool textiles that unquestionably need a shrinkproofing treatment receive it. Shrinkproof fabrics are no longer harsh, yellowish and poor-wearing; they can now be produced completely indistinguishable from untreated wool, even to the most critical observer, and this can be done by a variety of methods.

Considerable interest is now being shown in the continuous shrink-proofing of sliver so that shrink-proofed yarns can be spun for the knitting trade.

Machine-washable, minimum-iron wool fabrics can be produced by combining any chemical shrink-proofing treatment with a flat-setting. Fabrics are licensed under the trade name "Sironized", and have not yet been produced on a large scale outside Australia.

Vast research programmes all over the world are under way to develop better and continuous processes for the various finishing operations. Due to all these improvements in woollen goods finishes, large new markets for a variety of uses are opening up.

Durable press

Durable press finished garments are obtained through a process of deferred curing technology which transfers a major operation, the curing, from the finishing plant to the apparel manufacturer. In so doing it divides responsibilities. The finishing plant now merely prepares a "sensitized" fabric containing a selected crosslinker and catalyst dried to a controlled moisture content but not actually cured. After the fabric has been made into garments, desirable creases are put in and curing follows for a pre-determined time, at a specific temperature, causing the all-important crosslinking to occur within the cellulose fibres.

The benefits are many: the desirable creases are permanent to multiple launderings; the garment retains its contours; the fabric resists wrinkling and dries smoothly after laundering without seam puckering. Besides relieving the consumer of a tedious pressing job, durable press offers a new high in neatness of appearance.

Behind these amazing results lies a simple explanation. The fabric acquires a single and permanent memory after it is made into a garment and not before, as in pad-dry-curing where memory is imparted to fabric in a flat state, making desirable creasing difficult.

Not unexpectedly, deferred curing is creating some new problems: the resultant durable press garments make alterations extremely difficult if not impossible.

The apparent acceptance of durable press, particularly in the men's trouser market with expansions in shirts, blouses and dresses has brought an almost endless outpouring of fibre modifications, fibre blends, chemical technologies, and physical treatments. But it is not yet clear which technologies and fabric engineering approaches will dominate the market. Many appear to be sound and perhaps each will find a place. Much will depend on consumer acceptance.

The various technologies and approaches commercially used for producing durable press garments are:

(a) Garment treatment: a mixture of resin and latex is applied to the garment and then extracted, dried, pressed and cured;

(b) Recuring: The fabric is resin-treated and cured in a flat state and then made into garment. Creases are imparted, and recuring follows at high temperatures;

(c) Deferred curing: Fabric is sensitized with crosslinker and catalyst, dried but not cured. Then it is made into garment which is permanently creased and cured at high temperatures;

(d) Fibre modification: A reactant is applied to the fabric and "wet crosslinking" takes place in the flat state. Then the catalyst is applied and dried. Fabric is made into garment, creases are put in, and "dry crosslinking" follows at high-temperature curing;

(e) Fibre resin combinations: Cellulosic fabrics (cotton, rayon, or high-modulus rayon) are engineered so that they will have greater strength after the crosslinking treatment, usually by means of combinations with nylon 420 or with polyesters;

(f) Fibre blending: The fabric is engineered to contain 100 per cent thermoplastic fibres in filling (for press retention) and 100 per cent cotton or cellulosic fibres in warp. The deferred curing route is bypassed.

High-energy setting

Fabric may be conventionally treated in flat state (by the pad-dry-cure sequence), or may be untreated. Creases are imparted to the garment and a high-temperature, high-pressure setting, by pressing, follows.

In less than two years, durable press became a multimillion industry in the United States though the path to success was not always a smooth one. Polyester blends, with their superior strength have contributed to this skyrocketing popularity. As durable press offers consumers desirable properties which wash-and-wear goods were not able to impart, it can be assumed that the process is here to stay, and in ever-increasing demand.

Modern finishing equipment: cotton and synthetics

Textile finishing techniques are determined, fundamentally, by technological progress. Textile machinery therefore, is constantly being improved.

Many finishing processes today are completely automatic and require only that the fabric be fed, and taken away after treating. The control and regulatory technology does not impose any limits on further automation. However, the question does arise at what point operations become uneconomical, in spite of trends towards general automation, and this is a matter of special importance to smaller countries, which have to process a sizeable number of smaller lots.

There is no completely automatic production line in existence. The finisher must make use of the most practical type of finishing with the machines at his disposal. The general trend is towards specialization and towards larger, more economical finishing plants.

In developing countries it is often difficult to establish a non-integrated finishing plant, for financial reasons, or because of the small market and the existence of dyeing and finishing departments in larger, integrated mills.

Many weaving mills do not send their goods to commission finishers, because they feel that they can do a quicker and better job which sometimes includes a "secret" process or treatment that they acquire under licence. However, today's finishing plant with its expensive automatic machinery should do a good job at lower cost due to better machinery utilization and a high degree of specialization.

Undoubtedly many processes are becoming more and more automated. Dyeing equipment now has fully automatic controls which for the first time convert dyeing from a "rule of the thumb" profession into a scientific operation.

The main developments in finishing methods and equipment in the past few years are:

(a) Desizing:
- (i) By amylase of bacteriological origin;
- (ii) With sodium bromite;
- (iii) By impregnation with an active agent, either amylase or caustic soda, followed by steaming;
- (iv) By the rapid Montforts system with enzymes in the reactor.

(b) Continuous scouring and bleaching:
- (i) Benteler continuous bleaching range with two bleaching chambers;
- (ii) Dupont rapid bleaching system (range built by Rodney Hunt) with small J-boxes, reaction time ten to fifteen minutes;
- (iii) System of bleaching at high pressures and high temperatures 125-135^{0} Celsius; equipment built by Konrad Peter, Benteler, Kleinewefers and James Hunter (reaction time one minute);
- (iv) Open width continuous pressure bleaching system (Kleinewefer-Gerber).

(c) Open width washing:
- (i) Peter Mortensen or Artos system: scouring liquid runs opposite to cloth movement;
- (ii) Rotomat by Kleinewefers (desizing, boil-off, bleaching and washing in one operation);
- (iii) Vibrotex built by Kuester (with vibrating, perforated drums);
- (iv) Soaping and washing range by Benninger.

(d) Dyeing of piece goods:
- (i) Pad-jigg system;
- (ii) Pad-roll system;
- (iii) Pad-steam system;
- (iv) High temperature system in rolls;
- (v) High temperature system - Burlington dye backs;
- (vi) Cold pad batch process for reactive dyes;
- (vii) Thermosol process for synthetic and blends with tenter frames, hotflue, metal cylinders or the Artos Thermosol dyeing range;
- (viii) Continuous high temperature dyeing range of Konrad Peter or Benteler;
- (ix) Vat dyeing process Stanfast molten metal system.

Desizing, bleaching and dyeing of yarn:
- (i) High temperature system up to 140^{0} Celsius;
- (ii) Ordinary automatic yarn dyeing machines such as those made by Obermaier, Gaston County, Thies, and Scholl.

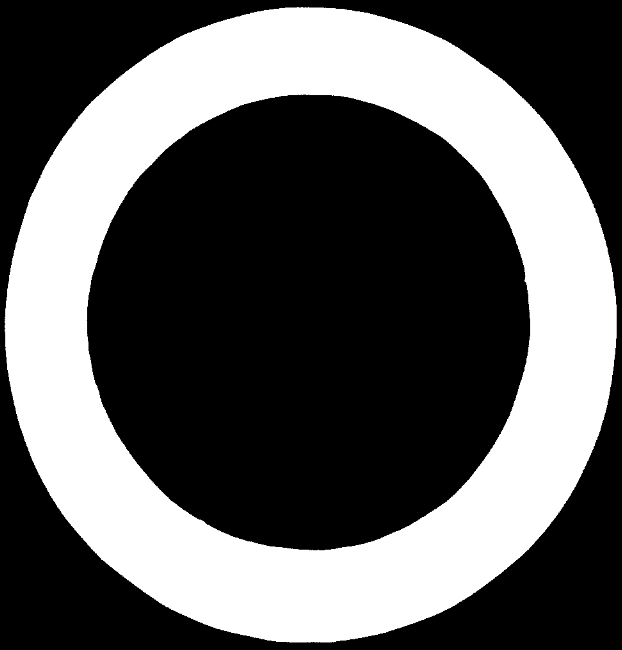
(e) Printing:

Roller printing:
- (i) New roller printing machine by Kleinewefer without mandrels (air pressure);
- (ii) Roller printing machine from Kleinewefer with reduced size of central cylinders;
- (iii) New roller printing machine from Kauscka-Brückner with individual pressure on each cylinder at an angle of 60^{0}.

Screen printing:
- (i) Buser system for synthetics; cloth to be printed is fixed to the blanket with heat-sensitive adhesive;
- (ii) Zimmer screen printing machine with metal rolls instead of rackles;
- (iii) Stork machine with seamless rotary screens;
- (iv) Zimmer machine with rotary screens.

(f) Drying machines:
- (i) Cylinder drying machine "Jetcyl" from Weston Evans;
- (ii) Brauckner with perforated tubes for knitted goods;
- (iii) Pegg with opener and pressing for knitted goods;
- (iv) Artos air dryer (Schwebetrockner).

(g) Thermofixation of cloth made of synthetic fibres:
- (i) Fixation with water overheated in a high temperature apparatus;
- (ii) System Vapotherm of Brueckner (drying and thermofixation);
- (iii) Artos and Montforts Thermosol system.



Chapter V. PLANT SIZE AND STRUCTURE

Economies of scale

Unquestionably economies of scale can be achieved when operating a mill under optimum or near optimum production conditions.

The problem of optimum size is an important one in many developing countries. Because of lack of capital, foreign exchange shortages or other reasons, small units are often set up which do not ensure the proper working conditions; they generally lack adequate buildings, air conditioning, and materials handling systems, and usually they are not operated economically because of insufficient workloads and the high cost of supervision.

In the last two decades the Economic Commission for Latin America (ECLA) undertook a number of studies, and some of the conclusions are reported below[6] The consensus of these studies was that in 1950 the lower limit for an economical cotton mill in Latin America would be about 25,000 spindles and [illegible] looms. For smaller developing countries, this would be too large, and other studies were therefore made, permitting the conclusion that units of even smaller scale can operate economically and efficiently although overhead administration costs are relatively higher if based on smaller output.

The United Nations Inter-regional Workshop on Textile Industries in Developing Countries held at Lodz in 1965[7] came to the general conclusion that an economical size for a spinning plant of a mill not integrated with weaving would be about 10,000 spindles, whereas for an integrated mill it would be about 30,000 spindles.

It should be noted that beginning at about 7,000 spindles and increasing up to around 25,000 spindles, investment and production costs per unit of output become progressively smaller. In some of the developing countries with limited markets, smaller size units may be of particular interest, since they avoid the need for large-scale capital investments and may also reduce technical and managerial problems. Thus smaller mills than the above-mentioned minimum size ones may be installed together with provision for future expansion which would achieve a better balance of equipment utilization and cost reduction. But it should be stressed that very small installations (less than 4,000 spindles) would give rise to disproportionate costs.

The process of growth of a textile mill should be gradual. At each step the alternatives of modernization, reorganization and expansion should be studied and the decision reached should be the result of careful evaluation of the existing situation, with a look towards future growth possibilities.

Theoretically there is no upper limit on optimum size as far as productivity is concerned. Yet when a mill expands beyond a reasonable size, productivity controls may decrease because management is not able to supervise effectively the functioning of a large mill. This may depend on the type of the mill: highly standardized mill producing only few yarn counts and few types of goods is easier to manage than one which is highly diversified, producing more elaborate goods.

6/ See also Tables 8, 9 and 10.

7/ See Recommendations and Report, First United Nations Inter-regional Workshop on Textile Industries in Developing Countries (Lodz, Poland), 29 September 1965.

Among the conclusions of the ECLA study[8/] was the observation that the greatest influence of economies of scale on investment costs as well as on production costs are noted in small plants of between 2,000 and 10,000 spindles. In larger units of 10,000 to 20,000 spindles the influence becomes less significant, and in mills that have 20,000 to 100,000 spindles even less so.

The economies of scale become more pronounced also where finer products are manufactured, for example those of higher yarn counts and higher fabric constructions.

For the three products analysed, coarse cloth, medium cloth and fine cloth, ideal mill sizes were established. From the point of view of the economy of investment 18,500 spindles and 830 looms for mills producing coarse cloth; 18,500 spindles and 680 looms for mills producing a medium type of cloth; and 18,500 spindles and 396 looms for those producing fine cloth.

From the point of view of economy of costs the ideal plant sizes were determined as: 10,000 spindles and 450 looms for coarse cloth, 18,500 spindles and 680 looms for the medium type and 18,500 spindles and 395 looms for fine cloth.

The decrease in investment costs from the initial mill size of 2,000 spindles and the ideal sizes decided upon are: investment per unit 21 per cent, 30 per cent and 40 percent for coarse, medium and fine cloth respectively; and production cost 19 per cent, 27 per cent and 40 percent respectively.

The cost factor decreases rapidly with the increase in the scale of production mainly due to fixed labour costs. Nevertheless in Latin America this item represents only from 3 to 9 per cent of the cost in balanced units.

The other important elements are direct labour and the depreciation factor. These two items plus fixed labour represents from 17 to 25 per cent of the production cost in balanced mills.

The idle capacity of equipment, inevitable in certain processes, has an effect on economies of scale in small-sized units but its importance decreases progressively becoming insignificant in factories with 20,000 spindles.

Idle capacity has a tendency to increase in importance in mills producing finer yarn counts: for instance a 2,000 spindle plant manufacturing coarse cloth shows an investment in equipment with an idle capacity of 8.5 per cent; a plant of the same size making medium and fine cloth increases it to 17.3 per cent and 30.2 per cent respectively.

A plant of ideal size having 10,000 spindles for coarse cloth and 18,500 spindles for medium and fine cloth would require a total investment (spinning, weaving and working capital) of about $5.5 million for coarse cloth, $7.1 million for medium cloth and $4.9 million for fine cloth. It should be mentioned that these investments could be reduced to $3.5, $4.0 and $2.8 million respectively if one were to decide to build a plant of the next smaller size. This would mean 6,000 spindles for coarse cloth and 10,000 spindles each for medium and fine cloths. This size would entail an increase in unit costs of only 2.5 per cent, 4.1 per cent and 5.7 per cent for products coarse, medium and fine cloths respectively.

The average cost per spindle is reduced substantially with the increase in size of the installation. Actually in the case of coarse cloth it decreases from $144 to $114; in the case of medium cloth from $110 to $77,

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[8/] United Nations Economic Commission for Latin America, "Economies of Scale in the Cotton Spinning Mills" (E/CN.12/748), January 1966.

and for fine cloth from $116 to $72. A similar situation exists in the case of looms, though to a minor degree.

The cost per spindle in place also decreases with finer yarn counts; one can note a reduction of 37 per cent between yarn count 8 and yarn count 40. However in the case of looms there is a reduction of only 6 per cent between coarse and fine cloths.

The more elaborate processing required by fine combed cloth also requires a higher investment per unit produced. For instance, in the optimum sizes mentioned before, the production of cloth of the finest quality requires an investment 2.8 times higher than that needed to manufacture the coarse cloth. This ratio increases as the mill size decreases and reaches 3.7 times in the case of a plant with 2,000 spindles.

In the optimum plant sizes an investment of between $14 to 18 thousand per person employed is calculated.

In the manufacture of medium quality cloth, productivity increases from 4,000 to 9,000 grams of yarn per man hour in the spinning and from 28 to 60 metres per man hour in the weaving as the size of the plant increases.

The percentage of gross value added is on the average 31 per cent for coarse cloth and 41 per cent and 51 per cent for medium and fine cloths respectively, calculating the interest on capital at 12 per cent per annum.

In the wollen field it has been estimated by various authorities consulted by UNIDO that the lower limit for a worsted mill in Latin America is about 5,000 spindles and around 50 looms, depending on the types of goods produced.

Attention should be given to the question of an economic size of finishing plant. This is difficult to define because of the diversity and technical complexity of the processes involved. A finishing plant may exist as part of an integrated mill, its size in harmony with the capacity of the mill; or as an independent unit serving several weaving plants; or as a larger plant able to process grey goods from a large number of looms.

The installation of complete, modern finishing equipment in a single weaving mill with a small number of looms is certainly to be avoided.

Integrated and non-integrated mills

Vertical integration in the textile industry means that more than one of the main stages of processing are grouped together in a single enterprise: spinning, weaving, dyeing, printing and finishing. Firms confining themselves to one stage of processing are known as non-integrated; those undertaking two stages, such as spinning and weaving, or weaving and finishing, are said to be partially integrated; and those processing finished piece goods from raw cotton to the finished goods are fully integrated. Integrated mills operate in one place; the term "non-integrated" is applied to those which may belong to the same enterprise but whose operations, spinning, weaving and expecially finishing, are practised in different locations. In the United States many piece goods mills are semi-integrated, that is they do their own spinning and weaving after which the grey goods are usually sold to converters and finished by them; or they are finished on commission. It is also frequently the case that a group of semi-integrated spinning and weaving mills have a single dyeing and finishing plant in common.

Table 8

Characteristics of the three types of fabrics selected by ECLA[a]

Specifications	Product A Coarse cloth	Product B Medium quality cloth	Product C Fine cloth
Type of yarn	Carded	Carded	Combed
Yarn counts (warp and filling) No.	8	18	40
Width of grey cloth (cm.)	80	90	100
Number of warp end per cm.	13	20	47
Number of picks per cm.	10	20	32
Weight of cloth per lineal metre (gr.)	140	130	130
Weight of cloth per square metre (gr.)	175	144	130

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[a] Economic Commission for Latin America (ST/ECLA/Conf.23/L.9/Corr.1) (E/CN.12/748).

Table 9

Selected plant sizes and respective production volumes[a]

Case	Spindles	Product A - Coarse cloth Annual production Yarn (metric tons)	Cloth (Thousands of metres)	Looms	Product B - Medium quality cloth Annual production Yarn (Metric tons)	Cloth (Thousands of metres)	Looms	Product C - Fine cloth Annual production Yarn (Metric tons)	Cloth (Thousands of metres)	Looms	Scale of production
I.	2,000	865	5,961	50	365	2,714	73	135	1,022	43	100
II.	6,000	2,596	17,886	270	1,133	8,415	226	405	3,067	130	300
III.	10,000	4,326	29,808	450	1,827	13,567	364	675	5,102	214	500
IV.	18,500	8,005	55,146	800	3,399	25,039	680	1,249	9,434	396	925
V.	26,000	11,248	77,503	1,170	4,750	35,273	950	1,755	13,265	560	1,300
VI.	37,000	16,006	110,292	1,660	6,797	50,478	1,360	2,498	18,870	800	1,850
VII.	60,000	25,956	178,890	2,700	10,962	81,399	2,190	4,050	30,602	1,280	3,000
VIII.	100,000	43,260	298,084	4,500	18,270	135,658	3,650	6,750	50,998	2,140	5,000

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[a] Economic Commission for Latin America (ST/ECLA/Conf.23/L.9/Corr.1) (E/CN.12/748).

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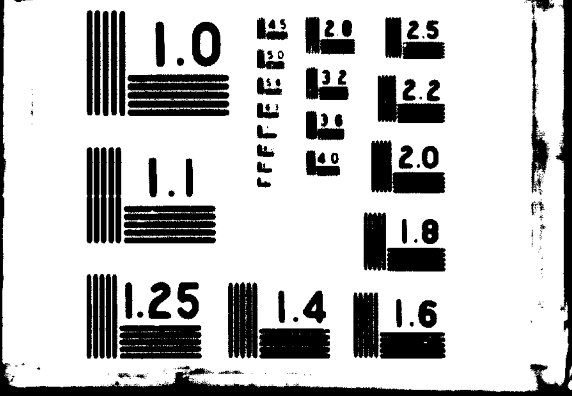

Table 10

Comparison of indices of production, investment, unit cost and idle capacity[a]

A. Product A: Coarse cloth

	Size		Index of production	Index of unit investment	Index of unit costs	Idle capacity %[b]	Necessary total investment (thousands of dollars)
	Spindles	Looms					
I.	2,000	90	100	100	100	8.5	1,386
II.	6,000	270	300	84	83	2.3	3,501
III.	10,000	450	500	81	81	1.7	5,635
IV.	18,500	830	925	79	80	0	10,132
V.	26,000	1,170	1,300	78	79	0.2	14,085
VI.	37,000	1,660	1,850	77	79	0.1	19,829
VII.	60,000	2,700	3,000	76	79	0	31,914
VIII.	100,000	4,500	5,000	76	78	0	53,163

B. Product B: Medium quality cloth

	Spindles	Looms	Index of production	Index of unit investment	Index of unit costs	Idle capacity %[b]	Necessary total investment (thousands of dollars)
I.	2,000	73	100	100	100	17,3	1,080
II.	6,000	226	300	75	78	1.1	2,550
III.	10,000	364	500	73	76	2.1	3,987
IV.	18,500	680	925	70	73	0	7,087
V.	26,000	950	1,300	70	73	1.2	9,958
VI.	37,000	1,360	1,850	69	72	0.1	13,978
VII.	60,000	2,190	3,000	68	72	0.2	22,386
VIII.	100,000	3,650	5,000	68	71	0	37,169

C. Product C: Fine cloth

	Spindles	Looms	Index of production	Index of unit investment	Index of unit costs	Idle capacity %[b]	Necessary total investment (thousands of dollars)
I.	2,000	43	100	100	100	30.2	885
II.	6,000	130	300	72	69	13.6	1,904
III.	10,000	214	500	63	64	4.3	2,797
IV.	18,500	396	925	60	60	1.7	4,924
V.	26,000	560	1,300	60	60	1.3	6,881
VI.	37,000	800	1,850	59	59	0.6	9,689
VII.	60,000	1,280	3,000	58	58	0.5	15,428
VIII.	100,000	2,140	5,000	58	57	0.5	25,691

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[a] Economic Commission for Latin America (ST/ECLA/Conf.23/L.9/Corr.1) (E/CN.12/748).

[b] Relation between investment in idle capacity and total investment.

Integrated mills are more common in developing countries as lack of experience in the marketing of intermediate products and lack of adequate sales possibilities force mills to integrate. Also, finishing and dyeing plants do not do a sufficiently good job and often cause losses through lack of care in finishing and off-colour dyeing.

Vertical integration on a regional level and the consequent limitation of the market for intermediate industrial goods are leading to more and more integration at the mill level. Sometimes this practice leads to production units that are not economical in size. The result is idle capacity, an unsatisfactory level of specialization, a lowering of machine efficiency and labour productivity, with raised costs.

One important influence upon mill integration is taxes, especially the so-called sales taxes. When the transfer of yarns to weaving mills and of grey goods to finishing mills is considered a sale, subject to a tax, then integration is forced upon mills by institutional factors unless the sales tax is modified in such a way as not to impede transactions between mills.

Trends towards the vertically integrated mill

As the textile industry becomes more capital-intensive making it essential to use machinery to the utmost and to organize work in shifts, structural changes towards the vertically integrated mill are taking place in both developing and industrialized countries. This influence is joined by the so-called "marketing approach", brought about by the increasing role consumers play in the determination of product design, and obliging manufacturers to pay attention to quality standards throughout all stages of production.

The new requirements are better served by a vertical structure, notwithstanding whether this is achieved with autonomous groups or through some loose form of interfirm co-operation. Vertical integration does not necessarily mean financial integration.

Because of the rising standard of living and the extension of time available for leisure, the textile industry has good prospects for expanding consumption. However, such expansion may only be achieved through continuous adjustment to the tastes and requirements of the consumers. This, in turn, entails more market research and sales promotion. It also involves closer co-operation with other sectors of the industry, in particular with apparel makers and major distributors such as department stores, chain-outlets and mail-order houses; such co-operation may eventually lead to vertical integration.

The steady development of man-made fibres and new processing techniques have contributed to breaking down the barriers which used to divide the textile industry into various fibre and processing sections. The modern textile industry is a multi-process, multi-fibre industry. As a result, machinery in modern spinning and weaving mills should be sufficiently versatile to handle any fibres, natural or man-made, within limits imposed by drafting requirements.

Standardization of products manufactured and limitation of product range have also become necessary in modern mills. The need for highly efficient manufacturing methods, production rationalization and quality control from raw material to finished article is likely to lead to fully vertical, partly vertical and horizontally integrated concerns, while small independent units will remain, some of them highly specialized.

Nowadays the high efficiency and productivity which must be achieved in textile enterprises entails a higher ratio of executive and research personnel and in some cases, higher skills or greater responsibility among operatives. Much will depend on good teamwork between management and workers.

Mill balance

A balance of production should exist not only between but also within the various mill departments.

There are two possible imbalances: the first, within a department; the second, between departments.

Imbalance within a department

There may be a shortage of capacity in carding or roving or even spinning; and individual machines may have to operate longer hours wherever possible, or else under forced conditions, as at excessive speeds and too heavy slivers or rovings. This may be detrimental to the quality of intermediate products and show up in such defects as a higher number of neps in card slivers or uneven roving. Excessive speeds in spinning may cause a high number of ends down.

Balanced equipment is therefore important, and any imbalance under normal working conditions should be remedied either by acquiring a new machine or adjusting the mill organization in such a way that the balance can be restored without endangering the quality of intermediate products. An example of mill balance and draft organization in a hypothetical spinning mill is shown in Table 11.

Table 11

Typical mill balance

Abbreviated calculation

	Picker
English count	0.0012
Prod./hr./del. at 100%	190 kg.
Expected % eff.	88
Prod./hr./del.net.	168 kg.
Stock required/hr.	168 kg.
Deliveries required	1 kg.
% waste	4.0

Combed

	Card	Sliver lapper	Ribbon lapper	Comber	First drawing	Second drawing	Roving	Ring-spinning
English count	0.14	0.097	0.097	0.14	0.14	0.14	1.00	30
Prod./hr./del. at 100%	8.00 kg.	480 kg.	480 kg.	13.6 kg.	44.4 kg.	44.4 kg	1254 g.	16.7 g.
Expected % eff.	95	70	70	92	80	80	65	92
Prod./hr./del.net.	7.60 kg.	336 kg.	336 kg.	12.5 kg.	35.5 kg.	35.5 kg.	796 g.	15.4 g.
Stock required	30.2 kg.	30.0 kg.	29.9 kg.	24.9 kg.	24.8 kg.	24.6 kg.	24.5 kg.	24.0 kg.
Deliveries required	4	0.10	0.10	2.00	0.70	0.70	31	1.550
% waste	4.0	0.5	10.5	16.5	0.5	0.5	0.5	2.0

Carded

	Card	First drawing	Second drawing	Roving	Ring-spinning
English count	0.14	0.14	0.14	1.00	24
Prod./hr./del. at 100%	12.50 kg.	59.6 kg.	59.6 kg.	1254 g.	20.4 g.
Expected % eff.	95	75	75	65	91
Prod./hr./del.net.	11.90 kg.	44.7 kg.	44.7 kg.	796 g.	18.6 g.
Stock required/hr.	132.0 kg.	131.3 kg.	130.7 kg	130.1 kg.	127.5 kg.
Deliveries required	11	2.94	2.92	164	6.870
% waste	4.0	0.5	0.5	0.5	2.0

There may be, of course, special circumstances in which imbalances occur for a short period, for example, due to changes in yarn count. It is up to management to work in the best possible way to alleviate the situation, and it can be tolerated only if it is temporary. Apart from the disruption of the normal manufacturing process, all plans and standards have to be temporarily suspended and production takes place in a climate which is not conducive to efficient operation. Therefore, any imbalance within a department should be avoided.

Imbalance between departments

In such cases experts agree that generally it is the weaving department that should operate fully and must therefore be supplied with a sufficient quantity of yarns. Production should be planned in such a way that weaving continues without interruption if demand is adequate. At times trends in the market are for heavier goods and possibly at other times finer goods are required. Such changes in production cause difficulties in planning, as coarser yarns mean higher production and possibly overcapacity in spinning, whereas finer yarns may cause shortages of yarns and possible loom stops. Also other changes, for instance in styles or width of the cloth, can cause temporary imbalanced conditions.

There are different ways of calculating and predicting the extent of any imbalance that exists between spinning and weaving departments, and with these exact calculations, steps may be taken in time to avoid any serious imbalance. This can possibly be done by asking the sales department to offer different styles, or perhaps to change to a slightly coarser yarn count, or use other types of yarns. It is necessary to purchase in good time yarn qualities and counts needed for these changes.

Chapter VI. MILL ADMINISTRATION

Mill controls

Progress in administration

In the last few decades, remarkable administrative progress has been achieved in the textile industries of the industrialized countries. The organization of labour has been perfected. Working methods have become more efficient. Training has been intensified and workloads have been determined through scientific approaches. Methods have evolved for controlling the quality of products, the efficiency of the various processes, the waste in raw materials, manufacturing costs and the yield per worker. In this manner it is possible to determine and correct all causes contributing to low productivity, defective quality and wastage of resources.

Up-to-date management consists of careful planning of operations and effective controls. Careful planning alone is not sufficient in a modern factory; effective controls are extremely important, especially in developing countries.

The establishment of correct standards is imperative, and these should be based on each mill's optimum performance goals. This of course, does not mean that international or regional optimum conditions should be disregarded; optimum results obtainable within a country or a region should be established and aspired to.

Every standard must be well figured out and form part of a co-ordinated programme. Some regional organizations, for instance the European Economic Community (the Common Market), have worked out standards for unit production, the number of workers per 1000 spindles and productivity in spinning and weaving which can be applied to all member countries. The Economic Commission for Latin America (ECLA) has also elaborated certain standards for spinning and weaving mills for Latin American countries.

The functions of modern management are: the proper organization of the mill and clear definition of responsibilities; planning production and developing suitable products; providing the best conditions for productivity, with equitable workloads; establishing quality controls, including fabric inspection, and cost controls; co-ordinating production and distribution; maintaining a labour-training programme; and marketing.

Some of these points, namely mill controls, quality controls, productivity, labour-training programmes and marketing are taken up in this chapter.

Control laboratory

At the heart of the system of controls is a special control laboratory, one of the most important and efficient tools of modern mill management. Here the programmes are established and the tests devised; decisions are taken upon their scope and method, number and frequency, and the time needed to accomplish them.

The mill control programme

An efficient mill control programme must include:

(a) Establishment of optimum production levels combining top speeds and efficiencies with satisfactory quality of product;

(b) Maintenance of the production levels by check-ups and analysis of down-time;

(c) Tests and controls made at strategic production stages from raw material to finished product, in order to pinpoint immediately deficiencies in production;

(d) Maintenance of adequate statistics to assist in detecting factors which cause sub-standard conditions before the deficient product causes problems in subsequent operations;

(e) The establishment of standards for waste and its controls;

(f) Establishment of a machinery maintenance programme;

(g) Quality control of in-process and finished products.

The following are some of the main features of a typical efficient mill control programme:

1. Control of raw materials; for example for cotton: checking of grade, fineness (in Micronaires), fibre strength, maturity, staple and moisture content; for wool, fibre fineness, staple, moisture and grease contents. There are various tests, applicable to other natural or man-made fibres.
2. Control of in-process products; only a few tests are enumerated to demonstrate the basis for such a programme:
   (a) Weight and uniformity of the picker lap;
   (b) Weight, uniformity and number of neps in card, drawframe and comber slivers; weight of cans;
   (c) Yarn count, evenness, appearance, resistance and elongation of yarns;
   (d) Weight, width, resistance, colour, number of threads in warp and filling, per centimetre or inch for gray and finished piece goods.
3. Production standards:
   (a) Elaboration of a mill balance;
   (b) Detailed calculation of production and efficiency of each machine or group of machines;
   (c) Size and weight of laps, bobbins, packages, cans and other items;
   (d) Standards for settings and speeds of equipment.
4. Testing programme:
   (a) Setting of standards and tolerances for raw materials, intermediate and finished products;
   (b) Setting of test procedures;
   (c) Elaboration of a control and testing programme with details and frequencies of tests;
   (d) Control and the reporting of results to management.
5. Waste control:
   (a) Establishment of the basis for wastes (Divisor);
   (b) Classification of waste;
   (c) Setting of standards of percentages of waste;
   (d) Waste reports.

6. Machinery maintenance programme:

(a) Preparation of a machine inventory;

(b) Preparation of an inspection plan and its time-tables;

(c) Programme of machine maintenance and preventive maintenance;

(d) Establishment of programme for the regular cleaning of halls.

Quality control

Responsibility of management[9/]

Quality control should receive a good proportion of management's attention. As long as a firm uses fibres, yarn or fabrics, has machines and employs labour, it has quality variations. Managements must never think that their product is so diverse that it cannot be controlled.

Effective control is not possible unless staff and managerial relationships are good. Quality products are not obtained by mere testing but by the state of mind of everyone in the mill. Given this state of mind, testing can ensure efficient and effective control; but no amount of testing can overcome apathy to quality control. The testing staff can be rendered ineffective simply because the management has not encouraged the control of quality by mill operatives.

Tact is required when introducing a control scheme. Production staff who have opinions about the probable causes of defects will not always agree that a person new to the job can provide useful information by analysing irregularities. Also, the testing staff must be careful not to ascribe to quality control the inherent qualities derived from the process, raw materials, and machines, and the labour.

As can be seen, mill and quality controls are a complicated matter and involve never-ending dedicated work which shows up favourably in the overall mill picture. The results can be summed up as better and more uniform quality of products, reduced costs due to operating with equipment of the highest efficiency, equitable workloads, and reduced waste.

Fabric inspection

The inspection of the fabric quality is one of the important functions of quality control. Some of the complaints frequently heard in developing countries are those concerning the quality of cloth and its deficient grading by factories, especially those operating in highly protected markets, to the detriment of consumers.

The grading of fabrics whether in the grey or finished state, has two primary functions: first, to classify them according to standard qualities such as first and second, based on the demands of the market and customer; and second, to supply information as to the qualities actually being produced.

The classifying or grading of fabric can be a most difficult and controversial task. A length of fabric acceptable to one person as first-quality piece may be accepted by another only as second quality. The situation is more complicated from the mill point of view because any given type or style of fabric may be destined for three or four different customers, each of whom

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[9/] Based on the lecture given to the Quality Control Group Conference, September 25, 1964, by R.T.D. Richards, M.A., B.Sc., A.Inst.P. (Wool Industries Research Assoc.).

has his own particular quality requirements. One of the main reasons for this situation is that no official standards have been established, recognized by the industry at large. Some segments of the industry have moved in this direction by installing what is commonly referred to as the "point system" by which each defect is assigned a certain value or number of points, so that when a certain total number of points is exceeded the piece is classed as second quality. This system has proved successful, and different versions of it are being adopted by many organizations.

The second object in grading fabric, that is, to supply management with information pertaining to quality level of the cloth being produced is of signal importance to the mill's quality control system and of vital interest to all levels of management. The profits of a mill are determined mainly by the percentage of first-quality fabric produced by the weave room, because there is little if any profit realized in the sale of fabrics classified as seconds. Also, any fabric sold as first quality but which the customer, after examination, does not accept as first quality could result in a claim for adjustment that might cost the company more in settlement than the profit realized from the entire shipment. In addition to cost, the data collected from fabric inspection supplies the quality control department and weave room management with a complete and unbiased tabulation of the magnitude and frequency of defects in the woven fabric. If the data is properly collected and analyzed, it will not only provide the necessary information but will also indicate their causes and sources. For example, the defects may be separated by style, by weaving defects in the warp or in the filling, by yarn defects in the warp or in the filling, or by the type of loom.

Fabric defects [10]

Fabric defects are generally classified as either "major" or "minor". The definition of exactly what constitute major and minor defects depends upon the type of fabric and the end use, as well as whether the fabric is being graded in the grey or finished state. For example, a defect that would be considered a serious, or major defect, in a high-quality combed poplin would probably not be classified in the same way in a low-quality carded print cloth. Also, some defects that are major in grey fabric become minor or disappear completely when the fabric is finished. By the same token some defects such as warp streaks become more pronounced after finishing though they did not show up in the grey fabrics inspection.

From the foregoing, it becomes apparent that one grading system cannot be used for all fabrics, which means that the description of a major and minor defect will also vary with the types of fabrics to which they apply, as well as with end uses and the prevailing market conditions.

In grey fabrics the following general descriptions have been used: [11]

(a) Major defect: A defect that cannot be repaired in the grey so as not to be obvious in the finished fabric;

(b) Minor defect: A defect that can be corrected in the grey or will be covered in finishing so that it will not be detected in the finished fabric.

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[10] Handbook for Testing and Quality Control

[11] Presented by W.L. Clement, Jr., Dan River Mills, at the Textile Division Conference, American Society for Quality Control, February 1956

For finished fabrics the following descriptions have been most successfully used by one of the large textile organizations:[12]

(a) <u>Subminor</u>: A defect which is not obvious and may not be noticeable at first glance: It is not so considerable as to produce in the garment a flaw that would cause it to be sold as a second. No grading points would be assigned to such defects, but if they occur with great frequency, this fact should be called to the attention of the responsible personnel. If an excessive number of this type of defect occurs in a single piece of fabric, consideration should be given to grading the entire piece as second;

(b) <u>Minor</u>: A fairly obvious defect, noticeable more or less at first glance, that might easily cause a defective garment. From 1 to 3 grading points would be assigned to such defects, depending upon its length;

(c) <u>Major</u>: An obvious defect that can easily be seen from a considerable distance and would most likely cause a defective garment. From 2 to 4 points would be assigned to this type of flaw, depending upon its length;

(d) <u>Critical defect</u>: This is a classification used for defects of such severity that they would cause a garment to be unsalable even as a second. For this type of defect, 6 to 12 points would be assigned, depending upon its length. A warpwise major defect over twelve inches long is automatically classified as a critical defect.

Some of the more common and serious defects should be mentioned. Filling slubs and warp slubs are probably the most common of all defects, especially in fabrics for light-weight garments, where in some cases they amount to 50 per cent of the defects in a piece. Following closely in frequency and importance are holes, broken picks, jerked-in filling, coarse picks, thick and thin places, and broken selvages.

In finished fabrics, typical finishing defects which appear with the highest frequency are overbleaching, stains, streaks, dye specks, overdying, over-shrinkage or under-shrinkage, creases, selvage to selvage shading, and end to end shading.

Common defects for fabrics woven from filament yarns include, in addition to some of those listed above, faults such as mixed yarns (mixed deniers, mixed filament counts, or both), shiners, twist variations, broken filaments, and reed marks.

Proper fabric inspection and grading is one of the aspects of textile manufacturing to which mills in developing countries should pay particular attention.

Productivity

Productivity is not a matter of isolated effort on the part of progressive industrialists; it is a mental attitude of society at large, that makes for progress and puts to work a country's available resources. The higher the productivity, the better the living standards of a country.

Productivity is the ratio of output to resources consumed. It is important to consider productivity as a means of lowering or keeping down production costs and the relative costs of other production factors, especially those of capital and labour. Though in the majority of industrialized coun-

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[12] Presented by Gardner Hailes, Avondale Mills, at the Textile Division Conference, American Society for Quality Control, February, 1955.

tries, especially in most Western European countries, capital is more plentiful than labour, the situation in developing countries is the reverse. There, capital is more scarce and obtainable only at high interest rates, while labour is plentiful and relatively inexpensive. For this reason, in those countries the adoption of highly automatic production systems would result in an extensive utilization of scarce resources, such as capital, and a limited use of abundant available factors, such as manpower.

Therefore a detailed calculation has to be made in each case for each country. At times in developing countries, old depreciated equipment in reasonably good condition might operate on a more economical basis than would modern machinery.

Factors affecting productivity and output levels

Analysis has brought out that sometimes two mills of exactly the same size, using machinery of equal obsolescence and having the same maintenance standards, can differ widely in productivity and in per unit output. This indicates that in addition to those three basic factors, several others are apt to influence the success or failure of a mill.

Take for instance the ringspinning section of a cotton mill. The technical and organizational factors which must be considered are:

(a) Unit output: Mills, though equal in size, type and up-to-dateness, as well as maintenance standards, may have a different unit output due to the speed and operating efficiency of spindles.

Spindle speeds depend primarily on the yarn counts, twist factors and yarn strength. Spindle efficiency is determined by calculating the ratio of the theoretically possible output of one spindle, operating at full capacity, to the actual output. Two modifying factors are present: avoidable and unavoidable stoppages. In theory, avoidable stoppages could be completely eliminated, as they are due largely to yarn breaks. The frequency of yarn breaks is determined by:

(i) Constant temperature and humidity which may be controlled by air conditioning and a humidity control system;

(ii) Spinning room cleanliness;

(iii) The quality of the roving, which depends on the quality of all previous operations;

(iv) The yarn count produced; yarn breaks occur more frequently on finer counts and these counts require more careful spinning preparation.

Although unavoidable stoppages cannot be eliminated, they can nevertheless be held to a minimum in a well-organized mill.

(b) Productivity: Workloads depend on three factors:

(i) The level of workers' training (which management should keep raising by constantly improving the training of the supervisors who are responsible for instructing the workers;

(ii) On yarn breaks, caused by the factors previously described, which lead to loss of output and loss of production time;

(iii) The workers' operating capacity.

Faulty atmospheric conditions, a dirty spinning room, poor quality roving, yarn count, small size of roving bobbins and yarn packages all affect productivity by reducing output per operator.

Usually, additional investment is needed to improve productivity; yet careful studies by capable management can formulate a programme that minimizes the necessary outlay and yet achieves essential improvements. The best available technical talent, a reasonable degree of machinery modernization and most practical temperature and humidity controls must be selected when investment is undertaken. Many limiting factors are directly controllable by management and can reduce the need for substantial investment: such as systematic machinery maintenance, regular cleaning of equipment and workrooms, selection of good raw cotton, sound production planning and the selection of proper labour and supervisory personnel.

Strict waste controls, which result in reduction of raw materials costs, and control of both avoidable and unavoidable machine stoppages will increase productivity without any investment. Time studies of machinery operations permitting the calculation of reasonable, efficient workloads should be made, and systematic studies of the operational process will generally make it possible to reduce production cycles and increase output, in many cases even reducing the physical effort required from the worker. Frank and friendly relations between management and workers lead to a fruitful co-operation often contributing to increased output and productivity.

It is clear that every phase of a process and all factors must be constantly studied and controlled and no problem overlooked or ignored.

Analysis of over-all operational deficiency

To analyse the factors affecting productivity levels we shall use the term "over-all operational deficiency" which represents the ratio between results actually achieved in the production process and those that could be obtained in an optimum situation with completely modern machinery and normal working conditions. However, there is still a third situation, midway between the existing situation and the more advanced technology which represents the improvements that could be obtained by better use of existing machinery. The ratio between this intermediate improved stage and the present situation could be called the "existing machinery deficiency". The difference between the over-all operational defiency and the existing machinery deficiency shows us how far obsolescence can be regarded as responsible for the deficiency observed.

To illustrate this concept, twenty-five cotton mills in Brazil,[13] with a total of 550,000 spindles, were selected. These mills could be regarded as representative of mills of the old type since their machinery mainly consists of items that need to be reconditioned or replaced.

Analysis of the twenty-five mills led to the following conclusions:

1. The coefficient for the over-all operational deficiency (OOD) indicated that the present level of efficiency could be raised by 91 per cent if all the machinery were up to date and operating at the optimum level.
2. The coefficient for the existing machinery deficiency (EMD) indicated that unit output could be increased by 61 per cent if the existing machinery operated at a level of unit output equal to the standard adopted.
3. Thus of the over-all operational deficiency of 91 per cent, 30 per cent could be attributed to the effect of machinery obsolescence (EMO).

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[13] **United Nations "The Textile Industry in Latin America:** II. Brazil" (E/CN.12/623).

Consequently, the existing operational deficiency of the machinery represents two-thirds of the over-all deficiency, and the obsolescence of the machinery the remaining one-third. Thus modernization of the equipment of the twenty-five selected mills would reduce the OOD coefficient by one-third, whereas it could be reduced by fully two-thirds through better manpower training, administrative reforms, improved production flows, better layout and use of better quality raw cotton.

Thus, re-equipment, although an important factor in improving operating conditions, should not be regarded as the only possible measure to be taken, since organizational measures could substantially improve operating conditions.

Measuring productivity

Productivity measuring figures can be based on two different systems. One would be to use as comparison a so-called standard mill with optimum organization and labour consumption for the respective departments. The second system would be the "Van den Abeele" system, in which the organizational index is worked out by comparing man-hours actually worked to produce one hundred kilograms of yarn (actual HOK) with the man-hours estimated under the specific conditions prevailing in the mill (expected HOK). The expected HOK process is worked out in each mill according to the equipment and conditions in the particular factory.

There are two ways of comparing productivity. The first is comparison of the total productivity of a country's textile industry with productivities achieved in other countries in the same area and stage of development. There is no question that the average national productivity figures might be based on considerable differences between maximum and minimum figures within a country. In the case of Venezuelan spinning mills, for instance, the highest production registered per man hour for weighted yarn count Ne 18 is more than 28 grams, and the lowest is less than 13 grams for very similar cotton yarn of the same count.

The total figures of a country have to be considered as a major identification of production levels, that can be used for comparisons among various countries.

The second type of productivity comparison refers to those made among factories within a country, analyzing not only country-wide production figures but also figures that concern the main departments or sections, with the aim of diagnosing as exactly as possible productivity and deficiencies.

The system of using standard mills for comparison purposes has many advantages and is easy to apply; it is therefore preferred by individual mills. The setting-up of the standard mill is not easy. Usually this work is undertaken by productivity centres in the various countries or regions, which take into consideration the production factors and the institutional conditions under which mills operate. Such major changes as the introduction of high production carding, higher speed machines and elimination of processes, have to be taken into account.

The Van den Abeele method which is used in Argentina, and principally for cotton spinning, employs no ideal hypothetical standard mill. It is a detailed evaluation of the productivity that can be achieved with existing equipment working at maximum efficiency and with the labour factor at the optimum level. This evaluation is made by determining the minimum time necessary to complete each direct or indirect production operation. Comparison between the actual results and the expected results show the productivity index. The Van den Abeele method is extremely valuable for the individual analysis of each mill and operation within the mill including department sections, but it is complex, and factories with deficient organization do not find it possible to utilize these methods, because of lack of detailed production statistics and controls.

The measuring of productivity by standard mills can be used effectively for making simple comparisons of productivity levels on a national basis, by ranking each mill under a code number indicating its position relative to the standard mill. The standard factory will be different for each country or for each region, depending upon the situation; setting up hypothetical regional standard mills will permit significant area comparisons.

Latin-American standards

In order to establish standard comparison mills for the Latin-American countries, the Economic Commission for Latin America (ECLA) evaluated standard mills for cotton spinning and weaving and also for the wool industry. Although these standards are being revised at present, the figures indicated give a valuable basis for productivity comparisons. The production figures are:

(a) Cotton spinning: Based on yarn count Ne 18 and on a production of 90 per cent carded yarn and 10 per cent combed yarn, the production is 4300 grams per man-hour. This includes the processes from the opening room through the cone winders.

(b) Cotton weaving: Based on a cloth with 2000 picks per metre and 100 centimetres wide, the production would be 27 metres per man-hour. This includes the processes after cone winding to the grey cloth, including warping, filling, winding, slashing and the weaving operation itself. All direct and indirect labour is included.

European Standards

In Europe, the cotton spinners of six countries, principally the common market countries, have established a standard mill with four basic indications:

(a) The unit production per spindle;
(b) The number of operators per thousand spindles;
(c) The output of yarn per man-hour;
(d) Man-hours needed to produce 100 kilograms of yarn.

All these figures are being calculated individually as each firm is ranked in the particular group. It may happen, for instance, that a firm with high unit output has also an excessive number of workers, or that a mill with lower unit output has a greater productivity because of optimum use of resources. As one indication, standards could be mentioned which are used in these European countries for yarn, made of best types of cotton, with a staple length of 1 3/8" and longer. Calculated yarn production would be 26 grams per spindle-hour, with 3 1/4 workers per thousand spindles. The production would be 8 kilograms of yarn per worker-hour and the HUK (hours needed for production of 100 kilograms of yarns 1/20's) would be 12.5.

These trends are especially remarkable because before the Second World War, Europe was known as "the continent of production secrets".

The reorganization of existing mills to achieve optimum production levels is possible and desirable, but often it is not easy to achieve. It is necessary to create conditions favourable to production and to improve production conditions. The first calls for improvement of deficiencies in air-conditioning, lighting, machinery layout and work policies; the second concerns such aspects as reduction of yarn breaks through the use of more suitable types of cotton or blends, the installation of pneumatic waste removal systems and travelling overhead cleaners, analysis of loom stops and better loom programme planning, the simplification of processes and transport, better material handling and positioning, increases in package and can size, simplification of manual processes including simpler operation through the use of patrolling systems, introduction of better supervision and improvement in machinery efficiency by better maintenance.

This short outline illustrates that optimum productivity is not easy to introduce and to maintain. It requires arduous daily effort and intensive work, often under difficult operating conditions.

Every aspect of mill planning must be brought to bear when the time comes for actual implementation and this will deal not only with such matters as proper electrical and water supply, but with the functional lay-out of equipment, streamlined flow of materials, up-to-date machinery and future possibilities of expansion.

Training needs and problems of technological transfer

The fear has been expressed that the low levels of education in most developing countries will severely limit the possibilities of introducing modern production methods into these countries. While this may be true of some industries, it does not seem to be necessarily true of the textile industry. Most of the mills which have been set up in the developing countries in recent years incorporate modern equipment, and by no means all of them have been operated unsuccessfully. The problem of technological transfer in textiles is most marked at management level. Operative skills, and even the skills of intermediate management, such as shop foremen and maintenance workers, are relatively easy to acquire except in man-made fibre production.

Methods of technological transfer

There are basically two ways in which foreign technology can be obtained for textile production, and these broadly correspond to differing stages of development. The first method is to import the mill which incorporates the advanced technology, complete with the key administrative personnel; the second is to acquire patent and production rights. Generally speaking, the first method is especially applicable to countries that have little or no experience of basic textile production - natural fibre spinning and weaving. It allows the country concerned to benefit from the advanced production techniques without having first to assimilate them. If the mill set up in this way is controlled entirely by expatriate staff, subject to the policies of a foreign firm, that is, an overseas branch of the parent company, then there is a danger that little of the advanced technology will be allowed to leak out to the rest of the economy. There may also be little attempt to train nationals beyond the level of intermediate management. The enclave system of production generally tends to have little dynamic effects. However, this "overseas branch" type of technological transfer is rather uncommon in the textile industry at least for production based on the natural apparel fibres. For some industrial textiles, such as cordage, and for man-made fibre production this system seems to be more applicable. As an alternative to a private enterprise "branch" it may be possible to transplant a mill as a result of government initiative. In this case, there is a better chance of the technology being acquired by nationals after a period, as the expatriate staff are usually required to train nationals up to all levels of management.

The second basic way in which advanced textile technology can be acquired by a developing country, is by the granting of patent rights and production licences. This method pre-supposes a higher stage of development in the receiving country. It is not generally applicable to textile industries based on the natural fibres, being more often concerned with the production of yarns from man-made fibres, usually synthetic fibres such as nylon, polyesters, and polyvinyl derivatives. In the nature of things, such technological transfers are negotiated between private firms, and while the Government of the developing country may encourage such a scheme, it can hardly initiate it. As the patent transfer takes place from strictly commercial motives, very little of the advanced technology will be allowed to leak out into the economy. The donor firm has expended considerable sums on research and development, and is unwilling to part with the results unless adequate remuneration is obtained.[14] Neither the donor nor the receiving firm will be willing to allow the technology to be obtained by third parties without similar payment. The royalty payments can be burdensome. The amount is usually fixed in terms of the annual quantity produced or sold, but sometimes a fixed sum is required to be paid each year irrespective of these.[15]

It is worth noting that the acquisition of technology from foreign firms implies the adoption of standards applicable to the plants installed in industrialized countries. Textile machinery manufacturers in these countries are reluctant to offer anything less than the most advanced machines available, but while certain features, such as automatic transportation devices, may be superfluous in the conditions of the developing countries, and can be dispensed with, the basic mechanism of the advanced equipment is usually substantially cheaper in terms of capital cost for a given level of output.

Each of the methods of technological transference outlined above involves considerable expenditure of foreign exchange. In both cases, the machinery and equipment will have to be imported, and the plant may be designed and constructed by expatriate engineers and architects, using, perhaps, highly capital intensive building methods. Resident expatriate management are relatively highly paid, and it is usually necessary to allow them to remit a substantial proportion of their salaries overseas. It will also be necessary to send several nationals overseas on government grants for some months of in-plant training in the donor country.

Methods of training

The problems of training staff for a new textile mill in developing countries can be examined under three heads: operatives; intermediate management; and top management.

(a) Operative training presents few problems. The development of textile equipment over the last few years has tended to reduce the labour content of a machine, while at the same time reducing the risk involved in its use - the human element. Far from becoming more arduous, operative skills are actually becoming simpler with less complicated operations being called for. Thus the training of machine operators can be achieved in a short period of around

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[14] It should be noted here that it is in the commercial interest of the donor firm to overvalue the benefits which can be derived from the patent transfer.

[15] At a given profit level, the reduction in unit production costs which will be permitted by the new technology clearly must be greater than the unit payments of the royalties necessary to obtain it. For a formal discussion of this theorem see Ing. E. Orosco, *Conocimiento Técnico Necesario para la Industrialización de Paises poco Desarrollados y Obstáculos que se oponen a su Transferencia* (ST/ECLA/Conf.23/6.12). A useful general study is given in *The Role of Patents in the Transfer of Technology to Under-Developed Countries* (E/C.5/52/Rev.1).

one or two months, usually in the plant itself. In many cases operatives can be left to learn the routine by watching other workers.

(b) For intermediate management and maintenance mechanics, the increasing complexity of the machinery has meant some rise in the skills necessary. Intermediate skills are best obtained abroad in the plant of the appropriate machinery manufacturers, who often make little charge for these services. The time period involved is usually from three to twelve months. The staff selected for this training will normally have some industrial experience, not necessarily in a textile mill. When they return from abroad, it is sometimes still necessary to employ expatriate staff for a short period to avoid start-up difficulties. In general, the level of intermediate skills required for the production of man-made fibres is higher than required for textile production based on natural fibres, and may take longer to inculcate. However, the developing countries which set up man-made fibre plants are normally relatively advanced, so that the fund of talent available for training is correspondingly larger.

(c) The training of top management involves the largest expenditure of foreign exchange. In some cases the key personnel may require to study abroad in technical colleges or universities for two or three years before taking over control of the mill from expatriate staff. In other cases the expatriate staff alone are expected to train their successors. Expatriate staff are usually recruited, sometimes by the firm supplying the machinery on a two or three year contract, and considerable pressure is brought to bear to have the staff completely nationalized at the end of that term. However, management skills consist mainly in adapting an organization to suit various circumstances rather than merely organizing a routine which is immutable. As this is a matter of experience rather than training, a period of two or three years from the start up of the mill is probably much too short.

Training schemes required

Much attention has been paid recently to the technological gap between academic training at a university or technical college, and the practical training on the shop floor. Generally, the knowledge acquired at a university or technical college tends to be theoretical. The instruction concentrates on the exploration of fundamental principles and phenomena, often by means of abstract mathematical formulae. Exploratory models are usually constructed on a theoretical basis rather than being derived from actual experience in a mill. Little attention is paid to the properties of individual machines manufactured by competing firms. Too little attention is paid to the commercial and business aspects of technological training. For these reasons, academic training must be supplemented by a considerable period of practical in-plant training. All too often, mills in developing countries are run by recent graduates from a technical school with no practical experience whatever.

A general outline of a desirable in-plant training programme for the textile industry in developing countries has been discussed recently 16/. The class should not consist of more than 25-30 persons composed of mainly graduates or students of textile engineering with no previous experience, together with men with work experience of the textile industry or similar

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16/ United Nations Centre for Industrial Development, Workshop on Textile Industries (E/C.5/101) 1965.

activities but with no academic training. The curriculum should include instruction on the applications and basic properties of both the traditional fibres and the newer synthetic fibres. Attention should be given to the potential of the modern methods of spinning and weaving, including the use of automation. This should be done with actual machines similar to the ones which are to be used in the new textile mill. Some attempt should also be made here to display the versatility of the various machines and to indicate the operating problems which they might encounter in developing countries. Optimum conditions and work loads should be indicated for each machine. Much attention should also be devoted to maintenance and repair requirements. The technological knowledge thus acquired will be of limited value unless it is supplemented by studies of mill management methods including the planning of production and mill distribution, cost and labour controls, and quality control.

The training envisaged above deals with technological considerations only. For mill management, however, commercial training is just as important. Bookkeeping is a very scarce skill in developing countries, but without an adequate account of inpayments and outpayments proper management becomes impossible. Again, some attention should be paid to the sources of commercial information such as international textile magazines, and U.N. and other international agency publications. Finally it is often desirable to impart even a rudimentary knowledge of market study methods, sales organization, and advertising.

Training institutes

Most developing countries suffer from a lack of specialist training schools for the textile industry, and thus have to send students abroad with a consequent loss of foreign exchange. It is worthwhile, therefore, to examine the question of the minimum economic size of training institutes. Considering the low proportion of technically qualified workers required in the textile industry, it has been suggested that the workforce should reach over 10,000 people, before a training institute for intermediate management and skilled workers specializing in the textile industry would be worthwhile. 17/ A minimum of 50,000 employees would probably be required before the erection of a special department at a University devoted to textile engineering could be contemplated. Such a department would probably have an annual throughput of 10-15 technicians and engineers. As many developing countries have workforces in their textile industries well below the minimum economic size, it may be possible to arrange these courses on a regional basis.

Marketing

Marketing is the integration of all functions in moving any type of goods from production to consumer. The marketing functions, as applied to the textile industry, are direct selling, customer service, product development, advertising, sales promotion, and market research, plus, of course, co-ordination with the manufacturing and financial divisions of the company.

Modern marketing must include the following:

(a) An individually tailored programme containing both long and short-range objectives;

17/ R. Hour, Policies Regarding the Development and Operation of Textile Industry in Developing Countries, paper presented to the United Nations Inter-regional Workshop on Textile Industries in Developing Countries, Lodz, Poland, 1965.

(b) A functional organization to carry out the marketing plan;

(c) An integration with the manufacturing and administrative components of the organization.

It is the task of a company's chief officer to maintain a balance among the marketing, production and administrative services.

Market research is continuous investigation of individual markets. It can be divided into two areas: internal and external market research.

Internal market research takes under consideration all past sales records in such categories as fabrics, styles and customers, in order to project sales expectations.

External research involves the organized collecting of information, from a variety of sources, as to what the customers are using and what portion of the total market the company is getting. It is field research in its strictest sense, providing a knowledge of what takes place in each market; the habits, prejudices and predilections of the customer; the prospects, competition, channels of distribution, spheres of influence and many other factors.

Market research can assist operations by establishing acceptable quality standards. It is essential in setting up realistic forecasts, production schedules, advertising and promotion needs and sales targets. It may also advise mill management with regard to the purchasing of raw materials, chemicals, dyestuffs and other needs.

Market research is also a tool for obtaining information on trends, particularly in connection with products based on changing living standards, new fibres and materials and general economic fluctuations.

The product development department is responsible for formulating and recommending plans for adding, changing, or discontinuing product lines. It prepares fabric specifications and manufacturing information to guide the mill in carrying out its experimental runs.

It is often advisable to have an independent group responsible for product development so that it can be free from the pressure of making rapid profits. Direction for the group should come from the marketing manager, who should certainly be the one best equipped to forecast the potential of a new product.

It is essential for the sales personnel to be kept up to date on its company's advertising and promotion programming.

The sales staff should be responsible for maintaining a pre-determined sales volume within the established price structures. Through market research, quotas can be set up and record systems used to predict what fabrics should be sold and in what quantities, during each period of the year. Such forecasts should be periodically compared with the actual sales efforts.

The importance of customer service is often overlooked. Many American textile companies are industry leaders today because of the effectiveness of this marketing effort. Others have suffered adversely when their deficient product service was unable to cope with customer demands.

With price and quality differentials between goods from various textile manufacturers becoming increasingly smaller, it is now up to the salesmen more than ever before to provide something beyond products at the right price in order to book the orders.

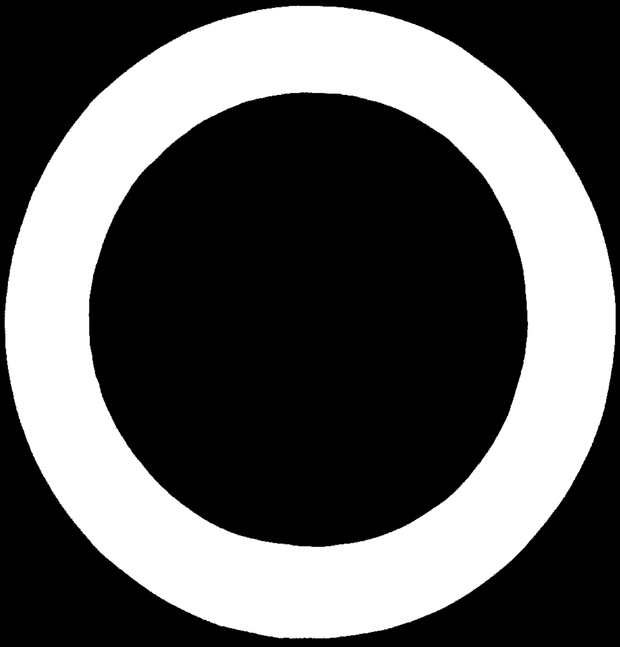
The synthetic fibre producers present excellent examples of customer service. While it is true that most textile mills cannot afford to do this as well as the fibre producers do, there is practically no textile organization that cannot do more by giving improved customer service the attention it deserves.

Marketing administration and control consist of (a) the marketing administration and (b) the production and sales co-ordination and inventory control. Proper functioning of the marketing departments staff divisions involves considerable handling of tremendous amounts of data. Analysis of orders as they come in, the need to keep up with inventories, goods in process and supplies on hand are only a few of the demands placed upon marketing administration and control developments in sales, market and production areas that must all be balanced constantly. This department is the closest link between the manufacturing and the over-all marketing programme.

Marketing administration is directly responsible for scheduling orders in keeping with manufacturing possibilities and requirements, for working with accurate up-to-date cost data, provided by the mill, so as to achieve the most economical operation possible. Their accuracy of forecasting and scheduling can do more to reduce production cost and the amount of capital tied up in investment and inventory than almost any other management function.

The marketing administration should also have the responsibility for maintaining inventories and for providing market research with accurate data drawn from past sales records and inventory control reports.

This can be done by setting up data processing equipment so as to get facts and figures as fast as possible, working directly from the original orders and comparing this data with sales forecasts, inventory, production schedules and other items.



VII. RECENT TECHNOLOGICAL DEVELOPMENTS AND THEIR APPLICATION TO DEVELOPING COUNTRIES

Policies in developing countries with regard to automation

Automation is not only revolutionizing textile machine manufacturing and mill operations but causing economic upheavals that undoubtedly will have repercussions. Many developing countries, intent upon building up their own textile industry, are eager to set up modern and sophisticated plants that may neither satisfy their desire to absorb significant numbers of available labour, nor their ability to compete effectively with highly developed mills in countries more industrially advanced. Others among the developing countries are installing less sophisticated, even good secondhand equipment, which is becoming increasingly available in the United States and in Europe, which is likely to utilize more of the available manpower and at the same time require operation and maintenance of a less complicated nature.

Whatever course the developing countries choose in establishing their own mills, they will rely on the more developed countries for the supply of machinery, equipment and techncial know-how for many years to come.

Transition to automatic equipment

The revolutionizing trend towards partial or full automation keeps manufactures, especially those with recent large investments in conventional euqipment, greatly preoccupied. However, as these changes are being introduced gradually, their equipment will not become obsolete overnight.

Textile machinery builders are conscious of the fact that present-day equipment cannot be discarded for some time to come, and they have therefore been developing numerous special attachments for these machines which permit a certain amount of automation with existing equipment. These modifications and attachments have become familiar to spinners and weavers everywhere. There have been installations of high draft attachments and replacements of small spinning packages by larger ones. The replacement of small cans by large ones is common and of great value to mills that have not long ago made substantial investment and do not find it justifiable to replace their equipment with completely new machines.

Another popular change-over is the rebuilding of conventional cards to high production units by means of an attachment manufactured in both the United States and Europe. Both the card comb and the comber box are removed from the front of the card, and card web crush rolls, which pulverize the dirt and other impurities in the web and parallelize the fibres to some degree, are installed. In combination with metallic card clothing and the replacement of cylinder and doffer bearings, this attachment may permit an increase in production of up to 400 per cent. The cards produce up to forty or fifty pounds of sliver of a superior quality and strength against the mere twelve pounds obtained previously.

A potential saving can be achieved also by an attachment permitting automatic doffing and possibly going even a step further by combining the doffing and winding operations on the spinning frame or transporting bobbins to an automatic winder without manual handling of material.

Installation of Unifil attachments to looms has been another step towards automation in weaving departments. Naturally, the installation of an automatic winder may go a long way towards reducing handling and winding costs.

Problems of automation

While considering the advantages obtainable through automation, mills in developing countries might well consider the disadvantages inherent in an automatic system which requires much better maintenance and higher skilled mechanics and at the same time does not absorb a sufficient quantity of the labour available. In the spinning department for example with previous techniques, usually two to four operators per 1000 spindles were employed. The automatic system requires just about one skilled operator or even less per 1000 spindles.

Automation may, however, be attractive for developing countries if besides labour savings, substantial advantages, such as less material handling and a more uniform quality of the intermediate product, can be obtained. It may be possible to produce a more even card or drawing frame sliver in one operation through carding or drawing, as no manual material handling or positioning takes place and human error is reduced to a minimum. If the same operations are non-automated, variations in the picker lap might occur, or the picker lap might be damaged during transportation or by bad manual handling.

Automated, semi-automated, non-automated and "systemated" cotton spinning; comparisons of these systems

1. The Saco-Lowell semi-automated spinning system

Saco-Lowell Shops in South Carolina, U.S.A. has designed its automated machinery for versatility so that certain units can be phased in with conventional machines. With this arrangement, a mill can choose machines or components best suited to its particular requirements. For instance, in fibre preparation a completely automated system operates from the bale of raw stock through the first drawing. Mills running small lots with frequent changes would be at a disadvantage with this system because all the stock would have to be run out for each change, and the output gained by means of the continuous automated processing would be offset by downtime for changing stock.

For such mills an alternate method is available that utilizes a single-beater picker and lap-fed cards. By this method a set of laps can be run and, by inserting manual handling of stock at this point, all the machines can be kept in full production with the stock allotted when and where needed.

The continuous automated system uses the Blendmaster bale-plucker, which removes fibres from five slabs of stock simultaneously. In the model mill, four of these bale-pluckers deliver into a control reserve box, which gives a twenty-bale mix. A reserve bale of stock is manually loaded onto the feed table of each bale-plucker and the bagging and ties are removed. No further manual labour or control is needed until full cans of breaker-drawn sliver are ejected from the coiler of the drawbox.

Conveyor tables pass the slabs of stock back and forth over revolving beaters. The beater pins pluck the stock from the slab in almost individual fibre form. The stock is transported by air to the reserve box. Trash and dirt are cleaned from the stock in the process, these heavier particles being diverted by baffles as they are removed.

The slabs of stock are arranged in step formation so that the reserve bale is fed to the first beater when the slab nearest the opposite end of the bale-plucker is almost exhausted. Each slab is indexed forward to the next beater section every time a fresh bale is added. The remainder of the last slab - about twenty to thirty pounds of stock - is routed to an opener-cleaner and thence into the main stream of stock at the reserve box.

From the reserve box the stock is conveyed by belt to chutes located at the back of revolving flat cards. As mentioned earlier, a picker can be used and the cards can be lap-fed instead of using the chute feed system. The cards are coupled in line with a common drive shaft, driven from a single motor. Stock is fed to the card licker in slightly compressed form, prepared by fluted feed rolls at the base of the chute. Each card processes twenty-five pounds per hour and is capable of even higher production.

The cards do not have coilers. The web is removed from the doffer by rolls, passes through a vertical calender over a turning bar, and is deposited upon a conveyor belt. The slivers are in ribbon form and they are stacked one upon the other to form a rectangular sandwich which is delivered by the conveyor belt to the rolls of the drawbox at the end of the card assembly.

The drawbox has an output speed of 1600 feet per minute and delivers into 24 by 48-inch cans. The full can is doffed automatically and an empty can is placed in position by the same mechanism. Automatic controls slow, but do not stop the cards and drawbox during the doffing operation.

In the model mill after the finisher drawing, and the comber lap preparation, there are Saco-Lowell Versamatic drawing frames of two deliveries each. These drawing frames have power-driven creels, fluted calender rolls; they operate at speeds up to 800 feet per minute, and deliver into 20 by 48-inch cans. The sliver for carded yarn goes directly from finisher drawing to the frames. The stock for combed yarn is processed into laps by Saco-Lowell's 10 1/2 inch lap winder and goes to the comber. These combers have electric controls and full stop motion coverage. Each comber has twelve heads delivering into 18 by 42-inch cans, and operates at 140 nips per minute. Versamatic frames are used for post-comber drawing.

Roving is processed by the Rovematic, Saco-Lowell's high-speed roving grame. This machine is available in six different models that have the versality to process 90 per cent of the fibres produced commercially. The machine is capable of flyer speeds of 1200 to 1800 r.p.m. and produces either a 14 by 7-inch package or a 12 by 5 1/2-inch package, depending upon the model.

The spinning, utilizing Saco-Lowell's Spinomatic spinning frames, has an automatic doff preparation system and bunch builder. It can also be equipped with an automatic two-speed regulator to enable it to operate at the highest practical speed during different stages of the bobbin build.

The doff preparation system senses a full bobbin, builds a tip bunch (when required), places the ring rail in doffing position, tilts the thread guides, stops the frame, and signals the operator by means of an indicator lamp. The system also takes over the controls when the doff is completed, builds a filling bunch (when required), jogs the ring rails, and starts the regular bobbin build before relinquishing control to the frame mechanisms.

The Twin Automatic Doffer is used in the model mill in conjunction with the Spinomatic spinning frame. This doffer has twin units that proceed down both sides of the frame simultaneously, doffing full bobbins and donning empty ones. The complete doffing sequence is automatic from the time the operator positions the assembly at the frame until the doffing units return to the control unit after restarting the frame.

The model mill also has a winding process, the yarn being placed upon cones or cheeses by a travelling spindle winder. This winder is supplied by Saco-Lowell's automatic cop-feeder. The feeder stores up to 1000 bobbins of yarn on a horizontal feed table and they are fed by an inclined table to a rotatory magazine. The magazine supplies a knotter, which splices the end of yarn of the bobbin to that of the cone or cheese on the winder head. The bobbin is automatically placed on the delivery spindle of the winder. The feeder has provisions for sorting piece bobbins from the empty ones as they are doffed from the winder. A secondary conveyor feeds these piece bobbins back to the magazine.

Comparison of Saco-Lowell semi-automated spinning system with up-to-date non-automated mill

Such a comparison is very interesting, and some definite conclusions can already be drawn, although the semi-automated and automated mills are still to be considered at an initial stage. Of course, there already exist mills which operate with such equipment.

The following comparisons are based on a plant construction by the Saco-Lowell Shops.

The spinning that is being compared consists of 2 lines of pickers, 72 cards, 12 drawing frames with 2 deliveries each, 8 combers, 4 roving frames with 80 spindles each, and 66 spinning frames with 384 spindles each - a total of 25,344 spindles.

The difference between the automated and non-automated equipment consists in that the first processes - from opening through picking and carding up to the first drawing - are continuous. The roving and spinning remain unchanged, except that an automatic doffer does the doffing and positions the bobbins to automatic winders.

The mill is expected to produce approximately 250,000 kilograms of yarn monthly, in 120 working hours per week, average yarn count 24's (English count) of which 50 per cent is carded and 50 per cent is combed.

Labour complement: Details of the labour complement can be seen from table 12, which demonstrates that for the non-automated mill 1.77 workers are needed per 1000 spindles shift against 1.20 for an automated unit. Probably the figure for the automated mill could still be slightly reduced.

Table 12

Labour complement per three shifts of the Saco-Lowell cotton spinning mills (25,384 spindles)

	Non-automated 1963/1964	Semi-automated 1965
Opening and cleaning	12	6
Cards	12	3
Drawing	12	3
Combing	6	6
Roving	6	6
Spinning	24	24
Doffers	16	3
Overseer	1	1
Mechanics	6	6
Shift foremen	3	3
Secretary in charge of lab.	2	2
Direct workers	100	63
Indirect workers[a]	36	30
Total	136	93
Average:		
per 3 shifts, operators per 1000 spindles	5.30	3.60
per shift, operators per 1000 spindles	1.77	1.20

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a/ For traveller changing, oiling, card grinding, buffing, overhauling, transport and cleaning.

Spindle cost: It should also be mentioned that the price per spindle for the non-automated mill varies between $80 and $85, while the automated spindle costs between $100 and $110.

2. The "systemated" mill [18] Whitin Machine Works

Whitin Machine Works, Whitinsville, Massachusetts has developed a semi-automatic mill, called the "systemated" mill to describe the two concepts which form the development: systems and automation.

The process from opening to carding is continuous. Whitin uses Aerodynamic cards. The two drawing processes are non-automatic; so is the roving process. The Whitin systemated mill uses a so-called creel staging area, and the automatic doffer, Audomac, deposits a full creel of empty roving bobbins from the spinning frame in this area.

18/ D.G. Dockray, "The Systemated Mill", Textile Industries, Feb. 1965.

Roving: The protable roving-bobbin cleaner is positioned and actuated manually by a roving tender. It then moves automatically down to the creel in its staging area mount while rotating suction cans encapsulate each of the bobbins to remove any remaining layers of roving.

After the bobbins are stripped, the creel is ready to be transported in quarter sections to the roving frames. This is done by a light crane which operates only within the roving and staging areas blocked, by automatic signals, from collisions with the Audomac doffer which enters the staging area only to pick up or deposit spinning-frame creels.

Above the roving frame, the light crane with one quarter of the spinning creel holds empty bobbins for the roving spindles. As the operator removes these from the creel, he replaces them with full bobbins of roving; all further handling, boxing, or trucking of the roving is eliminated.

The small crane indexes as the operator works his way down the frame; it can be stopped by a foot pedal if necessary.

The cycle of creeling at the roving frame is repeated until the four sections of the spinning-frame creel are filled. The creel is then ready to be transported to the spinning frame by the Audomac.

Spinning: The cycle begins when a spinning frame signals to the Audomac that it is ready for doffing.

The spinner (or other operator) presses a button on the frame, which automatically winds down the ring rail, raises the balloon control rings and thread boards, and starts the doffing operation. The Audomac removes the full bobbins and replaces them with empty bobbins, then takes the full bobbins to the loading station, where it drops them off and takes on a fresh supply of empty bobbins. This is all done automatically.

When a new creel of roving is needed, the Audomac is sent ot the proper spinning frame, where it picks up the empty creel and proceeds to the staging area with it. There it picks up a full creel and returns to the spinning frame. This is done under the direction of the operator.

At the bobbin loading station the full bobbins are boxed, properly oriented, and taken by conveyor to the Foster-Muller Automat winders, to which in the near future they will be fed automatically. Empty bobbins go back to the station on a conveyor for return to the system.

While the full bobbins are being boxed, they are electronically monitored for bobbin shape and formation. Off-standard bobbins can be pinpointed as to the spindle they came from, making it possible to check on the causes of excessive ends down. Empty bobbins returned from the Automats are sorted, oriented, and fed into cleats to be picked up by the Audomac. Defective bobbins are automatically rejected.

Labour complement: Average 0.97 operators per 1000 spindles. The total estimated machinery investment is, as can be seen from table 13A, approximately $120 per spindle.
Production costs: The accompanying series of tables show the organization and costs for a systemated mill with 29,568 spindles designed to produce 1463 pounds per hour of 20's and 26's carded cotton knitting yarns. The total labour cost per pound would be 3.81 cents. A fair estimate is that the per pound labour cost for the same yarn in an existing mill with typical facilities and machinery would be in the neighbourhood of 9 cents.

Comparison between European semi-automated and conventional up-to-date spinning equipment

1. The Ingolstadt system

Previous comparisons between automated, semi-automated and non-automated spinning mills were made on the basis of equipment constructed by American machinery builders. Figures representative of European-made equipment are provided by the German spinning machinery firm of Ingolstadt concerning six different spinning plants, from conventional to automated model plants. Productivity comparisons are made for up-to-date plants now under construction as well as those planned for the near future. Quotations for the latter plants are estimated and subject to revision, but this does not substantially effect the figures.

The accompanying tables will show the comparative cheracteristics of the six spinning plants.

The following comments should be made regarding the cost estimates and requirements of the operator, expressed in table 19.

The calculations are based on three shift operations with 7000 hours yearly. Wages and salaries are based on operating conditions in the Federal Republic of Germany, the wages for a non-automated plant being calculated relatively lower, since an automated plant requires personnel possessing higher skills.

The costs of electric power are calculated at DM 0.08 per kWh, a price which will, of course, very for different countries, cities and plants, as will the amount for depreciation and interest and the building construction costs (estimated in the Federal Republic of Germany at DM 500.- per m^2).

These indications. however, form a good basis for comparison of the different projected plants anywhere. Naturally, the costs are only partial cost, and include factory wages and salaries, depreciation cost, interest and cost of electric power. Notwithstanding all such limitations these figures will form a valuable guide for cost comparisons of various types of spinning plants.

Table 13

A systemated cotton spinning mill (29,568 spindles)

A. Machinery list

6 bale pluckers (six-bale)

6 conveyors, gravity feed (six-bale)

2 blending hopper feeders, MBH

1 waste feeder, MBA

4 fibre separators, FC831F, 36"

4 fibre separators, FC831, 36"

1 Axi-Flo cleaner, Model B

1 opener-cleaner, HOS

3 two-way distributors

6 hopper feeders, KN

4 fine cleaners, SMSR

4 material-transport fans

4 condensers, LVZ

4 material-return controls

38 chute feeds

38 aerodynamic cards

14 filters, SF144

1 control panel

1 roving waste machine

4 blowers

6 breaker drawing frames, M7C; power creels; nested 24" cans; coilers to accommodate 20" x 48" cans, crush rolls

6 finisher drawing frames, M7C; power creels, nested 24" x 48" cans, crush rolls

12 Scotsman roving frames, 84-spindle (total 1008 spindles), 14" x 6 1/2" x 10", long draft

16 staging area positions (8 per bay); equipped with automatic bobbin-stripping devices (one for each two bays)

88 Vanguard spinning frames, 336 spindles each (total 29,568 spindles), 3 1/2" gauge, 10" traverse, 2 1/4" rings; Unitrol top rolls and saddles; combination builder (filling wind); Whitin automatic wind-down device; sectional creels on frames

12 extra sectional creels (six per bay) in staging area

24 Foster-Muller Automat winders

2 Audomacs, including frame-cleaning trunks, vacuum sweep collection, ceiling fans, and automatic tube-handling systems

1 small hoist for transporting spinning creel sections between roving frames and staging area

2 conveyor systems for transporting full tubes from tube-handling station to Automats

2 conveyors for transporting empty tubes from Automats to tube-arranging devices

Total estimated machinery investment	$3,565,083.00
Estimated machinery investment per spindle	$ 120.58

Table 13 (cont'd.)

B. Labour and wage schedule

	Employees per shift 1st	2nd	3rd	Employees per operation
Opening through drawing:				
Bale opener-plucker loader	1	1	1	3
Card tender	1.5	1.5	1.5	4.5
Drawing tender	1.5	1.5	1.5	4.5
Section hand	1	1	1	3
Card setter-fixer	1			1
Overhauler	1			1
Sweeper-can hauler	1	1	1	3
Utility	1			1
	9	6	6	21
Roving through winding:				
Roving tender	3	3	3	9
Spinners	4	4	4	12
Audomac operator	2	2	2	6
Section man	1	1	1	3
Roll picker	1			1
Traveller changer	1			1
Cleaner-creel pcr.	2	2	2	6
Overhauler and spindle setter	1			1
Overhauler-helper	1			1
Utility hand	1	1	1	3
Section man, winding	1	1	1	3
Winder tender	4	4	4	12
Utility hand, winding	1	1	1	3
Inspecting, wrapping, packing, etc.	2	2	2	6
	25	21	21	67
Totals	34	27	27	88

Wages, avg. $1.65 per hour, 40-hour week	$5,808.00
Fringe benefits at 15%	871.20
Total weekly labour cost	$6,679.20
Hourly production, standard pounds spun	1,468
Winding waste, %	.05
Net lb. wound/hr.	1,461
Hours operated per week	120
Total weekly production, lb.	175,320
Cost per pound	
Opening through drawing	$ 0.0077
Roving through winding	0.0304
Total cost per pound	$ 0.0381

Table 13 (cont'd.)

C. Production

Carding

Sheet fed, oz./yd.	16
Total grains/yd. entering	7,000
Draft (3.5% waste)	112.6
Grains/yd. delivered	60
Lb./card/hr. at 100%	45
Efficiency, %	95
Lb./card/hr. actual	42.75
Lb. required/hr.	1,537
Cards required	36
Cards recommended	38
Net lb./can, 24" x 48" (estimated)	80

Drawing:	Breaker	Finisher
Sliver fed, grains/yd.	60	60
Doublings	8	8
Total grains/yd. entering	480	480
Draft	8	8
Sliver delivered, grains/yd.	60	60
Delivery roll, feet/min.	1,000	1,000
Lb. delivered/hr. at 100%	171	171
Efficiency, %	75	75
Lb. delivered/hr. actual	128	128
Lb. required/hr.	1,529	1,521
Deliveries required	11.9	11.9
Deliveries/machine	2	2
Machines required	6	6
Can size	20 x 48	16 x 48
Net lb./can (estimated)	56	40

Roving:	Hank	
	.75	.95
Sliver fed, grains/yd.	60	60
Draft	5.40	6.84
Size roving bobbin	14 x 6 1/2	14 x 6 1/2
Net lb./roving bobbin	4.75	4.75
Twist multiple	1.40	1.40
Tpi	1.21	1.37
Spindle r.p.m.	950	950
Front-roll diameter, in.	1 1/8	1 1/8
Front roll r.p.m.	222	196
Lb./spindle/hr. at 100%	2.0756	1.4467
Efficiency, %	80.4	83.9
Lb./spindle/hr., actual	1.6687	1.2138
Lb./required/hr./bay	575	179
Spindles required/bay	345	148

Spindles/frame	84
Frames required	12
Actual spindles	1,008

Table 13 (cont'd.)

Spinning:

	Count	
	20's	26's
Hank roving	.75	.95
Doublings	1	1
Draft	26.67	27.37
Twist multiple	3.35	3.35
Tpi	14.98	17.08
Spindle r.p.m.	8,900	9,700
Traveller feet/min. (approximate)	5,242	5,714
Front-roll diameter, in.	1	1
Front-roll r.p.m.	189	181
Lb./spindle hr. at 100	.05891	.04339
Efficiency	95.1	95.6
Lb./spindle hr. front roll	.05602	.04148
Contraction, %	4.03	4.03
Lb./spindle hr., actual	.05376	.03981
Frames	62	26
Spindles	20,832	8,736
Std.lb.spin/hr.	1,120	348
Net lb./bobbin (estimate)	.31	.31

Doffer utilization:

	Count	
	20's	26's
Doffing cycle, hr.	5.77	7.79
Frames/bay	31	31
Doffs/hr.	5.4	1.7
Doffs/bay/hr.	7.1	
6 min./doff and clean	42.6	
Min. power creel/frame	10.0	
Extra doff (if desired)	6.0	
Maximum total use, min.[a]	58.6	
Maximum total use, %	97.7	

Waste allowances and stock requirements:

	Hank roving		
	.75	.95	Total
Yarn spun, lb./hr.	1,120	348	1,468
Waste at 2.5%, lb.	29	9	38
Roving, lb./hr.	1,149	357	1,506
Waste at 1.0%, lb.			15
Finisher drawing, lb./hr.			1,521
Waste at 0.5%, lb.			8
Breaker drawing, lb./hr			1,529
Waste at 0.5%, lb.			8
Card sliver, lb./hr.			1,537
Waste at 3.5%, lb.			56
Opening and cleaning, lb./hr.			1,593
Waste at 3.0%, lb.			49
Raw stock required/hr., lb.			1,642

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[a] Based upon creeling hour.

Table 14

Plant I (Spin plan BW 410/2755a)[a]

Blowroom

8	bale-openers: model BB1; inner width, 750 mm. The stock is introduced by a feed lattice 2.5 mm long	
2	conveying belts, model MTT	
2	dust exhaust fans, model SV 1	
4	condensers, model KD 1	
4	feeding chutes, model FS 1	
4	stepwise cleaners with 6 beater rollers STR	
4	horizontal openers and cleaners HO 1	
2	pneumatic two-way distributors	
4	scutchers, model SM 1	
2	electric control plants, complete with cabinet ES 2	
1	piping complete	
6	dust cage single filters, EF 2	
	Total price of blowroom	DM 740,895

Spinning department

124	cards, model KB; working width 950 mm. (about 37"), sliver delivery in coiler for cans 18" in diameter and 42" in height (450 mm. x 1066 mm.); cylinder with steel wire clothing; flats with special clothing	
	Price at DM 22,325 per card	DM 2,768,300
	Grinding equipment	DM 23,440
8	high speed drawing frames, model SB 64 with 4 deliveries and central drive for processing cotton and staple fibre up to 60 mm. in length; draft system: 3 over 4, with spring weighting from above; coiler arrangement for cans 18" x 42". Machine can be sunk into the floor, 35 mm. Delivery speed: 140-160-180 m./min.	
	Price each, DM 43,035	DM 344,280
8	high draft speed frames, model 6; for sliver Nm 1.0-2.4 with 96 spindles each; 260 mm. gauge, 300 mm. lift; 4 rollers; two-zone double apron draft system, with pendulum weighting arm PK 500; needle bearings for 4 lines of rollers; meter counter for pre-fixed sliver lengths; LTG pneumatic stop	
	Price each, DM 87,035	DM 696,280

Table 14 (cont'd.)

64 ringspinning frames, model RB 10; 400 spindles each, 75 mm. spindle gauge, 50 mm. ring diameter, 280 mm. lift, with HF2 spindles for paper tubes of 230 mm; double-apron high-draft system, with pendulum weighting arm, PK 211 E 60, and needle bearings for 3 lines of rollers. Drive by squirrel cage motor on tension rails.

Price per machine, motor included	DM 76,845	DM 4,918,080
Total price of spinning department		DM 8,750,380

Total price of Plant I

Blowroom	DM 740,805
Spinning department	DM 8,750,380
Tentative FOB price	DM 9,491,185
Without spare parts and accessories; approx.	DM 9,500,000

Plant IIa (spin plan BW 2818)[b]

2 automatic feeding and blending units with four pickers and automatic lap changers

32 high production cards with cans 16" x 42"

8 high-speed drawframes, with automatic can transport system

8 roving frames with 96 spindles each; 260 mm. gauge; bobbin size 12" x 7"

64 ringspinning frames with 460 spindles each; 75 mm. gauge; 50 mm. ring diameter; bobbin length 240 mm.

Total price DM 8,190,000

Plant IIb

Same equipment as plant IIa, but ringspinning department is equipped with cop doffing machines. The cop doffing machine moves along the ringspinning frame and doffs successively one cop after another. It can be moved from one spinning frame to another.

Total price DM 8,670,000

Plant III

2 automatic feeding and blending units with bale-openers but without pickers (direct card feed)

32 high production cards with automatic feed can size 36" x 42"

8 drawing frames with automatic can transport system

8 roving frames, 96 spindles each; 12" x 7" bobbins

64 ringspinning frames with cop doffing, as described for Plant IIb

Total price DM 8,880,000

Plant IV (spin plan 410/2819)[c]

2 automatic feeding, cleaning and blending units with bale pluckers with direct feed of cards

Table 14 (cont'd.)

32	high production cards with railway feed
8	drawing frames with automatic can dotting and sliver levelling device
8	roving frames with 96 spindles each; 260 mm. gauge; 12" x 7" bobbins
64	ringspinning frames automatic, with doffing device for each frame

Plant V (spin plan 410/2820)[d]

Plant V differs from Plant IV only in the construction of ringspinning frames, as ringspinning frames with doffer attached operate most economically, with the maximum number of spindles. The bobbin sizes are being kept small in order to be able to operate at high speeds. This, in turn, makes it possible to reduce the total number of spindles required. The small bobbin sizes, however, require the utilization of automatic conewinders which can process such bobbins economically.

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[a] See tables 15 and 15-A.

[b] See tables 16 and 16-A.

[c] See tables 17 and 17-A.

[d] See tables 18 and 18-A.

Table 15

Spin plan BW 410/2755 a; Plant I

Production: 5750 kg. yarn/10 hrs.
Average yarn count: Ne 24
Spindles: 29,400

					r.p.m.	Production in 10 hours				
Machine	Count (metric)	Draft	Doublings	Twist constant	A-Doffer 2-Front roll S-Spindle	Total kg. required	Per unit 100%	Efficiency %	Actual production kg.	Number of units
Opening & cleaning										
Cards	.12	100			A-9	6,070	57.5	90	51.8	117
Drawing frames	.12	6	6 x 6		2-280	5,950	830	90	750	7.95
Roving frames	.8	6.7	1	1.2	3-1,000	5,850	10.5	78	8.2	715
Ringspinning frames	24	30	1	4.5	S-12,000	5,750	.212	92	.195	29,400

Table 15-A

Equipment required, spin plan BW 410/2755 a

Machines specification

Type of machine	Number of machines	Del. or spindles per machine	Number of units	Working width gauge, mm.	Lift, mm.	Size of cans or bobbin	Length, m.	Width, m.	Power consumption per machine hp.	kw.
Pickers	4									
Cards	124	1	124	1,020		18" x 42" (cans)				
Drawing frames	8	1 x 2	16			18" x 42" (cans)				
Roving frames	8	96	768	260	300	175 mm. (bobbins)				
Ringspinning frames	64	460	29,440	75	220	50 mm. (ring)				

Table 16

Spin plan BW 410/2818; Plants IIa, IIb, III

Production: 5750 kg./10 hrs.
Average yarn count: Ne 24
Spindles: 29,400

Machine	Count (metric)	Draft	Doublings	Twist constant	r.p.m. A-Doffer 2-Front roll S-Spindle	Production in 10 hours: Total kg. required	Production in 10 hours: Per unit 100 %	Efficiency %	Actual production kg.	Number of units
Opening & cleaning										
Cards	.12	100			A-75	6,070	221	90	200	30.2
Drawing frames	.12	6	6 × 6		2-280	5,950	830	90	750	7.95
Roving frames	.8	6.7		1.2	S-1,000	5,880	10.5	78	8.2	715
Ring-spinning frames	24	30		4.5	S-12,000	5,750	.212	92	.195	29,400

Table 16-A

Equipment required, spin plan BW 410/2818

Type of machine	Number of machines	Del. or spindles per machine	Machines specification: Number of units	Machines specification: Working width gauge, mm.	Machines specification: Lift, mm.	Machines specification: Size of cans or bobbin	Length, m.	Width, m.	Power consumption per machine hp.	Power consumption per machine kw.
Pickers										
Cards	32		32	1,020		36" (cans)				
Drawing frames	8	1 × 2	16			18" (cans)				
Roving frames	8	96	768	260	300	175 mm. (bobbins)				
Ringspinning frames	64	460	29,440	75	220	50 mm. (ring)				

Table 17

Spin plan BW 410/2019; Plant IV

Production: 5750 kg. yarn/10 hrs.
Average yarn count: Ne 24
Spindles: 29,400

Machine	Count (metric) Engl.	Draft	Doublings	Twist constant	r.p.m. A-Doffer 2-Front roll S-Spindle	Production in 10 hours				
						Total kg. required	Per unit 100%	Efficiency %	Actual production kg.	Number of units
Opening & cleaning										
Cards	.12	100			A-75	6,070	221	90	200	30.2
Drawing frames	.12	6	6 x 6		2-280	5,950	830	90	750	7.95
Roving frames	.8	6.7		1.2	S-1,000	5,850	10.5	78	8.2	715
Ringspinning frames	24	30		4.5	S-12,000	5,750	.212	92	.195	29,400

Table 17-A

Equipment required, spin plan 410/2019

Type of machine	Number of machines	Del. or spindles per machine	Machines specification						Power consumption per machine	
			Number of units	Working width gauge, mm.	Lift, mm.	Size of cans or bobbin	Length, m.	Width, m.	hp.	kw.
Pickers										
Cards	32		32 in 8 groups of 4 cards each	1,020		Railway feed				
Drawing frames	8	1	8			18"				
Roving frames	8	96	768	260	300	175 mm. (bobbin)				
Ringspinning frames	64	460	29,440	75	220	50 mm. (ring)				

Table 18

Spin plan BW 410/2820; Plant V

Production: 5750 kg. yarn/10 hrs.
Average yarn count: Ne 24
Spindles: 24,000

Type of machine	Count (metric) Engl.	Draft	Doublings	Twist constant	r.p.m. A–Doffer 2–Front roll S–Spindle	Production in 10 hours: Total kg. required	Production in 10 hours: Per unit 100 %	Efficiency %	Actual production kg.	Number of units
Opening & cleaning										
Cards	.12	100			A–75	6,070	221	90	200	30.2
Drawing frames	.12	6	6 x 6		2–280	5,950	830	90	750	7.95
Roving frames	.8	6.7		1.2	S–1,000	5,850	10.5	78	8.2	715
Ringspinning frames	24	30		4.5	S–15,000	5,750	.265	96	.245	23,500

Table 18-A

Equipment required, spin plan BW 410/2820

Type of machine	Number of machines	Del. or spindles per machine	Machines specification: Number of units	Machines specification: Working width gauge, mm.	Machines specification: Lift, mm.	Machines specification: Size of cans or bobbin	Machines specification: Length, m.	Machines specification: Width, m.	Power consumption per machine hp.	Power consumption per machine kw
Pickers										
Cards	32		32 in 8 groups of 4 cards each	1,020		Railway feed				
Drawing frames	8	1	8			18"				
Roving frames	8	96	768	260	300	175 mm. (bobbins)				
Ringspinning frames	48	500	24,000	75	210	42 mm. (ring)				

2. The Platt system

The automated unit of Platt Brothers (Sales) Limited is the outcome of many years of research and development at Textile Machinery Makers' Research Limited, in the United Kingdom.

After early trial experience, Platt felt that further major advances could be achieved only by the installation of a full scale plant, operated under mill conditions. This unit, known as Briersville Mills has given Platt the opportunity of fully developing such a line of equipment. While the automation system described is of experimental nature it is nevertheless quite clear from the results achieved that such a plant is technically feasible and will produce satisfactory yarn. The procedure is as follows:

Opening, blending and cleaning: The initial section of the unit comprises blending hoppers delivering onto a conveyor. From the end of the conveyor the material is taken pneumatically to an Ultra-cleaner, after which it passes through the beater part and the jet part of an air-stream cleaner and onto a cage condenser. It is deposited by the condenser on a second lattice and then pneumatically conveyed to a stillage hopper.

Stillage hopper: Final blending takes place in a stillage hopper which feeds the blended stock forward at a controlled, constant rate to the cards. To simplify the problems of uniform distribution, a single hopper, with a maximum production rate of 240 pounds per hour (or 109 kilograms per hour) feeds four cards and acts as a reserve in the event of a stop motion operating at an earlier machine in the line.

Chute feed to cards: The weight of material fed to each card is between approximately 16 to 18 ounces per yard (or 496 to 558 grams per metre). This is a relatively light feed compared with the weight fed from conventional blowroom hoppers and in order to control the regularity of feed the front and back sheets of the chute are oscillated and driven from each individual card doffer. This ensures that the material from the bottom of the chute is compacted and also that if a card is stopped the material does not pack in the chute and so alter the density.

Cards: The cards incorporate all the major features of a high production machine and will produce sliver at up to 45 pounds per hour (or 20.4 kilograms per hour).

Table 19

Comparisons of spinning systems built by Ingolstadt plant[a/]

	I			IIa			IIb			III			IV			V			VI		
	Workers			Workers			Workers			Workers			Workers			Workers			Workers		
	Per shift	Per day	Total	Per shift	Per day	Total	Per shift	Per day	Total	Per shift	Per day	Total	Per shift	Per day	Total	Per shift	Per day	Total	Per shift	Per day	Total
Bale opener-loader	1	-	3	1	-	3	1	-	3	1	-	3	1	-	3	1	-	3	1	-	3
Picker tenders	1	-	3	1	-	3	1	-	3	-	-	-	-	-	-	-	-	-	-	-	-
Picker lap transport	1	-	3	1	-	3	1	-	3	-	-	-	-	-	-	-	-	-	-	-	-
Cards:																					
Tenders	3	-	9	2	-	6	2	-	6	1	-	3	-	-	-	-	-	-	1	-	3
Helpers	1	-	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Grinders	1	-	3	-	1	1	-	1	1	-	1	1	-	1	1	-	1	1	-	1	1
Sweepers	1	-	3	-	1	1	-	1	1	-	-	-	-	-	-	-	-	-	-	-	-
Can haulers	1	-	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Drawing frame tenders	2	-	6	2	-	6	2	-	6	1	-	3	1	-	3	1	-	3	1	-	3
Roving frame tenders	4	-	12	4	-	12	4	-	12	4	-	12	4	-	12	4	-	12	4	-	12
Transport of roving bobbins	1	-	3	1	-	3	1	-	3	-	-	-	-	-	-	-	-	-	-	-	-
Ringspinning frames:																					
Tenders	10	-	30	10	-	30	10	-	30	10	-	30	10	-	30	8	-	24	8	-	24
Doffers	8	-	24	8	-	24	2	-	6	2	-	6	-	-	-	-	-	-	-	-	-
Sweepers	2	-	6	2	-	6	2	-	6	2	-	6	2	-	6	2	-	6	2	-	6
Transport	2	-	6	2	-	6	2	-	6	2	-	6	2	-	6	2	-	6	2	-	6
Oilers, spindle setters, helpers	-	1	1	-	1	1	-	1	1	-	1	1	-	1	1	-	1	1	-	1	1
Traveller-changers	-	1	1	-	1	1	-	1	1	-	1	1	-	1	1	-	1	1	-	1	1
Supervision	3	-	9	3	-	9	3	-	9	3	-	9	3	-	9	3	-	9	3	-	9
Mechanics, Fixers	1	1	4	1	1	4	1	1	4	2	-	6	2	-	6	2	-	6	2	-	6
Electricians	1	1	4	2	-	6	2	-	6	2	-	6	2	-	6	2	-	6	2	-	6
Laboratory	-	4	4	-	4	4	-	4	4	-	4	4	-	4	4	-	4	4	-	4	4
General transport excluding cleaning	1	2	5	1	2	5	1	2	5	1	2	5	1	-	3	1	-	3	1	-	3

Table 19 (cont'd.)

Workers per 1000 spindles	145	130	112	102	91	86	88
Workers per 1000 kg. production	10.50	9.50	8.10	7.40	6.45	6.15	6.38
Yarn production per year of 7000 hours	4 million kg.	4 million kg.	4 million kg.	4 million kg.	4 million kg.	4 million kg.	4 million kg.
Average wages in Western Germany per year	DM 9,000	DM 9,250	DM 9,500	DM 10,000	DM 10,000	DM 10,000	DM 10,300
Yearly wages in millions of DM	1.30	1.20	1.01	1.02	.91	.85	.88
Depreciation and interests per year 15% (millions of DM)	1.42	1.23	1.30	1.33	1.60	1.40	1.36
Cost of electric power (DM .08 per kWh)	$\frac{.57}{3.29}$ (36 W)	$\frac{.60}{3.03}$ (37 W)	$\frac{.60}{2.91}$ (37 W)	$\frac{.62}{2.97}$ (38 W)	$\frac{.63}{3.14}$ (39 W)	$\frac{.58}{2.83}$ (44 W)	$\frac{.58}{2.82}$ (44 W)
Cost per kg. of yarn	82.2 Pfg.	75.9 Pfg.	73 Pfg.	74.5 Pfg.	78.6 Pfg.	71 Pfg.	70.5 Pfg.
Building area of the spinning mill	7,800 m^2	7,300 m^2	7,300 m^2	7,300 m^2	7,100 m^2	6,500 m^2	6,700 m^2
Cost of buildings in millions of DM assuming a cost of approx. DM 500 per m^2	3.9	3.65	3.65	3.66	3.55	3.25	3.35

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a/ Deutscher Spinnereimaschinenbau, Ingolstadt.

Autoleveller: In order to ensure that a regular draw box sliver is produced, the four card slivers are passed through an autolevelling device consisting of tongue-and-grooved rollers situated on the sliver table at the back of the drawbox. The position of the measuring roller operates a displacement transducer, and the total output of the card block is controlled by varying the rate of feed to one card by means of an infinitely variable gear which is controlled by an electronically operated servo-motor.
Drawbox: The group of slivers from the autoleveller is drafted in a high-speed drawbox based on the Mercury drawframe, operating at delivery speeds up to 1200 feet per minute (or 366 metres per minute).

Efficient web control is achieved by a new duplex calendering and condensing system, while liberated dust and fly is continuously removed by the Magna Vac system of direct suction cleaning.

A special feature of the frame is a fully automatic, pneumatically operated, can change mechanism which removes full cans and places empty cans under the coiler.
Fault control: Processing faults may occasionally occur which require operative action.

If the fault occurs within or in front of the drawbox, for example a roller lap or choked calender trumpet, the drawbox stops, the cards drop to slow speed and the slivers are run to waste in an air stream at a point immediately behind the drawbox. After splicing up, the line is restarted and gradually accelerated to full speed.

Faults behind the drawbox are detected by electric stop motions and the line drops to slow speed. During this time, the autoleveller is inoperative and the card at fault is automatically stopped. Having corrected the fault, the operative restarts the card and the line is returned to high-speed running.
Packaging speedframe: This machine has a single row of spindles only, two slivers being creeled to each spindle. With a gauge of 9 1/3 inches (248 millimetres) and a lift of 14 inches (356 millimetres), it produces bobbins 7 inches (178 millimetres) in diameter. Flyers are of the aerodynamic, lightweight, cast-alloy type.

An electronic stop motion is fitted at the front to operate whenever a roving breaks, while a similar back stop motion detects sliver breakages.
Automation in card rooms: Automation in the cardroom offers a worthwhile reduction in operatives for a moderate capital outlay. The elimination of laps and card cans reduces handling and obviates the possibility of faults arising from manual piecings. Plants of the Briersville type can be supplied where conditions are suitable.

Variations of this system are possible. One such modification which goes part way towards card room automation, but which avoids the complexities of linking cards and draw frames, is also available. Such a system provides a simple and flexible plant which does not require the same rigid standards of maintenance and operation, while further steps towards full automation can be taken in the future if required.

This latter system links blowroom and cards by a continuous chute feed, retaining large cans up to 36 inches in diameter at the front of the cards and at the drawframes. Coupled with the use of optimum package sizes, this provides an exceedingly attractive and economic layout. Several units of this type are already being manufactured.
Chute feed to cards: Basically, this plant consists of cards fed by chutes as in the previous scheme, but in this case each card delivers sliver to its own free-standing coiler. Cans from the card are then taken to two passages of drawframes, from these to a speedframe and then to ringframes.
Cards: The cards with their chute feed follow the same pattern as in the

automation line, except for the method of collecting the sliver from the front of the card.

Card slivers, instead of passing along a table to a common drawbox, are deposited in individual cans in front of each card. It is therefore possible to slow or stop a card for doffing purposes or any other reason without affecting the function of the plant as a whole. For operational efficiency both at the card and at subsequent machines the doffing frequency is reduced to a minimum by the use of large cans, the type employed being 36 inches in diameter by 42 inches high. As these cards are arranged so that they can be run at slow speed for piecing purposes, a measuring device is incorporated to bring them down automatically to slow speed after a given length of sliver has been deposited in the can; doffing and replacing of the can is manually effected at this speed.

Drawframe: Card sliver is passed through two passages of Mercury drawframes, the first passage being arranged to take the large diameter cans from the card and also to deposit the drawn slivers into cans of 36 inches diameter by 42 inches high, ready for feeding the second passage machine.

These cans are provided with castors on the base for ease of handling and as the cans are automatically replaced when full, a certain degree of automation is effected within the machine. This factor, coupled with the use of large size cans, gives a high machine efficiency with the minimum operative work load.

The second passage of drawframe varies from the first in the size of can produced, this being 18 inches in diameter by 42 inches high, a size determined to a large extent by the availability of space behind the speedframe. At the same time these are reasonably large cans, and as they are automatically doffed at the drawframe high efficiencies can be achieved. The cans are without castors and are carried on trolleys at the front of the drawframe, the trolley forming part of the doffing system.

Speedframe: The type of speedframe employed is the MS.2Mk.III, producing packages for the ringframe of 14 inches lift by 7 inches diameter. The number of doublings previous to this machine is thirty-six; thus obviating the necessity of doubling at the speedframe. Consequently, a single sliver per spindle is fed to the machine, enabling the conventional two rows of spindles to be employed. The frame is equipped with a 3-over-3 drafting system which, while simple in construction and operation, is adequate for the low draft requirements.

Spin plans and staffing: The following pages give comparable spin plans and staffing for an automation unit, a chute feed to cards system and a modern conventional plant. It will be seen that the automation unit requires 36 blowroom and card room operatives as against 43 for the conventional mill. In all three cases the OHP figures are low; only very few existing mills achieve this level.

Comparisons between automatic and non-automatic winders on the basis of Leesona winding equipment

In order to enable the textile technologist to determine the most advantageous equipment for winding he must consider such factors as the purchase price, the labour requirements, the quality of yarn to be produced and the space available. The attached comparisons were made on various types of Leesona winding equipment, built in the United States: the automatic winder or Uniconer; the regular Rotoconer; and the high speed Rotoconer.

1. Uniconer

The Uniconer, Leesona's automatic winder, has the following specifications:

Yarn range:	Types – all natural yarns and spun synthetics Counts – primarily Ne 8's to 80's
Winding speed:	Up to 1200 yards per minute
Type of knot:	Weaver's or Fisherman's

The factory price of the Uniconer is approximately $o20 per spindle, which includes: The head motors and controls, bobbin supports; positive waxing attachment; automatic weaver knotter; bakelite traverse; standard package holder; built-in cleaning mechanism (overhead travelling cleaner); built-in lighting; shelving for finished packages; two conveyors and escalators per side; empty bobbins and rails for travelling boxes.

Table 20

Spin plan and staffing for modern conventional plant; 15,960 ring spindles producing 20's

Lap fed high production cards followed by two passages of Globe draw frames

Machines	Hank roving or count	Ends into one	Draft	Front roller or spindle speed	Twist multiplier	Turns per inch	Waste allowance	Weight in process per hr. lb.	Production per machine, delivery or spl. per hr. hank	Production per machine, delivery or spl. per hr. lb.	Calculated machine efficiency %	Calculated number of machines, deliveries or spindles	Quantity and particulars of machines
Type 560 finisher scutchers	16 oz. per yd. lap							950		1,032	92	2	1 opening line feeding 2 scutchers
H.P. cards lap fed	.12	1	106	22.5 r.p.m. doffer 1.37 web draft			3	920		40	90	23	24 cards, coilers for cans 30" diam. by 42" high
Globe drawframes (2 passages)	.12	6	6.0	800 ft. per min.			2	902		127	80	7.1	8 drawframes, each 1 head of 2 deliveries; coilers for cans 18" diam. by 42" high
WS 2 Mark III speed frames	.60	1	5.0	800 r.p.m.	Hank x 1.3	1.01	2	884	1.1	1.833	70	482	6 frames, 84 spls. each; 9 3/4" gauge; 14" x 7" bobbins
Super Spinner ring frames	20's	1	33.3	1[illegible]00 r.p.m.	Counts x 4.0	17.90	2	866		.0544	92	15,960	42 frames, 380 spls. each; 3 1/4" gauge; 2 1/4" ring; 10" lift

Table 20 (cont'd.)

Machines	Job description	Number of operatives		
		Shift 1	Shift 2	Shift 3
Blowroom and cardroom				
1 opening line, 2 scutchers	Bale handler/waste man	1	1	1
	Cotton feeder	1	1	1
	Scutcher tender, etc.	1	1	1
24 H.P. cards	Tender	2	2	2
4 Globe drawframes 4 Globe drawframes	Tender	2	2	2
6 84 spl. speed frames	Tender	3	3	3
Blowroom and cardroom supervisory and ancillary				
	Shift supervisor	1	1	1
	Setter/mechanic	1	2	1
	Lap carrier/labourer	1	1	1
	General m/c. assistant	1	1	1
		14	15	14
		43 Operatives = 1.66 O.H.P.		
Ring room				
42 x 380 spl. ring frames	Spinner	7	7	7
	Doffer	4	4	4
	Roller picker	1	1	-
	General m/c. assistant	1	1	1
Ring room supervisory and ancillary				
	Shift supervisor	1	1	1
	Setter/mechanic	1	2	1
	Electrician	-	1	-
	Scouring team (also for cardroom)	-	6	-
	Oiler/bander	1	1	1
	Sett carrier/weigher	1	1	1
	Trav. changer/clean spindle blades, etc.	-	1	-
	Room cleaner	-	1	-
		17	27	16
		60 Operatives = 2.31 O.H.P.		

Grand total = 103 operatives = 2.31 O.H.P.

Table 21

Spin plan and staffing for automation plant: 15,960 ring spindles producing 20's

High production cards with chute feed followed by railway drawing

Machines	Hank roving or count	Ends into one	Draft	Front roller or spindle speed	Twist multiplier	Turns per inch	Waste allowance	Weight in process per hr. lb.	Production per machine, delivery or spl. per hr.		Calculated machine efficiency %	Calculated number of machines, deliveries or spindles	Quantity and particulars of machines
									hank	lb.			
Blowroom								940		188	90	5	Opening and cleaning machines serving 5 stillage hoppers
H.P. cards, chute fed	.14			26.3 r.p.m. doffer 1.37 web draft			3	912		40	90	23	25 cards (5 per set) feeding to draw-frames with railway head
Type 741 Mercury drawframes with railway head	.14	5	5.0	1,200 ft. per min.			1	903		184	90	4.92	5 drawframes with coilers for cans 20" diam. by 42" high
Packaging speed frames	.60	2	8.56	1,150 r.p.m.	$\sqrt{\text{Hank}} \times 1.4$	1.085	2	885	1.47	2.45	70	362	8 frames, 48 spls. each 9 3/4" gauge, 14" x 7" bobbins
Super-spinner ring frames	20's	1	33.3	10,700 r.p.m.	$\sqrt{\text{Counts}} \times 4.0$	17.90	2	866		.0544	92	15,960	42 frames, 380 spls. each 3 1/4" gauge, 2 1/4" ring, 10" lift

Table 21 (cont'd.)

Machines	Job description	Number of operatives		
		Shift 1	Shift 2	Shift 3
Blowroom and cardroom				
Opening machines to 5 stillage hoppers	Bale handler/waste man	1	1	1
	Cotton feeder	1	1	1
25 H.P. cards				
5 Mercury drawframes (each linked to unit of 5 cards)	Tender	1	1	1
8 48 spl. speed frames	Tender	4	4	4
Blowroom and cardroom supervisory and ancillary				
	Shift supervisor	1	1	1
	Setter/mechanic	2	2	2
	Labourer	1	1	1
	General m/c. assistant	1	1	1
		12	12	12
		36 Operatives = 1.38 O.H.P.		
Ring room				
42 x 380 spl. ring frames	Spinner	7	7	7
	Doffer	4	4	4
	Roller picker	1	1	-
	General m/c. assistant	1	1	1
Ring room supervisory and ancillary				
	Shift supervisor	1	1	1
	Setter/mechanic	1	2	1
	Electrician	-	1	-
	Scouring team (also for cardroom)	-	6	-
	Oiler/bander	1	1	1
	Sett carrier/weigher	1	1	1
	Trav. changer/cleans spindle blades, etc.	-	1	-
	Room cleaner	-	1	-
		17	27	16
		60 Operatives = 2.31 O.H.P.		

Grand total = 96 operatives = 3.69 O.H.P.

Table 22

Spin plan and staffing for chute feed to cards system; 15,960 ring spindles producing 20's

High production cards with chute feed followed by two passages of Mercury drawframes

Machines	Hank roving or count	Ends into one	Draft	Front roller or spindle speed	Twist multiplier	Turns per inch	Waste allowance	Weight in process per hr. lb.	Production per machine, delivery or spl. per hr. hank	Production per machine, delivery or spl. per hr. lb.	Calculated machine efficiency %	Calculated number of machines, deliveries or spindles	Quantity and particulars of machines
Blowroom								950		238	90	4	Opening and cleaning machinery serving 4 stillage hoppers
H.P. cards, chute fed	.12	1		22.5 r.p.m. doffer 1.37 web draft			3	920		40	90	23	24 cards (6 per set). Coilers for cans 36" diam. by 42" high
Mercury drawframes (1st passage)	.12	6	6.0	1,500 ft. per min.			1	911		253	85	3.6	4 drawframes, each 1 head of 1 delivery. Coiler for cans 18" diam. by 42" high
Mercury drawframes (2nd passage)	.12	6	6.0	1,500 ft. per min.			1	902		253	85	3.57	4 drawframes, each 1 head of 1 delivery. Coiler for cans 18" diam. by 42" high
WS 2 Mark III speed frames	.60	1	5.00	800 r.p.m.	$\sqrt{\text{Hank}} \times 1.3$	1.01	2	884	1.1	1.833	70	482	6 frames, 84 spls. each, 9 3/4" gauge, 14" by 7" bobbins
Super-spinner ring frames	20's	1	33.3	10,700 r.p.m.	$\sqrt{\text{Count}} \times 4.0$	17.90	2	866		.0544	92	15,960	42 frames, 380 spls. each, 3 1/4" gauge, 2 1/4" ring, 10" lift

Table 22 (cont'd.)

Machine	Job description	Number of operatives Shift 1	Shift 2	Shift 3
Blowroom and cardroom				
Opening machines to 4 stillage hoppers	Bale handler/waste man	1	1	1
	Cotton feeder	1	1	1
24 H.P. cards	Tender	1	1	1
4 Mercury drawframes 4 Mercury drawframes	Tender	2	2	2
6 84 spl. speed frames	Tender	3	3	3
Blowroom and cardroom supervisory and ancillary				
	Shift supervisor	1	1	1
	Setter/mechanic	2	2	2
	Labourer	1	1	1
	General m/c. assistant	1	1	1
		13	13	13
		39 Operatives = 1.50 O.H.P.		
Ring room				
42 × 380 spl. ring frames	Spinner	7	7	7
	Doffer	4	4	4
	Roller picker	1	1	
	General m/c. assistant	1	1	1
Ring room supervisory and ancillary				
	Shift supervisor	1	1	1
	Setter/mechanic	1	2	1
	Electrician	-	1	-
	Souring team (also for cardroom)	-	6	-
	Oiler/bander	1	1	1
	Sett carrier/weigher	1	1	1
	Trav. changer/clean spindle blades, etc.	-	1	-
	Room cleaner	-	1	-
		17	27	16
		60 Operatives = 2.31 O.H.P.		

Grand total = 99 operatives = 3.81 O.H.P.

2. Regular Rotoconer

For winding speeds of about 600 yards per minute it is priced at US$122 per spindle ex works, including: Drive head switch; coning attachment; paraffin attachment; slub catcher; tilting vertical supply; double deck with card rails; conveyor attachment; motors.

3. High speed Rotoconer

The high speed Rotoconer consists of practically the same parts as the Regular Rotoconer, except that instead of a vertical supply it has a vertical adjustable one. It has a variable speed drive and high speed parts that permit the machine to operate at speeds of about 1200 yards per minute.

Comparison tables:

The following comparison sheets for processing the same types of yarns under determined conditions (yarn count, bobbin weight, cone weight, and break rate) show that for winding a quantity of 5467 lbs. in eight hours (2476 kgs. per 8 hours or 308 kgs. per hour) there are the following requirements in spindles and personnel:

	Total number spindles required	Spindles per operator	Operator productivity per hour (in pounds)	Total number of operators required per shift
Uniconer	190.8	56	195	3.50
Regular Rotoconer	629.8	64.22	69.65	9.81
High Speed Rotoconer	343.2	36	69.65	9.81

These comparison figures clearly show the difference between the three winders. The advantages of automatic winders were described in a previous chapter. The high speed Rotoconer requires a smaller total investment and is recommended where yarns of good resistance are wound and where space is limited. There is however no saving in labour costs.

Table 23

Calculations for Uniconer

Yarn count	Winding speed, y.p.m.	Bobbin weight, lb.	Cone weight, lb.	Break rate, %	Mistie rate, %	Recreel rate, %	W & M* allow., min.	Prod. req. lb. per 8 hours	Creel, min.	Doff, min.	Service, min.	Down-time, %
(A) 18/1	(B) 1200	(C) .30	(D) 3.30	(E) 70	(F) 7.0	(G) 3.0	(H) .50	(I) 5467	(J) .05	(K) .12	(L) . [illegible]	(M) 10

Bobbin running time					
Winding	(840)(A)(C) + (B)	=	(N)	3.78	minutes
Knotting	(1 + E)(.18 min./knot)**	=	(O)	.31	minutes
Service	(1 + E)(F)(1/2)(N + O)	=	(P)	.24	minutes
Doffing	(1/2)(N + O) (C) + (D)	=	(Q)	.19	minutes
Total machine time/bobbin	(N + O + P + Q)	=	(R)	4.52	minutes
Operator cycle time	(N + O)	=	(S)	4.09	minutes
Operator times					
Creeling	(1 + G)(J)	=	(T)	.52	minutes
Doffing	(K)(C) + (D)	=	(U)	.011	minutes
Service	(L) (1 + E)(F)	=	(V)	.010	minutes
Walking	(T + U + V)(H) + (S—H)	=	(W)	.010	minutes
Total operator time/bobbin	(T + U + V + W)	=	(X)	.083	minutes
Operator assignment	R + X	=	(Y)	54.5	spindles
Efficiency while tended	N + R	=	(Z)	83.63	per cent
Over-all efficiency	(Z)(100—M)	=	(AA)	75.27	per cent
Net bobbins per minute	(Y) + (R)	=	(BB)	12.06	bobbins
Operator productivity/8 hours	(100—M)(480)(BB)(C)	=	(CC)	1,363.0	pounds
Requirements					
Operators required	I + CC	=	(DD)	3.50	operators
Spindles required	(DD)(Y)	=		190.8	spindles
Machine time distribution					
Winding time	N + R	=		83.6	per cent
Knotting time	O + R	=		6.9	per cent
Service time	P + R	=		5.3	per cent
Doffing time	Q + R	=		4.2	per cent
Operator time distribution					
Creel time	T + X	=		62.7	per cent
Doff time	U + X	=		13.3	per cent
Service time	V + X	=		12.0	per cent
Walk. & misc. time	W + X	=		12.0	per cent

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* Walk. & miscellaneous allowance per cycle

** Including 2nd tries

Table 23-A

Calculations for regular type 44 Rotoconer

Drum winding analysis

(Servicing spindles in cycles and doffing packages individually when full)

Yarn number	18/1	Yarn speed	600
Bobbins per pound	3.33	Bobbin runs	7.56 min. (A)
Yards per bobbin	4,536	Spindle stops turning in	.75 min.
Pounds per cone	3.30	Total time per cycle	8.31 min. (F)
Bobbins per cone	11.00	Estimated end breakage	70%

(1) 100 bobbins changed x .125 min. = 12.50 min.
70 breaks tied x .105 min. = 7.35 min.
9.09 cones changed x .173 min. = 1.57 min.
Allowance for walking time (150'/min.) = ..57 min.
Total for 100 bobbins changed and 170 (E) spindles serviced = 21.99 min. (B)

Average service time per bobbin $\frac{\text{21.99 min. (B)}}{\text{100}}$ = .2199 min. (C)

(2) **Spindles per operator**

Average service time per spindle = $\frac{\text{21.99 min. (B)}}{\text{170 spls. (E)}}$ = .1294 min. (D)

Spindles per operator = $\frac{\text{8.31 min. (F)}}{\text{.1294 min. (D)}}$ = 64.22 spindles (G)

(3) **Bobbins per operator per hour**

Allowances:

Cleaning & misc.	5%	
Fatigue	10%	
Total allowance	15%	

$\frac{\text{60 min. x 85\%}}{\text{.2199 min. (C)}}$ = 231.92 bobbins

(4) **Pounds per operator per hour**

$\frac{\text{231.92 bbns. per opr. per hour}}{\text{3.33 bobbins per pound}}$ = 69.65 pounds (H)

(5) **Machine efficiency**

$\frac{\text{231.92 bbns. per opr. per hour x 7.56 min. (A)}}{\text{64.22 spindles x 60 min. per hour}}$ = 45.5%

(6) **Spindles required**

$\frac{\text{683 lb./hr. required}}{\text{69.65}}$ x $\frac{\text{sp./op.(G) 64.22}}{\text{lb./op./hr.(H)}}$ = 629.8 spindles

(7) **Operators required**

$\frac{\text{629.8 spindles required}}{\text{64.22 spindles/operator}}$ = 9.81 operators/shift

Table 23-8

Calculations for high speed type MS 44 Rotoconer

Drum winding analysis

(Servicing spindles in cycles and doffing packages individually when full)

Yarn number	18/1	Yarn speed	1,200 y.p.m.
Bobbins per pound	3.33	Bobbin runs	3.78 min. (A)
Yards per bobbin	4,536	Spindle stops turning in	.75 min.
Pounds per cone	3.30	Total time per cycle	4.53 min. (F)
Bobbins per cone	11.00	Estimated end breakage	70%

(1) 100 bobbins changed x .125 min. = 12.50 min.
70 breaks tied x .105 min. = 7.35 min.
9.09 cones changed x .173 min. = 1.57 min.
Allowance for walking time
(150'/min.) = .57 min.
Total for 100 bobbins changed
and 170 (E) spindles serviced = 21.99 min. (B)

Average service time per bobbin $\frac{\text{21.99 min. (B)}}{\text{100}}$ = .2199 min. (C)

(2) Spindles per operator

Average service time per spindle = $\frac{\text{21.99 min. (B)}}{\text{170 spdls. (E)}}$ = .1294 min. (D)

Spindles per operator = $\frac{\text{4.53 min. (F)}}{\text{.1294 min. (D)}}$ = 35.00 spindles (G)

(3) Bobbins per operator per hour

Allowances:

Cleaning & misc.	5%	$\frac{\text{60 min. x 85\%}}{\text{.2199 min. (C)}}$ = 231.92 bobbins
Fatigue	10%	
Total allowance	15%	

(4) Pounds per operator per hour

$\frac{\text{231.92 bbns. per opr. per hour}}{\text{3.33 bobbins per pound}}$ = 69.65 pounds (H)

(5) Machine efficiency

$\frac{\text{231.92 bbns. per opr. per hour x 3.78 min. (A)}}{\text{35.00 spindles x 60 min. per hour}}$ = 41.7

(6) Spindle required

$\frac{\text{683 lbs./hr. required x sp./op. (G) 35.00}}{\text{69.65 lbs./op./ (H)}}$ = 343.2 spindles

(7) Operators required

$\frac{\text{343.2 spindles required}}{\text{35.00 spindles operator}}$ = 9.81 operators/shift

Cost comparisons and workloads for Schlafhorst winding equipment: BKN and Autoconers

A table prepared by W. Schlafhorst and Company of Moenchengladbach presents comparison data for winding with BKN, a non-automatic winder of recent model, and Autoconers, demonstrating that for processing the same type and quantitiy of cotton yarn one needs 264 BKN spindles with 9 operators, against 180 Autoconer spindles with 3 attendants.

Table 24

Comparison data[a]

BKN - 264 spindles		Autoconer - 180 spindles
20/1	Cotton yarn, English yarn count	20/1
900	Winding speed m./min.	1,100
120	Net weight of bobbin in grams	120
4.5	Winding time in min.	3.7
.4	Ratios per bobbin	.4
4°-20° Plastic	Type of tube	4°-20° Plastic
1,000	Net weight of cheese in grams	1,000
75%	Efficiency %	80%
1.25	Actual production in kgs./ hour	1.67
29-30	Assignable number of spindles	60
33.5	Production per operator per hour in kg.	100
300	Production of the installation in kg.	300
9	Workers per shift	3

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[a] Tables 24 and 25 prepared by W. Schlafhorst, Moenchengladbach, Federal Republic of Germany, builders of both machines.

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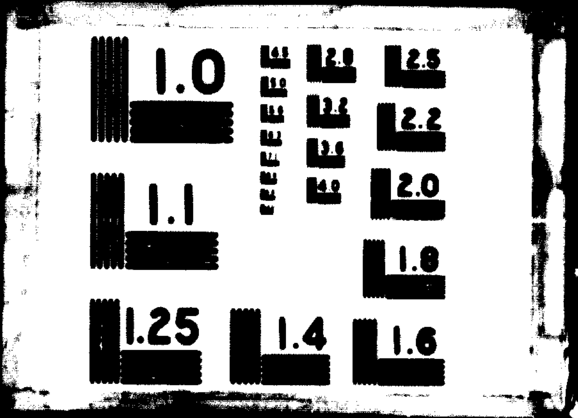

Table 25

Cost comparisons between operations of Autoconer and BKN non-automatic winder

Price per spindle – Autoconer DM 2,554 FOB
BKN – winder 638 FOB

	Operation 4000 hours yearly life span of machines 10 years		Operation 6000 hours yearly life span of machines 10 years	
	180 spindles Autoconer	264 spindles BKN winder	180 spindles Autoconer	264 spindles BKN winder
	(DM)	(DM)	(DM)	(DM)
Cost price of installation	459,720	180,312	459,720	180,312
Depreciation 10% / 12.5%	45,972	18,031	57,465	22,539
Interest 8%	18,389	7,212	18,389	7,212
Cost of electric power DM 0.10 /kWh.	12,640	6,448	12,640	6,448
Cost of space DM 3 – / m^2 / month	5,224	4,593	5,224	4,593
Spare parts: Autoconer .7% per shift/year BKN .2% per shift/year	6,436	721	9,654	1,082
	88,661	37,005	103,372	41,874
Wages per year and installation	42,000	126,000	63,000	189,000
Total production cost DM/year	130,661	163,005	166,372	230,874
Savings per year and installation	+ 32,344		+ 64,502	
Depreciation time in years[a]	$\frac{459,720}{45,972 + 18,389 + 32,344} = 4.7$		$\frac{459,720}{57,465 + 18,389 + 64,502} = 3.2$	

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[a] $\frac{\text{Capital invested}}{\text{Depreciation interest yearly savings}}$

Table 25 shows cost comparisons between automatic and non-automatic winding, based on two-shift and three-shift operations.

It also brings out that an improvement of quality can be achieved, as well as savings in winding cost, with the well-known Autoconer, which has found good acceptance in many parts of the world.

Comparison of weaving costs: Rüti machinery works

This study, made by Rüti Machinery Works Limited, Switzerland, analyses the manufacturing costs of medium quality cotton fabrics, whose specifications are given separately. It is based on secondhand weaving machines; modern weaving machines of simple design and handling; non-conventional weaving machines (gripper shuttle machines).

The study is based on an average wage, including social benefits, of SFr. 2.50 per hour. Figure XIII gives the weaving costs at the same wage level, yet in order to give a complete picture, weaving machines with box loader and Unifil have also been included.

The figures clearly show that on a wage level of SFr. 2.50 per hour, including social benefits (approximately US$ 0.60), weaving machines with rotary battery are most economical for the mentioned type of fabric, whereas with higher wages, machines with box loader or with Unifil should be used, to produce economically.

Consequently, it is important for developing countries to purchase weaving machines that may easily be modified by means of box loader or Unifil.

Technical data

Fabric

Type	Cotton cretonne
Grey width, cm.	148
No. of threads warp/weft, cm.	26/24
Total number of warp ends	3874
Yarn count warp/weft Nm.	34/34

Machine specification

A: Older, used conventional weaving machines;

B: Modern weaving machines;

C: Non-conventional weaving machines.

	A	B	C
Type	Cotton	Ruti	Non-conventional
Warp/weft, cm.	Autom. loom 160	Bazl 160	330 a/
Treading motion	Cam motion IT	Cam motion ST	Cams
Speed, picks per minute	150-160	180-190	200-210
Warp beam diameter, mm.	500-550	700-750	800

a/ Double width weaving.

Output per machine and hour

The stoppages listed below were taken from published reports and comparative studies.

	A	B	C
Stops per 1000 ends and 100,000 picks	2.6-2.8	1.2-1.4	1.4-1.6
Filling breakages per 100,000 weft metres	3.8-4.0	2.4-2.6	2.3-2.5
Mechanical stops per 100,000 picks	2.8-3.0	0.4-0.6	0.8-1.0

Stops per machine and hour at 90% efficiency

If these stoppages are converted to one machine hour at 90% efficiency, the following averages will result:

	A	B	C
Warp end	.86	.52	2 x .64
Weft breakages	.51	.41	2 x .42
Mechanical stoppages	.24	.05	2 x .10
Total stoppages	1.61	.98	2 x1.16

Output per machine and hour

	A	B	C
Machine type	Cotton automatic loom	Ruti Bazl	Non-conventional
Speed, picks per minute	150-160	180-190	200-210
Machine efficiency	84-86	91-93	88-90
Picks per machine and hour	7,926	10,200	10,926
Metres of fabric per hour	3.30	4.25	2 x 4.86
Number of machines required	303	236	110

Costs per 1000 metres of fabric

The following cost factors are taken into account:

(a) Capital expenditure;
(b) Personnel;
(c) Working cost;
(d) Weft winding;
(e) Difference in raw material consumption.

Capital expenditure

(a) Investment costs:

		A	B	C
Number of looms required for an output of 1000 metres per hour		303	235	110
Price of 1 machine including accessories	SFr	3,000[a/]	10,500	45,000
Estimated duty and taxes, 20%	SFr	700	2,100	9,000
Transport and erection charges	SFr	1,000	1,000	1,500
Cost of one machine ready for operation	SFr	4,700	13,600	55,500
Investment for a production capacity of 1000 metres per hour		1,424,000	3,196,000	6,105,000

(b) Depreciation and interests per 1000 m. of fabric:

Depreciation A 5 years

Depreciation B + C 10 years

Rate of interest 8% Average 4%

		A	B	C
Investment depreciation and interest: per cent	SFr.	1,424,000 24	3,196,000 14	6,105,000 14
Depreciation and interest: per year	SFr.	341,800	447,500	854,700
Working hours: per year		6,200	6,200	6,200
Depreciation and interest: per 1000 m. of fabric		55.1	72.2	137.8

Personnel expenses

(a) Machine allocations per worker:

	A	B	C
Overseer	60	96	48
Assistant foreman - warp gaiter	180	300	192
Tying and drawing in	240	480	192
Weaver	28-42	48-52	20-24
Assistant weaver	120	200	100
Battery filler	56	48	-
Weft transporter	540	480	144
Empty pirns collector and transporter	540	480	-
Piece transporter	540	480	288
Oiler	280	360	288
Machine cleaner	280	360	48

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a/ Secondhand machine with partly new accessories.

(b) Personnel and wages for 1000 m. of fabric:

	A	B	C
Machine hours per 1000 m. of fabric	303	235	110
Overseer	5.05	2.45	2.29
Assistant foreman - warp gaiter	1.68	.78	.57
Tying and drawing in	1.26	.49	.57
Weaver	10.10	4.70	5.00
Assistant weaver	2.53	1.18	.92
Battery filler	5.41	4.90	-
Weft transporter	.56	.49	.76
Empty pirns collector and transporter	.56	.49	-
Piece transporter	.56	.49	.38
Oiler	1.08	.65	.38
Machine cleaner	1.08	.65	2.29
Number of personnel: per 1000 m. of fabric in one hour	29.87	17.27	11.16
Average wage/hour including social benefits SFr.	2.50	2.50	2.90[a]
Wages: per 1000 m. of fabric SFr.	74.7	43.2	32.5

Operating costs per 1000 metres of fabric

The following factors are taken into account:

(a) Consumption of accessories and machine parts;
(b) Power consumption;
(c) Buildings.

(a) Consumption of accessories and machine parts (spares):

	A	B	C
Machine hours: per 1000 m. of fabric	303	235	110
Spare parts: per machine and hour	.05	.02	.05
Spare parts: per 1000 m. of fabric SFr.	15.2	4.7	5.5

(b) Power consumption:

	A	B	C
Machine hours: per 1000 m. of fabric	303	235	110
Average consumption: per machine and hour kW.	.8	1.0	1.5
Cost of electricity: per kWh SFr.	.10	.10	.10
Cost of electricity: per 1000 m. of fabric	24.2	23.5	16.5

---

a/ More specialized workers are required, hence higher average hourly wages.

(c) Buildings:

Calculations are based on 6200 working hours per year.

		A	B	C
Machine hours: per 1000 m. of fabric		303	236	110
Space required for 1 machine	m^2	11	12	19.5
Costs per m^2 including light and air conditioning	SFr.	25	25	25
Costs: per 1000 m. of fabric	SFr.	13.5	11.4	8.7

(d) Recapitulation of working costs per 1000 metres of fabric:

		A	B	C
Spare parts	SFr.	15.2	4.7	5.5
Costs of electric current	SFr.	24.2	23.5	16.5
Buildings	SFr.	13.5	11.4	8.7
Total working costs: per 1000 m. of fabric	SFr.	52.9	39.6	30.7

Costs of pirn winding per 1000 metres of fabric

The conventional weaving (A + B) requires pirn winding. The costs are tabulated:

		A + B
Average expenses for spindle and hour, including pirn cleaning, capital expenditure, personnel and working costs	SFr.	.20
Winding speed: in metres per minute at 80% efficiency		580
Output per spindle and hour: for Nm 34	Kg.	1,025
Required weft material: per 1000 m. of fabric including .6% waste	Kg.	110.8
Cost of pirn winding: per 1000 m. of fabric, machines A and B	SFr.	22.2

Costs relating to differences in raw material consumption per 1000 metres of fabric

(a) Warp:

	A	B	C
Total number of warp ends	3,874	3,874	3,848
Yarn count, Nm.	34	34	34
Weight of warp: per 1 m. of fabric: grams	120.8	120.8	120.0
Waste: in %	.4	.3	.3
Warp requirement: per 1m. of fabric: grams	121.3	121.2	120.4
Supplement required: per 1 m. of fabric: grams	.9	.8	-

(b) **Weft**:	A	B	C
Warp width in the reed, cm.	156	156	156
Supplementary weft required for special selvedge	-	-	3
Picks, per cm.	24	24	24
Yarn count Nm.	34	34	34
Weft requirement: per 1 m. of fabric: grams	110.1	110.1	112.2
Waste: in %	.7	.7	.4
Weft requirement, including waste per metre: grams	110.9	110.9	112.7
Supplement required: per 1 m. of fabric: grams	-	-	1.8

(c) Supplementary raw material cost:

	A	B	C
Supplementary warp: per 1000 m. of fabric: kg.	.9	.8	-
Supplementary weft: per 1000 m. of fabric	-	-	1.8
Raw material: cost in kilograms of warp	SFr.4.80	4.80	-
Raw material: cost in kilograms of weft	SFr.-	-	4.20
Supplement: per 1000 m. of fabric	SFr.4.3	3.8	7.6

Recapitulation of costs per 1000 metres of fabric

(a)	Depreciation and interest	SFr.	55.1	72.2	137.8
(b)	Personnel	SFr.	74.7	43.2	32.5
(c)	Operating costs	SFr.	52.9	39.6	30.7
(d)	Pirn winding	SFr.	22.2	22.2	-
(e)	Supplementary raw material	SFr.	4.3	3.8	7.6
	Total of costs mentioned above: per 1000 m. of fabric	SFr.	209.2	181.0	208.6
	Lower prime cost: per 1000 m. of fabric compared to A	SFr.	-	28.2	.6

General remarks

The comparative study of the prime cost does not take into account the fact that the quality of variant A cloth is poorer than the rest, nor that difficulties may arise during finishing due to the special selvedge for variant C. It is hard to assess in figures the cost of poorer quality and the difficulties with finishing. But it can be safely deduced that if these two factors were taken into account, the results would shift in favour of variant B.

For low wage countries lowest prime costs will be achieved by using modern, easy to operate weaving machines.

For countries where the wage level is higher, machines with box loaders or Unifil loom winders should be used. By cutting out the battery filler's job, personnel costs are reduced by approximately one quarter. The same modern, yet conventional weaving machine would also produce at lowest primary costs.

Figure XIII

Weaving cost and wage level

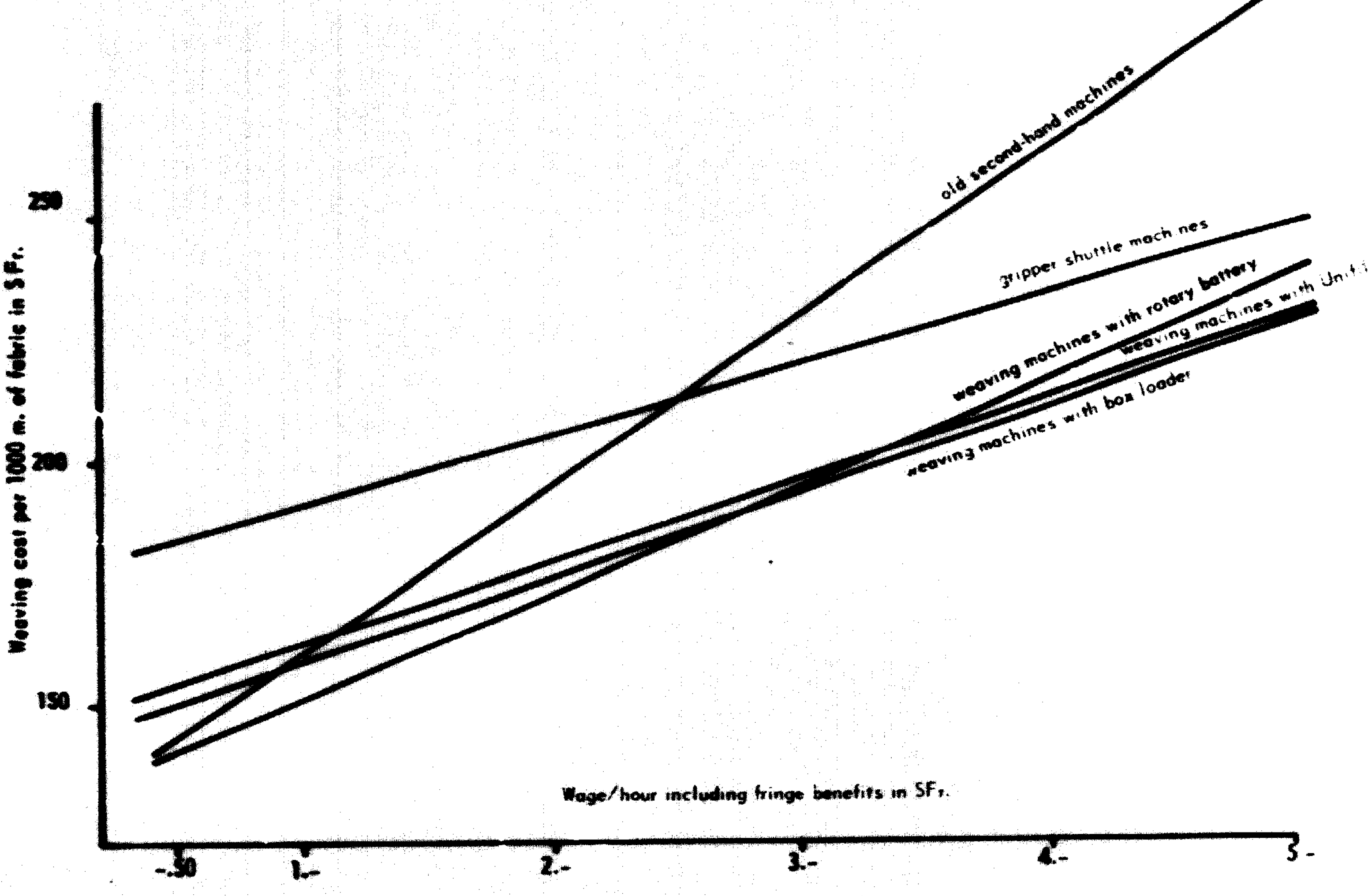
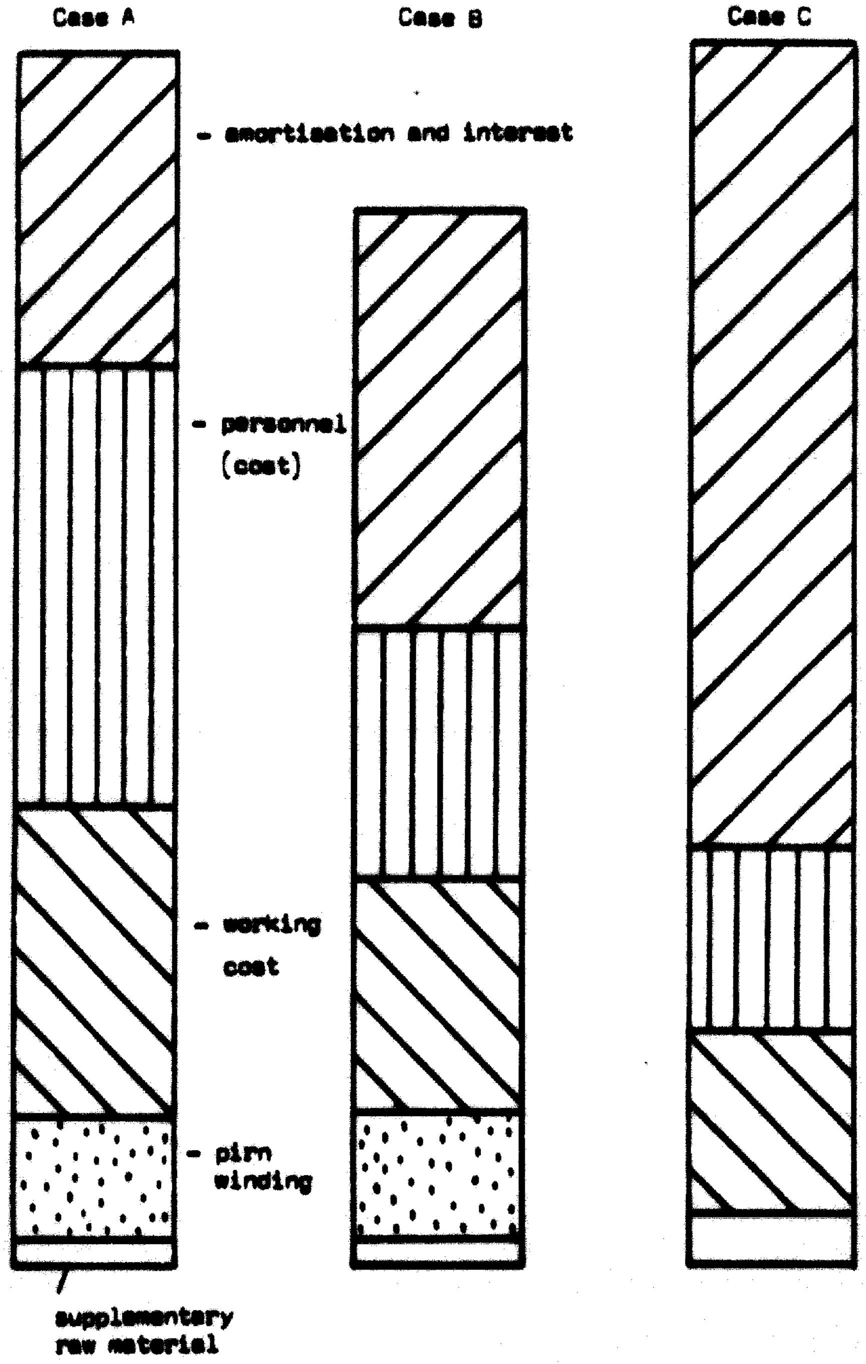


Figure XIV

Cost structure comparisons[a]



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a/ Rüti Machinery Works: Comparative Study of Weaving Costs.

The Sulzer weaving machine [19]

One of the most widely used shuttleless looms is the Sulzer weaving machine, which has been in production since 1953. At first, only a 130" single-colour version of this gripper-shuttle machine was manufactured, but a model with a reduced reed space of 85 inches soon followed. The next step was the introduction of a two-colour unit for use with either model, permitting two weft threads of different quality or colour to be inserted in any sequence. Since then a machine with a four-colour unit has been put on the market, and new models have been introduced with a working width of 110 inches and wider.

The following details were given to Sulzer by weaving plants with substantial installations of Sulzer equipment which has been operated in shifts for several years:

1. Cotton installation

The equipment consist of 288 Sulzer weaving machines of type 130 ESIDE.

(a) Plant figures:

Space requirements	5,700 m^2 (6,800 sq. yds.)
Labour requirements per shift	6 overseers 12 weavers 2 weft carriers 1 cloth carrier 6 cleaners 1 oiler 1 warp gaiter and tier
Production time	18 minutes per 1,000,000 picks

(b) Basic figures for standard cloth:

Material	Calico cotton
Picks and ends per cm. (per inch)	24/24 (61/61)
Count in tex. (English count)	30 tex./30 tex. (20's/20's)
Grey width	86 cm. (34")
Number or widths per machine	3
Picks per minute	210
Efficiency (including warp changes)	92%
Machine running time per month	540 hours
Production per machine per month	7,825 m.

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[19] Excerpts from the Sulzer Technical Review No. 2/1961 by M. Steiner.

(c) Cost figures (Basis: per 100 m. cloth)

Wages in DM:		DM
Overseers	(800/month)	0.83
Weavers	(3.50/hour)	1.31
Weft and cloth carriers	(2.40 and 2.70/hour)	0.23
Cleaners and oilers	(2.70/hour)	0.59
Warp gaiters and tiers	(3/hour)	0.09
Total (including social services)		3.05
Spare parts		0.40
Electricity		1.15
Building costs		0.50
Depreciation and interest		5.71

(d) Total cost:
Weaving costs per 100 metres 10.81

The weaving costs of this installation can further be broken down as shown in figure XV.

To simplify the picture, the many costing heads have been divided into several main groups and the figures rounded off. It should be noted that this cost structure applies only to a new installation where capital investments have not yet been written off. When the charges for depreciation and interest cease to apply, the weaving costs are reduced to about 47 per cent. It will be clear from this that such weaving equipment operates at extremely low cost when fully amortized or depreciated.

2. Wool installation

The equipment consists of the Sulzer weaving machines of type 85 VSIDE;

(a) Plant figures:

Space requirements	1,200 m^2 (1,435 sq. yds.)
Labour requirements per shift	2 overseers 5 weavers 1 weft and cloth carrier 2 cleaners and oilers 1 warp gaiter and tier
Production time	78 minutes per 1,000,000 picks

(b) Basic figures for a standard cloth:

Cloth	Worsted twill
Picks and ends per cm. (per inch)	26/22(66/56)
Count in tex (English count)	30 tex x 2/30 tex x 2 (2/20's/2/20's
Grey width	165 cm. (65")
Number of widths per machine	1
Picks per minute	236

Efficiency (including warp change)	92%
Machine running time per month	540 hours
Production per machine per month	3,186 m. (3,500 yds.)

(c)	Costing figures (basis: per 100 m. cloth; in DM)		DM
	Overseers	(800/month)	2.72
	Weavers	(3.50/hour)	6.43
	Weft and cloth carriers	(2.70/hour)	0.82
	Cleaners and oilers	(2.70/hour)	1.65
	Warp gaiters and tiers	(3/hour)	0.92
	Total (including social services)		2.54
	Spare parts		1.10
	Electricity		2.74
	Building costs		1.04
	Depreciation and interest		16.06
(d)	Total cost:		
	Weaving costs per 100 metres		33.48

Although the situations in the cotton and wool industries show parallels, there are differences in the various costing heads, as a comparison of figures XV and XVI shows.

Figure XV

Weaving costs of a Sulzer weaving machine installation for cotton

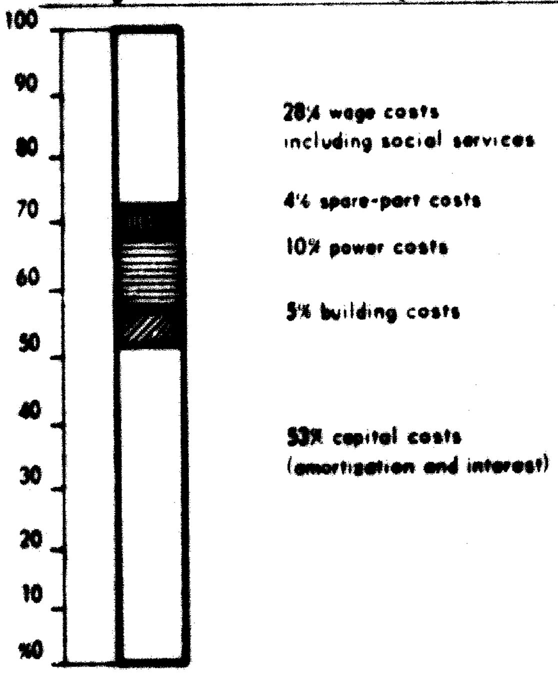
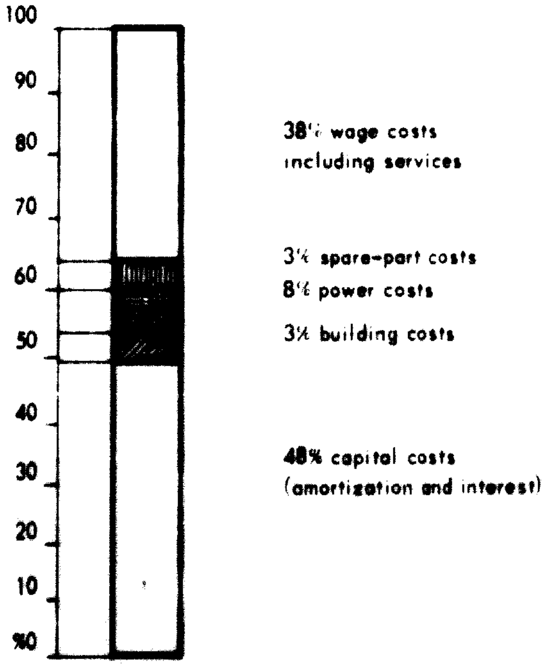


Figure XVI

Weaving costs of a Sulzer weaving machine installation for wool



The increase in the costs for wages and social services to 38 per cent (as compared with 28 per cent for the cotton installation) is due to the higher labour requirements in the wool weaving mill. Once the investment has been written off, that is after full amortization or depreciation, the weaving costs will be further reduced to about 52 per cent.

The main point brought out by the cost analysis given above is doubtless the fact that wages, and thus labour requirements, here figure much less prominently than before. The significance of this in view of the present-day labour shortage in industrialized countries is obvious. In the future, weaving machines will continue to be a valuable means of reducing manual labour.

Future trends in weaving

Future trends in weaving are pinpointed as follows:

Capital outlay (and amortization)	Rising
Performance and productivity of machines	Rising slightly
Quality of yarns	Improving considerably
Efficiency levels	Limited improvements to be expected
Personnel requirements:	
Number of weavers and assistants	Further savings possible
Number of supervisors	No change
Cleaning	Substantial improvements probable

Preparation of warp	Introduction of mechanical drafting and dropper setting
Preparation of filling	Introduction of larger weft packages
Transport of material	Limited efficiency measures possible
Versatility of machines	Increasing

The discontinuous operation in weaving caused by warps of limited length would not be altered substantially by the introduction of longer warps. In addition, the use of longer warps is opposed to the present trend towards greater versatility in the weaving mill. Generally speaking, therefore, while improvements are still possible, a fully automatic weaving mill is likely to remain beyond the bounds of feasibility.

Automatic and non-automatic finishing

The new technological and chemical advances have brought about important changes in the finishing techniques of textiles, and reductions in the cost. Still, only certain sections of the process are working automatically. These are used to greatest advantage when large quantities of the same type of goods or same colours are processed. For instance, the new dyeing machines operate at an approximate speed of 70 metres per minute on average colours, for example a current type of khaki colour used for uniforms. This speed means that the average hourly production is around 4000 metres. In order to prepare the machine, it must be properly cleaned and the new dye bath prepared. At least 1-1 1/2 hours are needed. In other words, it would not pay to run 5000 metres of cloth on a continuous dyeing machine because one would need more time for the cleaning and preparation of the machine than for the actual dyeing process. Generally speaking economy dictates that at least 10,000 metres and an average minimum of at least 20,000 metres should be dyed on automatic equipment. On the other hand, in non-automatic jiggers one can easily dye lots of 1000 metres per colour without complicated preparations.

This example illustrates the drawback of continuous high speed operations, when production is small: especially in view of the high depreciation cost, automatic finishing equipment cannot be said to be the most advantageous solution in such cases.

Continuous versus non-continuous finishing

From a fairly large Venezuelan finishing mill it was possible to obtain reliable comparative figures for mercerizing and bleaching of cotton cloth on only jiggers, as well as on the semi-automatic mercerizing and bleaching equipment that is installed there.

The following operations are involved in the non-automatic process: singeing, desizing and boiling-off in jiggers, bleaching in jiggers with hypochlorite, dyeing, mercerizing, neutralizing and finally drying. A base salary of $5.60 per day was taken into consideration for two jiggers operated by one man with a capacity per jigger of 100 kilograms of cloth. Also, the usual rates for depreciations and general overhead expenses prevailing in Venezuela were calculated.

In the case of bleaching and semi-continuous mercerizing, the actual data of this efficient Venezuelan finishing mill was taken into consideration. The plant singes and impregnates the cloth with the desizing agent and boiling-off is generally done in one operation. The cloth is mercerized, peroxide is applied, and the washing is done in a second continuous operation, after which the drying process takes place.

Table 26

Bleaching and mercerizing in jiggers

(Cost in $US per kg. of cloth)

	Chemicals and other auxiliary products	Labour	Total
Singeing	.0004	.0377	.0381
Desizing in jiggers	.0148	.0044	.0192
Boil-off in jiggers	.0144	.0155	.0299
Bleaching in jiggers	.0400	.0104	.0504
Drying	-	.0411	.0411
Mercerizing	.0422	.0577	.0999
Final drying	-	.0411	.0411
Overhead and depreciation	-	-	.0880
	Total cost		.4077

Table 27

Semi-continuous bleaching process

(Cost in $US per kg. of cloth)

Casing and desizing	.0004	.038	.0384
Mercerizing, bleaching and washing (all in one operation) including overhead and depreciation	.0402	.0677	.1079
Drying	.0411	.0411	.0411
	Total cost		.1874

The calculations in tables 26 and 27 below are based on the figures obtained from the Venezuelan finishing mill and indicate the costs in US currency of the various stages of processing per kilogram of cloth.

It is important to note that substantial savings occur not only in labour but also in auxiliary materials for mercerizing and dyeing, so that the cost per kilogram of cloth in continuous processing is less than half of the cost of the non-continuous processing.

It is worth mentioning that for most modern bleaching techniques completely continuous machines are already being offered. This will lower production costs further. But higher depreciation costs will have to be applied for such new machines, which might temporarily offset the benefits.

Comparison between continuous dyeing and pad-jig dyeing

Calculations were made to compare production costs in the same Venezuelan finishing mill dyeing cloth by both methods. Continuous dyeing was calculated best with lots of 20,000 metres dyed with vat dyes in a regular khaki colour. The equipment consists of a 3-cylinder foulard with a hot flue, a chemical foulard, vaporizer and 8 washing compartments, with a production speed of about 70 metres per minute. This dyeing unit is operated by three workers.

For non-continuous dyeing the same colour was chosen with the same type of dyestuffs, applied by dispersion on the foulard with the reduction, oxidation and soaping performed on jiggers. The equipment consists of a foulard and four jiggers, which are operated by two workers with a production of 1200 kilograms for 8 working hours.

Depreciation could not be taken into consideration, since between the two equipments there is considerable difference in age. The following table shows the costs of the two methods of dyeing.

Table 28

Comparison between continuous and pad-jig dyeing

(Cost in $US per kg. of cloth)

	Continuous process	Pad-jig
Labour cost	0.0271	0.0295
Overhead	0.0880	0.0979
Dyestuffs, chemicals and other products	0.0344	0.0636
Total cost:	0.1495	0.1910

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Figure 1	Textile Industries
Figures X, XI and XII	Textile Indtitute and Industry
Figures XIII and XIV	Ruti Machinery Works, Switzerland
Figures XV and XVI and excerpts from Sulzer Technical Review No.2/1961	Sulzer Brothers, Switzerland
Tables 1 and 2	The International Wool Secretariat
Table 7	The International Textile Bulletin
Table 12	Saco-Lowell Shops, USA
Table 13 and material from "The Systemated Mill", Feb.1965 issue	Textile Industries
Tables 14, 15, 15A, 16, 16A, 17, 17A, 18, 18A and 19	Ingolstadt Mills, Federal Republic of Germany
Tables 20, 21 and 22	Platt Brothers Ltd., United Kingdom
Tables 23, 23A and 23B	Leesona Inc., USA
Tables 24 and 25	W. Schlafhorst and Co., Federal Republic of Germany
Data from "Selection and Blending of Wool in Relation to End Use"	The International Wool Secretariat
Data from W. von Bergen's Wool Handbook, Vol.I and from the Handbook of Textile Testing and Quality Control by E. Grover and D. S. Hamby	Inter-Science Publishers Division of John Willey and Sons Inc., USA
Data from article on "Spinning", April 1964 issue	International Textile Bulletin
Data from article on "Durable Press" by S. M. Sucheski, January 1965 issue	International Textile Bulletin
Data for comparative figures on automated and non-automated cotton spinning mills	Saco-Lowell Shops, USA
Data for comparisons of weaving costs	Ruti Machinery Works, Switzerland
Data for comparison of semi-automated and conventional spinning equipment	Platt Brothers, United Kingdom, and Ingolstadt Ltd., Federal Republic of Germany
Information on weaving equipment for cotton and wool	Sulzer Brothers Co., Switzerland

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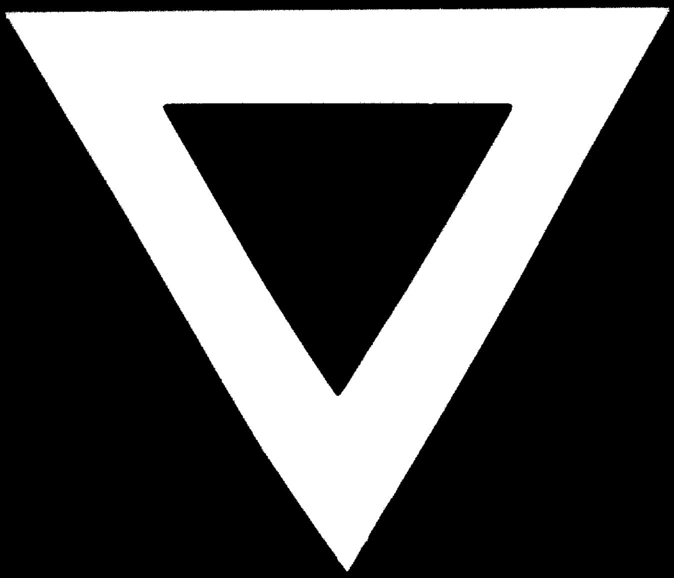

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