Kurt Salmon Associates Management Consultants

THE 1980's: THE DECADE FOR TECHNOLOGY ?

- A STUDY OF THE STATE OF THE ART OF ASSEMBLY OF APPAREL PRODUCTS

prepared for

THE COMMISSION OF THE EUROPEAN ECONOMIC COMMUNITY

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CONTENTS

SECTION 3. THE IMPACT OF TECHNOLOGY

What is the potential impact of technology on the apparel manufacturing industry ?

3.1 The Significance of Technology
  - 3.1.1 Cost Reduction
  - 3.1.2 Quality Improvement
  - 3.1.3 Customer Service
  - 3.1.4 Product Innovation
  - 3.1.5 Risk Reduction
  - 3.1.6 Job Enhancement

3.2 The Impact of Technology on the Apparel Manufacturing Firm and its Competitiveness

3.3 Barriers to Progress
  - 3.3.1 Criteria for Investment as Applied to today's technology
  - 3.3.2 Attitudes to Investment
  - 3.3.3 The Structure of the Industry

SECTION 4. POTENTIAL BREAKTHROUGH TECHNOLOGY

In which areas of technology is there promise of significant breakthrough in terms of achieving a substantial competitive advantage for high-wage cost apparel producers or of contributing significantly to meeting the success criteria of the individual manufacturing enterprise ?

4.1 The Infrastructure of Technology Development
  - 4.1.1 The Nature of The Technology Business
  - 4.1.2 The Development Cost of Technology

4.2 Future Development Directions
  - 4.2.1 Criteria for Future Development
  - 4.2.2 Key Task Areas
  - 4.2.3 Priorities

SECTION 5. RECOMMENDED ACTION AND PRIORITIES

In what ways could the development of breakthrough technology be accelerated and with what priorities and through what mechanisms might Government help at the European level ?

5.1 Publish State of the Art Study

5.2 Steering Group

5.3 Strategy for the Apparel Industry (1980 - 1990)

5.4 Working Party

5.5 Symposia

5.6 Proposals

  5.6.1 Research and Development Proposals
  5.6.2 Existing Technology Application Proposals
  5.6.3 Eductional, Promotional and Legislative Proposals

5.7 Overall Budgeting

5.8 Project Evaluation

  5.8.1 Development of Criteria for Project Viability
  5.8.2 Project Management and Co-ordination
  5.8.3 Budgetary Control

5.9 Funded Research Contracts

5.10 Funded Application Contracts

5.11 Demonstration of Prototypes

5.12 Patent Acquisition and Licensing

5.13 Communication Activities

5.14 Legislative Initiatives

5.15 Commercial Exploitation

5.16 Timing

APPENDICES

A. PREFACE

PREFACE

The Association Europeenes des Industries Habillements (AEIH), in its discussions with the E.E.C. Commission, focussed on the problem of manufacturing cost in the high-wage countries and the role that technology could play in reducing the competitive advantage enjoyed by the low-wage countries. It is clear that there are political and economic limits to the role which protectionist measures can play in ensuring the survival of the European apparel manufacturing industry. On the other hand it is realised that any breakthrough in technology which makes the industry more capital-intensive and reduces labour content significantly would be to the benefit of the high-wage country, and that such breakthroughs are unlikely to come about unless substantial sums are made available for research and development. Such investments are unlikely to be made by the hard-pressed industry or its relatively fragmented supplier industry, but it was felt by AEIH that supporting such research and development could indeed be a legitimate method for Government to help the European industry in a way which did not depend on multilateral or bilateral agreements and did not rely on quid pro quos from other trading blocs.

On the invitation of Dr Angelo Zegna, Chairman of the International Committee of AEIH, Kurt Salmon Associates was asked to comment on this line of thinking. KSA was able to confirm that in the United States similar involvement of Government support might be proposed by the industry, and KSA was able to identify, from its own experience, a number of areas of development which, if pursued, could hold out the promise of large reductions in the manual work content of clothing manufacturing processes, or which could contribute to other criteria for success in the marketplace.

It was on the basis of these discussions that KSA was asked to submit proposals for assisting the EEC to identify opportunities, so that the Commission would have a basis for deciding in what ways it could consider this type of assistance to the European apparel manufacturing industry.

It was recommended that the logical starting point should be a "STATE OF THE ART STUDY", which would enable all interested parties to acquire a common perspective, and which would identify the most promising areas where accelerated development might be successful in contributing to the main objective of reducing dependence on manual labour in the assembly processes, or of otherwise contributing to competitive strength.

That is how the study came to be undertaken and it attempts to up-date and bring together in one place the knowledge and experience of technology which is available within and to the apparel industries of the high-wage countries, as far as the assembly processes are concerned.

It is hoped that the study also provides a firm basis on which to develop the next logical step, which is to get the parties most interested and capable of developing new technology to discuss ways in which they would be able to move forward if the appropriate funding was available. It should also enable the EEC to determine its own policies towards supporting such technological development in the industry. In any event the authors hope it stimulates thinking by all those who read the report, regardless of the eventual decisions on funding technology developments.

The report has been written with four readerships in mind -

1. THE EEC COMMISSION, which commissioned the study as a basis for formulating the clear objectives for development of technology which are necessary if it is to make policy decisions as to whether and in what directions it would support such development. It is hoped that the report clarifies what these objectives should be and will therefore form a basis for moving forward.

2. THE TECHNOLOGY ORGANISATIONS, including apparel equipment manufacturers and technology organisations at present not serving the needs of the apparel manufacturer. These firms need to understand where the real leverage is in getting appropriate returns on capital investment in this industry, and to examine the directions of their research and development effort. It is hoped that this report gives them a new point of reference for re-examining their policies, and for participating in any subsequent discussion with the EEC and with their potential customers.

3. *THE APPAREL MANUFACTURING INDUSTRY, which needs to be aware of the latest developments in technology and to make its requirements known to those from whom they buy technology. Management in this industry needs at least to influence technological directions, and in some cases the larger companies can and do participate in major developments. Management needs to review its attitudes to return on investment, and to influence Government on depreciation rules for new technology.*

   The Trades Union need to determine their own policies towards increased capital intensity, and most do recognise that to survive at all the industry may have to become smaller in employment terms, but in the process become a higher-added-value higher-paid industry.

   Management and Unions together need to influence Government where there is a proper and legitimate role for Government to play, at both the European and national level. It is hoped the report will help to ensure that such influence is towards assistance for the right things which can have significant and positive impact on the fortunes of the industry.

4. *NATIONAL GOVERNMENT AND APPAREL INDUSTRY ORGANISATIONS. Many national governments have introduced policies to benefit the apparel industry and have set up organisations to help them relate to the industry's problems. The officials concerned need to understand where the real leverage is in terms of industry performance, and to understand the role technology can play as well as its limitations. It is hoped this report will assist those concerned in this task.*

For KSA, it has been a privilege to carry out this study. It has involved work in 3 continents and has involved 12 members of KSA's consulting staff, working out of its offices in Windsor, England, New York and Atlanta, U.S.A. and Darmstadt, Germany.

KSA would like to express its appreciation to AEIH, particularly to its President Mr Gaston Siau, and to Dr Angelo Zegna, and to the officials of the EEC in Brussels who have helped frame the study requirements and have guided the work. Thanks are of course particularly due to the 60 or so organisations, listed in the Appendix, who have given their inputs and have shared their thinking with KSA, and to the many individuals in those organisations who gave so generously of their time.

The study was managed and the report prepared by

Stephen Webb

Stuart D Hollander

for KURT SALMON ASSOCIATES

B. SCOPE METHODOLOGY AND GUIDE TO THE REPORT

B. SCOPE, METHODOLOGY AND GUIDE TO THE REPORT

The objective of this study, as agreed between KSA and the EEC Commission has been *"to provide a point of departure from which it will be possible to identify fruitful avenues for research and development which might be accelerated by injection of EEC funds"*. The study has been *"restricted to assembly and finishing operations in the manufacture of apparel. It excludes cutting and finished goods handling"*. It was also agreed that the study should *"encompass technology being used or developed in the United States, Europe and Japan"*.

To achieve these objectives it was necessary to visit three types of organisation :

1. The major manufacturers of assembly (stitching) and finishing equipment supplying the apparel or shoe industries.
2. Some higher technology companies and research institutes from which the equipment manufacturers are drawing their technology.
3. A few major international apparel manufacturers who were known to have major technology developments of their own.

The objectives of these visits were not only to establish the current lines of technological development, but also to assess their potential impact on the labour content of apparel products. The study was to be *"primarily concerned only with developments that can have a substantial impact on reducing labour content across a broad range of products"*. It was not to be concerned with developments that are highly product-specific, unless principles are being applied which have more general application.

In pursuing the technological developments and research being used by the equipment developers the study was to be *"concerned with identifying lines of development which are likely to lead to radical approaches"* but it was agreed to *"exclude fundamental research from the study"*.

The methodology adopted and the structure of this report have therefore been designed to deal with five key questions; as follows :

1. *WITH WHAT PERSPECTIVE AND BY WHAT CRITERIA MUST TECHNOLOGY'S CONTRIBUTION BE JUDGED in the light of the issues facing the apparel manufacturing industry in the high-cost countries.*

2. *WHAT IS THE CURRENT STATE OF THE ART with regard to the technology applicable to the assembly of apparel products ?*

3. *WHAT IS THE POTENTIAL IMPACT OF TECHNOLOGY on the apparel manufacturing industry ?*

4. *IN WHICH AREAS OF TECHNOLOGY IS THERE PROMISE OF SIGNIFICANT "BREAKTHROUGH" in terms of achieving a substantial competitive advantage for high-wage cost apparel producers, or of contributing significantly to meeting the success criteria of the individual manufacturing enterprise ?*

5. *IN WHAT WAYS COULD THE DEVELOPMENT OF "BREAKTHROUGH TECHNOLOGY" BE ACCELERATED, and with what priorities and through what mechanisms might Government help, at the European level ?*

Each of the five sections of the report have been written to try to answer each one of these questions in turn.

It is inevitable that a report of this nature contains considerable technical detail which will be of most interest to the apparel manufacturer and supplier of technology. The Commission, and officials of national government or its institutions, will be more concerned with the main issues to which technology might contribute (Section 1) and the recommendation for action (Section 5). It is considered that an understanding of the significance of technology and its potential impact (Section 3) is essential to the justification of any attempt to accelerate the pace of change.

Section 2 describes the current State of the Art in detail and Section 4 distills from this the recommended directions for development, bearing in mind the potential impact and the criteria which must be met. These two sections demand that the reader has some basic understanding of the apparel assembly process and an interest in the technical nature of the problems which will need to be solved.

For those who wish to first acquaint themselves with the conclusions of the report there follows a brief summary of these.

For those who wish to read the whole report, it is recommended that they take the sections in order so that the logic of the five key questions is followed.

For those who wish to absorb the reasoning behind the recommendations, but do not wish to wrestle with the technicalities of apparel manufacturing, study of Sections 1, 3 and 5 should suffice.

C. SUMMARY OF CONCLUSIONS AND RECOMMENDATIONS

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The basic conclusion of this study is that:

> *If the technology which is now available is developed into the correct practical applications and then harnessed to the important leverage points in apparel manufacturing, it can make a significant impact on the performance and competitiveness of the individual manufacturer and thereby create competitive advantages for the apparel manufacturing industry in the high-cost countries.*
>
> *The size of the advantage enjoyed by the low cost countries is such that technology alone can in no way be regarded as a panacea, but it can and must be used to erode the significance of that advantage if the industry is to survive.*

As a result of evaluating the current state of the art of apparel manufacturing technology, this report first concludes that there are in existence technologies at various stages of development, both inside and outside the traditional suppliers of technology to the apparel industry, which can dramatically reduce the labour content of apparel products and contribute significantly to other key success criteria including:

- cost reduction
- quality improvement
- customer service
- product innovation
- risk reduction
- job enhancement.

It is demonstrated that given certain assumptions regarding the impact of future technology on the profit mechanics of the typical apparel manufacturer, investment in technology will be able to improve corporate performance and/or will enable products to be manufactured at more competitive prices.

One of the reasons why technology has not in the past made the contribution which can now be foreseen is that equipment on the market has, on the whole, tackled only a small part of the key competitive elements and the amortisation periods are therefore often unacceptably long.

The study also concludes that there are significant barriers to progress because of the traditional attitudes and current lack of confidence which influence many apparel manufacturers' investment decisions. There is also a major barrier in that to develop the technology which is needed will take considerable resource, beyond the capabilities and fiscal constraints of the manufacturer and most of the traditional supplier industry. It is considered that Government at the European level can play a vital role in overcoming these barriers.

The present structure of the industry is also seen as a barrier to progress, but is believed that technology will in any case increase the trend towards large more capital-intensive companies, while at the same time contributing to the competitiveness of the smaller firm.

The study identifies a number of key task areas which must be tackled by the technology supplier if the proposed criteria for future development are to be met. These are:

- full cycle automation
- full sequential automation
- alternative processes (such as moulding, full garment knitting, non-woven technology and plastic forming)
- improved management through computer technology.

Within these areas a number of critical elements have been identified which must be at the heart of the next generation of development projects. They include the early development of:

- versatile ply pick up and place devices
- alignment devices
- acceptable rigidification processes that are reversible and can be applied selectively
- an automatic sewing machine head which is demountable and incorporates self-threading and omni-directional capability.

The report concludes with a framework for discussion of recommended actions whereby the EEC Commission can consider its legitimate role. The recommendations can be summarised as follows:

1. Publication of the study
2. Organisation of a steering group and working party
3. Articulation of the EEC's strategy for the European apparel industry for the period 1980/90, *including* the role and targets of achievement for technology
4. Organisation of symposia to enable interested parties to develop consensus on viable directions and projects.
5. Determination of a budget for assistance in the development of apparel manufacturing technology
6. Request for and evaluation of proposals for research and development, applications of existing but as yet uneconomic technology, and educational, promotional and legislative actions.
7. Development by the working party of criteria for project viability and a methodology for evaluation, management, co-ordination and budgetary control of individual projects.
8. Formulation of policies and mechanisms for assisting the industry, including:
    - funded research contracts
    - funded application contracts
    - demonstration of prototypes
    - patent acquisition and licensing
    - communication activities
    - legislative initiatives

The study concludes that the rate at which the apparel industries in the high cost countries are declining and the rate at which low cost imports are increasing notwithstanding the MFA, are such that there is a danger that the size of the industry in individual countries could reduce to the point where viability is threatened. This could happen on present trends within a time-scale of the same order of magnitude as that required to develop practical technology with the impact needed. Without that impact it could reasonably be speculated that the threshold of viability could be reached during the last decade of the century. Given the necessary resource, technology can help to reverse the trend within a 10 year period.

SECTION 1

TECHNOLOGY IN PERSPECTIVE

With What Perspective and by What Criteria Must Technology's Contribution be Judged in the Light of the Issues facing the Apparel Manufacturing Industry in the High-Cost Countries?

1. TECHNOLOGY IN PERSPECTIVE

In this section of the report, the reader is given a perspective from which to judge the importance of the apparel industry, the key factors which affect the strategy of individual manufacturers and hence the contribution which technology might make to the key success criteria as well as its limitations.

It will be seen that technology alone cannot overcome the disadvantages of high-wage economies or ensure survival of the industry, but there is reason to believe it has a major contribution to make. It is suggested that the nature and scale of the problem is such that Government has a legitimate role in supporting the acceleration of technological development.

The manufacture of apparel products is labour intensive and relies on the manipulative skill of sewing machine operators. As long as this remains the case, the high wage, high social security, high fringe benefit economies have a built in competitive disadvantage in the production of apparel.

What is the size of this disadvantage?

In the high wage economies there is a labour force in the manufacture of apparel and knitwear of approximately 2.7 million people* (of which 1.1 million are in the current EEC countries). The weighted average annual cost of each member of this labour force is approximately $12,000. In the main apparel-producing less-developed countries (excluding COMECON and China), the average annual cost of each member of the labour force is approximately $2,000. Thus the cost of the high-wage apparel manufacturing labour force is higher than an equivalent size labour force in the LDC's by approximately $27,000,000,000 per annum, an amount equivalent to the total apparent consumption of apparel in the USA in 1976.

The current and potential apparel labour force in the LDC's is of course much larger than that in the developed world, and the impact of China will increase the size of the disadvantage with its average annual labour cost of near $600. It would be ludicrous to suggest that an advantage of this size can simply be offset by the application of technology. It may, however, suggest that substantial efforts are worth making to erode the significance of that advantage.

To determine what efforts are worth making it must be established to what extent technology can contribute to helping the individual firm deal with the key issues facing it. So first it is necessary to identify these issues. It is a necessary condition for all future technological development that, if it is to be viable, it must contribute to meeting those criteria which are critical to the commercial success of apparel manufacturing enterprises.

The apparel manufacturer who can only compete in Western markets on the basis of price in price-sensitive sectors of the market is doomed in any case. To succeed, the apparel manufacturers must have a marketing strategy based on design, fabric selection, quality, image and appeal.

* USA, Canada, Japan, UK, France, Germany, Italy, Denmark, Holland, Austria, Finland, Norway, Sweden, Switzerland.

Because the manufacturer goes to the consumer via complex distribution channels the manufacturer must also provide unique value packages to the distributor, in terms of achievable margin certainly, but perhaps more importantly to compete with imports, in service, reliability, flexibility, short lead-times, and trade-marketing support activities such as new collections, innovative merchandising, promotion at the point of sale, and efficient distribution.

Given these essential criteria for success, the most productive manufacturers will also win on their ability to hold, and to help their retail customers to hold consumer-sensitive price points. So minimising cost and maximising productivity is important in all segments of the market. The point is that, while price may not always be decisive, the high-cost country's apparel manufacturer is vulnerable to low-cost competition to the extent that the labour content is high. The same technology is available to both areas of the world, but the more the labour content can be reduced as a result of technology, the less of a competitive advantage is enjoyed by the low-wage producer.

Furthermore, it is the thesis of this report that technology is not just a tool for cost reduction. It is also a tool for quality improvement, for raising the level of customer service, for product innovation, for risk reduction and for job enhancement. In other words technology is a major weapon in the fight to be successful in the marketplace, and it has its role in the small as well as in the large manufacturer.

It has often been mooted in political circles that the battle cannot be won on the basis that sale of Western high technology to the lesser developed world requires a sacrifice of labour-intensive capacity. The low-wage countries have skilled operators in large numbers and they have all looked to apparel manufacturing as a large-scale provider of employment in the early stages of their development. Hong Kong, Korea, Taiwan, India and now China all have growing capabilities and motivation to develop apparel manufacturing for both domestic and export needs. There is no technology available which could be applied now which would dramatically alter the labour-intensiveness of this industry, thus giving the Western economies a productive advantage, although the productivity increases achieved in the last 10 to 15 years have moved in this direction.

So while at first sight it may appear that investment in apparel manufacturing technology is ignoring the political and international trading realities, there are in fact a number of imperatives which require developed economies to keep an apparel manufacturing capability.

First, there is a strategic need to be able to clothe the nation in the event of economic or military war. Second, the erosion of apparel manufacturing leads to the erosion of upstream textile manufacturing as well, employing an additional 3.7 million people in the developed economies. Third, there is a balance of payment requirement in some countries that lack of domestic apparel manufacturing competitiveness can only make worse. Fourth, the retail industry will in any case suck in imports if it cannot get what the consumer wants from the domestic market. Finally, there is a social imperative in that this industry provides jobs on a large scale - jobs that traditionally have appealed to women, who increasingly need to work or wish to exercise their new-found freedom to do so.

However, as logistics and communications become easier, and lower-wage countries' apparel industries become more sophisticated and fashion capable, the high labour content of the apparel products as required by current technology,will become an increasing vulnerability and feed further erosion from imports. The 3% to 4% annual productivity increases achieved in the industry as a whole, while better than the record of many other industries, is *insufficient to remain competitive and inadequate in the light of what is possible even with existing technology.* Further, the overall average performance of the industry is very much lower than the best, and a relatively small shift of the average towards the best would have a major impact.

Another factor which must also be considered is that one of the main causes of increased import erosion is the decline in capacity. The U.S. shirt industry can no longer supply the domestic market, and the reversal of the decline is extremely costly. A recent study has shown that with today's technology, to start up a plant it is probably necessary to absorb a loss of $8,000 per operator, on top of capital investment, even with the best training techniques.

Technology may have a significant role to play in reversing the decline of capacity, not only with increased competitiveness but because the management of start-up would become much easier than is the case with today's highly labour-intensive operation.

However, the rate of decline of the apparel industry has been such that in some countries (e.g. Sweden) it has already dropped below a viable size threshold, at which it becomes difficult to attract management and/or the attention of the domestic retail buyer. It could be speculated that in some other countries that position could be reached before breakthrough technology can be developed if the pace of development is not accelerated by injection of the necessary funds.

In other industries which have successfully competed with low wage-cost competition there has been heavy investment in technology to make it more capital-intensive, justified by the saving in high-cost labour and in the ability to supply a different or superior product. To the extent and for the time that the under-developed countries have not been able to justify, acquire or maintain that technology, it has given the high-cost economies the means of survival and growth in these industries. German steel, Italian cars, Japanese audio/TV, American textiles are all examples of this approach, where domestic high-wage industries are competing successfully with low-wage sources.

The changes achieved in these industries in order to to survive have not come about within the same structure of the industry that existed prior to the technological development. If the apparel industry moves in the direction indicated in this study, the post-technology structure will be very different to the pre-technology structure. Some technology will require larger firms to come into being with added financial strength. Yet other technology will enable the small firm to offer more of the flexibilities of the smaller firm at lower cost. The shift will however, be to bigness. The trend is to some extent discernable already.

This report discusses the "State of The Art". It probes the supportive technology which is feeding in to apparel manufacturing technology, or which could feed in to it. It develops the concept of *breakthrough technology* in those areas where significant impact on the key criteria for success of an apparel manufacturer can be achieved.

Inevitably there is considerable emphasis on the application of technology to mechanising or even automating the handling of limp fabric to and from the needle point, notwithstanding the impact of technology on other key areas. To the reader who is unfamiliar with the current technological processes, it is important to understand that 80% of the direct operative workforce spends 90% of its time picking-up, positioning, manipulating and removing one or more pieces of fabric around a stitch-making device. That the sewing machine has become more sophisticated over the last 20 years there can be no doubt, but the impact has largely been on the stitching cycle and not on the 90% of labour content spent handling. But while the report addresses this problem in depth, it should also be appreciated that the actual labour content of apparel products is usually between 20% and 50% more than the machine and handling-time. The difference comprises the losses under management's control, so the study addresses itself to how technology can impact this cost-factor too.

It must be appreciated that labour-cost *per se* represents only about one twelfth of the retail selling price, so that to be viable, technology must contribute far more than merely reducing that one-twelfth to something even significantly less.

It will be seen that the impact of technology on overhead costs, on the consistency of quality, on customer service, on risk reduction and on job enhancement are also considered and in some sectors of the industry may well be of more critical concern.

Finally, the reader should also have in his mind the fact that the apparel manufacturer, like any other, will invest in technology when the return is commercially attractive. Apparel manufacturing is a relatively high-risk business and investment decisions must reflect this by calling for relatively high returns. Much of the technology available to the manufacturer today does not produce such returns even at the highest European wage levels. In some of the more recent developments in the cutting process (not considered in this report) the returns can be highly attractive, but until the limp fabric handling problem is solved this will continue to be a barrier to a high return-on-investment from assembly equipment.

The cost of *breaking through* from many of the ideas and basic technologies available, to commercially viable equipment is such that no apparel manufacturer, and few, if any, of the current machinery manufacturers serving the industry, will be able to justify the investment and risk. It is perhaps significant in this context that breakthroughs in automatic cutting came from aero-space nd associated high-technology large-scale enterprises. he thesis behind this study is that sharing that risk is a viable supportive role for government, which does not require the short-term returns essential to a commercial enterprise. Such a role is seen to be compatable with the imperatives of maintaining the high-wage countries' apparel manufacturing capability, and possibly more compatable than increased protectionism in the light of the growing economic and political realities of multi-lateral trading arrangements.

It is hoped that the report will begin to indicate how and why this role for Government, at the European and national level, might be legitimate and valuable.

SECTION 2

THE CURRENT STATE OF THE ART

What is the current state of the art with regard to the technology applicable to the assembly of apparel products ?

2. THE CURRENT STATE OF THE ART

This section first provides the reader with a brief history of the developments leading to today's technology. It then describes the nature of the apparel assembly process in order to ensure that the non-technical reader develops an understanding of the kind of problems which need to be solved.

There follows a classification of the technology in current use or known to be under development.

The State of The Art chapter describes, for each major product category, the current technology in use, and the final chapter distills from the foregoing broad conclusions on the current directions of technological development.

2.1 A HISTORY OF TECHNOLOGY DEVELOPMENT IN APPAREL MANUFACTURING

Since Wisenthal invented the needle with an eye in the centre in 1775, Thommonier patented the first working sewing machine in 1830, Howe invented the lockstitch in 1846 and Gibbs the chainstitch in 1856, there have been thousands of patents which cover improvements in the sewing machine. However, there is little fundamental difference between the way stitches are made now and the way they were made in the middle of the 19th century. The machine moved from hand or foot power to shaft power, the shaft attaching the equipment to water or electrical supplies and finally to individual electric motors, beginning in the 1930's. There have been significant changes in the productivity of sewing machines during the past 75 years, primarily in speed as measured by the stitches made per minute. By 1930 machines were available which operated at just over 3000 stitches per minute. With the introduction of automatic oiling, the speed increased to 5000 stitches per minute, which remained the practical maximum from about 1930 until 1962 when speeds began to increase with the new metals technology. For all practical purposes the maxima are now about 6000 stitches per minute for lockstitch machines and 8000 stitches per minute for chainstitch machines. Chainstitch machines have now virtually exceeded the ability of the operator to control the fabric at the speed which they are capable of running. Machines capable of 10000 stitches per minute or more will probably be seen if and when the handling by the operator is eliminated or assisted.

This evolution in sewing speed has been important to productivity for a number of products. However, it will be understood that on many sewing operations the time that the actual sewing takes place forms only a small part of the total time required to perform the operation.

Literally thousands of minor work aids have been developed during the past 75 years. These consist primarily of attachments, folders, and guides which assist the operators in producing a variety of seams with a minimum of human control. Examples of this are hemming folders, binding attachments, and edge guides.

At about the turn of the century another major breakthrough was made when the first automatic cycling machines were invented. This automatic cycling feature made possible the bartacker, the buttonhole machine, and the buttonsew machine. Advances in the development and application of automatic cycling machines continue to go forward, but at a slow pace.

Around 1960, needle positioners began to find their way into the apparel industry. These rather simple devices were designed to place the needle automatically in either an up or down position at the will of the operator, without the turn of the hand wheel previously required. Perhaps more importantly, the needle positioner made possible the development of the underbed thread trimmer, which provided the most significant productivity improvement device which came into use during the 1960's. Like the needle positioner, the automatic thread trimmer made possible other developments in automatic disposal. During the 1960's and to the present time, numerous disposal and stacking devices have been developed both internally by apparel manufacturers and by suppliers to the trade. The decade of the 60's was a rich one in the development of apparel mechanisation. The sewing machine manufacturers began to think about the human side of the fabrication task in addition to the mechanical problems. In the USA the American Apparel Manufacturers Association began its efforts to pool the resources of the apparel manufacturing community to find ways to have research conducted which would enhance the industry as a whole, thus contributing to solving the problem of a fragmented development effort.

The machinery manufacturers moved from a preoccupation with stitching speeds, feeding mechanisms, and stitch formations, to thread trimming, guidance mechanisms and disposal devices. The automatic cycling machine took a giant step forward with the introduction of the first patch pocket setting machines and the first welt pocket machines. At first, these were enlargements of the early cam-controlled bartackers and buttonhole makers, but they gradually moved to pneumatic, optical and electronic controls.

Notably during the 60's were two major research projects, one funded by a German sewing machine manufacturer and the other by the U.S. Apparel Industry, with government support.

The German development was called the transfer street. This large and complex machine was designed to perform all operations on a shirt front including pocket setting, front edge folding, buttonholing, and buttonsewing. It even hemmed the pocket in preparation for attaching. In order to perform this series of operations, a great deal of basic research and development had to be undertaken in the area of picking up, moving, and re-aligning pieces of limp fabric. Although this machine was not commercially successful, it provided a great deal of the technology and the mechanical logic which led to automatic pocket setters, automatic underfront machines, sequential buttonsew machines, sequential buttonhole machines, the the pick-up and disposal devices used on numerous other mechanized devices throughout the range of apparel products.

A joint effort of a number of U.S. apparel manufacturers with government support went toward some basic research in the handling of limp fabric. The result was a report accompanied by an experimental prototype called the "Rink". The Rink was intended to be a test of a number of technologies involving the pick-up, alignment, orientation, and disposal of limp fabric pieces. Not intended as a commercial venture, the Rink project stimulated a great deal of thinking among apparel equipment manufacturers as well as among the apparel manufacturers themselves.

The development of the needle positioner and thread trimmer, the increased use of the air operated devices, the transfer street, and the Rink, stimulated manufacturers in both Europe and America to really begin to pay greater attention to the development of equipment to improve the productivity of the apparel industry. Much of the more advanced equipment in use today owes its development to this early research, and perhaps demonstrates the potential for breakthrough if more appropriate resources could be applied to this type of project.

There was also a dramatic increase in the internal expenditures being made by apparel manufacturers on engineering and specialised equipment development.

Some apparel manufacturers turned to equipment development companies which heretofore had not been involved in the apparel industries. These automation companies did specialised research on certain apparel products under contract with one or more producers of those apparel products. The real return on investment provided by the research and development done by these companies was poor and no successful production equipment was delivered from these efforts ; only prototypes and pre-production models were demonstrated. However, certain breakthroughs in basic technology were made and both efforts contributed to the general state of the art of soft goods mechanisation.

In addition to the sewing technology developments of the 1960's and early 1970's there were significant developments in the marking and cutting operations. In about 1962, the first pattern miniaturisation equipment specifically developed for the apparel industry came onto the market.

Pantographic pattern reducers and cutters as well as cameras and other reproduction equipment were designed to improve the marker making function and to provide an improved technology for the control of material waste.

Simultaneously, a joint venture operation between a large apparel manufacturer and a high technology corporation led to the first numerically controlled fabric cutters utilising a laser beam to cut a single ply of cloth. Simultaneously a machine tool manufacturer who had enjoyed great success in the development and sale of numerically controlled tools for cutting metal and wood was working on a mechanical cloth-cutting head for numerical control. A similar development led to today's latest cutting technology.

Interactive marking and planning of markers with the assistance of computer technology is today widely used by the larger, more progressive apparel manufacturers of the world. The numerically controlled cutting head is now commercially successful and is usually guided by the electronics furnished by computer aided marker making.

Due to its ability to cut only a single ply of fabric, the laser cutting head has not met with significant commercial success. It is being used by one or two tailored clothing companies and, more important, has been adapted to cut patterns used in the manufacturing process.

During the 1970's some additional new thinking has gone into apparel mechanisation. A number of edge guidance devices have come on to the market and the automatic cycling machine, the old bartacker married to modern electronics, continues to offer new potential. Electronic control is rapidly becoming a standard element of the latest generation of sewing equipment.

2.2 THE NATURE OF THE ASSEMBLY PROCESS

In this section the conventional assembly process will be discussed; that is the process of joining together precut parts to form a finished garment.

With very few exceptions garment assembly is organised as a batch processing system. Each batch is typically called a bundle. The batch size can vary from a single unit to over 100 depending on the product, and the production and handling system in use. Similarly, the number of discrete processes (operations) the batch goes through can vary from less than five to over 100. This also depends on the product, but the extent to which the assembly process should be split up into separate operations is much more a management decision. This decision is in turn influenced by the quantity being produced and the amount of investment available for specialised industrial engineering and equipment at each operation.

Traditionally the highly efficient producers set up production units with very short individual operations producing at high volumes. Such action had the advantage that each workplace could be specialised to a high degree and the basic work content of the operation brought down to the minimum. The resulting short cycle times allowed the operators to achieve relatively short learning periods and extremely high pace. The disadvantages of this approach were that because it was impossible to set up all the operations with identical capacities a considerable "balance" problem arose requiring the transfer of operators from one operation to another to equalise output throughout the system. Excess times (and costs) then started to arise as operators waited for assignment and as operations were performed by less experienced workers. These problems could be minimised by carrying high work in process for each separate operation but this in turn involved considerable investment in working capital and protracted throughput times. A further disadvantage of this approach was that such production units were inflexible in the face of product changes often of even relatively minor ones.

Because of the much greater demand for flexibility now placed on the garment manufacturer, production units as described above are only appropriate for a narrow range of products, such as jeans.

The more recent trend has been for manufacturers to aim for fewer separate operations which entails less specialisation, higher basic work content, a lesser though still significant balance problem, lower work in process and faster throughput time. However, dependence on operator skill is higher, the work pace tends to be lower and training times are longer. Once established such production units are relatively flexible.

In both cases there has been almost universal adherence to the principle of one operator working one machine. Numerous studies have shown that the actual machine time in such circumstances rarely exceeds 30% of the total cycle time and averages closer to 15%, the balance being handling. Most current mechanisation strives to overlap some of the handling time with the machine cycle time. Machinery manufacturers describe this as "increasing the proportion of machine time". While this is valid, it is perhaps more constructive to think of it as eliminating the machine time from the total cycle time as this more clearly illustrates the fundamental limitations of this approach in that it attacks the smaller part of the total cycle time. This argument is developed further elsewhere in this report.

To fully comprehend the opportunities that technology offers to reduce manufacturing time and cost, it is necessary to distinguish between the two elements that make up the actual manufacturing time. These are :

- *The Basic Element*
- *The Excess Element*

The reason for recognising these elements separately is that their level or 'content' is determined by different people, and their reduction and control subject to different skills.

2.2.1 The Basic Element

The basic element of time or cost of a garment is the inherent work content as dictated by the design of the product and the processes used. It can in turn be broken down into:

- *the design component*
- *the engineering component*

The design component is the work content dictated by the designer and the assembly methods specified, and should be a reflection of what the particular market requires. The design component specifies the number of seams, the stitches per inch, the degree of check matching, the quality standards, the amount of basting, under-pressing and handwork. Thus, the design component might be termed the *'intrinsic work content'*.

The engineering component is a reflection of the way industrial engineering (work study) skills and machinery have been applied to produce the desired intrinsic work content at the lowest cost, and might be termed the *'process controlled work content'*.

The basic element is the measured work content or number of minutes required, at a defined level of operator effort, to produce the required design with the equipment and methods available, allowing for defined losses for machine delays and fatigue and personal time, but without any time losses of any other kind. This is the time per garment which would be achieved if everything went perfectly, if styles could be changed without loss, if operators were never absent and never required training.

2.2.2 The Excess Element

If the basic element is measured accurately to the above definition then it will, of course, always be less than the actual time achieved. The difference between the actual time and the basic time is the excess element.

The excess element can be reduced and controlled. It can also be split into two parts :

- *the intrinsic excess*
- *the managerial excess*

The intrinsic excess is a reflection of the conditions which are dictated by the market which the manufacturer is trying to serve and by the scale of the operation. These are factors which are largely beyond management's control once the policy of the company is established, and they will only change in the longer term (by expanding, by rationalising the range, by serving different markets, etc.)

> The manufacturing conditions dictate throughput time and flexibility, and they should be reflected in the design of the production system.
>
> The managerial excess is what is left, and *it is that part of the time taken which truly reflects managerial competence in administering production.* It reflects scheduling, shop and machine loading, supervisory skill in balancing, reduction of training times through use of modern techniques, and motivation and incentives for employees to give of their best.

To summarise, the apparel producer is faced with a continuing need to balance the basic element and the excess element in order to optimise the actual time and cost. It will be seen that technology properly applied can have a very significant impact on where that balance is achieved.

2.3 A CLASSIFICATION OF TECHNOLOGY

In order to discuss and identify opportunities it is necessary first to classify the various techniques used in the application of technology to the apparel assembly process. The following categories have been selected, though it is appreciated that there is a degree of overlap between them:

- Materials Handling Technology
- Joining Technology
- Controls Technology
- Process Technology
- Management Technology

Each category is discussed below.

2.3.1 Materials Handling Technology

This area encompasses most of the technology now used to mechanise the assembly process. A number of sub-divisions can be identified:

- Separate and pick up one ply of fabric
- Position and align fabric
- Load to machine
- Guide through machine
- Unload from machine
- Transfer to next process

Taking each of these in turn:

(a) Separate and pick up one ply of fabric

This is a key area. Due to edge welding caused by knife friction as garment parts are cut out, to surface fibres tangling under pressure in the cloth lay and occasionally to static electricity effects, the separate plies of a stack have a tendency to stick together with most fabric types.

Much time and effort has been devoted to the construction of devices designed to grip a single ply on the top of a stack sufficiently firmly for it to be separated from it manually via some sort of peeling or slicing action. To date none of these devices has been completely satisfactory, and many are awkward to adjust accurately for different thicknesses of fabric.

The alternative approach of separating one ply first then picking it up has been tried and appears to offer a solution to a number of the difficulties inherent in the more usual "grip first" approach.

However, in a fully automatic context, the separate and pick up operation is rather more complex. This is because workable devices would have to recognise their own faulty operation, they would have to pick and reject laps in the lay and they would have to sense the end of the stack. These last requirements potentially require much more sophisticated technology than simple pick up.

(b) Position and align fabric

To the extent that this element is concerned with separated plies the problems are more tractable. The technologies of aligning several parts accurately are well developed outside the garment industry. The added complexity of handling limp fabric arises and a number of techniques are available to facilitate this.

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(c) Load to machine

This area is largely an extension of the previous one in that it requires the accurate movement of a limp fabric piece, or a set of pre-aligned pieces. The precise nature of the 'load' action varies from machine to machine.

(d) Guide through machine

In general this is now regarded as a machine technology. Guidance can be accomplished in two principal ways:

- Edge following
- Predetermined path

In the first case a fabric edge is used to determine the seaming path. This is usually an external edge, though not necessarily so. Various techniques for creating a sharp edge on fabric parts have an application here. In this context the universal principal is for the machine to remain stationary and for the fabric to pass through it.

In the second case the seaming path is predetermined. Actual guidance can be hardware determined by jigs, cams, or rails, or it can be software determined by various systems of numerical control. In this context, although the workpiece passes through the machine in most instances, the alternative technique of fixing the workpiece and directing the seaming head around it is gaining ground.

In terms of flexibility it is clear that guidance systems dependent on edge-following are inherently more flexible, though developments in software guidance systems go some way to answering this. Such systems frequently have the additional advantage that numerous seaming paths can be stored electronically and called up on demand.

(e) Unload from machine

The techniques in this area are well developed. The usual objective is to get the unloading device to remove a finished piece and dispose of it in such a way that it is aligned optimally for the subsequent operation. Sometimes the unloading mechanism also transfers the workpiece directly to the next operation.

(f) Transfer to next process

The broadest spectrum of technology is employed in this area from straightforward tied bundles through to highly sophisticated computer controlled transportation systems. This is a development area which can greatly increase flexibility in that it frees the production process from the constraints of a sequential layout. Whilst the basic transportation systems have been available to do this for many years, the problems associated with managing such flexibility have yet to be fully solved. The computer controlled systems would appear to offer the best opportunities yet of managing total sequence flexibility.

On a different level this classification could be applied to sequential feeding devices where a prepositioned workpiece is fed repetitively through the same process as in buttonholing or belt loop attaching.

Of course not all the above processes occur on every operation nor do they always occur in the sequence discussed. As far as present development is concerned, the first three items (pick up, position and load) are almost always performed by an operator. It is on the latter three (guide, unload and transfer) that the bulk of the development work has been carried out.

2.3.2 Joining Technology

Three techniques of joining pre-cut parts can be identified:

- Sewing
- Welding
- Adhesives

Each of these is discussed below:

(a) Sewing

The basic technology of sewing could be said to have existed since prehistoric times, with development directed towards making the process faster and of higher quality. This is obviously an oversimplified view, but it serves to emphasise the point that the development level of sewing machines has reached a point where there is virtually no benefit in making the machines run faster, unless the machine is fully automatic and independent of a human operator from cycle to cycle. As conventionally designed, a sewing machine performs two distinct functions. First it penetrates the fabric with a thread and creates some type of stitch, using a mechanism under the fabric; secondly it transports the fabric through the machine to position it for each successive stitch. It is the latter function which has tended to create the most quality problems, and much development has gone into solving these by a multitude of different feeding mechanisms. As a result the modern sewing machine is a highly developed mechanical device capable of a wide range of subtly interconnected motions. Until recently sewing machines were completely 'dumb', but the advent of electronically controlled motors has allowed a degree of feedback, where rising needle heat causes the motor to slow down. Electronic motors have the capability of extremely rapid acceleration and deceleration. This feature has allowed some automatic machines to be controlled on the basis of each stitch position being fully specified rather than the conventional "sew from A to B" type of control. No completely satisfactory alternative to the lockstitch stitch type has been developed, and the requirement for a small thread package underneath the needle that needs frequent replenishment is a problem for fully automatic processes. Technologically this problem could be solved fairly easily - it is certainly no harder, for example, than changing a loom shuttle bobbin during operation - and at least one low cost device exists.

However, all current automatic machines utilise modified sewing heads that were originally developed for conventional sewing machines. What is really needed is a sewing head designed from the start for automatic operation.

Combined with the technology of the sewing process, there is the technology of the sewing thread. Development is continuous here, with a major objective to produce thread that has the widest tolerance to machine adjustment together with seam strength, colour fastness, compatibility with sewn fabric and good appearance.

Although recent developments have made alternatives to sewn seams available, the properties of sewn seams such as softness, stretch, strength and reversability (allowing garment alteration), make it extremely unlikely that sewn seams will be replaced as the major system of seaming in the foreseeable future.

(b) Welding

Welding is used in garment assembly with two main technologies, thermal welding and ultrasonic welding, and some experimentation has been carried out using a laser as a heat source. Thermal welding is used almost exclusively on plastic film type of garments and is often a die process as well as a continuous seaming process. As well as seaming, the process is used to create features such as buttonholes and for reinforcement in strain areas.

Sonic welding can be applied to films, but its main application is on fabrics with a high thermoplastic fibre content. Again both dies and continuous seaming are used. In the automatic seaming context, the process has the advantage that the complexities associated with thread, such as bobbin changing and end of piece thread trimming, are absent. The actual welding mechanisms are also less massive than conventional sewing heads. For conventional seaming these advantages have tended to be overshadowed by the limitations of the process and for this reason ultrasonic seaming machines have gained only limited acceptance up to now.

(c) Adhesives

Adhesives of all types are used in apparel assembly. The most common application is for the joining of interlinings to body fabric panels. In this instance the adhesive is precoated on the interlining and the bond with the body fabric is created by a pressure and heat fusing process. Fusible tapes and threads have also replaced blindstitching in a number of instances; in such cases the tape or thread is virtually 100% adhesive.

Development is also under way on adhesive processes where the adhesive medium is applied in the seam directly and then heat set by the same equipment.

As in the case of welding, the most attractive area for adhesives would appear to be in automatic applications rather than as alternatives to conventional seaming.

2.3.3 Control Technology

This classification comprises the technologies associated with the automatic monitoring and control of processes. As a broad generalisation, the rate of advance in the capability to control processes, through microprocessors, for example, has not been matched by a similar advance in the technique of interfacing the process and the microprocessor.

For the apparel assembly process, these technologies are involved in two levels of application. The first level is the actual control of the seaming operation. Areas affected here are the control of the motors, intermittently-operating attachments such as thread trimmers together with control of the seaming direction and duration.

On a larger scale control technology also has a role when the transfer of work from one work station to another is performed automatically, or even non-automatically but under computer guidance.

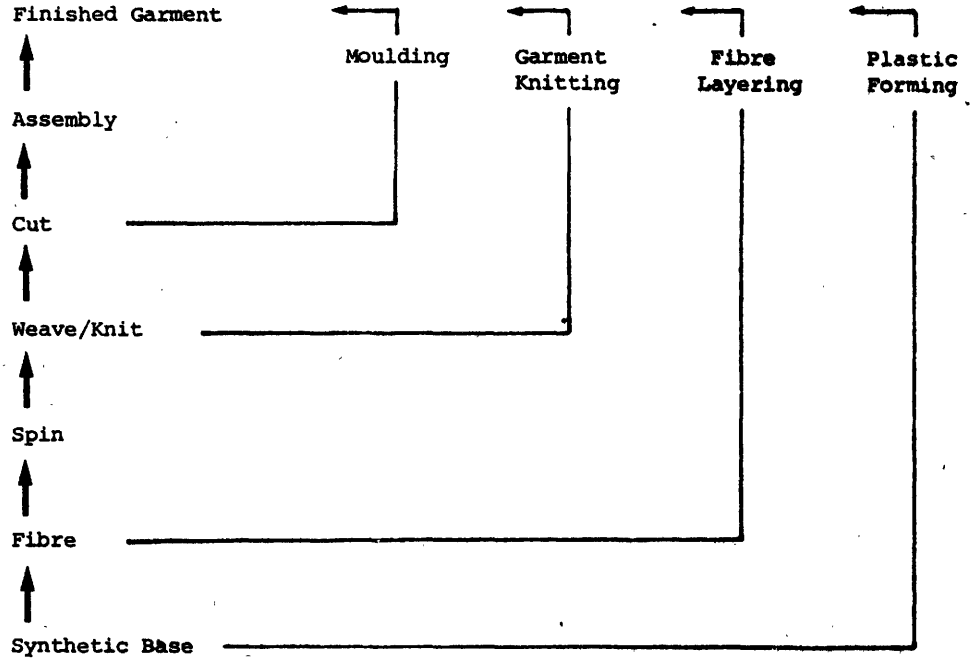
2.3.4 Process Technology

In this classification appear those processes which offer radical alternatives to the conventional making up process. These include:

- Moulding (Direct fabric to garment)
- Garment knitting (Direct yarn to garment)
- Fibre layering (Direct fibre to garment)
- Plastic forming (Direct thermoplastic to garment)
- Rigidification

As can be seen from the parenthesised items, each of first four processes attempts to bypass some of the usual intermediate processes. The diagram in Fig. 2.1 is conceptual in that it fails to take account of the fact that none of these processes as yet can completely bypass the intermediates, but nevertheless it does clearly show the hierarchy of the various techniques. Each one is discussed in some detail:

SHORTCUTS IN MANUFACTURING FIG. 2.1



(a) Moulding

These techniques arise from the observation that virtually all garment seams create shape in a a garment, and that it is frequently possible to form the required shape in the fabric directly. Various moulding processes exist for both woven and knitted fabrics as flat piece goods or tubular form.

In the case of flat piece goods, complete garment moulding has been demonstrated, resulting in elimination of a large proportion of seams. It is probable however, that the inevitable penalties in material utilisation incurred as a result of cutting a large and complex part, together with problems of flexibility, will prevent widespread adoption of the technique. In the case of moulding woven or knitted parts, the process appears more attractive in that it can offer considerable comfort and fit advantages, and eliminate some shape-creating seams such as darts. In this form the process has been widely accepted for foundation wear. Currently available processes require a proportion of thermoplastic fibres in the fabric, but new processes are being developed that are expected to allow moulding of 100% natural fibre fabrics. The precise mechanism of these processes is not yet announced, but at least one of them uses the principle of laminating a thermoplastic layer to the body fabric.

Full garment moulding of knitted fabrics when done on a knitted tube does not suffer the same material utilisation difficulties as the equivalent process on woven fabric. Development is continuous in the field and a number of products are on the market. In general these processes aim to eliminate all body construction seams whilst leaving the sewing for applied features such as pockets, collars and so on.

(b) Garment Knitting

A number of processes now exist that allow complete garments to be produced on knitting machines. Such garments require little or no subsequent operations. Examples are gloves, tights, girdles, sweaters, and dresses.

A range of technologies are used involving most types of knitting, from the circular/reciprocating machines used on hosiery, to warp knitting machines for girdles, and 'V'-bed machines for sweaters and dresses. Some processes produce completely assembled garments whilst others produce a complete garment blank which requires a minimum of finish seaming. The garment knitting technologies can be combined with moulding to heat set the finished product. In general the advantages of these processes are the reduction in the direct labour cost of assembly coupled with elimination of the yarn wastage associated with "cut and sew" operations.

With the advent of electronic rather than mechanical needle selection combined with developments in computer aided design, further progress in this field can be expected to be rapid.

(c) Fibre layering

The construction of non-woven fabrics has a very wide technology. In the past the use of such fabrics in clothing has tended to be confined to interlinings and specialist disposable workwear. Currently new fabrics are being developed that have the handle and durability of similar weight woven fabrics. Although non-wovens are normally produced as piece goods, specific types can be built up on a form to create a garment or garment part.

The processes used include centrifugal deposition inside a hollow form, or spraying onto a garment shaped form. The latter process would appear to offer considerable long term potential, particularly when combined with the rapidly developing technologies of numerically controlled ink jet printing.

However, it would be foolish not to acknowledge that this type of process has considerable aesthetic hurdles to overcome before it can offer a widely acceptable alternative to more conventional processes.

(d) Plastic forming

A process has been developed that allows the production of PVC garments directly on a former by a powder-dipping process. Garments were produced commercially but the process economics have resulted in its discontinuation. A major consideration was the cost of the moulds coupled with low machine output. This type of process appears generally unattractive because it is restricted to film garments which can be effectively produced by dielectric welding processes.

(e) Rigidification

Fabric rigidifaction in the form of starching has been practised for almost as long as fabric itself has been manufactured. However, in the context of this classification, reversible rigidification could be one solution to the difficulties of handling limp fabrics. A number of processes have been tried but no really satisfactory solution has yet been developed. Problems have existed in either uniformity of application in the chemical unpleasantness of the rigidifying medium, or in the reversing process. New developments in the application of non reversible stiffness (as an alternative to fused interlinings) do however offer some cause for optimism that a satisfactory process could be developed.

2.3.5 Management Technology

In this classification the developments in electronic data processing are considered when used both off line and in real time.

(a) Off line processing

There is no doubt that proper application of EDP to the planning and scheduling task in most apparel manufacturers would create a better operating environment for the production process.

This is particularly true of the high style manufacturer who usually has many, often conflicting, priorities to meet. However, the fundamental scheduling and production balance problems of batch manufacturing are similar whether the products are clothing, light metal fabrications or any other batch produced items. These problems have been recognised in other industries and acceptable solutions produced. Much of this technology can be transferred almost directly to clothing manufacture. It is certain that if automation is introduced and the machines themselves become interchangeable among a range of operations, then scheduling a sewing room will assume great similarities to scheduling a machine shop, with the optimisation of machine utilisation a major objective. The algorithms for this optimisation are already well developed.

(b) Real time processing

This is potentially one of the most rewarding areas for the application of technology to the apparel manufacturing industry. Traditionally management information systems have been historical, in that the control data relates to the past hour, or the past day or the past week.

Naturally such systems frequently cannot identify trends until they are well established, and appropriate management action is often triggered too late to avoid problems. By capturing the control data in real time and continuously monitoring trends and performances, EDP offers the possibility of initiating corrective action before problems have become severe enough to generate excess costs in manufacture.

With these technologies, the major barrier to widespread use is cost, of both the hardware for data capture and processing and the software. As hardware costs decline it can be hoped that the opportunity to amortize software costs over a large number of installations will bring real time systems within the reach of the majority of manufacturers. At the time of this study, two real time systems are commercially available although development continues on both. There is, in addition, a prototype system in operation where the computer also controls the movement of work throughout the assembly process. This is a particularly exciting development as it not only allows the computer to generate warnings to the management, but also enables it to initiate corrective action.

2.4 THE CURRENT STATE OF THE ART

Over the last few years many workaids have been added to the machine to help the operator and to reduce the time taken to perform an operation. The list of items which may be added to a basic sewing machine is quite large. Some of these may be incorporated into the machine at its design stage.

Attachment

- Folders
- Binders
- Presser foot lifter
- Special presser feet
- Impact cutter
- Guillotine cutter
- Thread chain cutter
- Scissor type cutter
- Lace feeder
- Special feed dogs
- Automatic chain cutting

Design

- Large hook
- Underbed thread trimmer
- Stitch closer
- Belt feed for delicate fabrics
- Photocell control
- Autotacking

This list is not exhaustive.

Sewing machines equipped with such equipment have higher output with skilled operation.

Such equipment does not make the operation automatic. The operator must still sew the seam using the sewing machine. A large proportion of the seams sewn on most garments, even in a well engineered factory, are sewn with such equipment.

In determining the current state of the art for sewing equipment, we have looked beyond the equipment briefly described above to assess the degree of automation that is available in each of the following range of popular products :

- Shirts and blouses
- Knitted underwear (T-shirts, men's and ladies' briefs)
- Trousers
- Jeans and workwear
- Jackets and coats
- Ladies wear (dresses and skirts)
- Tracksuits and knitted pyjamas
- Other products.

2.4.1 Shirts and Blouses

Collars

Collar profiling determines the shape of the collar. Some of the machines for this operation are now microprocessor controlled either with a x-y moving sewing head or with moving clamp and fixed head. Whilst some versions of the automatic collar profile stitcher incorporate automatic point trimmers and throat notchers others do not and operators continue to do this simple operation manually. With the two piece collar, the three operations of paring the points, notching the throat and turning and pressing the collar leaf can all be done on one machine.

Using the principle of automatic profile stitching a method of assembling the two main parts of the two piece collar has been developed. Firstly the band is manufactured on a creasing machine which fuses the band lining and turns in all the edges of the band. The two parts of the collar, leaf and band, are then assembled in a clamp and sewn on a machine controlled by an electromagnetic cam.

Fronts

In front making, automatic pocket setting machines now perform all the sewing and stacking part of the operation but the positioning of the front and the alignment of the pocket to it are still under the control of the operator.. She is aided in this alignment by workaids and guides.

Sewing the front strap has been fully automated with automatic feeding into the machine being followed by automatic cut off and stacking.

Buttonsew and buttonhole fronts

Automatic machines are available which will index the front to the next sewing position and require merely that the operator feeds the next front in accurately. The machines will stack at the end of each front. A variety of methods are used to achieve the indexing, ranging from mechanical stops on a bar to easily reset decade switches on a control box.

For tunic type fronts on blouses and knit shirts an automatic machine is available to attach the plaquet.

Cuff Making
A fully automatic cuff making unit with automatic transfer between sewing units has been demonstrated. More usually, the automatic machines in use are individually fed by the operator. Attach lining, run stitch cuffs on a turret machine, topstitch cuffs and cuff press can all be performed automatically and the cuff stacked after the operation has fed the machine. Tandem buttonhole machines with automatic stacker are also available.

Sleeves
A recent development in shirt manufacture is a machine which automatically folds and attaches the sleeve piece and sews the box in one operation after the operator inserts the two parts. Left and right are sewn alternately.

For attach yokes, a semi automatic machine is available. Here the back and yokes are positioned by the operator prior to automatic sew and stack.

Shirt assembly is normally carried out on a number of specially set up machines. However, no automation has taken place in this area. In each case the operator controls the flow of work past the needle.

2.4.2 Knitted Underwear
(T-Shirts, men's and ladies' briefs)

Sleeves
A semi automatic machine is available for blindstitch hemming sleeves.

Bottom Hemming
An automatic machine for hemming the bottoms of T-Shirts is available. A pick up device aids the operator in loading the garment. The machine sews the seam automatically and finally stacks the garment. One operator can use two machines.

Cam operated machines
Tacking where necessary is done by cam controlled tacking machines.

Labels
These are attached by cam controlled line tackers. Automatic devices exist to pick up and accurately position the label for sewing. Labels may also be attached by PROM (Programmable Read Only Memory) controlled stitchers.

Long Seamers
These are used to sew the side seams in T-shirts. After the operator has aligned the parts, the edge guide and 'mouse' clamp control the fabric past the sewing head, followed by automatic stacking.

Waistbands
The waistband elastic may be inserted in an automatic two station machine. After loading by the operator, the machine rotates the garment to the sewing head for automatic sewing. Simultaneously, the operator loads a second garment on a second loading head.

Binding
Semi automatic machines with sensor controls are available to attach and cut off the binding on T-shirts.

Gusset and side seams
These seams may be sewn on an integrated sewing machine where a feed off the arm flatlock machine is equipped with photocell control, horizontal edge trimmer, chain cutter, belt feed behind the needles and flip stacker. Semi automatic action enables the operator merely to feed the parts into the machine.

Most other operations in this sector of the industry are best carried out on engineered workplaces. The appropriate sewing machine is equipped with folder, binder, lace feeder, cutter, thread chain cutter, etc., and the operator sews the garment together using manual control.

2.4.3 Trousers

Serging
Automatic serging machines which merely require the operator to load the cut plies are capable of sewing right round the trouser parts. Finally, they stack automatically. One operator can operate several machines.

Darts
A cam controlled line tacker is available for trouser dart sewing.

Pockets

A semi automatic machine for attaching straight pocket facings is available. The operator loads the machine which sews and stacks automatically.

A special cam operated machine is available to set and raise the side pockets.

For hip pockets an automatic machine is available.

Labels

These may be sewn in with tackers which automatically index from side to side of the label. Alternatively a PROM (Programmable Read Only Memory) controlled stitcher may be used).

Buttonsew and Buttonhole

These are sewn on semi automatic cam controlled machines.

Sideseam

Automatic machines are available for sideseam which may be rail guided or controlled through a special edge guide, perhaps with a free end clamp (a 'mouse').

Fly

A semi automatic unit is available for the top stitch fly operation. This gives consistent good quality on a difficult operation.

Hooks and Eyes

The most modern equipment now has automatic feed of tops and bottoms of both the hook and eye together with a pneumatically operated press.

Belt Loops

An automatic machine for attaching drop belt loops is available. This machine feeds in from the roll of prepared belt loop. It automatically cuts, folds and tacks the loop and then indexes to the next position.

Trouser Bottoms

Special automatic machines are available for pinking and taping the trouser bottoms. The operator loads the machine which then sews and disposes.

The remaining operations in making up the trousers are carried out on engineered workplaces with the appropriate sewing machine, set up with the correct feeders, presser foot, folders, cutters and other aids.

2.4.4. Jeans/Workwear

Labels

These may be attached by PROM (Programmable Read Only Memory) controlled stitchers or by programmable stitchers. The latter are programmed during the first trial seam and afterwards sew the same pattern of stitching although the time interval between seams may be altered by the operator. Alternatively the label may be automatically fed in at pocket hemming.

Pockets

Patch pocket preparation, hemming and decoration is an area where the greatest progress has been made in automation. For hemming alone, equipment is available which works from a stack, picking up a pocket, feeding it, sewing it and stacking it.

For hemming and decorating the patch pocket, fully automatic microprocessor controlled equipment is available on which two sewing heads simultaneously sew the pocket (hemming and decorating). This equipment works from stack to stack and is one of the most sophisticated set ups available in garment manufacture.

For attaching facings to the pocket, machines are available which automatically stack the parts after sewing.

Pocket setting equipment is semi automatic with the operator loading the machine. The machine folds the pocket, sews the seams, and stacks the completed part.

Fly Making

A semi automatic machine is available which sews and stacks after loading by the operator.

Belt Loop Attaching

Loop material is made by feeding cloth into a machine which cuts it to size, sews the pieces and takes it up on a roll.

The automatic belt loop attaching machines cut the loop to size, fold the ends, position to the jeans, tack them on and reposition to the next position. One operator can control two machines.

Decoration
For decorating pockets or legs the programmable equipment is available. This may be of the freely programmable type, where the input is from a drawing tablet or from a digitiser.

Tacks
In jeans, cam controlled tackers are used for the strengthening tacks. Finishing the end of the waistband may also be done by a special tacker either cam controlled or PROM controlled.

Studs
Pneumatic automatically fed studding machines are available.

For studding jackets, automatic machines are available which apply the stud, reposition to the next position for the appropriate number of studs. Finally the part is stacked.

Assembly
Assembly of the garment, attaching the waistband, finishing the trouser bottoms are all operations where the best equipment is an engineered workplace with the appropriate sewing head with the necessary folder, cutter, thread trimmer, puller, presser foot lifter, etc., to perform the operation effectively. The operator has to handle the garment throughout the operation.

2.4.5. Jackets and Coats

The manufacture of jackets and coats is currently further from wide use of automation than any other garment.

A number of operations have had special machines designed for them. These are:

(a) Pocket welt machines. Here the operator feeds in the parts and activates the machine. At the end of the sewing/cutting cycle the machine automatically disposes and stacks. Attachments are available for automatic zip insertion where required.

(b) Dartsewer. Here again, the operator loads and the machine sews and disposes automatically.

(c) Contour seamers are available to make sleeve lining seams both with and without vent (or interruption) in the seam.

(d) Automatic machines sewing small parts (e.g. flaps) in a jig are available. Introduction of this principle to larger parts is made difficult in menswear because of lack of consistency in design, especially in the length of the garment. In ladies' coats this type of machine is being more widely used.

Some machines are cam controlled. These are mainly the buttonsew and buttonhole equipment. Locally produced cams are also used to control the machine which controls the amount of fullness as the sleeve crown and the back armhole are taped.

Automatic indexers to move the coat between buttons or buttonholes are available.

In ladies' wear, a buttonsew machine is available which will sew on and lash almost any type of button.

For attaching labels to the lining an automatic machine is available which cuts the labels from the roll and attaches them. The operator loads and unloads the machine.

Specialist tackers using PROM (Programmable Read Only Memory) are being used to make the triangular tack in raincoats.

In the other operations necessary to make a coat or a jacket, the best equipment consists of an engineered workplace with the appropriate sewing machine. This has available the necessary folders, edge guides, special feet and feeders, cutters and similar attachments. Using this equipment the operator sews the necessary seams into the garment.

2.4.6. Ladies' Wear

(Dresses and skirts)

Serging

Semi automatic machines are available which will automatically serge and stack garment panels once the operator has fed them into the machine. Such equipment has guide rails, feed mechanisms, thread chain cutter and stacker. A wide variety of shapes may be sewn.

Long Seamers

Automatic long seamers using a guide rail are available for skirt seams. The operator positions the next parts during sewing.

Contour Seamers are also available with an overlock head which controls parts with slightly different contours. With this equipment the operator aligns the parts to the guides and sets the automatic preloading cloth clamp ('mouse').

Dart Sewing

Machines with automatic folding, clamping and guiding, under the control of the operator for pick up and stack are available for dart sewing.

Skirt Hemming

A semi automatic unit is available for hemming skirts.

Buttonhole and Buttonsew

Cam controlled machines are used for these two operations.

Decoration

Embroidery or decorative stitching may be carried out using PROM (Programmable Read Only Memory) controlled machines. Alternatively the freely programmable machines may be used.

Blindstitch Hemming

A stitch shortening mechanism is available together with thread trimming which locks off the end of the seam.

Most operations in this sector of the industry are best carried out on individual engineered workplaces. The appropriate machine may be equipped with workaids such as underbed thread trimmer, folder, cutter, etc., and the operator performs the operation manually.

2.4.7 Tracksuits and Knitted Pyjamas

Side Stripes
Automatic machines for attaching side stripes are available. The operator positions the panels, the stripe being fed from a roll. Automatic cutting and stacking. A machine is available that works from a stack of cut panels.

False Creases
This operation may be done on an automatic unit wherein the operator positions the work aided by optical guides. Sewing and guiding is automatic by means of rail and template, followed by automatic stacking.

Patch Pockets
Automatic machines are available to fold, sew on and dispose the part after the operator has loaded the two parts into the machine.

Assembly
Overedge assembly of sleeves and legs of these garments may be done on a long seamer with special edge guide, automatic cutter and stacker.

Tacks
Automatic cam controlled line tackers are available.

Decoration
Embroidery or decoration may be carried out my microprocessor controlled embroidery machines. Alternatively PROM (Programmable Read Only Memory) controlled equipment may be used.

2.4.8 Other Products

(a) Tights
In making tights, the toe closing operation is done automatically. One leg is drawn on to the former by the operator and then released. Toe closing and disposal is automatic.

Gusset seaming in making tights is a semi automatic operation, though work is underway to automate this.

(b) Knitted outerwear (Cardigans etc.)
The inseam and side seam forming a long sleeved garment may be sewn and tacked automatically. The operator loads the cuff ends, the underarm and the bottoms of the side seam into three sets of grippers. The grippers take the garment to the cup seamer which forms the seam; the grippers then transfer the garment to the bacrtacker which tacks the ends; finally the garment is transferred to the disposal point.

(c) Belts
A machine is available for the automatic top stitching of belts. At the end of the seam the belts are automatically counted and stacked. One operator can control two or three machines.

Interesting technological developments of recent years include edge guidance systems. The pivot point, pressure plate edge guidance system has been widely adopted and is used on many systems noted above. Also available is the closed loop system of feedback control. This is totally different except that it has a much greater potential for mechanisation/automation application as opposed to methods improvement opportunities.

More frequent use of twin needle sewing machines has led to improvements in needle knock out mechanisms with corner stitch counting equipment.

Occasionally machines from other industries are found to be useful as the semi automatic creasing and glueing machine from the shoe industry which may be used for turning over and glueing down the edge of a denim pocket prior to attaching it with a plain sew machine.

2.5 CURRENT DEVELOPMENT DIRECTIONS

In this section the current development activities reported to KSA by the organisations interviewed are reviewed. It should be appreciated that this type of information is commercially sensitive, and many manufacturers were understandably reticent in their responses. However, it is possible to draw some broad conclusions from the information obtained. In this phase of the interviews the questions were structured to obtain information concerning any work in a number of potential breakthrough areas. These areas were:

- Full cycle automation
- Full sequential automation
- Computer technology
- Universal parts handling devices
- Universal transfer devices
- Industrial robot applications
- Three dimensional operations
- Other assembly processes
- Fabric rigidification

The conclusions drawn under each heading were as follows:

2.5.1 Full Cycle Automation

Many of the latest generation of sewing machines operate automatically once the fabric parts are positioned or clamped in some device. Until, and unless the machines become fully automatic, a one operator to one machine situation continues to exist, with the inherent limitation on productivity discussed previously. In general the sewing machinery manufacturers did not report any intention to tackle the problems of full automation. Exceptions to this were machines designed to hem shirt fronts, to hem and decorative stitch jean patch pockets, and to sew decorative stripes onto active sportswear. All these machines pick up and position a single part, and the pick up devices were integrated with the sewing machine, thus allowing the operator to load a magazine of parts and leave it.

Typically the respondents agreed that full automation of many machines was technically feasible, but they considered it unlikely that the industry would pay the price required to recover the development costs. Their efforts were directed instead towards making existing machine concepts more flexible. Examples of this were profile stitchers that could run and topstitch cuffs, and rail guided equipment where the rail was flexible and could be reshaped quickly to adjust to different profiles and sizes. Manufacturers see lack of flexibility as the most significant market barrier to their automatic equipment.

Considerable development was also reported on more versatile and accurate edge guidance systems, with systems now available that can cope with cross seams in the fabric edge. One respondent reported a working prototype machine capable of picking up trouser front and back panels, aligning them and feeding them to an automatic seamer. Unfortunately no further information on this equipment will be available before mid 1980.

2.5.2 Full Sequential Automation

The only area in which sequential automation is being developed appears to be in the use of turret type machines for the manufacture of shirt collars and cuffs. Typically an operator loads the parts in a clamp and the machine then indexes the clamp to a number of sequential operations. The alternative transfer line approach does not appear to be under development at all. The main reason given for this was that such a transfer line would be vulnerable to machine breakdowns as the total line would be interlinked, and any machine breakdown would stop the entire process. This is in fact a variation of the cost argument, as the development of adequately reliable machines would not be considered a cost effective exercise.

2.5.3 Computer Technology

It is certain that any written statement concerning the state of the art of computer hardware will be out of date by the time it is published. It is equally certain that the cost of computer hardware will continue to follow the cost trend that exists at present, of increasing power for a given cost or lower costs for a given power. However, the comparative cost of the software for computers does not diminish, and is subject to normal effects of inflation. There are potential volume savings but the danger is that developments specific to the apparel industry might require substantial and costly tailoring to meet individual company needs.

It is probable therefore that the acquisition of computer technology will not become cheap. Such technology will nevertheless be available to an increasing number of companies. The main areas of development for apparel industry specific applications are as follows:

(a) Pattern Digitisation, Grading and Marker Production.

These applications are now in wide commercial use. Developments are in hand in two main directions. The first is computer aided design wherein the information bank is used by the designer to create new patterns, and where alterations on one pattern piece are automatically allowed for in complementary pieces. The second development direction is the extension downstream of the database created by the computer into cut planning and factory loading. In general these developments are expensive when compared to normal industry investment levels.

(b) Control of the Supply Pipeline

These applications monitor the processing of customer orders from receipt through to delivery and invoicing of the finished garments. Whilst the process has many similarities with other industries there are a number of requirements that are quite specific to the industry. Developments are in hand to make relatively low cost packages available to the industry. At present, available packages are limited in scope and still require substantial individual application modification. However, the development of available hardware power will lead to the creation of comprehensive software for which the market volume can offer the opportunity of substantial price deduction.

(c) "Real Time" Production Management

These applications involve the capturing and processing of data at occurrence, as opposed to off line processing of historical information. Major problems of these applications are the cost and reliability of the data capture mechanism, and it is in this area that development has been concentrated, coupled with continued development of the software.

There are also applications where a computer is used to directly control a garment transportation system within a factory. Although this application has identical data capture requirements to the real time production management application, the systems have not yet been amalgamated.

On balance it seems probable that the application of computer technology to the management process will be the most widely affordable technological development. It will have a significant effect on small companies, particularly high style companies for whom the other major technological developments may appear inappropriate.

2.5.4 Universal Parts Handling Devices

The information gathered indicates that most of the existing commercially available parts handling devices are integral with a particular machine or process. The device described earlier under development for trouser sideseaming is intended to have a universal application and to be produced in a range of sizes. It was also understood that a sewing machine company has such a universal device under development.

2.5.5 Universal Transfer Devices

No activity was reported under this heading.

2.5.6 Industrial Robot Applications

Developments in this field outside the industry are generally directed towards expanding the sensory perceptions of robots, which can now have vision and tactile feedback mechanisms. Experts in robotics foresee no particular technical difficulties in the application of robots to handling within the apparel industry, particularly if the pick up and separate ply problem has been overcome. However, the safety aspects of programmed mechanical devices working close to human operators needs careful consideration. No developments are in hand to develop robot handling mechanisms specifically to meet the needs of the apparel industry. The technology is already available to build such devices which could be much lighter than those currently used, and if sufficient volume could be generated, could be relatively inexpensive.

2.5.7 Three-Dimensional Operations

The three-dimensional working of a garment on some sort of jig, passing through a number of sequential operations would seem to be a valid approach to the automation of the more difficult assembly operations on most garments. Several companies reported research in this direction, but no further details were available.

2.5.8 Other Assembly Processes

A number of bodies are developing moulding processes with which they expect to overcome the problems of acceptance associated with this concept in the past.

Also in the technologies of welding and adhesives new developments are in hand aimed to make the processes more aesthetically and technically acceptable.

Alternative assembly processes, particularly moulding, are believed by a number of people to have a tremendous potential for making the industry more competitive. It is without doubt an area for long-term consideration that may have to wait for significant industry restructuring before its full potential can be realised. It is the sort of process that may be fully exploited by firms in other industries with a vested interest in the technology and/or the raw materials.

2.5.9 Fabric Rigidification

Processes are now commercially available for selectively stiffening fabrics as an alternative to complex interlining constructions. These processes are of course irreversible. The rigidification of fabric as an aid to automatic handling has been receiving some limited development attention, although current difficulties prevent the commercial introduction of such a process. This is a genuine *building block* technology to the extent that reversible rigidification is of no commercial value unless the mechanical handling equipment exists to take advantage of the process. For this reason development cannot be expected to be rapid.

SECTION 3

THE IMPACT OF TECHNOLOGY

What is the potential impact of technology on the apparel manufacturing industry ?

3. THE IMPACT OF TECHNOLOGY

This section of the report first discusses the significance of technology, highlighting the many areas in which technology can impact the apparel manufacturer.

It also uses an economic model to speculate on the possible impact of technology on the profit mechanics of the typical apparel company, and on the limitations of technology and a possible optimum level.

Finally, it discusses the barriers to progress, including the criteria currently used by management in making investment decisions on new technology, attitudes towards investment, and the structure of the industry and the way technology may change it.

3.1 SIGNIFICANCE OF TECHNOLOGY

A fundamental issue addressed by this study is whether the application of technology to the apparel production process can make a significant contribution to strengthening the European industry's competitiveness when compared with that of lower wage cost producers.

Frequently an assumption is made that such a contribution will impact solely on the product cost, and it is true that product cost has been an important factor in the growth of the industry in lower wage areas. However, it is important to realise that for many products the direct labour cost is a small proportion of the selling price, and direct labour cost is less of a determinant than is often suggested. For example, the massive penetration of the US shirt market by Far Eastern suppliers in the 1960's and 70's was due far more to the fact that fabric prices in the Far East were much lower, than because of low direct labour costs. It is interesting to note that now world demand and supply of polyester fibres has become more balanced and fabric prices as a result more compatible, the US shirt making industry is experiencing a recovery and a return of capacity to the USA.

Furthermore, to consider manufacturing costs as the only determining factor would fail completely to acknowledge the complexity of the apparel marketing equation, wherein the image of the product, the status of the sales outlet, fashion appeal and design features all play a part in the achievable price.

"The right product at the right price at the right time" is a well worn cliche for achieving success in any marketing situation. In the following paragraphs the key benefit areas offered by the application of technology are discussed with reference to this dictum.

3.1.1 Cost Reduction

The cost of an apparel product to the producer is typically made up of the following elements:

- Fabric and trimmings
- Direct labour
- Overheads
  - management and supervision
  - equipment depreciation and building costs
  - cost of working capital

Technology can offer opportunities for cost reduction in all these areas.

(a) Fabric and Trimmings

The prime technology to consider here is that of computers. Improved control and planning of the purchase of raw materials can reduce the costs of maintaining inventories, and can eliminate the acquisition of 'dead' fabric stocks. Wastage of trimmings can be controlled. Computerised loading of the manufacturing unit can help optimise the utilisation of fabric by maximising the quantities cut at the same time. Computerised marker making can help to ensure that the best utilisation of fabric is achieved.

(b) Direct Labour

Direct labour cost manifests itself in two main ways in the garment. These are the *intrinsic work content* of the product, and the *excess* costs due to process inbalance, defects, breakdowns, training and other management-controlled factors.

Product technology has and will continue to reduce the work required to put the product together, and technology can reduce the intrinsic work content by improved machines, fully automatic equipment, elimination of certain processes and so on. Interprocess handling can be reduced or eliminated with automatic transportation systems.

Computer technology will increasingly make a contribution to reduction in management controlled excess costs by improved loading and real-time monitoring of the process, allowing quicker management response to problems.

(c) Overheads

The acquisition of high technology equipment will add to overheads, particularly in the maintenance and depreciation of equipment. However, real time computer monitoring of the process can extend the effectiveness of existing management. It is likely that the high technology factory of the future will be much more compact than current factories with very much higher outputs per square metre. Improved controls will allow the manufacturing facility to run with a lower work in process level thus reducing the working capital requirement.

3.1.2 Quality Improvement

Any discussion of quality in garment manufacture must recognise the differing aspects of quality, namely design quality and manufacturing quality. Design quality is reflected in the style, fit and durability of the finished product, whereas manufacturing quality is reflected in the success of the production process in consistently achieving the target design quality with the minimum number of rejects.

Computer aided design is still in its infancy in the garment industry though development is rapid. Advances in automatic pattern grading offer some solutions to the problems of achieving consistency of fit across a range of sizes.

In the manufacturing process, fully automatic machines offer a quality consistency unobtainable with human operators. The new generation of cutting equipment illustrates this. Technology can also offer sophisticated monitoring devices that will detect poor stitching quality right at the sewing head.

Technological development can also enable features to be included in a garment that would previously have been confined to higher priced merchandise. An example of this is the familiar "hand" edge stitching machine process used on outerwear. A more recent example is the use of a presser foot knitting machine with the

"Pfauti" technique to produce knitwear with absolute accuracy of pattern matching across fronts, back and sleeves.

3.1.3 Customer Service

As far as the apparel manufacturing industry is concerned the customer is usually not the end user, but a retail buyer. Although such buyers place a high importance on price, service factors such as on-time delivery, consistent quality and rapid response to fashion trends also have a significant influence on the buying decision. Buyers currently using Far Eastern and other lower wage cost producers often have to accept many compromises in the products themselves, in the lead time for delivery and in the order quantities required. Significant improvements in these areas could create a situation where the value to the buyer of a reduction in his own risk more than offsets the price advantage he gains from the offshore purchaser.

Computerised systems of loading and scheduling have a tremendous potential for assisting both the accurate specification of delivery dates and the achievement of them. The production control process within many style manufacturers is a bewildering array of conflicting requirements involving fabric availability, material utilisation, delivery needs, load optimisation for both cutting and making up, combined with day-to-day variations in the actual capacity of the factory. Computers can greatly assist the production controller by analysing the effect of a much wider range of potential combinations than would be possible manually.

These procedures can also influence response times by facilitating the processing of garments required quickly. Furthermore, advanced production control systems allow factories to run with considerably lower work in process. As it is the work-in-process level that has the greatest influence on throughput time, such units would have a quicker throughput for all garments not just priority items.

3.1.4 Product Innovation

The fourth area where technology can improve the competitiveness of the European manufacturer is in product innovation. Under this heading should be included such things as:

- Special fabric effects unobtainable with conventional equipment such as the three dimensional effects obtainable with presser foot knitting.

- Improved shape and fit with reduced bulk obtainable from fabric moulding processes.

- Direct fibre to garment processes wherein non woven fabrics are produced in garment forms with no intermediate piece goods stage; this would have significant impact on protective clothing for example.

- Direct yarn to garment processes. A number of manufacturers have technology available for virtually complete production of garments on knitting machines. This has the double benefit of reducing yarn wastage and eliminating labour cost. Such techniques also allow the production of garments otherwise impossible to produce.

- Products in which sewn seams have been replaced by welded or bonded seams. In the past there has been a number of aesthetic objections to such processes, but many of these objections will be overcome as the technologies develop.

When dealing with processes which require actual changes in the product it is of course necessary to ensure that such changes are acceptable to the buyer. This is a marketing problem which must be faced by all innovators.

3.1.5 Risk Reduction

The improvements in response times discussed above also have an impact on the level of risk borne by the manufacturer. This is because it can make it possible for him to carry a lower stock level to offer the same degree of service to his customers, it reduces his work in process costs and it allows him to respond to more immediate market demands. Above all it allows him to commit the fabric near the time of sale.

3.1.6 Job Enhancement

The apparel manufacturing industry has a poor record for labour retention when compared to other industries, and pay levels, while improved in the last decade, still lag behind the majority of other industries. The introduction of high-technology, high output equipment should offer the opportunity to create more responsible and better paid jobs, analagous to machine setter/minders in the engineering industry. A consequent reduction in labour turnover would diminish a significant source of cost to the industry. From the same source training times will be significantly reduced.

It is apparent that technology can offer many benefits other than merely cost reduction. Product appeal and a rapid response to market demands play an important part in the marketing equation and the improvements that technology can offer in these fields should not be ignored.

3.2 THE IMPACT OF TECHNOLOGY ON THE APPAREL MANUFACTURER

It is clearly difficult, if not impossible, to generalise in a study of this nature, on the potential impact of technology on the apparel manufacturer. The impact will vary considerably according to the cost-benefit relationship of the technology itself, the product, the nature of the market, the financial structure of the firm and above all the level of performance the company has already achieved.

The latter point is particularly important, as so much of existing equipment available to the industry is sold on the basis of savings compared to a performance level, which, with better methods and management, can often be improved by 20%, 40% or more, without any change in the basic equipment or investment.

In order, to illustrate the potential impact of technology, KSA has developed a simple model based on the basic profit mechanics of a typical apparel manufacturer, owning its own assets, and operating at relatively high performance levels. The model is in the form of a *profit tree* showing the return on capital employed, and its components.

To build the model has required that certain assumptions are made as to the effects of various degrees of technology investment on the key areas of impact. These assumptions are based on KSA's experience and a consensus of consultants' experienced in apparel manufacturing and technological innovation in this industry.

The model is constructed for each of three levels of technological investment. In the first level it is assumed that investment in hardware per direct operator is increased by a factor of 3 times - referred to as *medium technology*. In the second level it is assumed that investment in hardware per direct operator is increased by 7 times referred to as *high technology* (i.e. if today's technology as applied by a typical apparel manufacturer averages $2500 per operator, it would be $7500 in the medium technology model and $17,500 in the high technology model).

It has then be necessary to assume a relationship between technology investment and reduction in labour content, and this assumed relationship is illustrated in Fig. 3.1. It will be seen that an increase in investment per operator of 3 times today's level is assumed to produce a 25% reduction in labour content and an investment at 7 times today's level per operator is assumed to produce a 50% reduction in labour content.

Obviously any such assumption on this relationship for technology not yet developed is highly speculative, but there is some equipment on the market which on single operations is producing cost-benefit ratios in this pattern. The model, of course, assumes that technology can be developed which produces such a relationship for the whole product, across all operations.

In order simply to illustrate the limitations of the process of technological investment, the model is also constructed at a third level or *super technology* level, with an investment of 20 times today's level per operator with an assumed reduction in labour content of 75%, in accordance with Fig. 3.1

In Fig. 3.2 the assumptions are given of the impact on each of the main areas discussed previously, at each of the three levels. It will be seen that the model assumes a significant average earnings increase for the reduced labour force; it also allows for an increase in maintenance costs. The effects on overheads are considered, first from the additional depreciation of equipment, and secondly from reduced inventory carrying costs.

Quality improvement, customer service improvement and product innovation are assumed together to give an opportunity to increase sales and improve average price levels up to the high technology level, but no further improvement is assumed possible at the super-technology level.

Risk reduction is considered to provide a reduction of inventory levels at the different levels of technology as indicated. Job enhancement is considered to reduce labour turnover and absenteeism with an appropriate additional reduction in labour costs up to the high technology level.

The model itself takes the form of a *profit tree*, by computing the ingredients of return on capital employed (ROCE). This model is illustrated in Fig. 3.3 for a typical well-managed apparel manufacturer, effectively using currently available technology. Based on the assumptions in Fig. 3.2, the profit tree is recalculated for each of the three technology levels in Figs. 3.4, 3.5 and 3.6 respectively. The details of the calculations can be seen in Appendix II.

The main conclusions from the model are as follows:

1. If the assumed relationship between the investment and labour content holds, then technology will offer an opportunity for apparel manufacturers to either

   - increase profitability
   - or reduce prices by as much as 10% below those achieved by the most efficient companies,
   - and still maintain profit margins at levels adequate to the nature of the apparel business

   While a 10% price reduction may not at first sight indicate a competitive reduction vis-a-vis low labour cost countries, sourcing studies carried out by KSA for a variety of products show that where the fabric is sourced at the same price, and after allowance for transportation, normal tariffs and other charges, the real difference in cost between *best* domestic practice and low cost imports is often of this order and rarely higher, subsidised products apart. (Some exceptions certainly exist at the fringes of the range of products such as very specialised, high work content products). If the domestic product has non-price advantages, as discussed in Section 1, then an erosion of the cost differential of 10% will have a significant impact on the industry as a whole.

   Perhaps more significantly, the higher technology company will be able to include more items in its product mix which are competitive with low cost imports than is possible today, without reducing profitability to unacceptable levels.

2. Technology with the assumed impacts is affordable, in that increases in capital employed are covered by the additional cash flow (additional profit plus depreciation of the increase in fixed assets) within a period of -

   - 1.2 years in the medium technology model
   - 1.2 years in the high technology model
   - 1.7 years in the super technology model

3. If such technology becomes available, the ratio of fixed assets to working capital changes as follows:

   - 0.76 in the base model
   - 1.75 in the medium technology model
   - 3.42 in the high technology model
   - 4.75 in the super technology model

   thereby assuming the pattern of capital intensive industry, and the relative attractiveness of such industries to financial institutions.

4. If it is assumed that at today's level the average investment per operator is $2500, then the average investment per operator is computed to be:

   - $7,500 in the medium technology model
   - $17,500 in the high technology model
   - $50,000 in the super technology model

5. There are obvious limitations to the impact of technology, and there is logically an optimum level to strive for. The assumptions made will of course dictate the conclusions of any model of this nature. In order, however, to speculate on these limitations and on the optimum level of technology, the model has been extended to investment levels at which depreciation costs exceed contribution. In extending the range of application of the model, it is assumed that:

   - there can be no reduction of work content beyond 80%, reached at an investment level of x 30 of the base model
   - the impact on sales, price increases, inventory reduction and material utilisation do not improve beyond that in the high technology model
   - indirect labour cost would double in order to reach the 80% level
   - average earnings would increase by 70% at the 80% level.

   The result of applying the model to these assumptions is shown in Fig. 3.7.

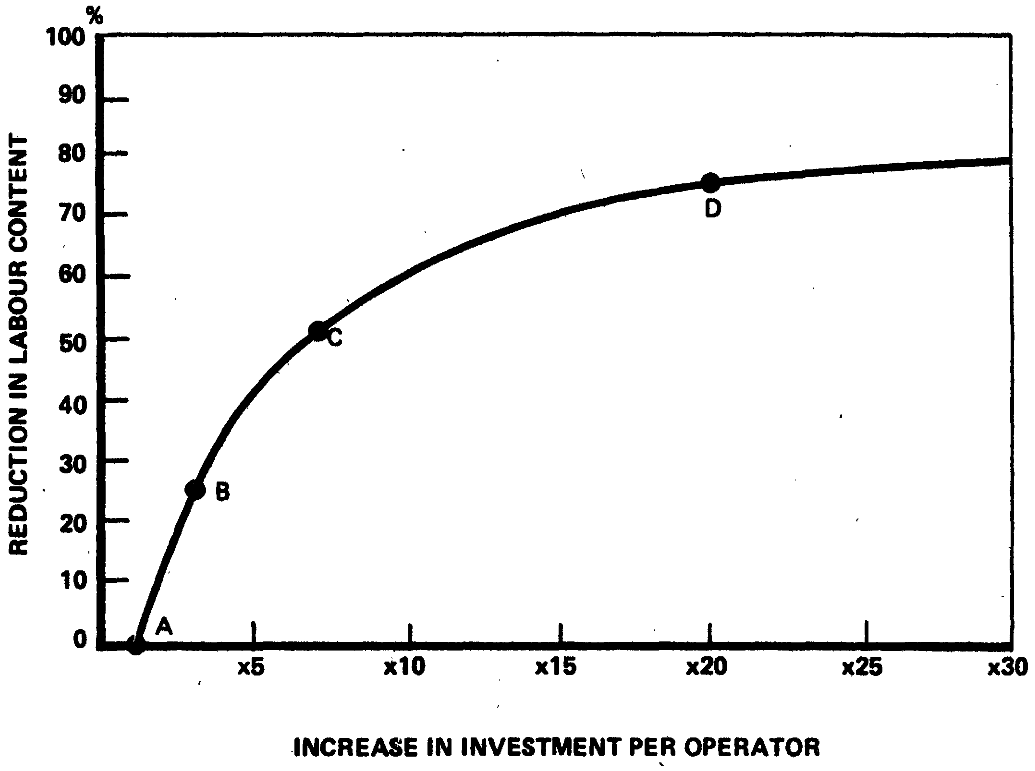
> It will be seen that return on capital employed (ROCE) and return on sales (ROS) peak at a level of technology where investment per operator is between 8 and 12 times the base model level. On the same assumption that current hardware investment per operator in the industry is approximately $2,500, the model suggests that the most viable level of technology investment will be in the range of $20,000 to $30,000 per operator, assuming of course that the cost-benefit relationship in Fig 3.1 holds good, as technology applications develop.
>
> This level of investment, at today's prices, would create a capital intensity equivalent to that in a number of relatively sophisticated manufacturing industries such as textiles and electrical and electronics assembly.

It will be clear that such conclusions are dependent on the assumptions about the impact of technology on different aspects of the apparel manufacturer's business. No claim is made that the assumptions used here would necessarily be more valid than others that might have been selected, although they fit KSA's observations and experience. It is hoped that the *approach* might be developed and used by the technology industry and the apparel manufacturers, on the basis of their own assumptions and as a guide to creating a level of technology which fits the needs and commercial realities of the apparel manufacturing business.

KSA

ASSUMED RELATIONSHIP BETWEEN LEVEL OF TECHNOLOGY AND LABOUR CONTENT

FIG. 3.1



A = Base Model
B = Model 1 - Medium Technology - Investment per Operator x3
C = Model 2 - High Technology - Investment per Operator x7
D = Model 3 - Super Technology - Investment per Operator x20

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ASSUMPTIONS ON QUANTIFIABLE IMPACT OF TERMINOLOGY ON THE INDIVIDUAL MANUFACTURER

FIG. 3.2

AREA OF IMPACT	ASSUMED EFFECT OF IMPACT	ASSUMED CHANGE ON BASE MODEL		
		MEDIUM TECHNOLOGY MODEL 1	HIGH TECHNOLOGY MODEL 2	SUPER TECHNOLOGY MODEL 3
CUSTOMER SERVICE QUALITY PRODUCT INNOVATION	. Increase in sales volume	+ 10%	+ 20%	+ 20%
	. Increase in average price level	+ 2%	+ 5%	+ 5%
RISK REDUCTION	. Reduction in inventories and work-in-process	- 10%	- 20%	- 20%
FABRIC/TRIM	. Increase in material utilisation	+ 4%	+ 4%	+ 4%
DIRECT LABOUR	. Reduction in labour content	- 25%	- 50%	- 75%
	. Increase in average hourly earnings	+ 20%	+ 40%	+ 60%
INDIRECT LABOUR	. Increase due to higher maintenance cost	+ 20%	+ 40%	+ 80%
OVERHEADS	. Increase in depreciation charge proportional to increase in fixed assets	+ 15% of increase in fixed assets		
	. Reduction in inventory carrying costs proportional to reduction in inventories and work-in-process	- 20% of decrease in inventories		
JOB ENHANCEMENT	. Reduced labour turnover and absenteeism, leading to reduction in labour cost of	- 5%	- 10%	- 10%

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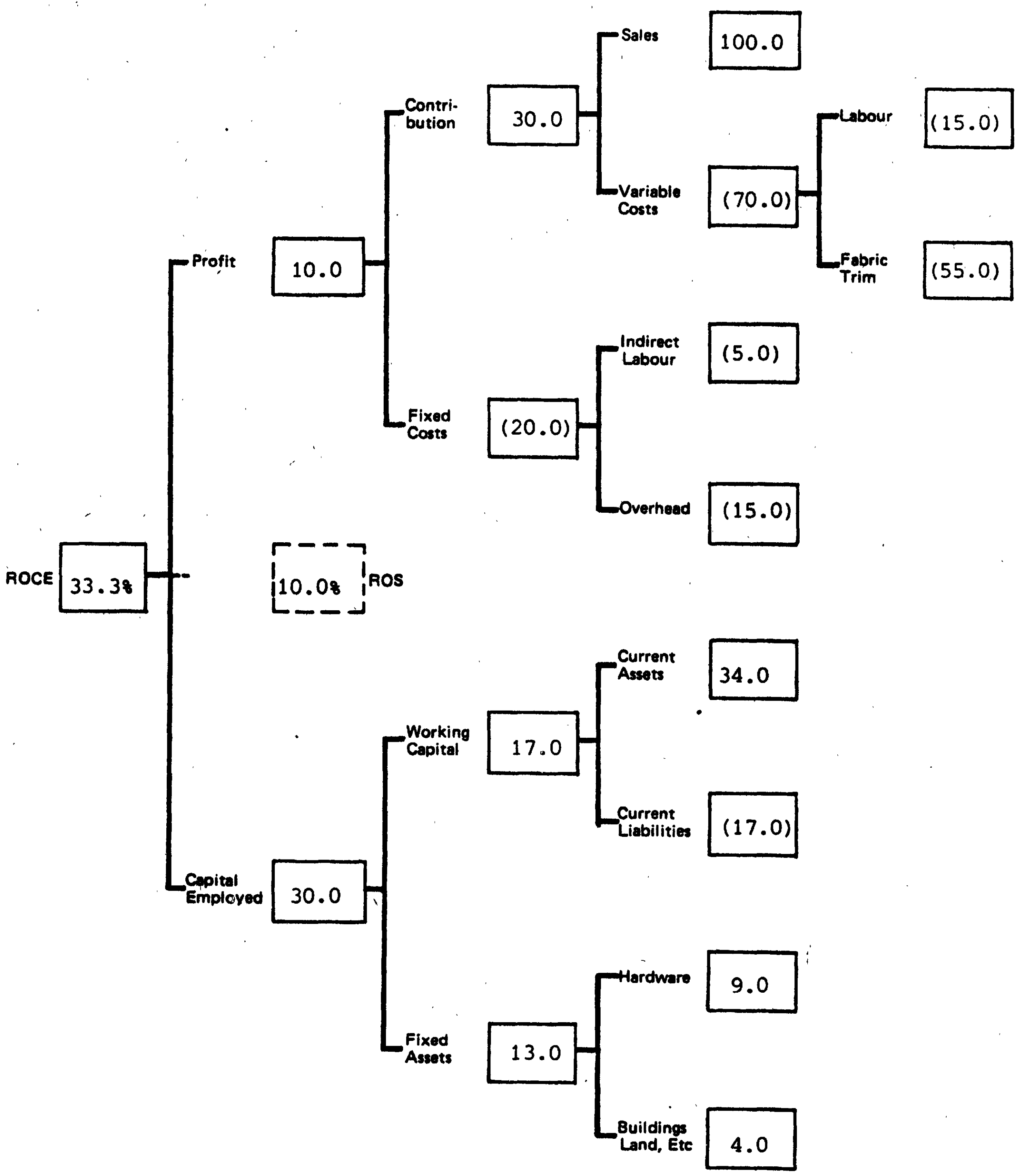
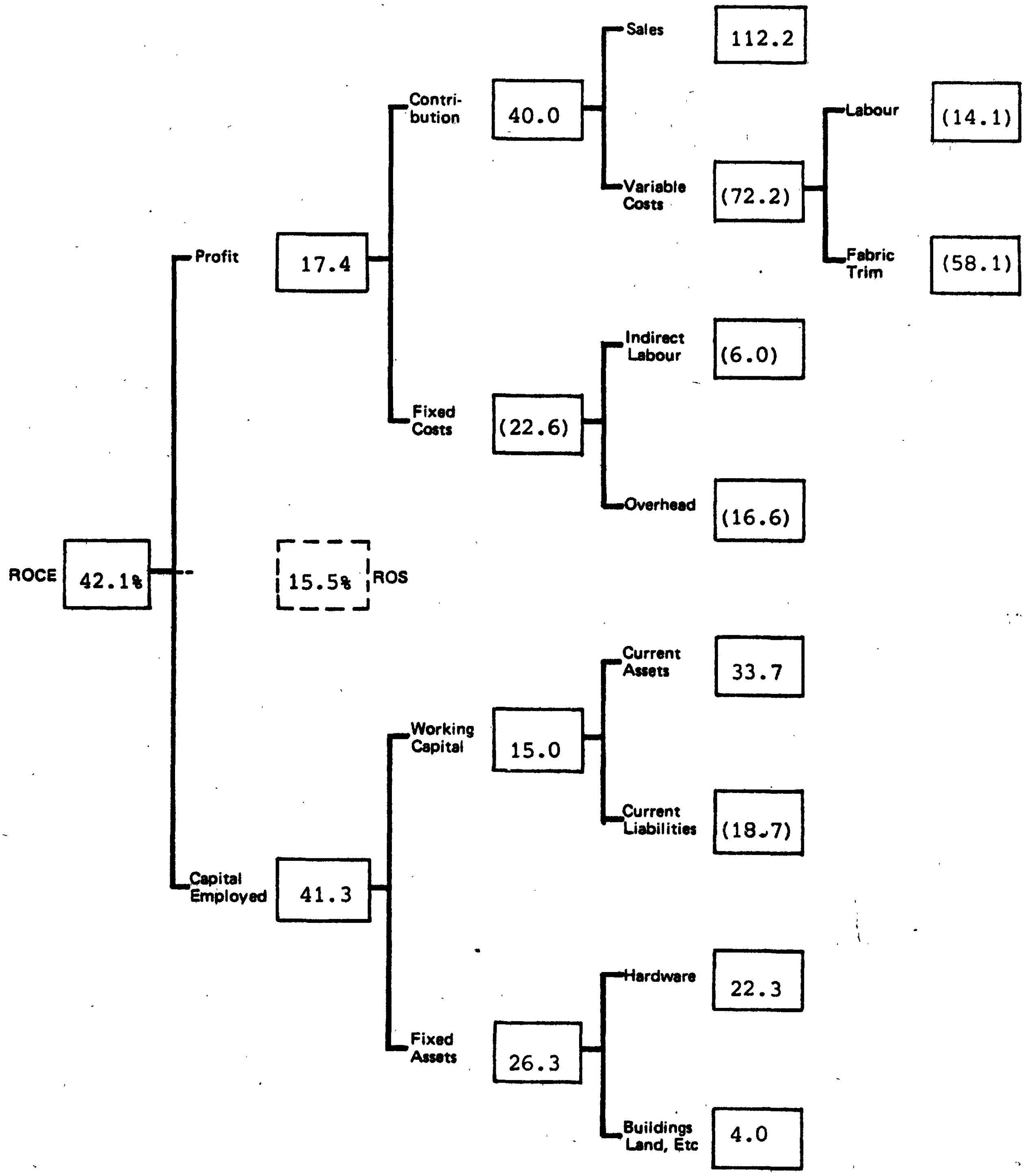
POTENTIAL IMPACT OF TECHNOLOGY ON PROFIT MECHANICS

FIG. 3.3



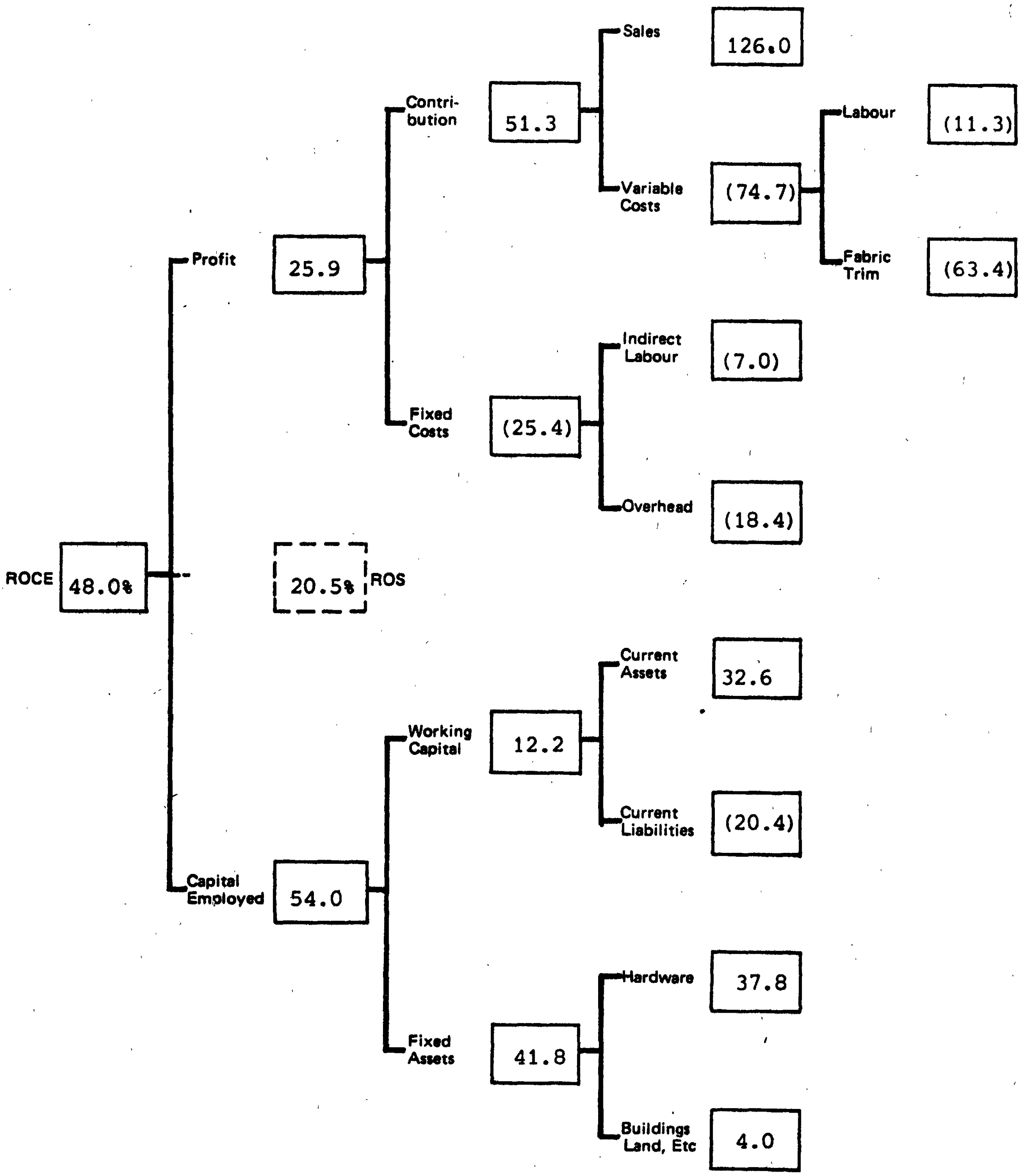
<u>BASE MODEL</u> FOR WELL MANAGED MANUFACTURER USING CURRENTLY AVAILABLE TECHNOLOGY EFFECTIVELY

KSA POTENTIAL IMPACT OF TECHNOLOGY ON PROFIT MECHANICS FIG. 3.4



MODEL 1 - <u>MEDIUM TECHNOLOGY</u> - INCREASING INVESTMENT PER OPERATOR BY FACTOR OF 3.

POTENTIAL IMPACT OF TECHNOLOGY ON PROFIT MECHANICS FIG. 3.5



MODEL 2 - <u>HIGH TECHNOLOGY</u> - INCREASING INVESTMENT PER OPERATOR BY FACTOR OF 7

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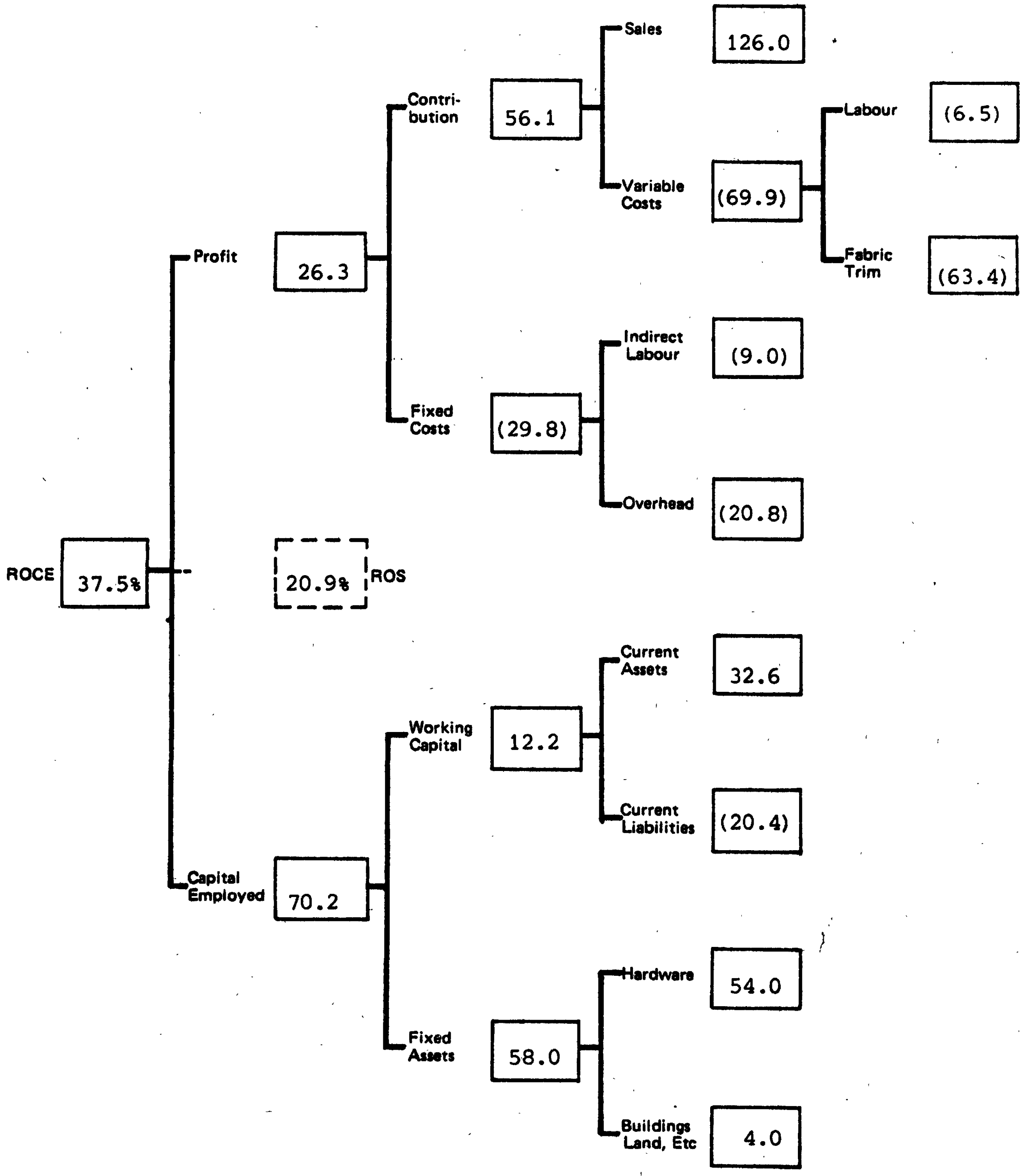
POTENTIAL IMPACT OF TECHNOLOGY ON PROFIT MECHANICS FIG. 3.6



MODEL 3 - <u>SUPER TECHNOLOGY</u>, INCREASING INVESTMENT PER OPERATOR BY FACTOR OF 20

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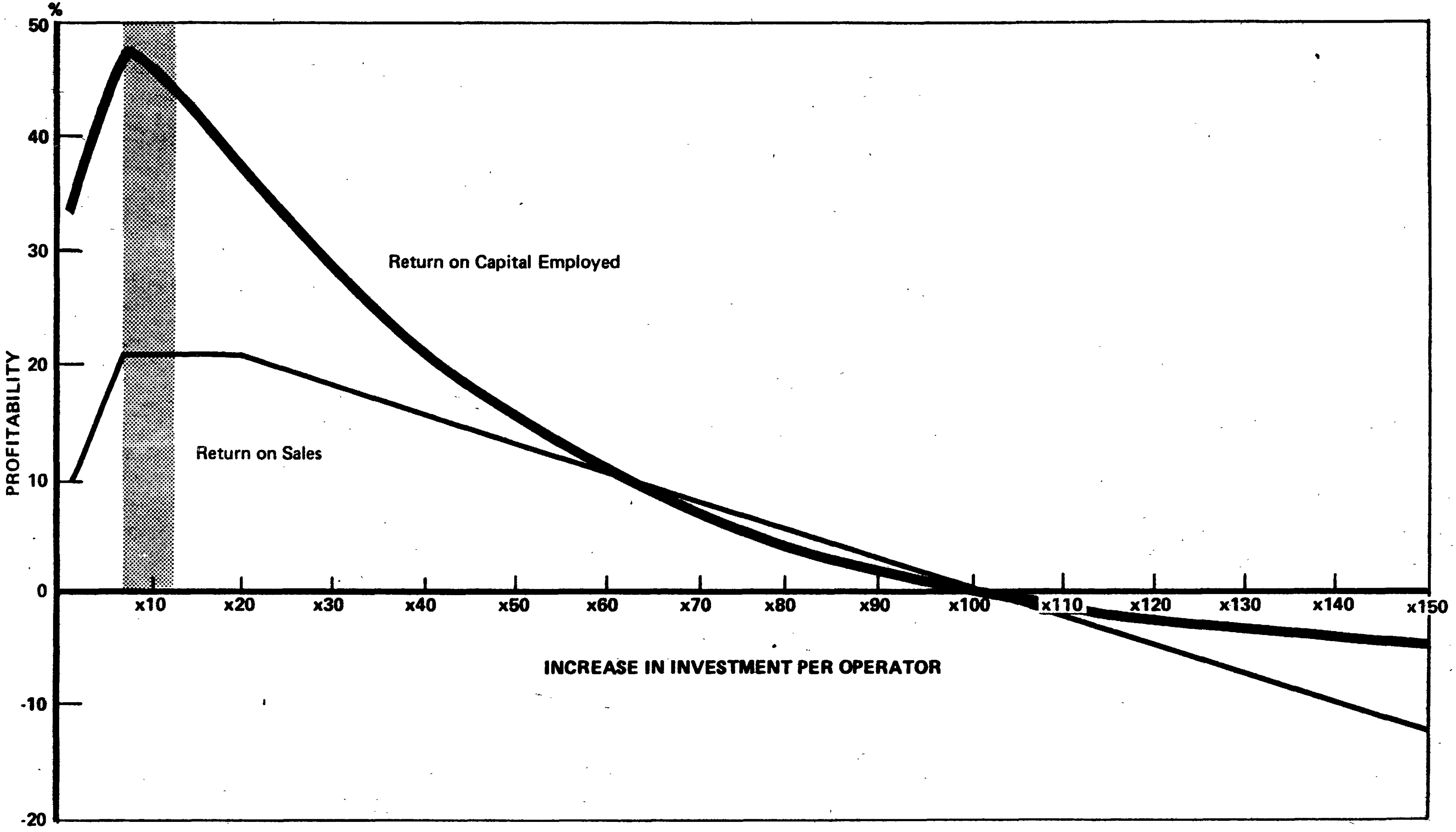
OPTIMUM TECHNOLOGY

F . .7



3.3 THE BARRIERS TO PROGRESS

While the technology model illustrates a situation which would be different if other assumptions are made about the impact of potential future developments, its overall findings are considered to be of sufficiently general validity as an indication of the future paths which the apparel manufacturing industry must tread if the technology is made available and the industry is to benefit from it. There are, however, aspects of the industry which need to be understood by those who will be concerned with technology development and its effective application.

There are three main barriers to progress which should be taken into account, assuming the appropriate technology becomes available. These barriers are:

- Criteria for Investment as Applied to Today's Technology
- Attitudes to Investment
- The Structure of the Industry.

3.3.1 Criteria for Investment as Applied to Today's Technology

There are a number of criteria which management may apply in determining the validity of hardware investment. The most common ones used are:

- Return on investment, or pay-back period
- Flexibility
- Improvement in quality consistency
- Reduction in training times and turnover
- Reduction in labour requirement to offset labour shortages
- Servicing and maintenance
- Exposure to the technology
- Cash flow and cost of money.

(a) Return on Investment

Most apparel managements will compute, whether on a simple pay-back basis or with more complex DCF approaches, the ROI from equipment expenditure.

Some firms will have a target, such as 2 years pay-back, although many are appreciating that longer pay-back periods may well be justified if other benefits accrue, and if their business as a whole is making substantial returns so that longer pay-backs on equipment will not dilute their return on capital employed.

The technology available today is often difficult to justify on a high pay-back basis unless high volumes are available. The availability of technology requiring high volume to justify it will have an impact on the structure of the industry, as is discussed later.

As long as the pick-up and position problem, as discussed earlier has not been solved, the current generation of automatic equipment (pocket setters, parts assembly, profile stitchers etc.) will still require one operator to a machine, so that the labour content, while reduced due to higher output, will not on the whole meet the ROI criteria of many companies. If volume is high and multi-machine setups can be justified with one operator tending several machines, using the cycle time of one to load another then the ROI becomes much more attractive.

There is therefore a volume threshold for much equipment today because the equipment itself is specific to one operation only.

It must also be said that much equipment is sold on a pay-back basis compared with the *current* level of performance on existing equipment, when that level can itself be improved by 20%, 40% or 60% by better industrial engineering and workflow controls. Management is increasingly aware of this factor, which makes it necessary to justify ROI on the more realistic basis of comparison with what is avhievable with existing technology, rather than with what is being achieved in the particular plant at the time the comparison is made.

(b) Flexibility

The lack of flexibility in today's technology, is probably the single biggest barrier to progress. Except in the most staple parts of the apparel industry, it is not possible to guarantee that a particular feature or operation will be required in the following season or in subsequent years (e.g. pocket setting on shirts). Thus some manufacturers require a 1-season pay-back before they will invest in specialised equipment of that nature.

While flexibility of specialised equipment is increasing, it is essential to get away from the one-operation machine before this criterion for investment will cease to be a major barrier.

Electronics, rather than mechanics, for control and guidance offer a major breakthrough opportunity for more flexible machines, but meanwhile management will continue to resist investment in inflexible hardware.

(c) Improvement in Quality Consistency

Much of today's technology sells on the basis of being able to provide quality consistency greater than that with conventional machinery. Profile stitchers, automatic cutting, pocket setters, fly stitchers, automatic pressing, etc. all provide a consistency of quality which only the most skilled operator can match on a regular basis.

New constructions of garments as well as market requirements are putting an increasing premium on quality consistency. Furthermore, automation of new operations will be dependent on greater consistency of prior operations in the sequence, from cutting onwards.

In commercial terms there are many manufacturers who have used technology to enhance the quality of their product. Much of the equipment with this feature provides little or no direct labour saving but makes a substantial contribution to the marketability of the product.

(d) Reduction in Training Times

One of the increasingly appreciated benefits of technology is reduction in training time. Labour turnover in the apparel industries is often in excess of 60%. Much of the turnover is among trainees where it may be 100% or more. Even at 50% the typical 300 operator company is employing 150 people each year at a cost in lost production of the order 25% of total capacity of the plant.

Training times with today's most advanced technology can often be reduced by 75% with a significant impact on labour costs and needs.

Much of the newer technology has made a substantial contribution to reducing training times in the making of parts, in the setting of pockets and in profile stitching, but the assembly operations of more complex products still benefit little from technology as far as training time reduction is concerned.

This criterion will continue to be of importance to apparel manufacturing management, and increasingly so if at the same time the job can be enhanced by using savings to pay higher wages for more sophisticated responsibility (for example, for setting up and monitoring automatic equipment over a number of operations).

(e) Reduction in Labour Requirements to Offset Labour Shortages

In many high wage countries there is a growing shortage of labour available to the apparel manufacturing industry. This is partly due to low pay relative to other employment opportunities, to departure of foreign workers in some countries since the oil crisis and to the perpetual waves of shrinkage of the industry following each recession, resulting in higher imports and a smaller pool of people with the apparel skills needed with today's technology.

Many managements have reduced their investment criteria by increasing acceptable pay-back periods, providing that there is an adequate contribution to the reduction in overall labour requirements. The cost of having to relocate or open new, smaller plants is to be seen as a penalty avoided if output can be increased or the labour requirement decreased. This *opportunity cost* does not enter into normal ROI calculations, but nevertheless it influences management decision-making.

(f) Servicing and Maintenance

One of the important barriers to technology is the standard and availability of service. The apparel manufacturer must increasingly expect a higher level of service for sophisticated equipment and his perception of the suppliers' ability to provide this will often be a key criterion in the investment decision.

He will also consider the need to build up his own maintenance capability - a task which is difficult to accomplish in many traditional apparel areas, and the cost of which is often neglected in assessing the impact of new technology.

(g) Exposure to Technology

A non-fiscal but important psychological criterion for investment is the opportunity to gain exposure to new technology. Many managements believe that while they cannot justify equipment on an ROI basis, they must experiment and get experience on which to base their future manufacturing strategy. There is sometimes an element of *me-too* investment and such motivations cannot be ignored.

(h) Cash Flow, the Cost of Money and Subsidies

Obviously the company's cash flow and interest rates have a major influence on the timing and size of investment decisions. The general health of the industry has a significant bearing on the speed at which it will make progress towards using available technology.

Different countries have different rules for depreciation and there have been a variety of subsidy schemes available, which have had an impact on equipment purchases. The impact of depreciation rules may be a significant area for review by the EEC in determining a consistent basis for encouraging the use of available technology.

In discussing these criteria applied by management to technological investment, it must be understood that one of the keys to getting a high return from such investment lies in the engineering of the environment of the equipment. Environmental engineering includes the flow of work controls, the supervision of the allocation of operators, the loading of the equipment, the design of the workplace and the incentives provided to the operator. The environment in these respects is often inadequate and must receive proper attention if technological investment decisions are to pay off.

In this connection KSA believes that there are two concepts which assist management make the right investment decisions - these are the concepts of *leverage* and *time span*.

The leverage of a specific improvement is the impact of improvement on the financial performance of the business. The time span is the time it takes to get the result.

In general, work with *people* in this industry has high leverage and a low time span - i.e. the results are large and the time taken to get them is small. Investment in much of the *equipment* on the market has a low leverage but a short time span, in that the ROI is low, but implementation is quick. Some specialised machinery developed to dramatically reduce the manual element of high work content operations has had a high leverage but involves a long time span; in this category might be included equipment developed for making specialised products in total, such as gloves and T-shirts. Successful breakthrough technology will, by definition, have a high leverage but inevitably a long time span.

Fig.3.8 gives some examples of time span and leverage for different activities to illustrate the point. Management must in its day-to-day efforts concentrate on high leverage low time span activities. Breakthrough technology must have high leverage to be justified but, because of its inevitably long time span, cannot claim the attention of ordinary commercial companies, therefore making it an appropriate focus for central or Governmental support.

The rate of decline of the high cost apparel industries is such that the threshold at which it becomes difficult to maintain an industry with confidence to invest and an ability to recruit and attract high calibre management will be reached within an undetermined but finite time. This period may well be of the same order of magnitude as the time span required to develop breakthrough technology, a consideration which might place the development of breakthrough technology in the forefront of these strategies for this industry in which Government has a hand.

EXAMPLES OF LEVERAGE AND TIME SPAN FIG. 3.8

	Area	Leverage	Time Span
1.	Intensive Operator Training	High	20 - 30 weeks
2.	Performance Development Programme *	High	12 - 15 weeks
3.	Production Engineering	High	6 - 12 months
4.	Material Utilisation	High	8 - 12 weeks
5.	E.D.P. Applications	Medium	2 - 3 years
6.	Proprietary Equipment	Low	3 - 4 weeks
7.	Developed Equipment	Medium	2 - 3 years
8.	Breakthrough Technology	High	3 - 10 years

* denotes a programme of supervision training and improving work flow control to raise operator utilisation, eliminate bottlenecks and improve management control in a making-up unit.

3.3.2 Attitudes to Investment

If the EEC, or others, are to try to accelerate the pace of acceptance of technology there needs to be a process of education and promotion of the cause of technology. There is an increasing understanding of the economics of technology but there are entrenched attitudes to be overcome before technological innovation will become widely acceptable. This syndrome is more prevalent in some countries than others. There is no doubt that the German industry far more readily accepts technological change than does the UK industry. The high cost of German labour is no doubt a contributing factor. In the USA the largest firms are in the forefront of technological developments. The majority of firms in European countries do not yet operate within 30% to 40% of what is achievable with current technology. There are reasons for this which should be understood, again emphasising that the degree to which they apply varies significantly from one country to another.

The two main attitude barriers to progress are *scepticism* and *apathy*.

KSA defines the *scepticism gap* as a lack of understanding of what is possible. Companies often accept performances well below what is achievable, either because they do not believe that higher performances are achievable or because they rationalise their low performance by assuming the conditions, style changes, size flexibility, quality etc. demanded by the marketplace are sufficiently different to justify the lower performance.

This industry must indeed shape its technological investment and its manufacturing systems in a way which reflects the conditions imposed by the marketplace, and factors such as style mix have a considerable influence on what is achievable. But for any given set of circumstances there is an optimum level of investment in technology and an appropriate performance level for that technology. As such levels are often significantly higher than those actually achieved, there is a need for constant effort to bring the average of the majority of companies nearer to the best.

If this is not done it will continue to distort attitudes to new technology and the *scepticism gap* will prevent new technology from being accepted, with unfavourable impact on the high-cost countries' industry as a whole.

Apathy is a by-product of scepticism and of erosion of confidence. KSA has referred to the *apathy chasm* to reflect the depth of the problem. There is a large section of the industry which does not have the confidence to invest. Management in this section believes that the Far East, or the U.S., or some other manufacturers can do things that it cannot. The *apathy chasm* has come about as a result of import penetration, the feeling that the industry is expendable, the confidence-erosion of inflation, periods of price control and "stop-go" policies. It is significant that on the whole those countries with less problems in these areas have accepted technological change more readily and have displayed the confidence to invest in technology.

As far as the apparel manufacturing industry in the EEC is concerned it will be important to influence the environment in a way which reduces the apathy chasm if investment in development of breakthrough technology is to pay off.

3.3.3 The Structure of the Industry

Finally, in the discussion of *Barriers to Progress* reference must be made to the structure of the industry. In most countries the structure is roughly as shown in 3.9.

TYPICAL APPAREL INDUSTRY STRUCTURE **FIG. 3.9**

SIZE OF COMPANY	% OF ESTABLISHMENTS	% OF EMPLOYEES
Up to 50	75%	24%
51 to 100	10%	16%
101 to 200	9%	22%
201 to 500	3%	21%
501 to 1000	2%	10%
Over 1000	1%	7%

The industry is still people-intensive. If technology is to play the part which is suggested then the structure will change. Technology alone will not bring about the pressures for changes, many of which already exist.

For large apparel companies today there are advantages which did not exist 10 or 20 years ago. These include :

- international marketing and consumer franchise needs the financial muscle provided by size.
- the ability to source internationally to offset changes in cost structure of different sources is a facility more readily available to the large firm.
- top quality management is more likely to be attracted to the larger firm.
- diversification of product and channels, properly organised, give the large firm a significant advantage in economic downturns.
- the larger firm enjoys economies of scale as technology becomes more important, and it is more able to finance the longer-term pay-offs.

As will be seen from the models developed in Figs. 3.3 to 3.6, fixed assets as a proportion of capital employed is 43% for the base model (today's technology) 63% for the medium technology apparel manufacturer, 75% for high technology company and 83% with "super technology".

In other words, if breakthrough technology becomes feasible the apparel company will become capital intensive, with a ratio of fixed assets to working capital of around 3 : 1 or 4 : 1 compared with 0.8 : 1 today.

It will thus become an industry where managing capital will become at least as important as managing people. At present the leverage on profitability in an apparel company is in managing people - the difference between the excellent and the average is in this area, not in technology.

Thus machine utilisation will become important and the question of shift-working will be raised. At present, studies on the benefit of shift-working have shown them to be minimal, not because machine utilisation is not improved but because the "people management" content of the management task is so high, and the availability of good people management is low, so that the shift-system cannot easily be made to pay-off. Shift-working brings with it social costs and needs additional management resources, so it is only in a situation where the people management content has been reduced and the capital management content increased that the benefits of spreading overhead can be obtained. There can be little doubt that such conditions would provide a major competitive advantage to the high-cost apparel manufacturer.

So it is speculated that any acceleration in the development of technology will impact the structure of the industry. The large firm will be able to capitalise on new production equipment and the small firm will be able to manage its flexibility at lower cost and more effectively. The result will be an increase in the number of large firms. The small firm will continue to prosper in its specialised market niche. The medium-size firm may well become the victim of change, with insufficient advantages of size to take advantage of technology and marketing punch, and without the flexibility and low overheads of the small firm.

SECTION 4

POTENTIAL BREAKTHROUGH TECHNOLOGY

In which areas of technology is there promise of significant 'breakthrough' in terms of achieving substantial competitive advantage for high-wage cost apparel producers, and/or of contributing significantly to meeting the success criteria of the individual manufacturing enterprise ?

4. POTENTIAL BREAKTHROUGH TECHNOLOGY

This section of the report starts with a description of the "technology business" and the nature of the investment involved in developing technology, an understanding of which is necessary if that business is to be more effectively harnessed to the needs of apparel manufacturing.

There then follows an account of those future development directions which as a result of this study seem to offer the most promise. First the criteria for future development are discussed, followed by identification of the key task areas.

INFRASTRUCTURE OF TECHNOLOGY DEVELOPMENT

4.1.1 The Nature of the Technology Business

The technology business is defined as consisting of those companies which manufacture and market production equipment for the sewn products industry as well as those technology companies which have the potential to develop such equipment. Like any manufacturing business, the important factors in their success are volume, profitability, and product line relevance. Research and development is a costly part of their expense of doing business, and quite naturally, the less they do in order to build and maintain a given sales volume, the more profitable they will be. They invest in research and development in order to either increase their volume or to protect themselves from the erosion of their volume by the obsolescence of their product line. Their product line becomes obsolete primarily because someone else is doing more and better R & D than they are doing.

The economics of sewing equipment R & D is complex. Manufacturers do not wish to make R & D investments unless a market analysis shows that a reasonable volume of machines can be sold in order to recover their investment in R & D and to make a profit.

The really successful R & D which has been done by the sewing equipment companies has been centred on special purpose machines to perform individual operations on specific products. Examples of this are the shirt patch pocket setting machine, the automatic belt loop attaching machine for jeans, and the shirt collar band creasing and collar assembly system. The research and development project applicable to a number of pieces of equipment such as the needle positioner is at the other end of the R & D spectrum. In order to develop special purpose equipment, the equipment manufacturer must look to the future market for the product he is focusing on and he must make some estimate of the potential payback to the apparel manufacturer and therefore the range of selling prices that the machine, if successful, can fall into.

So, the equipment manufacturer may first look at the product, for example shirts, and look at the various operations on the shirt to see which, if any, will lend themselves to the development of a new special purpose machine for this sub-industry. Having selected the product and the operation, and carefully investigated the market, he then must make a research and development gamble which involves investing money without knowing whether he will be successful or not.

Clearly, for the past two decades, the equipment people have been careful about selecting those operations and those products which would yield a market for the equipment which they have developed. They have also carefully chosen those operations which lend themselves to research and development within the available state of the art technology.

An equipment manufacturer is very reluctant to enter state of the art R & D in that he is really gambling with little economic basis and also stands the risk of not having exclusivity if he is successful.

For this reason, most state of the art technology in many industries in recent decades has been the result of research and development either financed by Government or by an industry. This research and development is then made available to the commercial equipment manufacturer who brings it to the market place in the form of a machine developed for a specific operation and product.

In addition to the developer of equipment, there is the in-house R & D department of some apparel manufacturers, where a similar, but even more limited situation exists. These researchers are constrained to developments specific to the product of the company which employs them. They must also be careful in their investment strategy because they have a limited market within their own organisation for the equipment they develop. A few exceptions to this are those companies who have developed equipment and then either sold it to the industry at large, or to an equipment company.

The most successful equipment developments have really been joint efforts by a firm producing a particular product and an equipment company which has the resources and the economic motivation to go forward with an R & D program. They get invaluable assistance from an apparel manufacturer interested in working with them in developmental process. The apparel manufacturer brings to the R & D effort his knowledge of the product, its quality and cost structure needs. Furthermore, it takes an interested, motivated apparel manufacturer to make a new development work. The introduction of the new equipment into the manufacturing process often requires changes to prior or subsequent operations and it always includes a major effort to "sell" the changes to the many operators, supervisors and mechanics involved.

In discussing the nature of the equipment industry, it is also important to point out the limitations of the maintenance mechanic and technician situation. Equipment developers are reluctant to develop equipment which is more sophisticated than can, in their opinion, be maintained by the average apparel factory staff. They understand that there are some shortcomings here, and that their new equipment will not be successful if it fails to achieve projected reliability with the skill available in the factories. Furthermore, some equipment salesmen are reluctant to sell highly sophisticated equipment even when it becomes available because they have had bad experiences with the equipment failing to perform as advertised under the relatively unskilled hands of apparel manufacturing mechanics. They would prefer not to antagonize their equipment customer by delivering to him a sophisticated machine which does not do the job.

Perhaps this is one reason why some technology which is available and offers a good return on investment is still not in use in much of the apparel industry. However, it must also be said that there are successful parts of the technology industry, especially those in the customised equipment business, which are using available technology which is more advanced than that used by the suppliers to the apparel industry.

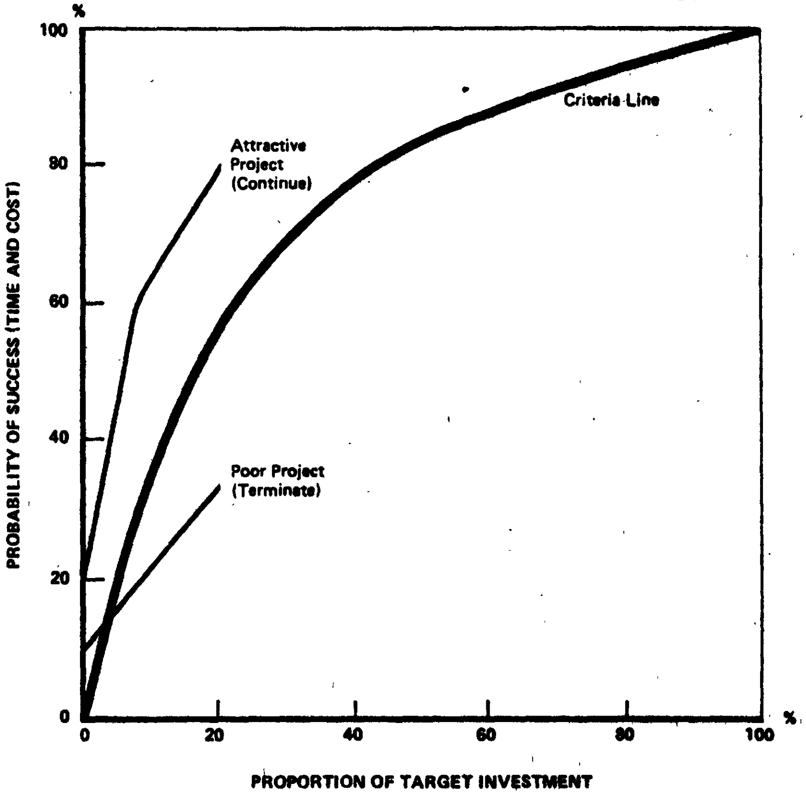
It is valid when discussing the technology business to examine the typical criteria that the suppliers use when evaluating the benefits to the sewing industry, as this obviously plays a significant part in decisions whether to develop particular products. This information was requested of the suppliers interviewed during the study. The range of responses showed that the suppliers' perception of the payback necessary for the purchaser of new equipment was a period of from one to three years. A number of suppliers said that they were trying to develop a more sophisticated attitude among their customers, but this was proving difficult.

To some extent this attitude has been justified in the past when specialised equipment has been overtaken by style requirements which have made it unusable. However, more recent developments have been designed with greater flexibility in mind. It is now a task for the suppliers of equipment to persuade the industry that the additional cost of this flexibility can be justified by allowing longer amortisation periods, more in line with the service life of the equipment.

4.1.2 The Development Cost of Technology

As an integral part of this study, a number of companies and institutions were visited who do not currently supply technology to the apparel manufacturing industry, but which are generally regarded as being involved in state of the art developments in the technologies that they specialise in. One particular company, involved in state of the art development on a commercial basis,used an interesting approach to limit its development risks, which is extremely valid in the context of apparel industry development. They modelled the probability of success of any particular project against the proportion of the total expenditure allowed for the project. The total expenditure was assessed from the probable commercial value of the breakthrough (Fig. 4.1). The major point to be taken from the model was that some expenditure is necessary before a realistic evaluation of potential success can be made. However, unproductive research lines can be terminated before a large part of the planned expenditure has been committed.

FIG. 4.1



This practice is reminiscent of the Chinese doctors who would quote a scale of fees for a range of chances of a cure. For incurable patients the fees for certain cures were always beyond their means. In a like manner incurable projects can be laid to rest with minimum of expenditure.

This method of R & D control should form part of the project management task in any programme that might be considered as a result of this study.

4.2 FUTURE DEVELOPMENT DIRECTIONS

4.2.1 Criteria for Future Development

In an earlier part of this report the current development lines being pursued by industry suppliers have been discussed. The nature of the *technology business* has also been reviewed. Understandably the major selection criterion for current development has been commercial gain, usually in the relatively short term.

On the other hand, many of the advances that could be considered desirable are arrested because an essential *building block* is missing. This is aggravated by the fact that the building blocks required to achieve a particular breakthrough frequently involve a range of different technologies. For example, the people most likely to achieve a satisfactory reversible rigidification process do not have the technology to build machines to take advantage of their process. Without the machines there is no market for the process, so development does not take place. Conversely the people with the machine technology do not proceed because they do not have the capability of producing a satisfactory rigidification process.

This type of vicious circle exists in a number of areas, and the important conclusion to be drawn is that although the development of any particular building block may in itself be of no particular value (and therefore commercially unattractive) the true significance of the development may only be realised when it is integrated with all the others.

Equally in the alternative processes previously discussed such as moulding, welding and adhesives, the full potential of the processes may not be available unless they are augmented by other developments. There are, without doubt, a number of very promising projects under these headings that are in danger of being terminated through lack of short term commercial potential.

In the field of computers there is also a great deal of development to be done. However, it does appear that the short term cost/benefit equation is less dependent on interlocking developments. The effect is that the commercial development of EDP systems is generally considered viable by the technology leaders.

In the longer term it may be valid to question the whole concept of current development in that it is centred on the machining process, and to develop an alternative concept of a *handling machine* with a range of interchangeable sewing, welding and adhesive heads. Such a machine would conceivably have the capability of 'X', 'Y', and 'Θ' motion, a range of interchangeable fabric handling systems and easily reprogrammable characteristics. This concept is to some degree an extension of the prevailing development of existing builders in that their aim is to get one machine to carry out several processes.

4.2.2 Key Task Areas

In this section the potential breakthrough areas identified in the earlier section on "Current Development Directions" (Section 2.5) are reviewed in the light of their potential significance to the assembly process as a whole. The list previously given represented the possible *means* of achieving the *goal* of increasing competitiveness. In Fig. 4.2 the structure of the relationship of the basic techniques in apparel assembly to the final product competitiveness is shown. The diagram indicates that competitiveness is improved both by reducing price and by increasing value. The latter means is, however, extremely difficult to quantify as the key areas of significance - service, quality and innovation- have values which are not absolute, but determined by the state of the market. Typically these factors might be expected to improve sales by 5 - 20%

In the area of price reduction, developments in the assembly process obviously have a direct effect on labour cost. There is also a secondary effect on manufacturing overheads associated with direct labour cost. These secondary effects are dealt with in the economic model already discussed in section 3.2 of this report, and the overheads in Fig. 4.2 refer only to those associated with work-in-process.

KSA | KEY TASK AREAS | FIG. 4.2

		AREA OF SIGNIFICANCE	KEY TASK AREAS	POTENTIAL LEVERAGE ON AREA OF SIGNIFICANCE	TIME SPAN
COMPETITIVENESS OF PRODUCT	PRICE REDUCTION	INTRINSIC WORK CONTENT	- Full system automation	40-60% reduction	SHORT
			- Full sequential automation	5-10% reduction	MEDIUM
			- Alternative Processes	10-70% reduction	CONTINUOUS DEVELOPMENT
		EXCESS WORK CONTENT	- Improved Management through Computer Technology	50% reduction	SHORT
		OVERHEADS	- Improved Management through Computer Technology (less WIP)	5-15% reduction	SHORT
	VALUE IMPROVEMENT	SERVICE	- Computer Technology	Not absolutely quantifiable, but 5-20% on sales	SHORT
		QUALITY	- Automation		MEDIUM
			- Alternative Processes		LONG
		INNOVATION	- Alternative Processes		LONG

It can be seen that there are four fundamental key task areas relating to the technologies discussed in this report :

(a) Full cycle automation

(b) Full sequential automation

(c) Alternative processes

(d) Improved management through computer technology

In the previous section, the concept of building blocks required to achieve certain goals was discussed, and the need to assess the value of each building block more in its relationship to achieving the goal, than in its intrinsic value. In this section it is perhaps worthwhile to consider the type of building blocks that can be identified in the key task areas.

(a) Full Cycle Automation

1. Ply separation from the top of a stack.

This problem has been widely discussed elsewhere in this report. It would usually be combined with a positioning of the separated ply. It must not be ignored that in some instances this problem may be most economically solved by single ply cutting, possibly with lasers or water jets. Numerically controlled laser cutting is extremely fast and compares with numerically controlled multiply cutting for small lays. It is not inconceivable that in some instances an increase in cutting cost could be offset by consequent reductions in assembly cost.

2. Alignment of one or more plies.

   The technology of precise shape recognition is well advanced. It is obvious that this function would be aided by fabric rigidification. Even in the single ply case selective rigidification would ensure fabric folded in a predetermined manner. (Note: Selective rigidification has been achieved already, but is non reversible). A purpose-built robotics device could offer the sort of flexibility needed to allow easy adjustment of the device to different operations or sizes.

3. Load into machine.

   This building block will probably have to be developed for individual machine types. However, provided it is input with a fully aligned assembly of parts no major developments are needed for a satisfactory solution.

4. Seam Guidance.

   Three guidance principles have previously been discussed; edge following, cam or track following and numerical control. These principles can be expected to solve the majority of application requirements. However, that should not exclude the development of alternatives. One possibility is an optically guided system perhaps following seam lines printed or sprayed onto the fabric (possibly at the same time as the rigidification process). The technology of optical guidance is well developed outside the industry.

5. Thread Trimming.

   Where thread trimming occurs within the boundary of a fabric panel an underbed thread cutter is used. Some development is required to make these devices sufficiently reliable for fully automatic operation, perhaps by incorporating multiple cutting actions rather than the single action as is now normal.

6. Spool loading.

   Market forces will probably demand the retention of the lockstitch for the foreseeable future. In this case a truly satisfactory solution to recharging the spool is required. It is likely that such a solution will only be obtained when a sewing machine head is developed specifically for automatic use.

7. Unload machine.

   There are a wide variety of proprietary devices for stacking finished assemblies. Unfortunately some of the very best have been designed for particular items of automatic equipment, and development to make these more universally applicable would be valuable. Such unloading devices should ensure the optimum alignment of parts for the subsequent operations.

8. Three-dimensional seaming.

   If full cycle automation is to extend into the more complex areas of garment assembly three-dimensional seaming must become a reality. The technology for controlling the seaming head for example, is already available. In this area, as in others, the availability of a sewing machine head specifically designed for automatic use would be highly desirable.

(b) Sequential Automation

1. Transfer device.

The assumption is made that sequential automation is developed as a flexible process involving individual machines which could be regrouped as necessary. A transfer device would be required that could be adjusted to handle a range of subassemblies. Ideally this device should be easily reprogrammable and robotics technology would have much to offer here. It is possible such a transfer device could be a development of the unloading devices discussed above. In this application, the unloading stack from the first machine would be *at the same time* the loading stack for the second machine. This principle would, to a certain extent, get around the interference caused by individual machine hold-ups in transfer lines and could also be adapted to allow two or more machines to supply a single machine (or vice versa) thus allowing the integration of several machines of different cycle times.

2. Machine reliability.

Once equipment has been integrated into a sequential process, individual machine reliability become more and more critical. For example, if a single machine has an inherent 5% down time, it would increase to 10% with two machines, 14% with three and 19% with four machines interdependantly connected. The development of machine heads specifically for automatic machines becomes even more urgent in this context.

(c) Alternative Processes

It is not possible to identify building blocks in this area in quite the same way. However, it can be stated with some degree of confidence that alternative processes generally involve very heavy expenditure and must therefore offer substantial competitive advantages if they are to overcome the extremely conservative nature of both the apparel assembly industry and the buying public. For this reason it seems probable that alternative processes will be introduced on a selective basis to produce parts of a garment rather than the entire garment. (For example, when fusing was first introduced it was shown that it was possible to use the technique to manufacture the entire garment without thread. This capability has never been taken up on a commercial basis, though fusing itself is widely accepted as a now indispensible process of manufacture).

(d) Improved Management Through Computer Technology

The breakthrough area here is unquestionably real time production process control. The other aspects of computer technology discussed elsewhere in this report are essentially developments of systems already in existence to a large extent. In the case of real time control two building blocks can be considered.

1. Data capture.

   Continuing evolution of the data capture process is required to achieve a cheap, reliable and secure data capture device. Recent developments are encouraging but are still a long way from ideal.

2. Management/Machine interface.

   Always a major problem with data processing, the techniques of translating the computers' information into effective action from management needs special attention in the apparel industry. Technologies that extend the power of the computer to implement decisions are particularly interesting and become more so the greater the the degree of automation in place.

4.2.3 Priorities

As has been indicated in figure 3.8 the potential leverage of breakthroughs in the key task areas varies considerably, as does the probable time span over which they might be achieved.

It can be seen that full cycle automation is considered to have the greatest potential impact. This is because it would allow a change in the one operator to one machine work pattern currently dominating the industry. The time span over which breakthroughs can be anticipated is also short, as most of the problems have been solved for specific instances and only a general solution is now required.

Full sequential automation is less significant because it is effectively eliminating only the inter operation handling of a product which is rarely more than 5% of total cost in any case. It has a longer span simply because full cycle automation is a pre-requisite.

Alternative processes will be continuously developed, but their main early impact may well prove to be as building blocks to automation, rather than as total alternatives to current assembly methods. In certain specialised fields such as surgical and protective clothing where function is much more important than fashion, the adoption of alternatives may be more rapid.

In computer technology, the technological breakthrough has already been made. What is now required is an evolution of the techniques so that they can be used widely in the industry. The potential impact on excess costs is significant and due to present availability the time span is short.

In the light of the above a number of key elements for further work can be identified. These are :

1. *Early development of versatile ply pick up and place devices.*
2. *Concurrent development of alignment devices.*

3. *Development of acceptable rigidification processes that are reversible and can be applied selectively.*

4. *Early development of the specification for an automatic sewing machine head to include possibly:*

   - *demountability; compatable with a range of devices;*

   - *self threading; upper and lower threads*

   - *omni-directional capability; without seam quality loss.*

SECTION 5

RECOMMENDED ACTION AND PRIORITIES

In what ways could the development of breakthrough technology be accelerated and with what priorities and through what mechanism might Government help at the European level ?

5. RECOMMENDATIONS FOR ACTION

This section of the report develops a framework for the EEC to consider in creating its policies towards the support of technology development for the apparel manufacturing industry. It is recommended that these policies are set into a well-articulated strategy for the industry in which technology will have a defined and critical place.

This section develops ideas on both the mechanisms and the steps which need to be taken in the short term, as well as the concept of a 10 year programme to support the Commission's strategy.

RECOMMENDATIONS FOR ACTION

In this section the framework of a possible action plan is developed. To be fully effective such a plan must encompass two separate objectives. The first objective would be to promote the development of breakthrough technology. The second objective would be to promote the implementation of that breakthrough technology in the industry itself. Past experience has shown that the industry has been slow to adopt new ideas, and much of the benefit of new technology may require a quantum leap in management thinking to be accepted at all.

In spite of this past reluctance to invest in technology, KSA has received many inquiries from individuals, companies and institutions who were interested to pursue a wide range of research and development projects which they believed could have significant impact on the future competitiveness of the industry.

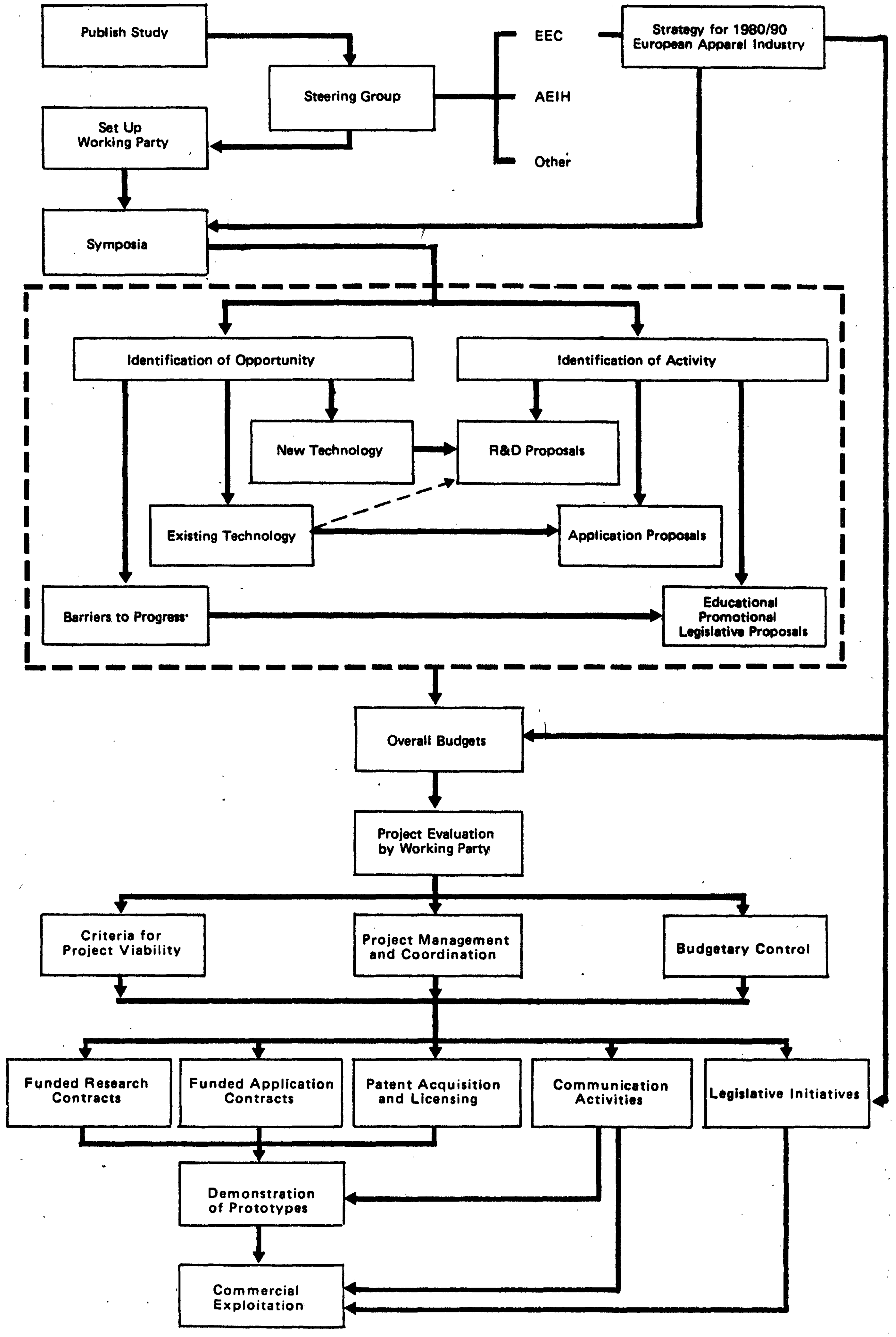
In order to capitalise on this interest, a framework for action has been developed. This is shown diagramatically in Figure 5.1.

Each of the key elements is discussed in turn in this section.

KSA

FRAMEWORK FOR POSSIBLE APPAREL TECHNOLOGY DEVELOPMENT AND IMPLEMENTATION PROGRAMME

FIG. 5.1



5.1 Publish State of the Art Study

This is a logical first step, and should be instigated with the minimum of delay whilst the project is still fresh in many peoples' minds. Steps should be taken to ensure the widest possible exposure of the report, and emphasis should be given to the intention (by the EEC) to treat the report as a basis for future discussions.

5.2 Steering Group

A steering group would be necessary which would have ultimate authority over the proposed programme. It must have a sufficient number of members who in no way have interests in the supply of technology. No doubt AEIH would be represented as well as national organisations. Because of the need at this level for such diverse representation, the steering group would be too large to act as an effective management body and as a result a separate small working party should be created which would report to the steering group.

5.3 Strategy for the Apparel Industry 1980-1990)

The recommendations in this report for the development of technology and its applications will depend to a large extent for their success on the environment in which the apparel industry operates during the next 10 years.

It is therefore important that there is an articulation of the objectives which the EEC has for the industry and the strategy which it is developing to support achievement of those objectives.

It is recommended for example, that the symposium takes place in a context which focusses not just on the potential impact of technology, but also on the impact of the apparel manufacturing industry itself on the economic development of the Community. All subsequent activities discussed below will be influenced by the EEC's overall strategy, and the atmosphere which this creates.

It would, for example, be desirable to state that the EEC expects technology to be making sufficient impact by say 1990, to have given the high cost countries a strategic advantage which permitted this to influence subsequent positions on protectionist measures, and to help implement this strategy, the EEC is prepared to fund specific technological programmes.

It is therefore suggested that the proposed steering group is composed so that it can work with the EEC in the necessary statements of objectives and strategic directions for the industry so that *its work in promoting the development of technology is seen to be part of that strategy*. This will help create the confidence that the future competitive conditions, which will be influenced greatly by EEC and Member State negotiations, will be such as to warrant a long-term effort to harness technology by the individual manufacturer.

5.4 Working Party

The working party would be assigned a range of tasks. The initial task would be to organise a series of symposia (see below). Subsequently the working party would be required to construct an overall budget in line with the long term strategy of the EEC for the apparel industry. The working party should then evaluate various potential projects and construct a set of criteria for their viability. Once satisfactory projects have been identified the working party would provide a project management and co-ordination role, together with budgetary control. It follows from this that the working party must have the capability for professional project management. It must fulfil the need to integrate efforts in R & D in apparel manufacturing technology and break the vicious circles currently inhibiting several potential developments. Its membership must be independent of technology suppliers.

5.5 Symposia

Although significant breakthroughs have in the past been the result of individual efforts, there is no doubt that most technological breakthroughs in recent times have been the result of achieving a *critical mass* of effort. The aim of the suggested symposia should be to achieve this critical mass by inviting key organisations to participate, with the stated intention of achieving a consensus in identifying the opportunity areas offered by both new and existing technology, as well as identifying barriers to progress. The participants would be invited to submit proposals subsequent to the symposia for projects that relate to the opportunity areas identified.

5.6 Proposals

As a result of the symposia, a wide range of proposals would be submitted to the working party for evaluation. These proposals could be expected to fall into three broad categories.

5.6.1 Research and Development Proposals

Under this heading would come the broad spectrum of work, both to develop specific building blocks and to combine building blocks into a working process. The emphasis would be on the creation of new technology and the development of existing technology.

5.6.2 Existing Technology Application Proposals

Many existing projects have come to a halt because of lack of funds, or because support from the industry in the implementation phase is not forthcoming. It is likely that a number of advances could be brought on in the short term by supporting such implementation.

5.6.3 Educational, Promotional and Legislative Proposals

To overcome the barriers to progress discussed in the report, it will be necessary to undertake a programme to educate management of both apparel and technology companies on the problems to be solved and their commercial potential. It will also be necessary to promote the cause of technology in general and the EEC programme in particular. It is also possible that in certain fields, such as depreciation rules the EEC will wish to take legislative initiatives. The steering group should be concerned to see that a suitable educational promotional and legislative programme is developed.

5.7 Overall Budgeting

In the light of the perceived EEC strategy for the industry, budgets would have to be prepared for further support of the programme. Decisions would be required on the nature and extent of possible funding. Alternatives could be a single allocation of central funds or an annual allocation over the strategic period. Means of obtaining industry support should also be examined. As a result of the study KSA believes that significant industry contributions could be available for well managed pragmatic research and development. Naturally, a mechanism for compensating contributing companies would need to be evolved.

5.8 Project Evaluation

As a result of the symposia, and in the light of the available funds, the key task of the working party must be to evaluate the various projects put forward. Three clear activities would be required :

5.8.1 Development of Criteria for Project Viability

The potentially most valuable role the working party could play would be to provide a strong central direction to research and development investment. The value of each element of research within the totality of the objectives must be decided, to avoid continued investment in projects whose development costs are likely to exceed their value.

5.8.2 Project Management and Co-ordination

Once project priorities have been assigned the working party should provide a project management role sufficiently flexible to direct additional effort to promising areas, to suspend non viable projects, and to identify necessary research priorities that arise during the course of each project. An important co-ordination role arises both to ensure that the minimum amount of duplication occurs and to ensure that optimum approaches to key problems are selected. This would not of course exclude the support of separate projects with a uniform objective, in circumstances where several promising research lines exist.

5.8.3 Budgetary Control

Central budgetary control is essential to ensure that the maximum benefit is gained from the available finance. Central control would also allow a flexible allocation of funds in line with changing priorities as projects proceed and as critical review points are reached between phases of specific projects.

5.9 Funded Research Contracts

These contracts would be directed towards technology companies and institutions both inside and outside the apparel industry. Finance could be provided, for example, to develop solutions to particular problems as a model for the more general application of the principles involved. The 'Rink' project and the T - shirt sleeve project funded in the USA in the 60's were examples of this type of activity. Such projects would be strictly controlled on a phase by phase basis to ensure that no project proceeds to the next phase unless the previous phase had met its objectives and had demonstrated the subsequent phase had a high probability of success.

Suggested phases would be :

- I Concept Development
- II Preliminary Design
- III Detailed Design
- IV Fabrication and Assembly (prototypes)
- V Modification Installation

Phases I and II give the largest gains in confidence for the lowest investment. Phases III and IV entail the major portion of the investment and must only be started if the confidence level achieved after the earlier phases is sufficient (say 80 per cent confidence of success after phase II).

5.10 Funded Application Contracts

These contracts would be directed towards the apparel manufacturing industry and would have as a general objective the exposure to the industry of many of the available technologies with long amortisation periods. For example, support could be provided for an outerwear manufacturer to install a moulding capability, or for a workwear manufacturer to invest in a new non-woven technology. In a similar vein funds could be made available to enable producers of new technology equipment to test out their products in a working industrial environment rather than in a laboratory.

5.11 Demonstration of Prototypes

Industry scepticism will remain high until working prototypes of processes which conform to the demands for flexibility, quality and affordability can be demonstrated. It is also extremely important to bring out the point that new technologies and processes can be managed, and do have something relevant to offer. Prototypes will become available as the programme develops and there will be a need to put on demonstrations, in live manufacturing situations where applicable.

5.12 Patent Acquisition and Licensing

A prerequisite to any research work is a thorough search of existing patents. Frequently the outcome of this is costly duplication of effort to get around a particular patent. In circumstances where a patent is in existence but work on it is dormant, funds could be made available to purchase the patent and subsequently licensing it to interested developers. Some promotional work is also required to make information on existing patents more widely available.

5.13 Communication Activities

As indicated, an essential task is to promote developments within the industry. Funds could be made available for promotional activities such as films and seminars. A regular magazine or newsletter could be published, reporting on the allocation and progress of contracts. Press coverage in trade and general publications should be obtained.

5.14 Legislative Initiatives

A function of the steering group could be to promote legislative action conducive to creating a favourable environment for the industry to accept change and invest in technology. Special depreciation allowances are used in several countries to encourage capital investment. Tariffs and quotas, while having no direct effect on technology development, can help create an aura of confidence that investment will be worthwhile. Schemes to assist industry restructuring could also play a significant role.

5.15 Commercial Exploitation

Once basic principles have been satisfactorily demonstrated, new processes must be commercially exploited. An opportunity could arise to generate funds on a licensing basis which could be reinvested in further development activity.

5.16 Timing

If this programme is to impact on the decline of the apparel industry it is clear that it must receive high priority.

It is obviously impossible to put a time frame around the proposed programme as much will depend on budgets, priorities and support given to the project.

However, we believe that within the overall target of the industry achieving a substantive advantage from technology by 1990, the first steps must be concluded within 12 months at the most. This requires that this report is published and promoted no later than mid-1980, and that the symposia are held no later than the last quarter of 1980. The steering group and working party would need to be in place by mid-1980.

Even on this basis the first contracts for development would not be agreed until mid-1981.

This programme obviously represents only *one* approach to launching the ideas in this report. There may be others and there are no doubt a number of policy issues to be resolved before a final programme could be agreed. It has not been part of this study to review such policy issues, but nevertheless it is hoped that this proposed framework will assist the EEC in deciding on its next actions.

APPENDICES

THE ORGANISATIONS WHICH PARTICIPATED IN THE STUDY

APPENDIX I

During the course of this study over 150 organisations were contacted. Of this number, the following 66 were visited or provided detailed information:

FRANCE

- CEITH

GERMANY

- Adler
- Beisler
- Bogner
- Durkopp
- Forschunginstitut
- Mustang
- Pfaff

ITALY

- Necchi
- Rimoldi

JAPAN

- Aisin Seiki
- Brother
- Export Clothing Manufacturing Association
- Fujimi Hosei
- Industrial Sewing Machine Manufacturing Association
- Juki
- Kondo
- Mitsubishi
- Onward
- Pegasus
- Research Institute for Polymers & Textiles
- Wacoal

SWEDEN

- Chalmers University

UNITED KINGDOM

- Atomic Energy Research Establishment
- British Printing Industries Federation
- Cheshire Engineering & Design Consultants
- Clifford Williams
- The Clothing Institute
- Coats Patons
- Courtaulds
- Data Sciences International
- Department of Industry (GARB)
- Golden Charm
- HATRA
- Hughes Apparel Systems
- ICI
- Jaeger
- Leeds University
- Loughborough University
- Mardrive
- Marks & Spencer
- National Engineering Laboratory
- National Research Development Corporation
- PERA
- SATRA
- Shirley Institute
- Textile Research Council
- WIRA

UNITED STATES

- Automated Steam Products Corporation
- Camsco
- Cluett Peabody
- Compo Industries
- Design Technology Corporation
- Gerber
- Ideal Handling Systems
- Joseph Galkin Corporation
- Kellwood Corporation
- Levi Strauss
- Microdynamics
- Oxford Industries
- Reece Corporation
- Rheem Textile Systems
- Robert Zoot Inc.
- Singer
- Union Special

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POTENTIAL IMPACT OF TECHNOLOGY ON PROFIT MECHANICS

APPENDIX II

ELEMENT	VALUE IN BASE MODEL	MEDIUM TECHNOLOGY MODEL - 1			HIGH TECHNOLOGY MODEL - 2			SUPER TECHNOLOGY MODEL - 3		
		EFFECT ON ELEMENT	CALCULATION	VALUE	EFFECT ON ELEMENT	CALCULATION	VALUE	EFFECT ON ELEMENT	CALCULATION	VALUE
· SALES VOLUME	100.0	Increase volume by 10% Increase prices achieved by 2%	100 x 1.10 x 1.02	112.2	Increase volume by 20% Increase prices achieved by 5%	100 x 1.20 x 1.05	126.0	Increase volume by 20% Increase prices by 5%	100 x 1.20 x 1.05	126.0
, LABOUR	(15.0)	Reduce labour content 25% technology Reduce labour content 5% job enhancement Increase average earnings 20% Increase costs pro rata to volume, 10%	15 x .75 x .95 x 1.20 x 1.10	(14.1)	Reduce labour content 50% technology Reduce labour content 10% job enhancement Increase average earnings 40% Increase costs pro rata to volume, 20%	15x.50x.90 x1.40x1.20	(11.3)	Reduce labour content 75% technology Reduce labour content 10% job enhancement Increase average earnings 60% Increase costs pro-rata to volume 20%	15x.25x.90 x1.60x1.20	(6.5)
· FABRIC/TRIM	(55.0)	Improve utilisation by 4% Increase costs pro rata to volume 10%	55 x .96 x 1.10	(58.1)	Improve utilisation by 4% Increase costs pro rata to volume 20%	55x.96x1.20 x 1.20	(63.4)	Improve utilisation by 4% Increase pro rata to volume 20%	55x.96x1.20	(63.4)
· VARIABLE COST	(70.0)			(72.2)			(74.7)			(69.9)
· CONTRIBUTION	30.0			40.0			51.3			56.1
· CURRENT ASSETS	34.0	Reduce inventories by 10% technology Increase inventories pro rata to volume, 10%	34.0 x .90 x 1.10	33.7	Reduce inventories by 20% technology Increase inventories pro rata to volume, 20%	34x.80x1.20	32.6	Reduce inventory by 20% technology Increase inventory pro rata to volume 20%	34 x .80 x 1.2	32.6
· CURRENT LIABILITIES	(17.0)	Increase pro rata to volume, 10%	17.0 x 1.10	(18.7)	Increase pro rata volume 20%	17.0x1.20	(20.4)	Increase pro rata volume 20%	17.0 x 1.20	(20.4)
· WORKING CAPITAL	17.0			15.0			12.2			12.2
· HARDWARE ➡	9.0	Increase investment per operator by 3 Adjust for reduced labour, 25% Adjust for increased volume, 10%	9.0 x 3 x .75 x 1.10	22.3	Increase investment per operator by 7 Adjust for reduced labour, 50% Adjust for increased volume, 20%		37.8	Increase investment per operator by 20 Adjust for reduced labour, 75% Adjust for increased volume, 20%	9.0x20x.25 x1.20	54.0
· BUILDINGS, LAND	4.0	Reduced space, offset by better buildings		4.0	Reduced space, offset by better buildings		4.0	Reduced space offset by better buildings		4.0
· FIXED ASSETS	13.0			26.3			41.8			58.0
· CAPITAL EMPLOYED	30.0			41.3			54.0			70.2
INDIRECT LABOUR	(5.0)	Increase for maintenance by 20%	5.0 x 1.20	(6.0)	Increase for maintenance by 40%	5 x 1.40	(7.0)	Increase for maintenance by 80%	5.0 x 1.80	(9.0)
OVERHEAD	(15.0)	Add 15% of increase fixed assets Reduce by 20% of reduction in inventory	15.0 + .15 (26.3-13.0) -.20(17-15)	(16.6)	Add 15% of increase in fixed assets Reduce by 20% of reduction in inventory	15+.15(41.8 -13.0)-.20 (17.0-12.2)	(18.4)	Add 15% of increase fixed assets Reduce by 20% of reduction in inventory	15.0+.15 (58.0-13.0) -.2(17-12.2)	(20.8)
· FIXED COSTS	(20.0)			(22.6)			(25.4)			(29.8)
· PROFIT	10.0			17.4			25.9			26.3
· R.O.C.E ➡	33.3%			42.1%			48.0%			37.5
· R.O.S. ➡	10.0%			15.5%			20.5%			20.9
CAPITAL TURNS	33			2.72			2.33			1.79