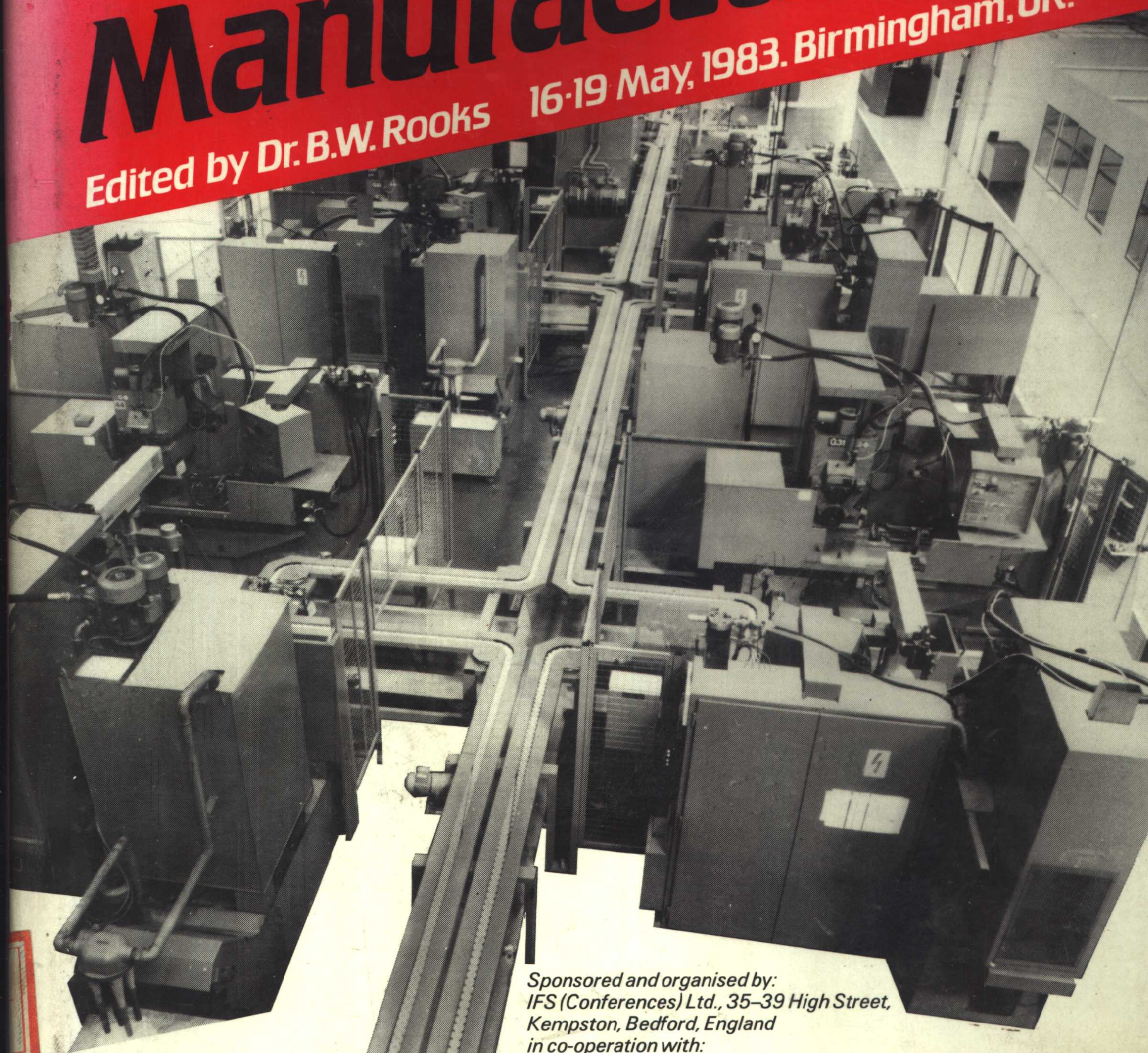
Proceedings of the
2nd European Conference on

Automated Manufacturing

16-19 May, 1983. Birmingham, UK.

Edited by Dr. B.W. Rooks



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A NEW APPROACH TO ASSEMBLY MACHINE JUSTIFICATION

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During this conference you will hear much about the technology of mechanized assembly; scientific achievements, ingenious developments and new applications of existing technology.

For some of you these presentations will open up new possibilities, suggest other approaches or confirm earlier conclusions. No matter how boring or interesting each of the following presentations are however, they are of importance to our managerial counterparts only if their practical application is financially rewarding. With the exception of present day interest in robotics applications, mechanized assembly equipment has not been seen as a tremendously rewarding expenditure by most corporate management. While hard figures are impossible to gather, there is sound reason to believe that world wide shipments of all assembly machinery and all robotic equipment last year probably totalled far less than 5% of the sales of the IBM Corporation.

It is accepted by most authorities that over half of all direct manufacturing labor expenditures are for purposes of assembly. Must we assume that those of us involved in the development of mechanized assembly equipment are poor salesmen, and that this is the basic reason for the low utilization of the developments seen at this exposition? To a significant extent this is probably true.

If we had better salesmen, therefore, could we anticipate that justification for mechanized assembly would become an easier task? To answer that question, we must look to a more basic question: Is there any essential difference between the means by which we must justify the installation of automatic assembly and the procedures for justifying other industrial and commercial equipment?

We believe there are essential differences which must be recognized if efforts to justify the purchase of assembly equipment are to become more successful. Once one gets beyond bricks and mortar, there are four possible areas of capital expenditure; parts fabrication equipment; computers for telecommunication, data processing and product design; assembly equipment and lastly packaging and storage equipment. Some may want to add a fifth area, that of test and measurement equipment.

Each of these areas will face a different managerial viewpoint when it comes to approval for large scale capital expenditure.

Management readily accepts the necessity of parts fabricating equipment; if one is a manufacturer, rather than a mere distributor. The traditional make - buy decision is fundamentally a decision to buy or rent such equipment. A mass producer cannot, however, consider any significant amount of hand fabrication. The need for the equipment is established; only the means of payment is in question.

The role of computers in manufacturing has become so widely accepted that anyone who questions whether or not they contribute to productivity is suspect. Since they are promoted as a management tool, with the promise of greater central control of operations, their purchase or rental is quite attractive to non technical management. Unlike other equipment in which initial purchase costs are paramount, entry costs for computers are low. Referring again to IBM it is interesting to note that hardware sales are but 30% of their sales, while operational support contributes 70% of their sales. Initial capital expenditures are but the tip of the iceberg, and any small controversy over justification usually involves a choice of vendors or payment terms.

Packaging and storage equipment is directly related to the marketing aspects of any operation. Poor return on investment for packaging and storage equipment is often overridden by marketing considerations, particularly by concern over the attitudes of wholesalers and retailers.

Until recently the cost of test and measurement equipment has been modest in comparison with other capital expenditures and often falls into a miscellaneous and sundry category, or is even paid for out of operating rather than capital budgets. More sophisticated equipment is usually integrated into fabrication or assembly operations.

We can now turn to assembly equipment. It can never be forgotten that assembly equipment remains the only area where capital expenditure is not mandated. There is no compulsion because of physical necessity as in the case of parts fabrication; because of management orientation such as in the case of computers, or marketing forces as in the case of packaging equipment. Any product with the possible exception of micro-electronics or other sub-miniature devices can be assembled without capital expenditure. There is no inherent physical nor psychological compulsion for management to approve significant expenditures for parts assembly.

Most early successful applications of mechanized assembly were for relatively simple applications the assembly of parts with stable design life; parts made in very high volumes. Justification was based on <u>direct labor reduction,</u> and product design often facilitated assembly. Unfortunately, this is <u>not typical</u> of most assembly operations. The more common potential applications are for complex products, often one of a family of products, with model changes frequent and production levels quite modest. These circumstances often mean that the <u>sole</u> use of direct labor reduction for justification may not be attractive to management. The capital cost and risk may be excessive for an optional expenditure. The simplicity of using direct labor reduction with its ease of designated specific areas of savings may simply not be sufficiently rewarding to justify the risk of capital investment.

Persuasion for management approval of the investment may be found, however, in a wide variety of indirect savings, inventory considerations, and improvements in product quality which are usually much more compelling than direct labor savings.

The difficulty of assigning quantitative values to these indirect advantages leads us to the essential problem with present day assembly machine justification procedures. We use the same approach for assembly machine justification as for parts fabricating equipment while astute management does not view them in the same light. Parts fabricating equipment is seen as necessary. Assembly equipment investment is seen as optional. There is no managerial argument about the necessity of fabricating equipment, only how its use is to be funded; outright purchase, lease or rental buried in the purchase price of parts supplied by outside vendors. There is no equivalent feeling of necessity to purchase assembly equipmemt. Management sees no geographic limits to their pursuit of cheap labor and the ease with which it can be abandoned in difficult times.

At the crux of the matter is the viewpoint prevalent in most management and among most manufacturing engineers that assembly equipment is by nature dedicated equipment. Engineers offer assembly equipment as a specific solution to a given problem and are bewildered when it is not enthusiastically accepted because they ignore that management today does not want specific dedicated solutions but universal flexible solutions. Management has little faith that the problem at hand will not be a different one tomorrow.

Until assembly equipment is offered to management as a unique managerial tool for ultimate management control and management begins to recognize that mechanized assembly offers a multitude of benefits other than direct labor reduction, we do not feel that the industries represented here will ever come to full maturity.

We should offer assembly equipment to management in the same light that computers have been sold, as a means of centralizing control. Assembly systems should be offered primarily as a management tool for controlling production, inventory and product quality while at the same time insuring direct labor costs in the assembly of the product are minimal and stabilized. At the same time any machine flexibility inherent in modular construction or electronically programmable controls should be emphasized and separated from the dedicated tooling costs unique to any project in the same way that dedicated mold costs are separated from the universal capabilities of the moulding machines.

Is this suggested approach an ethical one? Do assembly machines have in fact the means of offering management unique tools in controlling production scheduling, inventory levels and quality assurance? The answer is a most emphatic - yes. Anyone who has introduced a major assembly system into a facility formerly utilizing hand assembly will find all the weaknesses and inadequency of their present controls exposed in the ruthless light of costly and continuous systems downtime. It soon becomes apparent how much so called previous assembly costs are really rework, reinspection and repackaging costs all due to weaknesses in product design, parts fabrication, procurement and quality control programs.

The introduction of mechanized assembly equipment will put a sharp focus on the weaknesses in any facility. It will force a reintegration of each part of the whole manufacturing team. No longer can purchasing, product design or marketing take action independently without some consultation with the operating plant.

Both computers and to a lesser extent, robots have been sold to management as a means by which the management can secure a greater control of the manufacturing process, the means by which management decisions can be adjusted to the day-to-day problems.

Large scale assembly systems are in truth small factories that in themselves put to the test the capabilities of the purchasing, fabricating, production control, quality control and market projection management in that plant. It is no longer a question of "gaming" or computer modeling, but a synthesizing of all the various management and engineering skills into one sharply defined entity.

Direct labor reduction is not too attractive a topic to plant managers trying to find work for his plant. Reduction in floor space is not appealing when one's plant is half empty. But the management desire for better control of quality and inventory levels, areas where automatic assembly excels.

We must, if we are to see a greater utilization of mechanized assembly promote it and sell it to top management as the tool which will reveal the management weaknesses and integrate all the elements of overhead into a cohesive and efficient team effort.

Mechanized assembly must be promoted as a new system or approach to manufacturing. Until it is promoted, "justified" if you will, as a total systems approach to manufacturing it will limp along as a crippled and shackled giant.

Worldwide competition is a fact of life. Market share is more significant to profitability than return on investment. ROI cannot be rewarding without market share and market share will fall to the most efficient producer. Automatic assembly must be promoted as a significant management tool to develop the means, technical and managerial to achieve significant market share.

Product Design for
Automatic Assembly

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ABSTRACT:

The key to success in automatic assembly centers on the design of the product being assembled. So when planning for Automatic Assembly one has to take a careful look of **Product Design for Automatic Assembly.**

In this paper we will present a strategy and a number of guide rules with the aim of optimizing the design of the product as well as the automatic assembly system through parallel development of product and production technology. This strategy maximize the chances of success in an automated product assembly program.

The strategy will be exemplified by products and Assembly Systems designed by the authors.

0. INTRODUCTION

Product design is the first of many steps in the manufacturing process. All of the oppertunities for and limitations on effeciency in manufacturing and possibilities for rationalisation of assembly are established at the product design level.

The technical development of assembly equipment is relatively slow, and the efforts to create universal machines are not yet convincing. Thus the task of designing a new product for automated assembly is often combined with the task of designing new and specialised assembly equipment.

These tasks have to be performed simultaneously, with considerable demands on the designer to foresee the consequences of his decisions:

* he must design the product so as to attain high quality
* he must know which design parameters determine the quality of the assembly (in the broadest sense)
* he must, if he is to be able to deal with this very complex task, be acquainted with the general principles of designing for ease of assembly.

1. RATIONALISATION OF ASSEMBLY

The task of rationalisation of assembly must be looked upon as total, in other words as an optimization of a whole: product and production system. Many factors plays a part in this complex optimization, but there are four main goals which must be emphasized:

* Improvement of the effectiveness of assembly, i.e. increased productivity in relation to manpower and investment resources.
* Improvement of product quality, i.e. improved product value from the buyer's standpoint in relation to the product's price.
* Improvement of the assembly system's profitability, i.e. increased utilization of the equipment.
* Improvement of working environment within the assembly system.

Production system's are normaly conservative, i.e. changes in product or system create both forseeable and unforseeable problems - and therefore should be avoided. A re-organisation of assembly should not be regarded as an end in itself, but should be used as a link in a total rationalisation using the 4 goals mentioned above.

2. DESIGN RATIONALISATION

The designer determines the structure of the product, i.e. its component construction and the way in which these components are joined in addition to determining the detailed design of each of the components.

This will normally result in a fairly precise production process and a correspondingly precise assembly process. If the designer proposes another product structure the number and type of processes and assemblies will be altered. If he proposes a different component design still other process and assembly methods will have to be applied.

The most radical assembly improvements lie in selecting and designing product alternatives in which certain assemblies can be disposed of, or greatly simplified.

In other words:

> Assembly can first and foremost be rationalised by changing the products so that assembly becomes superfluous or at the least simplified.

3. PRODUCTION ORIENTED RATIONALISATION

If we assume the starting point is in the production system, particularly in the assembly system then opportunities for rationalisation lie in exploiting an optimal assembly system.

In his design of the product, the designer determines which type of assembly system is feasable, in addition to establishing how the system will function through his specification of the component's quality.

A product cannot be regarded in isolation when we are discussing assembly problems. A product is normally divided into a series of product variants, certain sub-systems in the product can appear in other products and certain components can be applied in various sub-systems or can be produced because of group-technological similarities with other components.

Thus design for automatic assembly can be said to be the process of achieving the insertion of a product into a well-structured product, building element and component program

4. WHEN SHOULD DESIGN FOR ASSEMBLY BE APPLIED?

The answer is not "always". The designer will normally concentrate first and foremost on getting the product to function within the economic limitations laid down. Time is at a premium; as a result the most important activity in the closing phase of design is to get the product detailed so it can be in production as soon as possible, in other words getting the drawings finished. Assembly deliberation can easily become a minor part of a large hectic process. The result being a non-optimal product from the assembly point of view.

Various modes of operation:

Products with optimal assembly are developed today by means of a design process consisting of many steps. The finished marketed product is given a quality "lift" by means of an extra effort focusing on assembly.

An alternative - better but seldom used - mode of operation is to attach greater significanse to assembly deliberations in the early phases of design, in order that the product's structure and design is geared to an optimal assembly process. Such a process will normally require parallel development of product and production system, with special emphasis on the assembly system.

Three areas of application

A constructive application with a wiew to rationalisation of assembly can be applied to three areas or on three levels:

- product assortment
- the product (structure, building blocks)
- the components.

Such application, whether it be purely revision of a product or a new design, can occur in the following ways:

- creation of design degrees of freedom, so that alternatives containing good assembly oriented characteristics can be created
- application of the principles of design for assembly, primarily elimination and secondly principles of improvement.

5. DESIGN FOR ASSEMBLY -

Product assortment

The overall goals for optimising the assembly may be expressed in the following terms:

- constant, high product quality
- high productivity
- high utilization
- high quality working enviroment.

By analysing these goals, one may determine the factors contributing to their attainment. High utilization for instance is influenced by the size of the production series assembled by the same equipment, which means that you have to follow the design princple: "Avoid variations" or "Make sure that variants can be assembled in the same way".

The goal "high productivity" is influenced by the number and length of stoppages in the use of the equipment. Thus one must either design a system to accept many variations in components or must ensure components with few variations.

So one have to decide upon an assembly and design policy and take decisions about the product assortment in order to obtain the maximum effect of rationalisation. The principles to be considered are listed in Table 1.

It is evident that these principles do not unanimously point to a solution. In a certain situation a principle may often lead to good results, in another it may be wrong. One have to choose which principle to follow.

DESIGN FOR ASSEMBLY - product assortment

Principles:

- Mechanical assembly requires quality control
- Automatic assembly requires high quality
- Assembly is (also) a management problem
- Design for mechanical assembly
- Design for automated assembly
- Design for automated, flexible assembly
- Manual assembly has many virtues
- Eliminate assembly
- Design for standard equipment
- Design for special equipment
- Avoid variations in the product
- Make sure that variants can be assembled in the same way
- Automatation may result in improvements in the working enviroment
- Avoid "dangerous" assembly methods.

Table 1.

The product (structure, building blocks)

The fundamental structure of the product in principle determines its components, but normally a much more detailed structure (a greater number of machine parts) is chosen in order to satisfy different demands. The designer works on two levels, a fundamental structure level, where techniques and solutions are logically connected, - and a quantitative structure level, where he takes decisions on distances, tolerances, positioning in space and division into machine parts. In this way the function of each components is defined and the detailed design may be carried out.

This structural design actively has many possibilities for alternatives and important principles of design for assembly may be applied.

Two main design principles should be noted, "simplicity" and "clarity" as means for obtaining optimum solutions, few parts, few assemblies and simple assemblies.

By analysing different products, one recognises different structural principles, and in particular solutions created by "integration" or "differentiation", this latter implying the use of more components. Both principles may be applied in design for assembly and may lead to good results. A survey of structural principles is shown in fig. 1. As an example fig. 2 shows the effect of intergration for the production of zip fastners.

The components

The structure of the product determines the basic design of the components and the principles of the assembly. This means that the choice of product structure fixes most of the assembly problems. But one still has to think carefully about the detailed design of the components, in order to faciliate the operations of the assembly system.

Detailed design of a component means specifying the following basic properties: Shape, material, dimension, surface quality and tolerances.

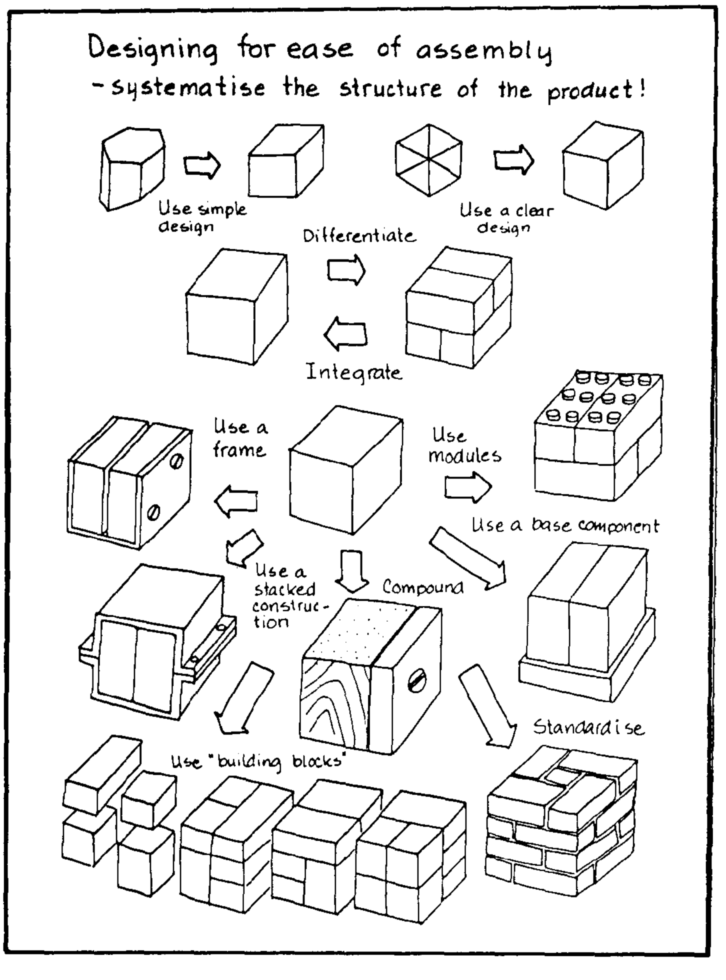


Fig. 1. Survey of structural principles for "design for assembly"

The assembly quality will depend on one or more of these basic properties, the most important is the shape, because certain surfaces on the component are utilised in the assembly process itself.

These surfaces, which limit a component, have a varity of tasks. The function of the component is realised by the functional surfaces. Among these, some surfaces, the connecting surfaces, relate to other components by touching them. The non-functional surface may be called free surfaces.

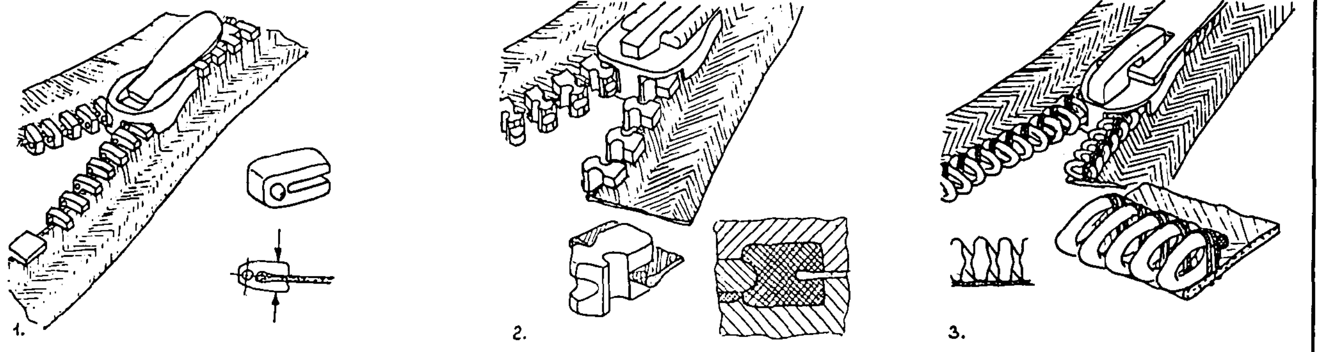
Assembly surfaces are surfaces used in the assembly system for orientation, transport, positioning and guiding. Designing the component for assembly implies utilising the functional surfaces and manipulating or changing the free surfaces, to create good conditions for the assembly operations, see fig. 3 and 4.

The dialogue between the designer and the production engineer is focused on the main conditions and the design possibilities, and is simplified if one uses sketches showing the functional surfaces and the free surfaces, for example in colors. This technique is important, especially with more complex components.

The main operations which you have to take into account when designing the components are the following:

- orientation, transport, connection and joining together.

Table 2. gives a survey of the main principles for designing good components.



1. 2. 3.

Fig. 2. Three different production methods for zip fasteners. (1) Metal zip fastener elements produced by pressure casting and mounted one by on a band. (2) Band layed in an injection moulding machine and moulding and moulding each element around the band. (3) Zip is formed from plastic cord, which is bent and sewn into shape as the teeth of the fastener.

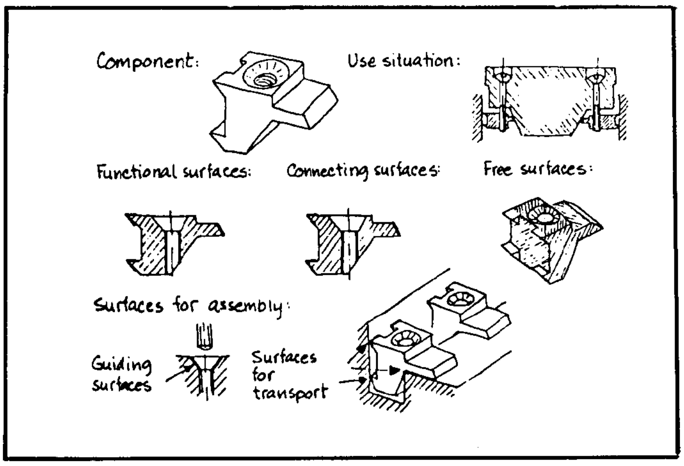


Fig. 3. Clamping piece from a switch.

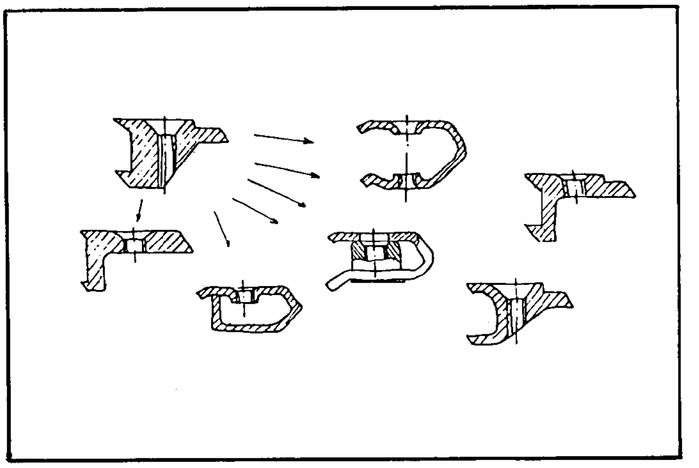


Fig. 4. Alternative designs for the clamping piece shows in fig. 3. The functional surfaces are unaltered, but new component shapes are indicated.

DESIGN FOR ASSEMBLY - the components

Principles:

Avoid assembly operations:
- integrate component
- utilise integrating production methods

Avoid orientation operations:
- use magazines
- use components connected in bands (tapes)
- integrate the production of components into the assembly.

Faciliate the orientation operations:
- avoid clamping or hooking
- put special faces on the component for orientation
- avoid components of low quality
- make the components symmetrical
- or make it clearly asymmetical

Faciliate transport:
- design the component for easy transport
- design a base component

Faciliate a simple pattern of movements:
- make all joins simple
- put special faces on the component for guiding purposes

Chose the right method for joining components together:
- avoid joins
- avoid separate connecting elements
- use integrating production methods.

Table 2. Survey of main principles for the designing of components for automatic assembly.