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UNITED NATIONS INDUSTRIAL DEVELOPMENT ORGANIZATION

FURNITURE AND JOINERY INDUSTRIES FOR DEVELOPING COUNTRIES

PART TWO
PROCESSING TECHNOLOGY

PREFACE

Two seminars on furniture and joinery industries have been organized by the United Nations Industrial Development Organization (UNIDO) in co-operation with the Government of Finland. The first was held in Lahti and Tuusula from 16 August to 11 September 1971, the second in Lahti from 6 to 26 August 1972. Their success was in no small measure due to the hospitality and understanding of the Finnish authorities and of the Finnish industry by granting participants these invaluable opportunities to avail themselves of their country's comprehensive expertise in the field of furniture design, production and marketing.

The aim of the seminars was to familiarize factory managers in developing countries with modern plant, equipment and production techniques to enable them to up-grade their own operations and to establish priorities for such improvement.

These seminars were attended by a total of 44 participants from 26 developing countries who were, for the most part, technical managers and production supervisors of woodworking plants.

This series is based on lectures delivered to either or both of the seminars. Many of them were complemented by illustrative material that did not lend itself to reproduction in the present form. The seminars consisted of these lectures, plus demonstrations, discussions and visits to medium-sized and small-scale furniture and joinery plants, plywood and lumber manufacturers and producers of upholstery foams, paints and woodworking machinery as well as vocational and technical training institutions.

Although these studies constitute a coherent whole, for convenience they have been grouped into three parts, bound separately, dealing respectively with inputs of materials, processing technologies and management matters.

The present publication is the second of these and deals with processing technology. It includes articles on such matters as furniture design, product development, plant layout, finishing operations and plant automation.

The previous part is the first of the series and is made up of articles on the materials from which furniture and joinery products are constructed, among them solid wood, composite boards of various kinds, upholstery materials, bonding agents and the hardware used in assembly and trimming.

The third and last part of the series deals with management problems and responsibilities in the areas of quality control, production management, marketing and export trade, and occupational hazards and safety at work.

It is hoped that publication of the material issued in the course of the seminars will contribute towards increasing the awareness of the results that may be achieved when furniture and joinery enterprises are set up in developing countries following established, rational industrial procedures. It is also hoped that this material will be of use to teachers in training institutes in developing countries.

Readers should note that, in some instances, the examples cited and the descriptions given represent Finnish conditions that may not be wholly applicable to particular developing countries.

The views expressed are those of the individual authors and do not necessarily reflect the views of UNIDO.

CONTENTS

EXPLANATORY NOTES

cP - centipoise

dB - decibel

f.o.b. - free on board

c.i.f. - cost, insurance, freight

f.a.s. - free alongside ship

11. MEETING THE DESIGN NEEDS OF THE FURNITURE INDUSTRY IN DEVELOPING COUNTRIES*

The introduction of industry into a country without industrial traditions always brings new demands. The more developed one branch of industry is and the more the product is sold to retail consumers, the greater the need for good design. The more necessary export markets are, the greater role good design plays.

Increasing consumer demand causes new demands on industry. In many developing countries, although there is great interest in good design among producers, the services of capable designers are difficult to obtain; these people are not only scarce, but paying them adequately is not economic because of the risk that competitors will pirate their models.

Mass production would be a way in which to cover design expenses, but unfortunately, in many developing countries, local consumers are very individualistic and do not like to buy mass-produced furniture. Another obstacle is that the existing furniture factories often lack storage space.

Mass-produced furniture is always cheaper than custom-made pieces, but in most developing countries furniture is still produced on a one-at-a-time basis. However, local people would probably accept mass produced furniture just as they accept automobiles, radios and other everyday items that they know to be mass produced.

In mass-produced as well as individually produced furniture, design and designers have very important roles to play in the development of the furniture industry of any developing country. There are several ways to cover design needs. The following survey shows different possibilities and describes each, illustrating the positive and negative aspects of each.

Education of local designers

Almost all industrialized countries have their own national systems of design education. In several countries, tradition reaches into the last century.

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*Paper presented to the seminar by [illegible] and [illegible], Lahti, Finland. (Originally issued as document ID/WG.[illegible]/31/Rev.1.)

Usually the institutes serve several branches of industry, producing industrial designers of all kinds. In many countries industry itself plays a remarkable part in this education and often works under the Ministry of Industry (or Commerce), rather than under the Ministry of Education. Artistic aptitudes and the ability to think creatively are the main criteria when selecting applicants, who must have at least completed secondary school. A two-week special selection course is usually used to sift the applicants.

Positive aspects

If a developing country sets up its own system of design education, it will guarantee the future needs of its industry. The tightening competition in the world markets is demanding better design standards, and if products can have the exotic touch that only designers who know tradition can give, there might well be better possibilities of penetrating foreign markets. Consumers are becoming more and more critical of design when selecting goods.

A design institute set up in one developing country should serve other countries in the region or subregion, if possible.

Negative aspects

Although good designers are now scarce and the need for them will increase over the near term, a new institute could produce too many designers after a while. If industry is unable to provide the new designers enough work at high enough salaries, it is possible that talented designers would migrate to other countries where their designs might be better appreciated. In such a case, the investment in their education would be largely wasted. This phenomenon is not new in some European countries; indeed, this is the problem of the "brain drain".

A major difficulty in setting up such a system would be that of finding really good, capable and up-to-date teachers. Unfamiliar local conditions, defective knowledge of the country and perhaps political factors could be obstacles to procuring such people, even at high salaries.

The establishment and operating costs of such a design institute would be expensive, and it would require the passage of twelve years before its benefits become apparent.

Overseas education

All considered, the sending of talented young people overseas to get their education is highly to be recommended. All industrialized countries, especially the United States and most industrialized European countries, have high levels of design education. Instruction is usually given in English as well as in the local language. Candidates for such training could be selected by competitive examination and a two-week selection course, as suggested above for local design institutes.

Positive aspects

As with local training, overseas training will fill future designer needs if enough students are able to participate. There would be no danger of over-production of designers, since it would be easy to limit the number of designers educated to that needed by local industry.

The professional level of designers trained overseas would be noticeably higher than that of those educated locally in newly established design institutes because of the better teaching in established schools in developed countries. It is very important that designers closely follow current developments in industry and make contacts in the international markets and see at first hand the competition in them. During their college vacations, student designers could gain experience in modern industry. This possibility is very important and should be encouraged.

Upon completion of their overseas training, the new designers will be able to transmit their experiences and knowledge to local designers, with a positive effect on local industry.

Negative aspects

If design education is to be financed by the Government, as it usually is, the designer normally undertakes to stay for a certain time in the service of the state. In the writer's opinion, the state can very seldom offer work commensurate with the education of these people, and there is thus a danger that they may become mere officials and not creative designers. It is very important that a designer get active work immediately after finishing his schooling in the service of industry; his best encouragement is to have him see the results of his work and its success on the market.

The failure of industry to employ these capable designers may cause them to remain in the country where they were trained, especially if they see better earning possibilities there, unless the state demands their return. If they stay abroad, their knowledge and ability is lost to their own countries.

Education abroad takes just as long as it takes when given locally. In either case, the practical results would take several years to be seen, but the quality of the foreign-trained designers would be better than that of the locally trained ones, as noted above. It should be remembered that overseas education is very expensive, since it requires long residence abroad, the average time being three to four years.

Importing designers

The migration of designers from one country to another has been very common for a long time. One reason for this is the internationalisation of products. National characteristics of goods tend to disappear because of the large-scale production that profitability requires.

When several factories are willing to co-operate with foreign designers the results are mostly positive. For example, co-operation between a designer from Thailand and a European furniture company has been very successful and is of considerable international interest in the furniture field.

Positive aspects

The importation of designers makes possible the creation of new saleable collections in a moderately short time. To make best use of the new designs they create it is necessary to modernize factory and production methods; in other words, increase "know-how". This system can be very informative to local industry as regards the quality demands of modern markets.

Negative aspects

Unfortunately, however, any designer from an industrialised country will have difficulty in understanding local working methods. His attempts to become accustomed to local ways of doing things may take a long time, and his slow progress may impair his interest in local design development. Also, if local salaries are appreciably lower than they are in his own country, this may have an effect on how quickly he returns home.

If the imported designer's income is paid on royalty basis, there must be really large mass production if the designer is to earn as much as he could in his own country, since local factory prices are much lower than in industrialised countries. If it is a question of only few years' contract work, his remuneration might hardly cover his expenses of travel, returning and making a new start. Also, by losing contact with the main trends of development in his field for several years, the quality of the work of the imported designer may well decline. Being in a different climate and the break with his normal social life can accelerate such a decline in working capacity. In sum, it is difficult to bring in really competent designers from abroad, and even when this is done their long-term usefulness tends to be limited.

Importation of plans and designs

It is quite usual to use imported plans and designs. They can be obtained from designers with whom an earlier relationship has been established or by approaching internationally known designers.

Positive aspects

When plans and designs are imported, a salable collection can be made in a reasonably short time. However, information about production possibilities must be provided and the forms of payment agreed upon. The technical level of the local industry will progress with new demands that are made on it. It is fair to say that the industry improves as the distance between international and local designs narrows.

Negative aspects

The value of imported plans and designs may decline if long distances and lack of personal contacts may cause the designer to lose interest, especially if his remuneration has not been strictly defined. Such a lack of co-operation between the parties may cause poor results and lead to the end of the business relationship.

Production under licence

Production under licence has been very common and will continue to grow in importance in international industry. This method is an economical means of becoming able to produce well-known products and to obtain industrial know-how.

Positive aspects

Production under licence makes it possible to produce good and well-known models. Since the products selected are already successful in other markets, there is less uncertainty about their acceptability in the domestic market. It helps the effort to modernize and streamline production and may permit the installation of new machines that could greatly enlarge production capacity. It provides new possibilities for export to the countries where there is not already a licensee. In sum, production under licence is a very economical way to get really good designs if there is good faith and fair dealing on both sides.

Negative aspects

On the other hand, every enterprise should have its own target for design development. Continuously successful production under licence, with long runs, will probably kill the future design plans of the licensee. Its independence and originality will be in danger of disappearing. Furthermore, if the licensee does not have its own design policy and the licensor stops co-operating, there will be difficulties replacing the discontinued products.

A local enterprise has an obligation to its community not to make too many of its products under foreign licence. It must, in the long run, support its own designers, and with production entirely under licence it will never be able to do so.

Unless sufficiently large production volumes are guaranteed, co-operation between licensor and licensee will be difficult to achieve. Also, the licensor cannot control the quality of the goods produced locally and may become dissatisfied.

Manufacture from the designs of foreign customers

In Finland, several large furniture sales chains and interior service firms have their own designers. The chains purchase their collections from the factories that supply their products at the best conditions. New industries in developing countries could compete successfully in this way, although there would be problems of transportation costs even if production costs are comparable and quality acceptable. Also, design offices may have difficulty when trying to serve their customers by using specially designed models for quick delivery. Large factories have planned their production for years ahead, and small ones, if delivery is urgent, charge prices that are unprofitably high. Local factories could help in this situation if the quality of their products is acceptable.

Positive aspects

Manufacture from the designs of foreign customers involves the local furniture industry in the production of goods that meet international quality standards. Furthermore, this obviates the need to make marketing investments in other countries. It provides a market for local industry and develops better production methods. It also may lead to the purchase of new machines to replace the old ones.

Negative aspects

If the deliveries are to be completed by an agreed-upon time, the factory's own programme may be disturbed. Also, local production capabilities are not always known by customers, and it may happen that only a part of an order can be made in a given local plant. When this occurs, customers usually cancel the entire order and place it elsewhere.

International furniture design competitions

A way that is often used to acquire a new collection of designs, especially when a factory finds that it needs some new ideas, is to sponsor an international design competition. In this case it is important that the jury be internationally respected. The contest could consist of several parts; home furniture, hotel furniture etc. The programme of competition should give very strict descriptions of the production capabilities and of the materials which may be used.

Positive aspects

The outcome of the competition should be known and published in a comparatively short time. If it has stimulated real interest among able designers, the collection should be new and suitable for international markets. The new designs may suggest ways of modernising production methods and bring up-to-date designs closer to the local producers.

Negative aspects

A disadvantage of the international design competition is its comparatively high cost, not only at the time but because its influence on production is usually short-lived. If the prizes offered are lower than the usual international level, there will be little interest in the contest, with the result that old drawings that have proved to be useless in other factories will be submitted.

If production capabilities are not clearly specified, the results could be uncertain, since the competing designers would have no knowledge of local industry.

Conclusions

To review all of the foregoing, the writer presents the following as his personal conclusions. The proposal for the training abroad of local designers would be best when thinking far into the future, if the industry seriously wants really capable designers. The rapid changes in modern methods and markets make it necessary for local industry to follow development. It is not enough that the factory give work to its designers, it must also keep them on the same level as those of other countries. This should be done by sending them regularly to follow up international events of its own branch, at fairs, designer meetings etc. It is also very important to obtain international contacts continuously if production is to compete successfully in already difficult markets. Discussions and contacts with buyers are always useful for designers. Over the shorter term, production under licence should be the best way to get fast and useful solutions. Because local industry is, for the present, incapable of offering products of its own design, this way seems to give a very natural solution. Furthermore, production under licence is an equitable arrangement, and its costs are very reasonable.

12. SERVICE CONDITIONS OF FURNITURE DESIGNERS IN SCANDINAVIAN COUNTRIES*

The working circumstances of furniture designers in Scandinavia, primarily in Finland, may be said to fall into the three following categories: free-lancers who are remunerated entirely on a royalty basis; designers who receive both a fixed salary and royalties on products made from their designs; and designers who work on a salary (perhaps with such perquisites as housing privileges or the use of an automobile). There are, of course, designers who do not fit exactly into any of these three categories; for example, an interior decorator may occasionally design furniture, but this cannot be considered his profession. Nevertheless, this threefold division makes a good basis for discussion.

Before proceeding, a word of caution is in order. The mobility of furniture designers, in Finland, at least, is very high, so their distribution over these three categories changes constantly. There is also the question of who can be considered a full-time, professional designer. It is the opinion of the author that there are only about forty active, full-time furniture designers in Finland, although this number is only about 23 per cent of the membership of SIO, the Society of Interior Designers.

Let us examine these three general categories of designers and compare their advantages and disadvantages.

Salaries and fees

Free-lance designers

Free-lance designers are remunerated in the following ways: 1, straight royalties, perhaps with an initial pre-payment (advance); 2, a relatively large fee plus a proportionately small royalty; or 3, conversely, a relatively small fee and a relatively large royalty; 4, a lump-sum fee for each design accepted; and 5, a salary for a fixed term (such as two years) with the obligation to complete a specified number of designs (perhaps three chairs).

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*Paper presented to the seminar by [illegible], Lahti, Finland. (Originally issued as document ID/WG.103/47.)

From the point of view of the designer, arrangement 1 has the important advantage of giving him independence; if he receives an advance against his royalties, he may be able to devote considerable time to a given design. Also, if he is working with, let us say, three different firms, the end of a working relation with one of them will not be catastrophic; he will have lost only about one third of his income and will be free to establish new working relations. There are, however, the disadvantages that he must pay all of the development costs and bear all of the risks before his design is sold - if it ever is! Also, there is a feeling among designers that, under this system, the share of the designer tends to be too small.

In system 2, in which there is a relatively large fee and a relatively small royalty, the designer still enjoys a great measure of independence and the employing firm pays part of the development costs. On the other hand, since the total share of the designer is still felt to be too small, he is consequently felt to bear too large a share of the risk.

In system 3, where the royalty is larger and the fee smaller, the designer still maintains a great part of his independence. When properly calculated, the relation can be advantageous to both parties. The difficulty is, of course, that of setting the shares to the satisfaction of both parties; the negotiations may degenerate into rather ungraceful haggling.

In system 4, according to which the designer receives a lump-sum payment for each design that is accepted, the advantage to the designer is that he gets his money at once. On the other hand, he will have borne all of the development costs. Furthermore, the fee will have to be negotiated, which can result in the same kind of unseemly haggling as in system 3 above. There is the additional disadvantage, to both parties, that the work is discontinuous.

Finally, in system 5, if the free-lance designer signs a fixed-term contract to produce an agreed-upon amount of work within a given time and for a set remuneration, he has given up his independence for the duration of the contract. This disadvantage may be offset, however, by the possibility of conducting research free from immediate financial pressure.

Salary-and-royalty designers

To the author's best knowledge, no designers in Finland work in a salary-and-royalty arrangement with furniture producers. Nevertheless, since arrangements of this kind can be quite advantageous to both designers and producers, they will probably gain a foothold in the future; indeed, there already have been some experiments in this direction. These arrangements are generally of two kinds: (1) the payment of a fixed salary, supplemented by royalties on furniture designed during the life of the contract, and (2) a fixed salary plus a normal royalty. In this case, the salary is considered as an advance (pre-payment) deductible from royalties, but this is not strictly correct, since a designer in this situation normally has other duties, such as participation in exhibitions.

In the first of these systems, that is, fixed salary plus royalties on furniture designed during the life of the contract, the greatest advantage to the designer is continuity of income. Even if he wishes to change employers or to become a free-lance designer, he will continue to draw income from his earlier work. He can also give precedence to his own ideas over those of his employer, but this could be considered a disadvantage by the employer.

The situation in the second system, namely the payment of a fixed salary plus a normal royalty, is much the same as in the first system. The principal drawback, from the designer's point of view, is that the salary may be too small.

<u>Straight-salary designers</u>

When a designer receives a fixed salary and perhaps some perquisites such as housing privileges or the use of a company automobile but not royalties or other supplemental remuneration, it is probable that this salary will be rather substantial. As long as the relation continues, the situation of the designer is satisfactory. When it is terminated, however, he retains no rights in, or income from, his earlier work.

Working place and time

<u>Free-lance designers</u>

The free-lance designer normally works in his own studio and at his own pace. However, his income will tend to fluctuate with changes in his productivity, the state of the market, changes in fashion and so on. Also, he may have difficulty in maintaining contact with his sources of commissions, and he runs the risk of losing familiarity with the production methods of his clients. Another consideration is that difficulties can arise when the working rhythms of the designer and the producer differ widely.

Salary-and-royalty and straight-salary designers

Designers who are salaried, with or without royalties, normally work at the plant and put in the normal working hours. They have the advantages of being in close touch with all of the other staff and can get support from them for their work. They are also aware of the production methods and the mechanical and other resources of the producer. On the other hand, some designers find the factory milieu depressing. Also, they sometimes feel that they lose their contact with the outer world and become unable to see their work in relation to human life.

Fixed working times are particularly distasteful to creative people such as designers. With a time-control system during regular working hours, personal development and the collection of external stimuli must be done on the designer's own time. There are, of course, visits to furniture fairs, but these occasions are usually brief and busy ones.

Working relations and commissioning

Free-lance designers

The free-lance designer normally receives his commissions direct from the management of a producer. He maintains his independence and need not limit himself to certain types of furniture. As this relationship develops, mutual confidence tends to increase, and exchange of information to become freer and more open. The risks are divided between the two parties. Also, when a free-lance designer accepts commissions from several different producers, it becomes easier for him to propose solutions suitable to the general situation in the industry without transmitting information about one supplier to a competing one. On the other hand, if such a long-term, continuing relation does not develop, his contacts with sources of commissions will be incidental and short-lived, and he will find himself taking all of the risks.

The free-lance designer thus must come to concentrate on a few producers and therefore become dependent upon them to some degree. He must often guess at the real requirements of a client, since the latter may be reluctant to give him information that might be of value to a competitor. Perhaps his principal disadvantage is that he does not participate in the decision-making process; the acceptance or rejection of his designs is entirely in the hands of the client. Also, for reasons of cost, producers are often reluctant to accept from a free-lance designer a design that might be expected to become a fast seller; the fee and/or royalty would be too great. Work of this kind is usually assigned to a salaried designer.

Salary-and-royalty and straight-salary designers

A designer who works for a salary, with or without royalties, normally works on a commission basis. Such a designer is usually part of the development team of the producer. He participates in all decisions when an item is put into production, including the purchase of new materials, paints and fittings. The employer normally bears all of the risks and provides accurate information about the requirements and capacities of the plant. In this situation, the designer has the support of the entire organization and will have good possibilities for teamwork, research and specialization.

Conversely, such a team approach is seldom successful, and the employer-employee relation is often distasteful to a creative person such as a designer. He will have to follow the development plan of his employer and may well find himself involved in routine or distasteful tasks such as the modification of designs of competing firms, and he will find it difficult to refuse to do so.

All too often, when a salaried designer comes up with a new and original idea, it is rejected out of hand by the decision-makers, who are inclined to deprecate the abilities of their own employees. When this happens, the designer cannot offer the idea elsewhere; that is the end of it.

It can be said that the employer-employee relation tends to be stultifying to a designer. He sees and works with the same people, year after year and comes to resemble them, since he knows their opinions, attitudes and reactions in advance. Furthermore he runs the risk of becoming entangled in the various intrigues that are found in most large organisations.

Connexions with consumers, retailers and factory agents

Free-lance designers

When a free-lance designer is in contact with several manufacturers he can get a wide range of information. He can thus see things from a broader perspective than a designer who is tied to one enterprise and can try to look at things from the point of view of the consumer.

On the other hand, his actual contacts with the consuming public are usually rather slight, and the information that he receives is generally outdated. He cannot conduct surveys of consumers, retail salesmen or factory representatives, so he can have no current information of what is being sold and where and why.

Salary-and-royalty and straight-salary designers

Designers who are in an employee relation to an enterprise have good possibilities for contact with consumers. Also, information becomes available directly from the market. Nevertheless, some of this information will be unreliable because loss of detail and the passage of time as it is passed along from the consumer to the retail salesman to the retail manager to the factory representative to the sales manager and, finally, to the designer. Also, much of the information thus accumulated is unsuited for use at the plant and is never used.

Research and development

To the present, research and development have had insignificant roles in the furniture industry. The traditional approach has been, and continues to be, that of trial and error. Nevertheless, they have their importance.

Free-lance designers

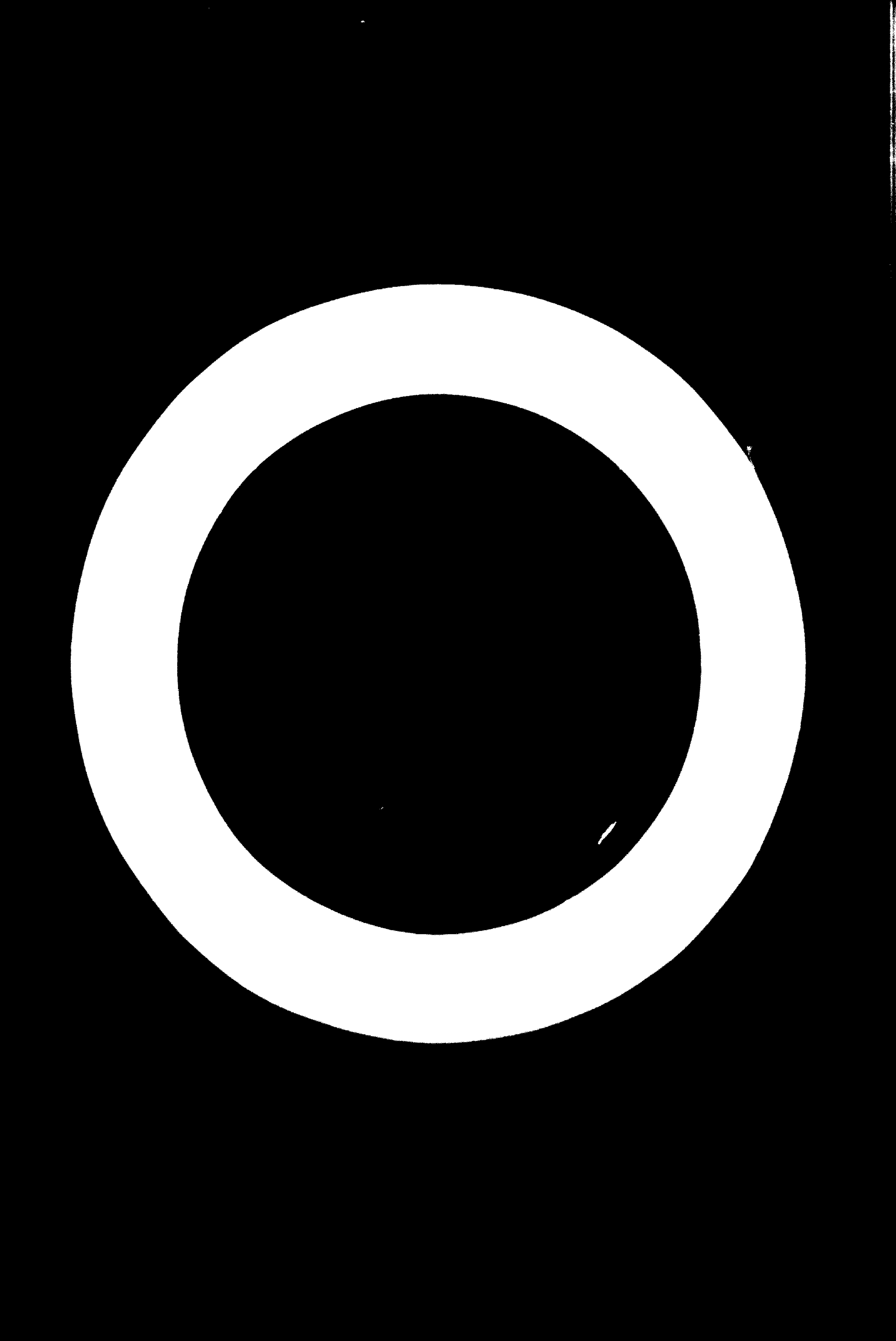
If a free-lance designer conducts some research and development work of his own, he can base his designs on it and offer them to the enterprise he considers best capable of making good use of it. If this offer is turned down, he can approach other enterprises with the same ideas. In actual practice, however, the free-lance designer does not have the resources to conduct investigations of this kind.

Salary-and-royalty and straight-salary designers

Designers who are retained by an enterprise on a salary or salary-plus-royalty basis have available to them all the information on new materials and other news of the furniture branch, since all such data are first presented to the manufacturers. On the other hand, it is still true that most furniture-producing enterprises have little interest in research and development. It is not unlikely, however, that the furniture industry, as it continues to evolve, will reach a point at which research and development work will become as important as they are in many other industrial branches.

Conclusion

While the standpoint of the author has been primarily that of the designer, he has attempted to do justice to the interests of the manufacturer. Indeed, this is as it should be; the interests of these two parties are more convergent than divergent. Both sides are, in the final analysis, desirous of producing attractive, practical and realistically priced furniture in a way that will benefit everyone.



13. PRODUCT DEVELOPMENT IN A LARGE FURNITURE ENTERPRISE*

It is very easy and modern-sounding to say that product development is market oriented, but in actual practice the determining factors are the possibilities of the production plant. In the writer's company, for example, management does not come into the design office and say, "The consumer wants a golden egg, so produce a golden egg for him." Rather, it will ask, "Have we the facilities to lay or otherwise produce golden eggs?" If the answer is "No!", the consumer is told that he really does not want a golden egg, and we try to get him to buy one that we can produce.

It would thus be better to say that product development is design oriented. While the word "design" has many meanings, the basic one is technical, that is, that someone creates a model of something. In Finland and the other Scandinavian countries, however, the word connotes something more; it has almost a mystic value. It is something connected with the arts in general and with sculpture in particular. When a Finn hears the word "design" he understands that, as well as engineering, aesthetics are being taken into consideration. This is true of design of any kind, be it of furniture, glass-ware, ceramics or whatever.

It must also be admitted that "design" has become an advertising word. As used here, it must be taken in its marketing and advertising contexts rather than in a purely technical sense.

Product development at the writer's plant is also materials oriented in the sense that its primary raw material is Finnish birch; everything that happens at the plant is derived, ultimately, from the fact that birch is plentiful in Finland. Even when metal, glass fibre and plastics are used, these materials are but experiments outside the everyday bread-and-butter activity of working with birchwood. Even painting and upholstery are always related to birch. On the other hand it should be noted that product development is materials-oriented in the sense that we accept the fact that new

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*Paper presented to the seminar by [illegible], Asko, Ltd., Lahti, Finland. (Originally issued as document [illegible].)

materials are becoming available. We are almost eager to experiment with them; but we are not so eager to involve them in our final production facilities until we are sure that they will stay in furniture production, so we have remained wood-oriented even with the advent of plastics and other materials.

It should be stressed that our product development comprises all four of the factors mentioned above, working hand-in-hand: marketing, design, materials and production. Representatives of all these phases of the company's workings are included in the body that we call the "product development committee", and that is the heart of the matter. This committee meets regularly once a week and also comprises representatives of the production and of marketing divisions, including retailing and exporting personnel. The manager of our woodworking factory is the chairman at these meetings and is responsible for the continued existence of this committee. He is also answerable for the results.

The work of the product development committee has been divided into two groups. One is involved with home furniture, and the other is involved with contract (institutional) furniture. There are, of course, people who work in both of these areas, and they attend meetings of both groups. Conversely, the people who are, in their daily routines, interested in only one or the other, attend only their specific meetings. The manager-secretary of the home furniture group of the design development committee has no other job to do; he acts as the day-to-day manager of the home-furniture development work, whereas the chairman oversees the workings of the entire committee.

Financially, the marketing director is responsible. He provides the money for this operation even if he is only one of the committee members. He is not the committee's chairman nor does he dominate it.

This organization is not like anything to be found in textbooks for organizing product development; it is something that has developed along with the company, in response to its changing needs and in accordance with the capabilities of its staff. It is thus not a concept that has been forced on the organization in the belief that it is the way that product development must be done; it is something that we have developed over years of experiments, and we will always say that it is subject to modification. It can change at any time, when and if a situation arises where a different organization is considered better. We feel that its important feature is that product development has reached the results that appear in our showroom and in the store building. The main reason has been that the operation has been flexible and that we have had, as the Americans say, "feelers out all the time", with different kinds of people involved in the meetings including, for example, somebody who knows about the American market, somebody who knows about the Finnish market etc.; finally, these people have, in co-operation, developed new products. It has never been a one-man show; teamwork has always been the key.

But let us return to the matter of design, and in particular, to the almost artistic meaning of this word to the Finn. The product development committee does not do its own designing; rather, it only looks at drawings and prototypes submitted to it. We use free-lance designers extensively; there are almost no staff designers to whom the committee could go and say, "Sir, because you are getting your daily bread from Asko, do this for us." No, it is kept on a very liberal, a very democratic basis where the designer can flatly refuse if he does not feel like listening to the people from Asko. This is very important because it enables us to get designs that the marketing or production people could never imagine. These people are specialists in their fields, but they are not necessarily specialists in design, or at least in future trends in it. The designer is the person to do this work, and therefore we use the assistance of free-lance designers as much as possible.

Of course, we sometimes say to them; "Our marketing (or sales) people would like to have a chair this big and of this shape and costing only this much," and the designer tries to solve the problem, he also feels free to dream up anything he feels that people would buy, and he can come to the committee and present his drawings.

It would be safe to say that most of the designs in our collection that have become internationally well known, well advertised, well photographed and well publicized are designs that we had never asked a designer to do; rather, it had been brought to us by someone who said that he had an idea that would fit well into our collection.

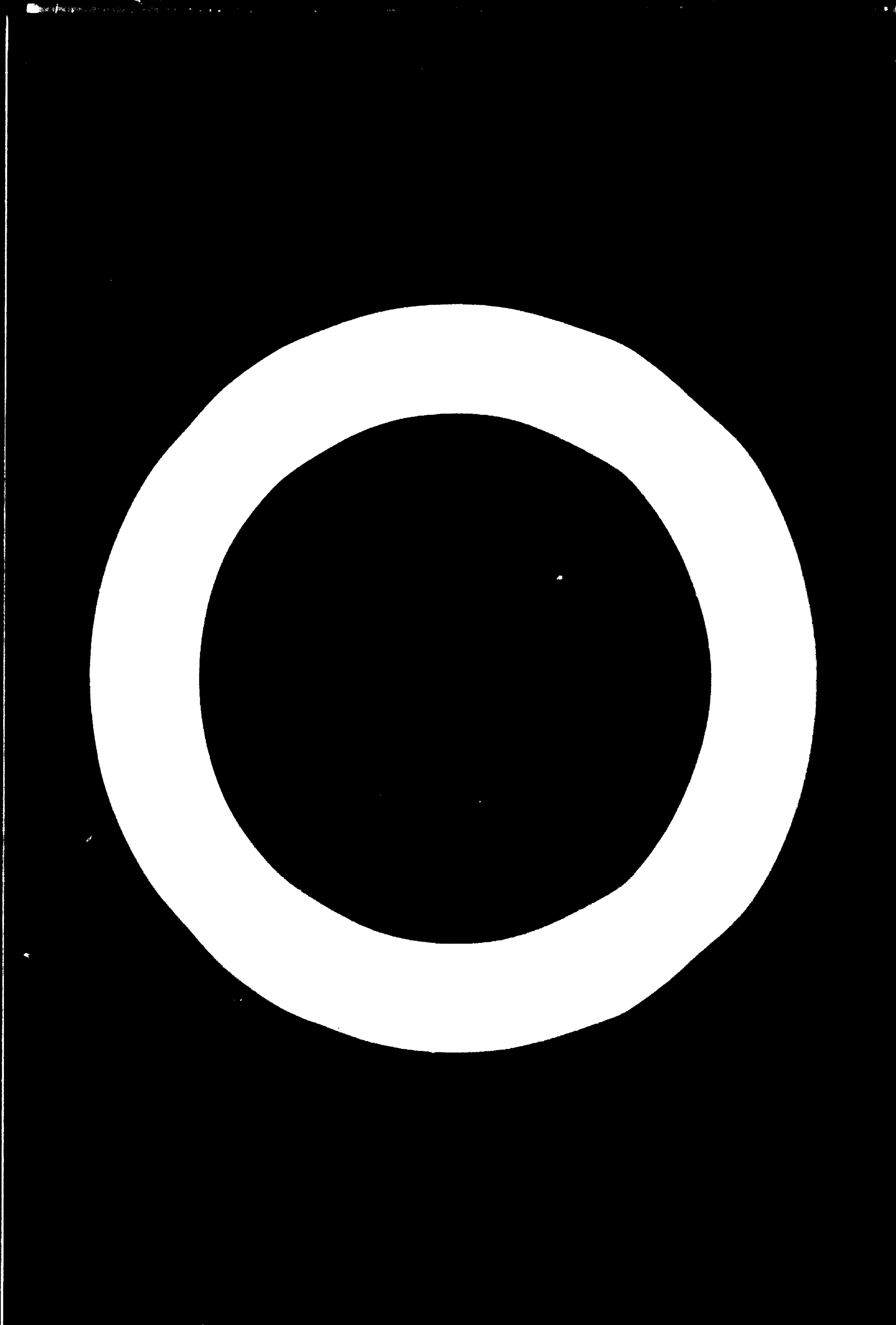
However, there is another side to the story. Just as a kite must be stabilised by a tail, the creative freedom of the designer must be steadied by the cold, hard facts revealed by product analysis. This latter function is now performed with computerised data on our past and projected performance, based on our day-to-day operation. Thus, while on the one hand we tell the designer, "Dream up something for us!", our operational data can tell us whether some of these dreams are realizable. It is this conflict that makes the work of the committee difficult; balance and results must be achieved even though one hand is free and the other bound.

Given the vast amount of computerized data that we have, it would be very easy to say, "Gentlemen, these are the figures; you can see what will happen, so go and do thus and so!", but this must never be done. The marketing and technical people may, among themselves, look at the figures and say that 2 + 2 = 4, but if the designer says that 2 + 2 = 5, this must be accepted. This approach is very difficult to explain and is certainly not to be found in textbooks. Indeed, it may seem to be very unbusiness like, but it is a very Finnish attitude and one that keeps Finland's export industries growing.

Market research is mainly concerned with the attitudes of consumers towards furniture, not with how much money they intend to spend on it. We do market research, and it is important for the operation of the design committee that it have these data. We still ask people whether they plan to furnish a bedroom next year and what pieces of furniture they would buy for it, and if they would like to have a bed that measures 2 x 2 m or one that measures 2 x 2.5 m. We get confusing answers because people do not really understand such questions, but we have found how general attitudes about furniture, such as how people feel about it and whether they would rather buy a new automobile or take their vacations in the Canary Islands than buy furniture, can be analysed. This helps us to find our what makes the furniture attractive to the consumer.

Let us return to our attitude toward design. We do not hold with the concept that function is per se beautiful; we consider it as an extra attitude toward furniture that attracts people to it. Technical design must often solve problems created by aesthetic design despite the many difficulties that this may present. As a general rule, the aesthetics are the prime consideration, or perhaps not the aesthetics but the form given by the designer and accepted by the product development committee. They prevail in a case where the technical planning people say, "Well, we just cannot do this!" It is this distinction that allows us to say that we are more marketing and design oriented than production oriented. Of course, all of these orientations must be present if the enterprise is to be successful.

Our designers are paid on a royalty basis; they receive a certain percentage of the gross receipts for the items they have designed. There is no down payment, no advance on royalties, no additional allowances and no anything else. The designer thus shares the risk. There are designers who come to us and say, "If you will give me so much money I will have the freedom to do something great for you," but we do not want to take that risk and so far we have been successful. We know that elsewhere in Europe, and especially in Italy and France, it is the custom that the des gner be paid something before he even starts talking to you, and a royalty is paid after that. We have not got into that system, and we feel that it is good that there be no pressure on the designer. We feel that if we give the designer 5,000 or 10,000 Markka he will then feel that he must produce something, and when these people feel that they must do something they do it less well than if they feel free to do it or not do it. I believe that this design philosophy prevails not in my company but rather generally in Finland.



14. TECHNICAL PRODUCT DESIGN*

Technical product design is the planning and designing of a product and its parts in such a way that its serial production will be as rational as possible, that is, it will be done at the lowest possible cost. The quality of the product must meet the demands commonly placed on the kind of product in question; the quality must be neither too high nor too low. Serial production is a manufacturing process in which a large number of one item is fabricated in a single batch by performing each operation to each member of the series at the same stage. The number of pieces fabricated in one batch depends greatly on the nature of the product and hence on the demand. For example, low-priced kitchen chairs can be made in quantities of 5,000 pieces, but expensive managers' desks can be made in batches of only about 50. The storage situation at the factory will determine when a given item should again be produced.

The starting point of a technical product design is the product idea, which may be obtained from a free-lance designer, who usually is paid a royalty according to the number of pieces eventually manufactured. The development of the idea to suit serial production calls for highly expert knowledge and experience on the part of the technical designing staff as regards raw materials, construction, machining, surface finishing and so on. It is particularly important that industrial designers be fully familiar with the sizes, dimensions and prices of raw materials, semi-manufactures and supplies available on the market.

The need for technical product design

Some of the more important reasons why technical product design is necessary in the furniture and joinery industries are the following:

(a) To maintain a competitive position on the market;

(b) The introduction of many new materials, which has resulted in a need to develop new forms of construction suited to them;

(c) The impact of new production methods and special machines, and the concomitant decrease in manual labour;

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*Paper presented to the seminar by Pekka Paavola, Lahti Technical Institute, Lahti, Finland. (Originally issued as document ID/WG.105/30/Rev.1.)

(d) The increasing importance of automation;

(e) The marked increase in export trade, especially from the northern European countries.

Even the smallest factories today attempt to carry out systematic product design or product development in which every detail in the design and fabrication of a product is thoroughly considered.

Properties required of a serial product

Modern serial production techniques usually place the following demands upon a product:

(a) The product must be suitable for the manufacturing process of the plant in question and allow, for instance, the efficient use of multi-purpose machines (for example, double-end tenoning machines and edge veneering machines).

(b) No manual work should be included; there should be no hand fitting in the assembly phase.

(c) Surface finishing of parts should be done, where possible, before assembly (as by curtain-coating machine or by dipping).

(d) In countries where timber is costly and labour costs are high, solid wood should be replaced, as far as possible, by various kinds of semi-manufactured materials that can be veneered, covered with plastic sheets or painted. The level of development of the industry and its degree of automation are additional factors to be considered in the selection of materials.

(e) The constructions should, as far as possible, be collapsible, so as to reduce storage and shipping costs, especially in the export trade.

(f) Similar details should be usuable as components in as many parts of a product and in as many products as possible.

(g) Dimensions, joints, metal fittings and so on should be standardised as far as possible. Profiles, roundings etc. should be standardised to suit the supply of machine tools at the factory.

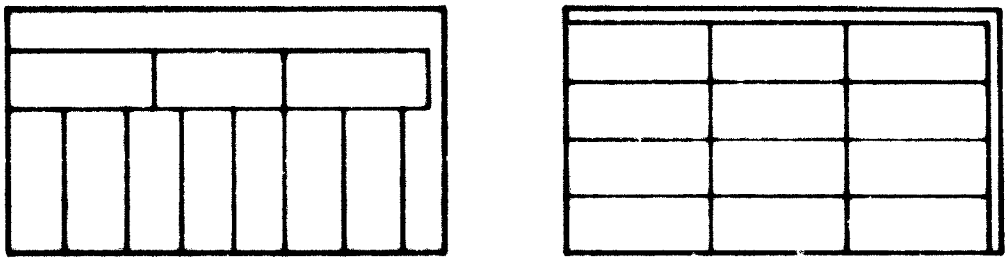
(h) Products should be so dimensioned that semi-manufactures available on the market can be used with a minimum of waste (figure I).

(i) The forms and joints of a product must be so designed that the machining of each part will be possible by a continuous through-feeding operation (figure II). It is a further advantage if several machining operations can be carried out at the same time, as with the four-side moulding machine (figure III).

Raw materials for different constructions

With the introduction of particle boards and many other semi-manufactures, many traditional constructions have been abandoned. The raw materials used

Figure I. Sawing panel components from a standard-sized particle board so as to minimise waste



10 pieces obtained 12 pieces obtained

Figure III. A final profile, including three machining phases, produced by a four-sided moulding machine

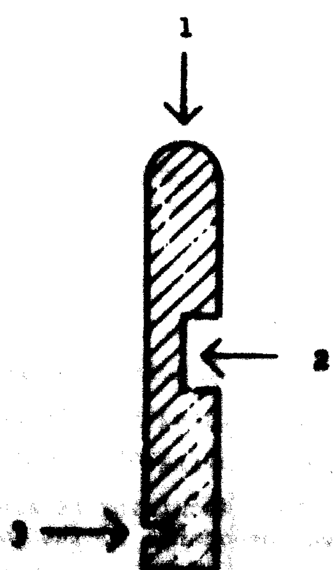
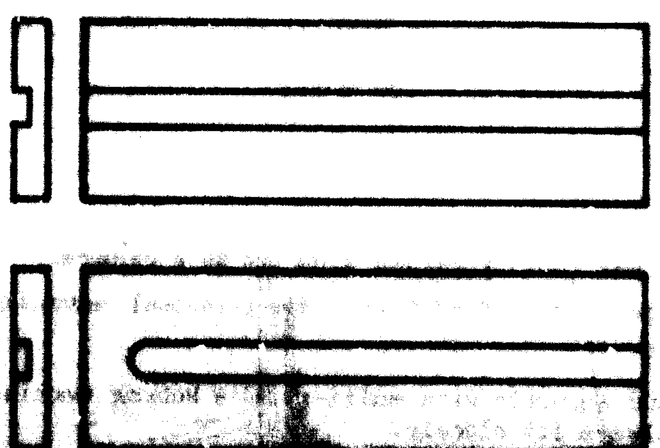


Figure II. Machining grooves in a through-feed operation (a) possible with standard machines; (b) not possible with standard machines

(a)

(b)



today for panel furniture such as cabinets and bookcases are chiefly particle board and various combination boards; solid wood is often used only for chairs, drawers, structural components and bases. For export, solid wood furniture of tropical woods may command better prices and attract a different demand profile.

The following is a brief review of the uses of various raw materials in different constructions and of their characteristics:

(a) Furniture members made of one piece of solid wood are seldom more than 100 mm in width. Some such furniture members are table and chair legs and rails, drawer parts and other narrow pieces.

(b) To reduce costs, solid wood is often veneered. The blindwood can be of low quality provided it is of sufficient strength. If the blindwood pieces are narrow, they are usually first glued to form a panel and then planed and veneered. The veneered panel is sawn to the required pieces, and the edges are veneered, as shown in figure IV.

(c) Cell construction (figure V) is commonly used in joinery products (doors, kitchen furniture); however, frame and panel constructions are also used in doors. In cell construction, the corners of the frame are stapled (no joints) to keep it together during the process. The frame is filled with paper honeycomb and covered with fibreboard in a hydraulic gluing press.

(d) The most common panel constructions used in furniture manufacture are: the solid wood panel, the veneered solid wood panel, veneered particle board and the panel with frame construction. These are shown in figure VI. The solid wood panel construction shrinks and swells across the grain and therefore must be fastened to, for example, a table base, in a manner that allows it to move ("buttoning"). Shrinkage is prevented in the two veneered panel construction types, and the external dimensions of the frame in the frame construction are also practically constant.

(e) Back panels of cabinets and bottoms of drawers are now usually made of hard or semi-hard fibreboard, which is painted or veneered. Plywood is considerably more expensive.

Joints

The dowel joint (figure VII) has rapidly gained wide use as a general method of joining the structural members of furniture. Its principal advantages are the following:

(a) Machining is simple and accurate with multi-spindle boring machines; the two components of the joint always fit closely.

(b) The driving of dowels is rapidly performed with a special instrument.

(c) The joint is easy to assemble.

(d) The wood is scarcely weakened by the holes because the fibres are cut over a very small area.

(e) Surface finishing can be carried out with a curtain-coating machine after boring but before assembly, since lacquer flowing into the holes does not affect the gluing (unless, of course, there are large open surfaces in the surfaces to be joined).

Figure IV. Veneered solid wood components

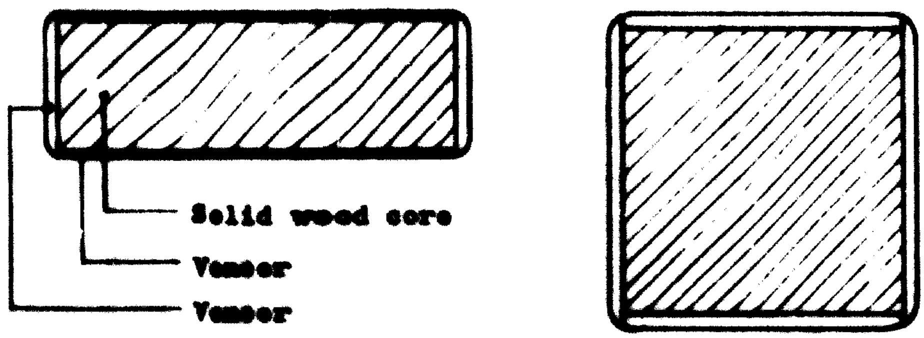


Figure V. Cell construction commonly used for flush doors and kitchen furniture

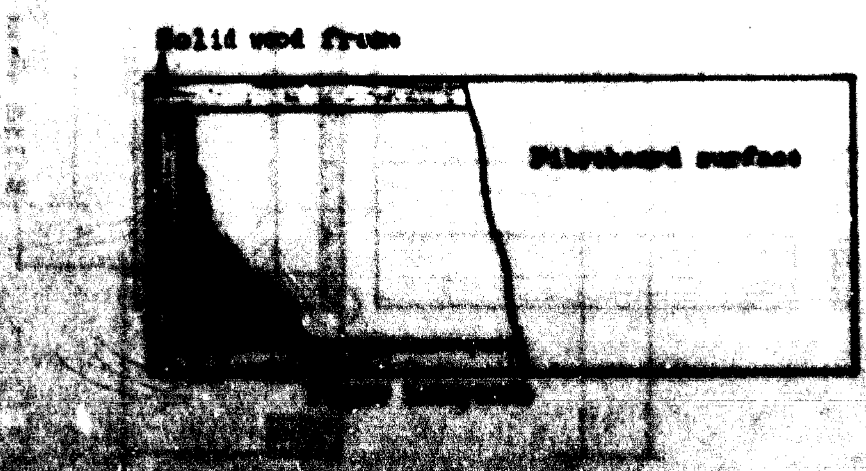


Figure VI. Four common furniture panel constructions

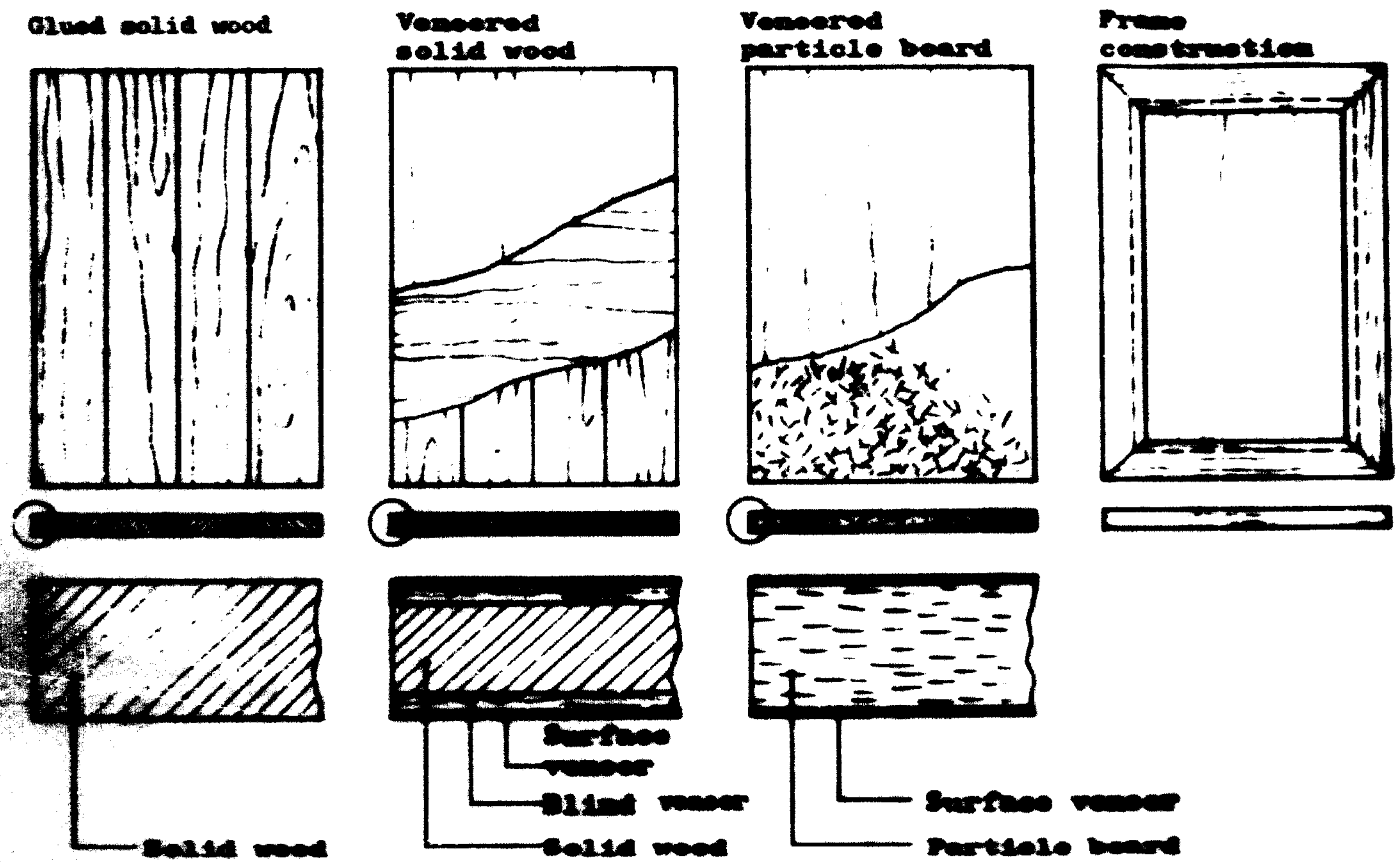
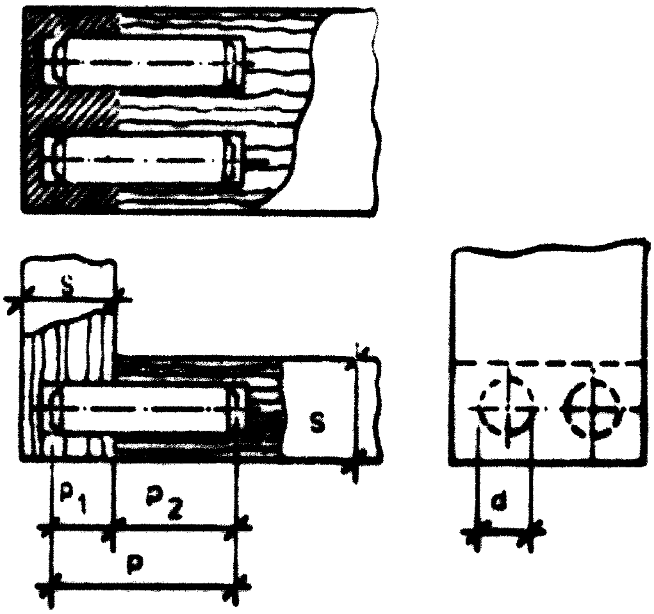


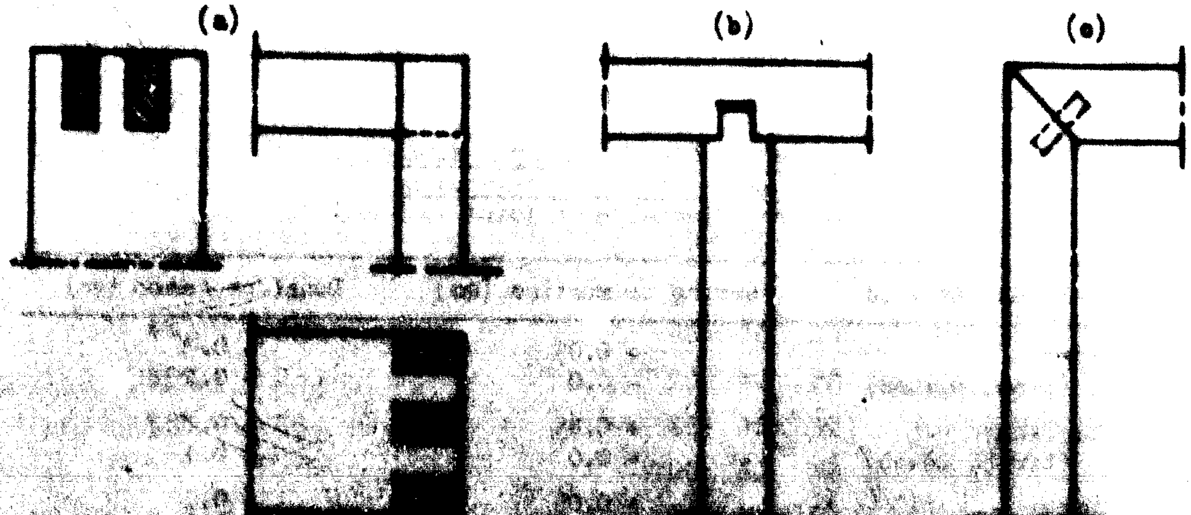
Figure VII. The dimensioning of a dowel joint used as a corner joint



Millimetres

s	d	p	p_1	p_2
11	6	20	8	12
14	6	25	10	15
17	8	30	12	18
20	10	40	15	25
26	13	50	20	30
32	16	60	25	35
38	19	70	30	40
44	19	80	35	45
50	22	90	40	50

Figure VIII. Three traditional joints suitable for modern furniture-manufacturing processes (a) corner-lock joint, (b) tongue-and-groove joint and (c) mitre joint



(f) Raw material consumption is reduced by use of wastewood for dowels.

(g) The use of dowel joints contributes to rationalisation as well as to automation.

(h) The dowel joint is the one best suited for particle board constructions.

Of the traditional joints, the following are suited fairly well to modern manufacturing processes: the corner-lock joint, the tongue-and-groove joint and the mitre joint; they are diagrammed in figure VIII.

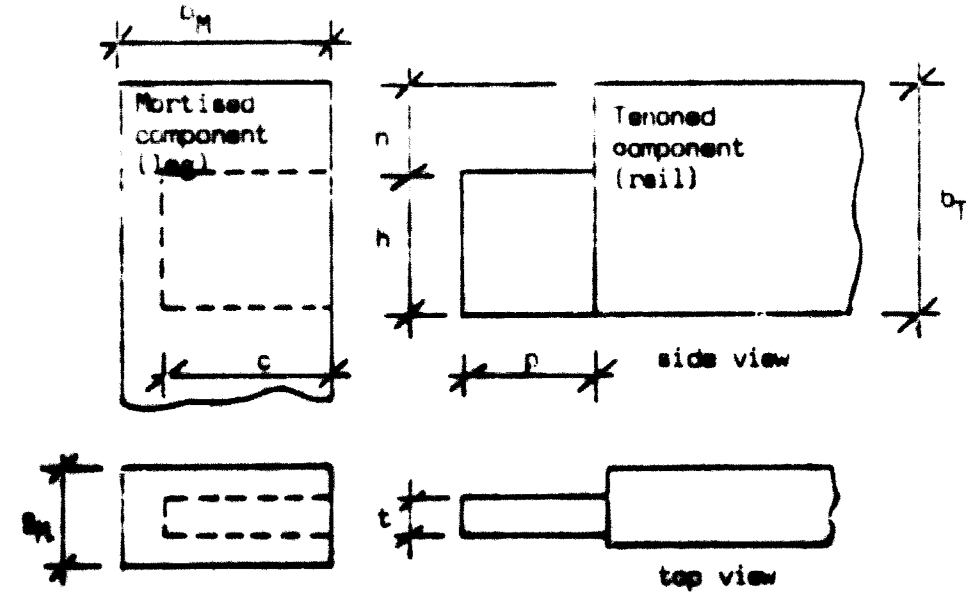
The stub-tenon joint (figure IX) is a traditional furniture joint but is less used today because it is time consuming to machine and, because the hollow-chisel mortiser makes rough inside surfaces, the strength of the glued joint is reduced. Various kinds of metal fasteners (figures X and XI) are being substituted for glued joints. They have the advantage that the product can be shipped to the customer in knocked-down form, packed compactly. The parts can be easily assembled at the destination even without special skill. An additional advantage is that surface finishing is done to the parts in unassembled condition. Type A in figure XI with a cylindrical steel nut implanted in wood (in the rail) has excellent strength properties and is therefore well suited for jointing of chair and table legs to rails. The rail is guided by two dowels. Type B with ordinary nuts, has not quite as good properties in respect to strength. Type C with nylon nut is suited only for light loads. Type D is a common fastener for table legs (guiding is not necessary).

To simplify design and fabrication, the joints should be standardised to a few types. The machining dimensions of selected joints should also be standardised. The recommended practical tolerances for mortise and tenon joints are shown in table 1.

Table 1. Lower and upper limits of mortise and tenon dimensions
(Nominal dimension of joint is 8 mm)

Hardness of wood	Boring or mortise (mm)	Dowel or tenon (mm)
Soft (pine, spruce)	+ 0.05 - 0.0	+ 0.3 + 0.2
Semi-hard (birch, beech)	+ 0.05 - 0.0	+ 0.2 + 0.1
Hard (oak, teak)	+ 0.05 - 0.0	+ 0.1 + 0.0
Very hard (rosewood, wenge)	+ 0.05 - 0.0	+ 0.0 - 0.1

Figure IX. The dimensioning of a stub-tenon joint. The tenon must be as long as possible and machined about 0.2 mm thicker than the mortise



Millimetres	
a_M	t
6	3
8	4
11	5
14	6
17	8
20	8
26	10
32	14
38	16
44	20
50	23
[illegible]	[illegible]
[illegible]	[illegible]

Millimetres		
b_T	h	n
14	8	6
17	10	7
20	12	8
26	16	10
32	20	12
38	22	16
44	26	18
[illegible]	[illegible]	20
[illegible]	34	22
[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]

Figure X. Some fasteners used in furniture construction: A, cylindrical steel nut embedded in the wood; B, ordinary nuts; C, nylon nut; D, common fastener for table legs (no guiding necessary)

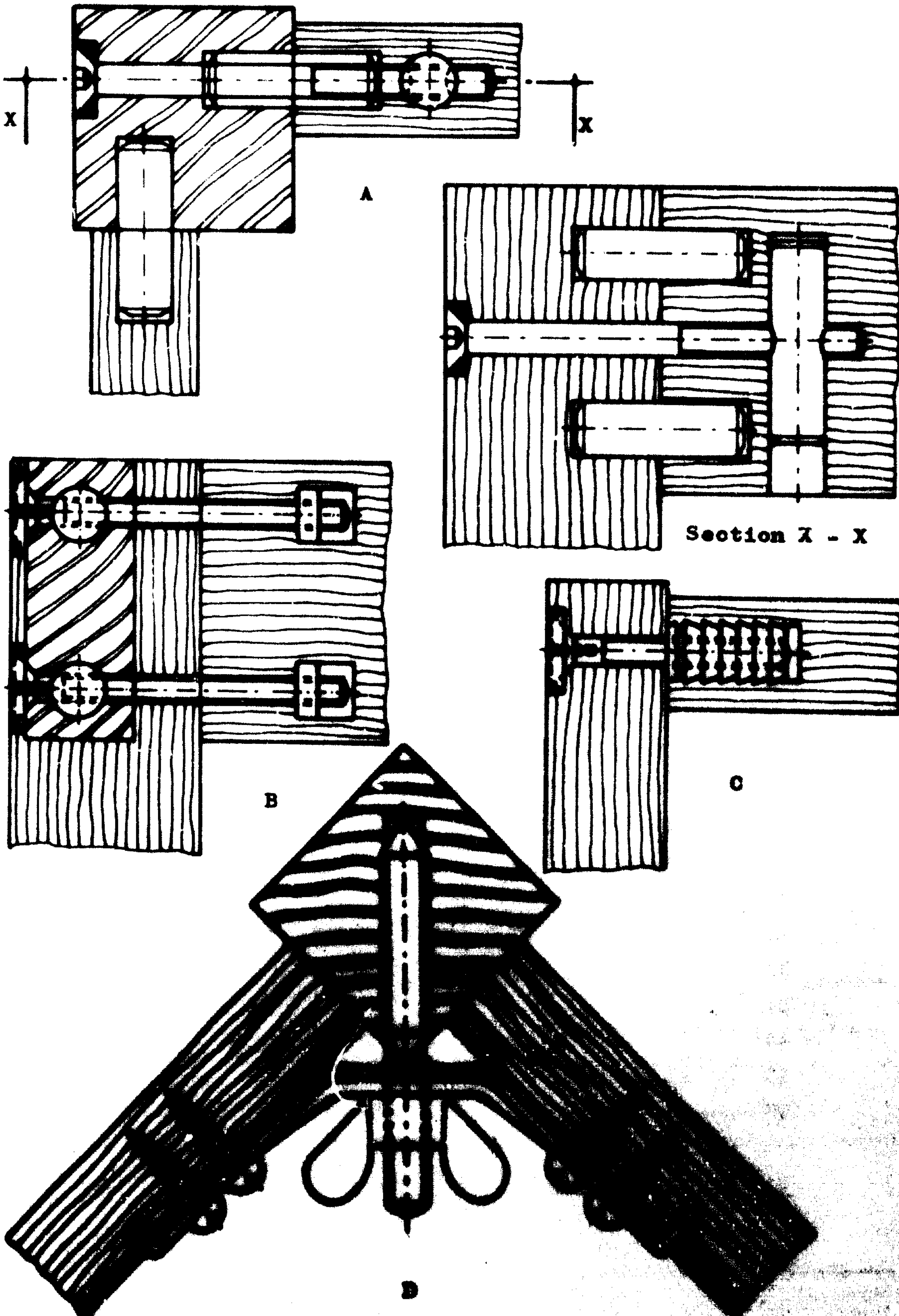


Figure XI. Dimensions of some metal fasteners used in furniture production

(M3, M6 etc. refer to standard metric threads)

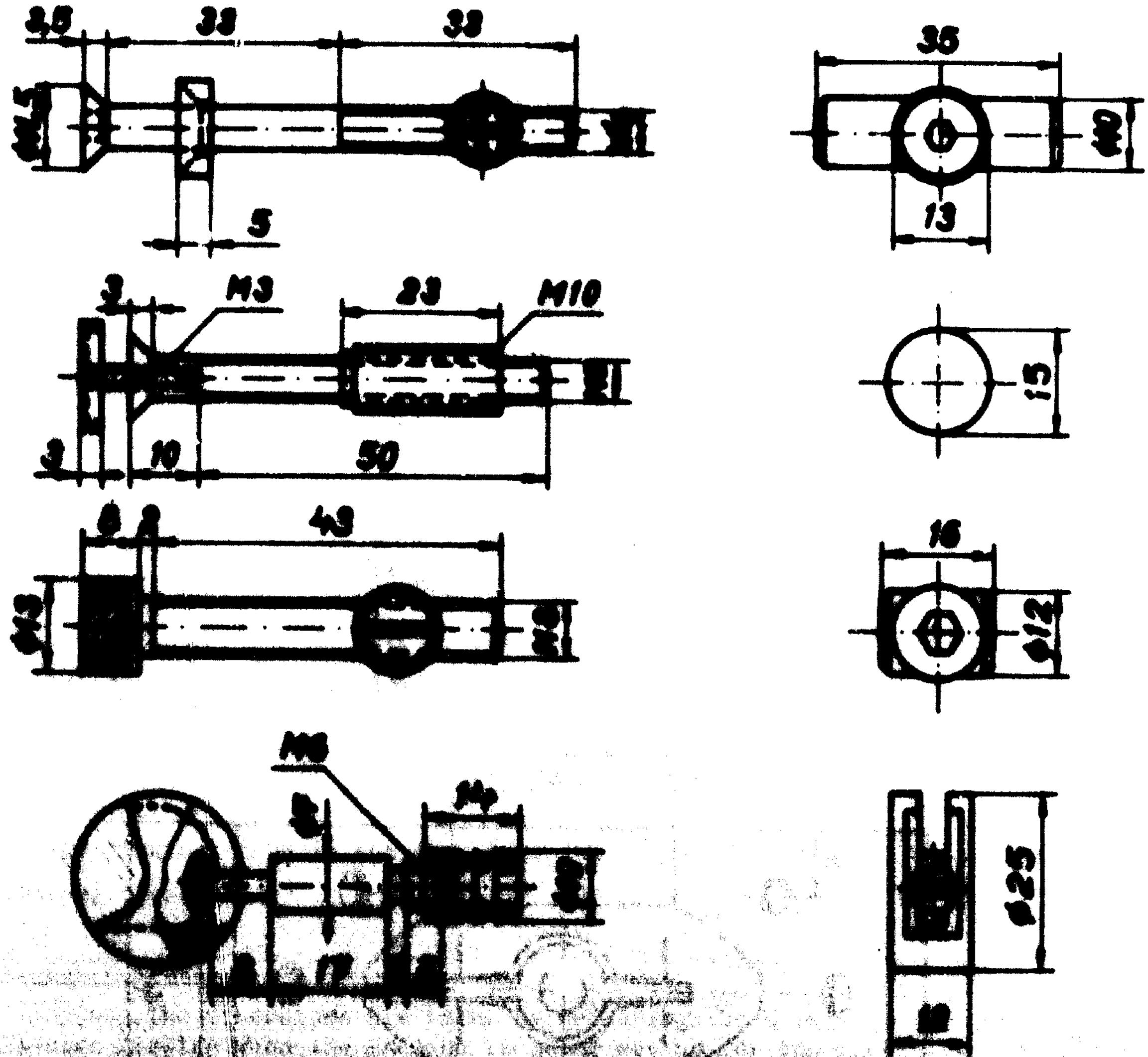
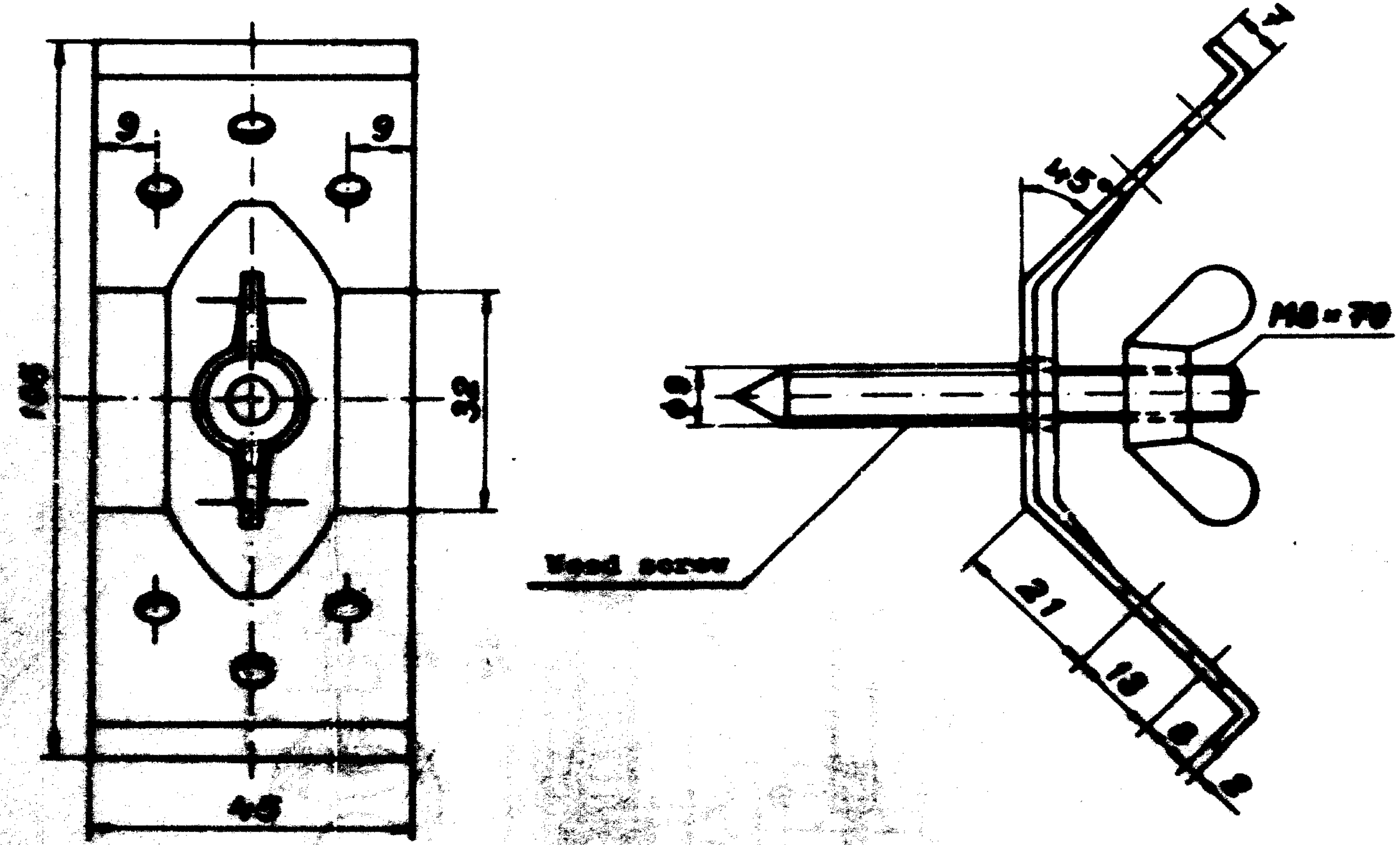


Figure XI (continued)



The modular dimension principle and element furniture combinations

A module is a basic unit of measurement, all larger dimensions being multiples of it (figure XII). Much home, office and kitchen furniture, both movable and stationary, are dimensioned today very generally on the modular principle. Basic pieces of furniture manufactured on the modular principle, called element furniture, can be combined by customers into larger units according to their individual needs and tastes. The variety of combinations possible is very great in many element furniture systems.

Concealing dimensional inaccuracies by structural means

Inaccuracies resulting from dimensional deviations in raw materials, such as variations in particle board thickness and inaccurate machining can be rendered inconspicuous and practically invisible to the naked eye by appropriate constructional designing. At the same time, hand fitting in the assembly phase will be avoided. Some structural means of this kind are overlap of one component and rabbeting or bevelling at the line of joining (figure XIII).

In veneered particle board products, because of the thin surface-veneer, only overlap can be used, whereas rabbeting and bevelling are particularly suitable in solid wood constructions.

Drawings and dimensions

The drawings used in the furniture and joinery industries are of two principal types:

Full-scale drawings (1:1 scale)

(a) The dimensions are taken by measuring the workpiece against the full-size drawing when the machine is being set up for the machining operations.

(b) No dimensions are indicated on the drawing.

(c) Accuracy of manufacture is poor.

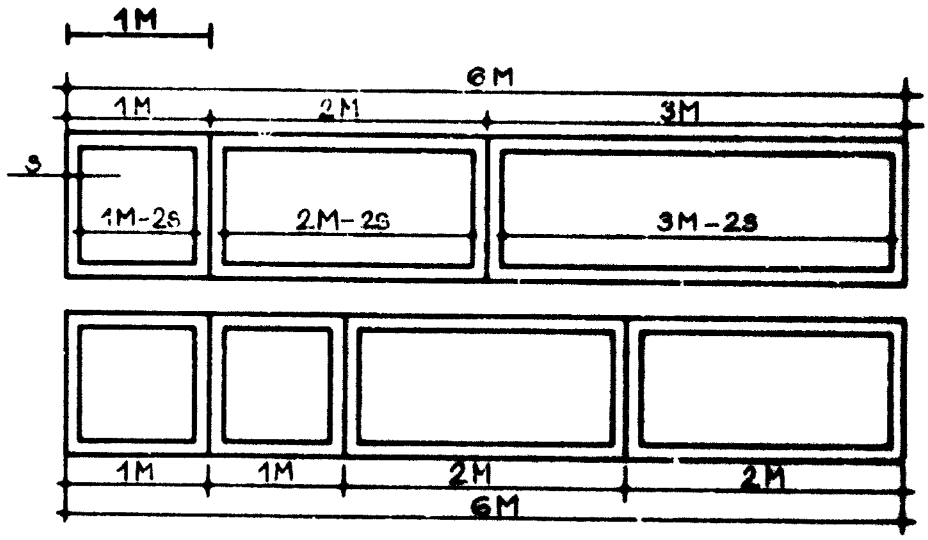
(d) These 1:1 drawings are not suited for modern serial production in general. They are useful, however, in presenting the dimensions of, for example, curved and complicated details of chair members, profiles and the like.

Drawings to scale

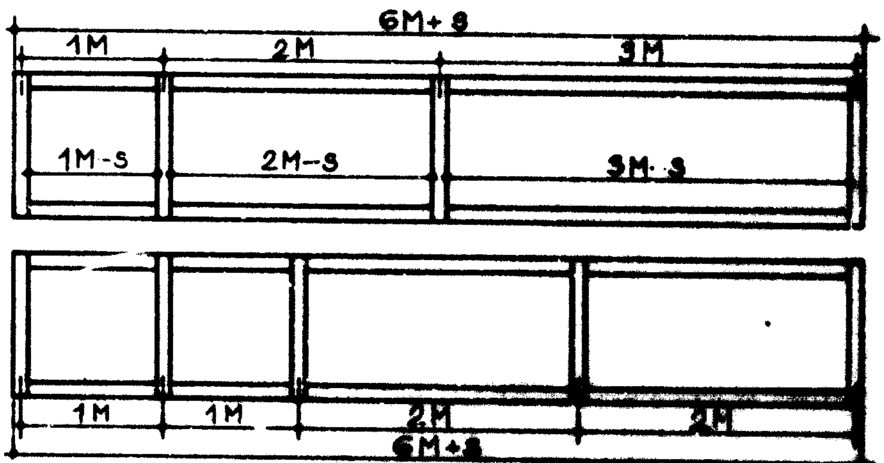
(a) For each member of the product, a complete drawing is made according to a given scale (1:2.5, 1:5, 1:10, details 1:1).

Figure XII. Some commonly used ways of expressing width combinations, showing the importance of the inclusion or exclusion of the side pieces in the calculation of space requirements
(M = module, S = side piece)

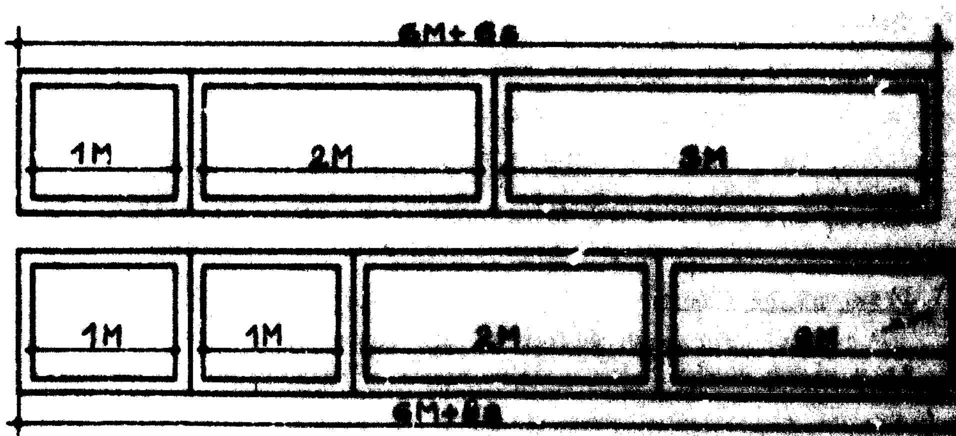
(a) modular design using outside measurements



(b) modular design using centre-to-centre measurements



(c) modular design using inside measurements (abutted components)



(d) modular, design using inside measurements (one component)

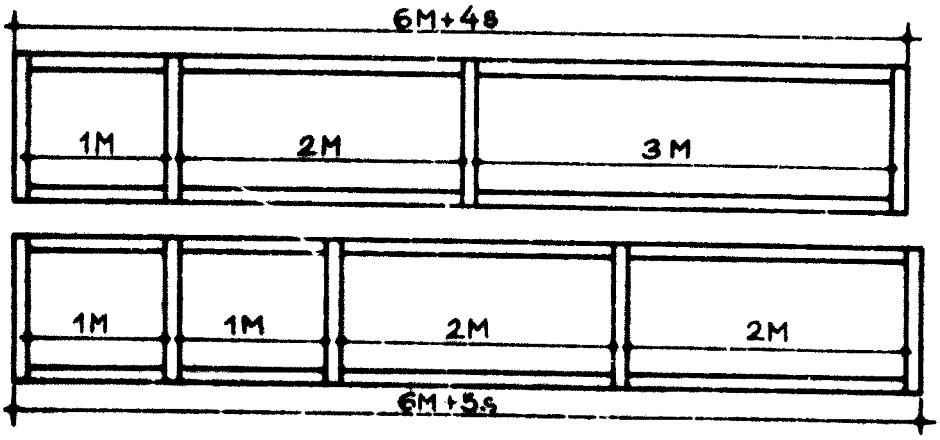
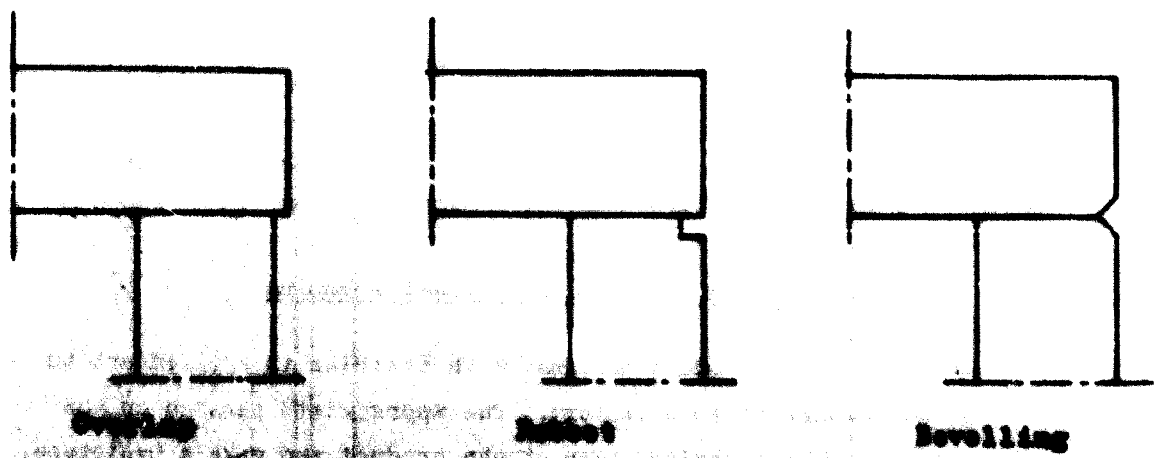


Figure XIII. Structural means of concealing dimensional inaccuracies



(b) Section drawings of details (in scale 1:1) are often very illustrative.

(c) The furthest development method is to draw each original part-drawing on a separate standard sheet (size A4), which is easy to file and to copy with modern copying devices. Copies are then sent to the respective points in the factory.

(d) The dimension figures on the drawings are decisive, not the measures obtained with a scale ruler from the drawing.

(e) Only the dimension figures need to be changed if alterations in dimensions are necessary.

(f) An assembly drawing is made of the complete product, showing the position of members.

(g) Joint types can be indicated on the drawings by appropriate abbreviations and symbols.

In the drawing series of figures XIV to XVIII, a simple product is presented with one assembly drawing and four part-drawings (one of each member). The drawings are also provided with markings for veneer quality (II,IV) and grain direction (⟷).

Prototypes

Before the serial production of any object is started, it is necessary to make a prototype in order to avoid costly mistakes in the manufacturing phase. The main points in prototype-making are:

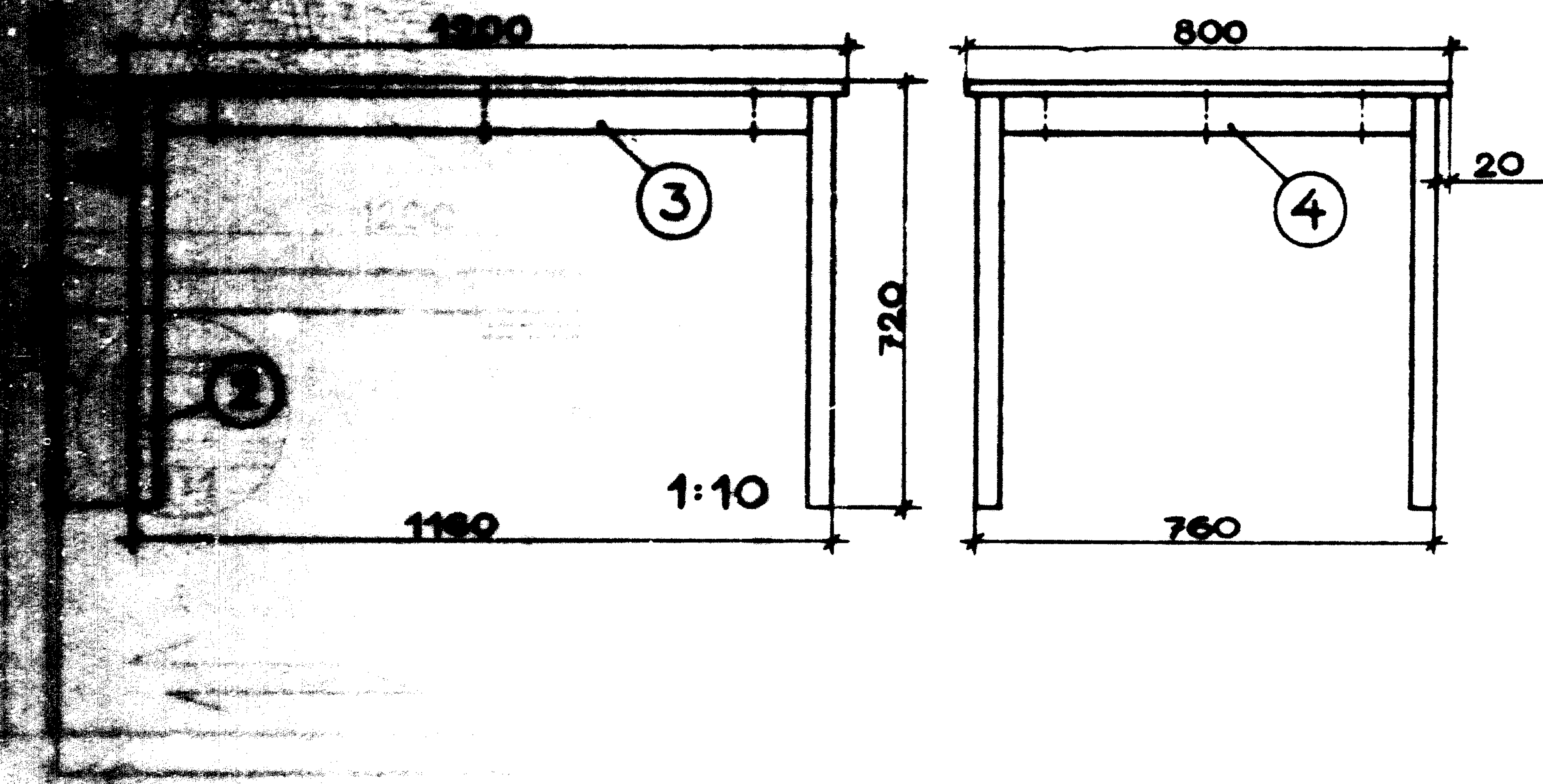
The prototype must be similar in all respects (jointing etc.) to the intended serial product so as to bring out any defects in construction or fabrication

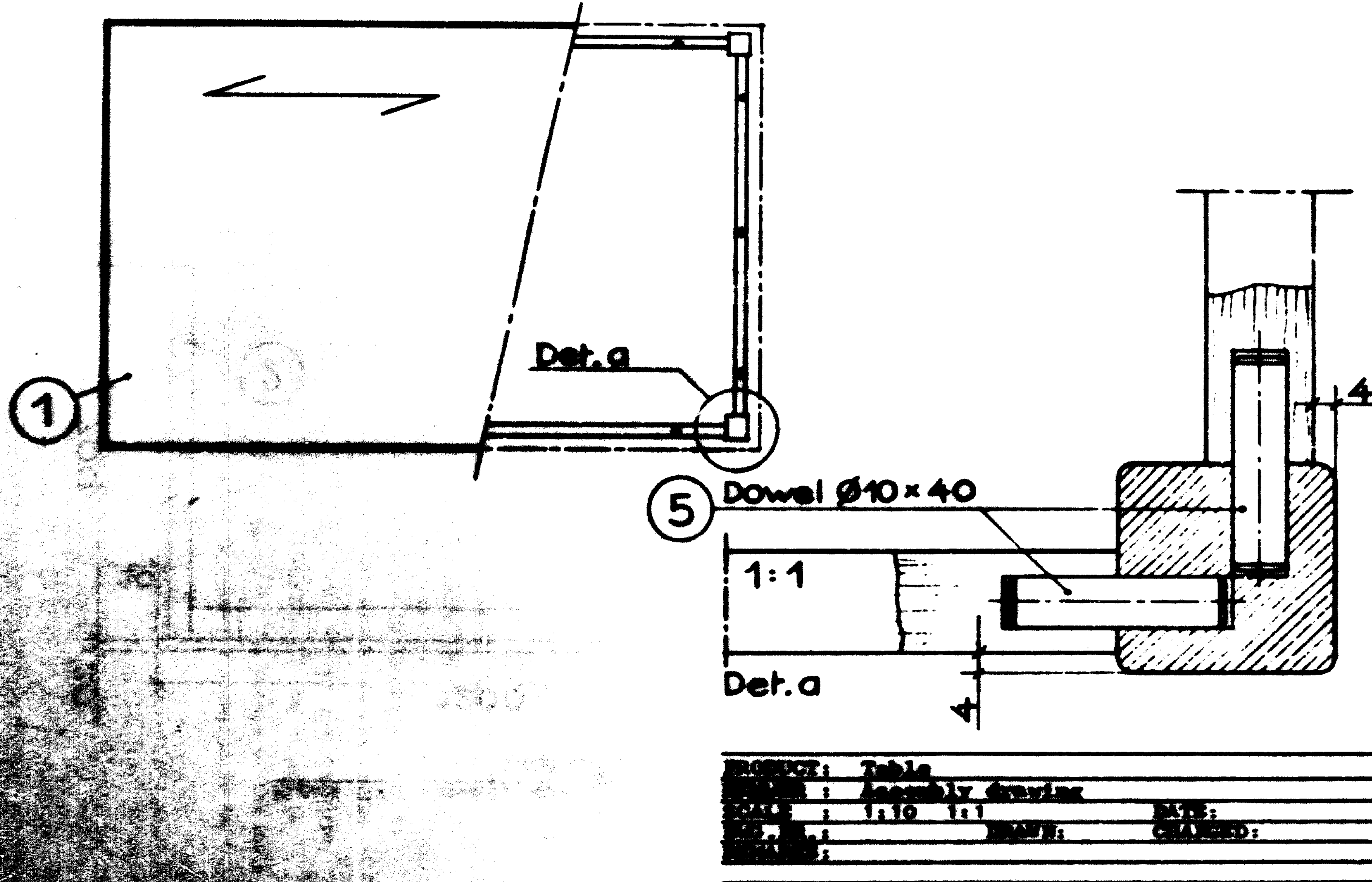
The prototype is used to examine and test the properties - dimensions, strength, rigidity, appearance - of the product in service

Organisation of technical product planning

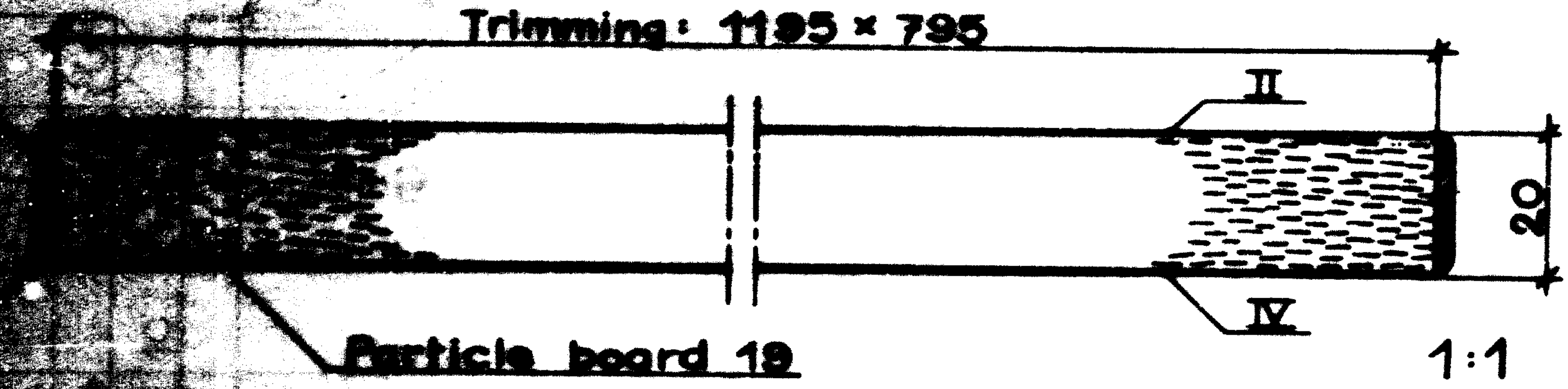
It is customary for a product designer with training in applied art to create an idea and submit it to a factory. The appropriate persons on the factory staff develop the technical plan of the product and make a prototype, which is submitted to critical examination and altered until the object is either considered ready for production or is rejected. The phases of the whole of product development from idea to manufacture are shown schematically in figure XIX.

[illegible]: Assembly drawing of a simple table. (Parts drawings 1, 2, 3 and 4 are [illegible] respectively.)

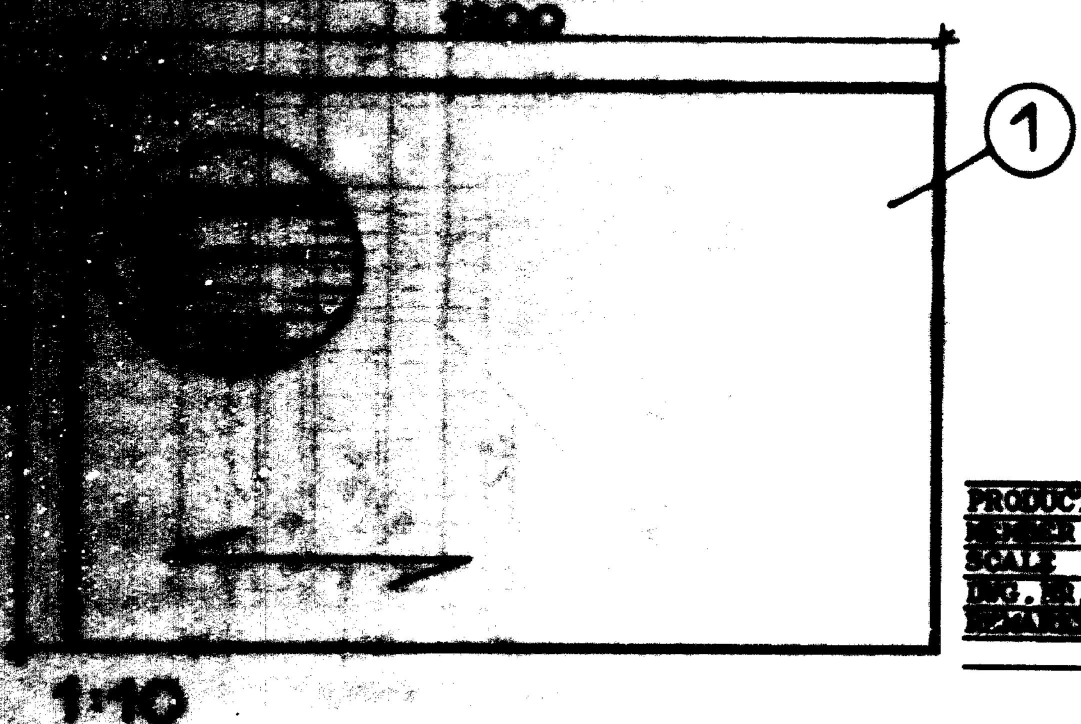



1
Det.a
5
Dowel Ø10 x 40
1:1
Det.a
4
4
Table
Assembly drawing
1:10 1:1
DATE:
DRAWN:
CHECKED:

[illegible]. Part drawing 1 of an assembly drawing of a simple table (figure XIV)



Veneer	Thickness Raw	Thickness Sanded
Surface	0.7	0.5
Edge	2.8	2.5



PRODUCT:	Table
MEMBER :	Top panel (1)
SCALE :	1:10 1:1 DATE:
DWG.NR.:	DRAWN:
REMARKS:	

Figure XVI. Part drawing 2 of an assembly drawing of a simple table (figure XIV)

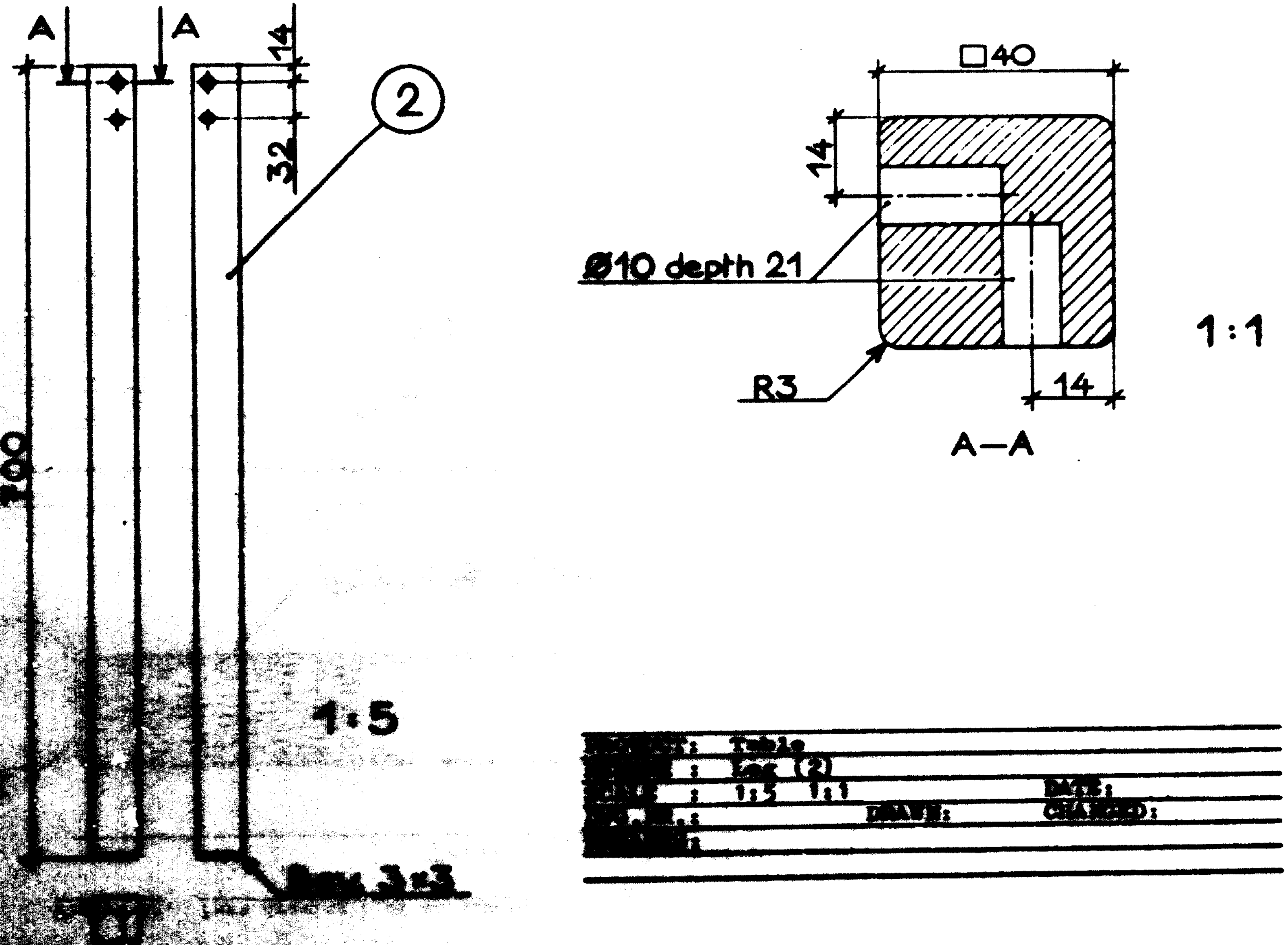


Figure XVI. Part drawing 3 of an assembly drawing of a simple table (figure XIV)

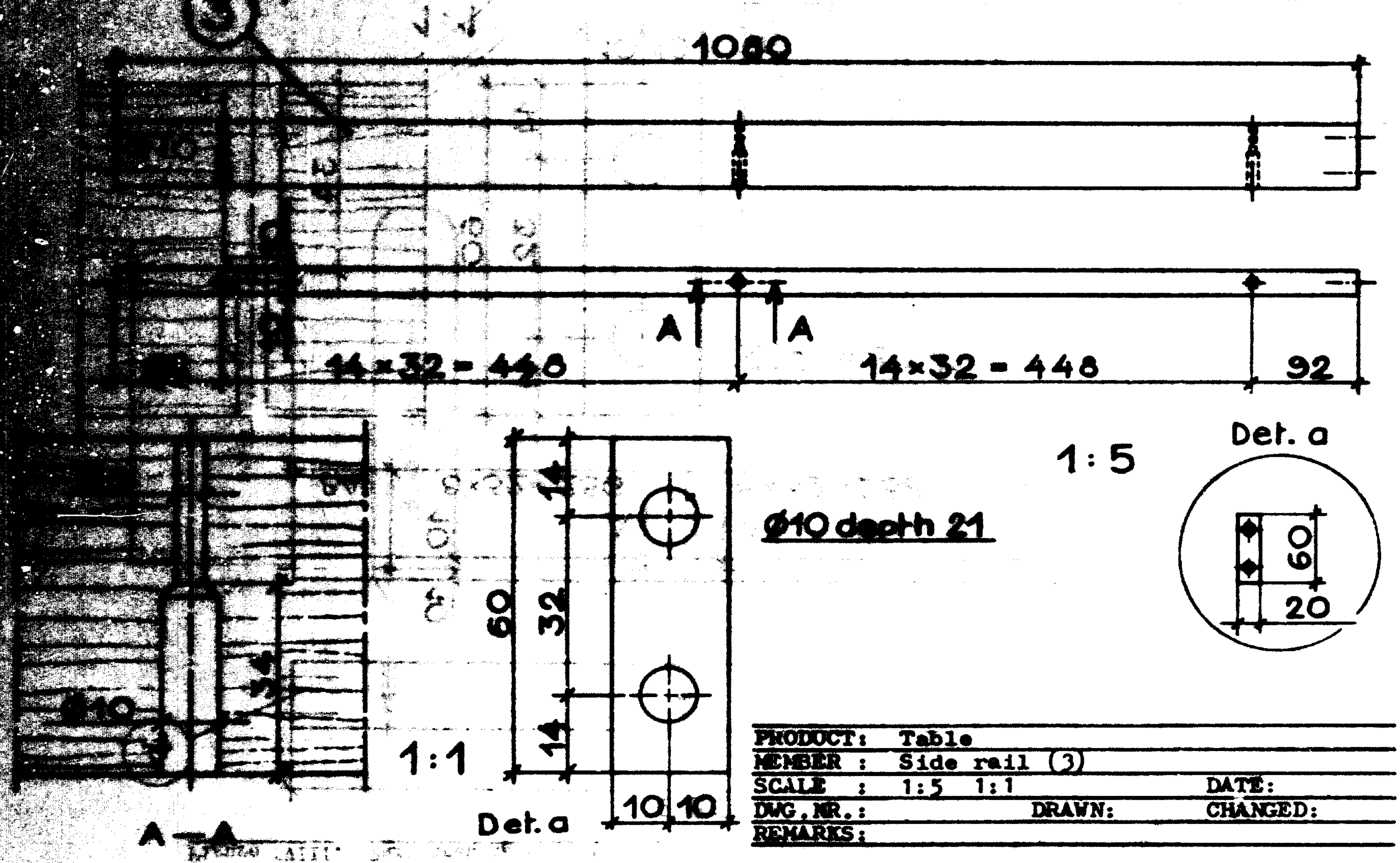


Figure XVIII. Part drawing 4 of an assembly drawing of a simple table (figure XIV)

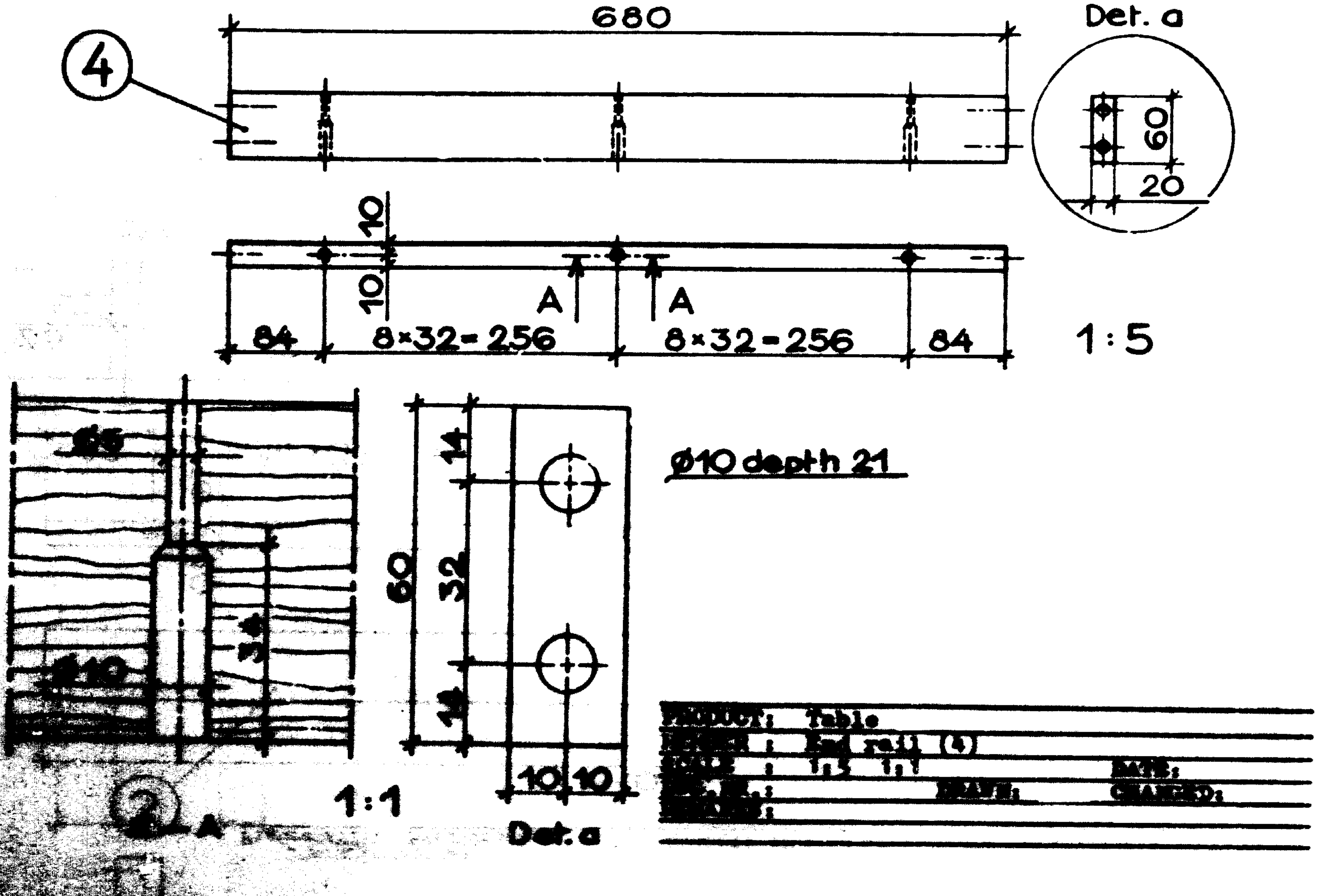
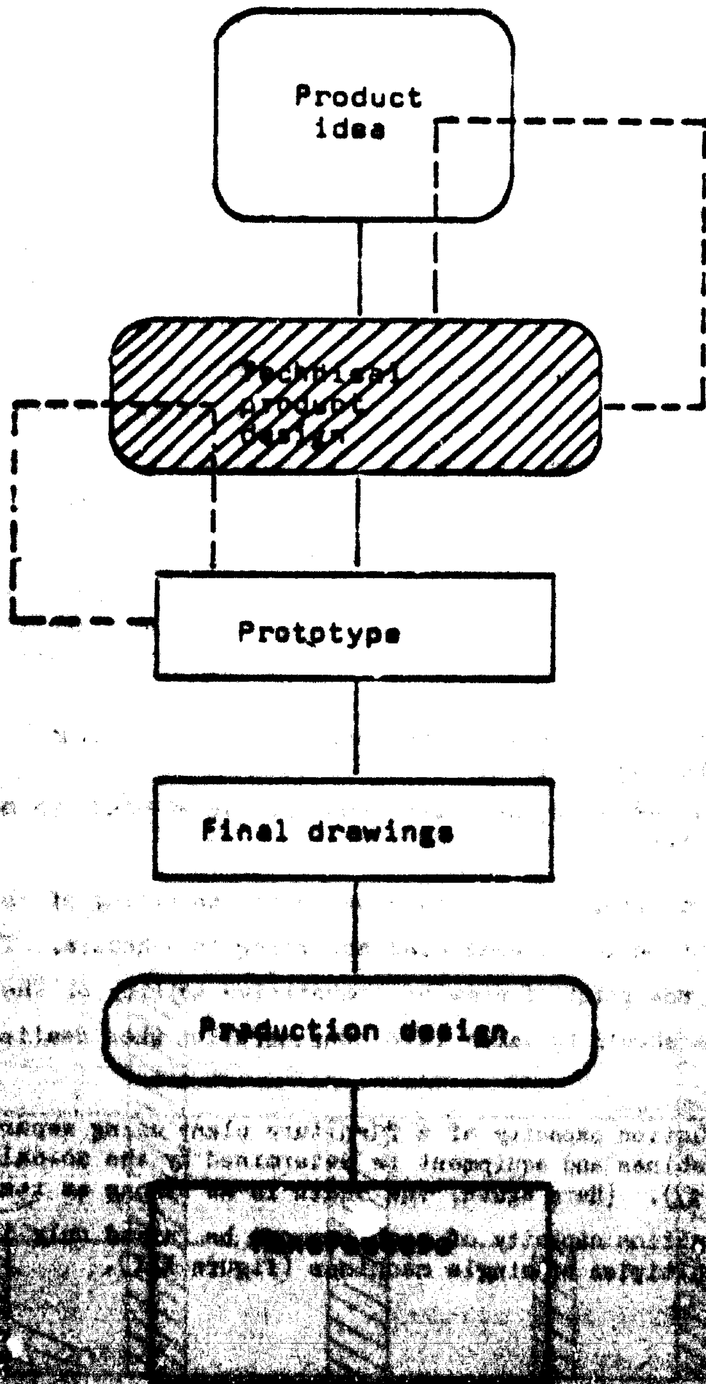


Figure XII. Schematic representation of the phases of product development



It is more efficient to carry out product planning on a teamwork basis. Product development is greatly facilitated when the various aspects of technical production can be taken into consideration throughout the planning process.

Production design

Production design is one of the preliminary steps to be taken before starting manufacture. Careful production design makes possible the economic utilisation of raw materials as well as the most efficient utilisation of the production capacity of the plant. It has as its principal task the compiling of two kinds of lists; first, lists of all raw materials and requisites and of dimensions and numbers of necessary pieces (piece lists for cross-cutting and edging, for cutting veneer and particle board etc.), and second, operation lists (that is, lists of work phases) of all machining, assembling, surface finishing and other phases, separately for each different part. The lists follow, in card form, the production lot through all manufacturing phases. The operation lists give the following information:

The machines and other equipment to be used, listed in the order required by the work phases. Machines and other equipment are indicated by code numbers. The capacities of some basic woodworking machines are shown in table 2

Details on each manufacturing phase (special tools, grit number of sanding belt to be used etc.)

Completed and uncompleted work phases. Every phase is marked on the card when completed

Production control is also concerned with the timing of the production so that each production lot is completed according to schedule. This is of prime importance from the point of view of competitive ability of the factory. The following points should be taken into consideration when dealing with production capacity:

The production capacity of a furniture plant using separate detached basic machines and equipment is determined by the so-called bottleneck (figure XX). (Here again, "the chain is as strong as its weakest link".)

The production capacity of machines can be raised only in steps; that is, as multiples of single machines (figure XXI).

Figure XI. Graphic representation of the formation of a bottleneck in a production line

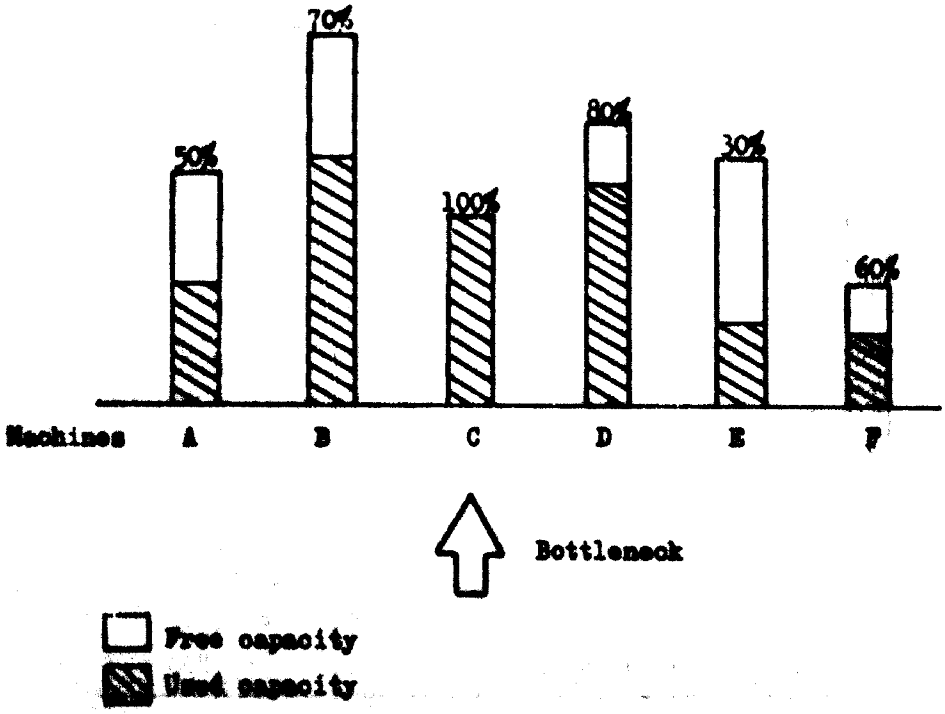


Figure XII. Graphic representation of the fact that the capacity of a machine line can be increased only as multiples of the capacities of individual machines

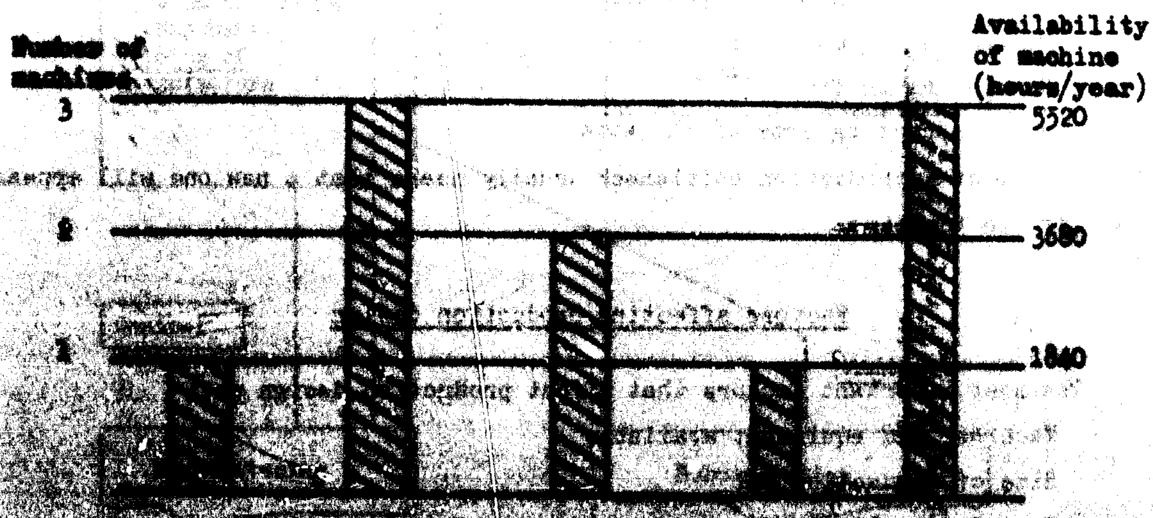


Table 2. Average capacities of some basic woodworking machines[a]

Machine	Capacity (Cubic metres/year)
Cross-cut saw	2,300
Edging saw, chain fed	2,300
Surface planer	1,400
Thickness planer	4.7/mm in width
Four-side moulder	2,300 to 4,700
Trimming saw, single-blade	1,400 to 1,900
Trimming saw, double-blade	2,800 to 3,700
Band saw	2,300 to 4,700
Vertical spindle moulder	700 to 1,400
Router	2,300
Chisel mortising machines	1,400 to 1,900
Horizontal belt-sanding machine	1,900 to 2,800

a/ The values are valid in average furniture production where different kinds of furniture are manufactured from solid wood.

The means used to remove bottlenecks in production are the following:

- Procuring additional machines
- Procuring more efficient machines
- Hiring more competent personnel
- Working overtime
- Working in shifts
- Sub-contracting some of the work

The removal of a production bottleneck usually means that a new one will appear elsewhere in the line.

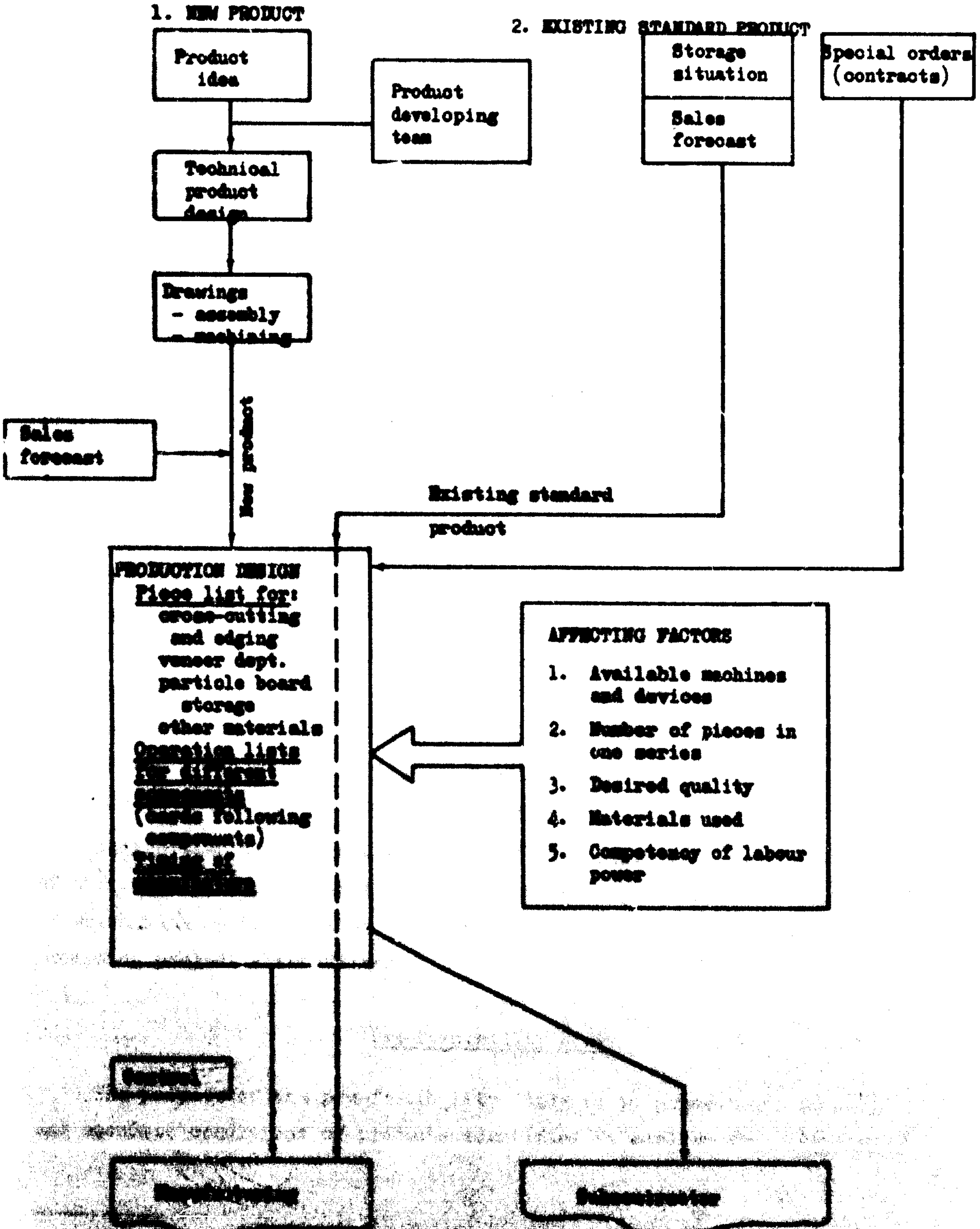
Factors affecting production design

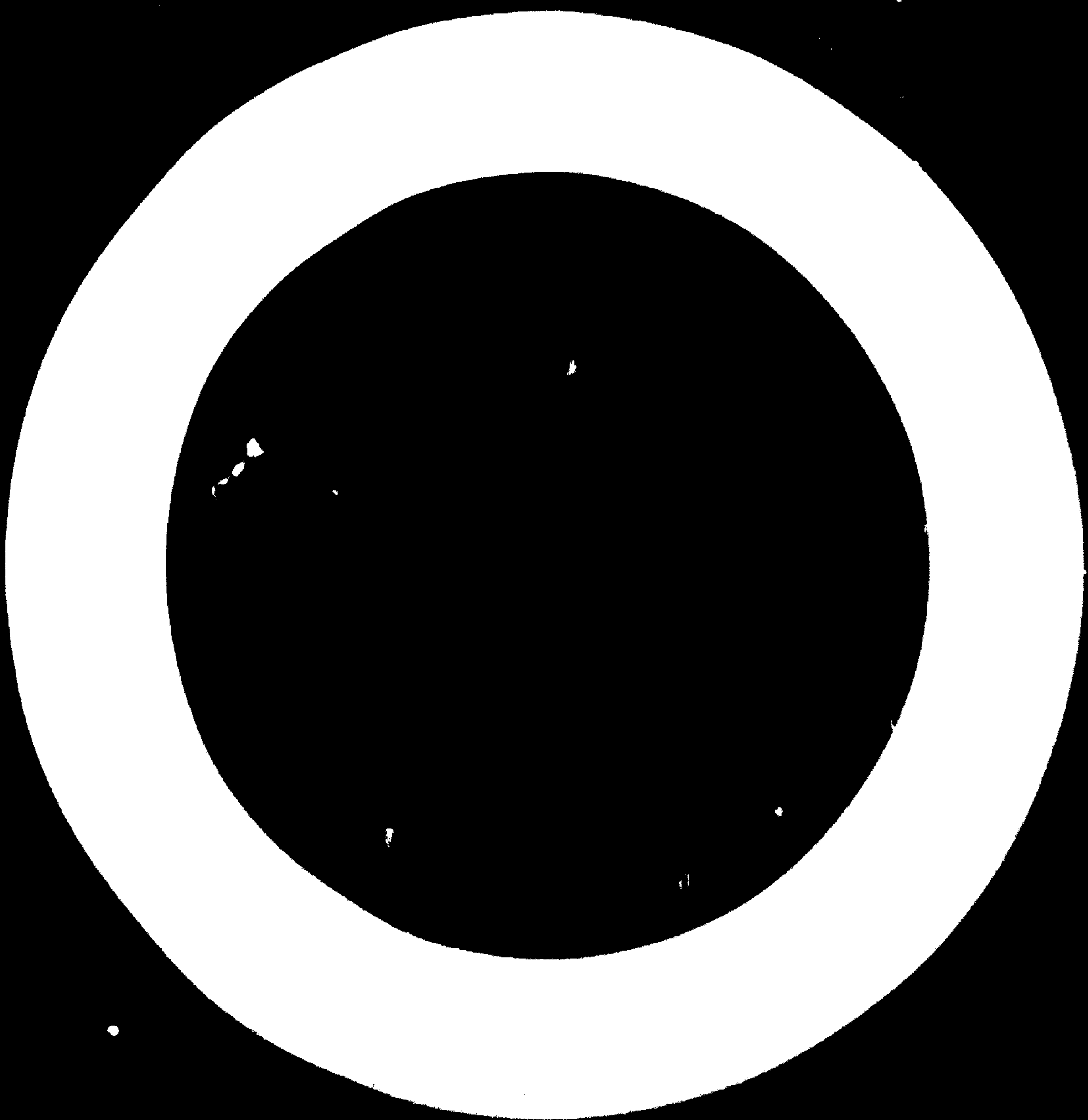
The most important factors that affect production design are:

- Machines and equipment available
- Size of production lot
- Intended quality
- Raw materials and requisites available
- Professional skill of the labour force

Figure XXII shows schematically the connexion between production design, product design and the manufacturing process.

Figure XXII. Schematic representation of the position of production design in the furniture production process





15. PROJECT PLANNING IN THE FURNITURE AND JOINERY INDUSTRIES*

General principles of investment studies

The investment decision is generally the result of an investigative chain that involves many studies and decisions at different levels. At the outset, there will appear to be several equally promising alternatives. To identify the most promising alternative and to permit more detailed investigations, there must be a system for eliminating the weaker project alternatives as early as possible. Figure I shows the principle of an investigation chain that eliminates weaker alternatives. This chain has three phases: project identification, the pre-feasibility study and the feasibility study. Each of them is followed by a decision whether to stop or to continue investigations.

The purpose of such an investigation chain is to direct the research potential primarily toward those objectives that would first affect the feasibility of the various project alternatives. By using this method, both money and resources can be saved, and it is likely that the best alternative will be chosen for further consideration. In the case of a large, export-oriented concern such as a pulp and paper mill, a thorough study is necessary, but quite large companies such as furniture plants can also be built up over time.

This presentation deals with project planning, that is, with the part of the investigative chain that has already been performed and the results of which have indicated that the furniture and joinery industries are most promising project alternatives.

Pre-feasibility study

The purpose of the pre-feasibility study is to present the technical and economic conditions of projects identified in earlier studies prepared

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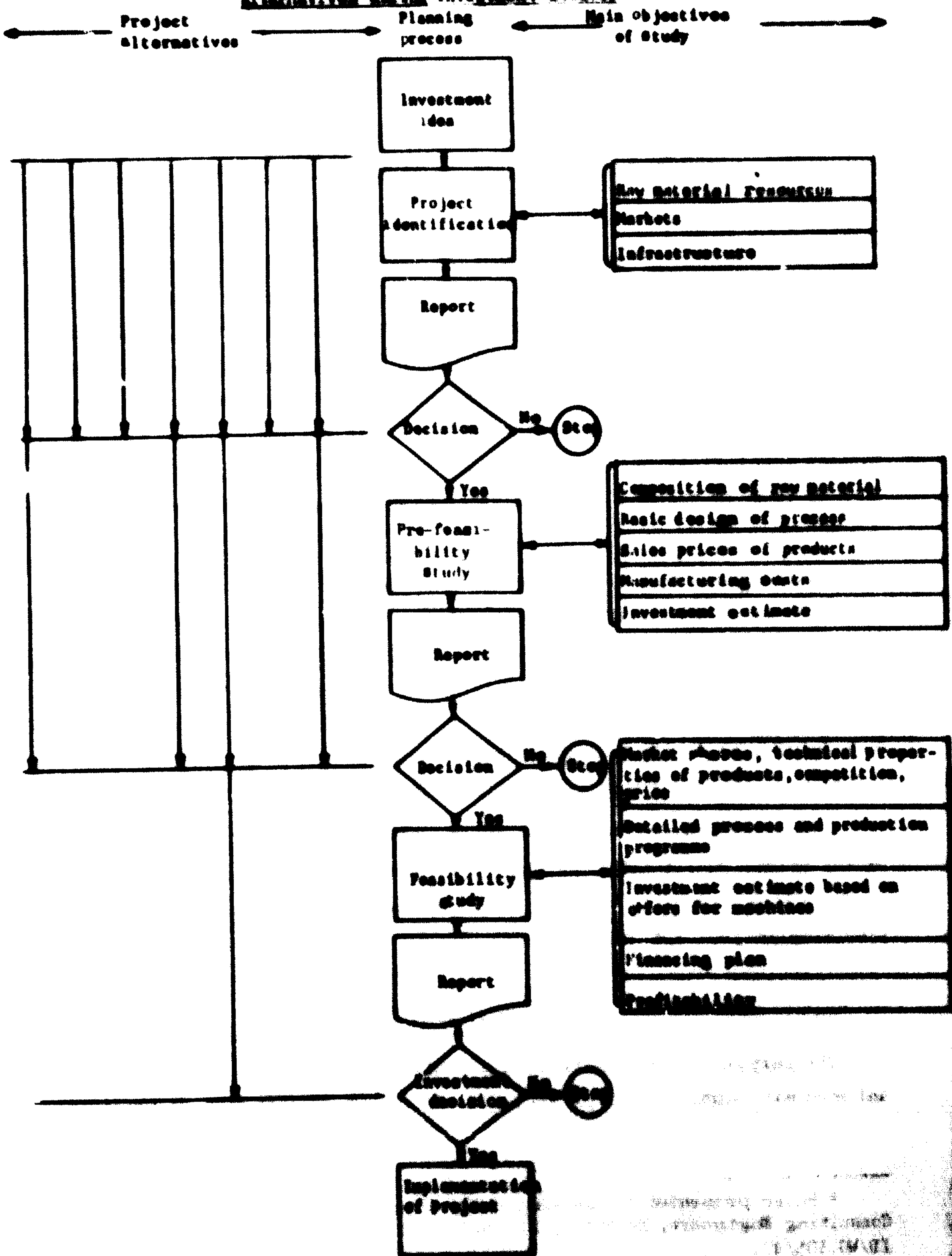
* Paper presented to the seminar by Antero Liusvaara, Jaakko Pöyry and Co, Consulting Engineers, Helsinki, Finland. (Originally issued as document ID/WG.105/40.)

Figure 1. Schematic representation of the selection of project alternatives during investment studies



by the furniture and joinery industries. The contents of a typical study of this kind is presented in the annex to this article. The economic evaluation of alternative projects is based on a detailed market projection, a reasonably complete raw material inventory and a description of the production programme and processes. The economic calculations provide a basis for establishing priorities between the identified alternatives for the projected mills, indicating their approximate profitability. The economic risks involved in the execution of the projects are indicated through sensitivity analyses.

Market survey

The market survey should include a description of the historical development of production, trade and consumption in the furniture and joinery industries. Based on this material, a projection is made concerning domestic demand, future production and foreign trade. Depending on the supply and demand situation, selected export markets are covered. The analysis includes such factors as prices, quantities and grades as well as incentives and barriers in foreign trade. The assessment of the competitive strength of the project is the most critical task of the survey. The survey should give a complete breakdown of the prospective markets of the projected mill, stating total sales to each area, sales prices, market shares and competitive position. The value of the project to the national economy should be pointed out in quantitative terms (export earnings/import substitution), since this consideration will be important when seeking financing.

Raw material resources

If properly performed, the resource inventory will be reasonably complete; at least the total volume will not be subject to change. Frequently, the results of special investigations related to raw material availability (for example, present consumption) are also accessible. Similarly, the availability of veneer and wood-based panels must be carefully investigated. (Above all, attention should be paid to the possibilities of using smaller and shorter pieces of wood.) The results of this survey will serve as a basis for the decisions to be made concerning the alternative possibilities of raw material utilization and concerning the possible location of the contemplated industrial units. The salient factors determining or limiting the supply of raw materials should be presented and evaluated in fairly great detail.

Technical description

Mill site study. No more than two or three mill sites should be considered. The relevant site factors should be subjected to a closer examination than in preliminary studies. The purpose of the study is to provide a basis for a technical and an economic comparison of the sites. The latter comparison requires an estimation of the unit prices of raw materials, power and services. The impact of the transportation of wood raw materials on the selection of the final mill site is considered. The maximum loads and capacities of transportation elements, such as road connexions, ports and existing eqipment, are evaluated in order to calculate the unit costs of transportation. Furthermore, it is necessary to make suggestions as to how the investment costs for infrastructure, such as for roads and community development, should be shared by the company and the government.

Production programme and process description. This section is intended to provide all necessary technical information required for the establishment of priorities between alternative projects, and thus to serve as a basis for a feasibility study. The programmes should constitute a rational synthesis of the information already compiled. Types of mills, end products, and capacities are specified. Block diagrams, process flow sheets, lists of major equipment, and general and departmental layouts are presented. A brief written description is called for in order to tie the elements together and to give the reader, who may be a potential investor, a clear concept of the process and the production lines. It is understood that only the key items of the process are studied and that the scope is just adequate for a comparative economic analysis. The production programme should define, in addition to the production rates of intermediate and end products and their specifications, the operating ratios of the various production lines during the first years of operation. As an example, the process flow in a joinery factory is shown schematically in figure II.

Economic calculations

Investment requirements. Based on the technical description, the investment requirements by department or function are determined, taking into account regional factors (coefficients or data collected for the project). The investment estimates are usually based on cost data obtained from the recorded;

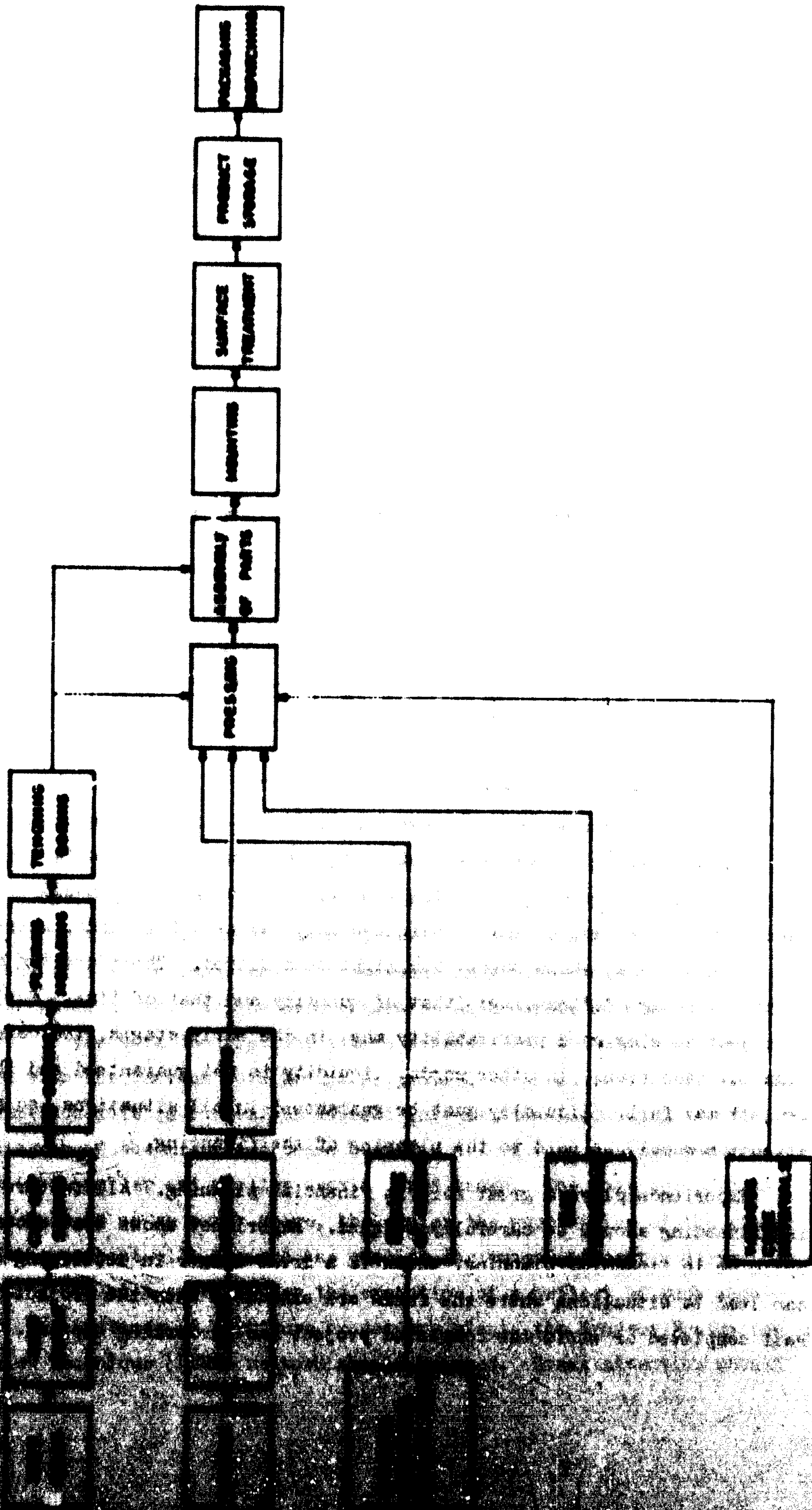


Figure 11. Schematic diagram of process flow in a joinery factory

and sometimes specifications for the main machinery can be given. The purpose of the investment estimates is to determine the total investment requirements of the plant at a given cost level. If required, the investment requirements are spread over a number of periods or divided into different groups for depreciation purposes. Furthermore, the assumptions regarding financing are considered.

Production costs. The annual production costs are calculated on the basis of the production programme and the process planned. Raw materials, packing materials, and the costs of energy and fuel are then taken into account as variables; wages, maintenance and administration are treated as fixed costs.

Profitability calculation and financial statements. The profitability calculation is done using the discounted cash flow method. Thus, the economic life of the project is usually considered to be fifteen years and the annual earnings are calculated for this period. The discounted cash flow rate is determined before and after taxes, both on total capital invested and on equity. A sensitivity analysis is performed for the assessment of the most critical profitability determinants.

Planning of project financing

The financing plan is an integral part of the economic evaluation of a project. It should be completed before the investment decision is taken; prior to that, the schedule for the execution of the project should be at hand. The investment estimate indicates only the need for funds, whereas the financing plan shows where they might be acquired. There are two aspects in the planning of financing: that of quantity and that of time. For example, a project showing good profitability may, in the early stages, indicate a negative cash flow; in other words, liquidity is not guaranteed and the project may fail. Liquidity must be guaranteed in all situations, so great attention should be paid to the planning of the financing.

Experience plays a great role in financial planning. All factors affecting financing should be carefully weighed. Experience shows that excessive optimism in financial planning, which is a great danger in developing countries, can lead to situations where the funds are exhausted when the project is only half completed or where the completed project has no working capital. Sound industrial projects for developing regions must not only be technically sound; they should also be economically secure. In addition, they should be able to produce early profits to both the investor and the economy.

Feasibility study

The feasibility study should contain all information required for making the investment decisions. Consequently, the report should convince potential investors that the project is technically, economically and financially viable and, if necessary, that the investment climate of the country satisfies potential foreign participants.

At this stage the comparison of feasible alternatives has already been carried out, and only one basic solution is proposed. The work is performed with specific investors in mind, so it also considers their concepts of the project. In principle, the structure of the feasibility study follows that of the pre-feasibility study, the difference being the depth of the presentation. Consequently, the report includes the same elements as the pre-feasibility study.

Execution of the project

On the basis of the information contained in the feasibility study, an investment decision is made, after which the planning of the execution of the project proper can begin. This phase generally starts with listing the work necessary for the execution of the project. In this connexion it should be emphasised that it is important to the execution of the whole project that the description of the various work phases be as accurate as possible. On the basis of the work description, a time schedule for the whole project is prepared with the various work groups programmed in chronological order. The total time schedule is thereafter divided into sections according to the block diagram of the mill, and these sections are in turn divided and subdivided into smaller and smaller sections and tasks. The more specific the time schedule is at an early stage, the easier the supervision of the execution of the project will be, and the smaller the amount of costly delay. In the working out of a schedule for the execution of a project of such magnitude as, for instance, a furniture or joinery plant, the Project Evaluation and Review Technique (PERT) network should be used. Great attention should have been paid in the early stages of the project to the so-called critical times, that is, to the amounts of time required for the execution of the work sections which, when exceeding the schedule, may delay the entire project. A typical project work model is presented in figure III.

In machine procurement, the investor can use various procedures, depending on the know-how available. Normally, the easiest way for the investor is to order total delivery, but the easiest way is not always the soundest one, neither economically or technically. If the investor himself has sufficient technical and economic know-how, and possibly using the services of a consultant, he can purchase the machinery item by item, acquiring the best and most suitable machines from various sources.

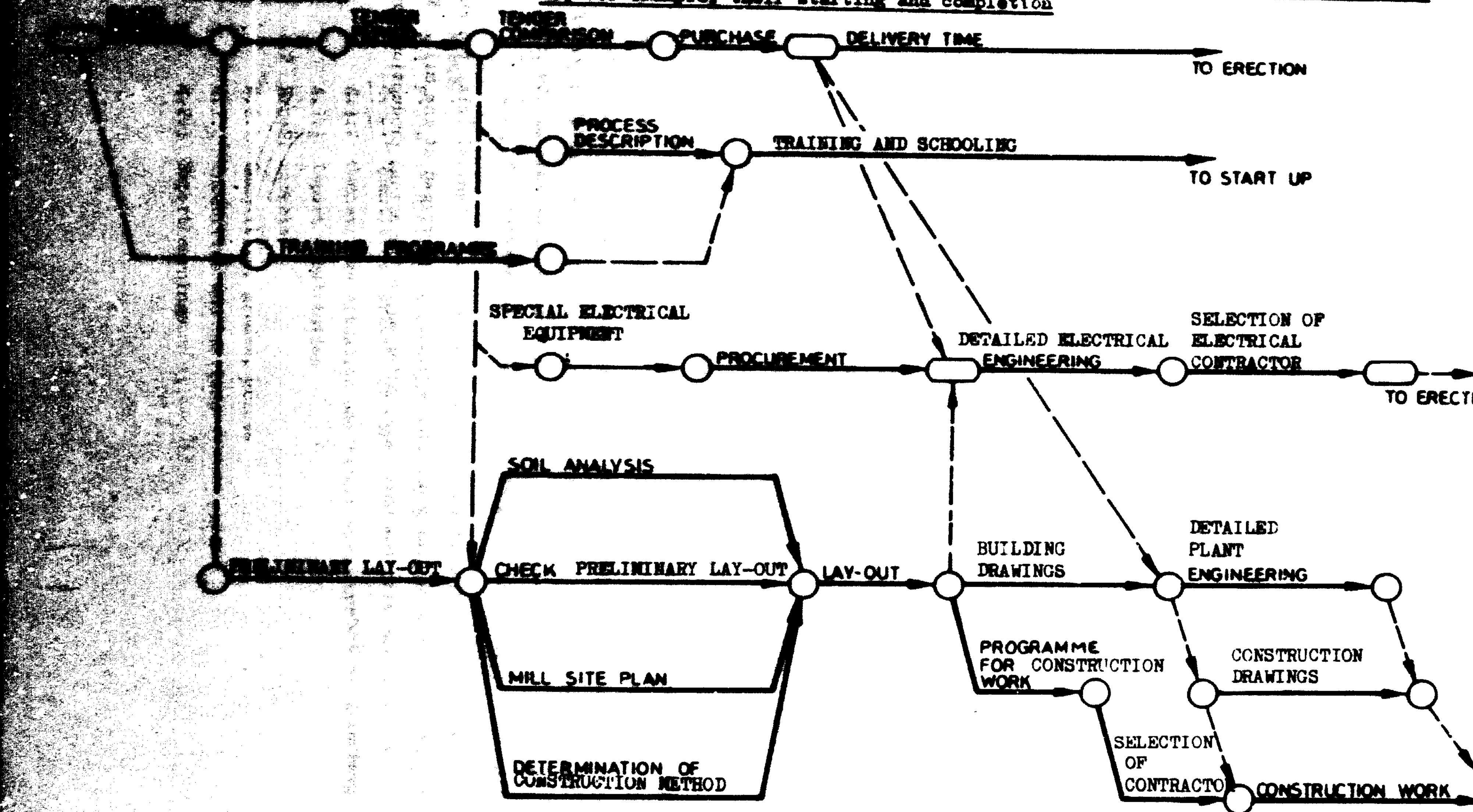
For planning, machine procurement and the like, the plant should be divided into departments according to production. Such departments in a furniture and joinery plant are, for instance:

Mill site area
Reception and intermediate storage of sawn goods
Drying of sawn goods
Woodworking department
Pressing department
Assembly and mounting department
Surface treatment department
Product storage and dispatch department
Power generation
Electrical equipment and instrumentation
Heating, water, air-conditioning and compressed-air systems
Social facilities
Knife-grinding and maintenance space

If the work required to execute the project is examined, it can be seen that the various steps can be placed in chronological order, although some of the activities are simultaneous and their duration may vary. This is done in the following list presented below, which in the main follows the basic information given in the feasibility study:

Soil analyses
Technical specification of machines and equipment needed for the process
Preparation of tender requisitions and their submission to the vendors
Preliminary block diagrams

Figure III. A typical project work model. The solid lines represent activities, and their lengths indicate their durations. The broken lines show the interdependence of two activities as, for example, their starting and completion



Final mill-site drawing

Specification of construction methods for plant buildings

Comparison of tenders for machines and equipment, and negotiations with vendors concerning technical and commercial details of tenders

Commencement of electrical and instrumentation layouts

Preliminary investment budget

Final preparation of block diagrams and preparation of construction cost estimate

Purchase of main machinery and equipment

Process description and preparation of department layouts

Preparation of specifications for building subcontracts

Checking of cost estimates for buildings

Start of construction

After this, the technical details are checked during the construction phase.

In addition to the actual technical engineering, plans for hiring personnel and, if necessary, for their training, must be initiated from the very start of the project. The training period should end when the erection phase begins, so that the employees may participate in the erection, together with the representatives of the machine suppliers. They can thus quickly and most efficiently acquire the special knowledge of the work, on the machines and the equipment that they will need when the mill goes into operation.

On completion of the plant buildings, the erection of machinery and the general installation of electrical, water, heating and air conditioning systems for the plant building are started. The installation of the compressed air system and of sprinkler and other fire protection equipment is also begun. When the erection of machinery is nearing completion, the installation of electrical and compressed air lines for the machines as well as the installation of chip and dust extraction systems can be started.

When the erection phase has been completed, a mechanical trial run and adjustment of the machinery and the equipment is performed at the mill. Next is the trial run with raw materials, after which the actual production can gradually be begun.

Annex

CONTENTS OF A TYPICAL PRE-FEASIBILITY STUDY

1. OBJECTIVES AND SCOPE OF STUDY
   - 1.1 Terms of reference
   - 1.2 Justification of project

2. SUMMARY
   - 2.1 Conclusions
     - 2.1.1 Suitability of fibrous raw material resources
     - 2.1.2 Production programme and processes proposed
     - 2.1.3 Economic aspects (markets and marketing, investment requirements and profitability, analysis of risk)
   - 2.2 Recommendations
   - 2.3 Time schedule for project implementation (Mini-PERT)

3. CULTURAL, POLITICAL, AND ECONOMIC BACKGROUND
   - 3.1 Geography, climate, population
   - 3.2 Education, social institutions
   - 3.3 Political system
   - 3.4 Economy
     - 3.4.1 Structure and growth
     - 3.4.2 Foreign trade
     - 3.4.3 Economic integration
     - 3.4.4 Development policies and trends

4. MARKETS
   - 4.1 Projected domestic demand and market structure
     - 4.1.1 Quantities, grades, prices
     - 4.1.2 Competitive situation and market structure
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     - 4.2.2 Incentives and barriers
     - 4.2.3 Export earnings

5. RAW MATERIAL RESOURCES

5.1 Forest resources

5.1.1 Natural forests

5.1.2 Plantations

5.2 Other raw materials

5.3 Logging and transport of timber

6. TECHNICAL DESCRIPTION

6.1 Mill sites

6.2 Production programme and process description

6.2.1 Programme

6.2.2 Mill descriptions

6.2.3 Materials handling at the mill

6.2.4 Heat and power, water and effluent disposal

6.2.5 Personnel requirements and training

7. ECONOMIC CALCULATIONS

7.1 Investment requirements

7.2 Production costs

7.3 Profitability and sensitivity analysis, cash flow statement

7.4 Financing budget and pro-forma balance sheets

7.5 Economic evaluation

8. LEGAL ASPECTS

16. PLANT LAYOUT*

By the term plant layout is meant the general organization of production and the placement of machines, equipment and working places as well as the planning of internal transport and of the factory building itself in a way that will provide optimal conditions for the manufacturing process.

The following degrees of plant layout can be distinguished in respect to the comprehensiveness of the task:

Complete planning of a new plant

Necessary changes of plant layout when moving into an existing factory building

Rearrangement of an existing factory within a total plan

Minor rearrangements in various sections of a plant

The principles of plant layout presented below are independent of the branch of industry and are generally applicable to any kind of plant or establishment (for example, a service station, a farm, a kitchen or a photographic laboratory). Plant layout must not be understood only as a one-time process but rather as a continuous activity that is necessary to maintain the ability of the enterprise to compete.

Objects of plant layout

The main objects of plant layout can be divided into following groups:

Working methods and places

Their placement into operating sequence

Planning machine groups and sections

Locating different sections at appropriate places

Designing factory buildings around machines and processes

Designing electrical installations and pipe networks (water, heating, steam, sewage disposal, compressed air, chip and dust extraction etc.)

Installation of a power plant (or supply)

Planning handling of waste

Laying out the factory area

*Paper presented to the seminar by Pekka Paavola, Lahti Technical Institute, Lahti, Finland. (Originally issued as document ID/WG.133/27.)

Starting point for plant layout

The basic prerequisite information for layout planning is:

- Present and projected production programme
- Type, construction and materials of products
- Desired quality standard
- Desired production capacity

Special characteristics of production in the furniture and joinery industries

Important characteristics of the furniture industry that affect layout planning are the following:

- The product assortment is usually large
- Production runs tend to be rather small
- The life of most designs is short
- Continuous production of the same models is seldom possible
- In addition to solid wood or timber, many wood-based semimanufactures such as plywoods, as well as plastics and metals, are used as raw materials

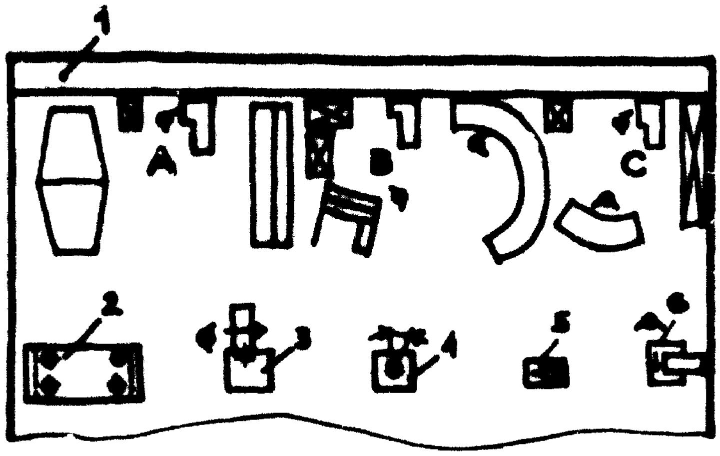
In the joinery industry, the assortment of products is considerably smaller than in the furniture industry. Although product size is variable, as with windows and doors, many products are standardised - at least in Finland - so their continuous manufacture is often possible. Consequently, a joinery factory is often easier to design than one for furniture. The life of the products (e.g. flush doors) is long, and the principal raw material is solid wood.

Arrangement of production

The following principles of arrangement can be distinguished:

- Stationary working places as in the manufacture of fixtures (figure I)
- Arrangement according to manufacturing method; for example basic wood-working machines in the furniture industry (figure II)
- Production lines (figure III): separate working places (e.g. machines) in line according to successive work stages (top), a conveyor-belt line such as in furniture assembly (centre) or semi-automated or automated production lines (bottom). (Sequential automation is common in the furniture and joinery industries)

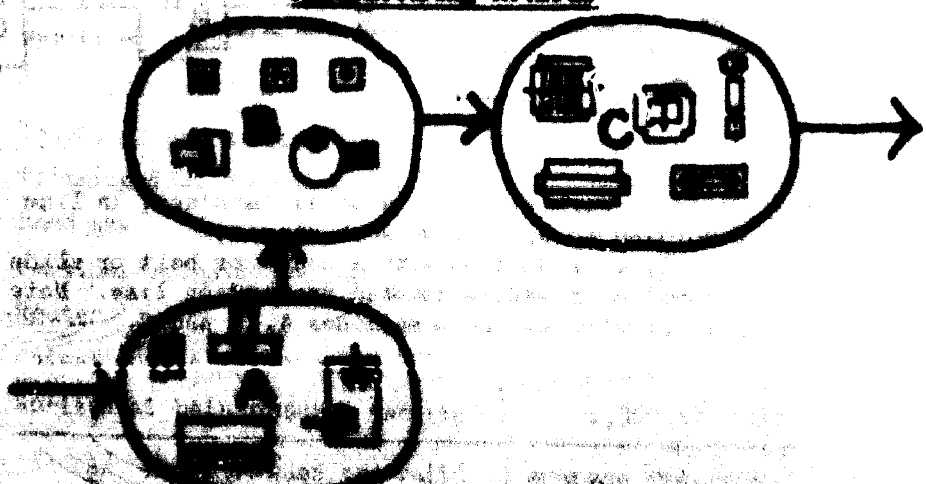
Figure I. Production with stationary working places



Key: 1, drafting and plan table;
2, single-opening press;
3, circular saw with feed table;
4, vertical spindle moulder with tilting table;
5, horizontal boring machine;
6, band saw;

A, boring and mortising machines;
B, moulders and routers;
C, sanding machines.

Figure II. Production arranged according to manufacturing methods



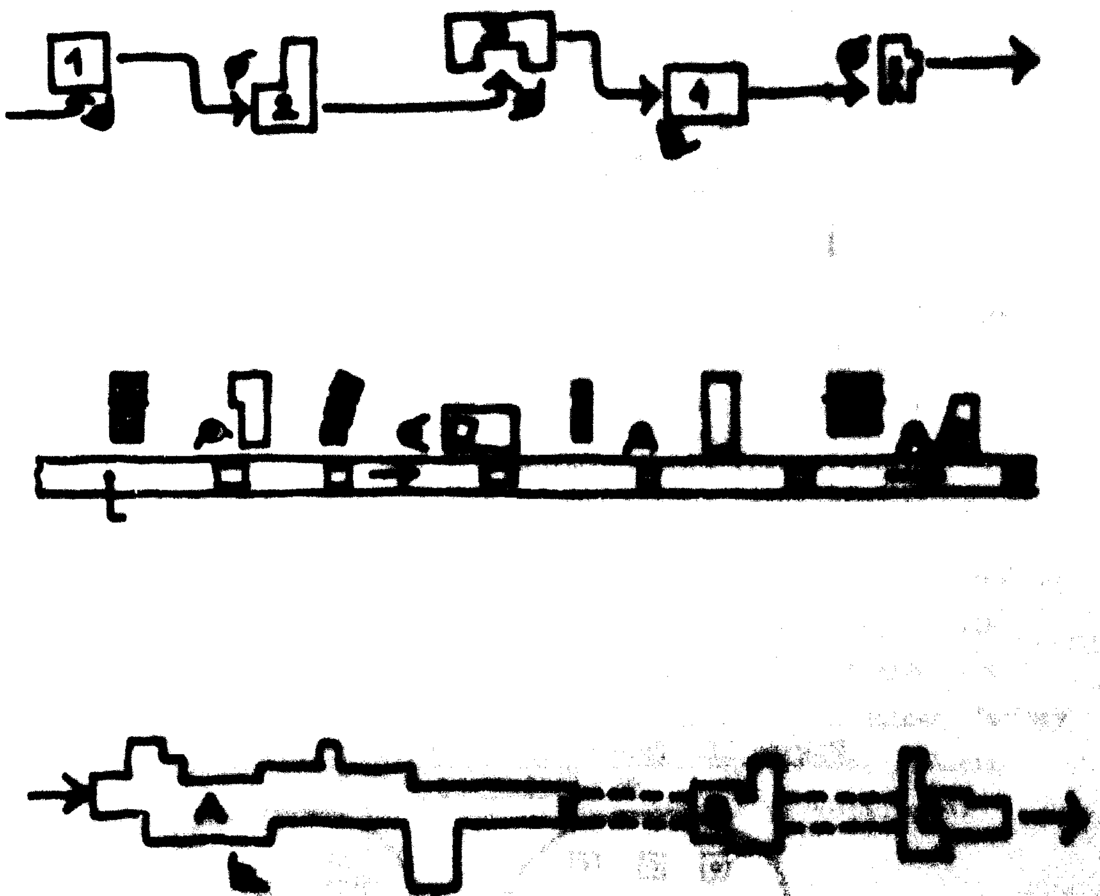
Key: [illegible]

Figure III. Production lines

(a)

(b)

(c)



Key: (a) separate work stations, such as machines, in line according to successive work stages
(b) flow-line production with a conveyor belt or [illegible]
(c) automated or semi-automated production lines [illegible] one operator controls machines [illegible]

Production capacity

In conventional production, using a set of separate machines and equipment, the machining or manufacturing capacity of the entire line is determined by the output of the least productive unit in it (that is, the bottleneck). This means that a machine or piece of equipment can operate at 100 per cent capacity while any or all of the other equipment is operating under capacity. The bottleneck can be removed only by the addition of another machine at this critical point. There will be two results: first, the over-all capacity of the equipment will be increased, and second, the bottleneck will later appear elsewhere in the line. Thus, in conventional machine lines, capacity can be increased only in multiples of the outputs of single machines.[1]

The requirements of a machine line can be estimated either on the basis of the number of machining hours per machine per year for a given production programme or on the wood-handling capacity (expressed in cubic metres per year) of the individual machines (see table). In an automated line, however, the capacity is the same throughout.

Average capacities of some basic woodworking machines[a]

Machine	Cubic metres/year
Cross-cut saw	2,300
Edging saw, chain fed	2,300
Surface planer	1,400
Thickness planer	4.7/mm in width
Four-sided moulder	2,300 to 4,700
Trimming saw, single-blade	1,400 to 1,900
Trimming saw, double blade	2,800 to 3,700
Band saw	2,300 to 4,700
Vertical spindle moulder	700 to 1,400
Router	2,300
Chisel mortising machines	1,400 to 1,900
Horizontal belt sanding machine	1,900 to 2,800

a/ These values are valid in average furniture production where different kinds of furniture are manufactured of solid wood in single-shift operation.

1/ See the final section, Production design, of article 14 (Pekka Paavola "Furniture product design").

Production flow

In general, the flow of production takes one of the five following forms: straight-line, zigzag, U-shaped, ring-shaped or odd-angle (figure IV).

Means and facilities for plant layout

The most important means and facilities for plant layout are:

- Internal standardization (of products, of materials, of working methods, of parts of factory buildings and of factory equipment and fixtures such as transportation pallets, storage shelves, workbenches and tool cabinets)
- Operation process charts, machine operation charts, schemes and drawings (figures V and VI)
- Scale models (figure VII)

The practice of plant layout

It is advisable to begin layout planning by drawing up, on 1-mm graph paper, a floor plan of the plant building, showing the walls, pillars and other construction details with limiting effects. (The usual scale of such building drawings is 1:50.) This done, one fills in the placement of the machines, equipment, conveyors, passages, storage areas and so on. This is best done with the aid of scale models of the various items. These can be cut from fibreboard covered with 1-mm graph paper or from coloured cardboard. When needed, three-dimensional models can be carved from a soft wood such as balsa or from polystyrene foam.

In many cases the production of a factory can be divided into two distinct parts or lines:

- The solid wood line (chairs, legs, rails, drawers etc.)
- The panel line (cabinet parts, table tops etc., components made from semi-manufactured boards)

A common practice that has proved advantageous is to place machines of similar function (in respect of working principle) into groups, as follows:

- Cross-cutting saw and edging saw
- Planing machines
- Tenoning machines
- Mortising and boring machines

Figure IV. Five patterns of production flow

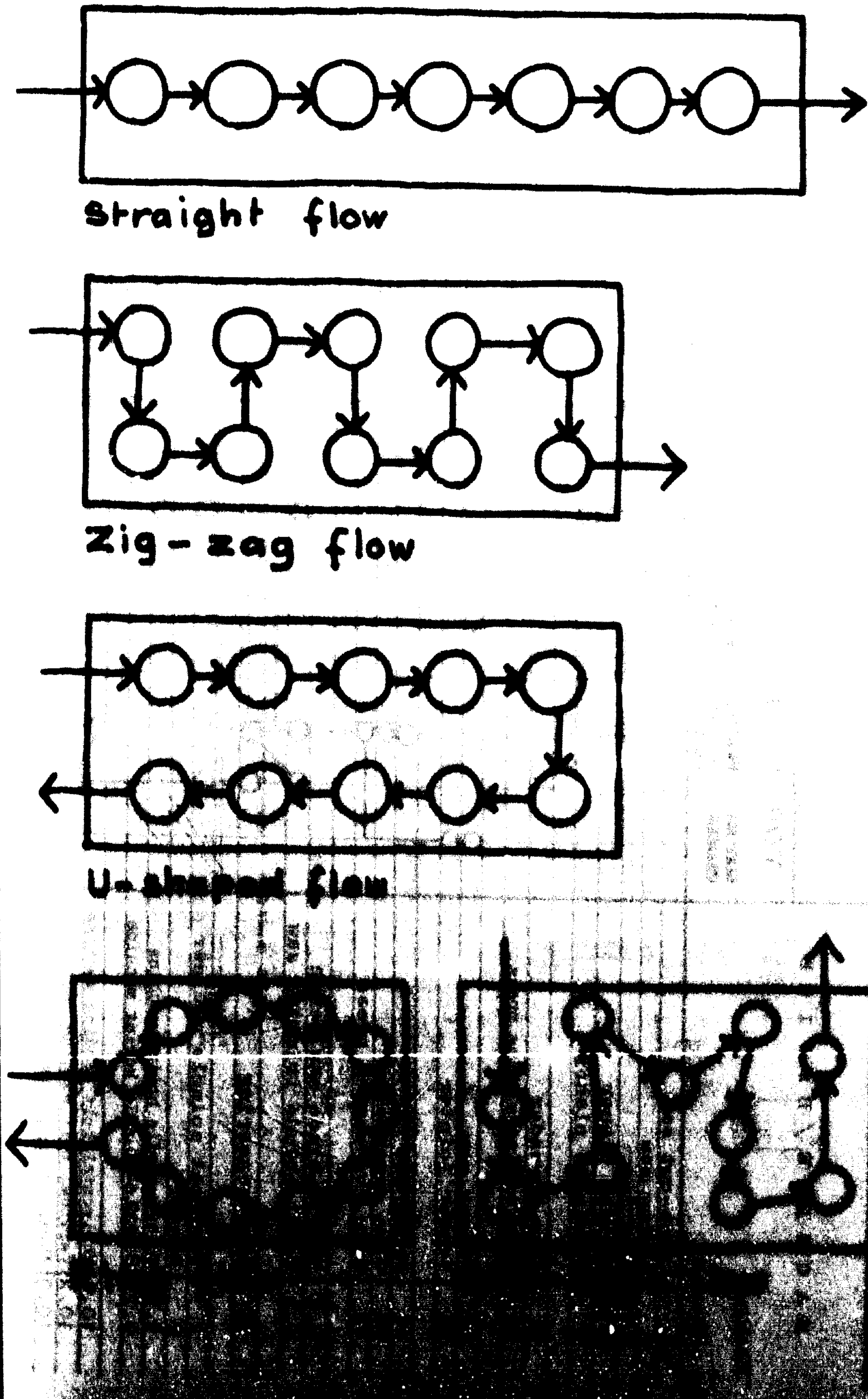
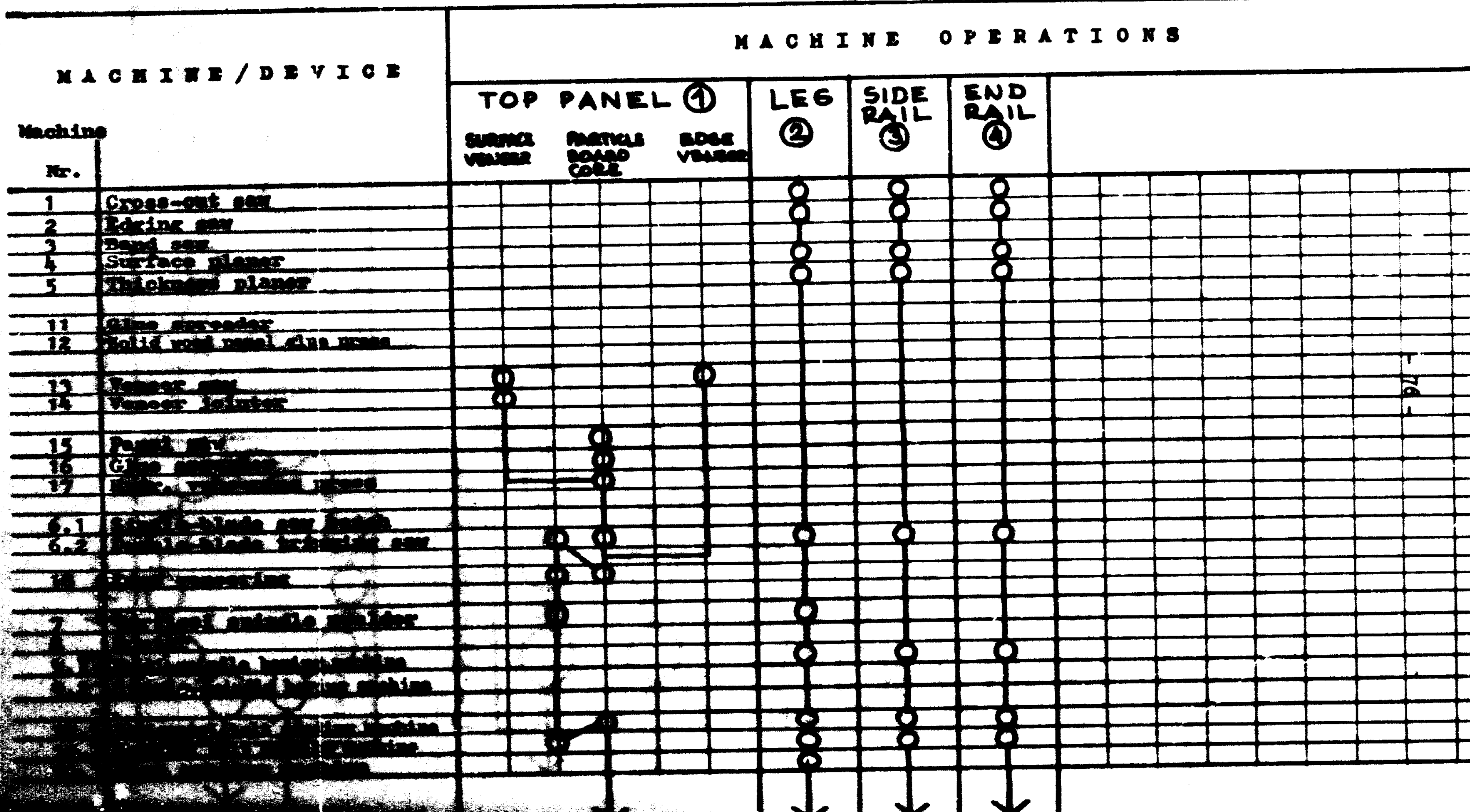


Figure V. A typical machine operation chart
(Operations refer to the production of the table shown in figure XIV of article 14 (Pekka Paavola "Technical product design")



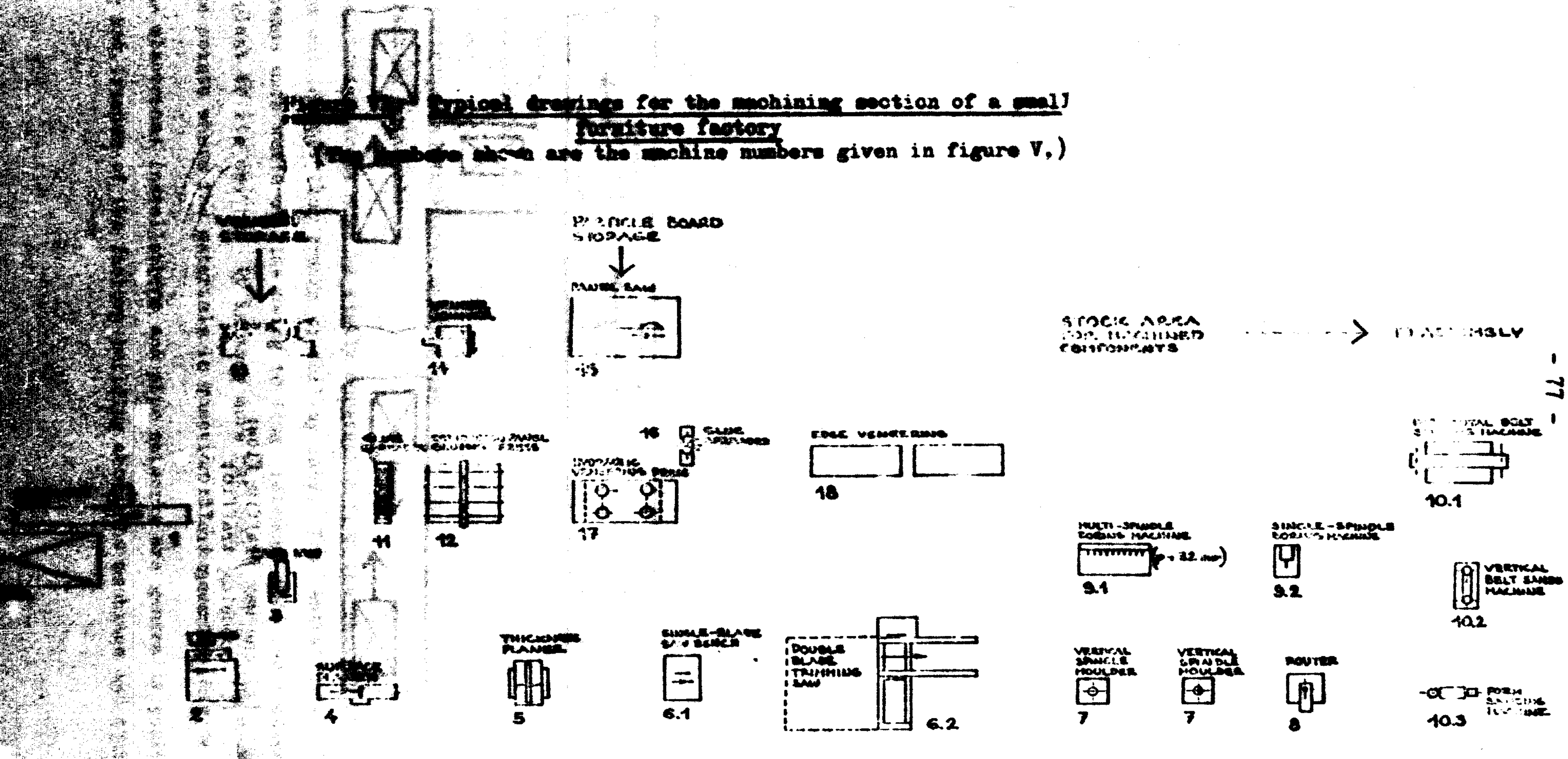


Figure [illegible] Typical drawings for the machining section of a small furniture factory
(The numbers shown are the machine numbers given in figure V.)

Figure VII. Scale models (1 : 100) of some typical woodworking machines

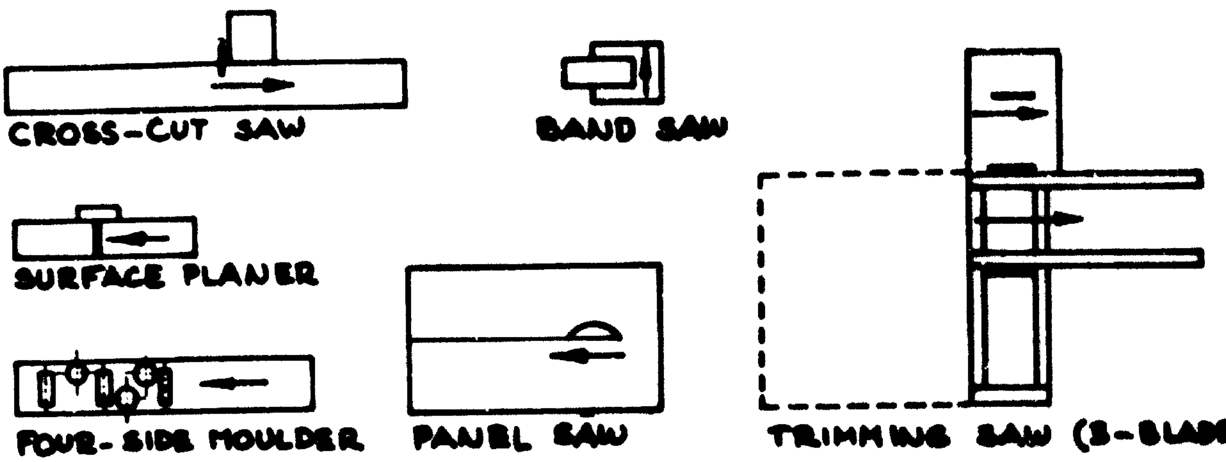
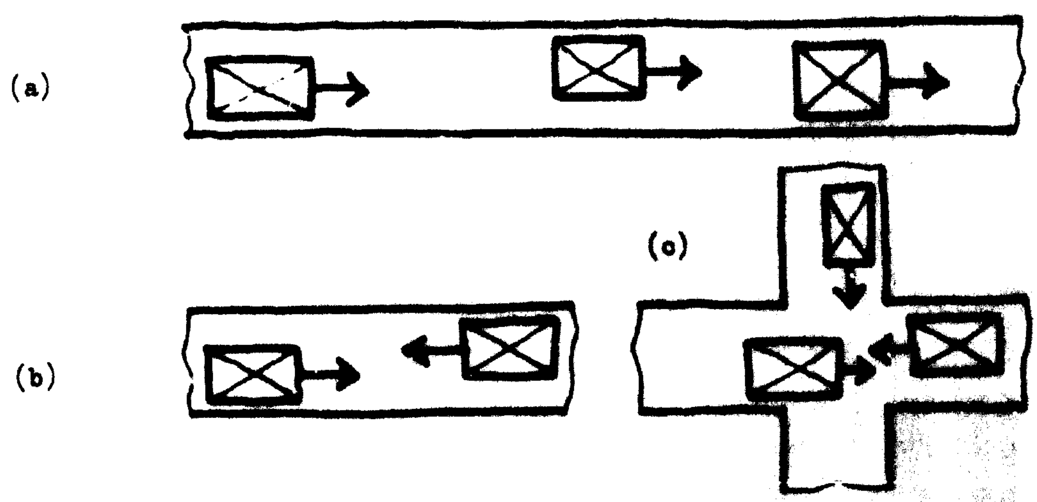


Figure VIII. Pallet transportation in factory passages



Key: (a) one-way traffic flow;
(b) opposing traffic;
(c) crossing traffic.

Vertical spindle moulders and routers

Sanding machines

Veneering machines

In the furniture industry, internal transportation is mostly done with pallets and hand-operated lift trucks. This system is very flexible and thus well suited to furniture manufacture. Roller tables and motor-operated fork lift trucks are also used in joinery industry. The conveyors used in surface-finishing shops are usually of a special type and thus unsuited to other stages of production. The modern tendency, especially in the furniture industry, is to do surface finishing before assembly.

The direction of load transportation (on pallets) must continuously follow the same direction on factory passages. Opposing and crossing traffic must be avoided (figure VIII).

The areas needed for storages of various kinds are always noticeably large in furniture and joinery factories; roughly one half of total factory area in many plants. Two kinds of storage areas are needed for components and products under manufacture:

Intermediate storage between different work stages (free floor area between machines or other work places)

Storage areas between main manufacturing stages (as for machined parts, assembled products, finished parts and finished products)

Further storage facilities are needed for the following items:

Kiln-dried timber

Veneers

Semi-manufactured boards, plywood, plastic laminates etc.

Glues

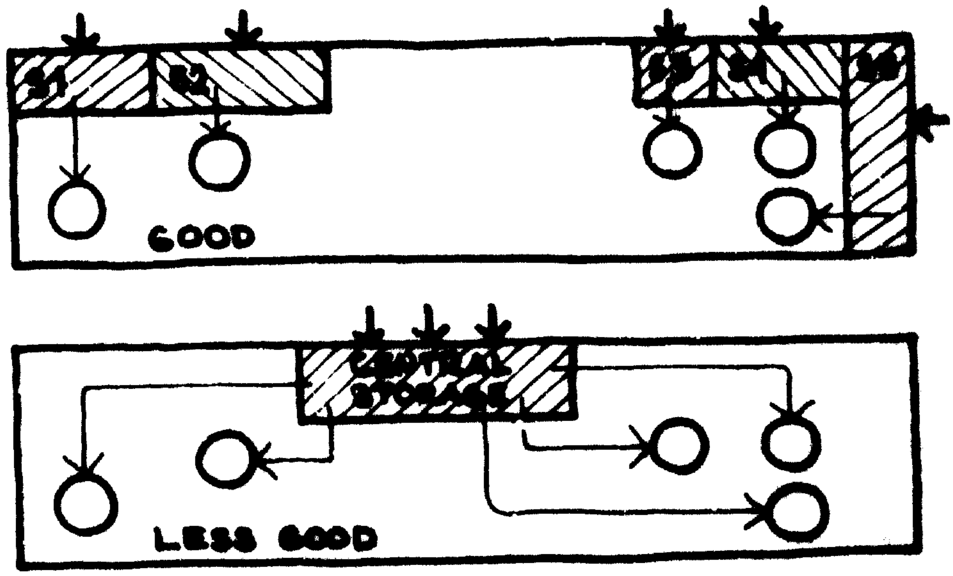
Fittings and hardware, sanding materials etc.

Packing materials

The storage areas must be easily accessible from the factory side by workers and from outside by motor trucks or railway cars. Too centrally located storage areas cause much waste of time owing to long distances from the remoter parts of the plant to its centre. It is thus more rational to place the storage areas near the points where the materials in question will be needed (figure IX).

The electrical installations and pipe networks are generally positioned in the ceiling and trusses of the factory building above the machines and equipment so

Figure IX. Location of storage 'reas. The dispersed areas shown above are to be preferred to the single central one shown below



as to facilitate later rearrangements. Safety must be taken into consideration in all details of plant layout.

The factory building

The principal characteristics of modern factory buildings in the furniture and joinery industries are the following:

The buildings are on one level. This avoidance of vertical transportation permits cheaper foundations and easier future enlargements

The buildings are rectangular in form. In large buildings, natural illumination through skylights is possible. In practice, however, electrical illumination is of decisive importance

Partition walls between sections are avoided (except in the surface-finishing section). It is especially for this reason that factories are provided with sprinkler networks

Pillars are avoided whenever possible

The number of corners must be kept to the minimum

Future enlargements are taken into consideration from the outset

Factory area

Among other things, the planning of the factory area includes consideration of the following details:

Positioning of the factory building on the lot in such a way that future enlargements will be possible. It is advantageous if the starting point of production can be maintained in its position in spite of enlargements

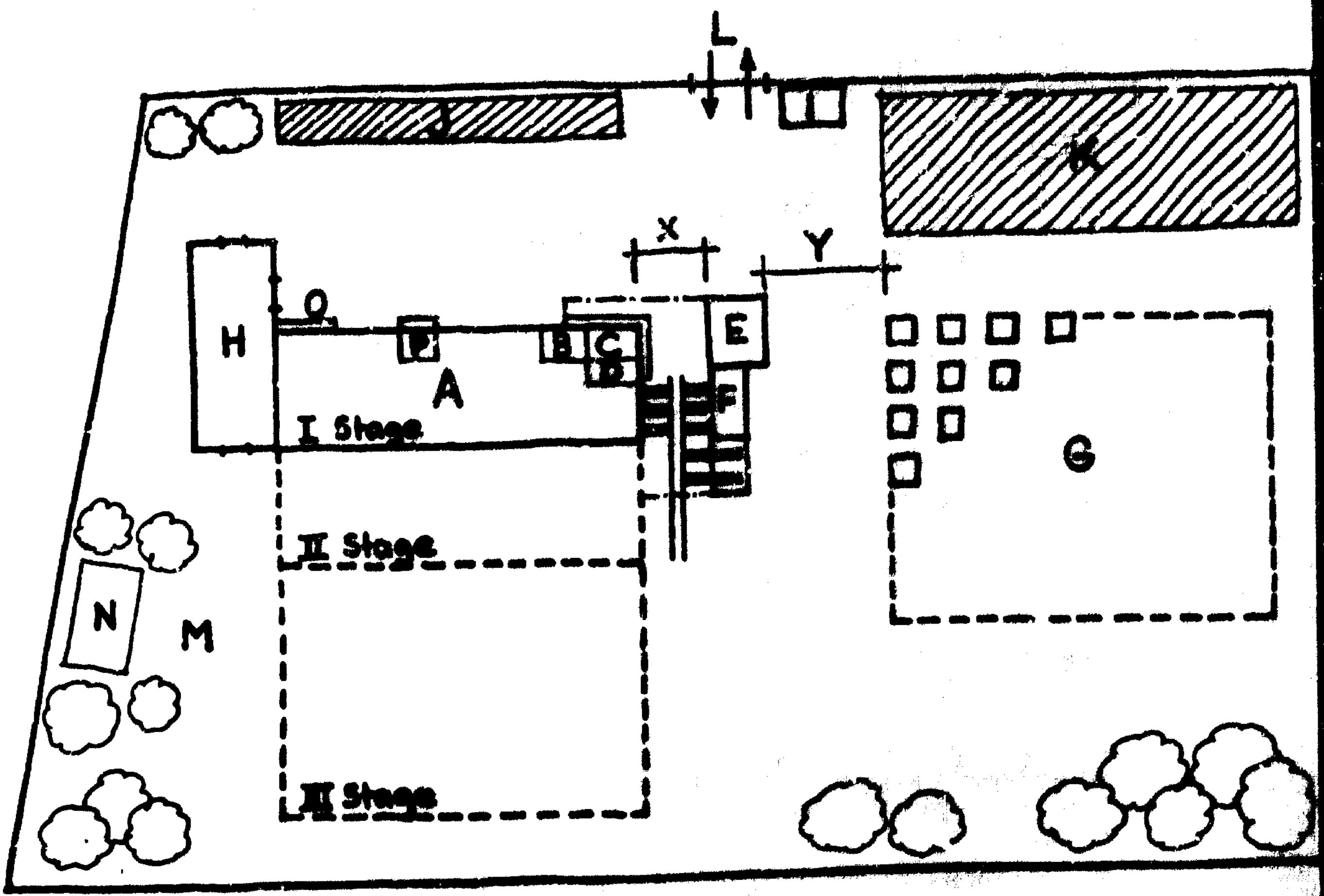
The placement of the timber yard and outer storage areas so as to minimize transportation problems

Organization of a traffic plan within the factory area for the movement of people, raw materials, finished products etc.

Provision of office space, either in the factory or in a separate building

A good example of factory layout is presented in figure X.

Figure X. A well-planned factory area



Key: A, factory building;
B, panel storage;
C, veneer storage;
D, storage area for kiln-dried timber;
E, boiler house;
F, drying kilns;
G, timber-storage yard;
H, office building;
I, gate-keeper's booth;
J, parking for office staff and visitors;
K, parking for workers;
L, factory gate;
M, lawn;
N, recreation field;
O, loading dock for finished products;
P, storage for fittings, hardware etc.;
X, permissible distance between heating plant and factory;
Y, permissible distance between heating plant and timber storage;
I Stage, original building;
II Stage and III Stage, space for successive expansions of the factory.

17. FURNITURE INDUSTRY TECHNOLOGY*

Special features of the furniture industry

The products of furniture industry represent the highest degree of refinement as compared with the products of other secondary wood-processing industries. The key characteristic of furniture products is that their external appearance has a decisive effect on their ability to compete on the market. In the climatic conditions of northern Europe, the demand for furniture is seasonal. Furthermore, furniture sales are considerably affected by fashion, which means that the life of a particular design is often very limited. Furniture manufacture can seldom be real mass-production, because consumers want their homes to have individuality. A reflection of this is the large number of wood species that are used for veneering or as solid components. In many cases they are lacquered in natural colour or stained in different shades. At the moment furniture painted in bright colours is also very popular and fashionable.

The greatest production problem in most furniture factories is, however, the great assortment of items. In many cases the different kinds of workpieces in various phases of machining may be numbered in many hundreds or even thousands.

A solution to this problem is specialization; this means limiting of the production programme in one way or other. The basis of specialization can be, for instance:

Kind of product (for example, a factory may specialize in chairs only)
Product group and end-purpose of the product (home, office etc.)
Raw material and construction (solid wood, particle board etc.)
Manufacturing method (special machines or techniques)

Another very practical method is to use subcontractors from whom such parts can be ordered that are not suited to the production programme of a particular manufacturer. In this case, furniture plants are assembly operations.

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*Paper presented to the seminar by Pekka Paavola, Lahti Technical Institute Lahti, Finland. (Originally issued as document ID/WG.105/35/Rev.1.)

Mode of production

Furniture is almost without exception made in series production. The number of items made at the same time usually varies from a few hundred to a few thousand, depending on the kind of product. The following features are characteristic of series production of furniture:

- Stock or storage areas are needed between the different phases of manufacture (figure I)
- Transport costs make up a significant proportion of production costs
- The components are usually transported on pallets using hand-operated hydraulic lift trucks. This method of transport is the most flexible in series production
- Belt conveyors and other types of conveyors can be used to a limited extent only (assembly, surface finishing) because of the great variety of items normally produced

The manufacture of furniture as a continuous process is, of course, possible in principle. In this mode of production, manufacturing is done in a fixed production line without stock areas. This, however, would require a large expansion of the market. In any case, a clear trend towards extended use of machine lines and automated production in recent years can be noted.

Accuracy of manufacture

The accuracy of woodworking machines is, at the most, ±0.05 mm when the bearings are new. The actual accuracy of working pieces in practice is ±0.1 to ±0.3 mm, taking into account the changes in dimensions resulting from variations in moisture content during the manufacturing process.

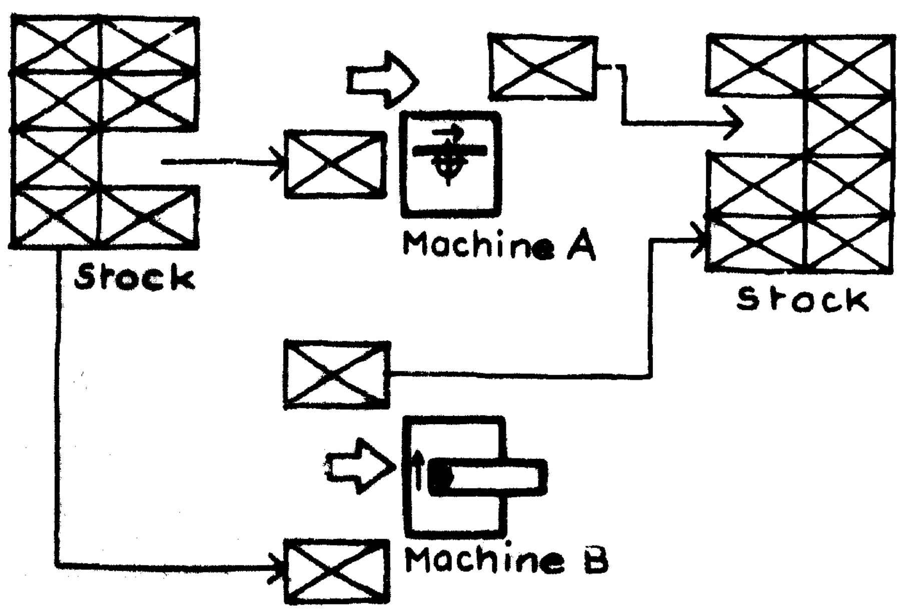
The advantages of a high accuracy in manufacturing are the following:

- Parts of products belonging to different series are interchangeable
- A sliding fit between parts is possible without manual fitting in assembly
- Joints are strong and easy to assemble
- Manufacture in large series is possible

In order to achieve high accuracy, the following measures are taken:

- The machines are regularly serviced according to their working instructions
- Dimensioned working drawings are used throughout. The numerical values indicate the nominal dimension to be achieved

Figure I. Stock areas between different stages of manufacture



Gauges and templates are used to control the dimensions during machining (figure II)

Jigs are used in machining and assembly whenever possible (figure III)

Drying of timber

At present, timber is usually dried in sawn lengths before cross-cutting, thus minimizing the loss of material owing to end checks. The drying kilns are in a separate building or in connexion with the factory building itself. The kiln charges are usually transported by means of wagons on rails.

The arrangement of phases of work in machining

The order of machining phases of different parts in furniture manufacture is generally that indicated in figure IV.

Machining

In machining, special attention should be paid to the following points:

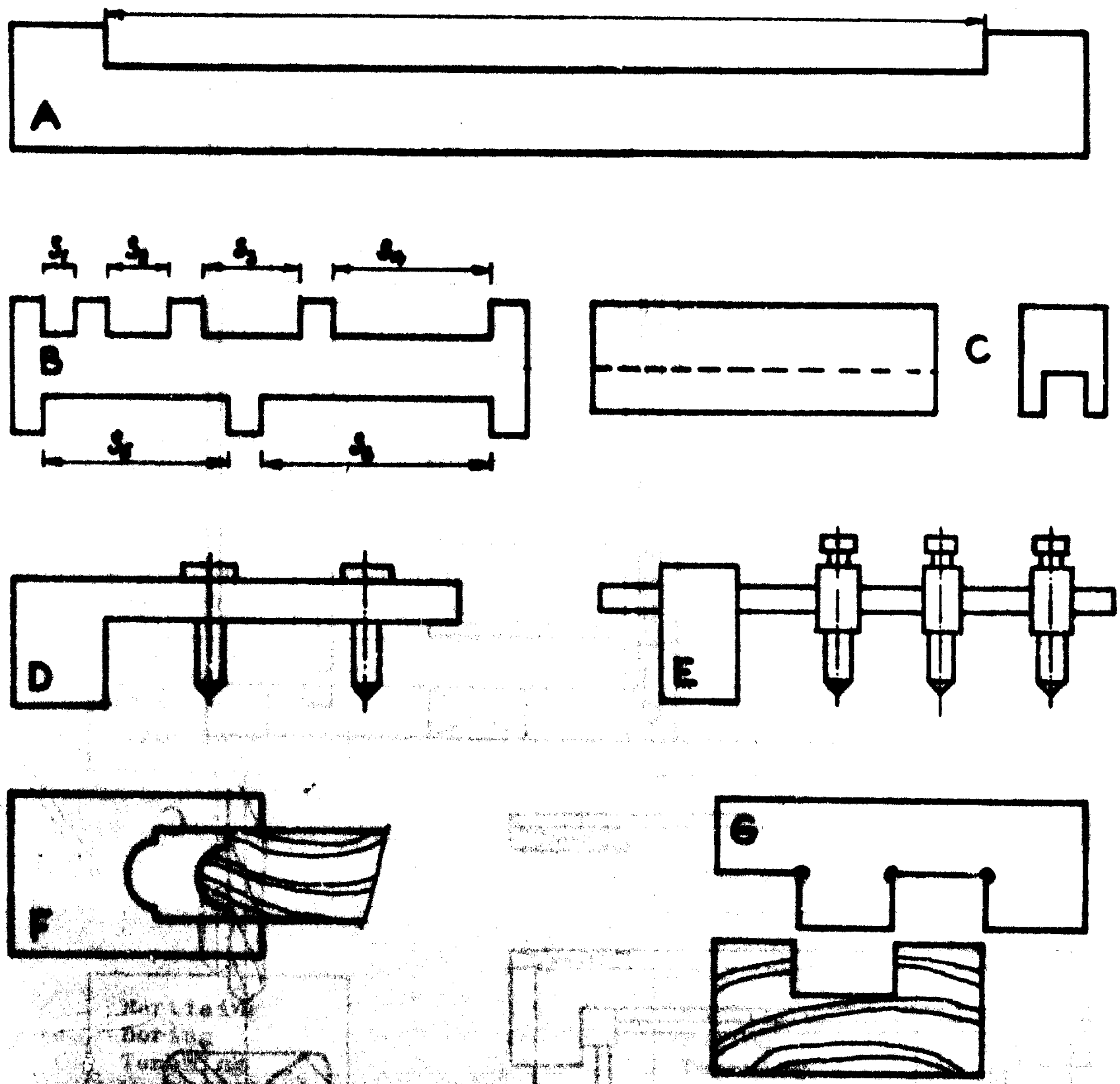
- Whenever possible, the machining should be done in continuous through-feed. This must be taken into account in the design phase
- Protective devices must always be used
- A chip and dust exhaust system is a necessity
- The use of tungsten carbide-tipped tools is advantageous, especially when machining particle boards and very hard woods. Proper tool maintenance is of prime importance
- The correct choice of feed speed strongly affects the quality of the finish
- Automatic feed attachments (figure V) increase the machine capacity, quality of finish and safety
- Machines with many working heads (such as four-sided moulders and double-end tenoners) are advantageous with large series. In small-scale production the setting costs are too high

Some of the most important machining phases and their special features are treated briefly below.

Cross-cutting and ripping

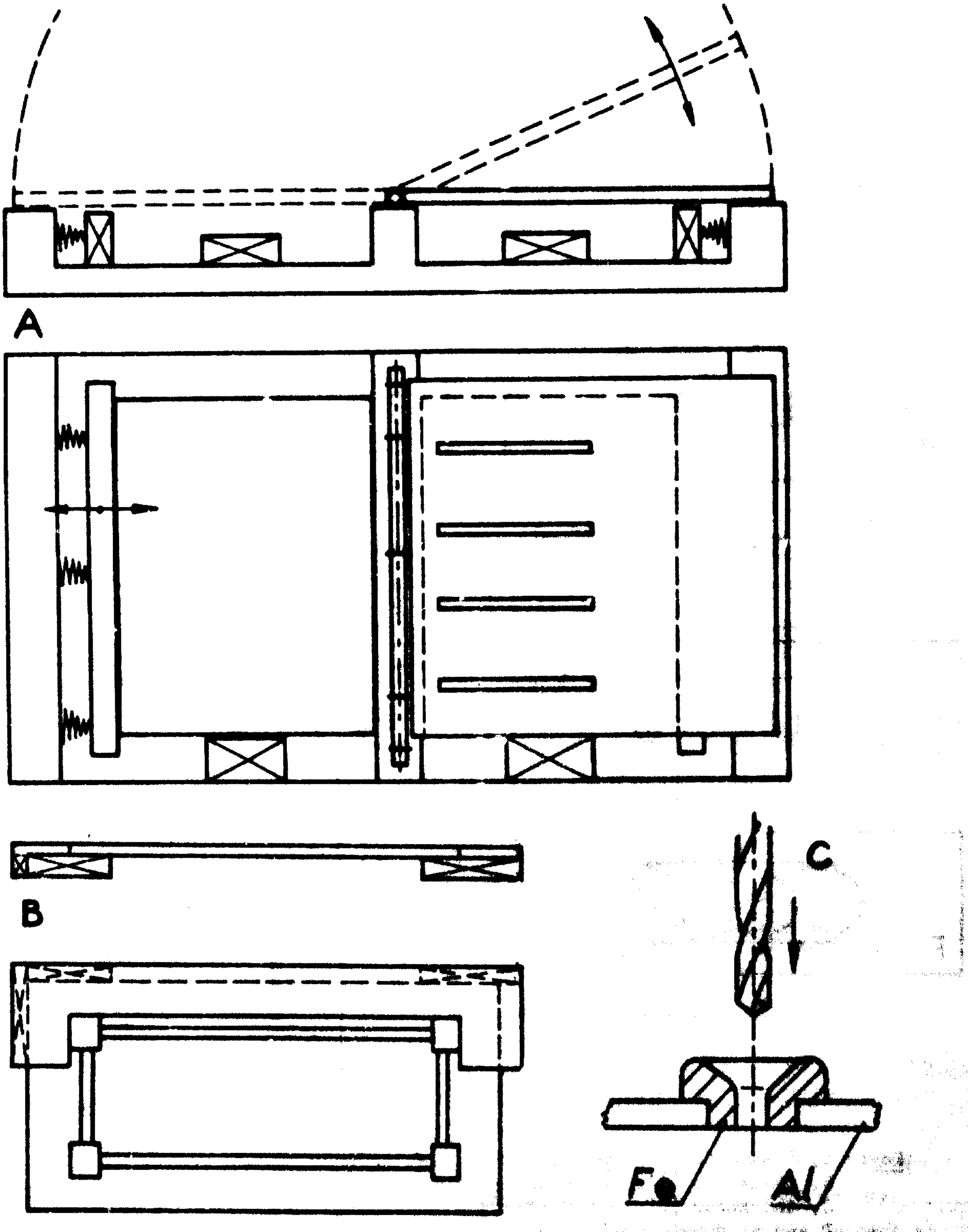
Cross-cutting is done usually with a machine having a circular saw moving horizontally. The timber to be cut is usually loaded on a wagon that can be lifted pneumatically or hydraulically (figure VI). The operator must possess a

Figure II. Gauges and templates for various measuring purposes



Key: A. length (for trimming);
B. thickness (for thickness planing);
C. thickness (of tongue etc.);
D and E. dowel joint pitch;
F and G. profiles.

Figure III. Three jigs used in furniture machining and assembly



Key: A, jig for wooden assembly of drawer-supporting strips by staple gun on the inside surfaces of the left and right panels of the drawer unit; B, assembly jig for fixing a cabinet base; C, detail of a boring jig.

Figure IV. The order of machining phases in a furniture factory

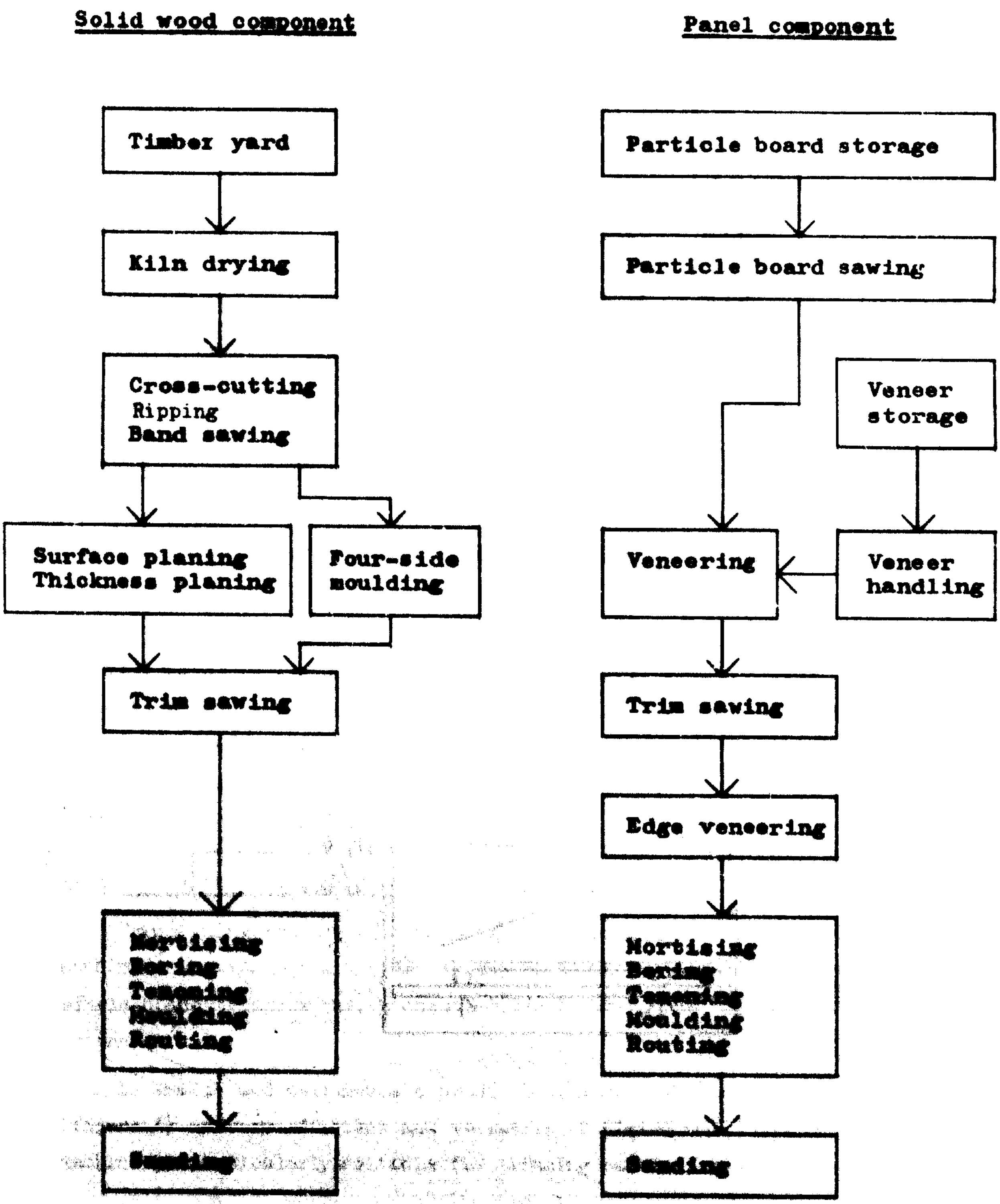


Figure V. Placement of an automatic feeding attachment for a surface planing machine

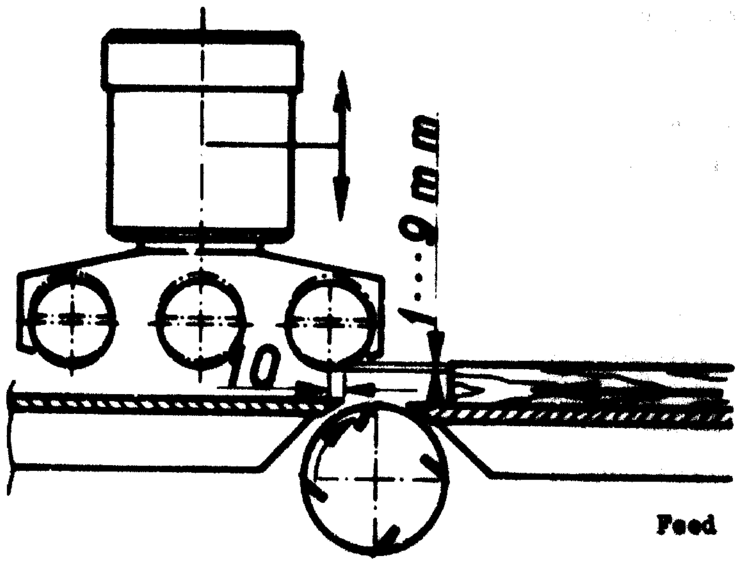
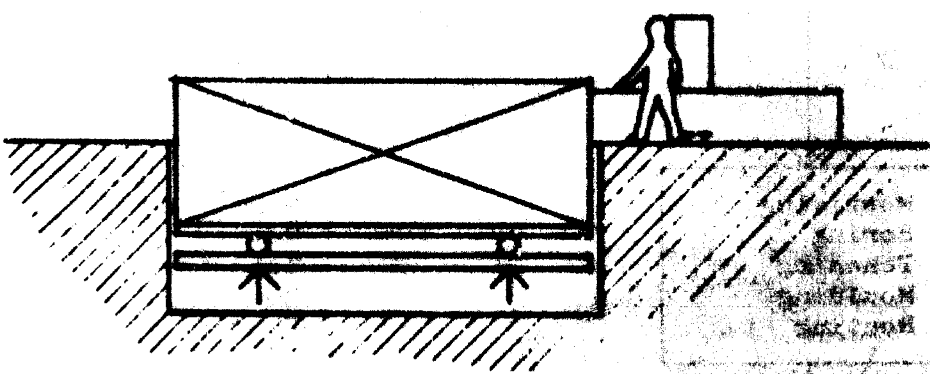


Figure VI. Timber wagon on a lift table (pneumatic or hydraulic)



good working skill in order to achieve small material losses (usually 5 to 20 per cent). The cutting margin varies between 10 and 50 mm, depending on the length of the pieces.

Cut material is transported for ripping, usually on pallets, but a rotating circular sorting table or other methods can be used (figure VII). The ripping saw usually cuts from above and is provided with a feed chain and a return belt conveyor. The position of the blade is made visible on the surface of the board by means of a shadow-line device (figure VIII). The cross-cutting and ripping are done according to a piece list; other raw materials needed can also be marked on the same list (figure IX).

Band sawing

Band sawing is necessary in the manufacture of all curved parts such as round table-tops and parts of chairs. The sawing is done either along a line drawn with a template or with a jig.

Surface planing, thickness planing and moulding

The cross-cut and ripped pieces are usually first machined in a surface-planer and thereafter in a thickness-planer. The pieces emerge from these phases with a rectangular cross-section. The surface-planer can be provided with an automatic feed attachment, which is installed on the rear table side (see figure V).

When more complicated profiles are machined, a four-side moulder is an efficient machine, provided the scale of production is large enough. In the furniture industry, such machines have a long front table for planing the undersides of boards.

Trimming to final dimensions

Trim sawing is done in a furniture factory with one of the following machines: a single-blade circular saw bench (often with sliding table), a single-blade trimming saw, a double-blade trimming saw or a double-end tenoner.

In small- and medium-scale production, a double-blade trimming saw (figure X) is very efficient and versatile if fitted with tilting blades. This machine is particularly suitable for trimming panels. A double-end tenoner is

Figure VII. A rotating circular sorting table between the cross-cutting and edging phases

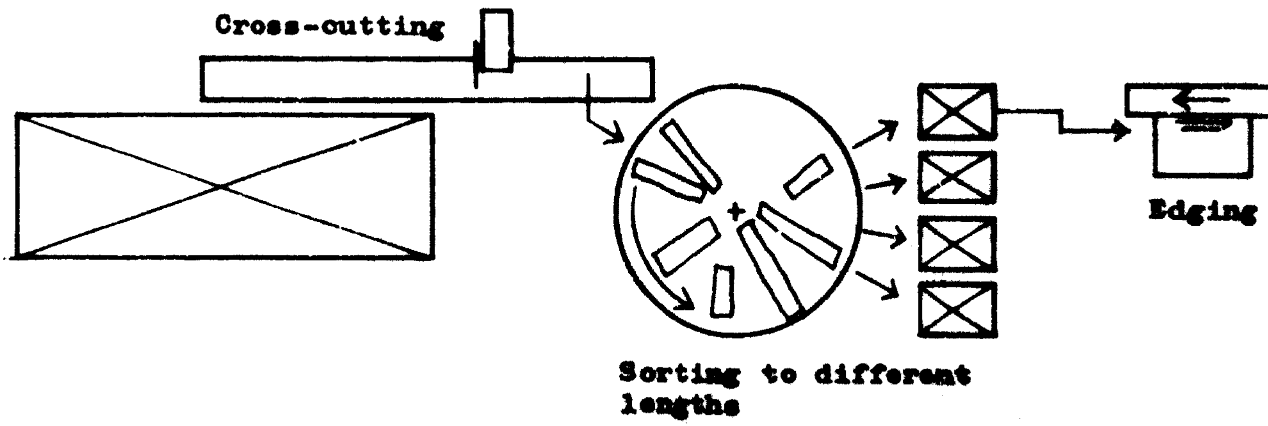


Figure VIII. Edging saw with a shadow-line device

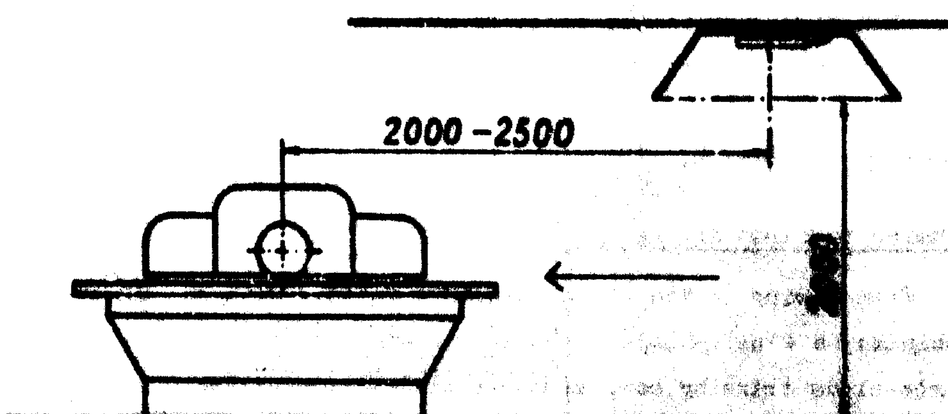


Figure IX. Piece list for cross-cutting and ripping

PIECE LIST

Product:

Pcs.	Item	Wood, particle board etc.					Blindveneer		Surface veneer, Plastic laminates etc.			Remarks
		Final dimension			Material	Quality	Material	Thickness	Material		Thickness	
		Length	Width	Thickness					Face	Reverse		

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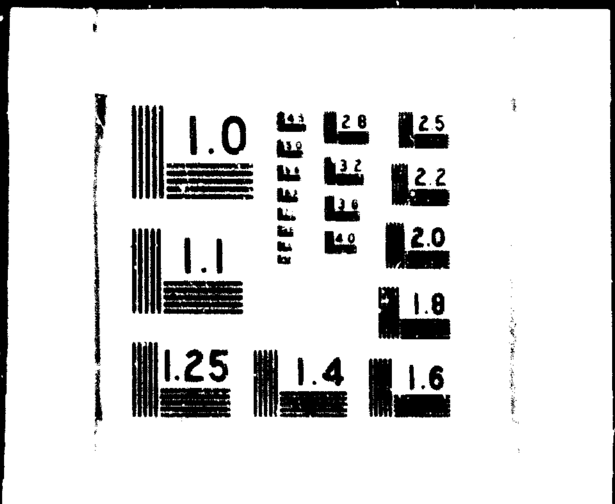
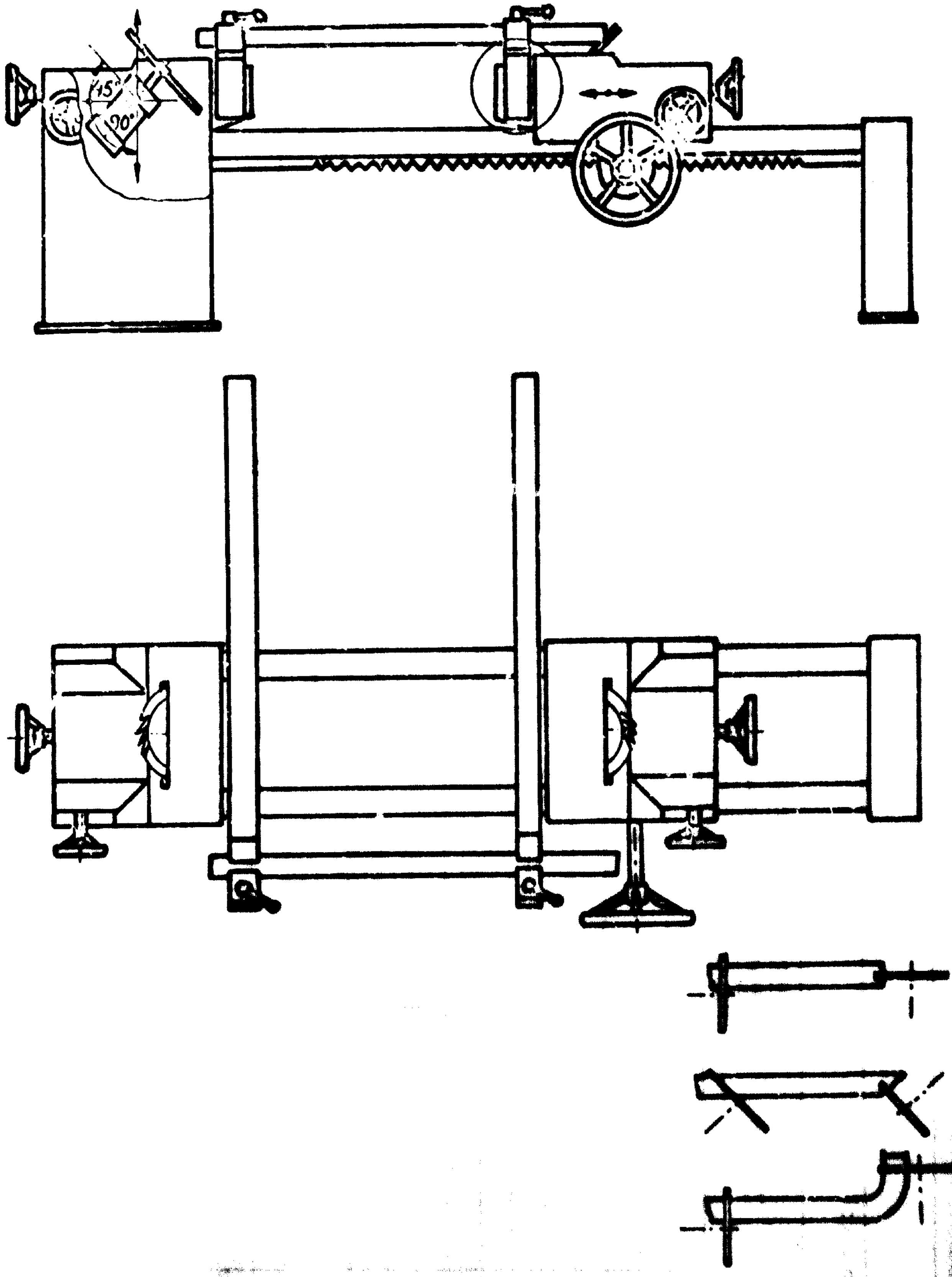


Figure X. Side and top views of a double-bladed trimming saw with tilting blades (possible cuts are shown at lower right)



useful for trimming the piece and many other machining phases such as tenoning and moulding.

Mortising and boring

The mortises needed in furniture joints can be turned out with the hollow-chisel, chain, slot and oscillating mortisers or with a dowel-hole boring machine (figure XI).

Hollow-chisel mortising is the traditional way of making the holes. The machine is hand fed, so its efficiency is low; this method thus is poorly suited to modern production.

Chain mortising is mainly used in the joinery industry for making deep mortises. Slot mortisers make a hole that is rounded at the ends. The tenons must, accordingly, be machined in a special machine in order to achieve corresponding form. For this reason, slot mortisers are not used very widely.

Mortisers with oscillating tools make rectangular holes, as does the hollow-chisel mortiser. By combining several such units, the capacity can be made quite large.

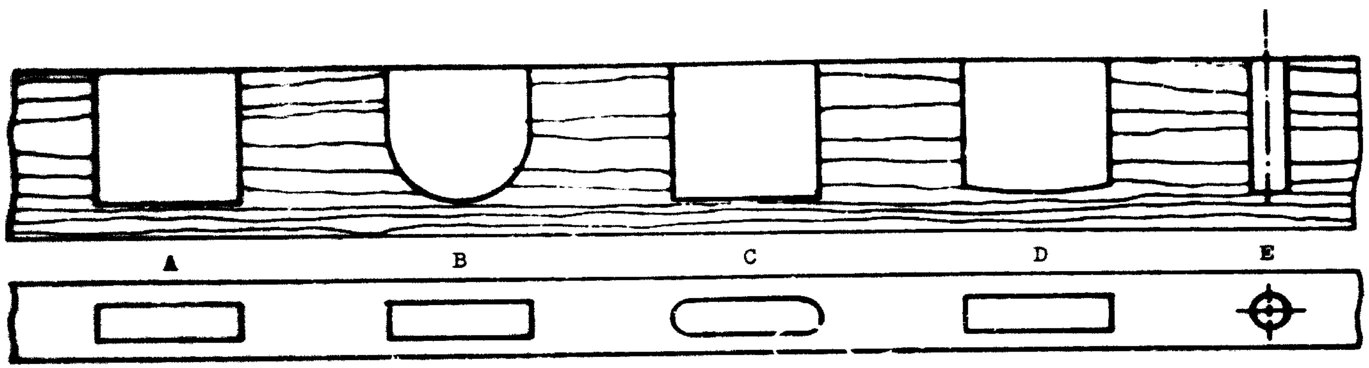
The dowel joint is nowadays one of the most important jointing methods in furniture production. The machining is usually done with multi-spindle boring machines where the standard pitch usually is 32 mm (figure XII). For boring narrow parts of chairs, drawers etc., special spindle heads with fixed or adjustable spindle centres are used (figure XIII).

Tenoning

For maching corner-locks, tongue-and-groove boards and stub tenon joints, any of the following machines may be used: a vertical-spindle moulder with a special attachment, a single-end tenoner or a double-end tenoner. The tenoners are provided with many tool heads, and they also always trim the piece to be machined by length with the aid of circular blades (figures XIV and XV).

Many models of double-end tenoners are available. In addition to horizontal and vertical working heads, there are router units that machine grooves as the work-piece goes through the machine. The machine can be programmed to make various cut-outs and other complicated phases of machining.

Figure XI. Mortises produced by five different machines



Key: A, hollow chisel;
B, chain;
C, slot;
D, oscillating;
E, dowel.

Figure XI1. A multi-spindle boring machine. The detail drawing shows the construction of a spindle head with a standard pitch

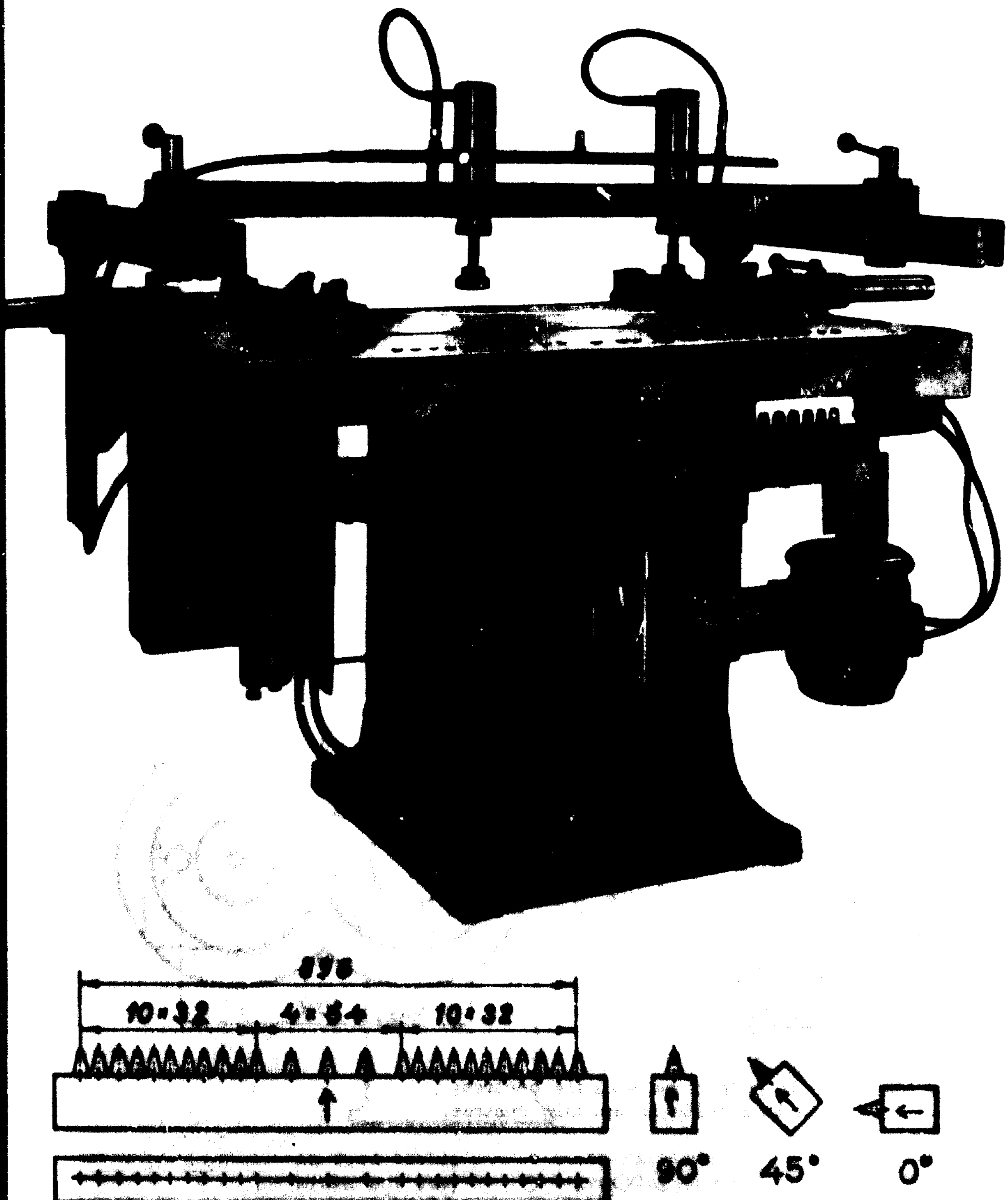
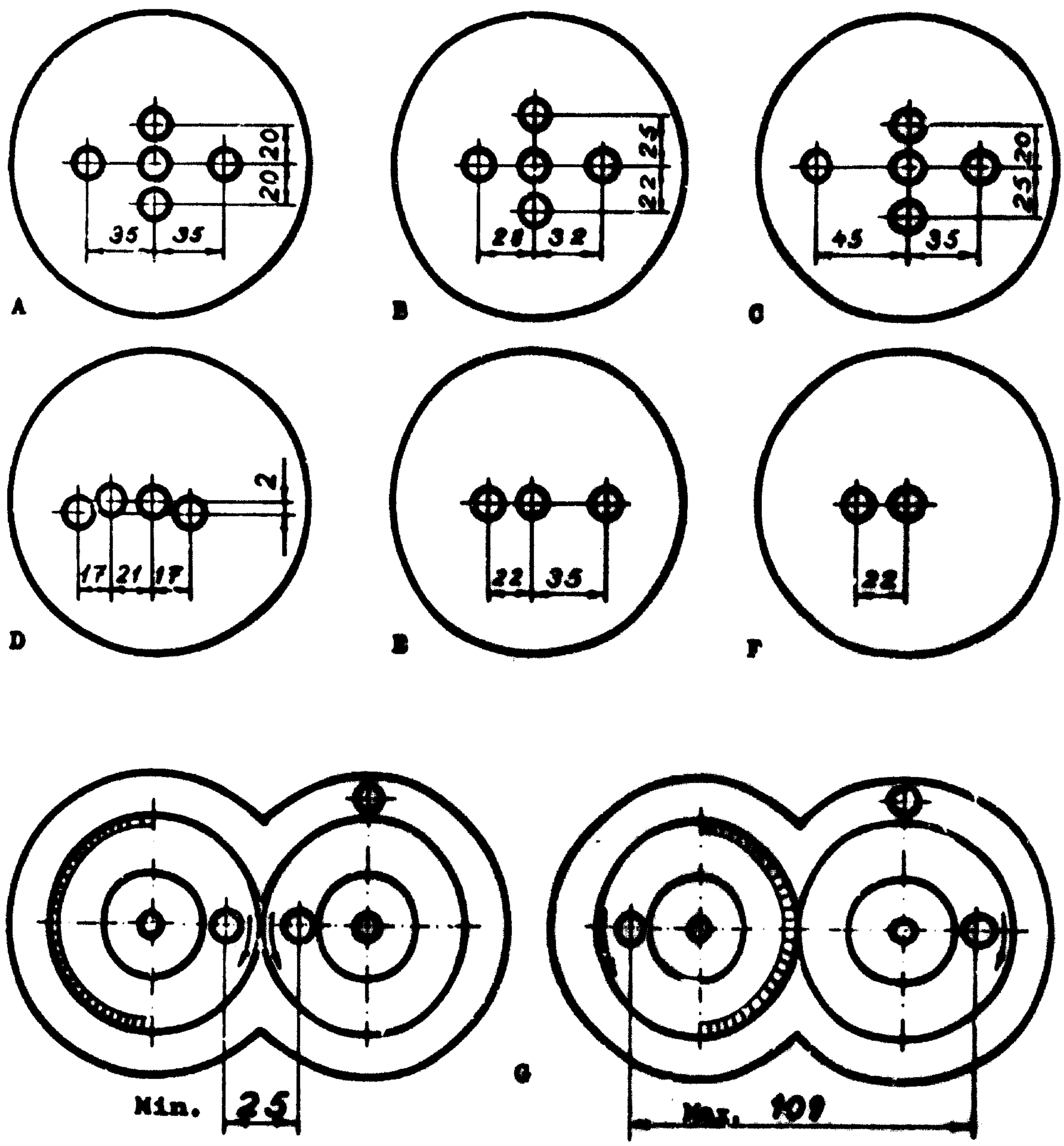
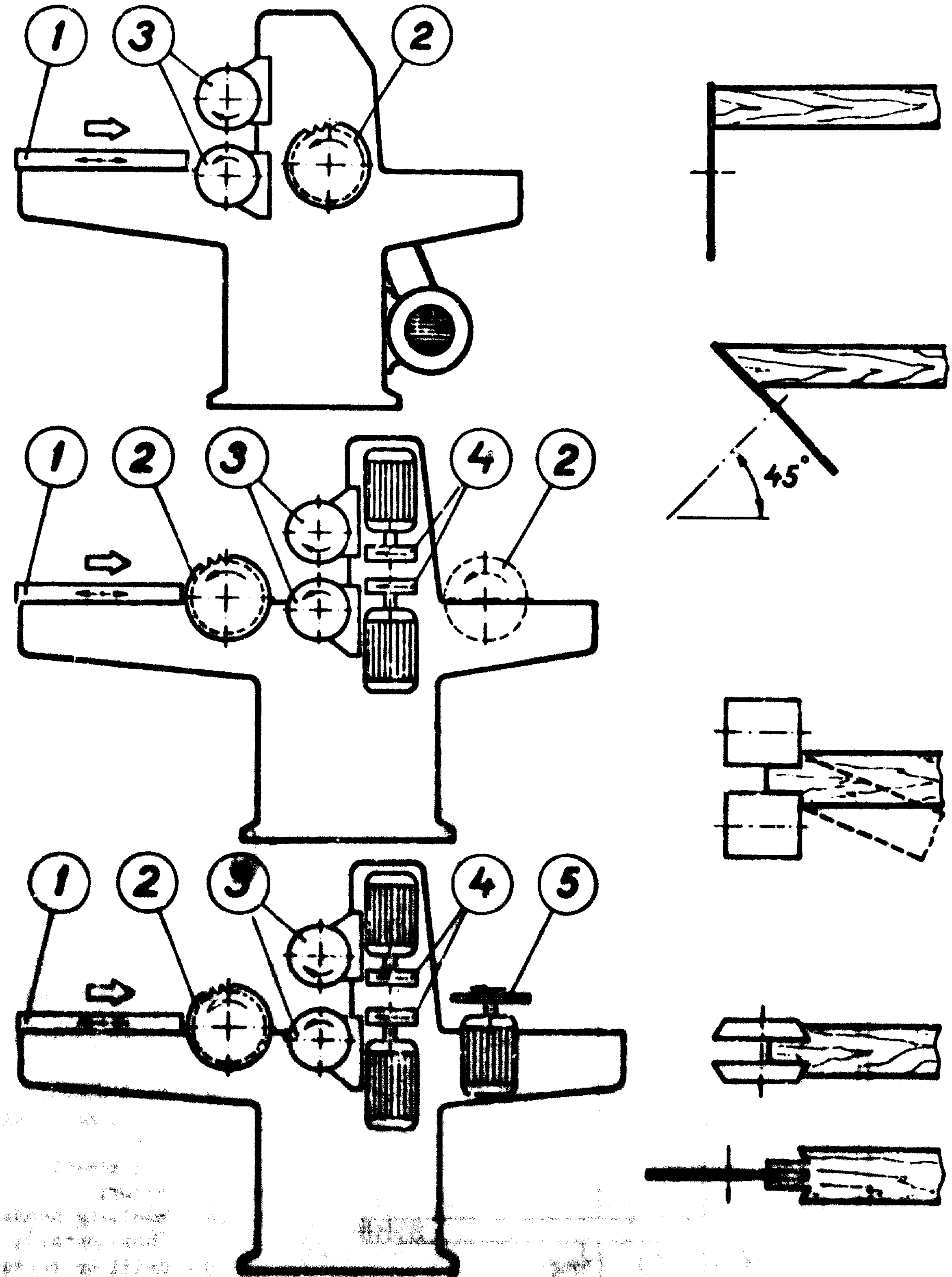


Figure XIII. Spindle heads for boring narrow furniture parts



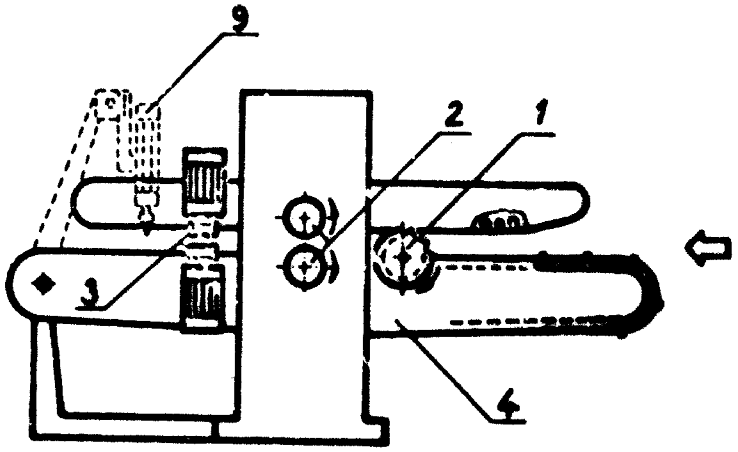
Key: A - F, with fixed spindle centres;
G, with adjustable spindle centres.

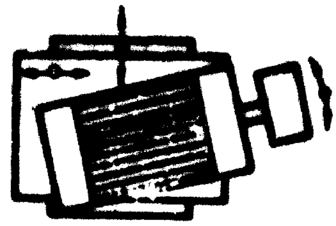
Figure XIV. Three types of single-end tenoners

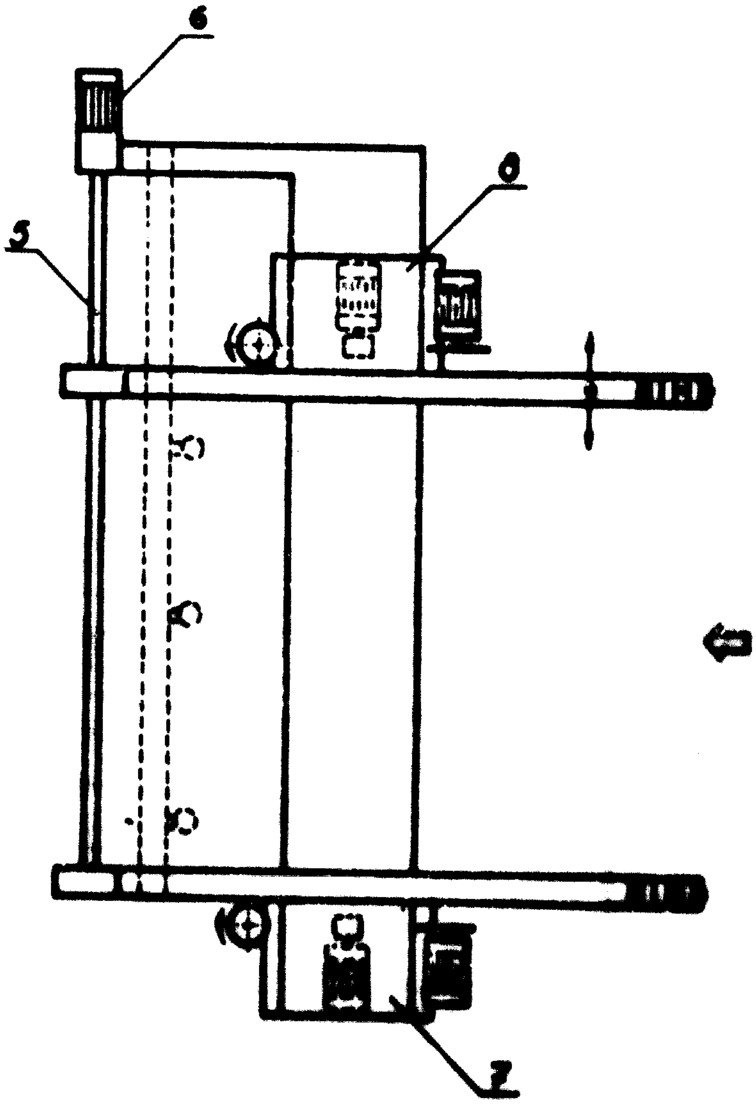


Key: 1 - in-feed table;
2 - cross cut saw;
3 - planing heads;
4 - coping [illegible];
5 - grooving [illegible].

Figure XV. A double-end tenoning machine







Key: 1 - trim saw;
2 - moulding heads (horizontal);
3 - moulding heads (vertical);
4 - feed chain;
5 - width adjuting bar;
6 - adjustment motor;
7,8 - moulding heads (horizontal);
9 - drill or router.

Vertical-spindle moulding

The vertical-spindle moulder (figure XVI) is one of the most versatile machines used in furniture industry. It is most commonly used for making grooves and rabbets; roundings and more complicated profiles; tenons and slits; and moulding with a template. If a feed attachment is used, the capacity can be considerably increased, the quality of the finish improved and the risk of accident diminished. (A considerable proportion of the accidents that occur in furniture factories occur in connexion with the careless use of a vertical spindle moulder.)

Sanding

Sanding is the last working phase before assembly or surface finishing. The quality of surface finishing depends greatly on the quality of sanding. At present, the most important sanding machines are: narrow-belt sanders with vertical or horizontal belts, wide-belt sanders and special-purpose sanders such as profile sanders and curve and form sanders.

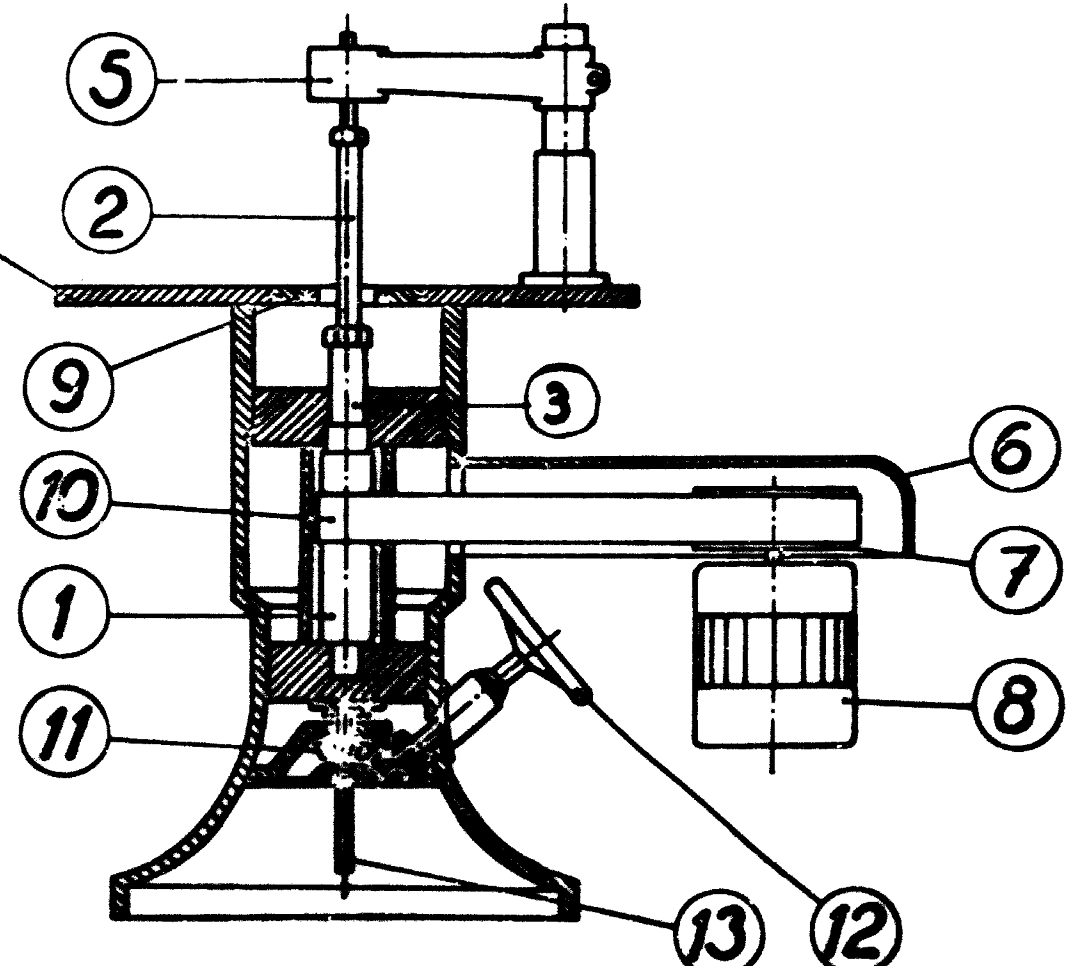
Narrow-belt sanders with vertical belts are used especially for sanding the edges and sides of assembled drawers. Horizontal-belt machines are chiefly used for sanding veneered boards. The newest type of sanders is the wide-belt sander, which has rapidly become prevalent in the furniture industry because of its versatility and the good quality of the finish it produces. This machine is suitable for sanding solid parts as well as veneered boards. The construction principle for one such machine is shown in figure XVII.

Of the abrasives used in sanding belts, aluminium oxide is most important. Silicon carbide, however, is better suited for sanding hard species of wood. In sanding soft woods, belts with open structure of abrasive material are used. The backing is paper or cloth (for heavy sanding).

Sanding is best done at least in two phases, but sometimes a third sanding is necessary. The coarseness is usually selected as follows:

	Grit number
First sanding	50 to 70
Second sanding	80 to 100
Third sanding	120 to 140

Figure XVI. A vertical spindle moulder



Key:
1 - spindle axis (and pulley shaft);
2 - loose spindle;
3 - spindle unit;
4 - table;
5 - top counter bearing;
6 - drive hood;
7 - drive pulley;
8 - motor;
9 - ring set;
10 - pulley belt;
11 - adjustment gear for height;
12 - adjustment wheel;
13 - threaded height adjustment shaft.

Figure XVII. Operating scheme of one type of wide-belt sanding machine

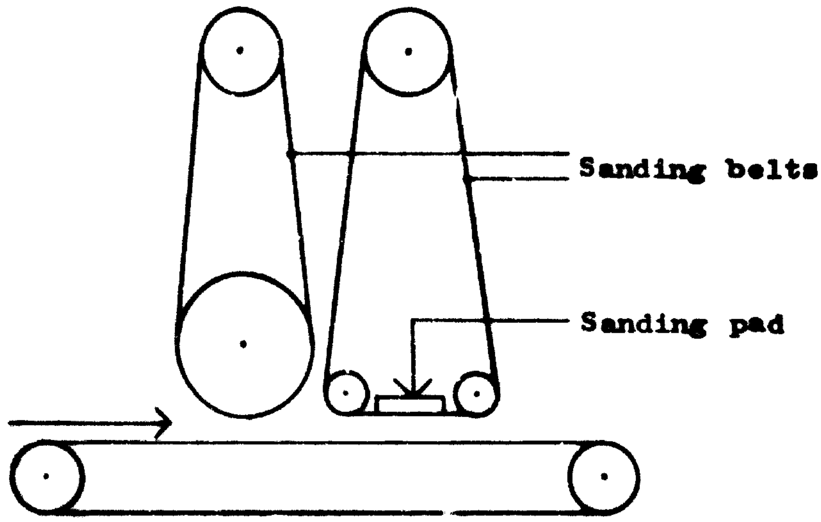


Figure XVIII. The placement of veneer sheets

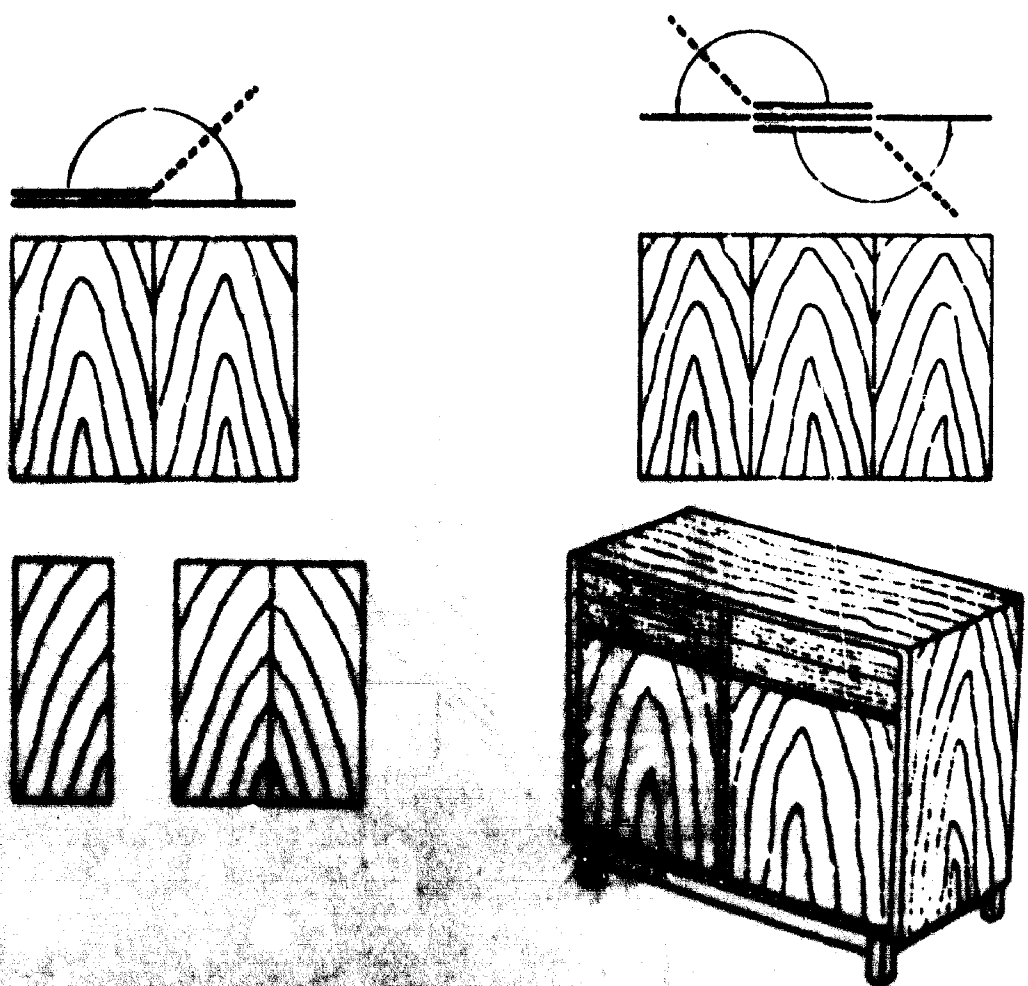


Figure XIX. A hydraulic veneering press with a steel band-feed conveyor

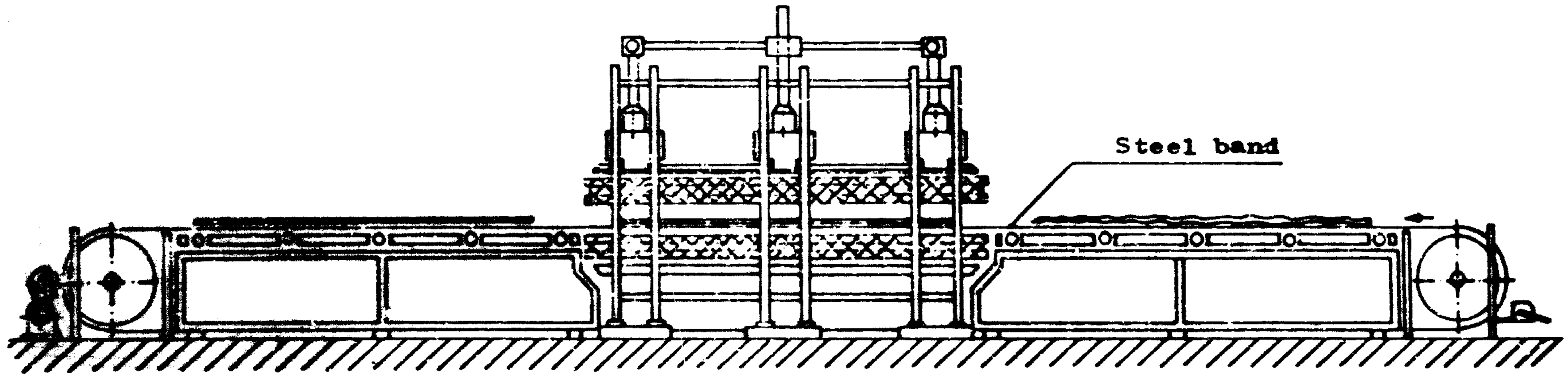


Figure XX. Principle of the fire-hose pressure unit

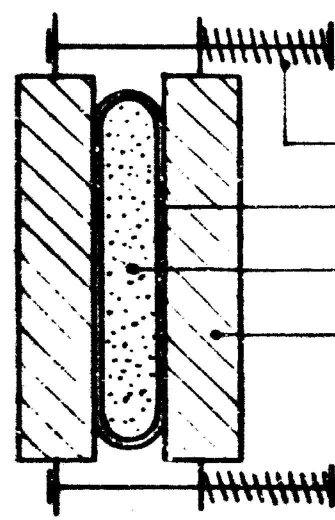


Figure XXI. Set-up for edge veneering, using a fire-hose pressure unit

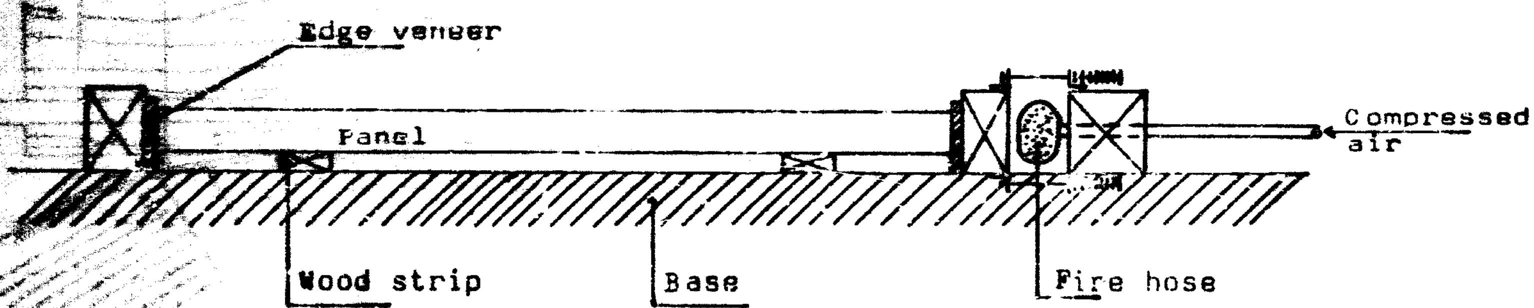


Figure XXII. Principle of automatic veneering machine with additional working units (seen from above). The machine uses thermoplastic glue.

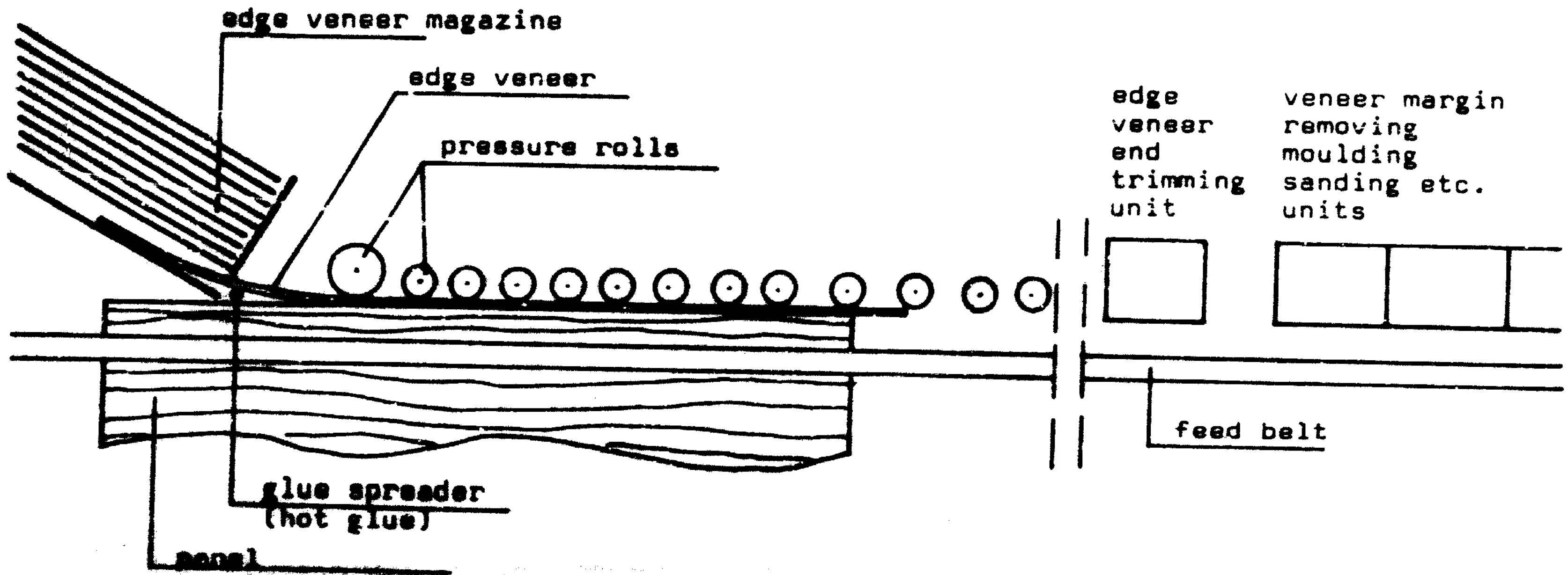
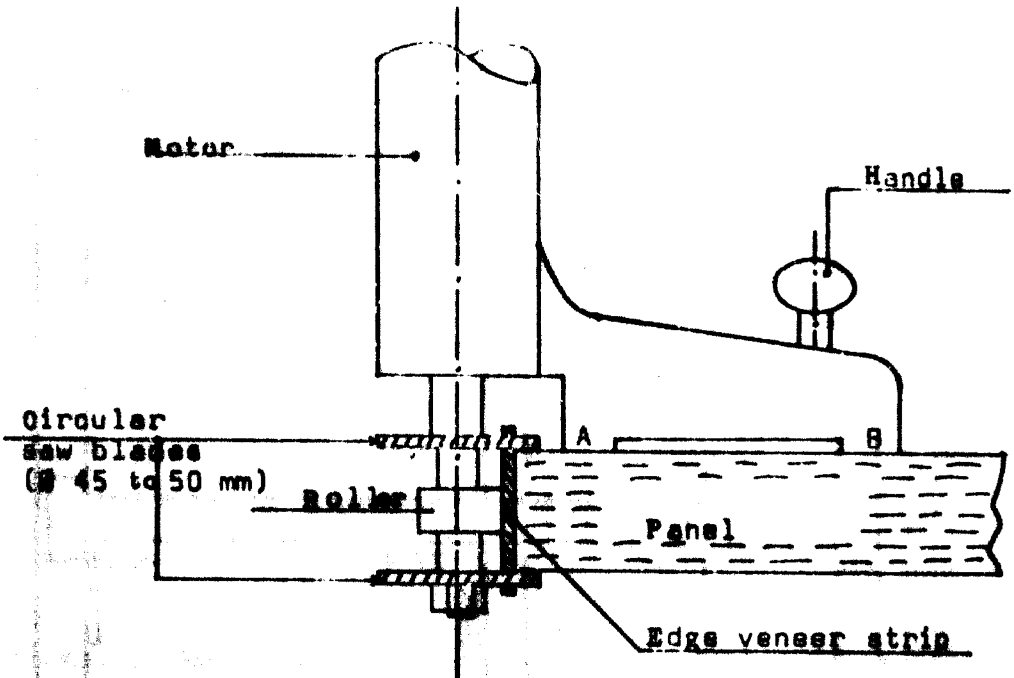


Figure XXIII. A hand-guided machine for sawing the margins of edge veneer work: A and B are guiding surfaces



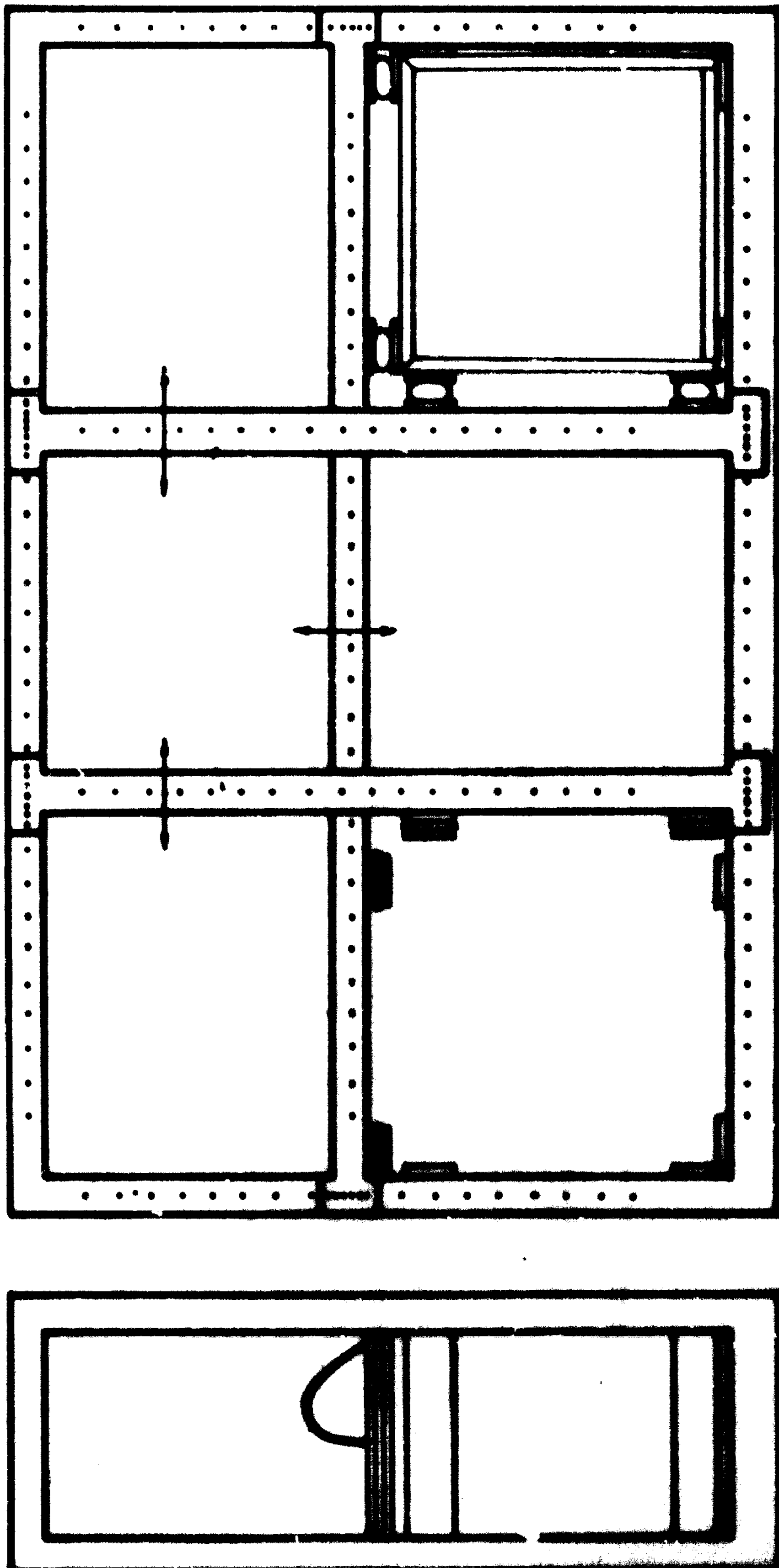


Figure XXIV. Carcass clamp with fire-hose pressure units.
Two cabinets can be assembled at one time with this arrangement

There is a considerable danger of through-sanding when smoothing thinly veneered boards (0.7 mm veneer); in this case, therefore, the grit numbers 50 to 70 should be avoided.

Veneering

The surface veneering of furniture is usually made with veneers of about 0.7 mm thickness. For veneering edges and for blind veneer (cross banding), thicknesses of 1.5 to 3 mm are used. The veneer is cut with veneer saws or clippers. Veneer sheets used for surface veneering are usually composed as shown in figure XVIII. The pieces are joined with glued tape or a zig-zag machine. The tape must be sanded away after veneering, but the plastic thread used in the zig-zag machine melts and is left underneath the veneer.

Urea glue is used, and the pressing is done hot (100° to 120°C) with a multiplaten hydraulic press. Recently, the type of press shown in figure XIX has become more common. The boards are fed to the press by means of a moving steel band. For edge veneering, devices with pneumatic cylinders or firehose pressure units are used (figures XX and XXI). The pressure of the compressed air in the network of a factory is usually 6 to 8 kp/cm^2. In large factories, edge veneering machines (figure XXII) are already quite generally used. Some of these machines have several additional working units. Small factories use portable machines, as shown in figure XXIII.

Formerly, assembly was always the next phase after machining. Today, however, it is usual to try to complete surface finishing before assembly whenever possible. In this connexion, the curtain-coating machine can be used advantageously. The main phases of assembly are detail assembly (drawers, frames, bases etc.) and final assembly. (Cabinet and cupboard frames etc. are fitted with parts coming from detail assembly.) In assembly the adhesive commonly used is PVAc glue, which is strong and sets rapidly.

The most important tools and equipment in assembly are the following:

Glue spreaders (soft plastic squeeze bottle or hand pump)
Dowel-driving machines
Staple guns
Mechanical screwdrivers
Assembly jigs (see figure III)
Presses and carcase clamps (figure XXIV)

As noted, manual fitting in assembly should be avoided.

Because of storage space limitations, assembly series cannot usually be as large as machining series. For this reason, assembling is done in smaller lots according to orders received. It is possible, however, to store the products as ready-machined parts even in the case of very large production series. In order to improve the competitive capacity of the factory, one can in this way attempt to shorten delivery times.

18. JOINERY INDUSTRY TECHNOLOGY*

Module dimensioning of joinery products

In 1960 the module department of the Nordic Building Regulations Committee (NKB)1/, formulated a system of standards called the Module System for the Building Industry. The International Organization for Standardization (ISO) has used these standards as the basis of a system of international recommendations. The Finnish Standardization Commission (Suomen Standardisoimislautakunta) in Helsinki has developed this system for joinery products and has permitted the use of several of their standards to illustrate the present paper.

The starting point in the module dimensioning of joinery products is that their joining dimensions must be compatible with the dimensioning system for the building industry mentioned above. The basic module (M) of this dimensioning system is M = 1 dm = 100 mm. The joining dimensions of the products are integral multiples of the basic module n x M, in which n ≥ 3.

This presentation is restricted to three principal groups of joinery products: doors, windows and kitchen furniture and closets. They have long been made in a range of standard sizes at various factories. The latest Finnish standards are considered separately in connexion with each of these groups of products and are annexed to this paper. Quality regulations and structural data are considered together with standard dimensioning.

Structure of doors

The Finnish standards for several kinds of doors, both flush (not rebated) and rebated, are reproduced in the annex to this paper. The structural requirements for flush doors are given in standard RT 210.52. Their components are the frame, the filling and the surface boards.

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*Paper presented to the seminar by Juhani Jantunen, Enso-Gutzeit Oy, Lahti, Finland. (Originally issued as document ID/WG.105/34.)

1/ The Nordic Building Regulations Committee (NKB) is the common standardization organization of the Scandinavian countries. Questions connected with it are dealt with by the following governmental offices and organizations: Denmark, [illegible]; Finland, Sisäasiainministeriö; Norway, Kommunal- og Arbeidsdepartementet; Sweden, [illegible].

The main purpose of the surface boards is to give the door the desired appearance but, together with the filling, they also have a decisive influence on the rigidity of the structure. If the door is to remain straight in use, its structure must be symmetrical, and this requirement makes notable demands on the covering boards, which must be homogeneous both in thickness and in quality. Generally, covering boards are of hard fibreboard or plywood, which answer this purpose quite well. Doors for more exacting use are often veneered with oak, okoumé, teak or pine.

The filling and the framework of the door form the base on which the covering boards are glued. The framework can be made either of solid wood or by gluing together of thin sheets or pieces. Pieces are usually glued together by automatic finger-jointing machines. In this case, timber of quite low quality can be used, cutting away their faults and joining the suitable pieces. Earlier, framework pieces were 4 in (10 cm) wide, and the corners were strengthened with corner-locks or dowel joints. Gradually, the framework has become narrower and is now only 10 to 50 mm wide. At present, framework pieces are joined only with staples, which facilitates the assembly phase. Since the framework has become so much narrower, it has become necessary to use special additional pieces for installation of the lock and hinges so that fastening screws can be fixed in solid wood.

The filling of flush doors used to be solid wood, but block filling has become more common. The distance between the blocks varies greatly, depending on the demands made on the evenness of the surface. The blocks can be of solid wood, plywood, or porous or hard fibreboard. The blocks can also be used to form grids so as to obtain better filling than with blocks set in only one direction. At present, paper honeycomb fillings, the best-known of which are the Dufolite and Wellite fillings, are used almost exclusively.

Paper honeycomb fillings are formed of sections. The compression strength of the filling can be regulated by changing their size and the thickness of the paper. Paper fillings are inexpensive and provide the product with evenness of surface, great bending strength, straightness and lightness of weight.

A separate group among flush doors is fireproof doors for dwellings and sound-insulating doors. These differ from ordinary flush doors only in regard to their filling. Wooden doors for dwellings belong to groups C 15 and C 30.

in their fire-resistance. (The numbers 15 and 30 indicate the fire-resistance of the doors in minutes.) The burning test is performed in a vertical oven of a fire laboratory according to a standard burning curve in which the oven temperature is 730°C after 15 minutes and 850°C after 30 minutes from the lighting of the oven. The door must stand the heat without burning through. The smoke formation and surface temperature on the unexposed side are also examined.

The inner structure of fireproof doors can be of solid wood, in which case a door 40-mm thick withstands burning for 15 minutes. The same result can also be obtained when using a particle-board structure or expanded cork as filling. In fire group C 30, the structure must be stronger. The required fire-resistance is obtained by using asbestos or some other special material.

Sound insulation is required mainly in doors for hotel rooms, patient and examination room doors for hospitals, classroom doors for schools and the outer doors of dwellings, as mentioned previously.

Sound insulation requirements are 25 or 30 decibels (dB), depending on the use. The degrees of insulation are obtained by increasing the weight of the door with thicker surface boards or with a multi-layer structure in which the inside is often soft and sound absorbing. Particular attention must then be paid to the packing between the door and the frame. (This is also true for fire doors.)

Windows and glazed doors

While space does not permit detailed discussion of the construction of windows and of glazed doors, this subject is well covered in some of the Finnish standards in the annex to this presentation. Of particular interest in this connexion is standard RT 210.81.

Kitchen furniture

Kitchen furniture is divided into three categories according to their types of cupboards:

Wall cupboards, whose standard widths are 400 mm, 500 mm or integral multiples of these dimensions. Their depth is 290 mm, and their heights are 1,100 mm, 600 mm and 400 mm.

[illegible], with widths of 600 mm and 900 mm or integral multiples; [illegible] and height of [illegible] which, when the table top (30 mm) is added, gives a total height of [illegible].

Closets, with widths of 500 mm and 600 mm, depth of 590 mm and heights of 2,350 mm and 1,900 mm, plus a separate upper cupboard (480 mm).

The main raw materials of kitchen furniture are particle board, plywood, hard or semi-hard fibreboard, and solid pine in the joints and framework. Structural boards are often made, using the honeycomb construction discussed above in connexion with flush doors, quality regulations are basically the same as the corresponding ones for doors so that it is unnecessary to repeat them here.

General information about manufacturing techniques for windows, doors and furniture

Main raw materials

The timber used in Finland is generally pine, which is quite suitable for manufacturing joinery products. For visible surfaces of the products dealt with earlier in this presentation, unsorted top-grade (u/s) or export quality wood is generally used. The faults allowed in the timber are given in standards RT 210.81 and RT 210.82.

The use of fir has been studied recently, and it has been used to some extent e.g. in door frames. Some manufacturers also use birch in certain parts of kitchen furniture.

As noted above, some other raw materials which are used are hard and semi-hard fibreboard, plywood, hardboard, blockboard and various species of imported hardwoods.

Various other manufacturing materials are also needed, such as glues, paints, fittings and screws.

Special features of manufacturing in the joinery products industry

Finger-jointed timber

The joinery industry has begun to use finger-jointed timber in increasing amounts. This has become possible because waste in cutting is being reduced and timber of lower quality is now being used. Finger-jointing is usually done with kiln-dried timber that is driven through a rip and cross saw and possibly also through a surface planer to a finger-jointing machine. After jointing, it is cut again to the required length. The strength of the joint is determined by the length of the fingers, so that finger-jointed timber can be made up for almost any use.

Simultaneously with the development of the above timber-lengthening technique, edge-gluing has also become important; indeed, it is even necessary in some products. Edge-glued timber does not twist nearly as much as do solid pieces, which is important in the manufacture of structures such as door frames. In general, door frames wider than 5 in (6.25 cm) must be made of edge-glued timber. This is because wider pieces, when cut from the small-diameter trees available today, contain a mixture of radial and tangential grain directions that can cause differential shrinking.

Automatic production lines

The continuous rise in production costs has increased the importance of economy in the use of raw materials and of the productivity of labour. The tendency is thus toward greater and more rationalized serial production. This tendency has also accelerated the introduction of automatic machines and machine lines. An example is the automatic door-manufacturing line of a Finnish producer. In this set-up the door goes automatically from the press through double-end tenoning, surface sanding, edge sanding and the installation of fittings. After these phases the doors are stacked and then, if necessary, sent to another automatic line where all the phases of surface finishing are performed automatically. These phases include base painting, sanding and finishing, first on one side, then on the other. Similar examples are to be found in the window and furniture manufacturing industries.

The manufacturing of furniture, of course, is more complicated, owing to the wider range of products. However, the newest furniture factories have also advanced considerably in their assembling phases. It is now common to use assembling presses, from which the furniture items go to a conveyor where doors are fixed and inside fittings are installed. It should be noted that furniture parts are painted before they are assembled; it is easier to paint furniture in parts than as a whole cupboard, for example. The use of assembling presses has brought about changes in types of jointing. The type best suited for presses is the dowel joint, which is again in favour.

Materials and performance of finishing

Surface finishing is treated elsewhere in this publication 2/, so only a few points are mentioned here. The demands made on finished surfaces depend on the surroundings, personal taste and other matters connected with the use of the article.

As a base for surface finishing, solid wood, veneer, plywood, hardboard or particle board can be used. The final appearance of the surface depends on the quality of the board; good results cannot be obtained on a poor base. If the base is uneven, it must be sanded and filled before finishing.

Furniture parts and doors are usually painted by curtain-coating machines that [illegible] heating and drying ovens and a cooling area. The [illegible] sanding machines with brush equipment as well as a [illegible], with its own turning equipment.

The painting of windows is done with spray painting equipment either as parts or assembled. The temperatures of drying ovens are considerably lower so that when using softwood the resin will not boil out of the wood thus spoiling the painted surface. The paints used in windows differ also from door and furniture paints since they must be sufficiently resilient to resist weather.

The paints used are usually based on alkyd, amine and urea resins, which act as cementing agents. Nitrocellulose, urethane or polyester resins are the most common cementing agents varnishes. All paints and varnishes are very flammable, so that the equipment must be designed with particular attention to safety.

It should be mentioned in this connexion that, instead of paint, plastic profiles are now often used to coat door frames and windows. In this way no painting is necessary, and timber of a lower quality can be used under the plastic covering.

Marketing joinery products

In Finland, there are two principal outlets for joinery products: sales based on offers to building companies, and sales through retail organizations to small-scale consumers.

2/ See article 19 (P. Å. Biström "The surface finishing of wood and wooden products").

The first of these is by far the larger. Business is usually done so that a building company sends an inquiry concerning the joinery product in question to several manufacturers in the field and decides the purchase after severe competitive evaluation in terms of price and quality. Certain manufacturers operate entirely in this field of marketing and manufacture no products for stock at all. They are, indeed, often better able to compete owing to their flexibility and prices when a special product, that is, one of non-standard size, finish or fitting, is desired. Furthermore they have no inventory or interest costs. On the other hand, they may not have the benefits of longer manufacturing series that standard products assure.

The strongest retail dealers are builders' department stores, which have appeared in recent years. They have the great advantages of their specialized staff and stock. Hardware stores have traditionally been retail outlets. They do not, however, hold products in stock, but act as agents of manufacturers, thus receiving an agreed commission for their sale. Larger companies also have district representatives all over the country, who generally sell from stock on a commission basis.

Traditionally, manufacturers operated alone with their own sales organisations, but the increased competition that forced them into product rationalisation has led to the formation of joint sales organisations by several factories. An example in Finland is Sovi Oy, which is the sales organisation of three door factories. It divides its orders according to an agreed principle so that each member company manufactures for it the products best suited to its process capability.

The degree of manufacture of joinery products has changed considerably during the past few years. Kitchen furniture is now delivered almost 100 per cent finished and is also fixed to the walls, at least in new buildings. Also, doors and windows are increasingly painted, provided with fittings and glazed. Building companies have found that this saves costs, and, when the product is prefabricated the quality is also better than it would be if made on the site in poor conditions with deficient machines and equipment. Thus, the completion time-table for buildings has accelerated, and capital interest costs, as well as labour, are saved.

Annex

REPRESENTATIVE FINNISH JOINERY STANDARDS[a]

RT 210.81	Wooden windows and outside doors, quality
RT 210.82	Wooden flush doors, quality
RT 860.22	Windows, wood, installation
RT 860.23	Windows, wood, fittings
RT 861.42	Windows, wood, opening inward, double casement
RT 861.46	Windows, wood, opening inward, coupled casements
RT 862.46	Windows, wood, opening inward, coupled casements
RT 870.22	Door, wood, fixing and fittings
RT 871.05	Doors for dwellings, standard sizes
RT 871.21	Wooden doors for dwellings, not rebated door leaf
RT 871.22	Wooden doors for dwellings, rebated door leaf

Suomen Standardisoimislautakunta Finlands Standardiseringskommission

WOODEN WINDOWS AND OUTSIDE DOORS, quality

SFS 2455
SfB A
UDK 674.21
Page 1 (3)

Lumber defects	RT 210.7	
Wooden flush doors, quality	RT 210.82	SFS 2456
Wooden storage units, quality	RT 210.83	SFS 2457
Boardings, selection of character and quality	RT 216.01	
Industrial finishing of joinery products	RT 148.032	

1 CONTENTS

11 This standard gives quality provisions for windows and glazed doors as well as for outside and other panelled doors.

12 The standard includes provisions for the materials used the construction of windows and glazed doors as well as for outside and other panelled doors, their manufacture, accuracy of form and appearance of the surfaces 'in the white'.

2 NOTATION

Notation: Manufacturing degree of the product and quality grade (type of timber) and the RT number of this standard.
E.g. in the white 1 pine, RT 210.81
E.g. painted 2, RT 210.81

3 QUALITY GRADES

The products are classified: special grade, varnishing grade and painting grade. In classification a 'main face' principle is applied. This means that other than main face surfaces (e.g. surfaces seen only occasionally) may, in the case of the special grade and the varnishing grade be of the next lower grade, unless otherwise specified.

31 Special grade, notation E

This class comprises products, which meet high requirements and to which the timber has been chosen with particular care. These products are usually intented to be finished with varnish. The sort of timber should be specified in the order.

In grade E the frames are of grade 1

32 Varnishing grade, notation 1

This is the normal quality grade for products intended to finished with varnish. The sort of timber should be specified in the order.

33 Painting grade, notation 2

This quality grade comprises conifer products meant to be painted.

4 PROVISIONS FOR THE MATERIALS

41 Timber

.1 Quality

The basis of grading softwood is the u/s quality given in the grading rules of export timber with the limitations given later.

For foreign hardwood the provisions in appendix 2 will be applied.

.2 Heading joints

The joints have to be finger joints or alternating butt joints. The length of an alternating butt joint may be at the most one third of the width of the lengthened piece, however not more than 50 mm. No visible heading joints are allowed for special grade and varnishing grade.

.3 Defects. Plugging.

Wane is not permitted in surfaces exposed to view. The knots have to be distributed evenly and they are not permitted in places where they might affect the strength of the timber. The plugs shall be of the same species of wood and the direction of their grains shall be the same as in the surrounding wood to which they shall be firmly fastened. The plugs are considered sound knots and their sizes shall be taken into consideration at grading.

In products used in humid surroundings plugging ought to be avoided

42 Plywood

Plywood shall as to quality, dimensioning and property comply with the requirements of SFS standards.

43 Block- and laminboards

Block- and laminboards shall suit the purpose as to quality and structure.

Boards for use, as main faces should on both sides of the board have 1 + 1 veneers glued at right angles to each other and so that the grain direction of the veneer adjacent to the core is running at right-angles to the grain of the core.

Boards with one or two parallel surface veneers on both sides, whose grain direction is running at right-angles to the grain direction of the core may be used for main faces only when they are faced with cross-wise glued veneer, laminated plastics sheet, plastics fabric or the like.

44 Particle board

Particle board has to be a LA/A board and comply with the requirements of standard SFS 0.IV.2.

45 Wood fibre boards

.1 Hardboard should have a density of not less than 850 kg/m^3.

.2 Medium hardboard should have a density of not less than 700 kg/m^3.

46 Face veneer

Facing veneer has to be sliced, except birch, which may be rotary cut.

Sliced veneer shall meet the requirements set in appendix 2.

Rotary cut veneer has to meet the requirements set in SFS standards.

47 Laminated plastics sheet

Laminated plastics sheet has to meet the requirements given in appendix 3.

48 Fittings

The manufacturer shall indicate in his offer the fittings he has used.

49 Degree of dryness

The timber has to be artifically dried. The moisture content calculated from dry weight shall not exceed 12 % during the manufacturing and delivery phases.

The moisture content also constitutes the basis for judging the accuracy of size and form.

5 PRODUCT SPECIFICATIONS

51 General

The productsand their parts have to be manufactured and assembled with care and skill. All timber joints which are known to be good and suit the appearance of the quality grade in question are allowed.

Joints in boards are not allowed. In veneers joints are not allowed across the grains.

Adhesives should comply with the requirements of the use of the product and should resist moisture and micro-organisms.

52 Accuracy of form

Testing methods for accuracy of form, see appendix 1.

The provisions concerning accuracy of form refer to the moment of delivery, to the guarantee period inspection and to a dryness degree of the timber of 10...12 %.

The continuity of the properties of the products implies that they are stored and handled on the site according to the general specifications for construction works, RYL 1980, RT 140.1/8, para. B 671 and B 673.

.1 Accuracy of angles (squareness)

at delivery	at guarantee period inspection
1 mm	1 mm

.2 Planeness of surface (dish or/and twist)

at delivery	at guarantee period inspection
4 mm	5 mm

These figures imply that the temperatures and moisture conditions are the same in the spaces on both sides of the door.

.3 Evenness of surface

	at delivery	at guarantee period inspection
with a 200 mm ruler	0,2 mm	0,3 mm

53 Panels (≦ 0,5 m²)¹)

Quality and minimum thickness

	special grade	varnishing grade	painting grade
Plywood, face veneer rotary cut	9 mm A1(A)	9 mm I(B)	9 mm II(S)
Timber	15 mm	15 mm	15 mm
Hardboard	not permitted	not permitted	2...3 layers glued, 9 mm in all

¹) If the size of the panel is bigger than the given size, the thickness should be correspondingly increased.

54 Matchboards

In accordance with RT 216.0.

55 Defects permitted in surfaces exposed to view

	special grade	varnishing grade	painting grade
.1 Window casements (42 mm x 42 mm)¹)			
Sound knots or plugs pieces/m	not permitted	2p. 10 mm 3p. pin knots	2p. 20 mm 2p. 15 mm and pin knots
Checks	not permitted	not permitted	small patched ones permitted
Blue stain	not permitted	not permitted	permitted as miscolouring
.2 Casement bars and linings			
Sound knots or plugs pieces/m	not permitted	pin knots	pin knots
Checks	not permitted	not permitted	small patched ones permitted
Blue stain	not permitted	not permitted	permitted as miscolouring
.3 Casements of glazed doors (42 mm x 104 mm)¹)			
Sound knots or plugs pieces/m	not permitted	1 p. 20 mm 2 p. 10 mm and pin knots	2 p. 30 mm 3 p. 20 mm and pin knots
Checks	not permitted	not permitted	small patched ones permitted
Blue stain	not permitted	not permitted	permitted as miscolouring
.4 Stiles and rails of outside and panelled doors (40 mm x 93 mm)¹)			
Sound knots or plugs pieces/m	not permitted	1 p. 20 mm 2 p. 10 mm and pin knots	2 p. 30 mm 3 p. 20 mm and pin knots
Checks	not permitted	not permitted	small patched ones permitted
Blue stain	not permitted	not permitted	permitted as miscolouring
.5 Frames (42 mm x 118 mm)¹)			
Sound knots or plugs pieces/m		1 p. 20 mm 3 p. 15 mm and pin knots	2 p. 35 mm 3 p. 25 mm and pin knots
Checks		not permitted	small patched ones permitted
Blue stain		not permitted	permitted as miscolouring

¹) If sizes are smaller or greater than the given, knots are permitted correspondingly less or more.

56 Finishing of surfaces 'in the white'

.1 As to special grade products all main faces should be very carefully finished. There should be no glue accumulations which might make finishing difficult or cause colour defects. Defects due to manufacture may not be seen.

.2 As to varnishing grade products main faces have to be carefully finished. There should be no glue accumulations, which might make finishing difficult or cause colour defects. Minor defects due to manufacture are allowed only in places not well adapted to machine grinding, like surfaces only a little or occasionally exposed to view.

.3 As to painting grade products main faces should be finished. No glue accumulations are allowed, which might make surface finishing difficult. Minor defects due to manufacture are allowed only in surfaces which are only a little or occasionally exposed to view.

6 MANUFACTURING DEGREE

Windows, glazed doors, outside and other panelled doors are delivered in the white, varnished or painted.

Varnishing and painting should be done according to RT 148.032.

If the products are required finished in some other way this should be indicated separately as well as the materials and the methods used.

APPENDIX 1

Testing methods for accuracy of form

1 Accuracy of angles (squareness)

Squareness is measured with a square at diagonally opposite corners. The measuring points have to be situated 500 mm from the corners or at a distance corresponding the width if the width is less than 500 mm. Deviation is given in millimetres with the accuracy of 0,1 mm.

2 Planeness of surface (dish and/or twist)

Dish of a surface is measured on the concave side with a ruler, which is as long as the surface, along the diagonals and all edges. The greatest measured grade is decisive. The deviation is given in millimetres with an accuracy of 1 mm. Twist is measured by placing the surface on a level plane so that three corners touch the plane. The distance of the fourth corner from the plane gives the twist of the surface to be measured.

The deviation is given in millimetres with an accuracy of 1 mm.

3 Evenness of surface

Evenness of surface is measured with a ruler which is 200 mm long by setting it in arbitrary directions on the surface to be measured and using a special measuring device to measure the checks.

The deviation is given in millimetres with the accuracy of 0,1 mm.

APPENDIX 2

Quality requirements for foreign hardwood surfaces

1 General

Foreign hardwoods are imported species (e.g. oak, teak, mahogany etc.).

These provisions are also adapted to veneers cut of domestic species.

Provisions have been given for special grade and varnishing grade products.

2 Veneer

Veneer has to be sliced and the thickness should be the minimum of 0,6 mm. The joints of the veneer have to fit perfectly and the veneers have to be jointed so that a uniform pattern typical of the veneer in question is achieved.

.1 Special grade

The veneer should be typical of the species in question, free from defects and altogether homogeneous both as to colour and structure. Inserts are not allowed.

.2 Varnishing grade

The veneer should be typical of the species in question. Slight defects in colour and some other imperfections which do not disturb the general impression are allowed. A small amount of knots smaller than 5 mm (bird's eye) are permissible. Defects which sometimes appear in veneer such as surface wood of different colours, blisters, decay etc, are not allowed. Small corrections like patchings done carefully so that they fit in with the surrounding veneer as to colour and structure are allowed.

3 Converted timber

The thickness of boards used for facing should be the minimum of 5 mm.

.1 Special grade

The timber should be typical of the species in question and the faces should be free from defects and altogether homogeneous as to colour and structure. Patches are not allowed.

.2 Varnishing grade

The timber should be typical of the species in question. Small defects allowed in main faces. Knots smaller than 7 mm are allowed to some extent. Surface wood of different colours and other imperfections sometimes appearing in timber are not allowed. Sole plugs, which are carefully made and fit in with the colour of the wood and are smaller than 15 mm are allowed. The plugs have to be of the same species and the grains of the plug shall run in the same direction as the grains of the surrounding wood, in which it should be tightly fixed.

APPENDIX 3

Quality requirements for laminated plastics sheet

1 Coating of desks

The coating of desks should be paper-backed laminated plastics sheet. Its thickness is the minimum of 1,4±0,1 mm and it has to meet the following requirements:

Wearing strength: NEMA LD 1-3.03/64 A

Impact strength: NEMA LD 1-3.03/64 K

Appearance: NEMA LD 1-3.03/64 J

Changes due to moisture: NEMA LD 1-3.03/64 H

Heat resistance: SIS 245803 (NEMA LD 1-2.03/64). At testing no trace allowed on a matt surface, a glossy surface may lose some lustre.

Durability in boiling water: SIS R 705002 (NEMA LD 1-2.02/64), no trace allowed on the surface.

Influence of chemicals: SIS 245805 (NEMA LD 1-2.05/64), the grade has to be 3. The grades are 1, 2 and 3, of which 3 is the best.

Light resistance: SIS 245804 (NEMA LD 1-2.06/64), the grade has to be the minimum of 5. Grades are 1...8, of which 8 is the best.

Water absorption: SIS 245801 (NEMA LD 1-2.07/64), the absorption may not be higher than the maximum of 500 mg/25 cm^2 for sheets 1,4 mm thick. For thicker sheets the maximum of 10 % of the mass.

2 Coating of vertical surfaces

The coating of vertical surfaces such as door leaves should be paper-backed laminated plastics sheet, the thickness of which is the minimum of 0,8 ± 0,1 mm which has to meet the following requirements:

Wearing strength: NEMA LD 1-4.03/64 A

Impact strength: NEMA LD 1-4.03/64 G

Appearance: NEMA LD 1-4.03/64 E

Changes due to moisture: NEMA LD 1-4.03/64 D

Influence of chemicals: SIS 245805 (NEMA LD 1-2.05/64). The grade has to be 3. Grades are 1, 2 and 3, of which 3 is the best.

Light resistance: SIS 245804 (NEMA LD 1-2.06/64). The grade has to be the minimum of 5. Grades are 1...8, of which 8 is the best.

Water absorption: SIS 245801 (NEMA LD 1-2.07/64), for sheets which are 0,8 mm thick the absorption may be the maximum of 350 mg/25 cm^2, for thicker sheets the maximum of 12 % of the mass.

3 Coating of shelves

The thickness of laminated plastics sheet used for coating of shelves has to be the minimum of 0,8±0,1 mm and the coating has to meet the following requirements:

Wearing strength: NEMA LD 1-4.03/64 A

Impact strength: NEMA LD 1-4.03/64 G

Influence of chemicals: SIS 245805 (NEMA LD 1-2.05/64). The grade has to be 3. Grades are 1, 2 and 3, of which 3 is the best.

4 Other laminated plastics sheet

Sheets may also be fabric-backed or other laminated plastics sheet if it meets all the requirements of the previously mentioned standards SIS and NEMA. The manufacturer has to indicate the thickness and type of laminated plastics sheet in his offer.

Suomen Standardisoimislautakunta Finlands Standardiseringskommission

WOODEN FLUSH DOORS, quality

SFS 2456
SfB A
UDK 674.21
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Lumber defects RT 210.7
Wooden windows and outside doors, quality RT 210.81 SFS 2465
Wooden storage units, quality RT 210.83 SFS 2457
Boardings, selection of character and quality RT 216.01
Industrial finishing of joinery products RT 149.032

1 CONTENTS

11 This standard gives quality provisions for flush doors

12 The standard includes provisions for the material used, the construction, the manufacture of doors and the accuracy of form as well as for the appearance of the surface "in the white".

2 NOTATION

Notation: Manufacturing degree of the product and quality grade (type of timber) and the RT number of this standard

E.g. in the white 1 pine, RT 210.82
E.g. painted 2, RT 210.82

3 QUALITY GRADES

The products are classified: special grade, varnishing grade and painting grade. In classification a "main face" principle is applied. This means that other than main face surfaces (e.g. surfaces seen only occasionally) may, in the case of the special grade and the varnishing grade be of the next lower grade, unless otherwise specified.

31 Special grade, notation E

This class comprises products, which meet high requirements and to which the timber has been chosen with particular care. These products are usually intented to be finished with vernish.

In grade E the frames are of grade 1.

32 Varnishing grade, notation 1

This is the normal quality grade for products intended to be finished with varnish.

The sort of timber for frame, lippings of door leaf and face veneer have to be specified in the order.

33 Painting grade, notation 2

This quality grade comprises products meant to be painted.

4 PROVISIONS FOR THE MATERIALS

41 Timber

.1 Quality

The basis of grading softwood is the u/s quality given in the grading rules of export timber with the limitations given later.

For foreign hardwood the provisions in appendix 2 will be applied.

.2 Heading joints

The joints have to be finger joints or alternating butt joints. The length of an alternating butt joint may be at the most one third of the width of the lengthened piece, however not more than 50 mm. No visible heading joints are allowed for special grade and varnishing grade.

.3 Defects. Plugging

Wane is not permitted in surfaces exposed to view. The knots have to be distributed evently and they are not permitted in places where they might affect the strength of the timber. The plugs shall be of the same species of wood and the direction of their grains shall be the same as in the surrounding wood to which they shall be firmly fastened. The plugs are considered sound knots and their sizes shall be taken into consideration at grading.

In products used in humid surroundings plugging ought to be avoided.

42 Plywood

Plywood shall as to quality, dimensioning and property comply with the requirements of SFS standards.

43 Block- and laminboards

Block- and laminboards shall suit the purpose as to quality and structure.

Boards for use as main faces should on both sides of the board have 1 + 1 veneers glued at right angles to each other and so that the grain direction of the veneer adjacent to the core is running at right angles to the grain of the core.

Boards with one or two parallel surface veneers on both sides, whose grain direction is running at right-angles to the grain direction of the core may be used for main faces only when they are faced with crosswise glued veneer, laminated plastics sheet, plastics fabric or the like.

44 Particle board

Particle board has to be a LA/A board and comply with the requirements of standard SFS O.IV.2

45 Wood fibre boards

.1 Hardboard should have a density of not less than 850 kg/m³.

.2 Medium hardboard should have a density of not less than 700 kg/m³.

46 Face veneer

Facing veneer has to be sliced, except birch which may be rotary cut.

Sliced veneer shall meet the requirements set in appendix 2.

Rotary cut veneer has to meet the requirements set in SFS standards.

47 Laminate plastics sheet

Laminate plastics sheet has to meet the requirements given in appendix 3.

48 Fittings

The manufacturer shall indicate in his offer the fittings he has used.

49 Degree of dryness

The timber has to be artificially dried. The moisture content calculated from dry weight shall not exceed 10 % during the manufacturing and delivery phases.

[illegible] also constitutes the basis for judging [illegible] form.

5 PRODUCT SPECIFICATIONS

51 General

The product and their parts have to be manufactured and assembled with care and skill. All timber joints which are known to be good and suit the appearance of the quality grade in question are allowed.

The faces should be plywood, which is at least 2.7 mm thick, hardboard, which is at least 3,2 mm thick, or other board of corresponding thickness. The facing boards should be fixed by gluing to the core.

Joints in boards are not allowed. In veneers joints are not allowed across the grains.

If the inner structure is not suitable for fixing of fittings inside wood blocks should be provided or the stiles should be dimensioned according to the fittings.

Adhesives should comply with the requirements of the use of the product and should resist moisture and micro organisms.

If the products are located in spaces which are continuously humid, this has to be indicated in the offer.

52 Accuracy form

Testing methods for accuracy of form, see appendix 1.

The provisions concerning accuracy of form refer to the moment of delivery, to the guarantee period inspection and to a dryness degree of the timber of 8 - 10 %.

The continuity of the properties of the products implies that they are stored and handled on the site according to the general specifications for construction works, RYL 1969, RT 140.1/B, para. B 671 and B 673.

.1 Accuracy of angles (squareness)

at delivery	at guarantee period inspection
1 mm	1 mm

.2 Planeness of surface (dish or/and twist)

at delivery	at guarantee period inspection
3 mm	4 mm

These figures imply that the temperatures and moisture conditions are the same in the spaces on both sides of the door.

.3 Evenness of surface

	at delivery	at guarantee period inspection
with a 200 mm ruler	0,2 mm	0,3 mm

53 Face veneer

	special grade	varnishing grade	painting grade
Rotary cut	AI(A)	I(B)	II(S)
Sliced, see appendix 2			

54 Defects allowed in surfaces exposed to view

	special grade	varnishing grade	painting grade
.1 Visible parts of door leaf frame and lippings thickness of doors = 40 mm			
Sound knots or plugs pieces/m not allowed	not allowed	1 p. 10 mm and pin knots	2 p. 20 mm 2 p. 15 mm and pin knots
Checks	not allowed	not allowed	small patched ones allowed
Blue stain	not allowed	not allowed	allowed as miscolouring
.2 Frames (42 mm x 93 mm)[1]			
Sound knots or plugs pieces/m		1 p. 20 mm 3 p. 10 mm and pin knots	2 p. 30 mm 3 p. 20 mm and pin knots
Checks		not allowed	small patched ones allowed
Blue stain		not allowed	allowed as miscolouring

55 Finishing of surfaces 'in the white'

.1 As to special grade products all main faces should be very carefully finished. There should be no glue accumulations which might make finishing difficult or cause colour defects. Defects due to manufacture may not be seen.

.2 As to varnishing grade products main faces have to be carefully finished. There should be no glue accumulations which might make finishing difficult or cause colour defects. Minor defects due to manufacture are allowed only in places which are not well adapted to machine grinding, like surfaces only a little or occasionally exposed to view.

.3 As to painting grade products main faces should be finished. No glue accumulations are allowed, which might make surface finishing difficult. Minor defects due to manufacture are allowed only in surfaces which are only a little or occasionally exposed to view.

6 MANUFACTURING DEGREE

Doors are delivered in the white, varnished or painted. Varnishing and painting should be done according to RT 148.682.

If the products are required finished in some other way this should be indicated separately as well as the materials and the methods to be used.

1) If the sizes are smaller or greater than the given, knots are permitted correspondingly less or more.

APPENDIX 1

Testing methods for accuracy of form

1 Accuracy of angles (squareness)

Squareness is measured with a square at diagonally opposite corners. The measuring points have to be situated 500 mm from the corners or at a distance corresponding the width if the width is less than 500 mm. Deviation is given in millimetres with the accuracy of 0.1 mm.

2 Planeness of surface (dish and/or twist)

Dish of a surface is measured on the concave side with a ruler, which is as long as the surface, along the diagonals and all edges. The greatest measured grade is decisive. The deviation is given in millimetres with an accuracy of 1 mm. Twist is measured by placing the surface on a level plane so that three corners touch the plane. The distance of the fourth corner from the plane gives the twist of the surface to be measured.

The deviation is given in millimetres with an accuracy of 1 mm.

3 Evenness of surface

Evenness of surface is measured with a ruler which is 200 mm long by setting it in arbitrary directions on the surface to be measured and using a special measuring device to measure the checks.

The deviation is given in millimetres with the accuracy of 0.1 mm.

APPENDIX 2

Quality requirements for foreign hardwood surfaces

1 General

Foreign hardwoods are imported species (e.g. oak, teak, mahogany etc.).

These provisions are also adapted to veneers cut of domestic species.

Provisions have been given for special grade and varnishing grade products.

2 Veneer

Veneer has to be sliced and the thickness should be the minimum of 0,6 mm. The joints of the veneer have to fit perfectly and the veneers have to be jointed so that a uniform pattern typical of the veneer in question is achieved.

.1 Special grade

The veneer should be typical of the species in question, free from defects and altogether homogeneous both as to colour and structure. Inserts are not allowed.

.2 Varnishing grade

The veneer should be typical of the species in question. Slight defects in colour and some other imperfections which do not disturb the general impression are allowed. A small amount of knots smaller than 5 mm (bird's eye) are permissible. Defects which sometimes appear in veneer such as surface wood of different colours, blisters, decay etc. are not allowed. Small corrections like patching done carefully so that they fit in with the surrounding veneer as to colour and structure are allowed.

3 Converted timber

The thickness of boards used for facing should be the minimum of 6 mm.

.1 Special grade

The timber should be typical of the species in question and the faces should be free from defects and altogether homogeneous as to colour and structure. Patches are not allowed.

2 Varnishing grade

The timber should be typical of the species in question. Small defects allowed in main faces. Knots smaller than 7 mm are allowed to some extent. Surface wood of different colours and other imperfections sometimes appearing in timber are not allowed. Sole plugs, which are carefully made and fit in with the colour of the wood and are smaller than 15 mm are allowed. The plugs have to be of the same species and the grains of the plug shall run in the same direction as the grains of the surrounding wood, in which it should be tightly fixed.

APPENDIX 3

Quality requirements for laminated plastics sheet

1 Coating of desks

The coating of desks should be paper backed laminated plastics sheet. Its thickness is the minimum of 1.4 ± 0.1 mm and it has to meet the following requirements.

Wearing strength: NEMA LD 1-3.03/64 A

Impact strength: NEMA LD 1-3.03/64 K

Appearance: NEMA LD 1-3.03/64 J

Changes due to moisture: NEMA LD 1-3.03/64 H

Heat resistance: SIS 245803 (NEMA LD 1-2.03/64). At testing no trace allowed on a matt surface, a glossy surface may lose some lustre.

Durability in boiling water: SIS R 705002 (NEMA LD 1-2.02/64), no trace allowed on the surface.

Influence of chemicals: SIS 245805 (NEMA LD 1-2.05/64), the grade has to be 3. The grades are 1, 2 and 3, of which 3 is the best.

Light resistance: SIS 245804 (NEMA LD 1-2.06/64), the grade has to be the minimum of 5. Grades are 1...8, of which 8 is the best.

Water absorption: SIS 245801 (NEMA LD 1-2.07/64), the absorption may not be higher than the maximum of 500 mg/25 cm² for sheets 1,4 mm thick. For thicker sheets the maximum of 10 % of the mass.

2 Coating of vertical surfaces

The coating of vertical surfaces such as door leaves should be paper backed laminated plastics sheet, the thickness of which is the minimum of 0,8 ± 0,1 mm which has to meet the following requirements.

Wearing strength: NEMA LD 1-4.03/64 A

Impact strength: NEMA LD 1-4.03/64 G

Appearance: NEMA LD 1-4.03/64 E

Changes due to moisture: NEMA LD 1-4.03/64 D

Influence of chemicals: SIS 245805 (NEMA LD 1-2.05/64). The grade has to be 3. Grades are 1, 2 and 3, of which 3 is the best.

Light resistance: SIS 245804 (NEMA LD 1-2.06/64). The grade has to be the minimum of 5. Grades are 1...8, of which 8 is the best.

Water absorption: SIS 245801 (NEMA LD 1-2.07/64), for sheets which are 0,8 mm thick the absorption may be the maximum of 350 mg/25 cm², for thicker sheets the maximum of 12 % of the mass.

3 Coating of shelves

The thickness of laminated plastics sheet used for coating of shelves has to be the minimum of 0,8 ± 0,1 mm and the coating has to meet the following requirements.

Wearing strength: NEMA LD 1-4.03/64 A

Impact strength: NEMA LD 1-4.03/64 G

Influence of chemicals: SIS 245805 (NEMA LD 1-2.05/64). The grade has to be 3. Grades are 1, 2 and 3, of which 3 is the best.

4 Other laminated plastics sheet

Sheets may also be fabric-backed or other laminated plastics sheet if it meets all the requirements of the previously mentioned standards SIS and NEMA. The manufacturer has to indicate the thickness and type of laminated plastics sheet in his offer.

Window, wood, fittings RT 860.23

0 GENERAL

01 This RT-sheet describes the number and location of fixing points of frames of wooden windows.

02 The frame of the window is always fixed by the jambs. Window frames, whose nominal width is ≥ 12 dm, are fixed also by their head and sill. See point 12.

1 NUMBER AND LOCATION OF FIXING POINTS

11 Number and location of fixing points in the jambs, fig. 2...5.

The distances are measured from the corner of the rebates, of the frame, fig 1.

Fig. 1

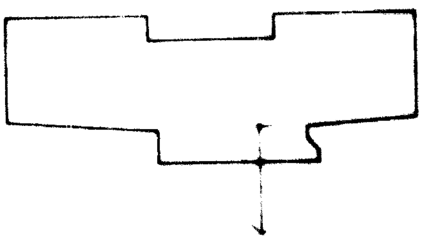
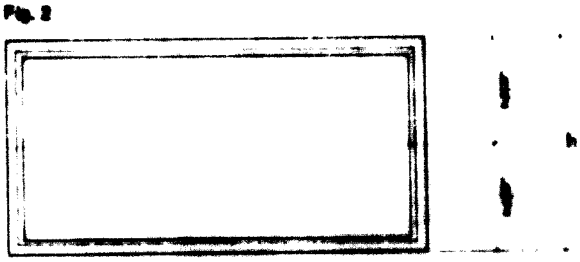
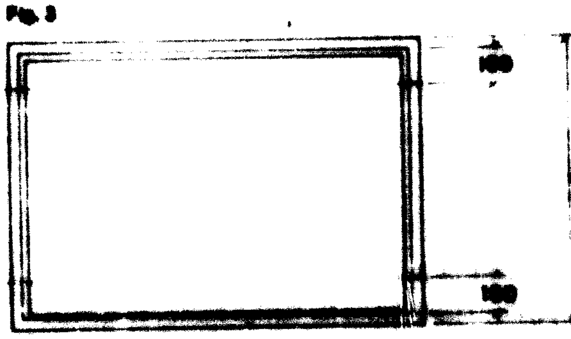


Fig. 2



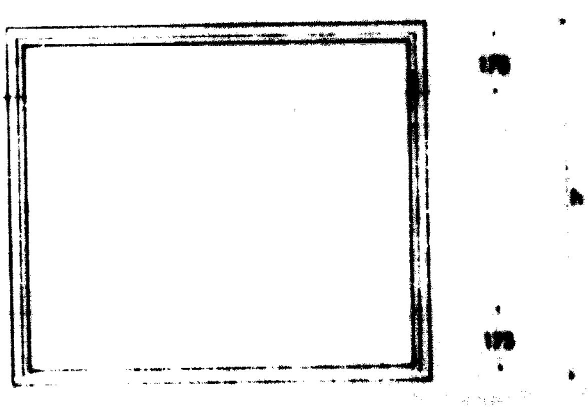
h < 6 dm

Fig. 3



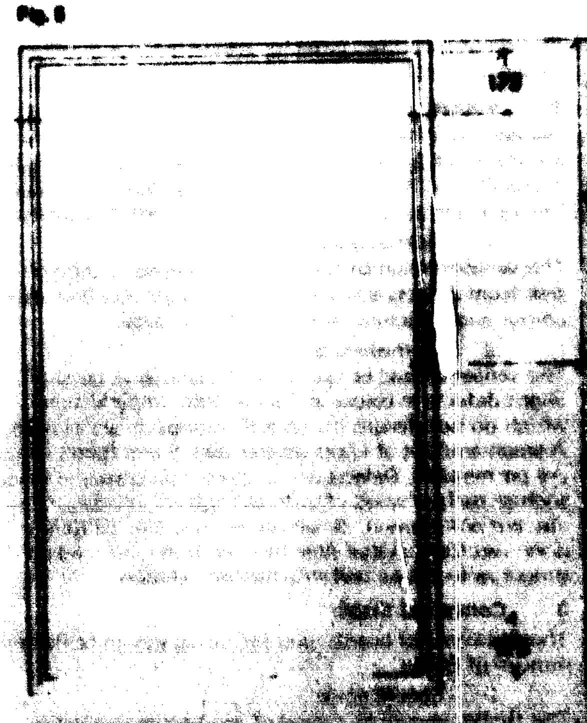
h < 6 dm

Fig. 4



6 dm < h ≤ 16 dm

Fig. 5



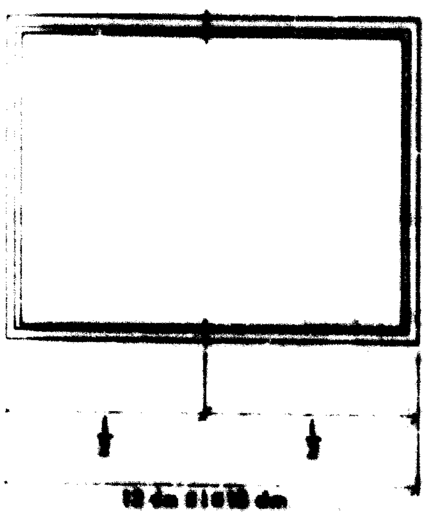


Fig. 6

12 Number and location of fixing points in the head and sill members of the frame, fig. 6 and 7. The distances are measured inside rebates.

When the nominal width of frame is < 12 dm no fixing by head and sill members is necessary.

13 Location of fixing points in the direction of depth is shown in fig. 8.

Fig. 8

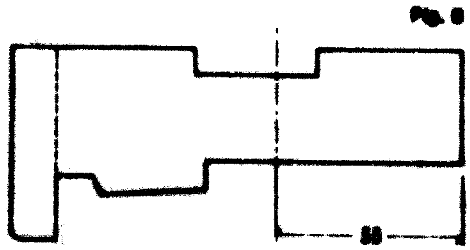
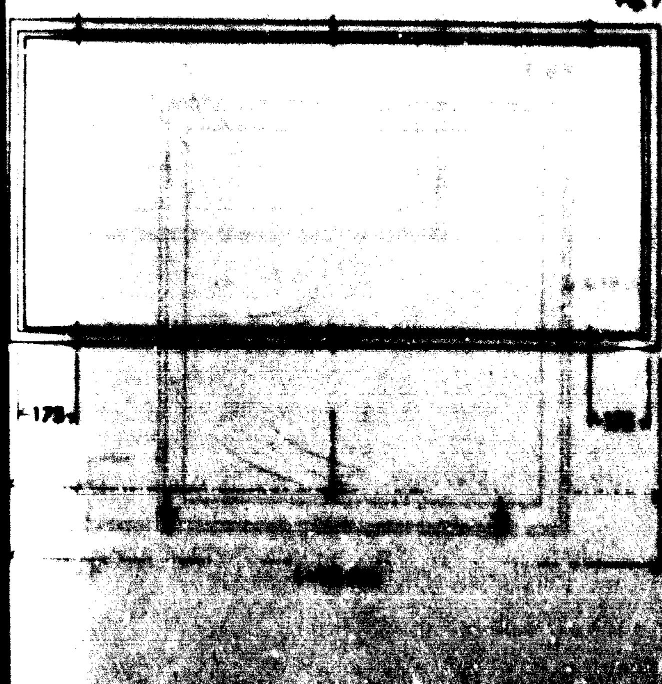


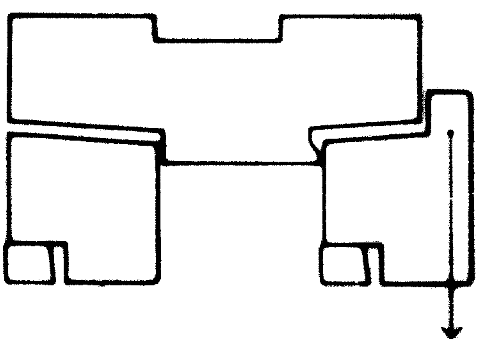
Fig. 7



1970 RT 860.23e
SfB X(31)
UDK 69.028.21:674
Page 1 (4)

Windows in group RT 861
Window wood installation RT 860 22

Fig. 1



0 GENERAL

This RT-sheet includes the position of hinges and the number and position of closure and coupling fittings in wood windows.

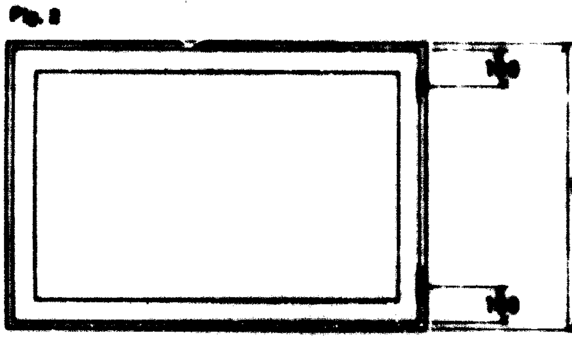
1 POSITION OF HINGES

The centre of hinges is measured from the corner of the inner casement, see fig. 1.
Number of hinges, see group RT 861...
Hinges of coupled windows
Coupling hinges should be placed near the bearing hinges. The strength of the casement must not be lessened. There should be 1 mm distance between coupled casements.

11 Hinges of side hung windows

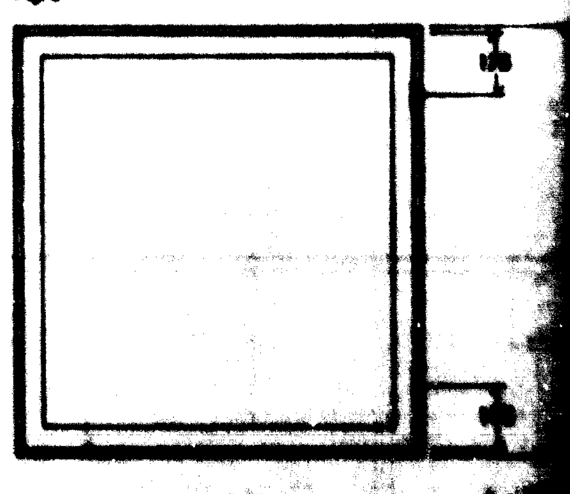
111 Side hung windows with two hinges, fig. 2 and 3.

Fig. 2



h ≤ 8 dm

Fig. 3



112 Side hung windows with three hinges fig. 4 and 5

12 Hinges of top hung windows

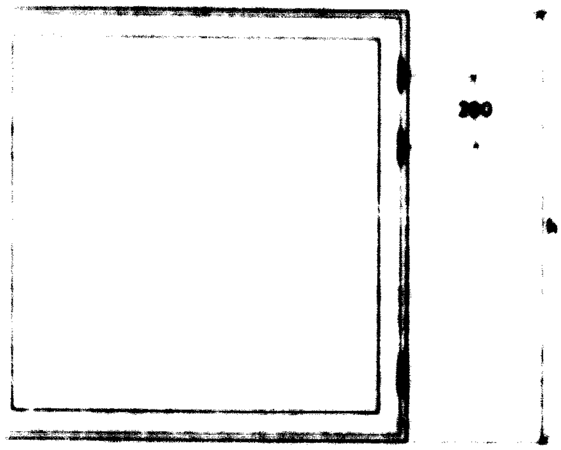
121 Top hung windows with two hinges fig. 6 and 7

122 Top hung windows with three hinges fig. 8

13 Hinges of bottom hung windows

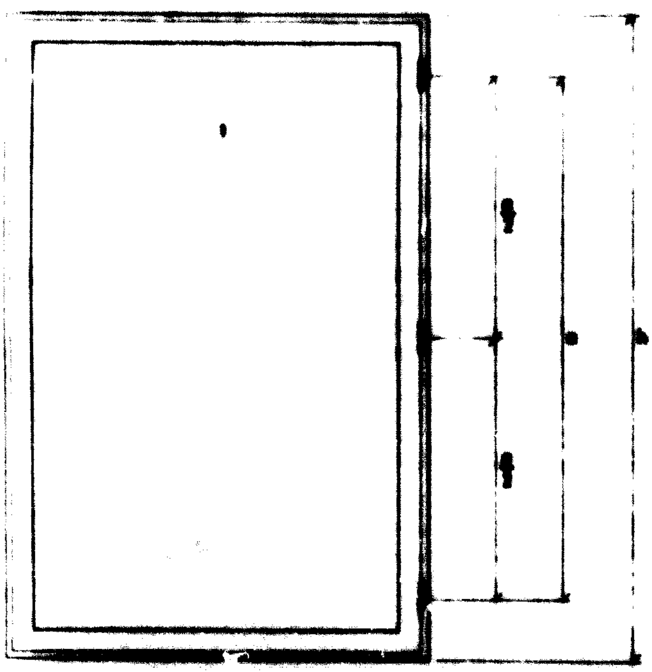
The hinges of bottom hung windows are fixed to the bottom member at places corresponding to the position of the hinges of top hung windows.

Fig. 4



8 dm < h < 10 dm

Fig. 5



h ≥ 10 dm

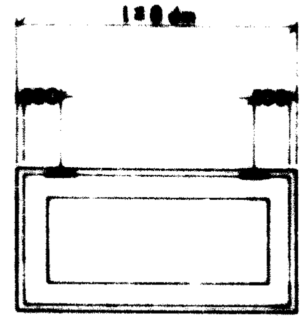


Fig. 6

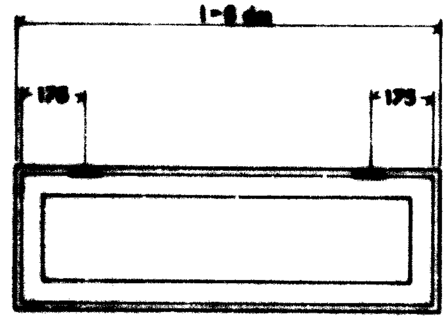


Fig. 7

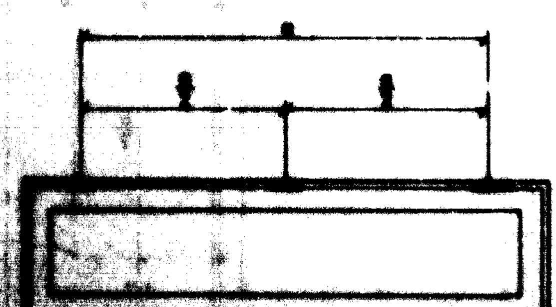


Fig. 8

Fig. 9

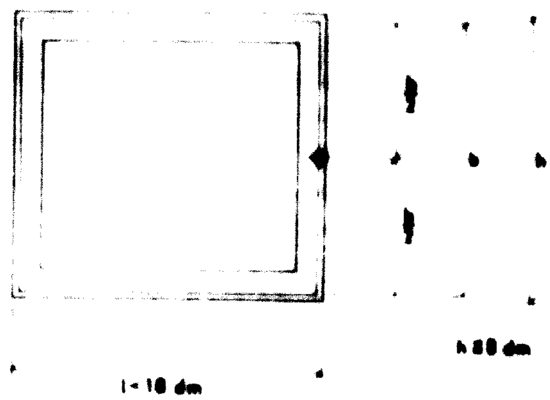


Fig. 10

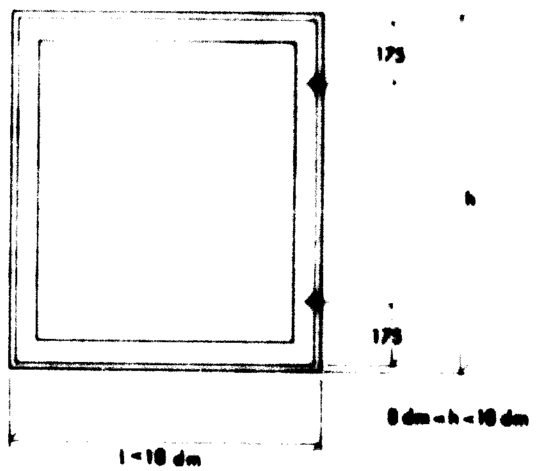
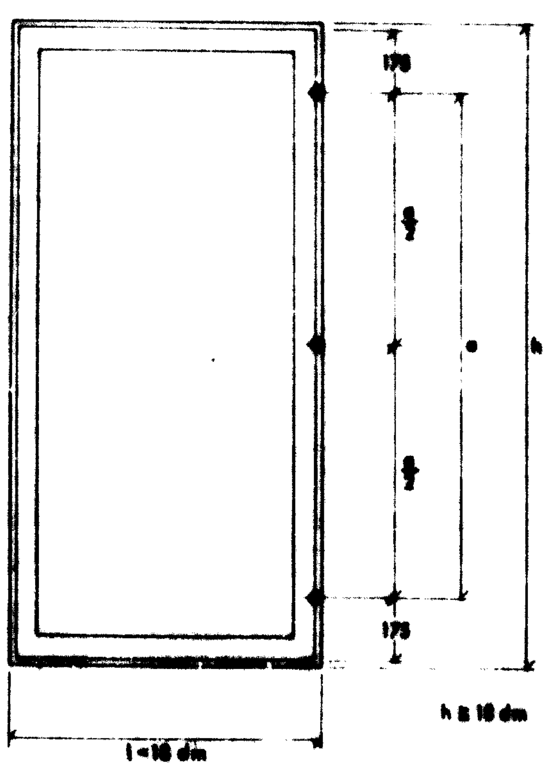


Fig. 11



2 NUMBER AND POSITION OF CATCHES AND ESPAGNOLETTES

The position of the centre of the hole for catch handle is measured from the corner of the inner casement, see fig. 1.

21 Catches of side hung windows, figures 9, 10 and 11.

If the nominal width of a side hung window is ≧ 10 dm, there should be one catch in the middle of both the top and the bottom members in addition to the catches in the stile.

211 Meeting stiles

Meeting stiles casements should have espagnolettes with both side and end fastenings.

The number and position of the side fastenings of espagnolettes is the same as the number and position of the separate catches in windows of corresponding height.
The handle of espagnolettes is in the centre of the stile, when the nominal height of the window is ≦ 14 dm, and 600 mm from the bottom corner of the casement when the nominal height is > 14 dm.

212 Ventlights provided with doors

One catch with permanent handle is enough for a ventlight door, whose nominal height is ≦ 8 dm.

If the nominal height is > 8 dm, espagnolettes are used. The espagnolettes should have side fastenings. For the number and position of fastenings and the position of handles, see point 211.

22 Catches of top hung windows, fig. 12, 13 and 14.

23 Catches of bottom hung windows

The catches of bottom hung windows are fixed in top and bottom members to such places as correspond to the position of the catches of top hung windows.

Fig. 12

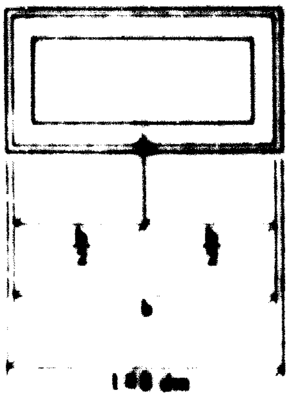


Fig. 13

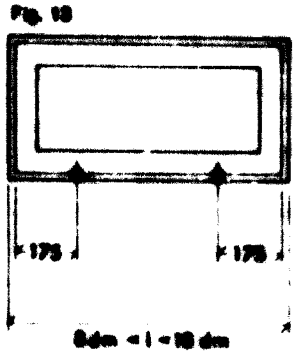
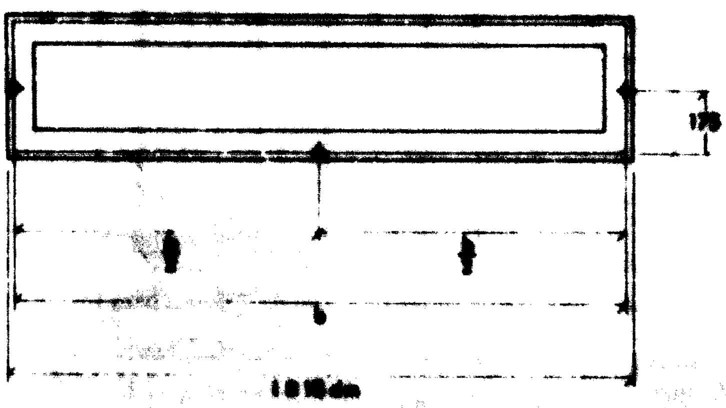


Fig. 14



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Suomen Standardisoimislautakunta Finlands Standardiseringskommission

WINDOWS, WOOD, OPENING INWARD, DOUBLE CASEMENT

SFS/RT 861.42E
SfB X(31)
UDK 69.028.21.674
Page 1 (8)

Windows, nomenclature SFS/RT 860.00
Wooden windows and outside doors, quality SFS/RT 210.81

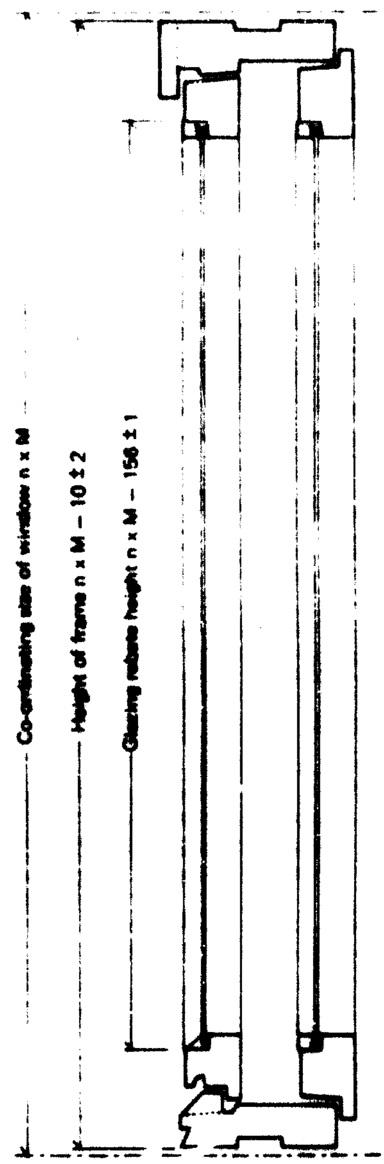


Fig. 1
M = 100 mm
n is an integer number ≧3

1 Contents

11 This SFS/RT standard includes modular wood windows with inwards opening double casements.

12 The standard gives the outer sizes of the frame, the size of the frame and the casement members, and the clearances as well as the standard sizes, glazing rebate sizes, and sizes of panes and hinges of one-light windows designed according to a horisontal module of 3M.

2 Notation

The nominal sizes of the standard windows is given in dm, width x height.
Notation: name of window, nominal size and the number of this standard.
E.g. One-light window 15 x 12 SFS/RT 861.42.
Manufacturing degree and quality class according to standard SFS/RT 210.81 has to be mentioned with the order.

3 Dimensioning basis

Basic module M = 1 dm = 100 mm.
The co-ordinating sizes of the windows are modular sizes, integer multiples of the basic module. Dimensioning implies that the moisture content of the timber calculated from dry weight is ≦ 12 %.

4 Dimensioning

The principle of dimensioning is given in fig. 1.

41 The outer sizes of the frames are 10 ± 2 mm smaller than the corresponding co-ordinating sizes the windows. Figure 1.

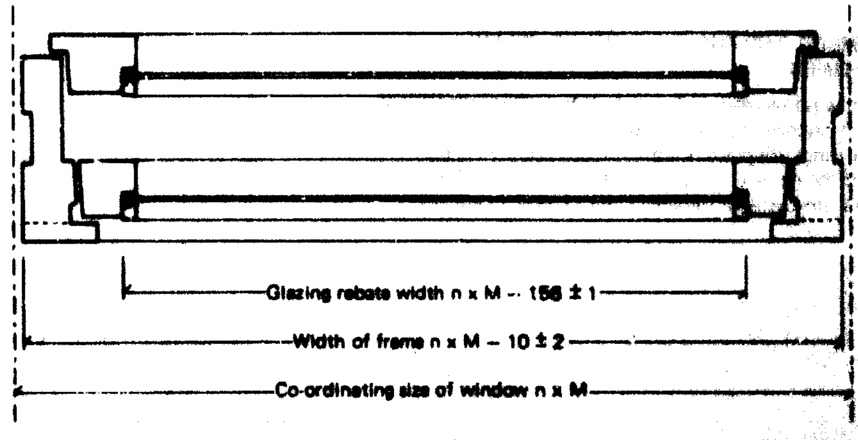
42 Glazing rebate sizes of one-light windows are 156 ± 1 mm smaller than the corresponding co-ordinating sizes of the windows. Figure 1.

43 The basic sizes of the panes of one-light windows are 160 mm smaller than the corresponding co-ordinating sizes of the windows.

44 Sizes of profiles, see figures.

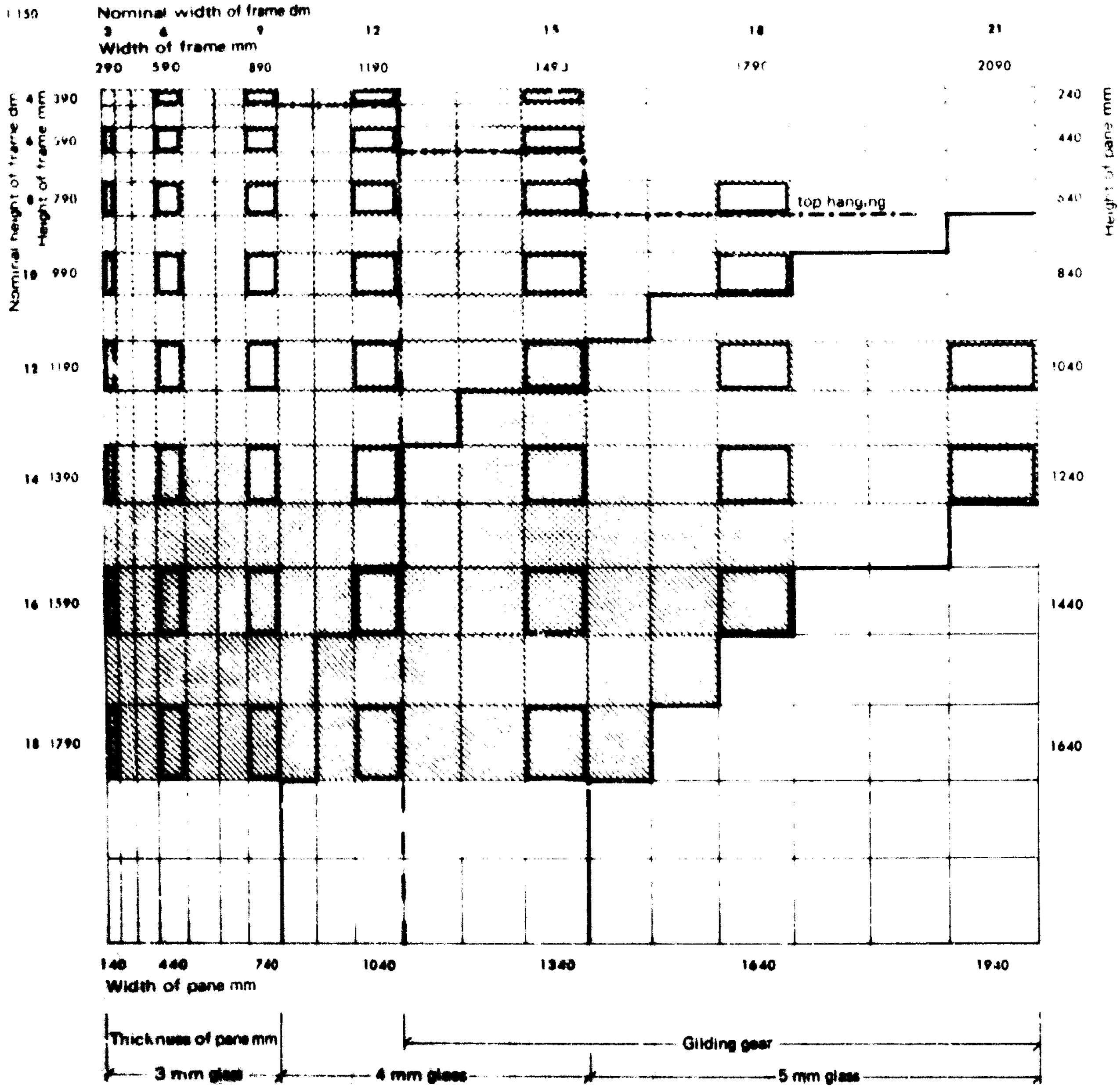
45 Sizes of clearances are valid for unfinished windows provided with fittings.

Clearance	Outer casement	Inner casement
at the hanging stile	2 mm	2 mm
at the closing stile	3 ...4 mm	3 ...4 mm
at the top rail	2,5...3,5 mm	2,5...3,5 mm
at the bottom rail	3,5...4,5 mm	3 ...4 mm



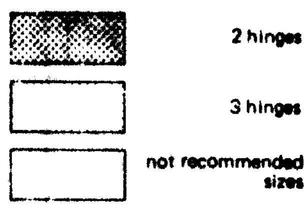
5 Standard sizes of one-light windows

In the table the hatched area includes the recommended sizes of one-light windows. The standard sizes that as to their width are based on the module 3M are shown as framed squares. The nominal sizes of the standard windows as well as the basic overall sizes are given along the top and left edges of the table. The corresponding glass sizes are given along the bottom and right edges. The thickness of the glass is given at the bottom of the table and as a black dividing line on the table itself. The number of hinges is shown by different hatching and dimensions for top hanging above the dot and dash line. A dash line shows the area within which side hung windows shall be provided with a gliding gear.



6 Combined windows

Window rows of two or more lights can be formed by joining together one-light windows. These types of windows and glazed doors are joined together as shown in fig. 2.



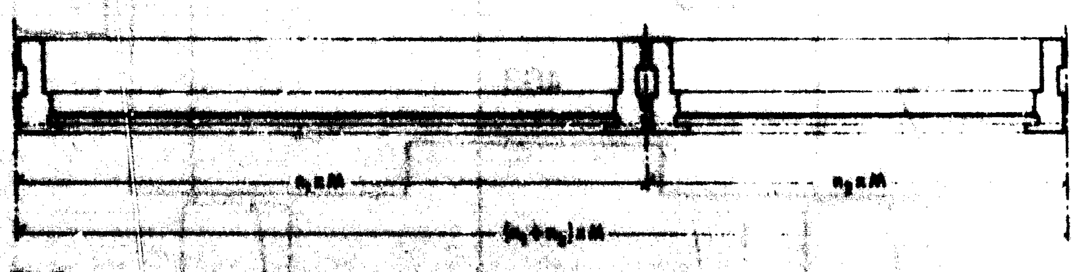
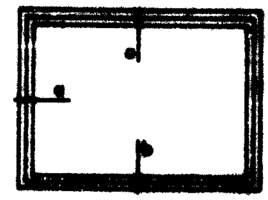
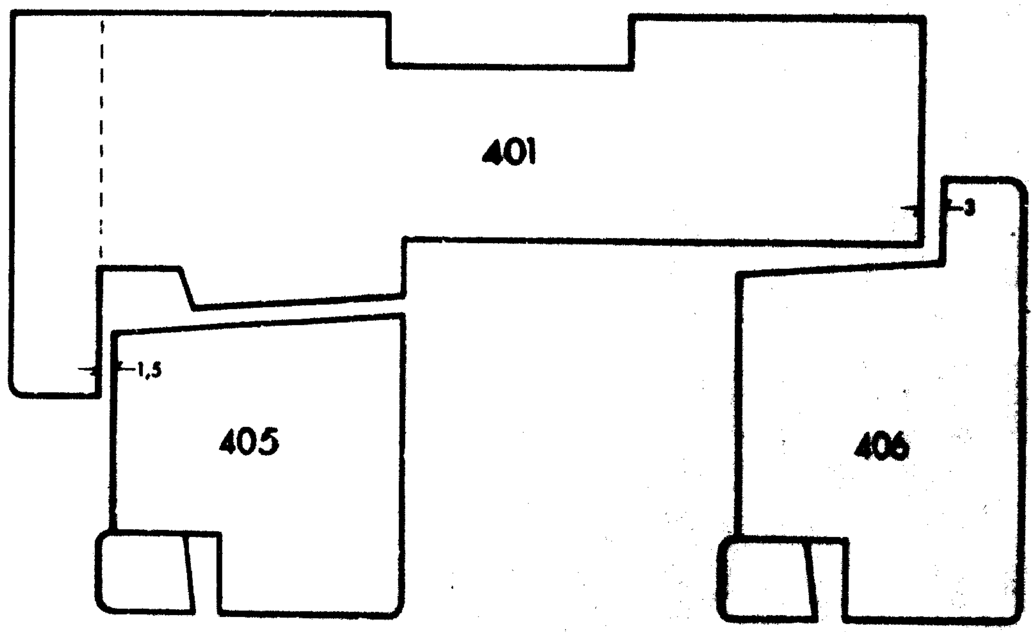


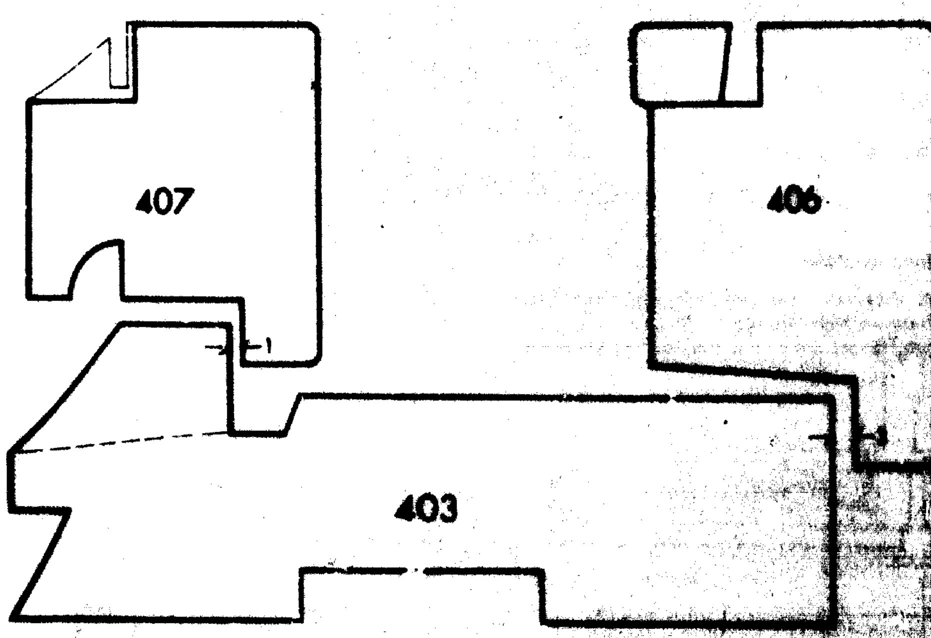
Fig. 2

Fitting of casement members to frame members by one-light windows



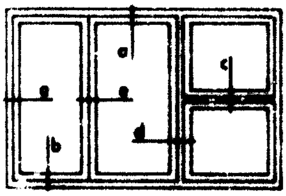


a



b

Fitting of meeting stiles and of casement members to mullion and transom members



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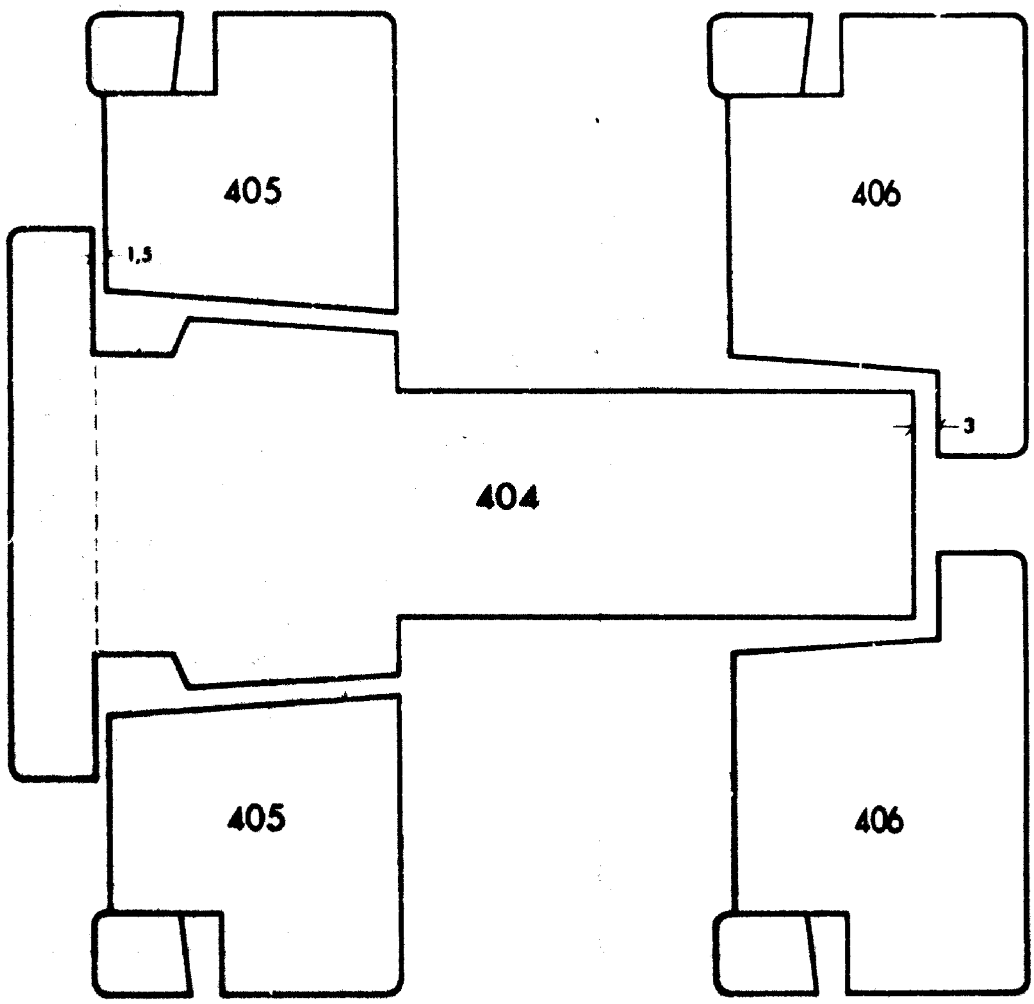
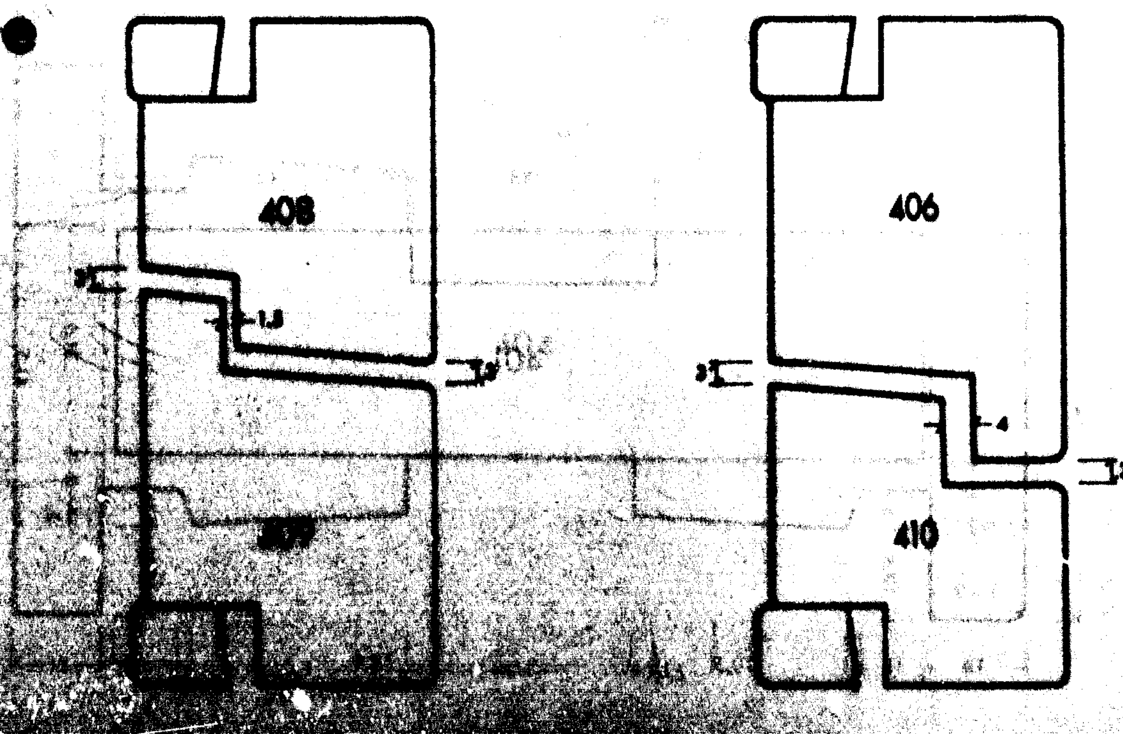
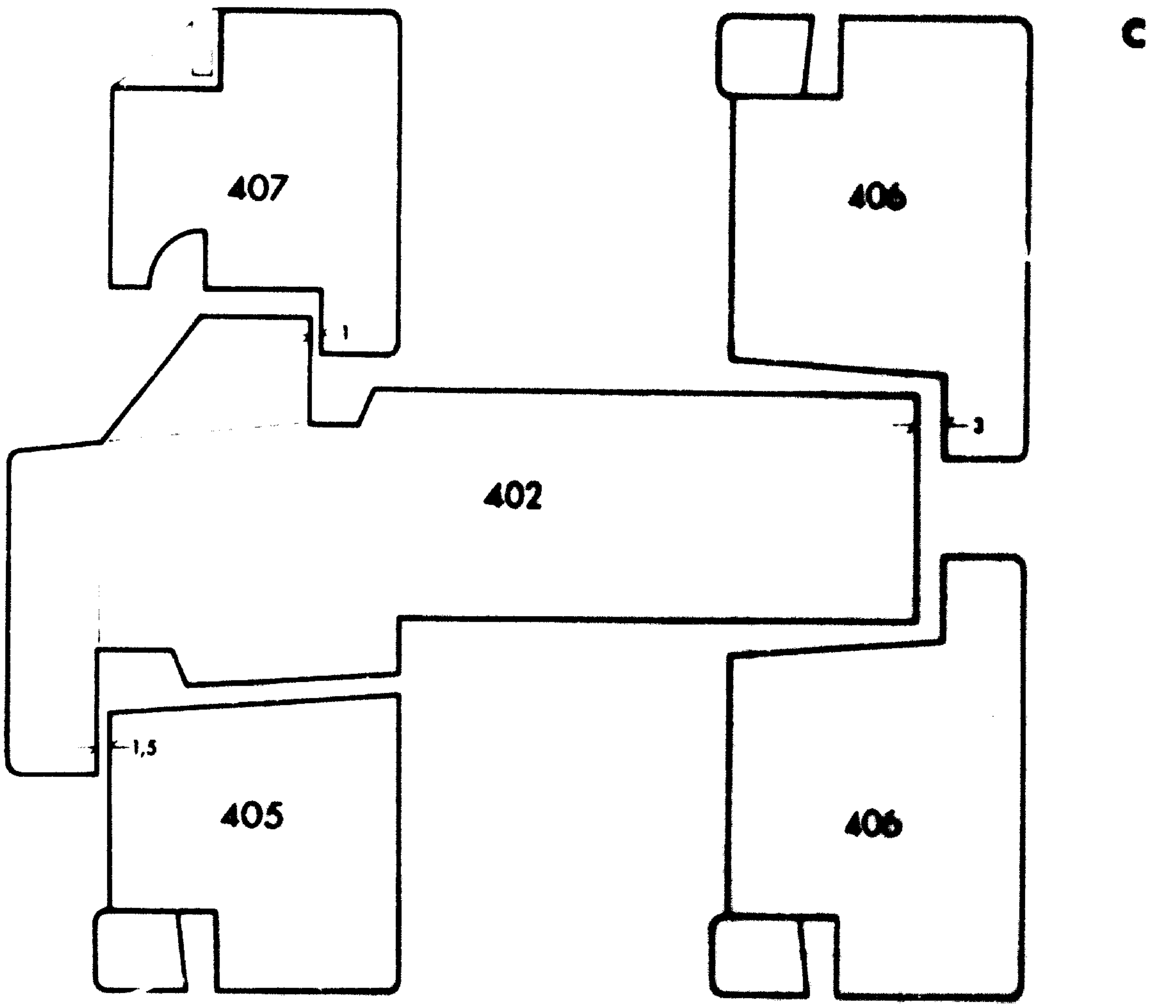
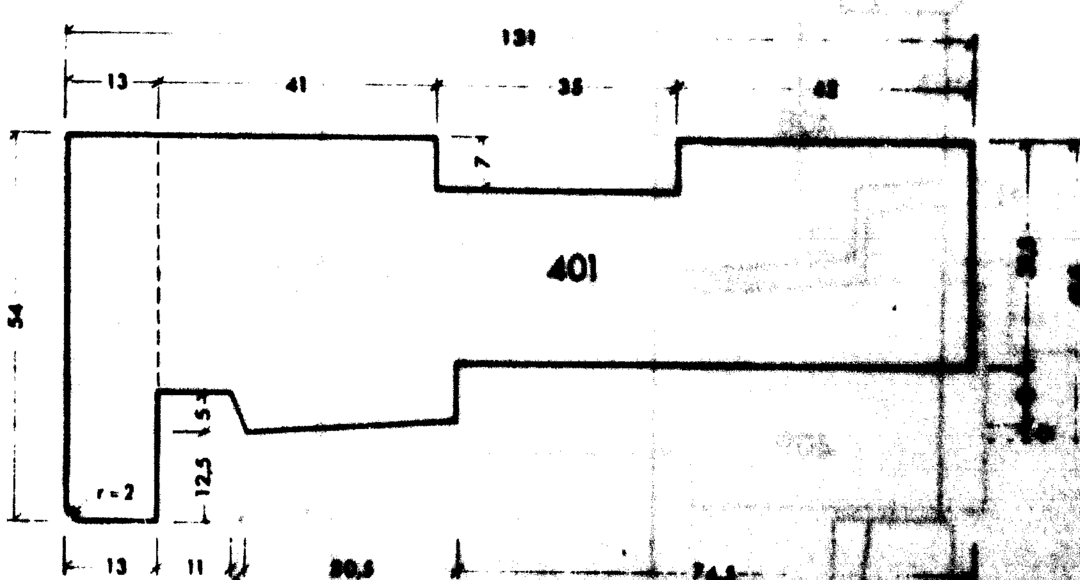
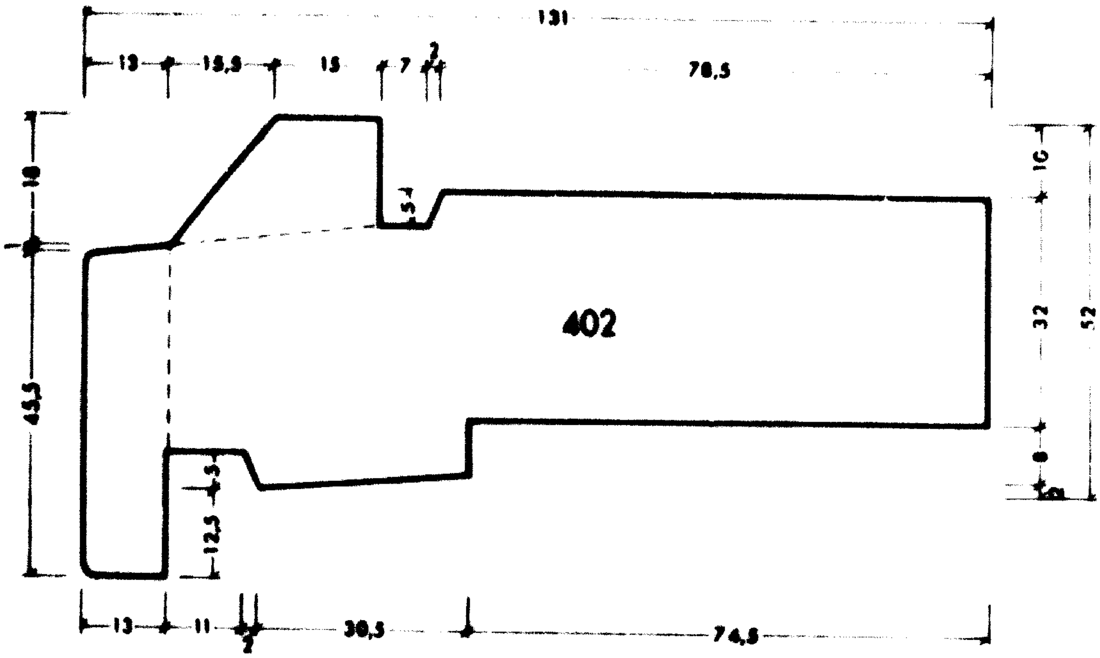






Basic sizes of frame and casement members
Permissible deviations for the main measurements of the members is ± 1 mm

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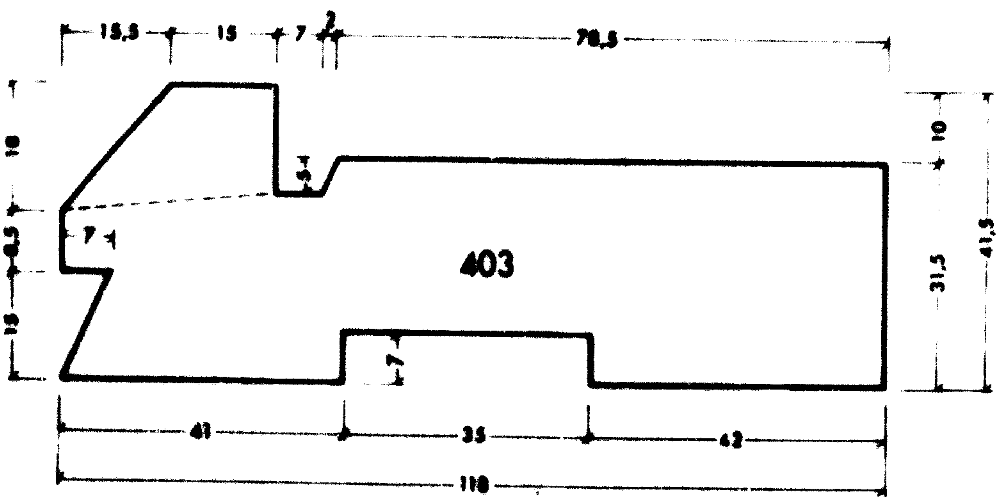
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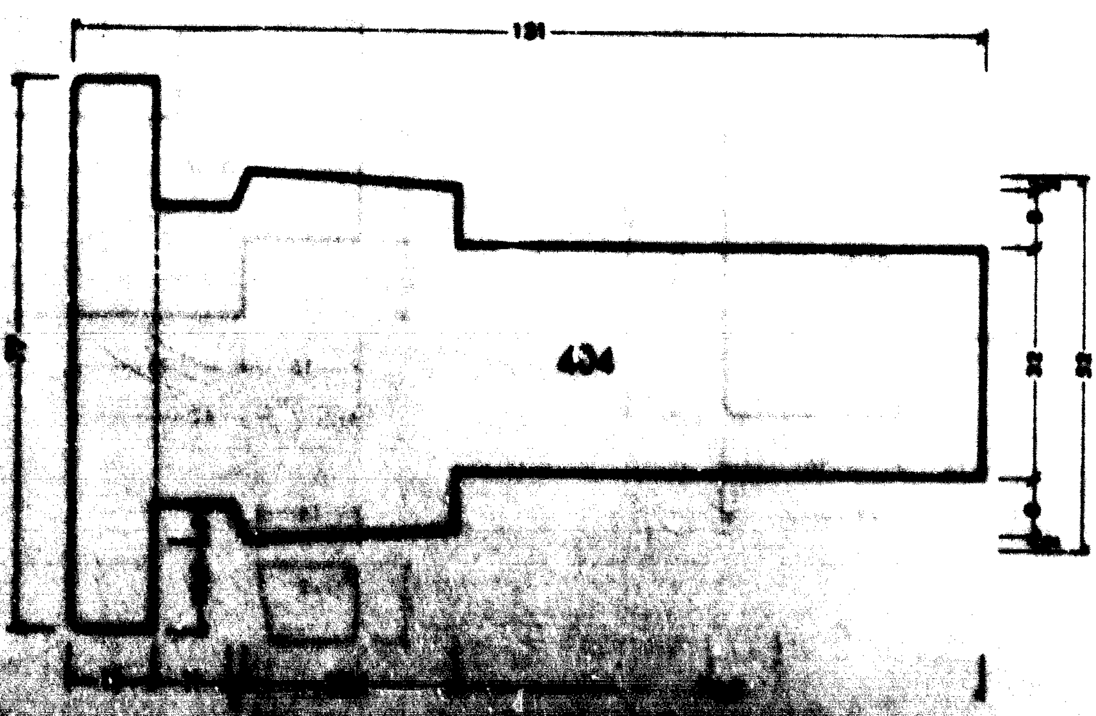
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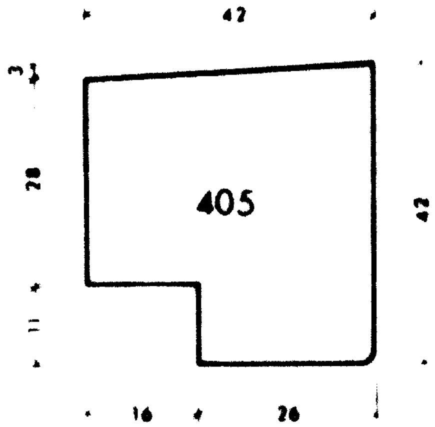
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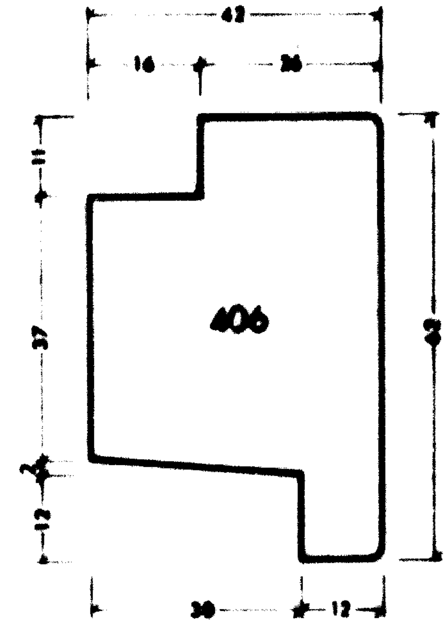
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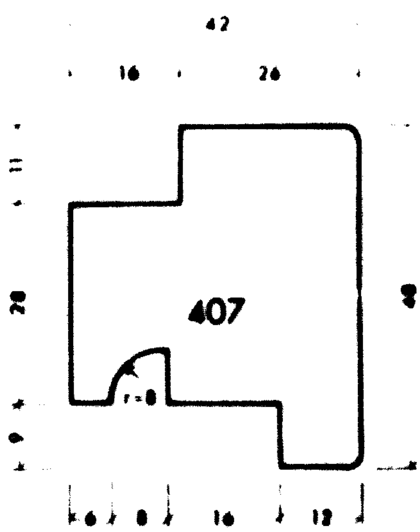
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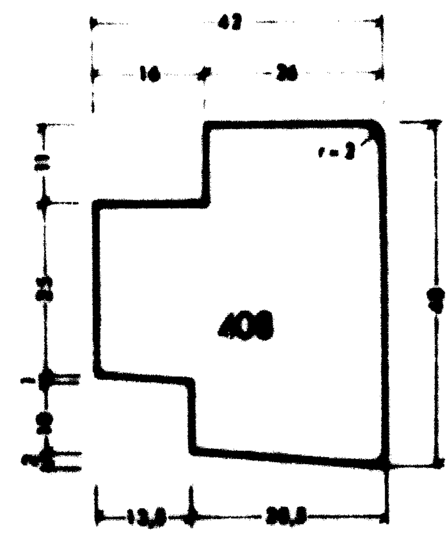
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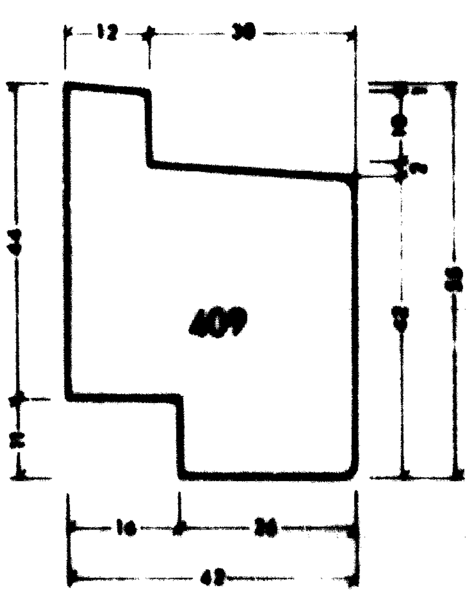
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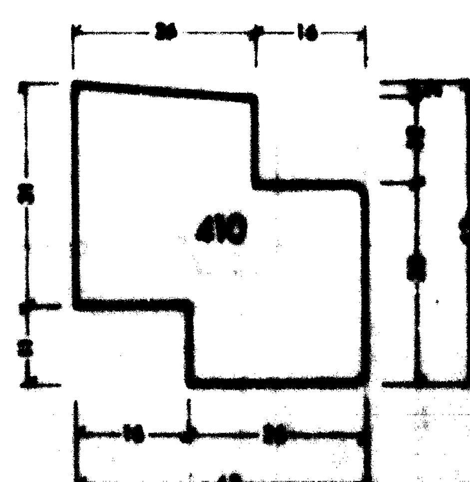
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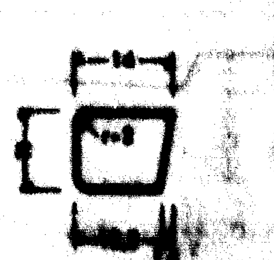
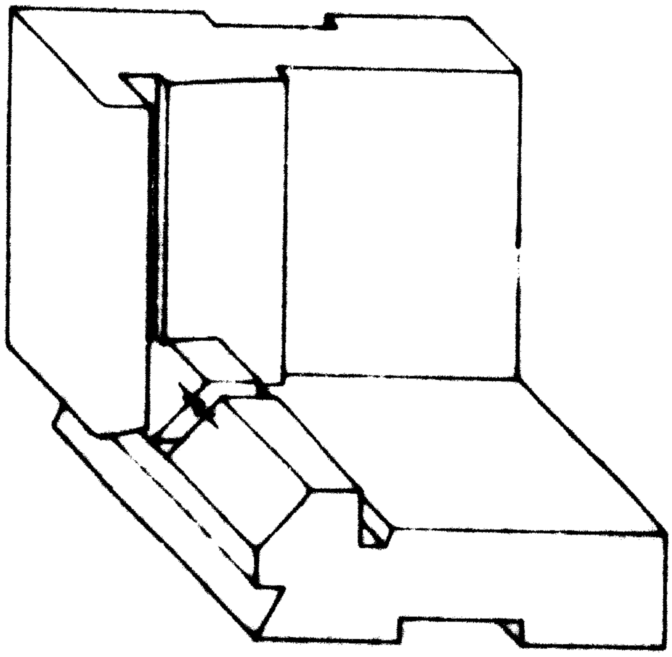


[illegible] of frame



Windows, nomenclature		SFS/RT 860.00
Windows	in group	RT 861
Wooden windows and outside doors, quality		SFS/RT 210.81

0 General

01 This RT sheet includes modular wood windows with inward opening coupled casements.

02 The outer sizes of the frame, the sizes of the frame and the casement members and the clearances are given, as well as the standard sizes, glazing rebate sizes and sizes of panes and hinges of one-light windows designed according to a horizontal module of 3M.

1 Notation

The nominal sizes of the windows is given in dm, width x height.

Notation: name of window, nominal size and the number of this RT-sheet.

E.g. one-light window 15 x 12 RT 861.46.

Manufacturing degree and quality class according to standard SFS/RT 210.81 have to be indicated in the order.

2 Dimensioning basis

Basic module M = 1 dm = 100 mm

The co-ordinating sizes of windows are modular sizes, integer multiples of the basic module. Dimensioning implies that the moisture content of the timber calculated from dry weight is ≦ 12 %.

3 Dimensioning

The principle of dimensioning the window is seen in figure 1.

31 The outer sizes of frames are 10 ± 2 mm smaller than the corresponding co-ordinating sizes of the windows. Figure 1.

32 Glazing rebate sizes of one-light windows are 156 ± 1 mm horizontally and 166 ± 1 vertically. Figure 1.

33 The basic sizes of the panes of one-light windows are horizontally 160 mm and vertically 170 mm smaller than the corresponding co-ordinating dimensions of the window.

34 Sizes of profiles, see figures.

35 Sizes of clearances are valid for unfinished windows provided with fittings.

Clearance	Outer and inner casement
at the hanging stile	2 mm
at the closing stile	3 ...4 mm
at the top rail	2,5...3,5 mm
at the bottom rail	3 ...4 mm

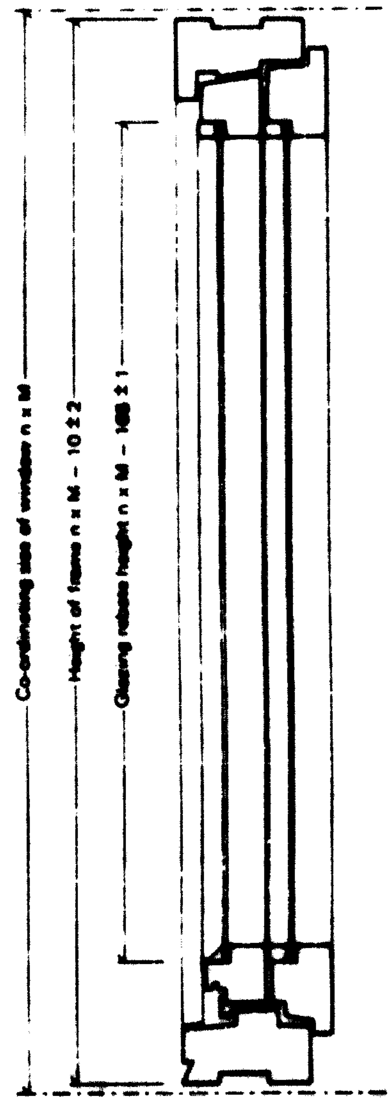
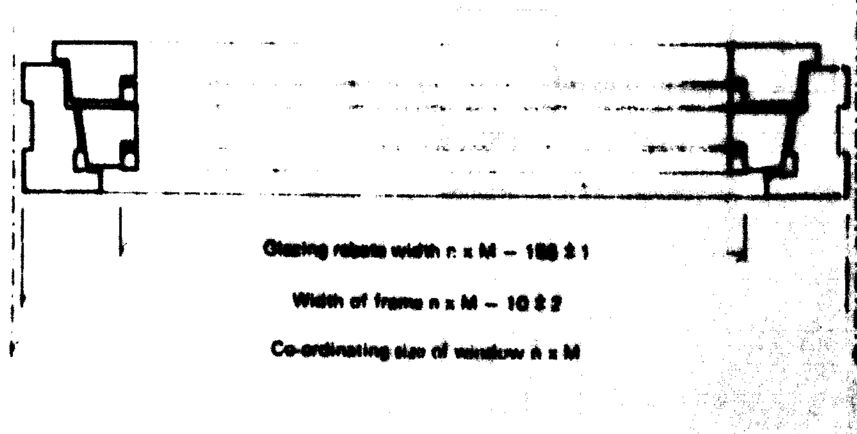
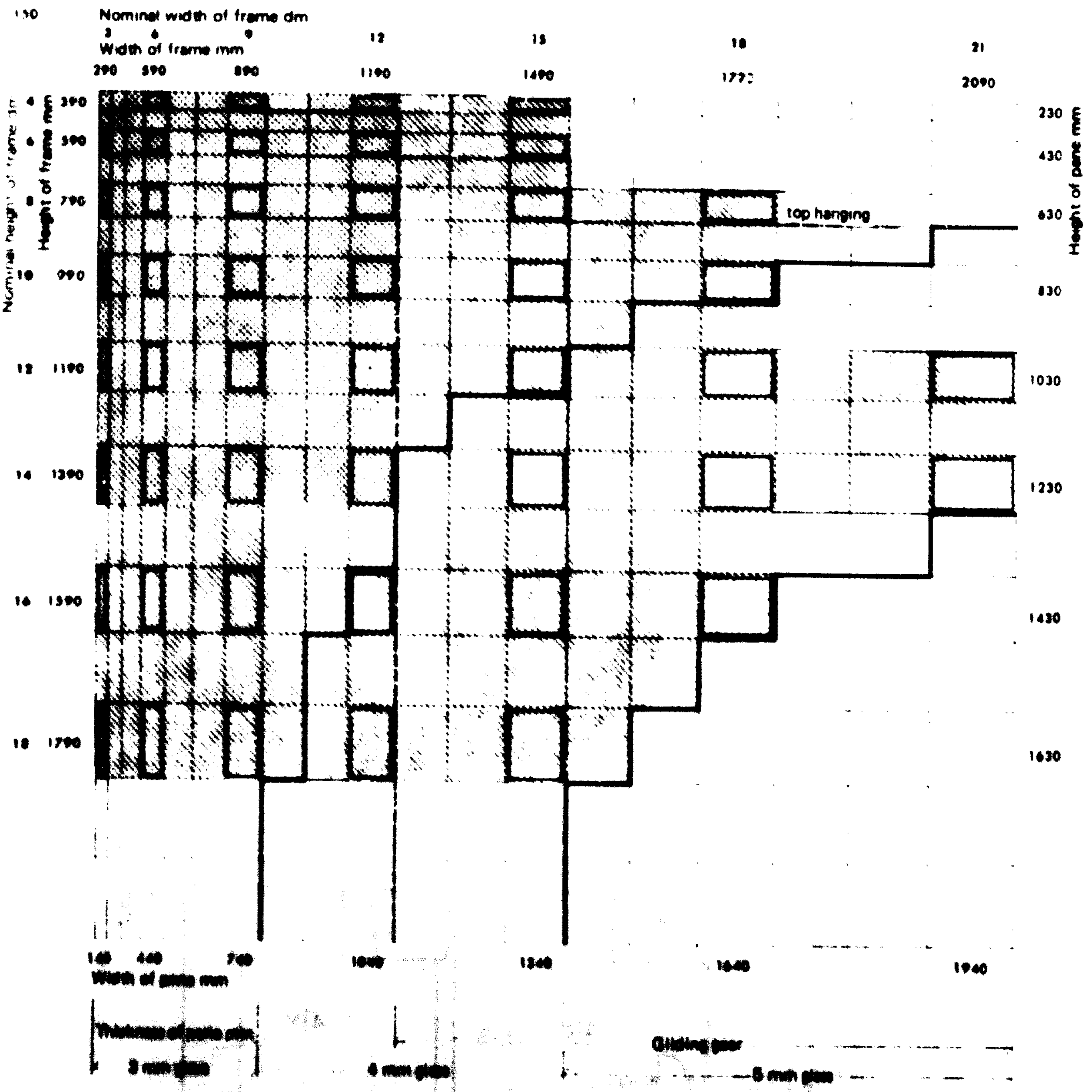


Fig. 1
M = 100 mm
n is an integer number ≧ 3



4 Standard sizes of one-light

In the table the hatched area includes the recommended sizes of one-light windows. The standard sizes that as to their width are based on the module 3M are shown as framed squares. The nominal sizes of the standard windows as well as the basic overall sizes are given along the top and left edges of the table. The corresponding glass sizes are given along the bottom and rigth edges. The thickness of the glass is given at the bottom of the table and as a black dividing-line on the table itself. The number of hinges is shown by different hatching and dimensions for top hanging above the dot and dash line. A dash line shows the area within which side hung windows shall be provided with a gliding gear.

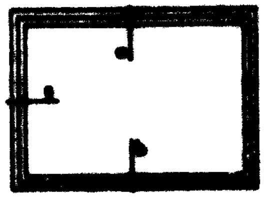


5 [illegible]

Window rows of two or more lights can be [illegible] by joining [illegible]. [illegible] of windows and glazed doors are [illegible] in fig. 2.

RT 881 46E

Fitting of casement members to frame members by one-light windows



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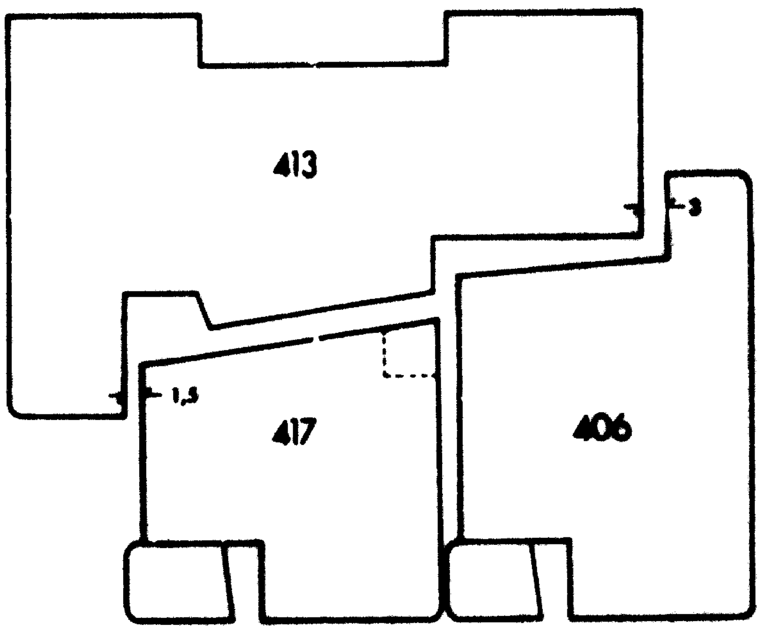

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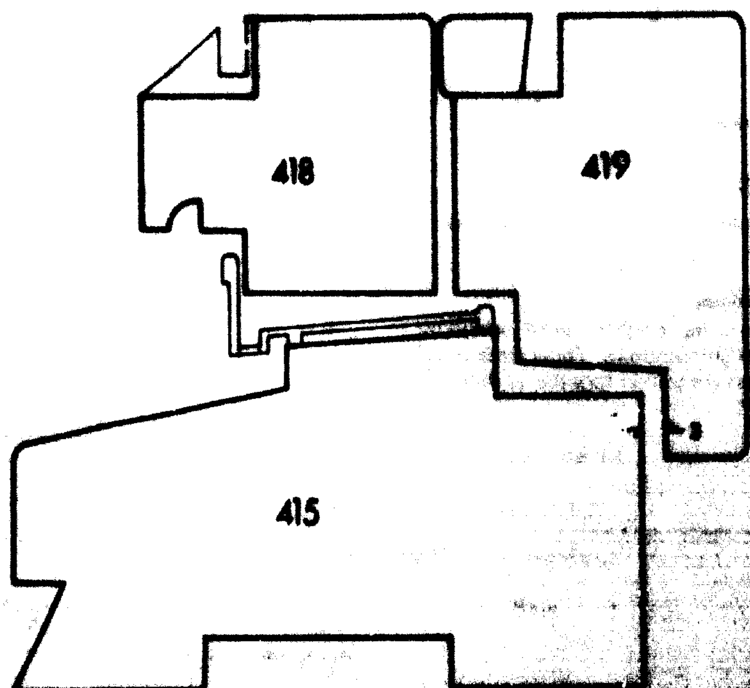
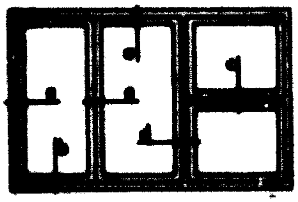


Fixing of meeting stiles and of casement members to mullion and transom members



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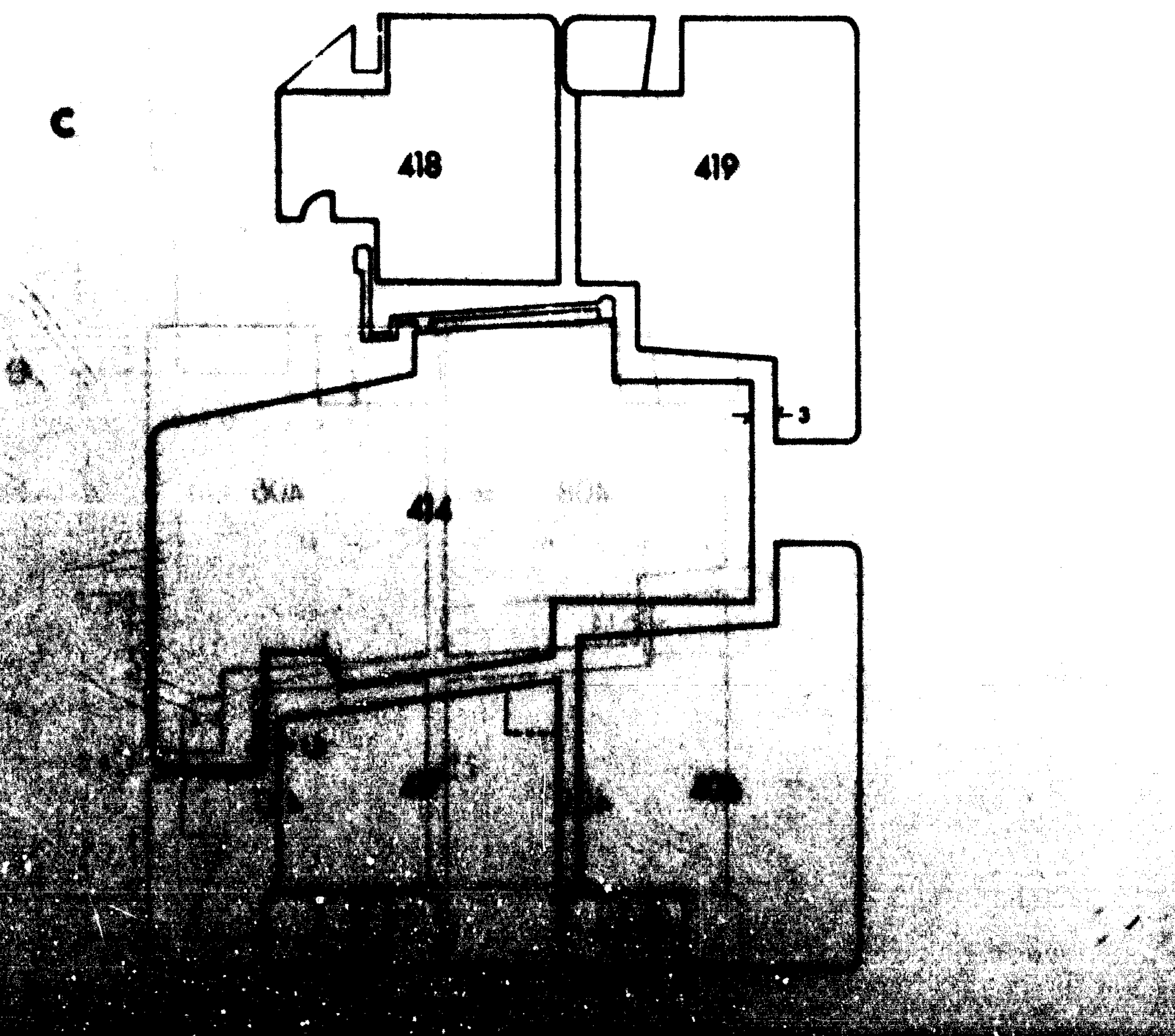

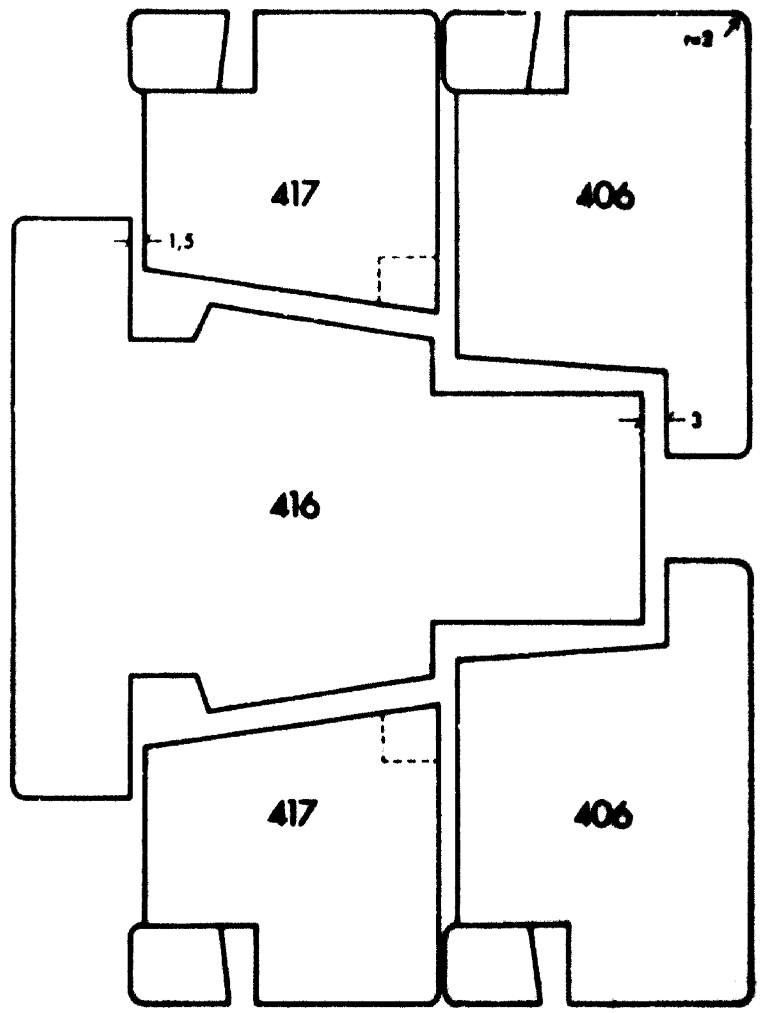

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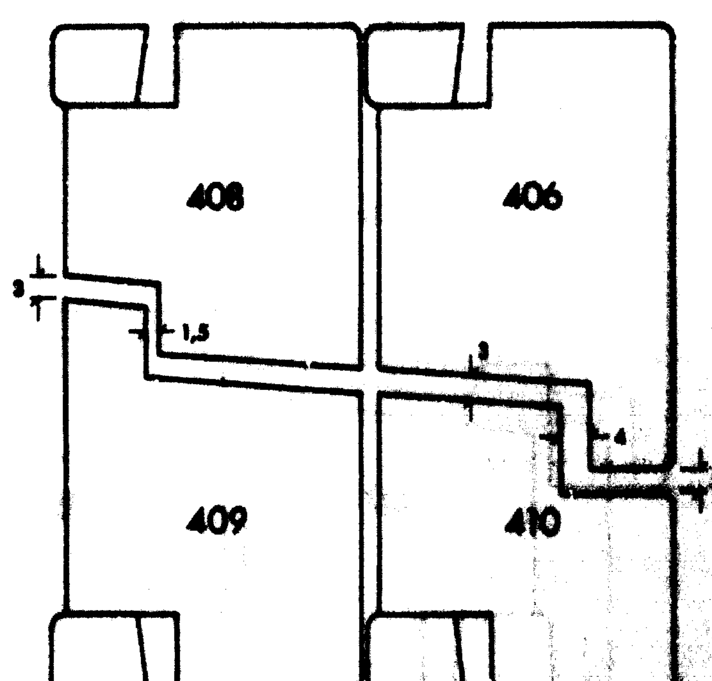
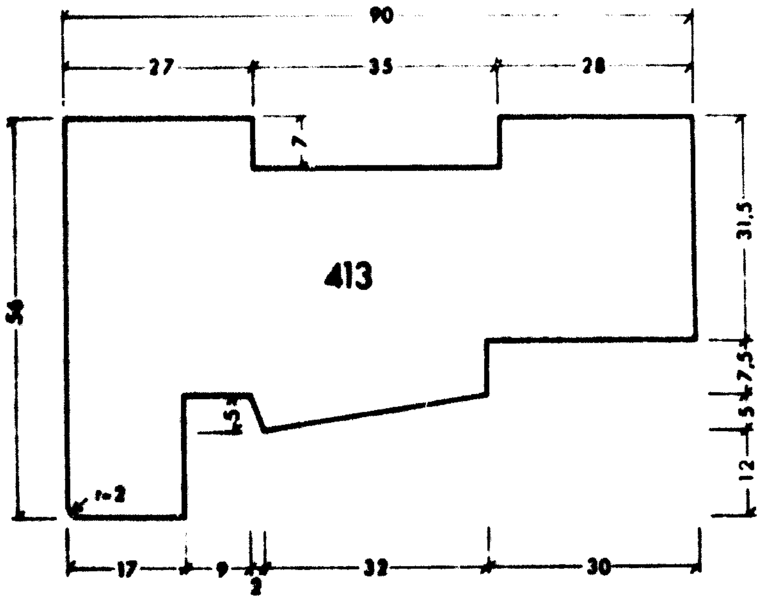
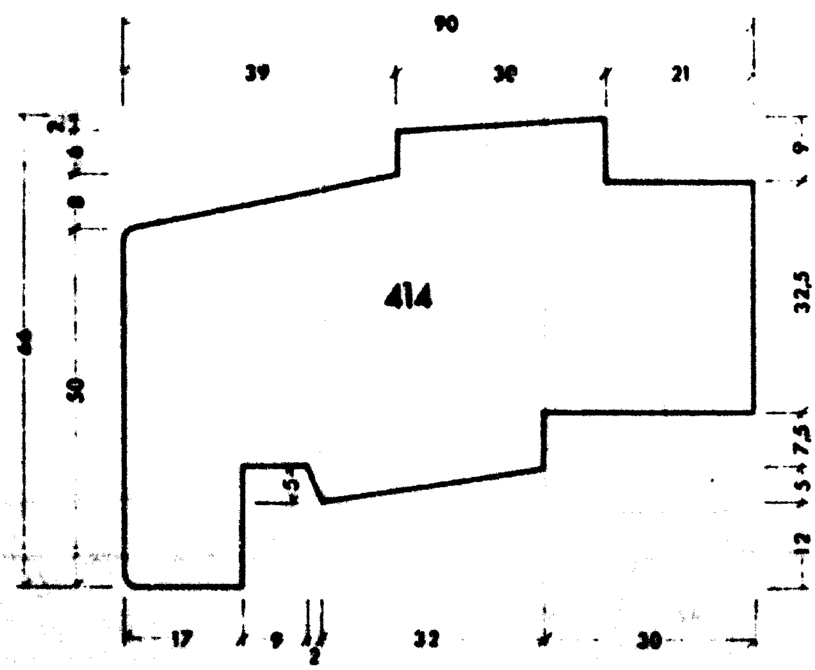
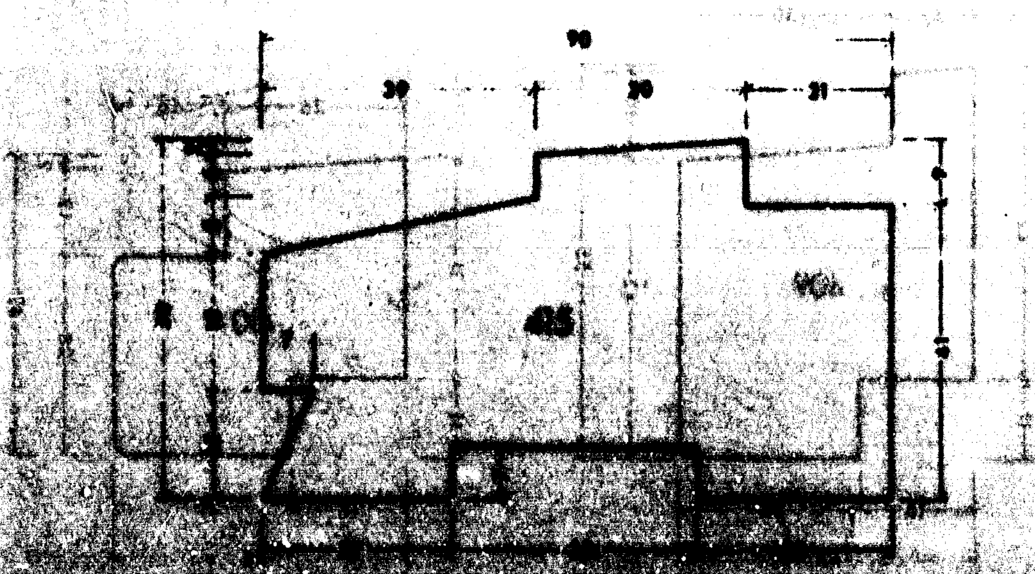
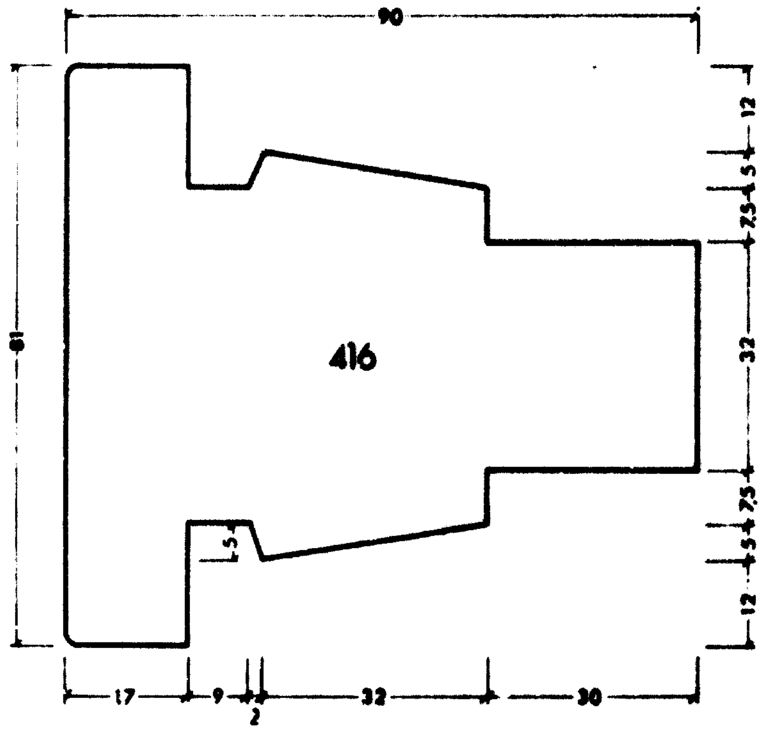


Basic sizes of frame and casement members
Permissible deviations for the main measurements of the members is ± 1 mm





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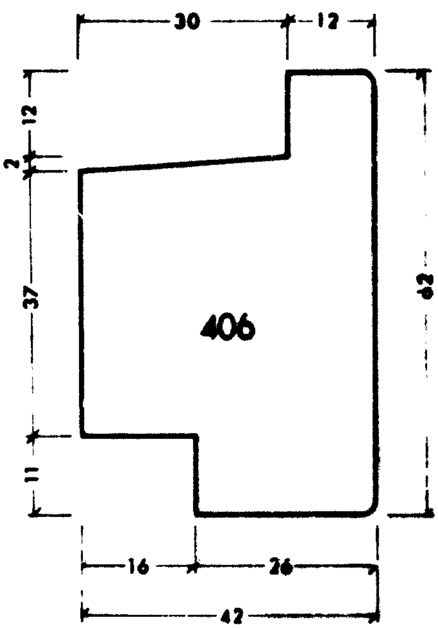
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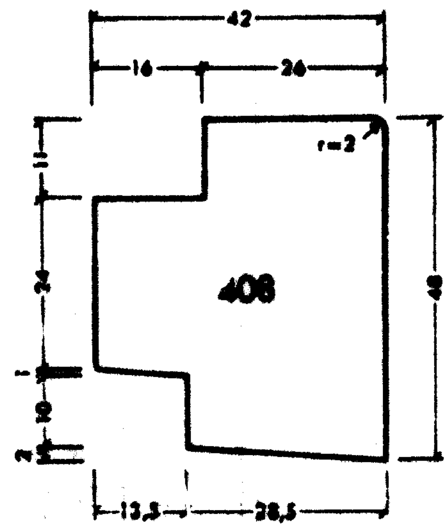
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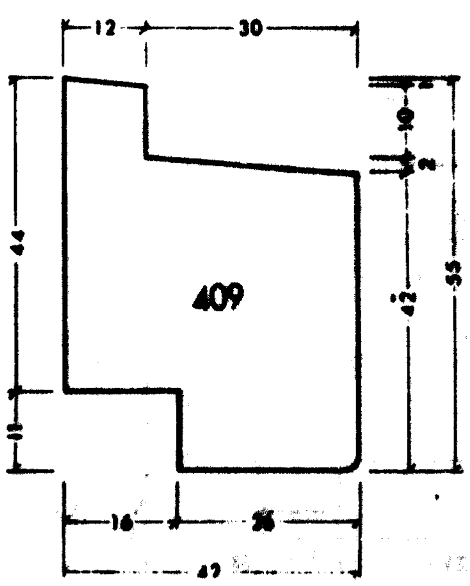
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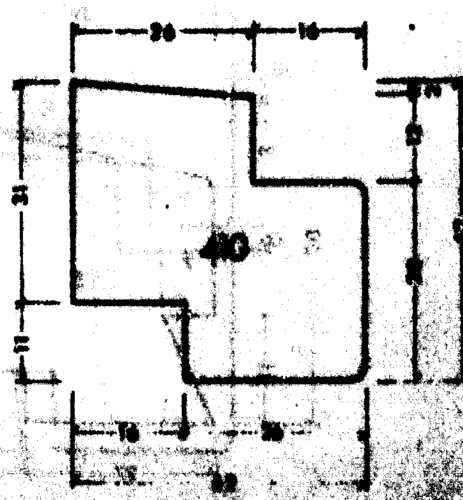
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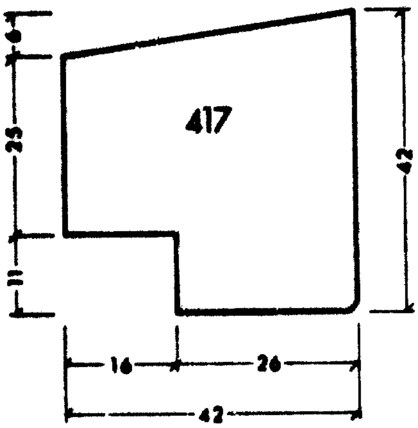
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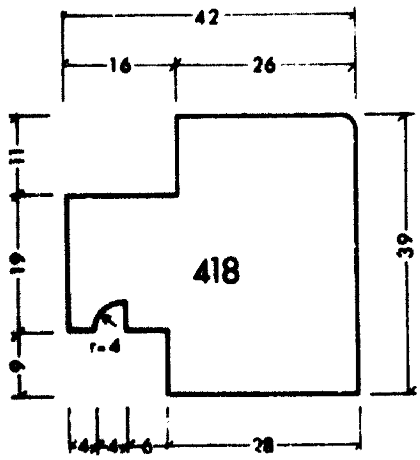
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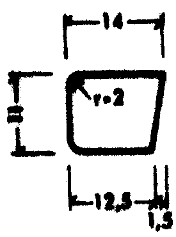
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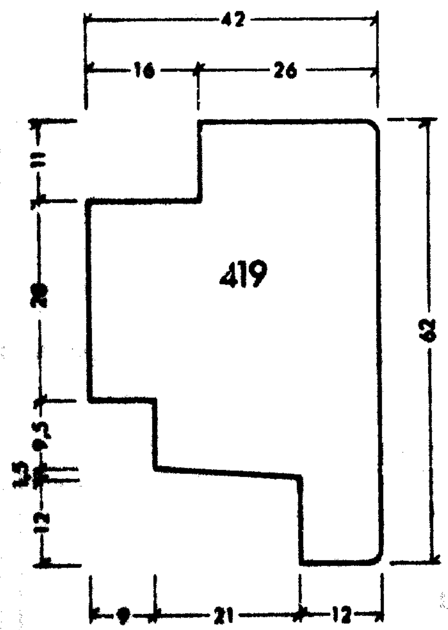
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GLAZED DOORS, WOOD, OPENING INWARD, COUPLED CASEMENTS

1968 **RT 862.46E**
SfB Y(31)
UDK 69.028.23:674
Page 1 (5)

Glazed doors, nomenclature		RT 862.00
Glazed doors	in group	RT 862
Wooden windows and outside doors, quality		SFS/RT 210 Et
The window for this door is		RT 861.46

01 This RT-sheet describes glazed wood doors, with coupled inward opening casements.

02 The RT-sheet gives the manufacturing sizes of the width of the frame, the frame and casement members, and the clearances of the casements.

1 DIMENSIONING

The dimensioning implies that the moisture content of the timber is not greater than 12 %, calculated from the dry weight.

11 The co-ordinating size of the width of the frame of glazed doors is a modular size 9 x M = 900 mm.
The manufacturing size of the width of the frame is 900 − 10 ± 2 mm = 890 ± 2 mm. Fig. 2.

12 A glazed door adjacent to a window ought to be dimensioned vertically so that the upper members of their frames will be at the same level. A deviation of ± 2 mm is permitted for the vertical manufacturing size.

13 Sizes of cross-sections, see figures.
Normal permissible deviations for the main manufacturing sizes of frame and casement members is ± 1 mm.

14 The sizes of clearances are valid for assembled doors provided with ironmongery but without surface treatment.

Clearance	
at hanging stile	2 mm
at closing stile	3...4 mm
at top rail	2...3 mm
at bottom rail (inner casement)	4...5 mm

15 The thickness of the panes used in glazed door is the minimum of 5 mm.

2 COMBINATING GLAZED DOORS AND WINDOWS

These glazed doors and windows fit to be joined with them are joined together according to fig. 3.

3 APPEARANCE OF DOOR

The sections of the casement members shown on this RT-sheet are designed for glass panels only.

Fig. 1

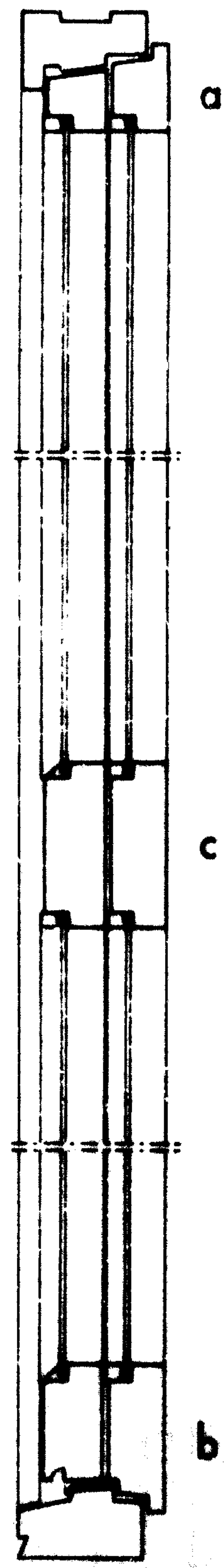


Fig. 2

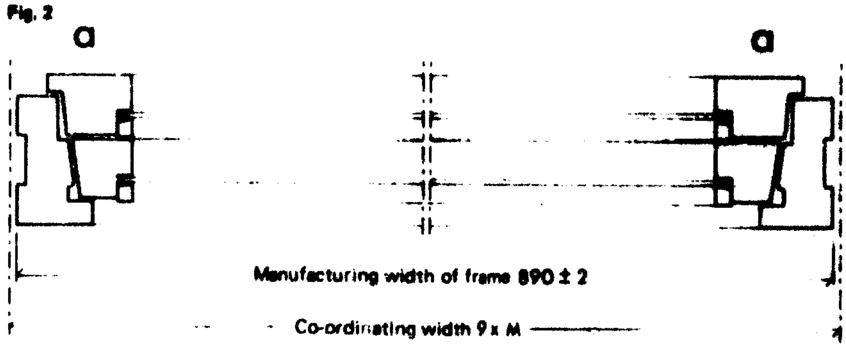
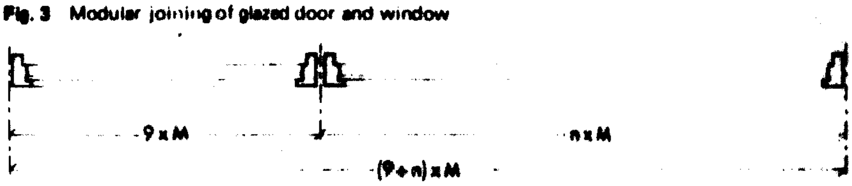


Fig. 3 Modular joining of glazed door and window

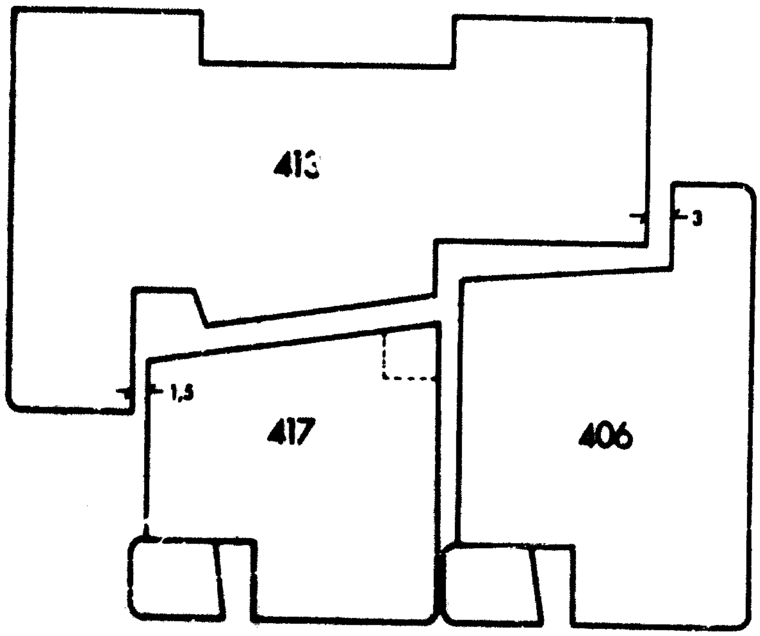


M = 100 mm
n is an integer number ≥ 3

Fitting of frame and casement members

The sill shall be provided with a protective metal section of the type shown in the fig.

a



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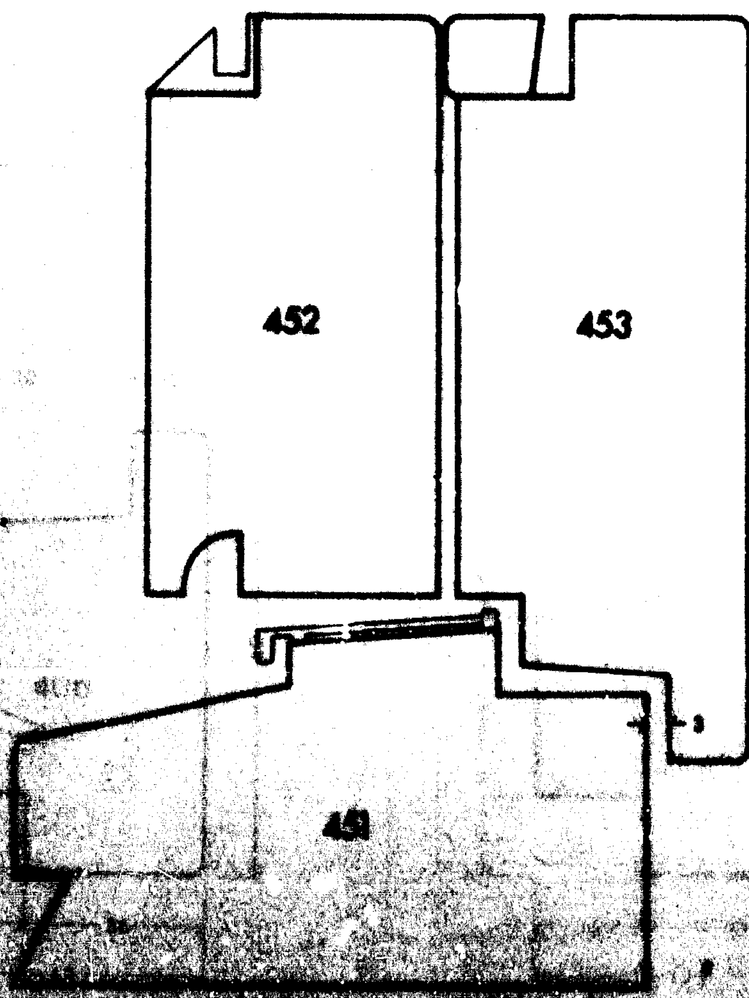

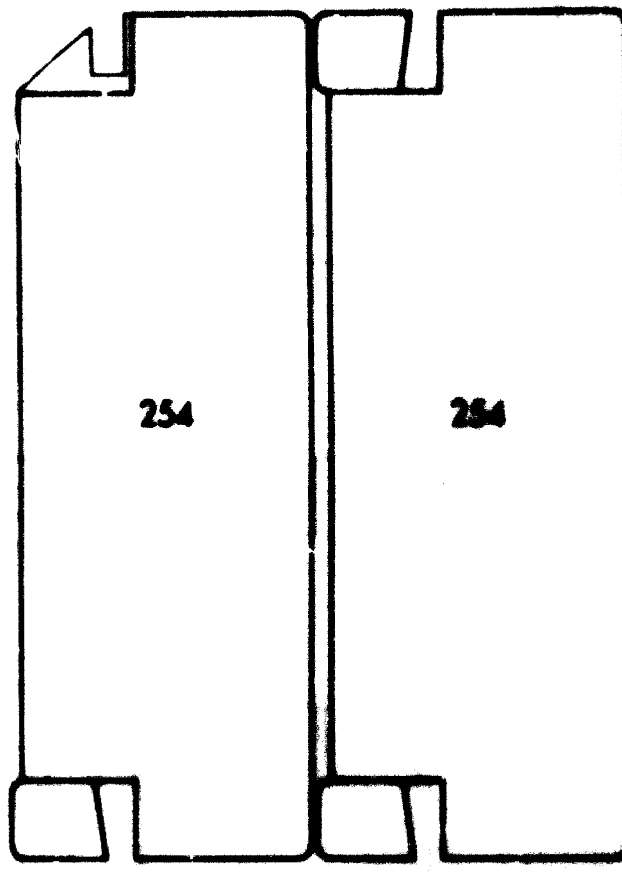

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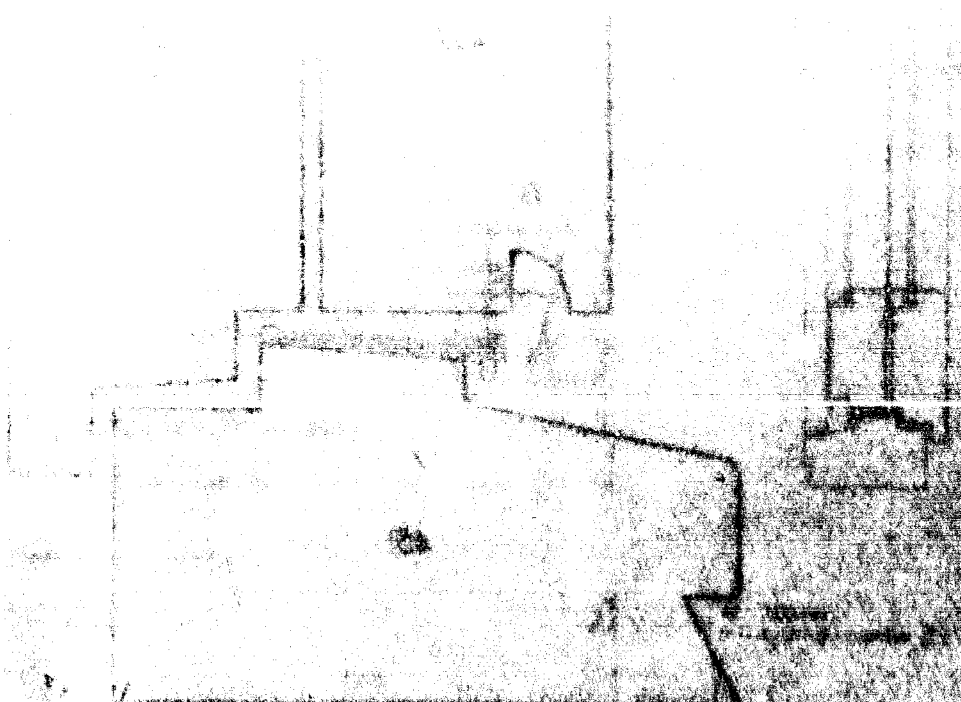
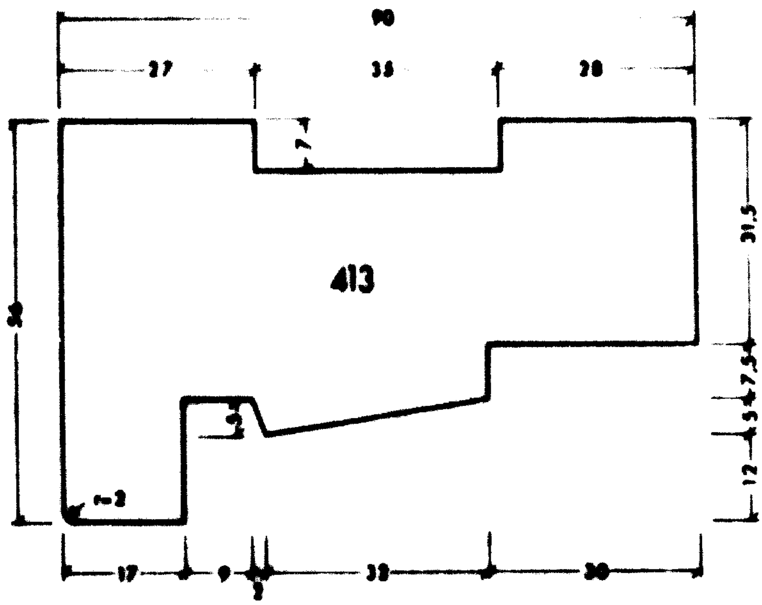
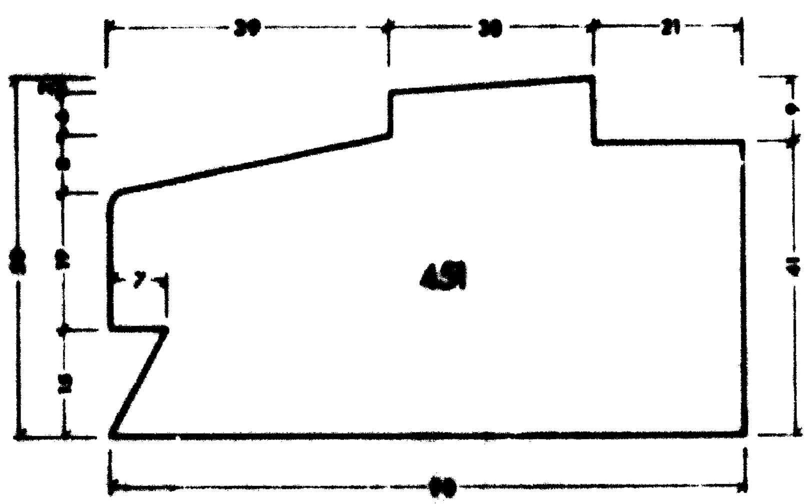
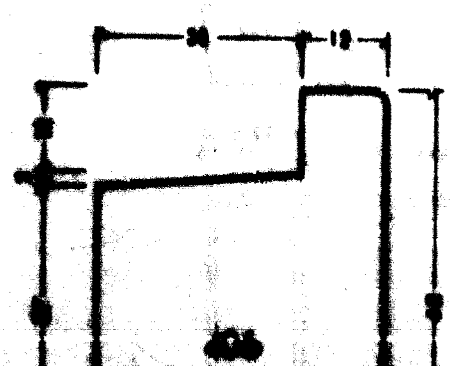


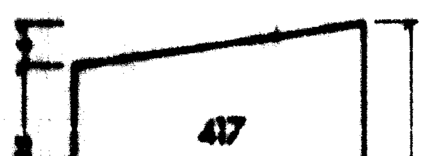
b

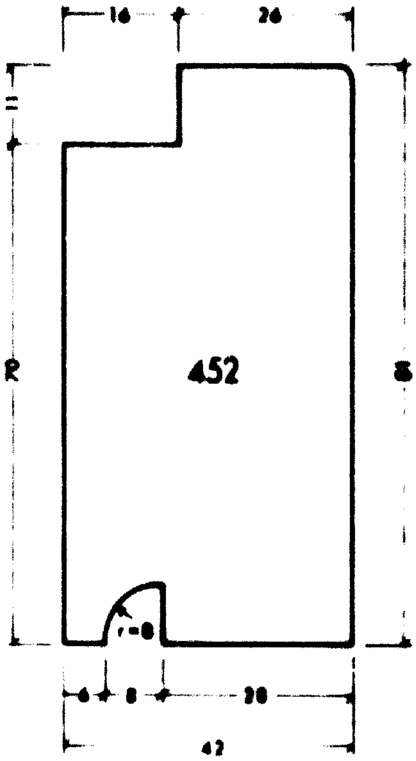
Measures for the drawing of frame







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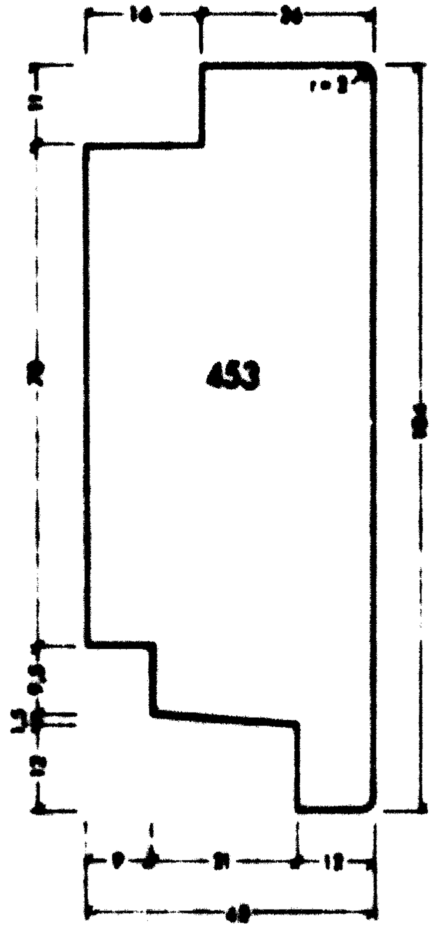
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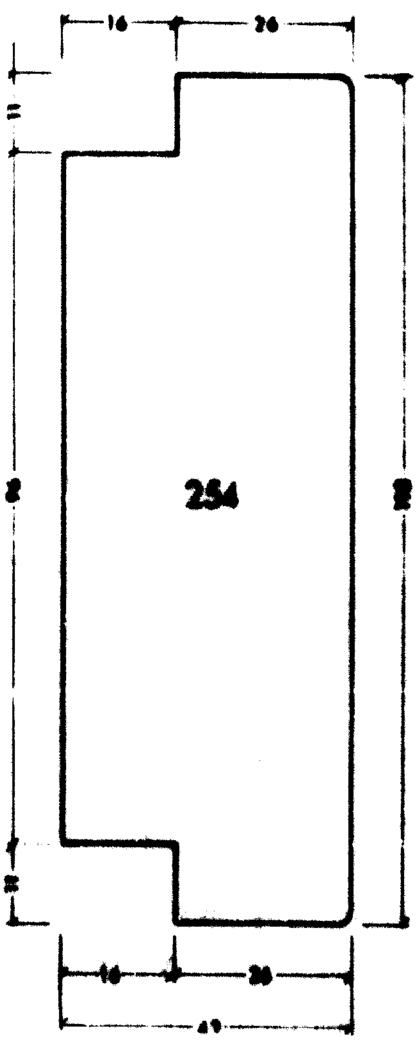
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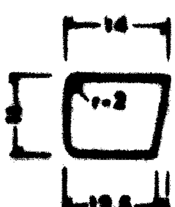
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r=2
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Suomen Standardisoimislautakunta Finlands Standardiseringskommission

DOORS FOR DWELLINGS, STANDARD SIZES

SFS 2483
SfB X(32)
UDK 69.028.1
Page 1 (1)

Modular co-ordination for the building industry	RT [illegible]
Modular co-ordination, application principles	RT [illegible]
Doors nomenclature	RT [illegible]
Doors in group	RT [illegible]

1 Contents

This standard comprises the standardized nominal sizes of modular doors for dwellings, offices etc.

2 Co-ordinating dimensions. Notations for door sizes

Door = frame + door leaf

The co-ordinating dimensions of the door determine the connection of the door to the wall. The co-ordinating dimensions of the door height are measured from the finished floor surface.

The co-ordinating dimensions of a modular door are modular sizes, integral multiples of the basic module. The basic module is M = 1 dm = 100 mm

22 As notations for door sizes, their co-ordinating sizes are used (width and if necessary also height).

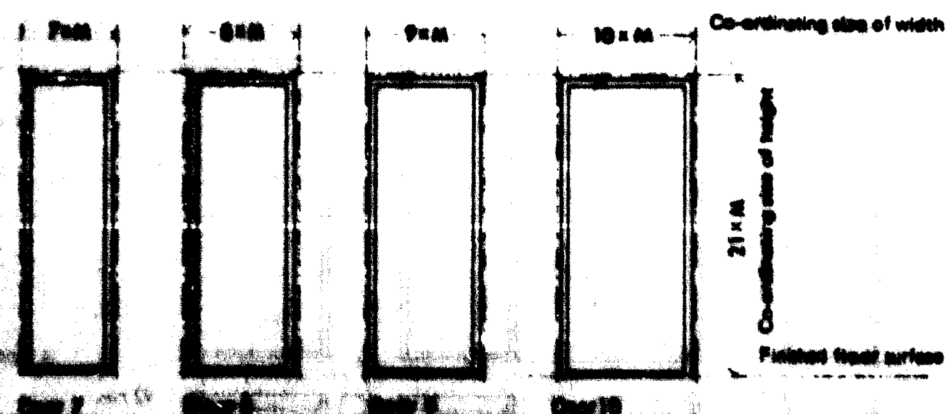
As notations for standard-sized doors for dwellings, offices etc. is adopted the co-cordinating size of the width expressed in decimetres, eg. (door) 9.

> A complete notation generally contains several components to express the various qualities of a door.

3 Basic sizes of standard doors

The basic sizes of doors for dwellings are n x M, in which n equals:

width	height
7	21
8	
9	
10	



WOODEN DOORS FOR DWELLINGS, NOT REBATED DOOR LEAF

Doors, nomenclature	RT C70.00
Doors for dwellings, standard sizes	RT 871.05
Doors in group	RT 87
Wooden windows and outside doors, quality	RT 210.81
Wooden flush doors, quality	RT 210.82

1 CONTENTS

11 This RT sheet describes standard size wooden doors with not rebated edges for dwellings, offices etc.

12 The outer sizes of the frame, the sizes of the frame members, the sizes of the door leaves and the clearances are given.

2 NOTATION

21 Notation for doors

Name of door, size of door (see RT 871.05), depth of frame (in mm), indication if sill not required, the number of this RT-sheet.

eg. Flush door 9/92 RT 871.21
Panelled door 8/92 without sill RT 871.21

Quality class according to standard RT 210.81 or RT 210.82 and manufacturing degree have to be mentioned in the order.

22 Notation for frames and door leaves when ordered separately

Notation for frame: frame, size of door, depth of frame, if sill not required indication thereof, number of this RT-sheet.

eg. Frame 9/92 without sill RT 871.21
Frame 7/68 RT 871.21

Quality class according to standard RT 210.81 or RT 210.82 and manufacturing degree have to be mentioned in the order.

Notation for door leaf: door leaf, size of door, number of this RT-sheet.

eg: Flush door leaf 9/RT 871.21
Leaf for panelled door 8/RT 871.21

Quality class according to standard RT 210.81 or RT 210.82 and manufacturing degree have to be mentioned in the order.

3 DIMENSIONING

Co-ordinating sizes or doors, see RT 871.05.

31 Manufacturing sizes of door frames are 10 ± 2 mm smaller than the corresponding co-ordinating size.

32 Sizes of frame members, see figures.

33 Manufacturing sizes of door leaves, see figures.

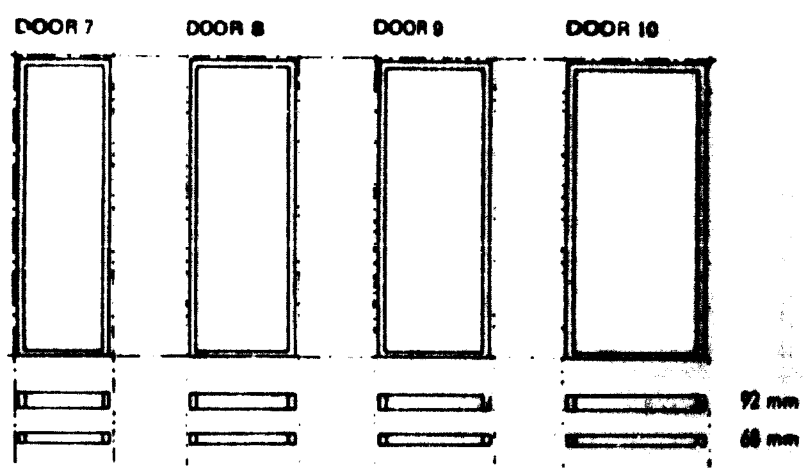
34 Door clearances are valid for assembled doors fitted with ironmongery, but without surface treatment.

Clearance	
at jambs totalling	2...6 mm
at heads	1...3 mm
at sills	2...4 mm

35 Dimensioning implies that the moisture content of timber figured of dry weight is ≦ 10 % for flush doors and ≦ 12 % for panelled doors.

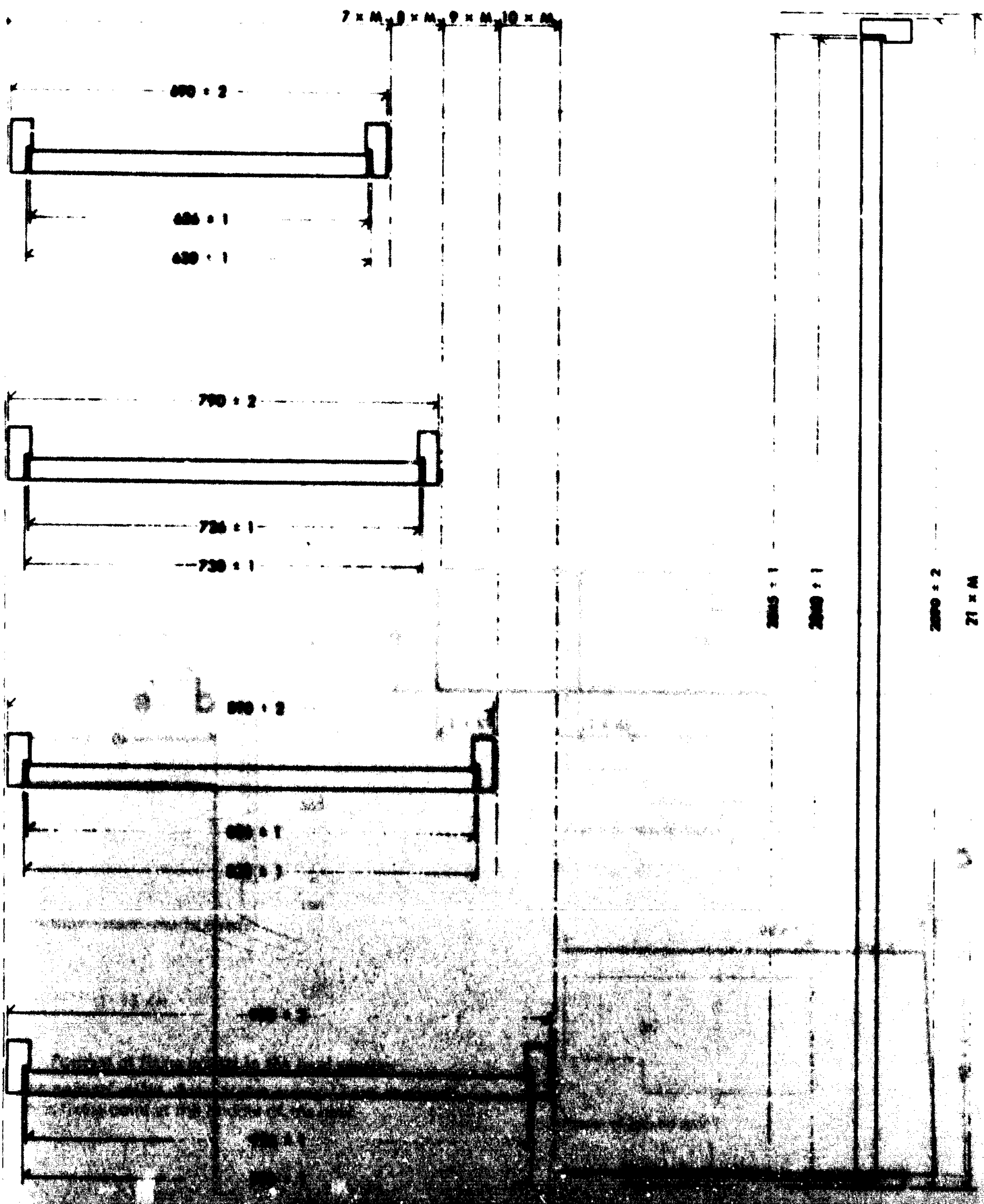
4 SILL

The sill for standard doors is loose. It may also be left out, in which case this must be mentioned in the order.

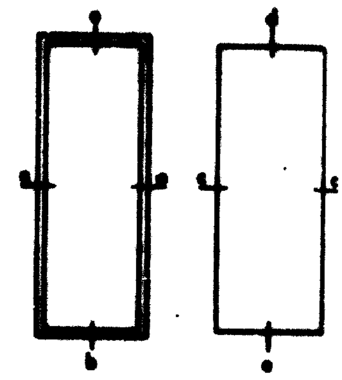


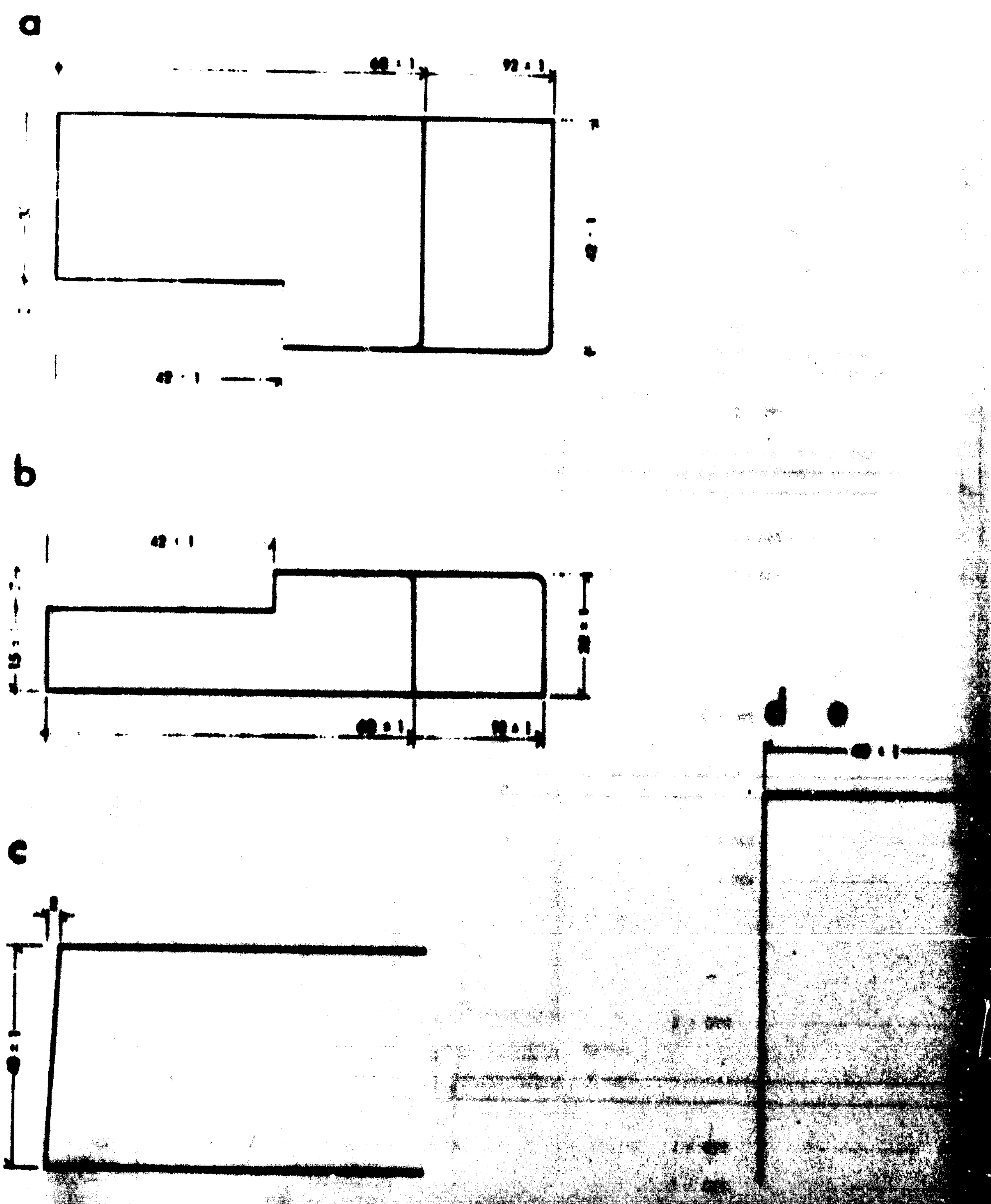
Door 7/92
Frame 7/92
Door leaf 7

Manufacturing sizes of doors



Sizes of frame members
and of door leaf edges





DOOR, WOOD, FIXING AND FITTINGS

1970 RT 870.22E
SfB X(32)
UDK 69.028.11:674
Page 1 (2)

Doors for dwellings, standard sizes RT 871.05

0 GENERAL

01 This RT sheet indicates the number and position of fixing points for door frames and the position of fittings.

1 NUMBER AND POSITION OF FIXING POINTS

11 Position of fixing points in the jambs, fig. 1.

The places of fixing points are measured from the surface of finished floor. A door fitted with two hinges should be fixed at the lowest and the two topmost points of fixing; a door with three hinges at each point of the jambs.

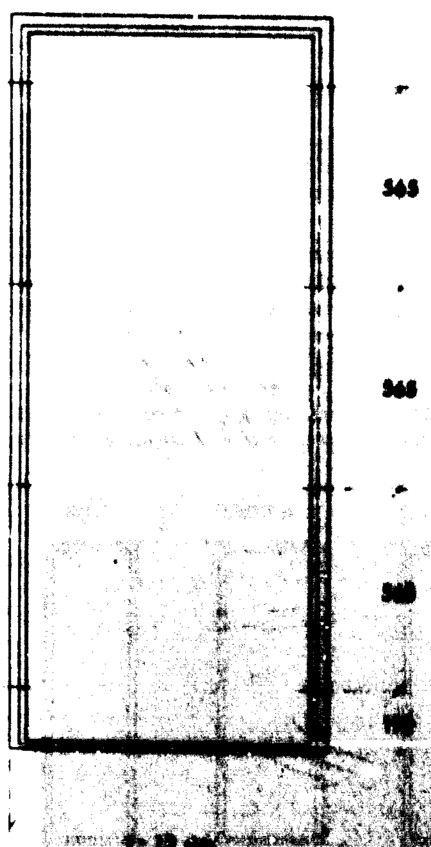


Fig. 1

12 [illegible]

If [illegible]
be [illegible]

13 Position of fixing points in the direction of depth of frame, see fig. 2, 3 and 4.

For all frames, whose depth is ≥ 118 mm, the fixing points are at the middle of the depth.

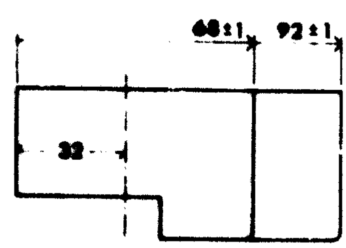


Fig. 2

Frames of not rebated door

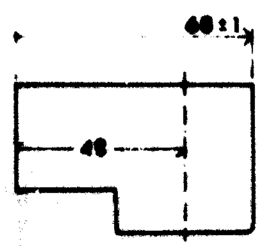


Fig. 3

Frame of rebated door

Fig. 4

[illegible]

2 NUMBER AND POSITION OF FITTINGS

Number of hinges, see RT 140.1/X, para. X(32)i.15.

21 Position of hinges, see fig. 6.

22 Position of lock

The lock should be positioned so that the centre of the hole for the pin of the handle is 1020 mm from the bottom of the door leaf, see fig. 5.

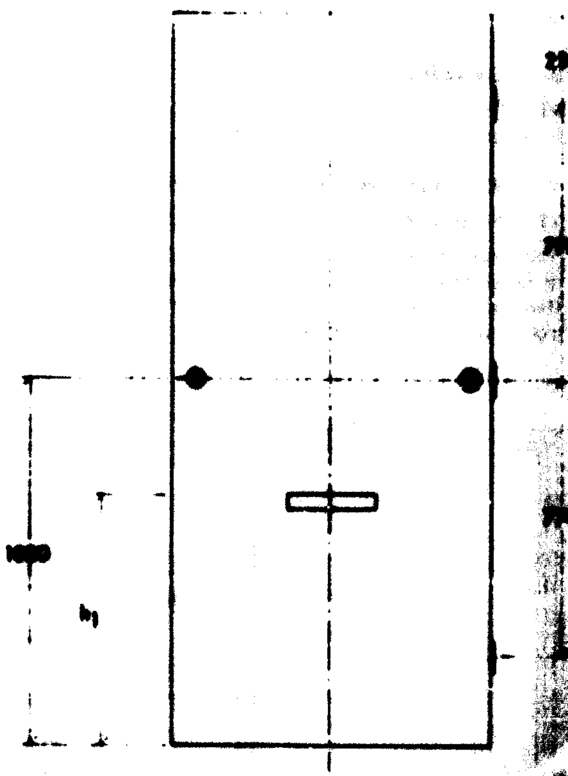
If the centre of the handle and the key hole are symmetrically placed in relation to the horisontal central line of the lock case, the lock can be positioned so that this central line is 1020 mm from the bottom of the door leaf.

23 Position of letterplate, fig. 6.

24 Position of doorbell

The doorbell should be placed symmetrically in relation to the lock.

Fig. 6



$460\ mm \leq h_1 \leq 800\ mm$

WOODEN DOORS FOR DWELLINGS, REBATED DOOR LEAF

1969 RT 871.22E
SfB X(32)
UDK 69.028.11.6/4
Page 1 (3)

Doors nomenclature	RT 870.00
Doors for dwellings, standard sizes	RT 871.05
Doors in group	RT 87..
Wooden windows and outside doors, quality	RT 210.81
Wooden flush doors, quality	RT 210.82

1 CONTENTS

11 This RT-sheet describes standard wooden doors for dwellings, offices etc. with rebated door leaf.

12 The outer sizes of the frame, the sizes of the frame members, the sizes of the door leaf and the clearances are given.

2 NOTATION

21 Notation for doors

Name of door, size of door (see RT 871.05), depth of frame (in mm), if sill not required indication thereof, the number of this RT-sheet.

eg: Flush door 9/92 RT 871.22
Panelled door 8/92 without sill RT 871.22

Quality class according to standard RT 210.81 or RT 210.82 and manufacturing degree have to be mentioned in the order.

22 Notation for frames and door leaves when ordered separately

Notation for frame: frame, size of door, depth of frame, if sill not required indication thereof, number of this RT-sheet.

eg: Frame 9/92 without sill RT 871.22
Frame 7/68 RT 871.22

Quality class according to standard RT 210.81 or RT 210.82 and manufacturing degree have to be mentioned in the order.

Notation for door leaf: door leaf, size of door, number of this RT-sheet.

eg: Flush door leaf 9/RT 871.22
Leaf for panelled door 8/RT 871.22

Quality class according to standard RT 210.81 or RT 210.82 and manufacturing degree have to be mentioned in the order.

3 DIMENSIONING

Co-ordinating sizes of doors, see RT 871.05

31 Manufacturing sizes of door frames are 10 ± 2 mm smaller than the corresponding co-ordinating size.

32 Sizes of frame members, see figures.

33 Manufacturing sizes of door leaves, see figures.

34 Door clearances are valid for assembled doors fitted with ironmongery, but without surface treatment.

Clearance	
at jambs totalling	2...6 mm
at heads	1...3 mm
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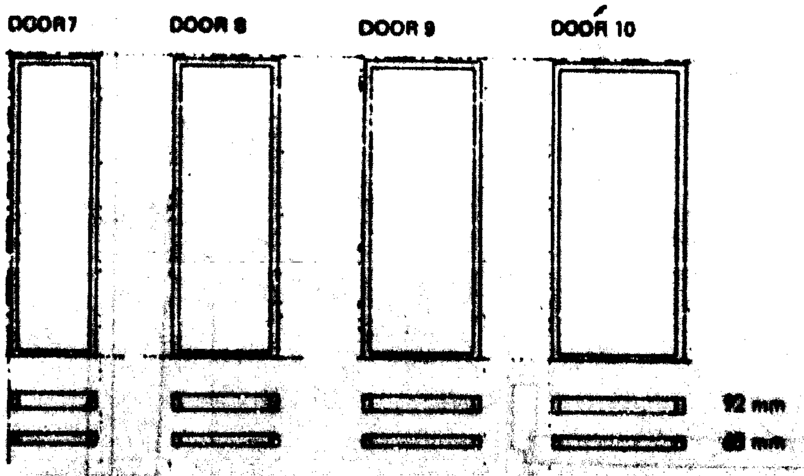
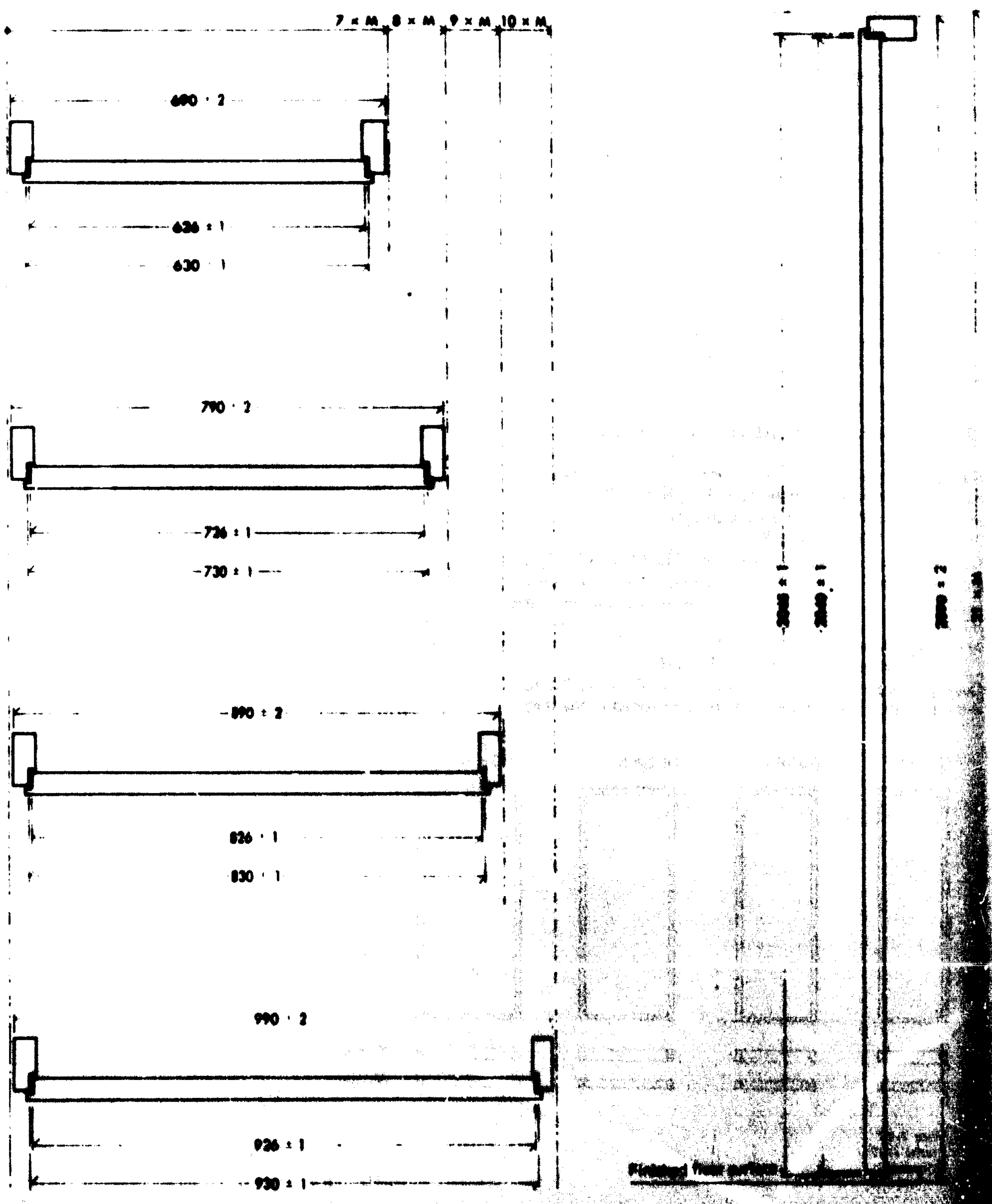
35 Dimensioning implies that the moisture content of timber figured of dry weight is $\leq$ 10 % for flush doors and $\leq$ 12 % for panelled doors.

4 SILL

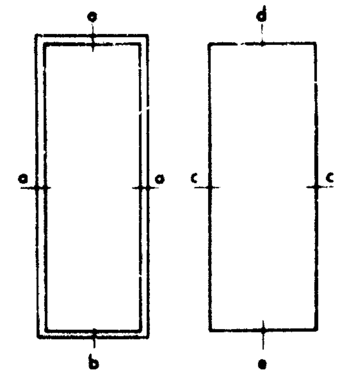
The sill for standard doors is loose. It can also be left out, in which case this must be mentioned in the order.

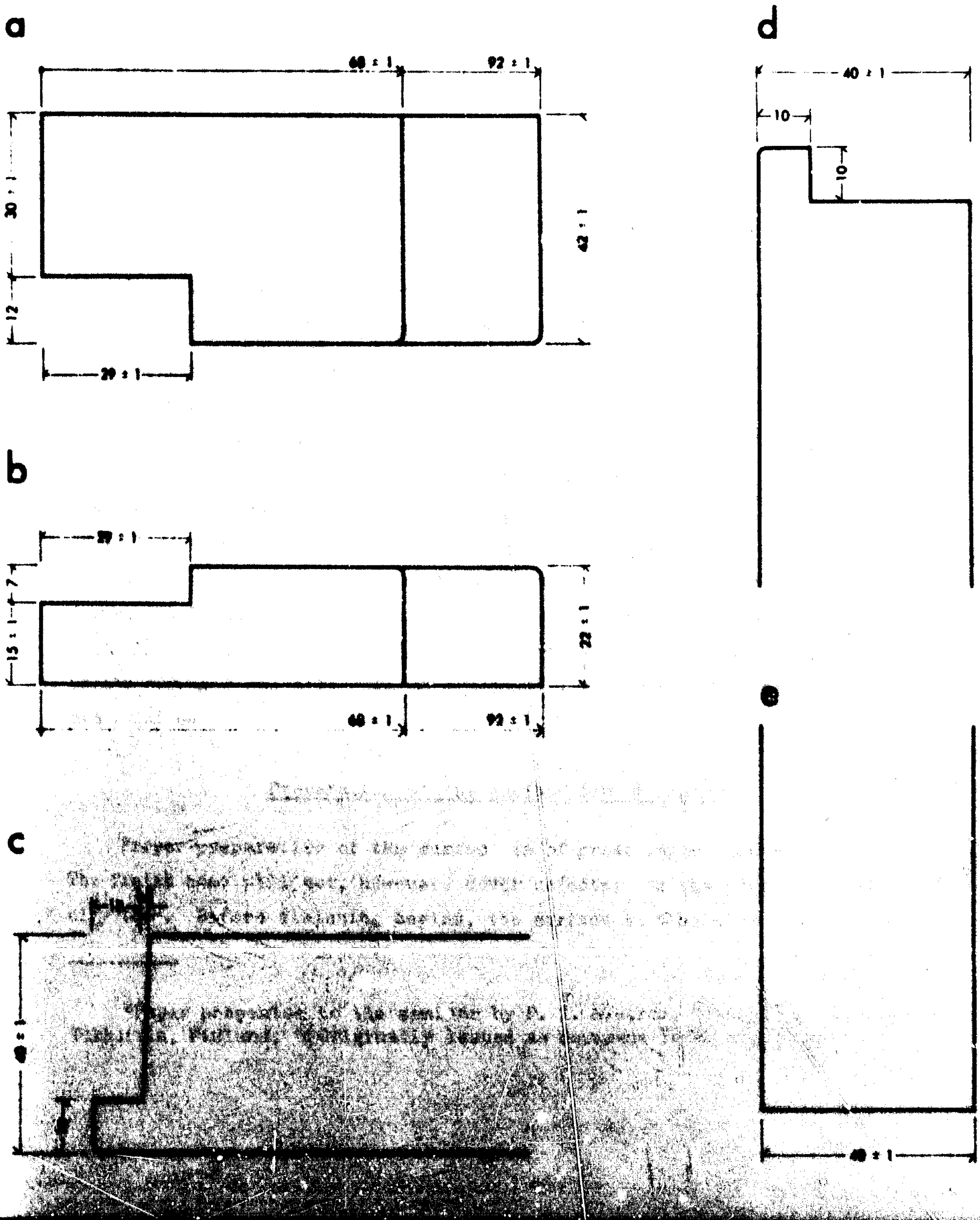


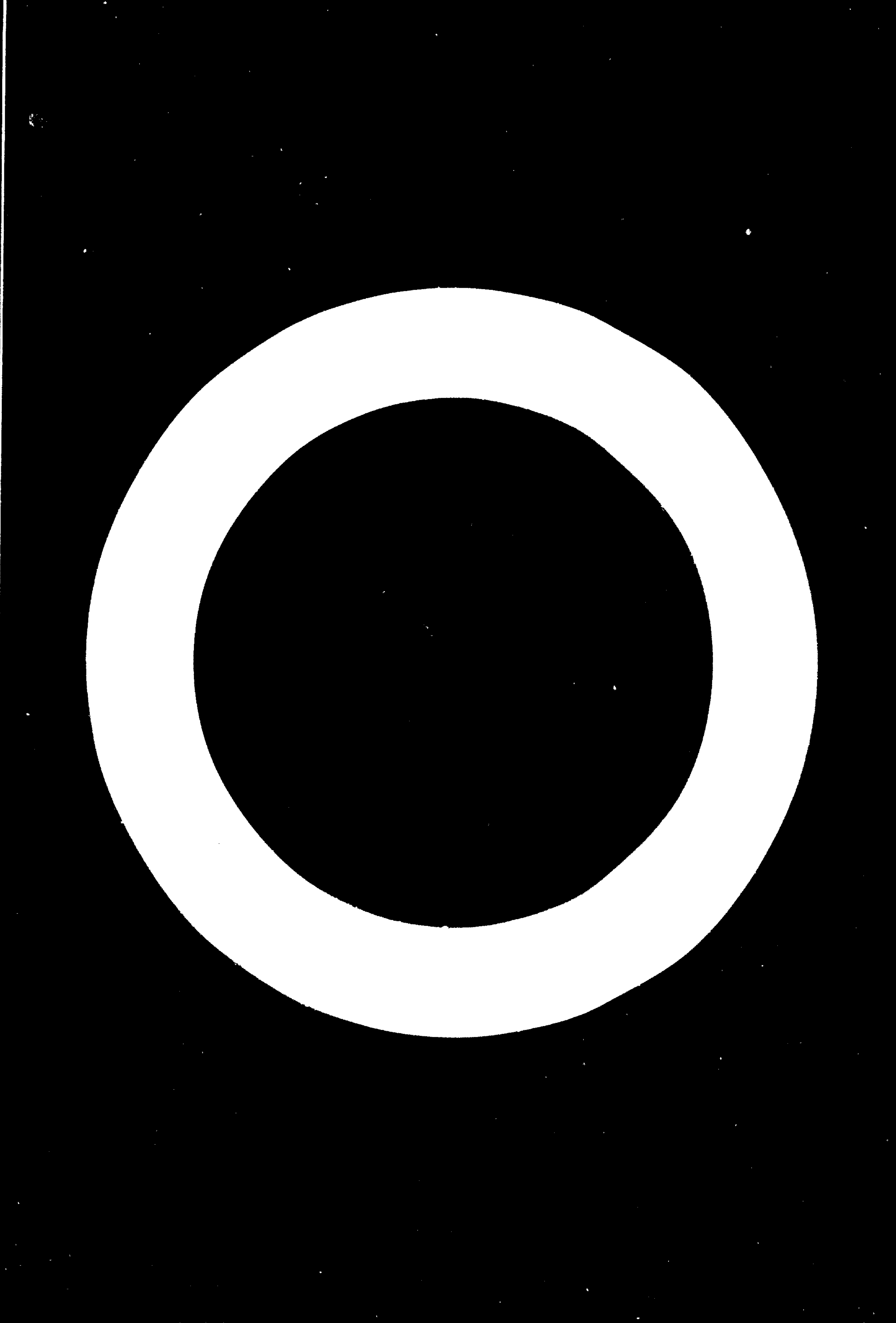
Manufacturing sizes of doors



Sizes of frame members
and of door leaf edges







19. THE SURFACE FINISHING OF WOOD AND WOODEN PRODUCTS*

A multiplicity of materials is presently available for the surface finishing of wood, and there is also a great variety of methods for applying them. Furthermore, there are also many different species of wood, so the problem facing the wood finisher is a really complex one. That the beauty of any wood surface depends upon its finish, and that it takes time and patience to obtain a good finish are, of course, truisms. The materials and methods used must be suited to the wood. Some species have large pores, others have small ones. Sometimes large pores are emphasized to achieve desired effects.

The finisher must always know for what purpose an article - a piece of furniture, a window-frame, a door - will actually be used. If he does not, it will be difficult, or perhaps impossible, for him to select the proper finishing material. When in doubt, he should check with his suppliers.

Paint is a formulation that includes a vehicle or binder, white or coloured pigments, solvents and various additives. In air-drying paints, the additives may be derivatives of lead, cobalt or manganese. Linseed oil was formerly the most important vehicle, but the alkyds (also known as the "synthetics"), have overtaken it. Some other vehicles are the polyvinyl acetates (PVAc) and acrylates, which are used in water-dispersed paints, and the polyurethanes, polyesters, epoxies and combinations of various resins in the more conventional paints. At present, titanium dioxide is the widely used white pigment. White spirit is still widely used as a solvent, but in many modern paints stronger solvents such as xylene, toluene, acetates, ketones and alcohols are required.

Preparation of the surface for finishing

Proper preparation of the surface is of great importance in wood finishing. The finish coat will not, however, cover defects; on the contrary, it will magnify them. Before finishing begins, the surface must be clean and smooth.

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*Paper presented to the seminar by F. Å. Biström, Tikkurilan Väritehtaat, Tikkurila, Finland. (Originally issued as document ID/WG.105/32/Rev.1)

Rough spots on the edges and elsewhere must be smoothed by sanding, planing etc. Also, the wood must have the proper moisture content. The effects of moisture in woodworking are discussed in considerable detail elsewhere in this publication.[1/]

Most of the wood is vulnerable to attack by bacteria and fungi. Sometimes their effect will be only a change in colour, such as blue stain, but sometimes they may cause rot. Not only the wood, but also the paint film can be attacked by bacteria; it has been observed that micro-organisms living between the paint film and the wood surface can have an injurious effect on the adhesion of the paint film. The appearance of a painted surface can very often be destroyed by mould even when the paint film is still fully intact.

Joinery factories in Finland use various wood species, the most important of these being pine, spruce, oak and birch. However, quite a lot of tropical species such as mahogany and teak are also used. Few of these species can withstand the elements without surface finishing; an exception is teak, whose mechanical properties do not decrease with weathering, although the surface will turn grey in a short time and lose its attractive colour under the influence of rain and sunlight.

Pine and spruce must be protected against bacteria by brushing with or dipping in wood preservatives. Oak and mahogany do not need this preparation. Some tropical species such as teak contain agents that can make their surface finishing difficult. For example, they can prevent an alkyd lacquer from drying. Even when the lacquer has dried after a long time, the adhesion will be very poor, and there will very soon be blistering and peeling.

Before such species can be finished, their surfaces must be washed with a solvent such as xylene or a thinner for nitrocellulose lacquer; this treatment will ensure good drying and adhesion. However, these agents remain within the wood, and from there they can emerge to the surface and attack the paint film. Prolonged investigations have shown that the best results can be achieved by priming the surface with products that prevent these agents from coming into contact with the surface finish. The two-component polyurethane products and some special acid-catalysed lacquers are useful for this purpose. After such priming the final finish can be done with urethane or alkyd lacquers.

1/ See part one, article 1 (Pekka Paavola "Solid wood as raw material for the furniture and joinery industries").

Although much stress has been given here to the influence of moisture on painted surfaces, painting is a very important part of the preparation of some wood products, such as window frames. In an investigation in Sweden on the durability of paints on window frames, the conclusion was that 20 to 80 per cent of such frames had failures in their lower parts within one year of their installation, so it is clear that this question is really important. Of course, this problem is not encountered with indoor joinery products.

Sanding

Sanding is very important in preparing wood for finishing. It must be done to remove defects in the surface and to smooth it so that the reflective properties of the finishing materials will bring out the full beauty of the wood grain. If sanding is done properly and unhurriedly, using correct procedures and the proper grades of abrasives, finishes of truly professional appearance and quality can be achieved. It should be noted that when glossy finishing materials are used, especially in dark colours, quite small defects in the surface can be observed very easily. Always use a fine sanding paper (No. 150 to 240) for the last sanding; and not only will the work be good but the cost of finishing materials will be reduced in the long run. True, using a fine sanding paper will take a little more time and may cost a little more in sanding paper but the finishing materials will have the best chance of producing top-quality articles. Always remember to do the final sanding along the grain.

Patching

Before applying any finish, all nail holes, open joints, twig holes etc. should be filled with a non-shrinking plastic wood. Fill them slightly more than full and sand the surface smooth when the filler has dried. If commercial plastic wood is unavailable, it can be made up, as follows. Take a piece of the same species that is to be filled, and scrape it to make as fine a powder as possible, then mix it with a binder such as nitrocellulose lacquer. When the surface is to be finished with a pigmented material, any type of filler can be used, provided that it can withstand the solvents in the finishing system. Polyester putties of a softer type as well as high pigmented one-component putties are used in Finland for this purpose. After the primer has been applied, it is advisable to look over the items again and put in some more filler, if need be.

Bleaching and staining

Although wood is bleached chemically in some countries, this is not done in Finland, because it is very difficult to get constant results. Instead, special primer lacquers that do not wet the surface too much are used. Sometimes small amounts of a white-pigmented product (0.5 per cent) of the same binder type are added, in this way giving an impression of whiter wood.

Staining is normally done with water-soluble products, but a more modern method is to put a coloured solution in the primer lacquer and thus apply both colour and primer in one operation. The colour solution must, of course, have an excellent resistance to light-induced fading.

Industrial painting and varnishing

In Finland's furniture industry painting and varnishing on an industrial scale has long been done. This is also true of such joinery products as kitchen equipment, doors, and window frames.

In recent years many factories have invested much in equipment for finishing. There are still factories that use brushes and rollers, but the more advanced ones use spraying techniques with air and airless guns and curtain-coating machines. The increased use of machines in industrial painting has increased the demands on the paints and lacquers. For example, it has been possible to speed up the drying properties of the finishing products so that coated articles can be stacked or packed directly and passed on to storage or transported to the customer. Despite this quickness of drying, the quality of the finish must be first class, and it must be achieved with as few applications as possible.

In the board industries such as hardboard and blockboard, the surfaces are increasingly being finished by the producers. Blockboard is puttied on roller coaters with products normally based on alkyds. These putties contain volatile solvents, and at least two applications are normally needed.

The modern tendency is toward the use of polyester putties. They are solvent free, and boards coated once with them are completely smooth and have compact surfaces. The drying process is forced by ultraviolet (UV) radiation; drying time in special ovens is only 15 to 30 seconds. One can achieve an excellent finish with only one application on such surfaces. Acid-catalysed paints are normally used.

Hardboards can also be precoated with UV polyester putties, but the usual modern practice is to use pre-coating with an acid-catalyzed primer and then an acid-catalysed finish paint. Often, it is enough to use only one finish paint. Application is done by spray or with curtain coating machines.

Pigmented finishes

Several procedures for painting of furniture, birch kitchen furniture, doors, and hardboard or blockboard are discussed below.

The Acid-catalysed system

Holes filled with alkyd putty. Coating is done with an acid-catalyzed primer, 80 to 120 g/m^2

Sanding

Smoothing with alkyd putty

Sanding

Top-coating with an acid-catalysed finish paint, 80 to 120 g/m^2

The primer is applied with spray guns or curtain-coating machines. After drying at room temperature for at least 2 hours (or for shorter time at higher temperature) sanding is done by machine. If defects remain in the surface after sanding, they are filled manually with alkyd putty. This material should dry fast when applied in thin coats, permitting repairs to be sanded within a few minutes. The final coat is applied to the boards by a curtain-coating machine or with a spray gun

Kitchen furniture is sprayed with an air or airless gun after assembly. The inside surfaces and the shelves and outside surfaces that are not seen are normally not puttied. Inside surfaces can be given a single coat of the primer or, better, the final coating material.

Reinforced acid-catalysed system

For a high-quality finish on furniture and doors for kitchen furniture, the surface can again be levelled with putty and a second top-coat applied.

UV-putty-acid-catalyzed system

This system has three steps: application of UV polyester putty (80 to 120 g/m^2, depending on the quality of the blockboard), sanding, and top-coating with an acid-catalyzed paint (80 to 120 g/m^2). It should be noted that the use of UV putty is possible only on wood-based panels.

Polyester system

This is also a three-step system: application of UV polyester putty (80 to 120 g/m^2, depending on the quality of the blockboard), sanding, and top-coating with polyester paint.

Dipping method for small components

An easy method for finishing furniture components such as cabinet legs is to dip them in paints based on nitrocellulose, alkyds or alkyd/melamine (acid catalyzed). With the last-mentioned type of paint it must be borne in mind that the pot-life of the mixed paint is only 8 to 12 hours, so that the size of the batch to be dipped must be big enough to justify the mixing of a paint bath.

Systems for unpigmented finishing

Some procedures for lacquering of furniture, kitchen cabinets, doors etc. are described below.

Lacquers for light-coloured woods

With light-coloured woods, when it is desired to keep the surface as light as possible, the following procedure is advisable. First, apply a primer lacquer that will keep the wood light, that will not wet the surface too much and that contains a preservative against UV radiation. Next, give the work a light sanding. For the top coat, apply either the same lacquer or a normal acid-catalyzed lacquer (mat or glossy).

Lacquers for dark woods

Dark woods and stained light woods should be coated with an acid-catalysed primer lacquer, sanded, and then finished with an acid-catalysed top lacquer.

Although water-based stains are still used, the present practice is to use a coloured solution mixed into the primer lacquer before application. In this way both staining and priming are done in one operation. The pigment is dissolved in a solvent with excellent light fastness.

Teak

Teak should be given two coats of a thinned acid-catalyzed lacquer.

Rosewood

This wood must be primed with a special primer lacquer; normal lacquers usually take on a greenish colour. The top coat should be an acid-catalyzed lacquer.

Window frames made from coniferous woods

Wood preservative system

Treatment is with a clear wood preservative based on linseed oil. The best application method is dipping. One or two coats of a coloured wood preservative can be applied later.

Alkyd system

Pretreatment is as above. Any holes should be filled with an alkyd putty. (Do not use putty on the outsides of frames.) Prime surface with a quick-drying alkyd primer. Smooth again with an alkyd putty before sanding. Apply an under-coating with a quick-drying alkyd paint and sand again. For the top coat, use a quick-drying alkyd paint, with an air or airless spray.

Acid-catalysed system

This system also begins with treatment with a wood preservative. Next, holes are filled with an alkyd putty. Priming is done with an acid-catalysed primer, and the article is smoothed with alkyd putty, sanded, and finally given a top coat of an acid-catalysed finish paint. The acid-catalysed paints should be of a special quality, so that they can withstand the "living" in the frames. The acid-catalysed paints normally used for kitchen furniture interiors are too hard for this purpose.

Polyurethane system

Treatment begins with the application of a wood preservative or a special primer lacquer. Next, all holes are filled with an alkyd putty, and a polyurethane primer is applied. After sanding, the article is given a top coat with a polyurethane finish.

Some comments on paints

Alkyd paints

The alkyd resins used in the production of alkyd paints are made by heating mixtures of higher alcohols such as glycerol or pentaerythritol with dicarboxylic acids such as phthalic acid anhydride and fatty acids of drying or non-drying oils. The properties of the resulting resins depend on how the heating is done and which raw materials were used.

Nitrocellulose

Nitrocellulose is still a very widely used material for wood finishing because of its speed of drying. Nitrocellulose products dry because of the evaporation of the solvents. At room temperature or higher, drying can be speeded by good ventilation. Nitrocellulose products have very low flash points, so precautions must be taken against fire and static electricity. Furthermore, these produts have a very low solid content, so several (3 to 6) coats must be applied before articles finished with them can be marketed.

Acid-catalyzed products

This is the largest group of industrial wood-finishing materials in Finland. The acid curing products are normally based on urea formaldehyde-melamine-alkyd combinations. The alkyd is of a non-drying type. In the presence of the catalytic acid that is mixed in before the paint is used, the urea resin reacts with the alkyd to form a rather hard film. The film has good resistance to abrasion and against alcohol and other household chemicals.

Do not combine an acid-catalysed top coat with a primer based on linseed oil or alkyd. Normally such an underlay is too soft for the top coat, and there will be cracking within a short time. Furthermore the film of an acid-catalysed paint will be harder if the relative humidity of the air is low at the time of curing. The risk of cracking of the paint film increases as the relative humidity rises. Some modern paints can stand changes in the relative humidity from 20 to 80 per cent without cracking. Do not apply more than two coats on the same day unless oven drying is used.

Acid-catalysed products can withstand a dry heat of 100°C. Also, they do not burn easily, so shipyards are using boards finished with acid-catalyzed materials for the interiors of vessels. Metal surfaces can be finished with acid-catalysed paints, but they must be pretreated with an etch primer.

Polyurethanes

Pigmented or unpigmented polyurethanes can be used on outdoor furniture. To date they are little used in Finland, but these paints are very sophisticated products and are still in the process of development. Polyurethane films have high chemical and moisture resistance. Normal polyurethane products consist of an isocyanate component and a component with two or more hydroxyl groups. When these two components are mixed, a chemical reaction begins and a film is produced by cross-linking. The isocyanate component is very sensitive to water or moisture; if the can is not closed tightly, there will soon be a gelation of its contents. This is caused by the isocyanate reacting with the hydroxyl groups in the water.

Polyesters

These finishing materials were mentioned above in connexion with the surface coatings for indoor furniture. These products are little used in Finland, and then mostly in some smaller-series such as tables and television receiver cabinets. They also consist of two components and must be mixed before use. The pot-life of normal polyester products for air spray is only a few minutes, so they are difficult to use. With forced heating these products can also be used on the curtain-coating machine by using another hardener composition that gives a longer pot-life to the mixture. There is also special air-spray equipment on the market. In these, the components are mixed together in the spray gun immediately before the paint leaves the gun.

Painting equipment

Finally, let us consider painting equipment and the air conditioning of the paint shop. Modern equipment is of many kinds, among them brushes, rollers, curtain-coating machines, dipping devices, roller coaters and spraying devices. Which equipment or painting method is best depends on the article to be coated and on the most economical way to do the job.

In air spraying, the surface-finishing material is transported from a pressure container (0.5 to 1.5 kp/cm^2) through a hose to the gun and atomized by air at 2.5 to 4 kp/cm^2. In airless spraying the paint or lacquer passes through a hydraulic pump (air pressure: hydraulic pressure = 1:25 to 1:40) and is atomized on passing through the nozzle of the gun. Different nozzles that give varying amounts of finishing material per time unit at constant pressure and with varying spray angles are available. Air spraying is mostly used on small items or when extreme smoothness of the surface is desired. The normal practice is to use a well-thinned paint or lacquer and spray it at as low a pressure as possible. Airless spraying is used on larger flat surfaces and on items such as cupboard interiors. For the latter, air spraying causes a considerable increase in consumption because of rebounding.

The application of paints and lacquers on wood with electrostatic spraying equipment is also possible. The paints and lacquers should have a flash point higher than 23°C. The moisture content of the wood should be 8 to 10 per cent, and the grounding contacts should not be too far apart (50 to 60 cm). The method has advantages on small items, where the overspray with other methods is rather high. However, investigations of the possibilities of this spraying technique should always be carried out before investments are made.

When considering investments in equipments for the application or drying of paints, consult with their manufacturers - and with more than one of them - before you make your decision.

Drying of applied finishes such as acid-catalysed paints is accelerated by high-temperature ovens in many factories. With modern equipment, curing time can be reduced to about 40 to 60 seconds. Special care should be given to the adhesives used to ensure that they can withstand high temperatures. The paint on coniferous woods is difficult to dry at high temperature because the resin is forced out. For such species, drying temperatures of 50 to 60°C will suffice.

Two advantages of the curtain-coating machine and the roller coater over all other paint-application equipment are that the film thickness is easily controllable and calculation of the painting costs is thus simplified.

The air conditioning and ventilation of the paint shop is very important to prevent the content of solvent vapours and paint dust in the air from rising to dangerous levels. Poor ventilation increases risks to health and of fire and affects surface finishing negatively. When there is an excess of solvent vapours in the air, the explosion limits are approached. These limits are different for different solvents; some of them are presented in the following table.

Flash points, explosion limits and MAC values[a/] of some important solvents

Solvent	Flash point (°C)	Explosion limits (vol. %)	MAC value (cm^3/m^3)
Butyl acetate	20	1.4 - 7.6	200
Ethyl acetate	-3	3 - 19	1,000
White spirit	30	0.7 - 4	500
Xylene	23	1 - 6	200
Toluene	6-10	1.3 - 6.7	200
Trichlorethylene	-	-	100
Turpentine	39	-	100
Acetone	-10	2.1 - 13	-

a/ MAC = maximum air concentration

The degree of ventilation depends on how big the paint shop is and on the painting method used. In Finland the law requires that the air be changed 30 times per hour in a shop with spray application. The efficiency of the ventilation depends not only on how many cubic metres of air are blown in or out but also upon the placement of the ventilator.

Over-all ventilation of the paint shop is insufficient. In places where the solvent evaporation is high, as in spray booths and in the neighbourhood of dipping equipment, local ventilation must be arranged. In planning the ventilation system, it should be remembered that solvent vapours are heavier than air.

[illegible]

20. LOW-COST AUTOMATION IN THE WOODWORKING INDUSTRIES*

Since the concept of low-cost automation is new to many developing countries, the purpose of this presentation is to provide some general outlines on why and how to automate. The term "low-cost automation" has two connotations: (a) automation to achieve low production costs, and (b) automation at low cost.

Why automate?

Before considering how to set up automatic operations, it should first be determined why and in which cases it would be advisable to do so.

In the furniture and woodworking industries every manufacturer encounters production difficulties at some time. These are solved in one way or another but not always economically or altogether satisfactorily. If there is enough very skilled staff at the manufacturer's disposal, he can manufacture parts with complicated shapes or cross-sections. A skilled joiner or upholsterer can, perhaps after some experimenting, develop a method that would produce the desired result as regards shape and accuracy, but his method will, all too often, presuppose very great skill, ability to concentrate and, above all, a disproportionately large expenditure of time.

It is difficult to recruit skilled joiners in sufficient number for industrial production, and their wages are higher than those of normal, efficient but unskilled workers. Thus, in the furniture and woodworking industries, the machines and methods used must be automated to a degree that would permit both the use of unskilled labour and the production of articles of good quality.

When planning low-cost automation in the assembly of products made in parts, it is absolutely necessary to manufacture each part so accurately that no finishing will be necessary during mounting. Conversely, some complicated shapes may be impossible to make without automation if all of the pieces produced are to be identical and thus fulfil the requirements for assembly by mass-production methods.

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*Paper presented to the seminar by Juha Haakana, Enve Oy, Lahti, Finland. (Originally issued as document ID/WG.105/45.)

One result of low-cost automation is the avoidance of human error; even the most careful operator cannot always concentrate so intensely that no mistakes occur. Human fallibility can result in an excessive number of faulty parts, with consequent difficulties at the assembly stage.

Perhaps still more important in estimating the value of automation is the fact that it reduces the number of accidents, thus reducing injuries to workers and damage to tools and machines. The controlled power feed of the tools and materials not only increases cutter or tool life, as the applied loads remain constant, but also makes possible consistent machining quality. The smooth and rapid flow of materials in automation ensures maximum output.

Materials feeding often begins rather far from the machine, in which case the material must be brought to it quickly and fed to it with no reduction in machining speed. With automation, these speeds can be set to the ideal values, and all movements can be programmed to occur in the proper order.

While it is often appropriate to put the material into the jig by hand, the fixing of the workpiece in the jig automatically is more efficient, saves time and reduces strain on the operator.

Particularly worthy of consideration is the way in which the operator receives the material. If he must reach for every workpiece or even leave his station to bring new loads from a distance, low-cost automation should be considered. The coupling of two or more machines with mechanical conveyors is the correct method for saving factory floor space by eliminating unnecessary intermediate storage. Such coupling normally requires that the outputs of the machines in question be about the same, but it is of course possible to couple two slow machines with one with about double their speed.

The removal of material from the machine or from the jig can often be done advantageously by low-cost automation. Here again, time saving and work safety are the prime considerations.

Because of the influence of the quality of machined components on the quality, marketability and selling price of the final product, automation should be developed to the extent that the operator will have time to control the quality and, if necessary, to remove defective pieces. In this manner the number of acceptable pieces will be sufficient without the need to stock very many reserve pieces, and defective material will not take up space in intermediate storage. If the operator has time to control continuously the dimensions of the machined pieces, he will be able to note, in good time, when the tools are worn enough to need sharpening or readjustment, thus preventing variations in quality and precision. If there is no automatic conveyor, labour costs can also be reduced when the operator is given time to stack machined pieces on pallets.

Degrees of automation

In any case, the appropriate degree of automation must be determined carefully. When the costs of supplying, mounting and using the automatic device are known and the savings in labour costs have been estimated, it is possible to calculate whether the investment will be profitable. There are certainly many arguments for automation, such as the improved and uniform quality of machined pieces, savings in tools and skilled labour and avoidance of accidents. These considerations are difficult to reduce to exact monetary terms, but they greatly influence the decision.

On the other hand, caution is always advisable; complete automation should be postponed until all favourable and unfavourable results have been carefully analysed. The start should be made in operations in which a reduction of costs or other savings can be achieved.

The effect of automation on the workers is another important consideration. If the machining of a piece of material is so completely automatic that the operator must only see that everything happens normally, he will soon become bored with his task and get no satisfaction from it. Craftsmen with years of experience may have difficulties in learning the industrial pattern of thinking. For instance, a joiner on a building site who equips windows or doors with fittings may be quite satisfied when completing twice as many as before, even if automation should make possible a tenfold increase without undue exertion. The inculcation in workers and their supervisors of positive attitudes in regard to automation is therefore highly important.

How to automate

The basic rules for low-cost automation are the following:

- The component machines must be of cheap, standard types that are simple, flexible and easy to set up and maintain
- Systems must be easy to build around one machine and later to modify without waste of time or money

The most commonly used automatic operations are:

Transferring the material into the machine

Clamping material into the operating condition

Feeding the material into the operating machine

Taking the processed material from the machine

Stacking the processed material

Transferring the material back to the operator for refeeding

In many cases it is possible to build closed-control loops to be sure that all movements happen at the right moment and in the proper order. It should always be borne in mind that good maintenance of the automatic devices is needed to ensure the anticipated results.

Very many kinds of experimental automatic components and systems are available. Some machines have automatic controls incorporated in them from the beginning; others must be equipped with them afterwards. In some cases the machines, such as double-end tenoners, have many working heads. In small-scale production, the prices of these machines and the setting costs are too high in relation to the length of the production series. When there is need for information about possibilities and standard equipment for low-cost automation, the easiest and cheapest way to get it may be to contact the manufacturers or sellers, who are often willing to give technical help. However, to reap the full benefit of the flexibility of such automatic components, it is very advantageous to have, on the plant staff, a person with extensive theoretical knowledge of - and practical experience with - electrical, hydraulic and pneumatic systems, because equipment for automation can be divided into these three categories or combinations of them.

The most usual elements of pneumatic equipment are the following:

Cylinders for movements in one direction (pushing, pulling, pressing and the like), depending on mechanical arrangements

Rotary actuators to effect torsional actions

Valves and other devices for regulating the above-mentioned devices

In principle, the same kinds of components are used in hydraulic systems as in pneumatic ones. However, it is easier to achieve accurately regulated speeds and more force with a smaller cylinder hydraulically than pneumatically. In many cases, however, a hydraulic system is more expensive than a pneumatic one, particularly when compressed air is already available.

A typical example of pneumatic equipment installed to operate a router is presented in the circuit diagram of figure I. Compressed air is fed from the mains through a shut-off valve (1) and filter-reducing valve-lubricator unit (2). When the foot pedal in connexion with the valve (3) is free, the router head (9) is in the upper position and the clamp (12) is opened by the spring in the cylinder (4). The table-moving cylinder (8) is held in plunger-out position by the spring return valve (6). When the operator presses the foot pedal, the cylinder (4) closes the clamp to hold the material on the right position on the table (11) while the router head is moving down.

When the router head is at the proper height, the adjustable cam (10) on it strikes a roller operated spring-return valve (5), which sends a mains air signal to reverse the valve (6). The double-acting cylinder (8) pulls the table with the clamped material past the cutter. The speed of the table movement is controlled by the one-way restrictors (7). The table travel is limited by adjustable mechanical stops.

Figure II shows a basic circuit diagram for the operation of a hydraulic cylinder. Pressure for the system is imparted by the motor (M) to a pump (1). When valve (2) is over to the left, the cylinder (3) pulls at full speed according to the pump capacity. The return oil flows freely through the filter (4) to the oil container (5). The relief valve (6) protects the pump against a too-high counterpressure. When the valve (2) is over to the right, the cylinder (3) pushes, controlled by the adjustable flow-control valve (7).

Some applications of pneumatic circuitry are presented in annex I, some simplified symbols of hydraulic and pneumatic circuitry in annex II, and some for control mechanisms in annex III.

Figure I. Diagram of a pneumatic circuit for a router

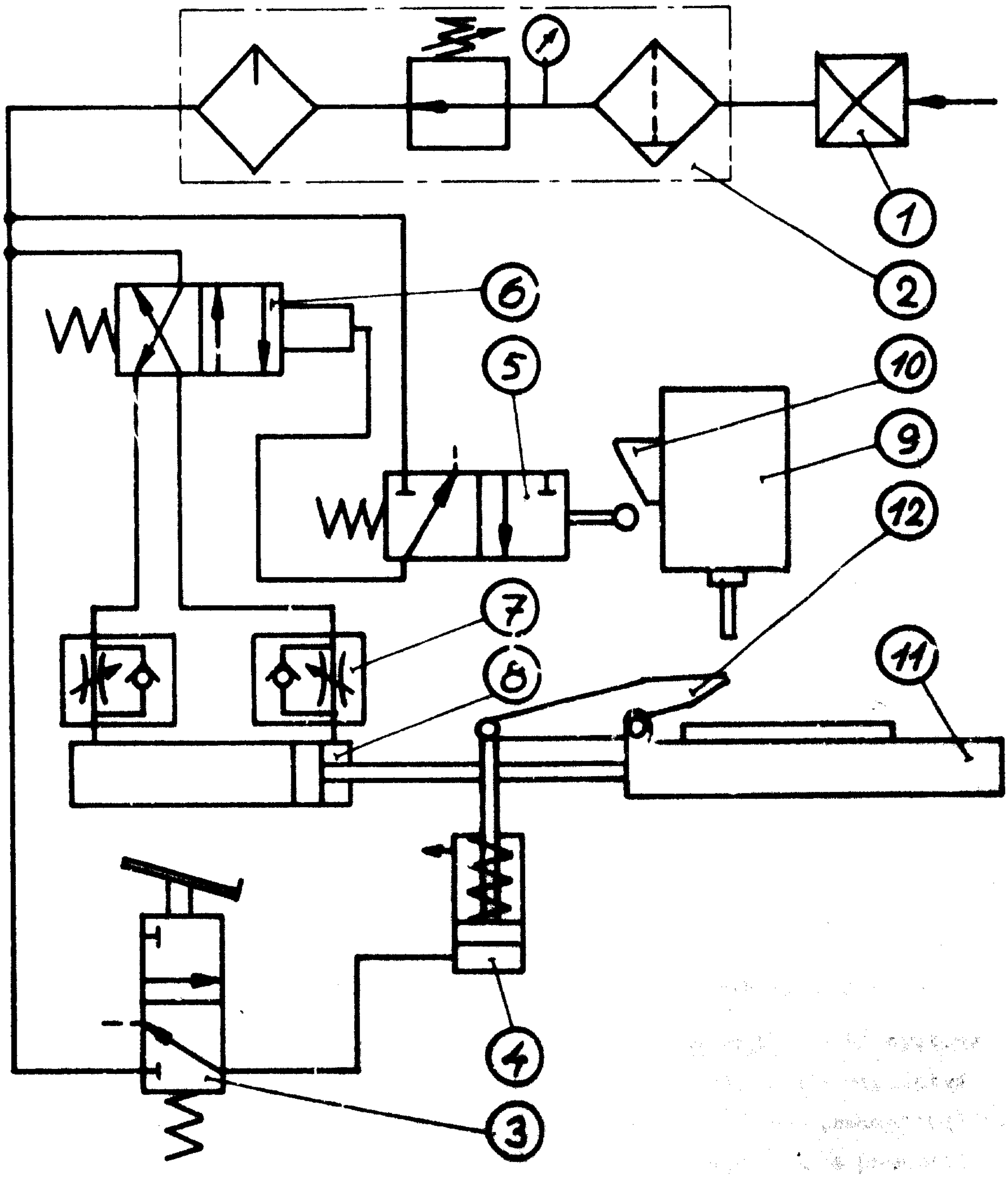
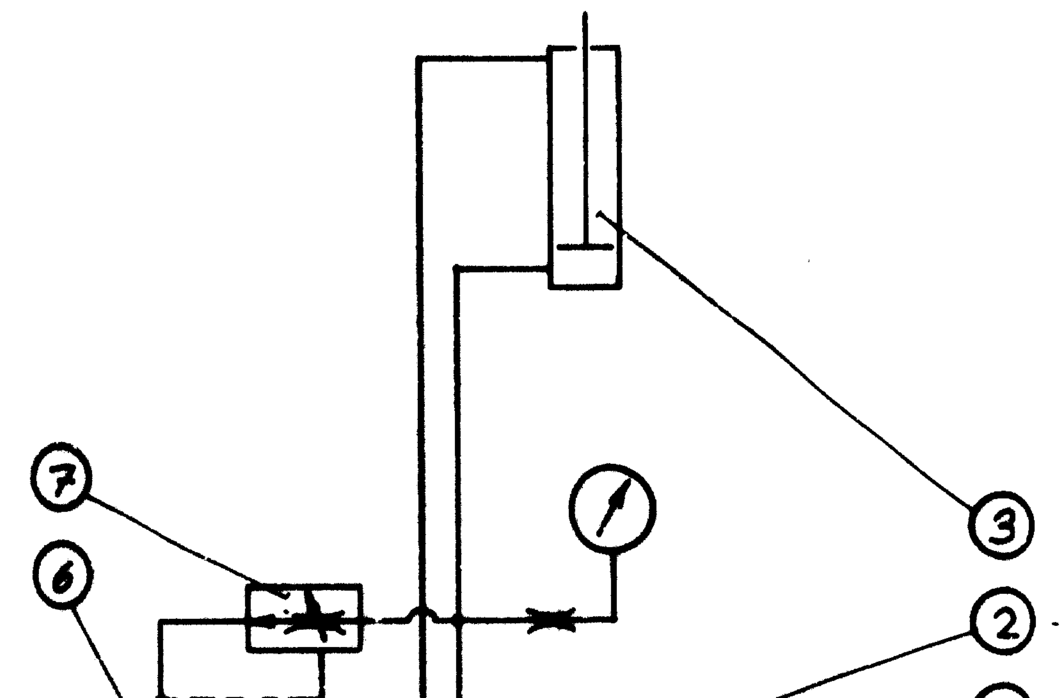
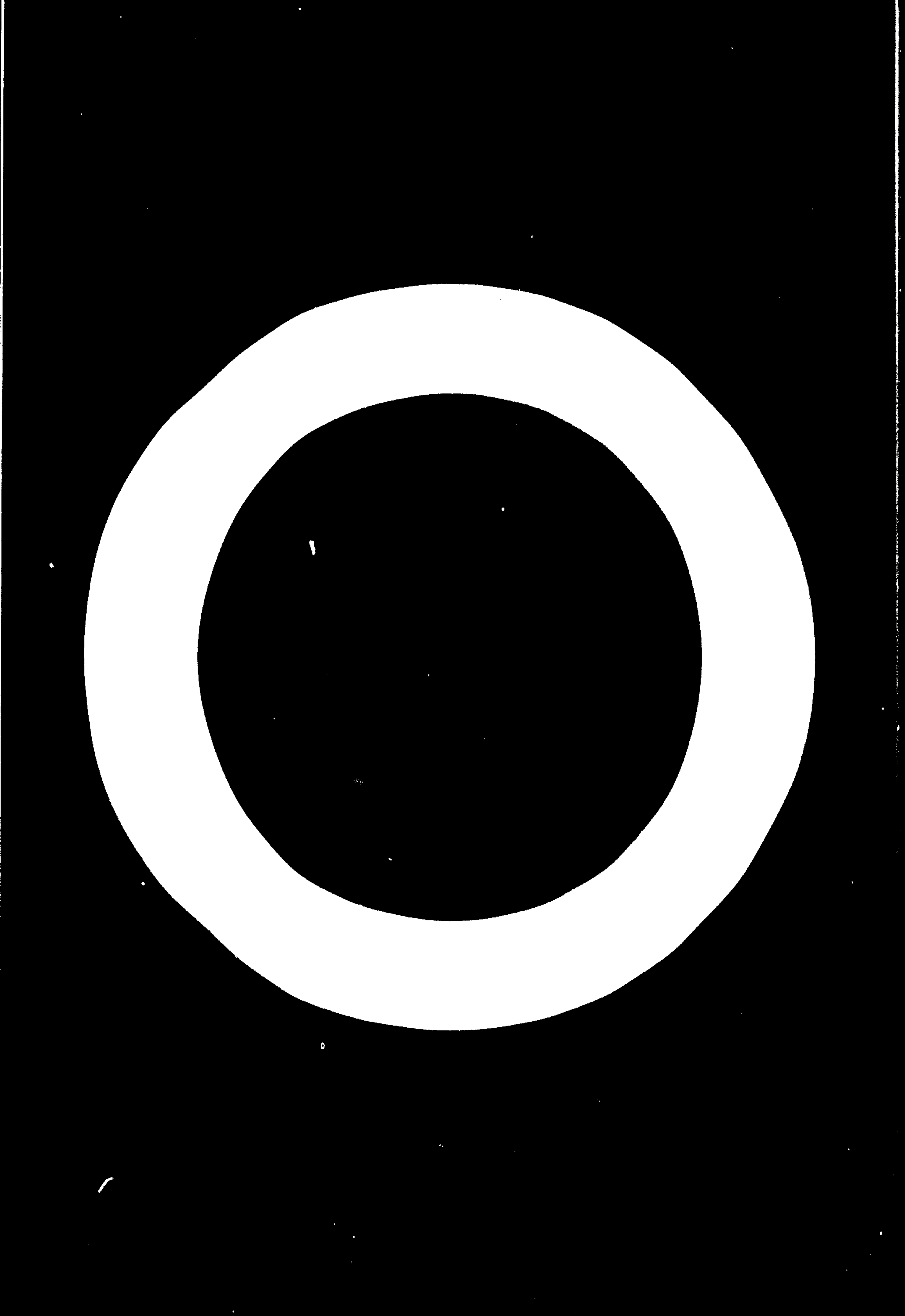


Figure II. **Diagram of an hydraulic circuit for cylinder operation**

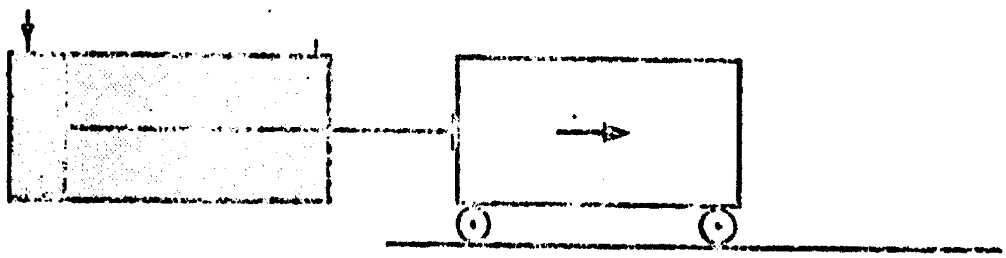




Annex I

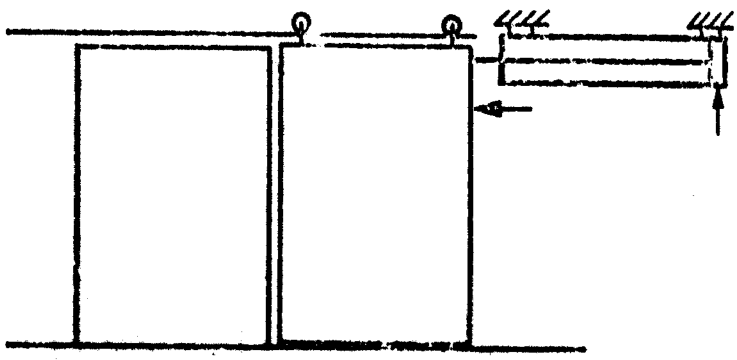
SOME APPLICATIONS OF PNEUMATIC CIRCUITRY

A



Pushing

B



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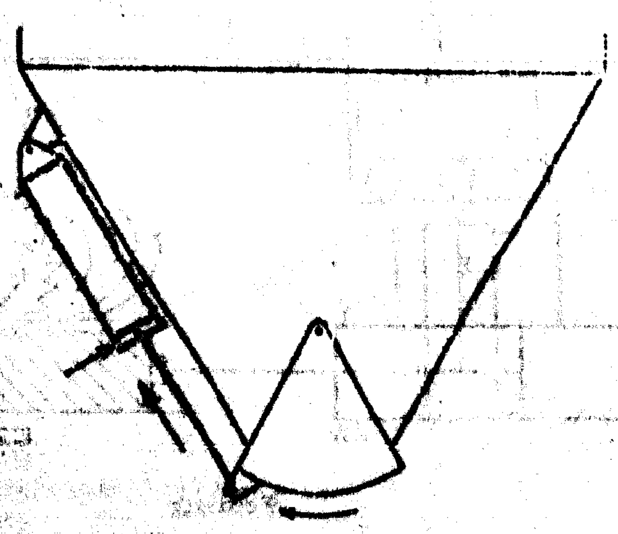
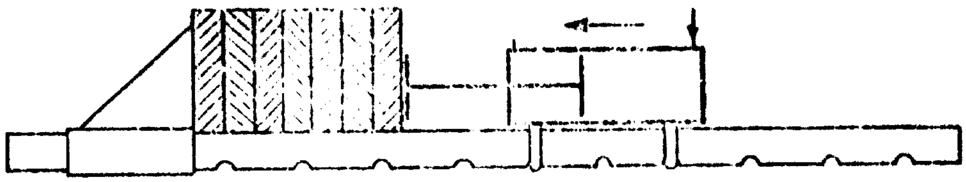
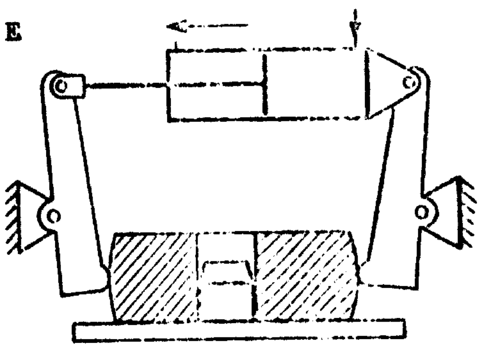


Opening and closing (doors, shutters and the like)

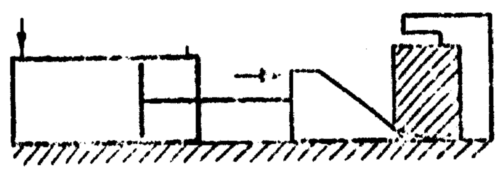
D



E

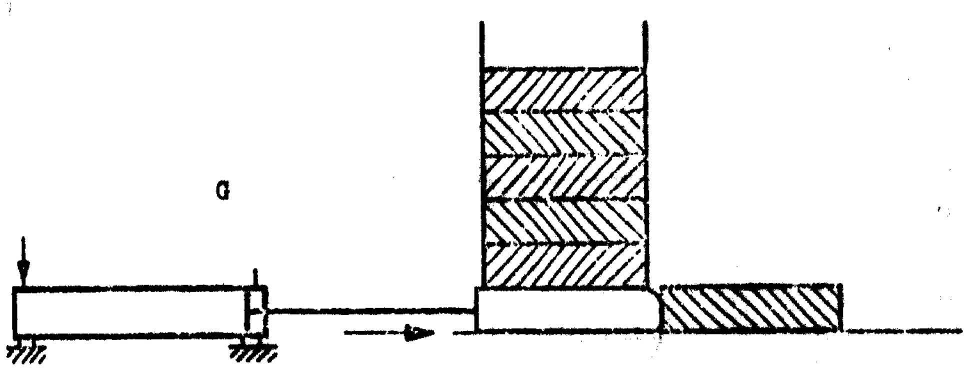


F



Clamping

G



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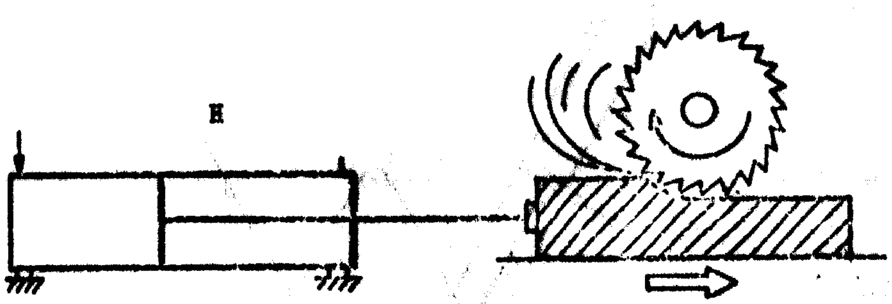
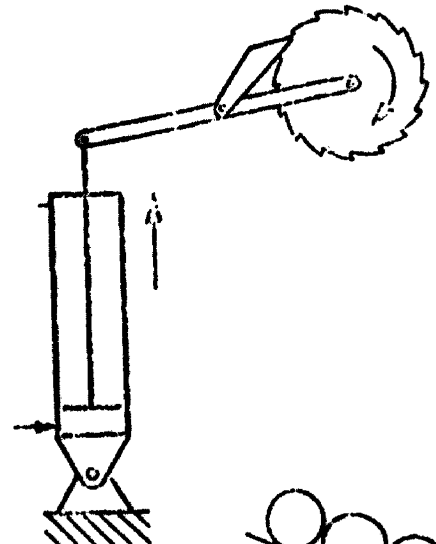
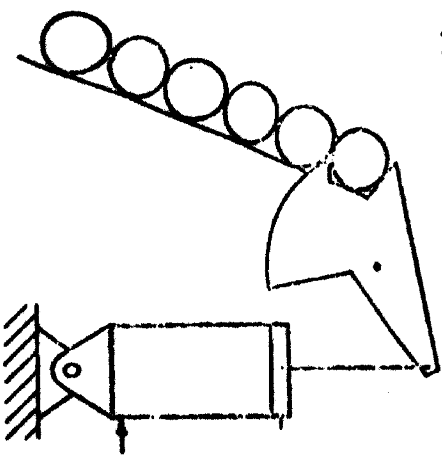


Feeding



I



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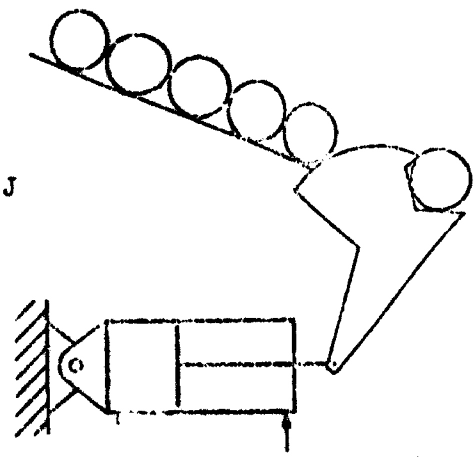
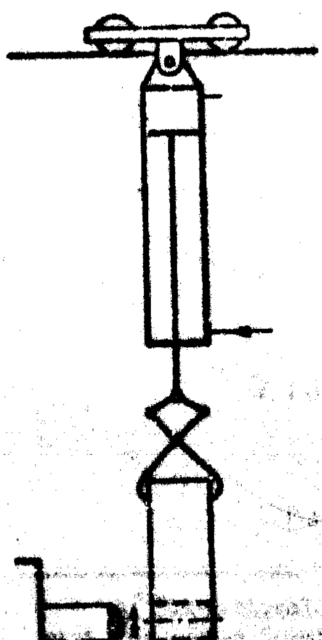
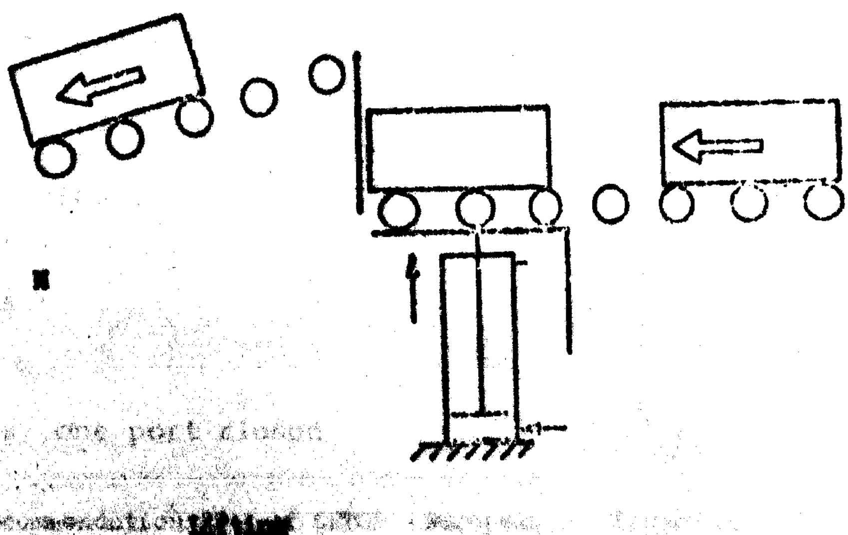
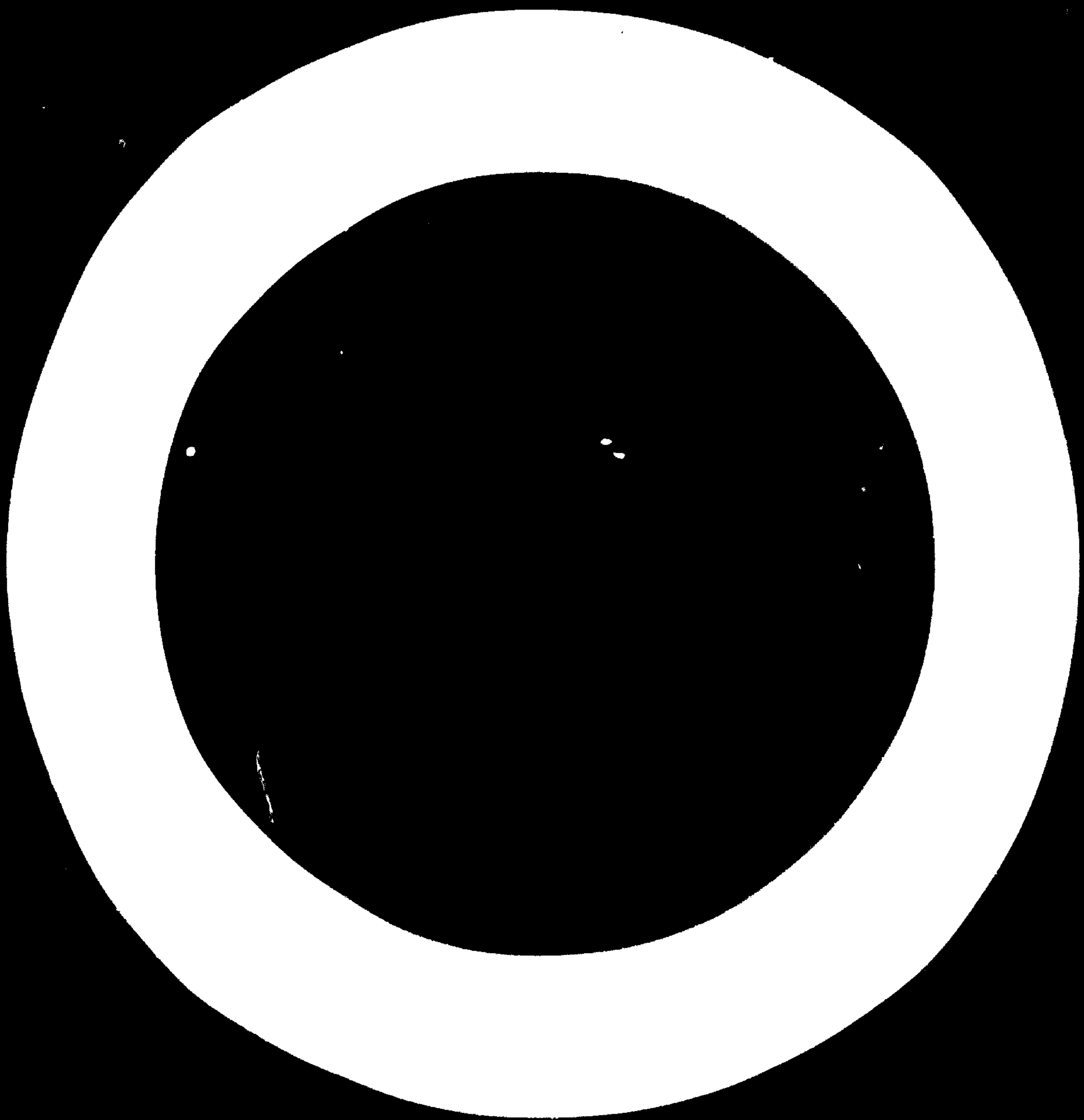


Indexing





Lifting

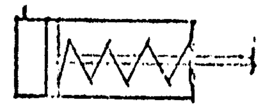


Annex II

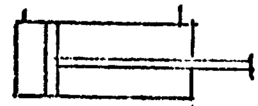
SOME SIMPLIFIED SYMBOLS OF HYDRAULIC AND PNEUMATIC CIRCUITRY a/

CYLINDERS

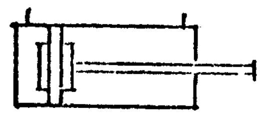
Single-acting cylinder
(Return stroke by return spring)



Double-acting cylinder
(The fluid operates in both directions)

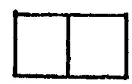


Cylinder with cushion

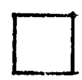


CONTROL VALVES

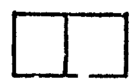
Directional control valves



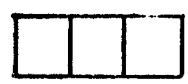
Several service positions
each shown by a square



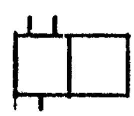
With two positions



With three positions

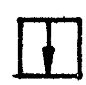


External flow lines

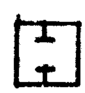


Internal flow paths

1 Path



2 Ports closed



2 Paths

2 Paths, one port closed

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a/ Provisional recommendation RP 3 of CETOP (European Oil Hydraulic and Pneumatic Committee), Frankfurt am Main, Federal Republic of Germany.

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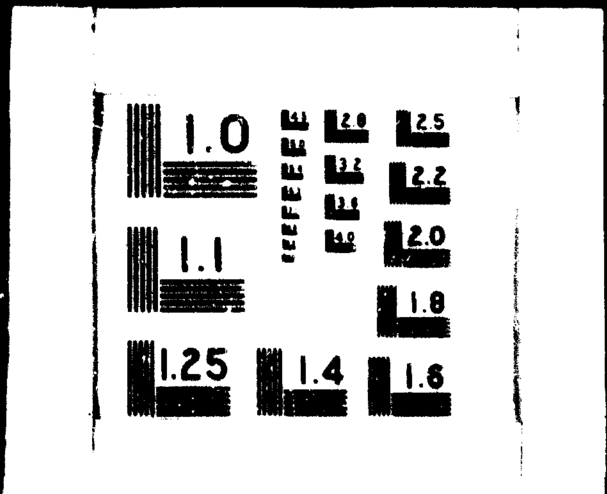


2/2 Directional control valve 

3/2 Directional control valve 

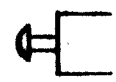
5/2 Directional control valve 

Annex III

SOME SIMPLIFIED SYMBOLS FOR CONTROL MECHANISMS[a]

Manual control

Without indication of method 

By push-button 

By lever 

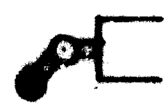
By pedal 

Mechanical control

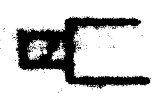
By plunger 

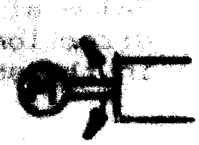
By spring 

By roller 

By roller trip 

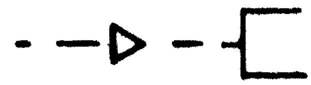
Electrical control

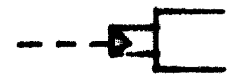
By solenoid 

By motor 

a/ [illegible] (European Oil Hydraulic and [illegible]), [illegible] Republic of Germany.

Pressure control

Direct control 

Indirect control 

Combined control

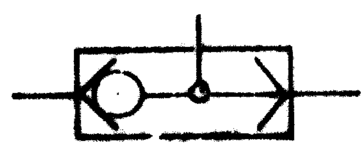
By solenoid and pilot valve 

Check valve

Without back pressure 

With back pressure 

Shuttle valve

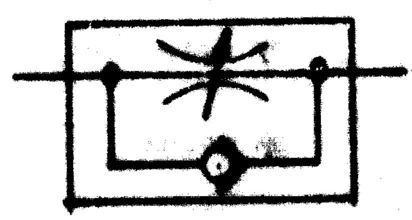
The inlet under pressure is connected to the outlet and the other inlet is closed 

Flow-control valve

Without control 

With manual control 

One-way restrictor

Valve allows free flow in one direction and restricted flow in the other. 

Shut-off valve 

Flow line

Working and return lines

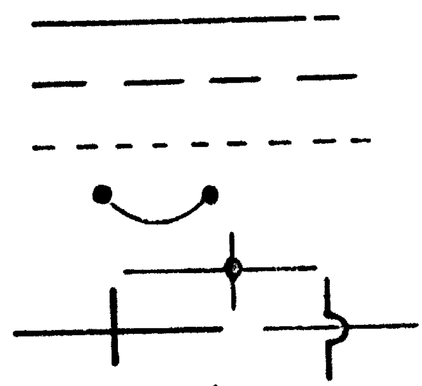
Pilot control line

Drain line

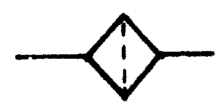
Flexible pipe

Line junction

Crossing lines (not connected)



Filter or strainer

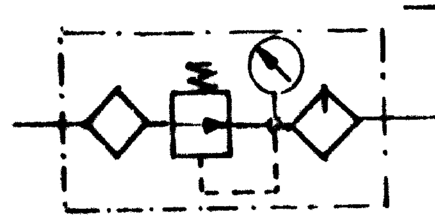


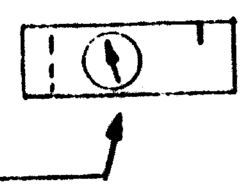
Water trap

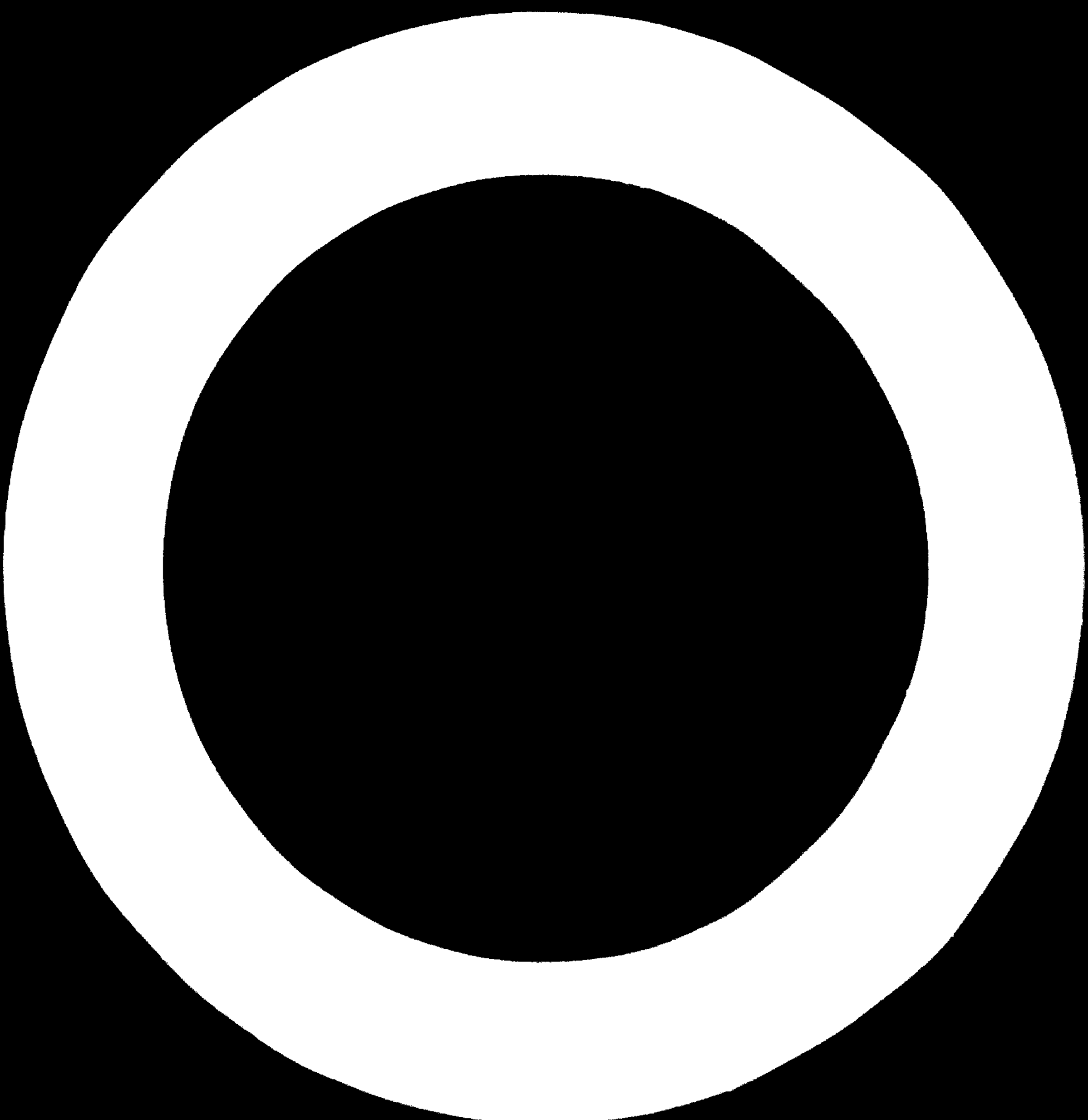
Lubricator

Maintenance unit

(Simplified)







21. MAINTENANCE OF MACHINES AND EQUIPMENT*

This presentation is limited to the machines and equipment that perform primary functions in middle-sized and small industrial plants. These functions comprise:

- Maintenance of machines and tools
- Advance service and lubrication
- Erection of new machines and equipment
- Alteration work of various kinds
- Generation and distribution of electricity, steam, compressed air etc.

The so-called secondary functions in maintenance work comprise:

- Cleaning
- Handling of trash, waste etc.
- Experimental work, building of new machines and equipment
- Certain stocking functions
- Plant security and fire protection

These secondary functions must be accomplished as a centralized part of maintenance in a large-scale plant if it includes several shops or if it deals with several fields of the woodworking industry and not only with joinery products.

The amount of maintenance work in industry has continually increased, and the same tendency may be expected to continue. At present, the number of maintenance workers in the mechanical wood processing industry is 10 to 15 per cent of the total number, and in the particle board industry this number is even greater.

The continual increase of maintenance work results from the following circumstances:

- The rapid and continual increase in mechanisation, automation and general development of the industry which have greatly reduced the number of production workers in actual industry
- The considerable increase in facilities and tools for maintenance

*Paper prepared for the seminar by Ahti Akkanen, Lahden Rautateollisuus Oy, Lahti, Finland. (Originally issued as document ID/WG.131/25.)

The relatively decreasing importance of worker absenteeism and increasing importance of machine downtime

The increasingly capital-intensive nature of industry, with the concomitant need for continuous operation, in other words, for two- or three-shift work

The increasing speeds, pressures, temperatures, capacities of machines, resulting in more rapid wear

Consumer demand for higher precision of machines and improved quality of products

Need to rearrange machines and equipment

Safety at work, air conditioning, industrial hygiene and other circumstances calling for new tasks

The increased awareness of the social and economic problems related to the treatment and disposal of industrial wastes

With the increasing amount of this work, the demands for craftsmanship required for maintenance have also continually increased, especially as regards instrumentation and automation which make quite new and difficult demands. The use and handling of new materials, such as plastics, contribute to this trend. Previously, and even now, to some extent, maintenance meant simply repairing, in other words: action taken when something broke down. At present, however, there is a strong tendency towards preventive maintenance, which must be considered as a fairly advanced form of maintenance.

Equipment is becoming so complicated and its maintenance and repair are beginning to call for workers with such great professional skill that only few industrial plants can afford to employ them; only very big concerns are self-sufficient in this respect. Other enterprises must resort to spare-part replacement arrangements, even for complete machines. Damaged parts are sent to a special factory or shop for repair. Importers or licensed manufacturers give information on such special repair shops. By making annual or other long-term agreements it can be ensured that the special repair shop will always have spare parts or machines in readiness for the customer.

In general, such external help in repair work will obviously become more usual, particularly since, by this means, it will be possible to get specialized service for tasks that cannot be done within small organisations. The diesel motor for trucks or for other machines is a good example of such a changeable part. This motor is usually changed and taken to a special shop for repair and where a new motor is in readiness if some damage occurs. This arrangement is very suitable for lumber and log yards. However, it should be remembered that, when the work machines are bought their motors should be of the same type and at least made by the same manufacturer, even if the machines are of different makes.

Organization of maintenance

The organization of the maintenance has changed very decisively over the years. Formerly, all repair work was done by only one man, but a modern form of organization has gradually developed. The position of maintenance in an enterprise has also changed decisively; having earlier been subordinated to production, it is now becoming equal with it and will be directly accountable to the highest management.

In connexion with the reorganization of the maintenance and with organisation in general, the following circumstances should be noted:

(a) If the field of tasks becomes wider, technical and economic know-how should be added to the supervision of maintenance. In general, when the amount of work increases, the number of fitters and other workmen is also increased, but not the number of engineers and technicians. If the office staff is inadequate, the maintenance supervising personnel must often do much mechanical and routine work, to the detriment of planning control, etc. It is often forgotten that increasing the number of persons and the amount of labour always calls for additional staff for supervision, control and routine work. If technical staff is lacking, foremen can be designated in certain areas, leaving supervisory personnel to control larger groups.

(b) The use of too many unskilled workmen must be avoided; the number of such auxiliary workers should not exceed 20 per cent of that of craftsmen. The maintenance department, however, should not become a place for superannuated persons, nor should the repair shop become a museum of outdated woodworking machines. Securing new and skilled labour calls for training, but the training should not be done in such a way that a young man goes from year to year helping an older craftsman. It should be done under the leadership of competent trainers.

(c) Furthermore, it should be noted in budgeting and in future planning that, entirely new tasks and departments are coming into the maintenance organisation, as for instance, separate departments for preventive maintenance, scrapping and repair, plastics, and instrumentation and automation (possibly even electronic).

In general within the over-all maintenance organisation, there are so-called decentralised and centralised systems. In the former, the maintenance men are divided into small groups all around the factory and are often in some way subordinated to the local production supervision, whereas in the latter, work is directed from one point and is subordinated to centralised supervision. Both systems have their benefits and disadvantages. The appropriate system should be selected separately in each particular case, taking into consideration circumstances such as the nature of the working process, the cost of downtime per minute, the number of interruptions in work, the degree of mechanization and automation and the general development of maintenance work.

As a rule, centralization should perhaps be striven for in small enterprises. However, when the factory area becomes so large that unnecessary (and time-consuming) walking is becoming a considerable cost factor, it is advisable to consider at least a partly decentralized organization. It is, however, advisable to try to retain centralized supervision. The same applies to automation and the situation where expensive basic machines with high capacities (for instance a paper machine or, in joinery industry, a painting line) are in operation. In such cases it is, of course, worth having maintenance workers to control the operation and condition of the equipment.

Nevertheless, the following functions should be centralised, nearly without exception:

- Planning work
- The generation and distribution to production areas of electricity, gas, steam, compressed air etc.
- Maintenance of elevators, cars, trucks etc.
- Care of the sprinkler fire-extinguishing system, pneumatic conveyors and air conditioning
- Machining works
- The major part of wood-based panel plants
- Building and repair shops
- The internal telephone network
- Assignment of auxiliary labour power

In principle, each manpower group should be led by a foreman of the same occupation. It is thus inadvisable, for instance, to make maintenance workers subordinate to production leadership. It would be advisable, however, to subordinate decentralized maintenance groups directly to the maintenance leadership, as far as the craftsmanship is concerned but, as regards assignment of work, they should be subordinated to the production leadership.

Maintenance card files

The proper organisation of maintenance is not possible without some recording, that is to say: without card files. It is almost impossible even to begin preventive maintenance without repair statistics made over several months, and preferably, over several years, for each individual machine. It is very easy to record data on a machine card, when it is at hand, such data as the numbers of bearings when the machine is disassembled and the numbers of belts before they are worn out and the weight of a machine when it is to be seen on the bill of lading.

The objects that should have file cards are almost the same in various industrial plants. However, it is worth thinking about which objects should have such records and which do not need them. For instance, in the joinery industry, the objects for filing are woodworking machines, presses, conveyors and certain hand tools such as sanders, etc.

The basic card also serves as a list for fire and other insurance. If it includes sufficient data on belts, bearings, lubricants and the like, it makes an excellent starting point for the standardization of maintenance procedures. Cards have sometimes been prepared separately for each machine type, but at least in the joinery industry, such differentiation is of little value. In practice, it is the data that are common to different machines that are most generally needed. Thus, a single form with plenty of room for notes is generally considered quite sufficient.

The card for electric motors might be mentioned as an exception. This form may be of small size and should usually be kept in the electrical repairs department. Only basic electrotechnical data such as motor type, serial number and revolutions per minute are entered on the card. For practical reasons, data on repairs and mainterance are entered on a separate blank form, which of course can be kept together with the machine card. Data on repairs accumulate so quickly that the columns of the basic card would be filled too quickly. It is also difficult to provide, on the basic card, space enough for detailed work descriptions, data on spare parts used etc. The basic card and repair card as such can also be used for time schedule control (inspections of preventive service, lubrication service etc.).

The numbering of machines for the machine card file can be done in various ways, but the most usual ones are a running number arranged in the buying or arriving order, or a certain number series for each machine type. A third alternative is to have a separate series of numbers for the machines of each individual department.

Preventive maintenance

Correct preventive maintenance should cover the entire plant, including the factory building and its transportation lines and utility mains and not merely the machines and equipment.

In general, the nature of maintenance is still passive, this function normally begins only when the machine breaks down. It should be active, however; by inspection and service lubricating, and continuous observation of the condition of the machine; the basic repair, carefully planned, should be made at the appropriate time with respect to production.

Preventive maintenance is not a new idea. In some fields, as for instance in lifts, aircraft, railroads and pressure chambers, regular inspection has been standard practice for decades. It is a very extensive function. Among its elements are:

- Inspection of machines and devices
- Minor repairs, adjustments, cleaning and the like performed during inspections
- Complete overhauls planned in advance and work done during shutdowns
- Lubrication service
- Investigation into, and selection of, new parts and raw materials
- Investigation, comparison and recommendation of various protective devices and coatings

Preventive maintenance naturally involves some costs, so the objects and scope of maintenance should be carefully planned. In the joinery industry, maintenance should be extended to painting and laminating equipment, rapidly rotating bearings, drive belts, chains and chain wheels.

Before an extensive maintenance programme is begun, the persons concerned should be charged only with this work and with nothing else. The following documents and data will then be essential:

- Card files on all machines and devices
- All documents, instructions etc. for each machine
- Drawings on machines and devices, particularly on large ones
- Statistics on breakdowns
- Data on repairs
- Diagrams of all utility lines
- Arrangement of a reliable spare parts service.

Furthermore, it is important that the preventive service group consist of eager and active workers.

The inspection activity includes two different functions: routine inspection and maintenance, and inspection according to the programme for each particular machine. In joinery and other industries, the former functions should be applied to:

Electric motors

Power transmission devices

Piping, valves and pumps

Conveying equipment, elevators and lift tables

Air-conditioning and dust-suction devices

Lighting devices

Office machines

Instruments and automation devices

As examples of inspection periods, the latter functions could comprise:

Weekly inspection of scales, cooling equipment, photoelectric cells, tools with electric or compressed air motors, and spraying and air-conditioning devices for paint shops

Inspection every second week of belts, couplings, starters and electric motors; instruments and electrical control devices; and of air compressors, pumps and air-conditioning equipment

Monthly inspection of blowers and belt, pneumatic and hydraulic conveyors; water-treating plants; lifting devices and elevators

Inspection every three months of chargers for accumulators; boilers and lighting, welding machines and transformers

Inspection every six months of fire-extinguishing equipment, water tanks and their fittings, piping, power lines and heating apparatus

Yearly inspection of small electric blowers and normally operating ball bearings

A good example of preventive maintenance is the observation of the bearing of a knife shaft that operates at more than 9,000 rev/min for a high-speed machine such as a single-spindle shaper. A broken bearing may cause the breakdown of the entire machine. By observing this bearing regularly, it will be possible to determine the right moment for replacing it and thus avoid the damage.

The above listings serve only as examples, because some equipment may require several different inspection periods, such as daily cleaning, weekly adjustment, monthly inspection of operation and annual overhaul. Correct determination of the inspection period is the basic requirement for a successful programme of preventive maintenance. Too frequent inspection is wasteful of labour and money; too infrequent inspection jeopardizes the machinery. The periods between inspections must be changed to conform to changed conditions, and by observing the changes that have occurred, it is possible to adjust these periods.

The inspections may take place either when the machines are operating or when they are not. In the first case, this is done when abnormal vibration, wear, lubrication faults (oil leakages), excessive heating, poorly fixed parts, play of shafts etc. can be observed. However, it should be noted in this connexion that, in the joinery industry, a knife in poor condition may cause some of these abnormalities, so that the intervals between knife replacements in woodworking machines should be observed carefully.

When machines are not operating, the inspection possibilities are of course considerably greater; experience has shown that at least every third inspection should be made in this way, since inspection and measuring of shafts, bearings, gear wheels, slide surfaces, belts and flanges, as well as of tensions, will then be possible. Machines producing much sawdust and chips should especially be inspected when idle, because parts not normally visible can then be checked. For inspection, the dust and chips should be removed from the machines. In tropical conditions, the thicknesses and protectiveness of grease coatings should be ascertained at the same time.

Preventive engineering

Preventive engineering is the investigation and selection of raw materials and various protections, so that the need for repair can be avoided or reduced. When the preventive maintenance programme has developed, some causes of various breakdowns and repairs are discovered, and in many cases constructions, raw materials and protections have been found to be inadequate. Much work is needed in this area.

Here the first task is to investigate repair statistics and analyse the most essential and frequent repair jobs. The second task is to determine whether changes in construction, raw material or protection would improve the situation.

Lubrication maintenance

The primary purpose of lubrication is to reduce the effects of friction. Successful lubrication has the following advantages:

- The machines are kept in condition
- The lifetime of machines is extended when wear is reduced
- The efficiency of the machines is increased
- Accident hazard is reduced

To attain these advantages, it is essential to use the proper lubricant at the right place and time.

All of the following considerations are important in lubrication:

The assortment of greases to be stocked should be as small as possible.

The lubricants chosen should be included in the factory standards and marked with the same sign as on the lubrication points and tools.

All lubrication points should be lubricated correctly; that is to say, the lubrication must be done according to a plan drawn up by an expert. Oil companies distribute such plans free of charge.

Lubrication should be accomplished at the right time, but unnecessary lubrication must be avoided. It has been ascertained that over-lubrication is more frequent than under-lubrication, especially where ball bearings are concerned. In general, a small or medium-sized bearing in normal use and with usual rates of rotation will need lubrication only once a year.

The amount of grease in one filling can be calculated approximately from the following formula:

$$G = \frac{D \times B}{200}$$

where:

- G = amount of grease required (in grams)
- D = major diameter of the bearing (in millimetres)
- B = width of the bearing (in millimetres)

To economise on lubrication costs and to ensure reliable lubrication, some larger enterprises, and especially sawmills and plywood factories, have installed automatic lubrication, whereby hydraulic pumps press grease through piping to lubrication points, as required. The amount of grease for each point is adjustable. This way of lubricating is becoming general, as for instance on the slide surfaces of conveyors and in the process industry. In the joinery industry, however, there are not many points that can be lubricated in this manner.

Oils that have been used once or even several times should not be discarded; efforts should be made to clean them. In general, waste oil is taken to special cleaning plants. If this is not possible, a filter arrangement can be easily built, using waste wool.

Prevention of corrosion

Most damage to machines and other equipment used in industry is caused by corrosion. While this is always a problem, it is particularly severe in warm and moist environments. For instance, the speed of rusting of steel is directly proportional to the temperature. Most usually, corrosion is caused by water or oxygen. Oxygen is an especially difficult factor, because the strength of the metal in some cases calls for its presence, since it causes the formation of a protective film of oxide on the surface of the metal; sometimes, however, it greatly contributes to corrosion.

In principle, the prevention of corrosion is rather simple. By protecting steel surfaces, for example, the speed of corrosion is reduced, either by mechanically preventing the surface of the steel from coming into contact with oxygen or moisture or by inhibiting the rusting process. In practice, the following methods of preventing corrosion are used:

Making constructions in ways that protect corrodable materials from air, warmth and moisture

Changing the environmental conditions

Covering vulnerable materials with corrosion-resistant materials (paints, plastics, rubber, ceramic materials), glasing or using protective boiler masonry, metal coatings or platings

Cathodic protection

Use of inhibitors of some reactions involved in corrosion

Using materials that do not tend to corrode in the given circumstances

The above listing shows that, in very many cases, the corrosion preventing methods require a considerable knowledge of chemistry. It is also to be seen that action on the first point seldom can be undertaken on the site; usually this is done by the manufacturer. When the machinery is ordered, however, the purchaser can influence the matter and try to obtain a construction solution suited to the conditions of use.

On the other hand, it is possible to alter conditions according to the second point:

The air of the factory hall can be cleaned and dried, and its carbon dioxide content can be reduced

If the problem concerns piping or conduits, flow speeds can be reduced
Ventilation may be improved

The protective measures listed in the third point above are the most usual and have been in use from very early times. With painting, the three following practices should be followed: the surface should be cleaned thoroughly, a corrosion-inhibiting primer should be used, and a tight and covering paint should be applied to the surface. Two excellent traditional primers are red lead and zinc yellow. Among the surface paints, bitumen paints, reaction lacquers and paints, and silicone resin paints should be mentioned.

Among the plastic coverings there is a wide range of paints, lacquers, pastes and solutions. They are now used very widely and have proved their value in protective and wear-resisting applications.

Rubberising can be considered for tanks, pipes, conveying rollers, glue rollers and gluing machines in general. Rubberising should be done only by a fully competent vulcanizer to ensure that the rubber will hold firmly to the surface to which it is applied.

Boiler masonries, glazing and ceramic coatings should be used only in places subject to very high temperatures.

Metal coatings and platings are not always intended to protect against corrosion but are sometimes used for protection against wear or to give gloss to the object in question. The hot-dipping, spraying and electrolytic methods are the most usual. Zinc, chromium, nickel, aluminium, tin and lead are used as covering layers.

The other methods listed are of little importance in the joinery industry except of such plants where metal furniture parts are used. In the last-mentioned cases, there should be an expert in this line available, so that such parts will be treated correctly and with the right materials.

Finally, the so-called provisional protection, which means the use of materials that inflrence the surrounding air or the use of protective films should be mentioned. These protective films are of PVC plastic, which can be torn off. They are first melted, after which the object in question is dipped into the molten mass (temperature [illegible]°C). The chemicals that influence the surrounding air are called the VPI (vapour phase inhibitors), which form a protective gas layer on the object [illegible].

Stocks for maintenance

The materials to be held in maintenance stock are mainly the following:

Parts of standard nature: pipes, nuts, bolts, fuses, bearings etc.

Parts for separate machines: special bearings, spare parts etc.

Spare assemblies: motors, pumps, condensers, couplings etc.

General supplies: packing materials, lubricants, paints etc.

Machine tools: knives, drills, grinding wheels etc.

Hand tools: wrenches, measuring gauges, compressed air tools, electrical tools etc.

The ever-increasing mechanisation and automation have also contributed to the capital value of maintenance stock. The increasing costliness of downtime has had the same tendency. Repairs must be accomplished as quickly as possible, and there should be sufficient spare parts in stock to permit this.

There are two opposing factors to be considered in relation to maintenance materials. On the one hand, to expedite repairs and reduce downtime, increasing amounts of spare parts and devices for the most essential machines should be held in stock. On the other hand, however, when capital and stocking costs are considered, the stock should be kept as small as possible. In general, the final solution must be some kind of compromise.

If the factory is located far from the country where its machinery is produced, as is the case in most developing countries, the spare part stock should be rather large so as to ensure continuous operation of the factory. However, the spare parts that will probably be needed should be noted when the machine is being ordered, and a list of spare parts to ensure the operation for two years, and for some machines even for a longer period, should be ordered. Furthermore, it is worth while to discuss the necessity of each particular spare part with other users of the machines, especially when these parts are expensive.

Standardisation should also be striven for; for instance, all the machines and machine parts, threads, holes, bearings etc., should be in the metric system; measurements in inches should be avoided.

It is easy to keep the stock up to date if it is kept in order and the cards duly filed. The so-called "alarm limit" or required time of ordering should be marked on as many cards as possible, so that an order may be placed immediately as soon as the amount of parts in stock falls beneath that limit. Here, the use of a goods card or spare part card is helpful. With regard to small machines, only the most essential spare parts are written onto the machine card. With standard spare parts that are used in many machines a summary must be prepared for departments and for the whole plant to indicate their total number. Such parts are, for example, belts, chains, motors and bearings. The summary list forms a base for acquisition, stocking and internal standardisation. In all such listings, spare parts are usually identified by number or letter code. The spare parts list and its record should be kept up to date in an orderly fashion so that needed items can be found without loss of valuable time.

As the maintenance function evolves to meet changing needs, repairs can be made with increasing rapidity. On the other hand, they entail costs, and there is inevitably a limit that it is uneconomic to exceed. It is thus advisable to calculate in advance how much capital should be tied up in spare parts for the more essential machines; alternative methods should be costed carefully. The example given below concerns a large, essential electric motor in three-shift operation. Its downtime cost has been calculated at mk 200/hour. When it is time for the regular servicing of this machine, this work can be done in any of four ways: (a) complete overhaul with no replacement of parts; (b) complete rewinding etc.; (c) replacement of the entire rotor; and (d) replacement of the entire motor. The costs of these four methods would compare as shown in the following table. Inspection of this table reveals that the third of these ways, namely the replacement of the rotor, is the method of choice, and it is therefore economic to keep a complete rotor in reserve.

Comparative costliness of four ways of performing
[illegible]

Type of overhaul	Repair time (hours)	Costs (Markka) a/			
		Downtime	Parts	Labour	Total
Complete overhaul	240	48,000	-	6,000	54,000
Rewinding etc. of motor	144	28,800	1,000	2,900	32,700
Replacement of rotor	8	1,600	8,000	100	9,700
Replacement of motor	3	600	16,000	100	16,700

a/ [illegible]

Mounting the machines

Each machine must be mounted with great care, since incorrect or faulty mounting can cause irreparable damages in operation. Before mounting is begun, the instructions that normally are delivered with the machine should be carefully studied. Indeed, when possible, these instructions should be ordered and received before the machine is delivered. Even though the ways of mounting the most usual woodworking machines do not actually differ greatly, it is worth while to note the necessary tools and arrangements in the instructions for each part of a machine. This is important even if the machine is of a similar kind, because designs of machines and devices change frequently.

Some heavier machines such as wide-belt sanders, wide planing and thicknessing machines can be mounted in place without fastening. In such a case, a vibration-damping rubber mat should be placed below the machine. However, this method of mounting requires an absolutely even and straight floor level.

In any case, no matter what the machine is, the mounting can be done with fastening screws. When the site of the machines have been fixed, cavities for the foundation screws should be made in the floor or, if the plant is under construction, the required holes can be located at an early stage. These holes or cavities must conform absolutely to the drawings of the manufacturer; in no case must the hole or cavity for the bolt be smaller than the drawing indicates, or the fastening bolt will work loose as soon as the machine is started.

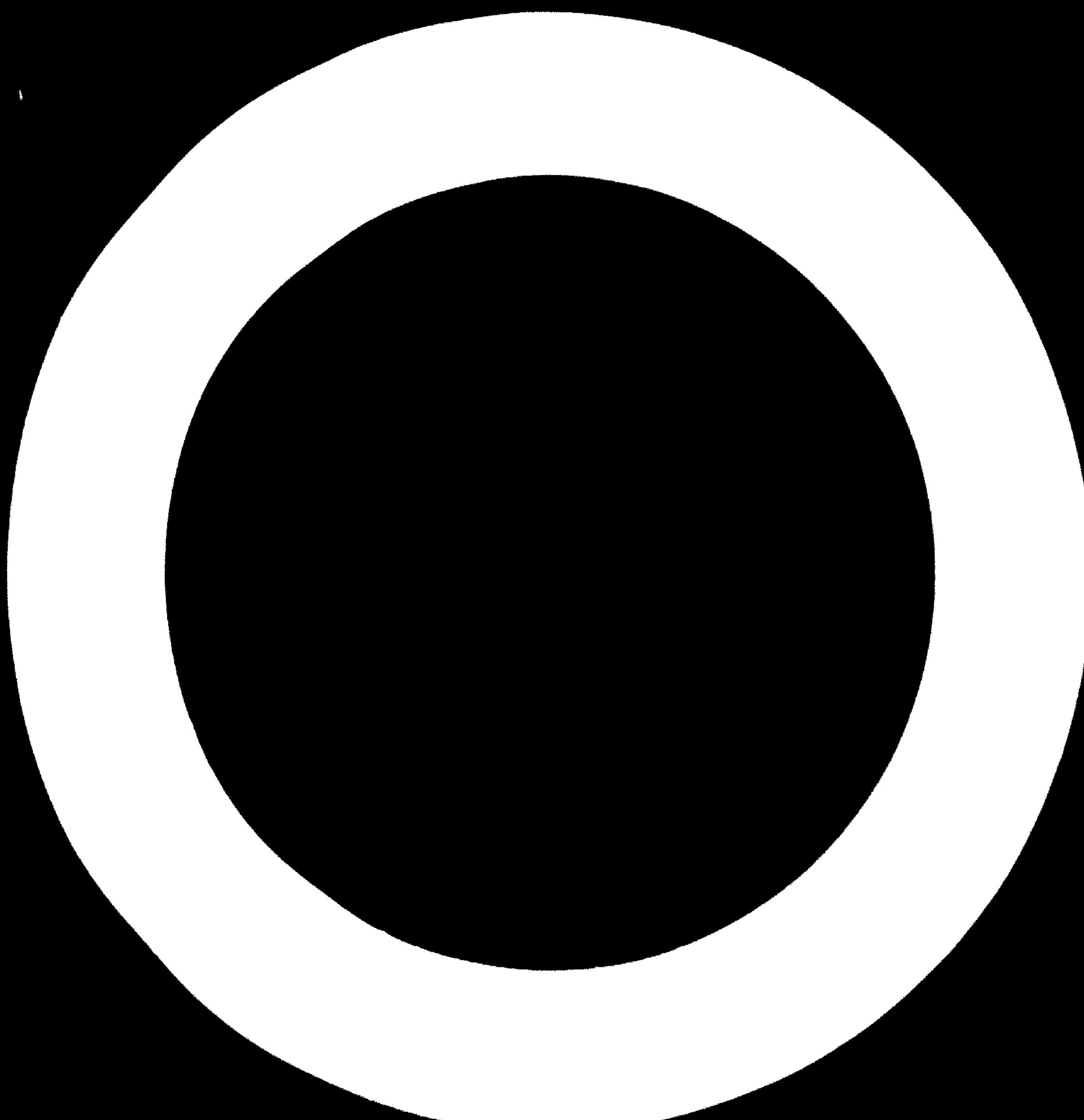
In the installation, the machine is placed exactly, and the foundation screws are inserted into the holes of the frame and project downward from them into the holes or cavities in the floor. The machine is then hoisted from the floor (about 20 to 25 mm) by means of metal wedges, lead plates or the like between the frame and the floor level. The wedges should be placed as near as possible to the fastening holes. (At this time a spirit level should be employed to check the horizontal position of the machine.) The screw cavities are then filled with cement grout. When it has hardened, the foundation screws are tightened. At this stage, care should be taken that no tension is created in the machine, in other words: the screws must not exert a bending or twisting effect on the frame, which can occur if the machine is not straightly or horizontally placed. Torsion and bending hinder the functioning of moving parts, and even the frame may be damaged.

When the placement of the machine is planned, the needed electric cables, compressed air and hydraulic pipes, and dust-evacuation ducts must be provided.

The removal of sawdust and wood shavings is a matter of prime importance. If this is not properly done, the efficiency, as well as the health and safety of the workers, will be impaired. Furthermore, the maintenance of a dusty machine is easily neglected. There is also an increased fire hazard, since drive motors embedded in wood shavings and chips often become overheated, and their windings burn, with consequent risk of major damage. Finally, it should be stressed that a clean factory produces more and better goods in fewer working hours per product unit, and that it runs with minimal maintenance costs.

The best way to cope with shavings and sawdust is to remove them pneumatically from the cutterhead knife, where they originate. The pneumatic shaving-suction system must be extended to the whole factory hall and to each working machine. The advantages of such a centralised system are not limited to safety and cleanliness; the waste thus gathered can be used further in particle-board or cellulose mills.

The fitting of such wood-waste ductwork in old buildings may present difficulties and extra costs, but they are not usually disproportionate. In such cases, ducts hanging from the ceiling are often the only solution. In new plants under planning or construction, it is possible to provide floor channels for this suction network so that the shavings on the floor can be swept into holes to be transported away.



[illegible]. WOODWORKING MACHINE TOOLS AND THEIR MAINTENANCE*

When contemplating the manufacture of furniture and joinery products on an industrial scale, the planners must have good knowledge of machine tools for woodworking and of their proper maintenance. The equipment is both complicated and costly, and its proper selection, operation and maintenance will be vital to the success of the operation. It is for these reasons that the nature, mode of operation and proper upkeep of some of the more important types of woodworking machinery are considered here in some detail.

Let us begin by discussing some machine tools used for cutting. As shown in figure I, there are three ways in which logs and lumber can be sawn: 1, perpendicularly to the grain (cross-cutting); 2, parallel to the grain (ripping) and 3, parallel to the grain but moving across it. The tools used to perform these operations must be designed accordingly.

Circular saw-blades

Circular saws can be obtained with tooth shapes suitable for either ripping or cross-cutting. The standard tooth forms and angles are shown in figure II. The saw must be well balanced when running and, in order to secure its satisfactory and steady rotation, the centre portion must be hammered in advance (pretensioned) so that it receives an extension corresponding to that produced in the saw rim when running at full speed.

The saws are balanced and tensioned correctly when received from the manufacturer, but cutting conditions will cause them to lose tension, which must be renewed by experienced personnel.

Normally the speed at the periphery is approximately 50 m/sec. Rim speeds higher or lower than normal require adjustment of the tension; higher speeds require "lesser" tensions, and vice versa.

It is very important that the blades be absolutely even and flat when rotating and do not deviate more than a couple of tenths of a millimetre from the straight plane. Hence the importance of tensioning.

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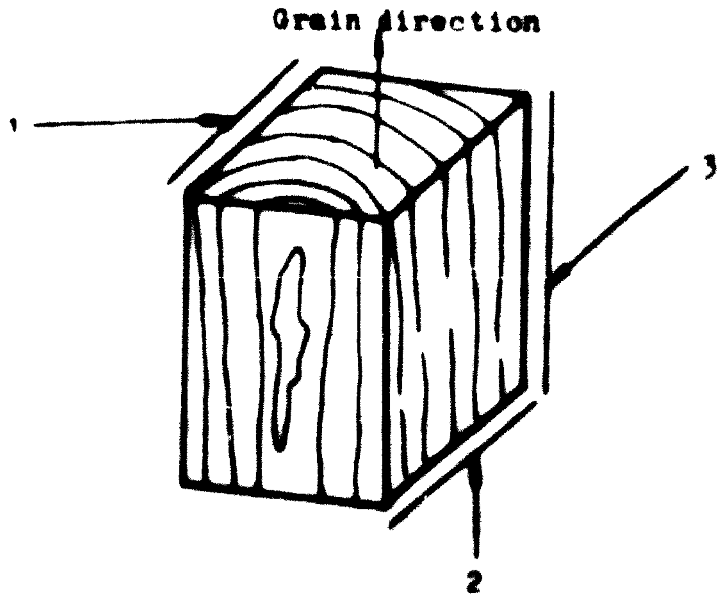
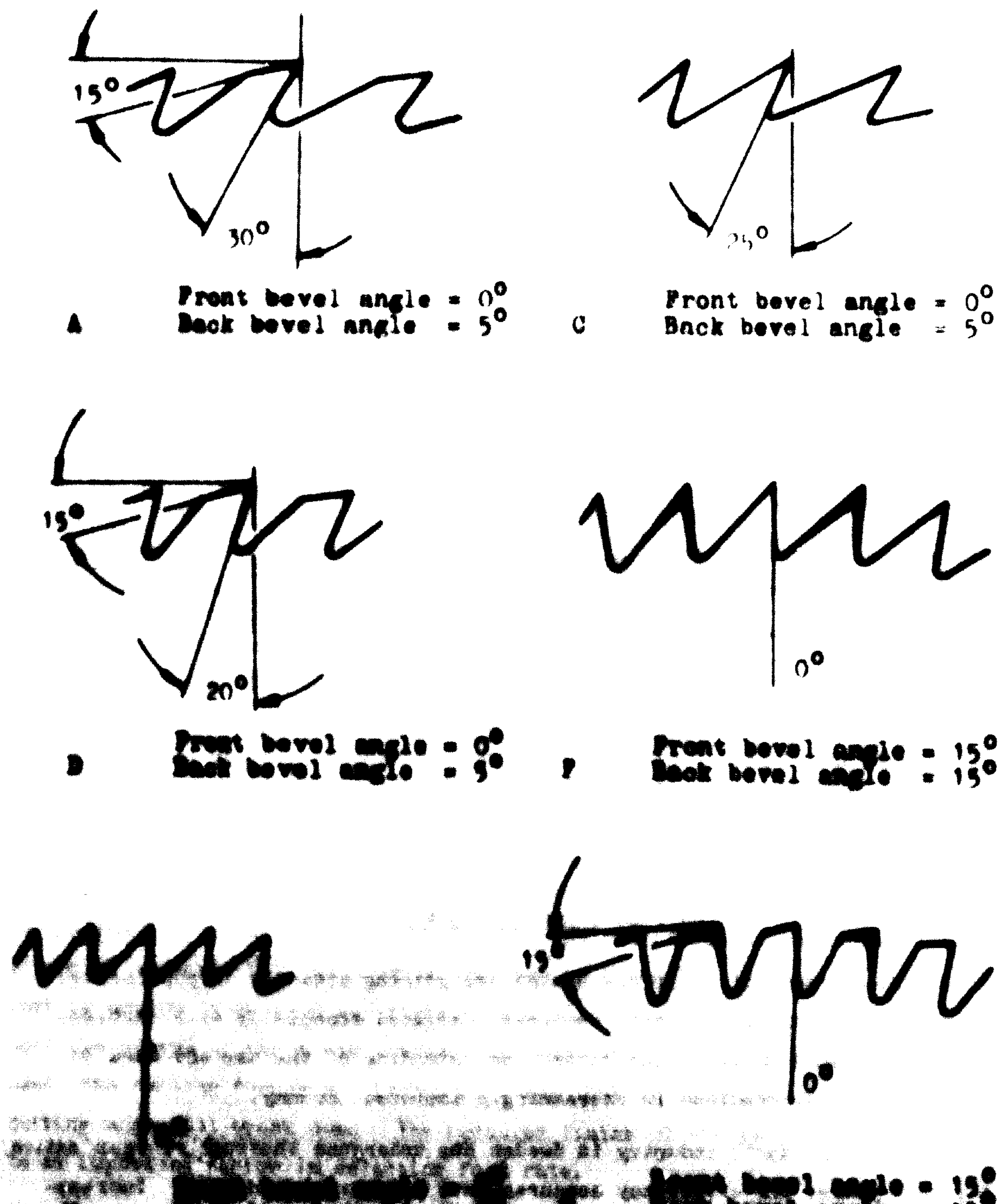
*Paper presented to the seminar by [illegible], Sandvikens Jernverks AB, Sandviken, Sweden. (Originally issued as document [illegible]/11/Rev.1.)

Figure I. Cutting directions with respect to the grain of the wood



Key: 1, cutting surface perpendicular to the grain;
2, cutting surface and movement parallel to the grain;
3, cutting surface parallel to the grain but moving perpendicularly to it.

Figure II. Standard tooth forms and angles for circular saw-blades



Steel qualities for saws usually have an even hardness of approximately 46 R_c with no sizeable deviations. For the saw-blades to do good work it is necessary that they be filed and set correctly and that correct tooth shape, with suitable angles, be maintained by the saw filer.

The saw-blade is mounted to a shaft which exactly fits its centre hole. The shaft is usually driven by pulley drive, but direct drive by the motor shaft is used on some smaller machines.

In sawing, the log is fed towards the saw-blade on a separate table or log carriage. Manual feed is used still in old-fashioned sawmills.

In joinery shops and similar industrial plants, manual feed is common, but rolls or bands are also used. The sawing of logs with circular saws is cheap as regards machine costs, but the exactness of the sawn timber is often not good, owing to the difficulty in supporting the saw-blade mechanically. Correct tensioning and levelling of the saw-blade are very important.

No sorting of the working material is necessary except to remove logs that are too large. In certain countries so-called twin saws are used for sawing big logs. This twin saw consists of two saw-blades, one placed above the other in such a way that the saw-curves meet in the kerf.

Circular saw-blades are not economical, as much wood is lost in the form of sawdust. These machines are therefore gradually disappearing, especially for log sawing. Instead, band-saws and carbide-tipped circular saws will take over more and more of the market share held by the conventional smaller circular saw-blades.

Carbide-tipped circular saws

Carbide-tipped circular saw-blades are gaining steadily in popularity. The introduction of more stable machines, designed especially with carbide-tipped saw-blades in mind, and better understanding of the use and care of these blades have resulted in increasingly improved economy.

The wood-products industry in Sweden has undergone thorough reorganisation in recent years, and efficiency measures have been widely adopted. Increasingly stiff competition has forced most companies to try to concentrate their efforts on a limited range of products, resulting in long runs. In the course of this development the previously used universal machines have lost ground in favour of specialised machines of great precision and capacity.

When acquiring these frequently expensive specialized machines it is necessary, however, to see that the tools used with them permit the full exploitation of the machines' potential. Carbide-tipped circular saw-blades play an important role in this context. Because of their high durability, it has been possible to raise output and reduce manufacturing costs per unit. However, the optimum performance of carbide-tipped blades can be achieved only under certain definite operating conditions.

Cutting speed

As a rule, machines of older types used in the wood-products industry are not adjustable for different speeds. They frequently have a speed which, with ordinary blades, gives a cutting speed of approximately 47 m/sec. (155 ft/sec., see figure III). When a switch is made to carbide-tipped blades, a smaller diameter can be employed because, with such blades, the diameter reduction will amount to no more than about 5/8 in (15 mm) during the life of the saw; in other words, much less than for an ordinary blade. Given these circumstances, a carbide-tipped blade in an older-type machine will give a much lower cutting speed than the conventional blade, which means in many cases that it cannot be used in the most economical way.

Table 1 gives recommended cutting speeds for various types of material. The cutting speed for each group can be given only within relatively broad limits, because of the differences in workability between wood species and wood-based panels. At the upper limits, it is necessary for the machine to be stable enough to ensure vibration-free blade running. If the feed per tooth is too low, no proper chip will be formed, the tooth edge merely acting abrasively on the material, with excessive wear as a result. To reduce wear it is best to employ large feed per tooth, since edge wear is principally dependent upon the course of the tooth through the material. If excessive feed speed is used, the cutting forces may become so large that the sintered carbide in the cutting edge will break down. The required finish of the section will always be an important factor in selecting feed rate.

Figure III. Cutting speed (m/sec) as a function of blade speed (rev/min)

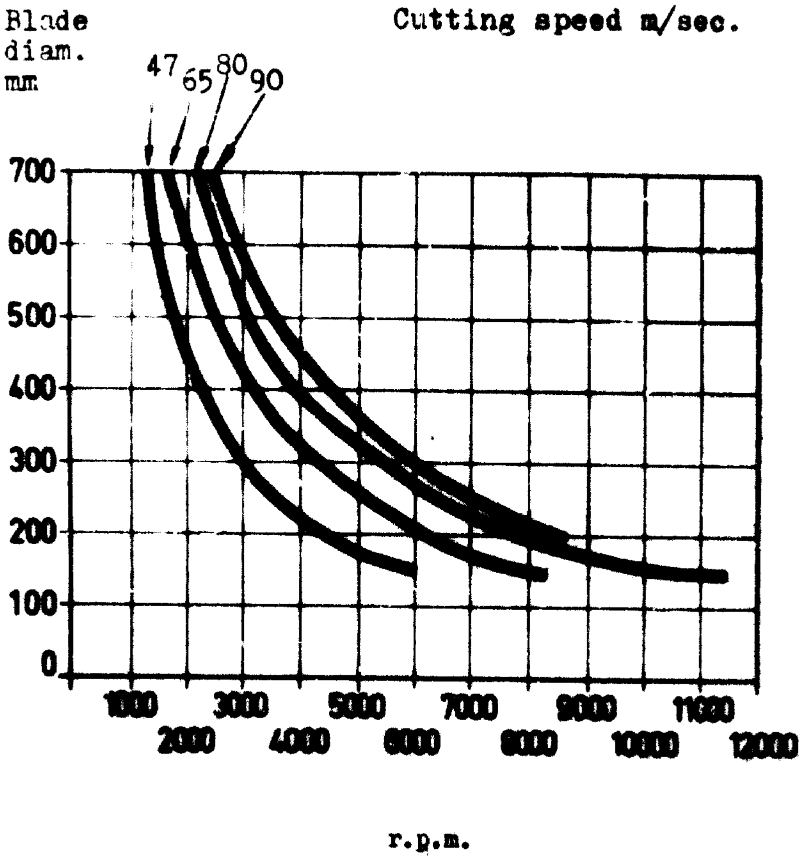


Figure IV. Variation of the angle of attack of the tooth against the material

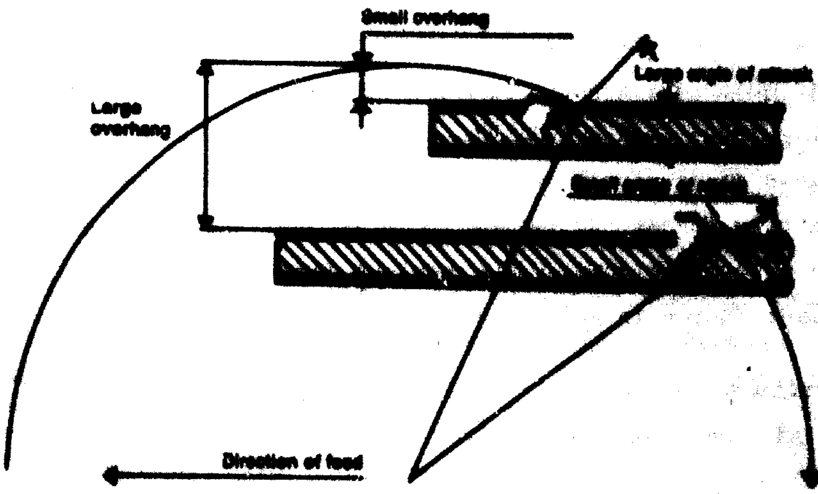


Table 1. Cutting speeds of carbide-tipped circular saws in different materials

Material	Cutting speed m/sec.	Cutting speed ft/sec.
Softwood	60–90	200–300
Hardwood	50–70	160–230
Plywood	60–80	200–260
Hardboard	70–90	230–300
Chipboard	60–80	200–260
Veneered board	60–90	290–300

Feed speed

The feed per tooth should be between 0.002 - 0.012 in (0.05 - 0.30 mm), according to the material being worked and the standard of finish required. It can be calculated using the formula:

$$F = \frac{s \times 1.000}{n \times z}$$

where: F = feed/tooth in mm

s = total feed in m/min.

n = rev./min.

z = number of teeth working on the section in question

Height of blade over work

The hook angle of standard catalogued carbide-tipped blades is usually designed for a blade height over the work of 3/8 - 5/8 in (10 - 15 mm). Figure IV shows how the angle of attack of the tooth against the material varies as the height of blade is changed. In other words, it is possible to influence the finish of the [illegible] to some extent by varying the overhang. This is especially true of [illegible] faced with plastic laminates or veneers. The optimum height of blade [illegible] by trial and error in each case. Generally speaking, the [illegible] the overhang the worse will be the break-through at the underside of the material, while the top face will be [illegible]. [illegible] overhang, on the other hand, results in break-through on the top side but a fault-free underside. The [illegible] situation gives a shorter cutting path through the material, meaning less feed force and, in theory, reduced edge wear. The latter case, however, results in smoother blade running and therefore a better finish in the cut.

Angles

The clearance angle is kept between 10° - 12° (figure V). Thorough studies have shown that increasing the angle above this range will not lead to reduced cutting forces but may well weaken the edge. The tooth point angle should not be less than 45°, for the sake of strength. The hook is determined by the specific cutting properties, workability and hardness of the work. Normal values lie between 0° and 30°, the largest angles being employed for ripping softwoods and the smallest for cross-cutting and for trimming.

In ripping, the wood tends to separate ahead of the saw, which reduces the cutting forces. It is therefore possible to increase the hook without any risk of overloading the edge. Increased hook results in lower feed forces.

The tangential clearance angle is normally between 3° and 4°. The radial clearance angle is kept between 1.5° and 2°. If the blade tends to pick up deposits. however, this angle should be increased to 3°.

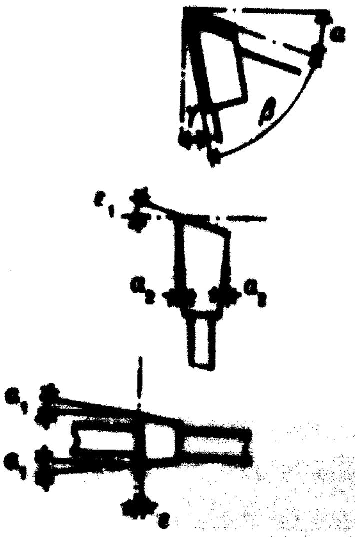
Front bevel is used on ordinary carbon steel blades with tooth shapes F and G, this being about 15° (see figure II). On carbide-tipped blades front bevel is employed for mitre cutting and also for plywood and veneered boards where a clean cut is required. In these cases the angle is never greater than 5° in order not to weaken the edge. Back bevel is currently featured on most carbide-tipped blades. Compared with a blade having straight teeth, a blade with back bevel requires less power and less feed force. The angle is between 5° and 15°.

As a rule, alternate teeth have left- and right-hand bevels; this applies to both front and back bevels. This practice results in smoother blade running than if all teeth were bevelled alike, although this would be desirable in some cases for the sake of a good finish in the cut.

Dimensions

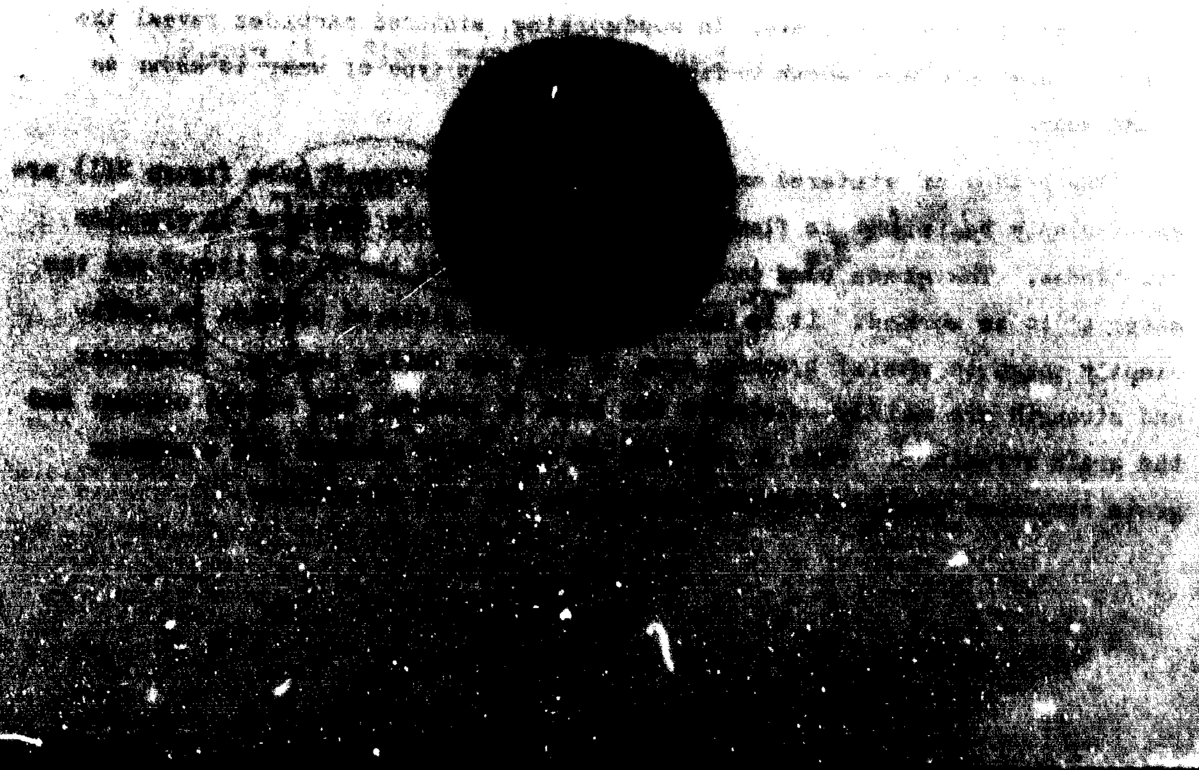
Swedish standards (SIS) governing the dimensions of circular saw-blades with carbide tips have recently been established. Swedish standard 2370

Figure V. The accepted angle designations for carbide-tipped circular saw-blades in Sweden



Key: α = clearance angle
β = tooth point angle
γ = chip angle
α_1 = tangential clearance angle
α_2 = radial clearance angle
ε = front bevel angle
ε_1 = back bevel angle

Figure VI. Expansion slits and pinholes of carbide-tipped saw-blades



contains a dimension schedule comprising diameter series, three tooth-width series and tooth-number series for pitches of 75, 49, 30, 19, 14 and 10mm, SMS 2371 sets forth data for cross-cutting circular saw-blades and SMS 2372 for ripping saw-blades.

The thickness of the blade itself has not been standardised. Normally it is about 1/32 - 3/64 in (1 mm) less than the width of the cutting edge. In other words, the blade has a clearance of about 0.02 in (0.05 mm).

Blades with extra-narrow cutting edges are sometimes made with a clearance of only 0.0182 in (0.3 mm). It is therefore necessary to pay extra attention to the setting-up of such blades and to take particular care in sawing. Blades with carbide tips are usually somewhat thicker than ordinary carbon steel blades for the sake of steady running and to provide a good brazing attachment for the carbide tip.

In order to release the stresses which arise in the periphery of the blade, which result mainly from the heat generated in sawing, carbide-tipped blades feature expansion slits and pinholes, as shown in figure VI. These slits are found on all close-pitch blades and on those used for continuous sawing.

Grades of sintered carbide

Since 1959 sintered carbides have been described by the International Organisation for Standardisation (ISO) designations with regard to chip-forming machining operations. There are three main groups, as shown in figure VII. The arrows indicate the directions in which durability and toughness, respectively, increase. In woodworking, sintered carbides reveal the abrasive wear picture shown in figure VIII. This type of wear is known as flank wear.

The grades of sintered carbide falling within group K (see figure VII) are particularly resistant to flank wear and are therefore employed in circular saw-blades. The grade used depends on the design of the blade itself and the material to be worked. It is important that the sintered carbide be sufficiently tough to resist breaking down of the edge during sawing. Toughness and strength are mainly related to the kind of carbide, the cobalt content and the grain structure. Thus an increase in the cobalt content and a coarser grain structure result in greater toughness but less durability.

Figure VII. ISO grades of sintered carbide

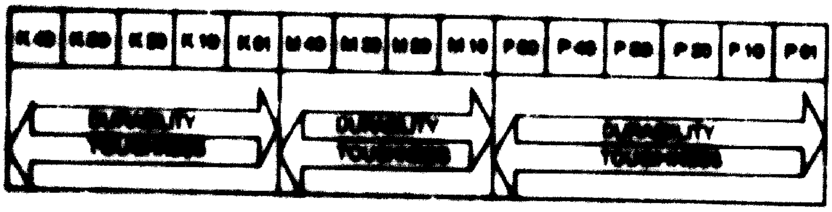


Figure VIII. Typical abrasive wear ("flank wear") of a sintered carbide metalcutting tool

Figure IX. Flank wear of a carbide-tipped saw-blade

Grinding

A frequent error is to regrind a carbide-tipped blade less frequently than is necessary to secure optimum results. Flank wear should be studied as a guide to the most economical time at which to regrind. The wear should not exceed 0.008 in (0.2 mm) (see figure IX). The simplest way to check this wear is with a measuring magnifier.

When regrinding, for which a diamond wheel should be used, grind the leading edge first and then the back one. As shown in figure IX, wear arises quite a long way down at the working corner, despite the radial clearance angle. If grinding is confined to the back only, a relatively large amount of the carbide tip must be removed to restore the edge to full satisfaction.

For coarse grinding, a 150-grain wheel is recommended, and for finishing, a 400-grain wheel. The grinding machine must be stable and the blade securely fixed, preferably with a support close to the point of grinding.

Summary

The use of carbide-tipped blades is increasing steadily. The introduction of more stable machines, specially designed with the use of carbide-tipped blades in mind, and better understanding of the use and care of carbide-tipped blades have resulted in increasingly improved economy. New patterns and new grades of sintered carbide, suitably composed for various sawing conditions, will increase still further the potentialities of the carbide-tipped blades. It is, of course, desirable that the standards governing dimensions be observed and applied as far as possible.

Band-saw blades

Band-saw blades are normally toothed on one side only, but a limited number of them are toothed on both sides. The distance between tooth points (pitch) varies depending upon blade dimension and use. The size and type of material to be cut also affects the tooth pitch. Band-saw blades are exclusively used for ripping. Wider dimensions are used at sawmills and narrower dimensions at joineries and similar wood industries.

Generally speaking, saw-blades up to 70 mm wide are considered as narrow, and those wider than 70 mm as wide. Band-saw blades for cutting logs are usually more than 150 mm in width.

The band-saw machine normally operates in a vertical position, but horizontal machines are gaining ground, especially in smaller sawmills. The machine consists of two wheels, held together by a rather steady body, around which passes a toothed, endless metal band, the saw-blade. The bottom wheel is driven by a motor and the top wheel by the saw-blade, which acts like a transmission belt. In a vertical machine the band-saw blade always cuts in a downward direction, and all teeth work.

The purpose of tensioning, that is, the elongation of the middle of the blade by roller, is to make the blade fit the band wheels properly over its entire width during sawing, with normal friction and heating and with suitable strain in the machine. It is very important that the toothed edge be sufficiently stretched during sawing; otherwise the blade will not cut straight. The stretching of the blade is done by pressing the upper wheel upwards. This stretching should not be confused with the tensioning of the saw-blade centre.

Band-saw blades are normally purchased in coils, cut to size, and the the ends joined, preferably by welding, although it is done by brazing in some sawmills. A log carriage is used for log-breakdown saws but other forms of log feeding are usual, for example a table-feed machine with saw guides above and below the workpiece. The upper one can be moved vertically and adjusted as close to the workpiece as possible, which makes it easier to cut straight.

The rims of the band wheels are convex, so as to prevent the blade from wandering back and forth on them, provided the blade is correctly tensioned. Large machines with wide blades, for instance in the United States of America, have flat wheels, as the large surface contact is considered to give sufficient contact support without any extra measures.

Band-sawing gives the smallest possible sawdust losses, and sorting of logs according to diameters is not necessary. Band saws of various types are considered as the most economical machines for log breakdown and resawing. This is because of the thinness of the blade and because logs can be sawn according to dimensions and quality without waste of time in handling. Band-sawing is becoming more and more popular all over the world.

The servicing of band-saw blades is more complicated than that of other machine-driven blades. The necessity for using good maintenance machines is more noticeable in band-saw mills than in other wood industries.

Machine knives

Most machine knives perform either reciprocating or rotary motions on discs, drums, shafts and the like; other knives remain stationary in the machine and the stock (workpiece) performs the necessary reciprocating or rotary motion. There are also single knives and knives that shear in conjunction with one another.

Machine knives can be classified by their cutting action, as follows: rotating units, such as revolving cutters and chipper knives, and stationary units, such as veneer knives and surface scrapers.

Rotary cutters

In its simplest form, the individual rotary cutter knife cuts principally along its face (cutting edge). Its function is to remove the surface, flat or curved, rather than to reduce the larger board into smaller units, which is the function of the saw. The action of such a device is shown in figure X.

Stationary knives

In many instances the knives for cutting wood are relatively stationary. The wood either revolves against the knife, as in a veneer lathe, or reciprocates across it as in a veneer slicer. Another example is the surface scraper, where the wood is fed across a rigid knife, with a slightly turned edge to remove a thin (about 0.006 in = about 0.15 mm) shaving. Some examples are shown in figure XI.

Chipper knives

Chipper knives are of two kinds: compound and case-hardened (figure XII). The writer's company (Sandviken) uses the case-hardening technique for chipper knives. The raw material (steel) has a low carbon content (around 0.10 per cent) and is consequently not hardenable. The carbon content in that part of the knife that is to be hardened is increased to a suitable percentage by a carburisation process that penetrates to the required depth. During subsequent hardening, only the carburised section becomes fully hardened. The toughness of the low-carbon steel is retained in the body of the knife. The transition from hard to soft material is progressive, with no sharply defined limits that could raise stress under certain conditions.

Figure X. Action of a rotary cutter

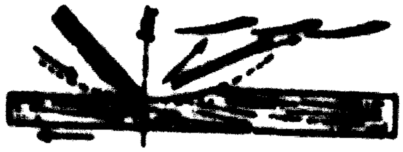


Figure XI. Cutting veneers with stationary knives (left) slicing veneer from a flitch; (centre) rotary cutting of veneer from a log or bolt; (right) half-round cutting of veneer from a flitch with a lathe

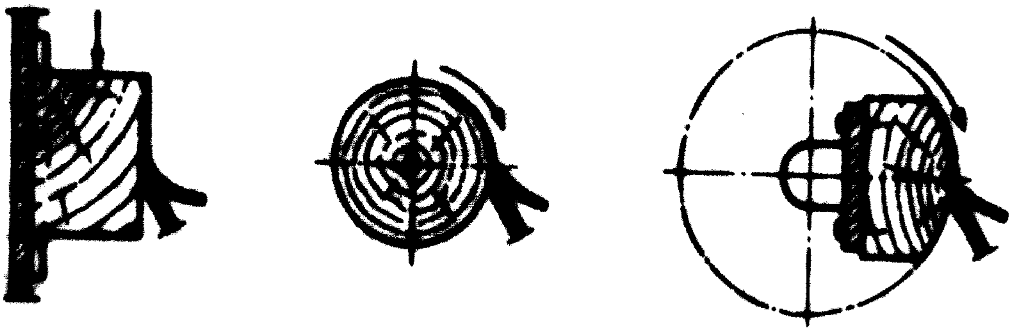
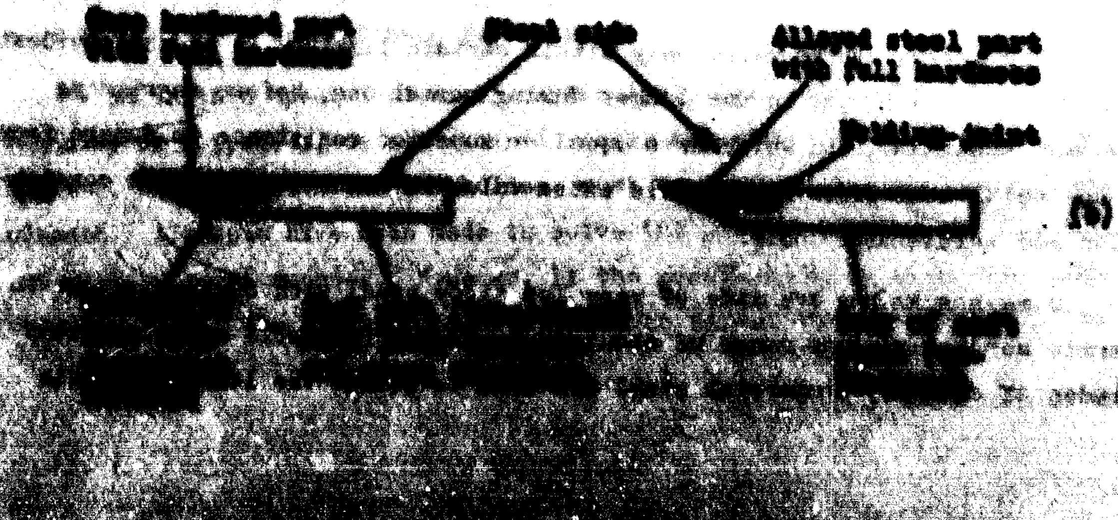


Figure XII. Chipper knives (a) case-hardened; (b) compound



At present, the company uses only high-chromium steel for chipper knives as some modern chippers operate at very high speeds and capacities, and the knife edge temperature can rise to 450°C. For these machines it is therefore necessary to have knife material with a high annealing temperature. Thin knives are all hardened, but the thicker ones are high-frequency hardened. The hardness configuration is practically identical to that obtained with case-hardening.

Hog knives

Hog machines are used primarily for reducing waste wood and bark into pieces of small size suitable for boiler fuel and are employed for this purpose by nearly all veneer mills and many other woodworking plants. Also, hog machines for converting bark to fuel are used by many sawmills that have a debarker and a steam plant, and by a number of pulp mills. Other applications include the processing of pitch-pine stumps for production of turpentine; chipping oak for tanning in extract plants and the preparation of fertilising material for potting plants. Machines now in use include a large variety of models from twenty or more manufacturers. Between 10 and 36 knives normally are required for a set. Other machines of this general type, known as "hammer hogs" and "pulverisers" do not use knives.

Since there is hardly any quality requirement on the product from most hog machine applications, and plant procedures on handling waste frequently permit metallic and other foreign materials to go through the hog, the knives regularly receive much more abuse and careless maintenance than knives of other kinds. Thus, it is a common belief that the cheapest knives obtainable probably are adequate for the purpose and most economical in the long run.

This theory can be valid only within certain limits. It is self evident that knives which stay in use longer during normal use, before regrinding becomes essential, and which have equal or superior resistance to damage from loose metal must offer worth-while extra value in reduction of knife consumption and maintenance costs.

Some hog knives are made of very low alloy steel with carbon content to permit hardness in the range of about 47 to 54 RHC (Rockwell scale). Cheap grades of ordinary commercial steel are used to permit the lowest possible prices so as to satisfy the prevailing theory of buyers. Since the knives are fully hardened by conventional methods, and properties of the low-grade steel can provide only moderate toughness, the hardness must be kept relatively low to avoid excessive breakage during use.

Veneer knives

During the years, Sandviken has manufactured a case-hardened veneer knife. The knife is zone hardened, which means that only a part of the knife (the cutting edge) has full hardness (59 to 60 HRC). The performance of this knife has proved to be very satisfactory with both softwood and hardwood.

About two years ago Sandviken introduced a veneer knife of a new quality. It is a low-alloy steel knife, high-frequency hardened. Its construction is identical to that of the old case-hardened, zone-hardened type. Its edge hardness is 59 to 61 HRC. The edge-holding ability of this knife is very good; it stays sharp very long. In case of minor edge damages, caused by stones, nails, hard knots and the like, the edge can easily be restored in the lathe. In case of a bend, the edge can be straightened by using a hammer and then touched up by honing; if there is a nick, it can be corrected by filing and honing.

Pressure bars

Pressure bars are used on both veneer lathes and veneer slicers. On the former, there is either a roller bar or a solid pressure bar. The most usual type of pressure bar is manufactured with a stellite edge, which gives it good edge-holding and wear properties. However, maintenance of this bar is expensive if it is damaged by a foreign item such as a steel nail. Often, the bar must be sent to a special shop for repair.

When certain species of wood, particularly oak, are peeled or sliced, staining is a problem, as all stained veneer is waste. To avoid such staining, the bar, together with the bar holder, must be removed quite frequently and cleaned. Attempts have been made to solve the problem by painting the bar, but with no good success. However, if the pressure bar is made from high-[illegible] steel, the staining problem seems to be solved. Furthermore, the [illegible]

[illegible]

customers are able to maintain the bar themselves, and in certain cases the edge-holding and wear properties are just about the same as in a stellite bar.

Sharpening machine knives

Careful sharpening of dulled knives results in improved cutting properties, longer life and a corresponding reduction of costs. Not infrequently, however, the sharpness of a reground knife is inferior and of shorter duration to that of a new one. In many cases, the reason for this is to be found in faulty regrinding, which has often given rise to unjustified complaints and may be prejudicial to the good-will built up between the manufacturer and the customer.

Knives should therefore be changed and reground before the cutting edge has become too blunt. If this precaution is taken, it is only necessary to remove very little material when regrinding, which saves both time and costs for this operation and lengthens the life of the knife. A correctly ground cutting edge should be clean and straight along its whole length and free from burrs, burnt spots and grinding cracks.

The quality attained when sharpening machine knives is dependent upon the following main factors: the grinding machine, the grinding wheel, the grinding method and the grinding performance. They are considered separately below.

The grinding machine

In most cases the machines used for grinding straight machine knives are surface grinders with horisontal spindles and reciprocating tables, fitted with cup- or cylinder-type grinding wheels. Small machine knives are frequently ground on surface grinders with vertical spindles and cup wheels.

Generally speaking, the machine knife is fixed by a magnetic chuck or by clamping it to the reciprocating table of the grinder, which moves reciprocally in front of the stationary spindle that carries the rotating grinding wheel. The quality of the grinding machine is of the greatest importance for the results obtained in grinding. It must be vibrationless and in good condition to ensure a uniform bevel and a clean, sharp cutting edge. In machines that are less rigid, particularly where no coolant is employed, grinding must be done with the greatest care.

The grinding wheel

It is extremely important to select a wheel of the proper grade and grain sise for the job in hand.

Grade (hardness). The degree of hardness calls for special attention. A wheel that is too soft will not retain its sise, particularly at the roughing stage, owing to its quick loss of shape its life will also be unduly shortened. On the other hand, a wheel that is very hard will give unsatisfactory working results. Such a wheel will rapidly become glazed and dull and will require repeated dressing. A glazed and dull wheel will tend to burn and ruin the knife.

The grade of the wheel should be selected in accordance with the composition and hardness of the knife material. The type and condition of the grinder, the shape and speed of the wheel as well as the cooling are also very important. It is preferable to try out a wheel that is on the soft side first, and then proceed gradually to a harder and more economical wheel.

Grain. Wheels with finer grains have come more and more into use for machine knives. In certain instances a No. 60 up to No. 80 grit is employed, these being correspondingly softer than coarser ones. The finer grains, being smaller and sharper, will penetrate the hard surface of the knife more readily than will the coarser grains. A finer grit wheel will therefore cut with less pressure and less risk of burning, and in addition, will produce a better surface.

Grinding wheel recommendation

The general rules applying to the selection of hardness and grain sise are as follows:

Hard wheels. Wheels of harder composition are used for soft material, small contact surfaces, greater depths of cut and with grinders that are not completely rigid.

Soft wheels. Wheels of looser composition are selected for hard material, larger contact surfaces, smaller cuts and very stable machines.

Roughing and finishing. For roughing, large-grain wheels are used; wheels with a small grain should be employed for finishing.

Standardized symbols. The system of symbols used for grinding wheels is internationally standardized; a grinding wheel designation contains all the data relating to the quality of the wheel.

Wheels for machine knives. For grinding machine knives of tool steel, high chrome alloyed steel, or high-speed steel Alundum vitrified wheels are generally used. As a rule only a vitrified bonding agent is used in wheels for knife grinding. The grain sizes, grades and structure of wheels for grinding machine knives are presented in table 2.

Table 2. Optimal characteristics of grinding wheels for machine knives

Type of knife	Grain size	Hard-ness	Struc-ture	Wheel shape	Peripheral speed (m/sec)	Peripheral speed (ft/sec)
Veneer knives	46	H	8	Cup	18 - 23	59 - 75
Chipper knives	46	H	8	Cup	18 - 23	59 - 75
Planer knives (high-speed steel)	60	J	8	Cup	20 - 25	66 - 82

The combinations presented in table 2 apply only to stable and vibrationless grinders; for machines that are less rigid, wheels with one or two more degrees of hardness should be selected. Similarly, lower peripheral speed necessitates harder wheels, and higher speeds need softer wheels than those recommended.

Segmental wheels. Where a segmental wheel can be used in place of a solid one (particularly of larger sizes), this should be done, as the air circulating around the segments during rotation contributes towards more rapid and cooled grinding. In addition, the removal of chips is more effective and the working capacity greater than with the solid wheel.

Truing and dressing the wheel. If the grinding wheel exhibits a tendency to burn, it must be dressed immediately. A newly mounted wheel must always be trued in order to get the grinding surface running evenly. The wheel must also be dressed from time to time to keep the cutting face clean, sharp and free cutting, thereby minimising the danger of burning the edge of the knife.

A special dresser for sharpening by hand, which is supported against the table and clamping plate, is recommended both for truing and dressing. A diamond tool may also be used but not an abrasive stone (such as a piece of a grinding wheel) as it is difficult to hold it sufficiently steady. An abrasive stone is also unsuitable on account of the fact that it is likely to produce a glazed surface instead of cleaning the wheel face and rendering it sharp and free cutting.

The grinding procedure

Partially hardened knives. The grinding of selectively hardened machine knives (such as high-frequency hardened ones or compound steel) must be regarded as a very delicate job, as the grinding wheel must work on soft and hard material simultaneously. The soft material easily tends to stick to the wheel, which is then very likely to become glazed and to burn the material.

Firm holding of the knife. The machine knife must be firmly held by a magnetic chuck or clamped to the table; it must never be held by hand. It is very important that the contact surfaces be free from projecting burrs, dirt or the like. The chuck should be rotatable to enable different angles of the cutting-edge to be obtained according to the type of knife. Where no suitable clamping device is available, the knife should be placed on an adjustable table with a stop against the rear edge of the knife.

Direction of rotation of the wheel. Machine knives should always be ground towards the cutting edge. By grinding towards the edge, the wheel retains its sharpness and the danger of overheating the edge is reduced. If grinding is done in the opposite direction, the wheel draws the softer material of the bevel towards the cutting edge, causing the wheel to become glazed and lose its sharpness.

Grinding is, however, sometimes carried out against the periphery of a cylindrical wheel. A hollow-ground bevel can be obtained by this method, which may be an advantage in certain cases. It is advisable here not to employ a wheel with too small a diameter which will produce too deep a hollow and thus weaken the edge. Before grinding is begun, the coolant should be turned on, after which the wheel is set in rotation, a small feed being maintained.

[illegible]. Grinding is finished with a [illegible]-out cut, that is to say, the wheel should be allowed to cut without any further feed until sparking [illegible] ceases. In this way a bevel with a smoother surface is obtained and honing is simplified.

Grinding speed. The speed prescribed for each wheel should be carefully observed, as the maximum cut will be obtained at this speed. If the speed is too low, the wear on the wheel will be excessive, but on the other hand, a speed that is too high will produce such a heavy grinding effect that the cutting edge will be burned and ruined. As mentioned earlier, however, an incorrect peripheral speed can be counteracted by selecting a suitable wheel hardness.

Maximum speed. It should be noted that, for safety's sake, the maximum speed given for every grinding wheel should not be exceeded. Generally speaking, the speed of the feeding table should be 18-24 m/min (60-80 ft/min).

Feed. The feed must be small and should not exceed 0.002 in/stroke (0.05 mm/stroke); this also applies to roughing. If the feed and speed of the table are too great, the knives may easily be ruined. The best results are obtained by taking a light cut with a moderately rapid table feed.

Detrimental heating of the knife. Heating at the point of contact between the grinding wheel and knife may exercise a detrimental effect on the properties of the steel. If the original tempering temperature for the knife is exceeded, the steel will be annealed, with a consequent loss of hardness. If the temperature rises high enough, the cutting edge will be ruined by unsuitable hardening, as it will become brittle.

An infallible indication of detrimental heating of the knife is the appearance of the tempering colours. As long as no colours are visible, no conversion of the steel has taken place. Tempering begins with straw (yellow) colour at 250°-300°C (480°-570°F) and increases over blue at 300°-350°C (570°-660°F) to blue-grey and grey at 350°-400°C (660°-750°F). At the last of these temperatures the cutting edge is ruined, so that the damaged part must be entirely ground off.

Cooling (wet) grinding. Machine knives of any kind should preferably be ground wet. The flow of coolant should be directed at the point of contact between the wheel and the knife or close above, in order to prevent burning the knife. A certain cleaning of the wheel is obtained at the same time (Figure XXX). The tank for the circulation coolant in a cooling system should be large enough

Figure XIII. Correct (a) and incorrect (b) clamping and coolant feeding when sharpening machine knives

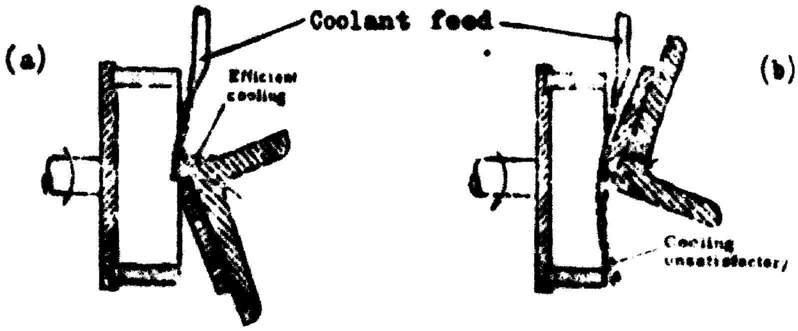
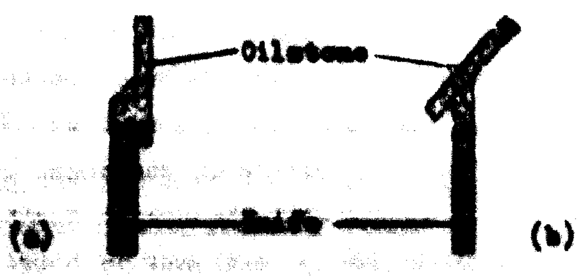


Figure XIV. Correct application of the oilstone on the [illegible] side (a) and on the [illegible] (b) of a machine knife



to allow a minimum circulation time of 10 minutes, which calls for a capacity of 200 litres (44 gallons). The use of a filter in the cooling system is a great advantage, as it prevents steel chips and fragments broken off the wheel from reaching the grinding point, where impurities of this kind may cause damage in the form of scratches on the bevel or edge of the knife.

Too little or intermittent cooling is worse than none at all. To direct the coolant against the knife when it becomes hot is a sure means of damaging or even entirely ruining the knife.

Coolant. Clear water may be employed as coolant, in which case plenty of it must be used; i.e. about 20 litres per minute (4½ gallons) at least.

Rust-preventing coolant. The coolant must not cause rusting of the knife or the machine. When using water a rust-preventing agent should be added. This may be sodium carbonate, in proportion of 4 kg/100 litres (8.8 lb/22 gallons). A large number of oil emulsions also available on the market are very suitable as coolants, as they generally possess the excellent property of facilitating the production of perfect surface.

Honing. After grinding has been completed, the cutting edge must be honed before the knife is ready for use. Not even the best grinding wheels are capable of producing a ground surface smooth enough for an entirely satisfactory knife edge. Scratches are always formed, resulting in a rough and uneven cutting edge that will soon become dull owing to the fact that the tops between the scratches on the edge are rapidly worn down. In order to obtain a satisfactory cutting edge that will retain its sharpness over a long period and permit the knife to work accurately, the wire or feather edge invariably left on the steel side by the grinding wheel must be honed away completely. Thorough honing has a direct influence on the life of the knife, the quality of its cut and on its operating economy.

The following description may serve as a guide for honing the edges of machine knives:

Support the knife in a vice or on a bench at a convenient height and with sufficient light on the edge

The oilstone must be perfectly even and should be applied against the bevel with a light pressure over the whole bevel and steel side to prevent the formation of a rounded edge (see figure XIV)

Honing of the steel side of the knife should be stopped as soon as the wire edge has disappeared or been straightened

Honing should not be forced and should be carried out with a sort of rotary motion along the bevel. It can be carried out quickest and best by first rough honing the edge with a coarse oilstone. Use a thin machine oil on the stone and reduce the pressure gradually

Continue honing in the same way with a finer oilstone

Finish honing with a fine-grain hard oilstone on both sides of the cutting edge. For this purpose the stone should be tipped up slightly about 2 mm (1/16 in) from the heel of the bevel

Examine the edge with a magnifying glass (10-power, for instance) to ensure that it is free from all burrs and nicks

One way to tell if a knife has been honed properly is to draw a piece of writing paper along the edge. It will cut the paper easily, but any uneven spots will inevitably cause slight but clearly perceptible vibrations of the paper. Such spots must be marked for further honing. After honing, the knife should be carefully wiped clean and dry.

Inserted-tooth cutter

The inserted-tooth cutter is a new tool intended for planing and milling. It is based on earlier designs used in the wood industry but has made use of and further developed the metal industry's advanced technique for mechanically clamped indexable inserts.

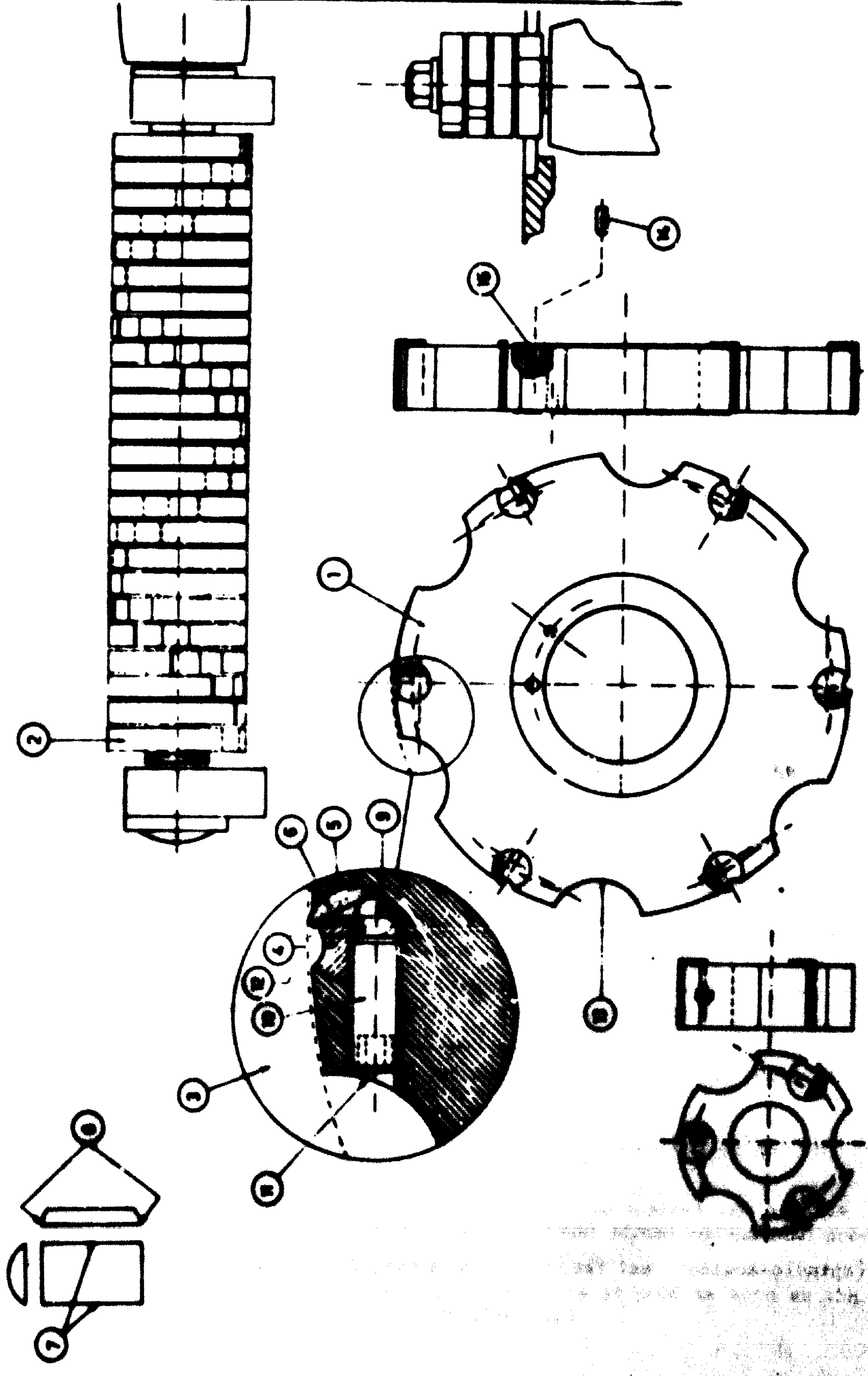
The new tool is constructed on the changeable-insert principle with the intention that the insert be discarded instead of being reground after becoming worn. (See figure XV.)

The miller body (cutter-head) is 25-mm thick (1) and at this writing is available in the five following standard forms:

Outside diameter (mm)	Centre hole (mm)	Number of inserts
100	40	3
120	60	4
140	60	4
160	60	4
180	60	6

The cutter can be used in all types of multi-cutting, table-milling (spindle-moulder) and tenon-cutting machines. In the first of these, several

Figure XV. Construction of the inserted-tooth cutter



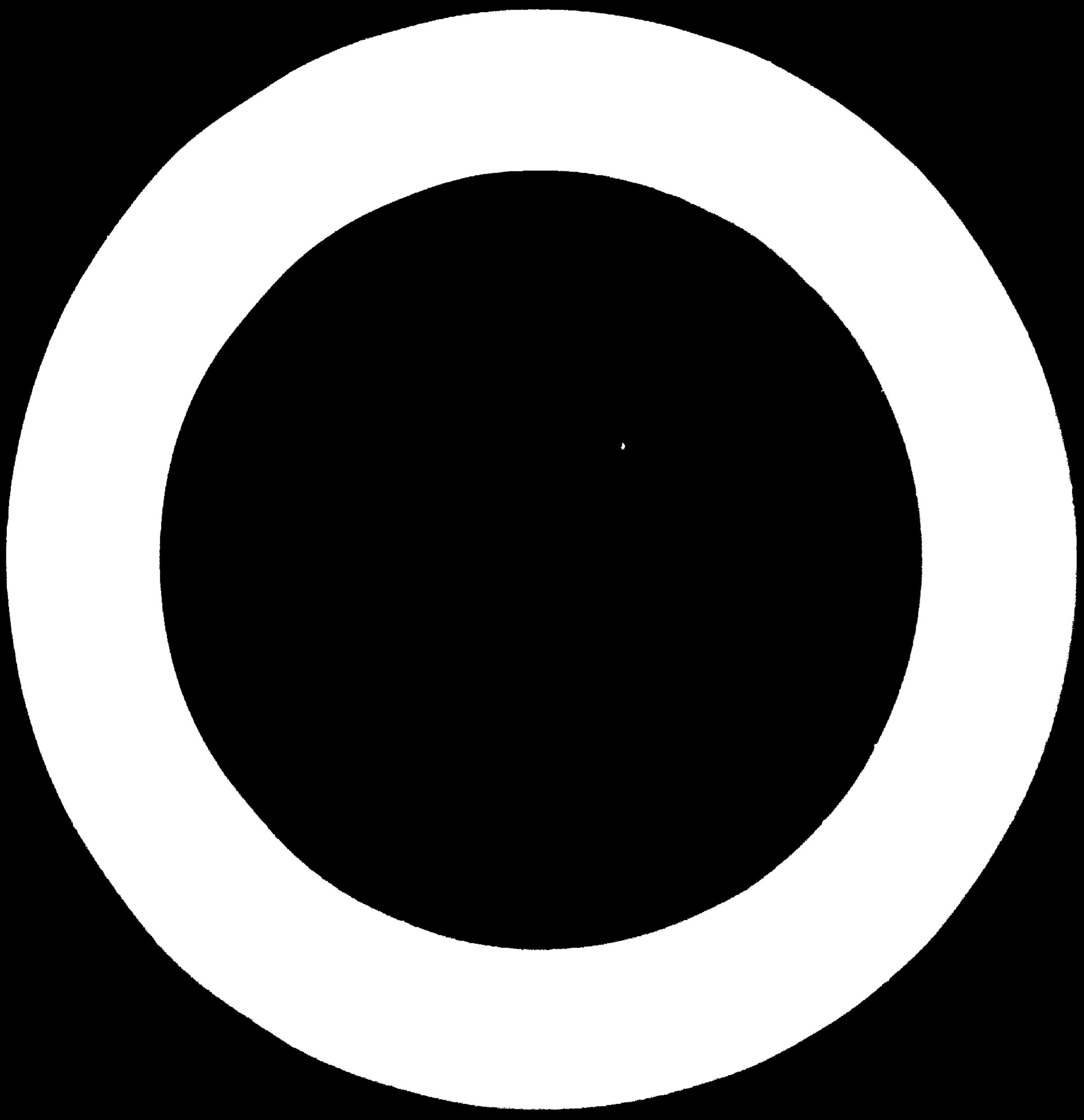
millers can be joined to form a wide cutter (2), while in the latter two, the cutter can be used either as a single-tool or a multi-tool unit (1 and 2).

The purpose of the clamping system (3) is to locate and firmly hold the inserts; it consists of a flat bearing surface (4) and a cylindrical seat (5). The shape of the insert is a semicircle (6) with cutting edges 26 mm long (7). Each insert has thus two cutting edges. The ends of the inserts (8) can also be used for cutting purposes in rabbeting and grooving applications.

The inserts are clamped by a steel ball (9) and a screw (10) at right angles to the insert. The ball thrusts the insert against the seating and clamps it there firmly. The chip-break (12) in front of the insert breaks up and guides the chips away from the cutting zone.

The recesses (13) in the circumference of the miller-body facilitate the adjustment or change of inserts when the tool is used as a multi-unit cutter (2). In order that the inserts of a multi-tool unit can be changed, an aperture is provided on the body lying alongside to permit access to the clamping system. Precise relative location is ensured by a pin and hole in each miller-body. One advantage of this mounting system is that the inserts take a spiral form, which can be very useful from many points of view. In order to prevent the occurance of length-wise ridges in the material when utilising a multi-tool layout (2), the inserts have been made 1-mm longer than the milling cutter's breadth. This creates the overlapping necessary to overcome this problem.

The steel used for the miller-body is SIS 1672, apart from the component that forms the chip-breaker; in order to reduce wear which chip-removal creates, steel quality SIS 2140 is utilised for this latter component. By this means it is possible to supply the miller-body without the necessity of special hardening processes.



The following studies on various uses of wood have been prepared by the United Nations Industrial Development Organisation:

ID/10 Production Techniques for the Use of Wood in Housing under Conditions Prevailing in Developing Countries, Report of Study Group, Vienna, 17-21 November 1969

(United Nations publication, Sales No.: 70.II.B.32)

ID/61 Production of Prefabricated Wooden Houses, by Keijo N. E. Tiusanen

(United Nations publication, Sales No.: 71.II.B.13)

ID/72 Wood as a Packaging Material in the Developing Countries, by B. Hochart

(United Nations publication, Sales No.: 72.II.B.12)

ID/79 Production of Panels from Agricultural Residues, Report of Expert Working Group Meeting, Vienna, 14-18 December 1970

(United Nations publication, Sales No.: 72.II.B.4)

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Guides to Information Sources No. 4: Information Sources on the Furniture and Joinery Industry

ID/108 Furniture and Joinery Industries for Developing Countries:

Part one: Raw material inputs
Part three: Management considerations

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