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APPLICATIONS FOR PARTICLE BOARD IN THE FURNITURE AND JOINERY INDUSTRIES 1/

prepared by

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INTRODUCTION

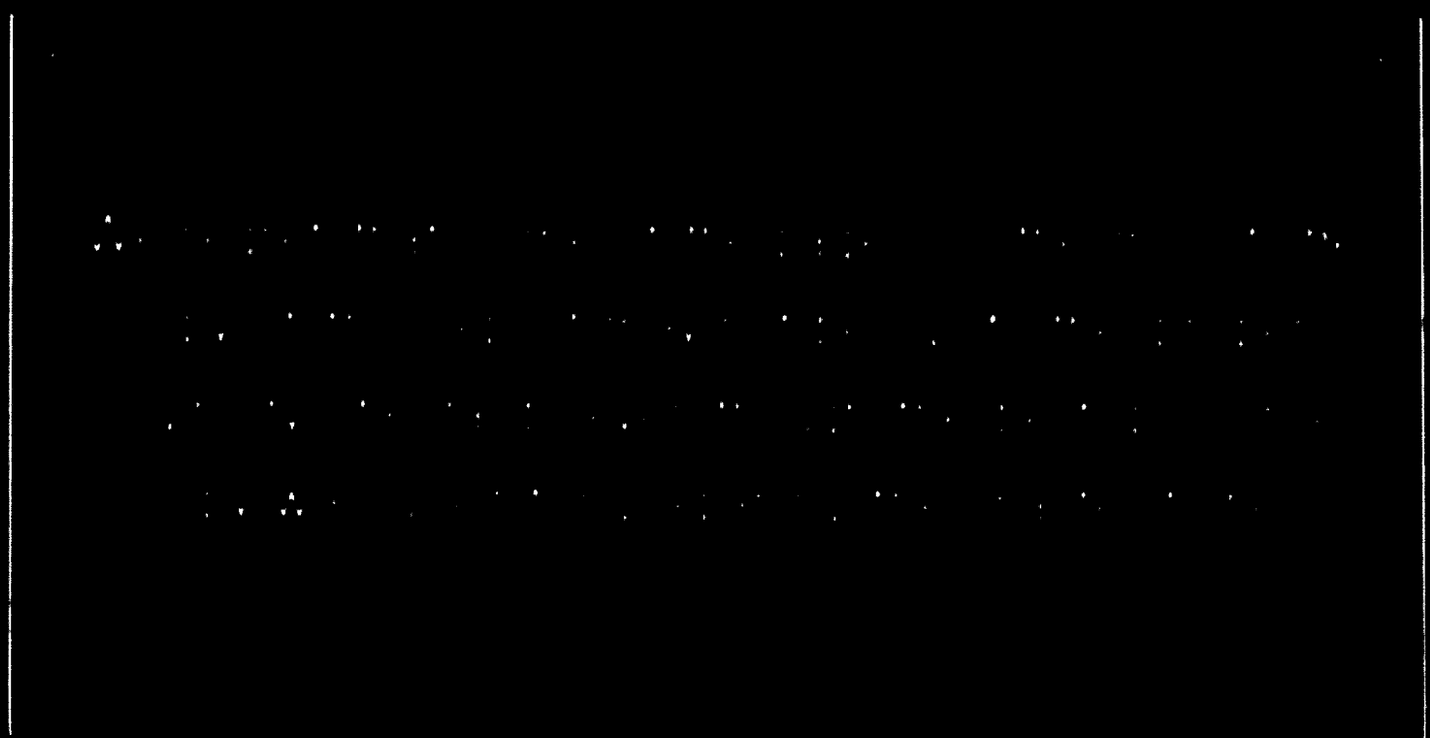
Particle board has been the "wonder child" of the wood based panels industries in the developed countries. Per capita consumption has exceeded in some European countries 40 kg per annum. To attain this figure it has had to replace sawnwood as well as the other wood based panels (fibreboard, plywood and blockboard) in many of their hitherto "traditional" application.

The acceptance of particle board in the developing countries has been far less spectacular. This can be attributed to several reasons, not least among them being the non availability to the potential end user of the necessary technical information on the applications of particle board in the furniture and joinery industry, its correct storage, machining, assembly and surface finishing.

The object of this paper is to diffuse some of this information to potential users in the developing countries and thus help in the development of viable furniture industries.

Much of the information contained herein has been gleaned from brochures and booklets prepared by the Chipboard Promotion Association (CPA), the Timber Research and Development Association (TRADA) in the United Kingdom, the National Particleboard Association (NPA) of the United States of America and the Particle Board Guide of the Finnish Particleboard Association of Finland.

This document has been prepared by the Secretariat of UNIDO after the 5th Seminar on the Furniture and Joinery Industries convened in co-operation with the Government of Finland in Lahti, Finland, from 11 to 30 August 1975, to complement the documentation made available to the participants on this subject.



PARTICLE BOARD

Definition

Particle board is a rather new industrial product, having been first introduced some 30 years ago in Germany and Switzerland. It is a sheet material manufactured from small pieces of wood or other ligno-cellulosic materials (such as chips, flakes, splinters, strands, shreds, shives, etc.) agglomerated by use of an organic binder, together with one or more of the following agents: heat, pressure, humidity, a catalyst, etc.

Boards made from wood wool, wood chips, or similar materials, and inorganic binders, e.g. cement, are not classified as particle boards.

Materials

Particles of chips of wood comprise 90 per cent of the bulk of wood particle board and in developed countries are generally obtained from coniferous softwoods, although hardwoods are sometimes used. The choice of wood species will depend on the type of chip required, availability and continuity of supply and cost. Two main sources of raw material are available:

a) forestry thinnings;
b) timber waste, such as off-cuts, edge rippings, planer shavings, or chippings obtained from other timber consuming processes.

Binders

The binder (adhesive) plays a key part in the stability of the final board and will to some extent increase the resistance of the wood chips to fungi, termites, wood borers, etc. The most common

binders are synthetic resins which, because their formation can be varied, have the advantage of flexibility of curing time. In addition, they are thermosetting and cure rapidly and irreversibly by the application of heat.

Either the wood chips can be treated or the binder can be mixed with additives to improve particular qualities of the finished board. The most common additive is paraffin wax which is introduced in small proportions as an anti-swelling agent. Fire retardant, insecticide and fungicide chemicals can also be added in small proportions.

Properties

Particle board is equal to ordinary wood in density but is more homogenous. It contains no grain direction (although it does have the so called "machine direction", that is, the direction of the material flow), knots or any other growth faults. Longitudinal swelling because of moisture is equal in both directions, slighter in comparison to sawnwood and to thickness swelling. It does have the two disadvantages of low rigidity and fairly low resistance to tension perpendicular to the surface of the board. Without protective additives it tends to swell in thickness.

Board formation

The chips are carefully coated with controlled quantities of binder in either a discontinuous batch process or in a continuous system of spraying of chips as they fall through vertical cylinders. In all instances the final moisture content is controlled at about 10 per cent. The coated chips are formed into boards either by pressing between steel plates "platen pressed" or by forcing the chips through a die "extruded" and at the same time applying heat to cure the binder.

a) Platen Pressed Boards

The quasi totality of particle boards are produced by this method which embraces a wide range of variations in spreading, formation of layers and pressing. The density of the boards will depend on many factors including the

type of chips and the pressure applied. One way of defining the type of platen pressed board is by the structure which results from the method of spreading the chips. The shrinkage and swelling of this type board in the direction of its surface is roughly 1/20 of that of solid wood perpendicular to grain direction. There are four basic types as indicated below and represented in Figure 1.

- Single layer where the board is formed from chips of the same size or mixture of sizes throughout the board so that it has a consistent density throughout the thickness of the board;
- Three layer where the board is a sandwich construction which usually consists of relatively high density surfaces between 1 mm and 3 mm thick, comprised of fine or long thin chips or thin flakes with a core of larger chips. The density will therefore be higher at the outer faces than in the centre;
- Multi-layer which is similar to the three layer except for an increase in the number of layers. A core of high density can be introduced for improved flexural strength and frequently a finer surface layer is included;
- Graded density is achieved through the method of spreading the chips as it makes it possible to use chips without pre-grading them and the boards are characterized by smooth, high density surfaces and low density cores without any abrupt change in chip size. This type has some of the attributes of both the single layer and three layer type.

The mat of already glued particles obtained by any of the above alternatives may be cold pre-pressed to reduce its thickness. The main pressing is a critical operation requiring carefully controlled heat, pressure and timing. Pressing may be by a batch process of pressing single boards in a single daylight press, but the most frequently used system is the multi daylight press which presses a number of boards at the same time. A process of pressing boards in a moving single daylight press is sometimes used to produce a continuous board.

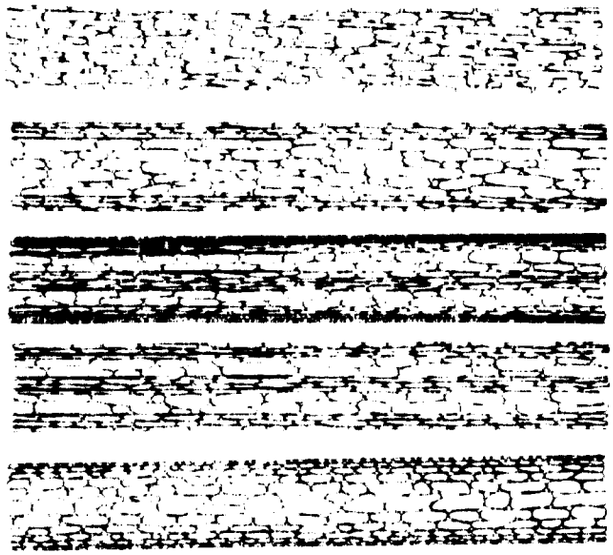


Figure 1: Platen pressed type particle board

b) "Mende" thin boards produced on a calender.

This is a recently developed method of producing a thin particle board through continuous pressing between heated rollers, producing a continuous single layer board which can be cut in random lengths, resulting in little or no waste. Thin boards can be produced and surface treatments can be incorporated into the process. Because of the close tolerances achieved in the pressing the resulting product, unlike platen pressed boards, requires no sanding.

c) Extruded Boards.

This method is also one which allows for an almost unlimited board length resulting in uses with little or no waste. It also enables the formation of thicker boards than is at present economically possible by means of platen pressing. The chips are fed into a vertical extrusion press where they are forced through a die formed of two parallel heated plates which can be adjusted so as to vary the width of the board. For the larger thickness boards heated tubes can be incorporated in the die to produce a hollow cored board. The orientation of the particles is at right angles to the plane of the board, thus giving boards which, unless veneered or surfaced with a laminate, have high swelling rates in the main plane and low screw holding properties, except on edges. They are not commonly used in furniture and are mainly used as partitions.

Board with laminated faces:

Board (tubular) with laminated faces:

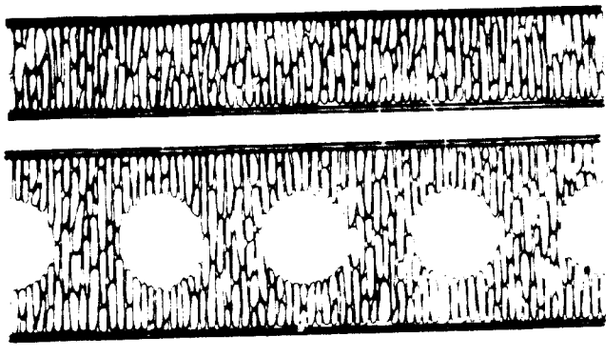


Figure 2: Extruded type particle board

Values for a representative Finnish, flat pressed particle board 1/ and for solid wood (Finnish birch)

Characteristics	Units	Values for Particle board	Values for Solid wood
Bending strength	Kp/cm2	180 - 250	1300-1600
Tensile strength (direction of plane) (direction of grain)	"	80 - 120	1200-1500
Tensile strength (perpendicular to plane) (perpendicular to grain)	"	3 - 8	60- 80
Withdrawal resistance of wood screws at surface	Kp/mm	6 - 10	n.a.
Withdrawal resistance of wood screws at edge	"	4 - 7	n.a.

1/ Density - 650 kg/m3

Choice of board sizes

Due to the annual increase in the use of particle board, particularly in developed countries, the board size which was originally 4 x 8 feet graduated to larger sizes. In the case of developing countries, it is still common to produce only 4 x 8 feet boards. The larger board sizes are manufactured since that when cutting the boards to size for their use in furniture the losses are lower.

Utilization problems

In the case of developing countries the technological problems which the industry has to overcome are many. These problems affect quality

of products, thereby adversely affecting acceptance of the boards by the furniture and joinery industries in developing countries. These can be summed up as follows:

- lack of adequately trained management and workers to operate the plants which in many instances, are judged to be sophisticated by local standards;
- product being adversely affected by a total or partial lack of adequate quality and process control; particularly where plants have been erected with no or only rudimentary laboratories which, even when they exist are often staffed by insufficiently trained technicians;
- because of market limitations, and in the absence of capable management, plants resort to producing very small runs of any given type of boards. This continuous changing of production parameters creates an unfavourable effect on the quality of boards produced;
- the possibility exists that the plant is confronted with specific problems that are unknown to industry in the developed countries; these can be due to the utilization of mixed tropical species of timber and/or the utilization of agricultural residues for which no known technology had been developed and for which it must bear the burden of introducing new industrial processes and techniques.

The lack of "standards" and the lack of "quality labels" issued by recognized bodies is a considerable hindrance to the utilization of the boards produced in developing countries for more sophisticated end uses and their inclusion in the specifications of governments, institutions and other large users, be it in the developing countries themselves or in the neighbouring countries to which exports could be envisaged. Furthermore, because of their low per capita income and lack of an industrial base, only very few of the developing countries have utilized particle board to any extent.

Utilization in buildings

In buildings such uses as door faces, ceilings and wall-panels panels are of major importance. It is for such uses that the extruded

type board could be used. However, it is not often used, since it is not a common process and flat pressed boards are often used in these applications. In developed countries special (higher density) flat pressed boards are used as floor underlays, e.g. under plastic tiles or wall to wall carpeting. This type of board would not find a large demand in markets of the developing countries.

Normally, the actual end uses in developing countries can be assumed to be similar to those of developed countries and this also generally applies with respect to technical requirements except that in a number of developing countries additional resistance to decay, humidity, fungal and insect attack is needed. There are preservative treatments available that can be applied where the natural durability of the raw material is not sufficient. Methods of treatment have been developed to fit particle board for different exposures. Similarly, glues with a high degree of moisture resistance are available, but such boards are still not commonly available.

In general, internal walls, ceilings and built-in furniture should not give rise to problems of humidity. Situations do, however, arise in some developing countries in the tropics where, because of the open nature of the houses and the habit of frequent washing of the internal surfaces, there is the risk of deterioration of the board due to its retaining excessive humidity.

For roofs and floors in particular, and also for walls and ceilings, correct ventilation to prevent build-up of humidity and condensation is very necessary. It is important, therefore, that the end users, in particular architects, be informed of correct installation methods so that the board does not fail because of fungal attack.

Utilization by the Furniture and Joinery Industry.

Particle board appears to possess unlimited scope for the furniture or joinery manufacturer, chiefly because it offers the following technical properties:

- good machineability, uniform and relatively low density;
- sufficient strength parpendicular to the surface;
- sufficient screw holding characteristics;
- a minimum of show through (or "telegraph") characteristics;
- low swelling characteristics;
- uniformity in thickness;
- freedom from warping, plus good stability;
- equal strength and expansion properties in two directions;
- availability in large sizes thus eliminating the need of producing panels from glued-up solid wood;
- ease of surface finishing with paint, wood veneer, low or high pressure plastic laminates.

Manufacturers of both home and institutional furniture have found particle board an answer to their needs. They utilize the flat pressed type board in the production of items such as office desks, kitchen cabinets, shelving, case goods, drawers, book cases, etc. Furthermore, it is not limited to any particular design or style. It is an efficient panel product which may be cut into a range of sizes with close tolerances that meet the requirements of the furniture and wood working manufacturers - with a minimum amount of waste. However, it must be pointed out that in many developing countries particle board has not been accepted by the furniture industry for the following reasons:

- it is sometimes more expensive than solid wood;
- furniture is still produced by craftsmen who lack the equipment to veneer and edge band the particle board, besides which already veneered board is not available commercially;
- the low (or fluctuating) quality of the locally produced boards has created consumer resistance to this "man made" product;
- utilizers in the developing countries have not realized that whereas particle board can replace sawnwood, it is not sawnwood (i.e. it does not have identical properties to solid-wood). Because of ignorance it has been used as if it were solid-wood and has failed, leading to consumer resistance; (i.e. it has been used without the necessary modifications to the design);

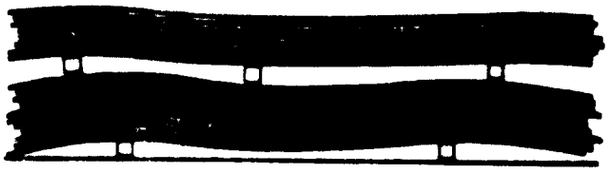
- it has failed because wrong fittings were used (especially hinges) which worked loose and contributed to it being declared an "unsatisfactory" product by end users;
- wrong construction methods (i.e. the use of thin particle board "faces" on a solid wood "frame" - such as is common for plywood - have pushed up the price unnecessarily and eliminated the price advantage particle board had, had the product been specially designed for construction from particle board).

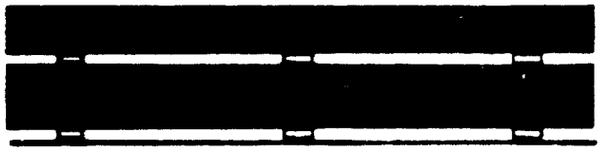
Other end uses

While possibly numerous other outlets exist for particle board in industries such as motor transport, caravans, railways (furnishings), containers, etc., it is worth noting that regulations in some countries exist whereby no "foodstuffs" can be packed in particle board containers. Acceptance, however, has been obtained for the packing of tobacco in such containers.

Storage of particle board

It is important to follow a few simple procedures for making sure that the board is stored under the right conditions. Particle board should not be stored in sheds with slatted sides, outside, or in an excessively damp location. It is preferable to store it flat on a flat surface. If more than one bundle is stacked horizontally, the stickers or bearers on which the bundles rest should be aligned one above the other so as to avoid warping or bowing. Particle board can also be stacked in an almost vertical position, provided it is placed in a special type rack as shown in Figure 3.





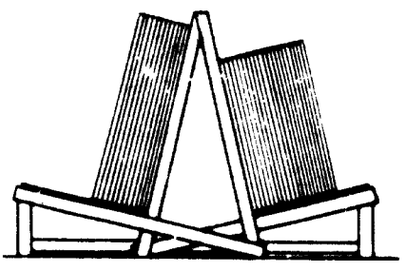


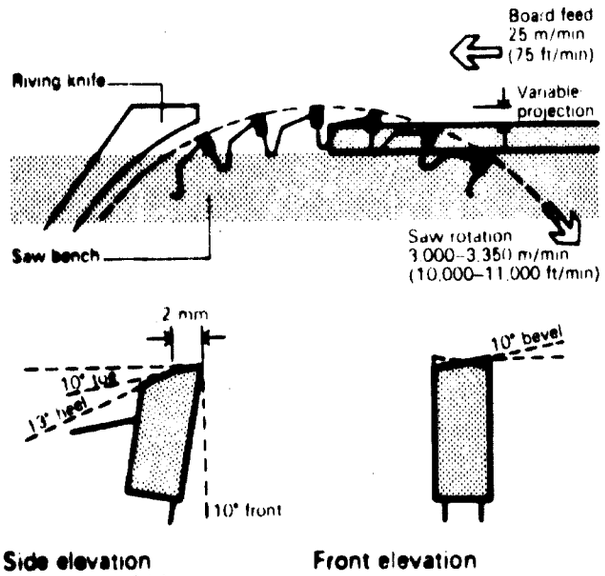
Figure 3: Incorrect and correct method for stacking Particle board

Machining

Particle board can be sawn, routed, spindled, planed or bored. The rate of feed should generally be slower than that used for sawn timber and cutting edges should be kept thoroughly sharp. This is particularly important in the case of boards faced with plastic laminate.

Sawing - plain particle board

For quantity production, any of the conventional machines used for cutting sawn timber are suitable. Saw blades should have a peripheral speed of the order of 3.000 - 3.500 metres/min (10.000-11.000 ft.min). Also the teeth angels are important, particularly the need for a positive front angle. The diagram below shows the recommended details for circular saws:



Side elevation tungsten carbide tip

Front elevation

The saw blade should rotate in the opposite direction to the feed and a riving knife should be fitted to open the cut

Control over the board during machining is important; boards should be properly supported and pressed down

Figure 4: Sawing method for Particle board

Control over the board during machining is also important; boards should be properly supported and pressed down firmly against the cutting table and guides to avoid vibration. The projection of the

saw above the board has a direct influence on the cleanliness of the cut. Breaking out or chipping of the top surface will occur if it is insufficient and on the bottom surface if it is too great. If either occurs, the projection should be adjusted accordingly until the defect disappears. If the fault persists, the saw speed should be increased or the rate of feed reduced. While it is suggested that tungsten carbide tipped saws be used this need not be considered as a hard and fast rule as other types of saws are capable of doing the same kind of work if sharpened frequently enough. Feed speed should not exceed 15 m/min. Mechanical feed is best but if hand feeding a steady rate is more preferable than precise speed. Projection of the saw above the work piece should be between about 8 mm and 20 mm.

Use of Spindle and Router

As wood particle board has a non-directional grain, grooves, recesses and housings can be easily and cleanly cut. These processes are best carried out on a router with tungsten-carbide tipped cutters. While it is not possible to lay down precise details, in general feed speeds should be slower than for sawn timber and the maximum possible number of cutting edges provided. The following are suggested:

Spindle moulder

Speed	-	4.000 - 6.000 rev/min
Cutter block	-	minimum of 4 cutters preferred
Cutters	-	toe 42°, heel 45°
Material feed	-	4 - 5 m/min

Router

Speed	-	18.000 - 24.000 rev/min
Cutters	-	double edge bit, minimum 1 inch cutting edge ground 53° angle
Material feed	-	4 - 5 m/min

V-Grooving for V-Folding Process

This process may appear as being somewhat advanced for application in most developing countries but for some the furniture industry could benefit from its use. The process consists of the utilization of a particle board with flexible laminate or film surface. The method in its simplest form employs a circular solid cutter with a 90 degree V cutting edge to machine two 45 degree miters through the entire thickness of the particle board, but without touching the bottom laminate. Using the foil to serve as a hinge as its fulcrum, the material is folded and glued to make a perfect 90 degree joint. Figure 5 shows a typical machining and folding operation for cabinet sides and top. To accomplish this process, conventional machines, such as double end tenoners with appropriate modifications and attachments can be set up to make not only simple but more complex cuts for V-grooved end products such as for example the machining, folding and glueing of kitchen cabinet tops so that the laminate is folded under the part of the board that overhangs. The system could also be used to machine and fold non-rectangular polygons. The use of this process implies the use of particle boards with very small thickness variations and a very precise machine, as well as special tungsten carbide cutterheads. A more advanced and sophisticated method of V-grooving for edge folding and doubling appears in Figure 6.

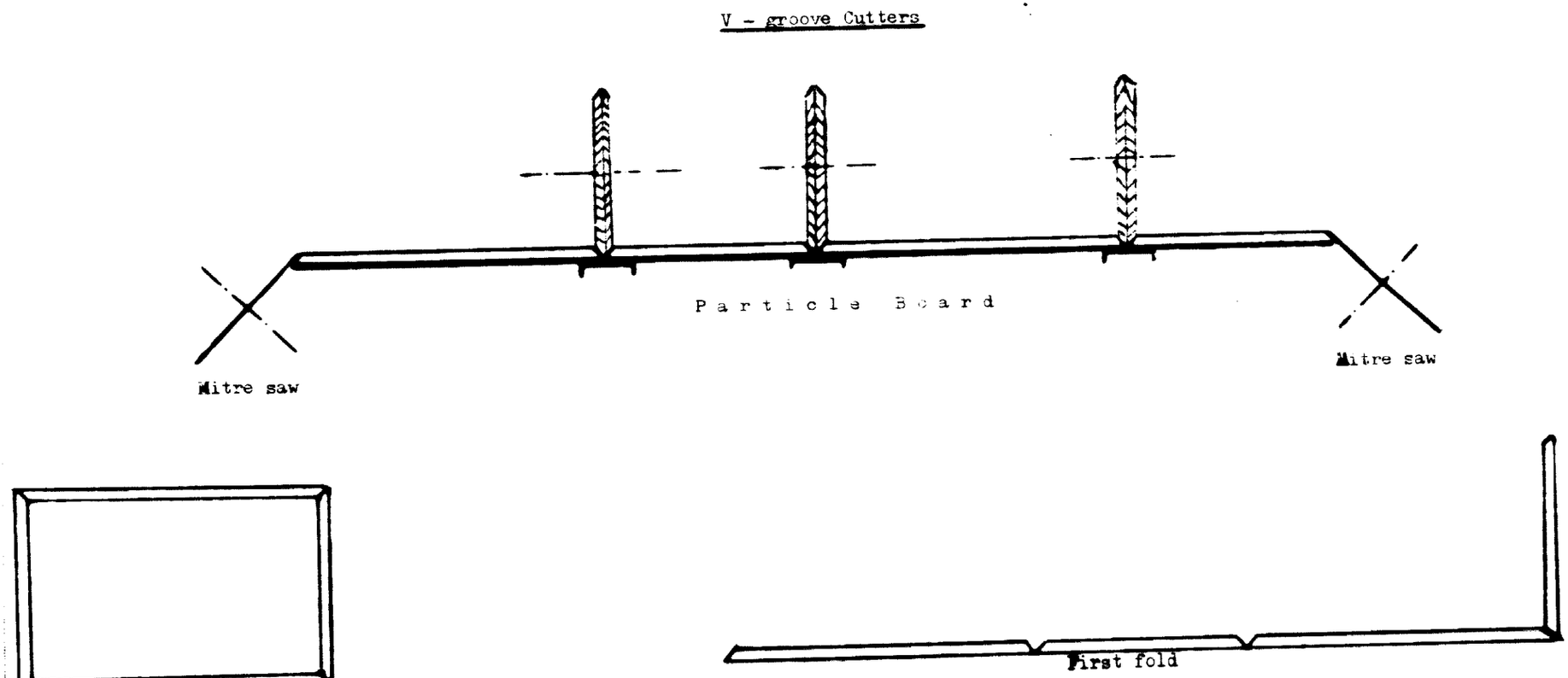


Figure 5: Machining and assembly of V-grooved panels into case goods

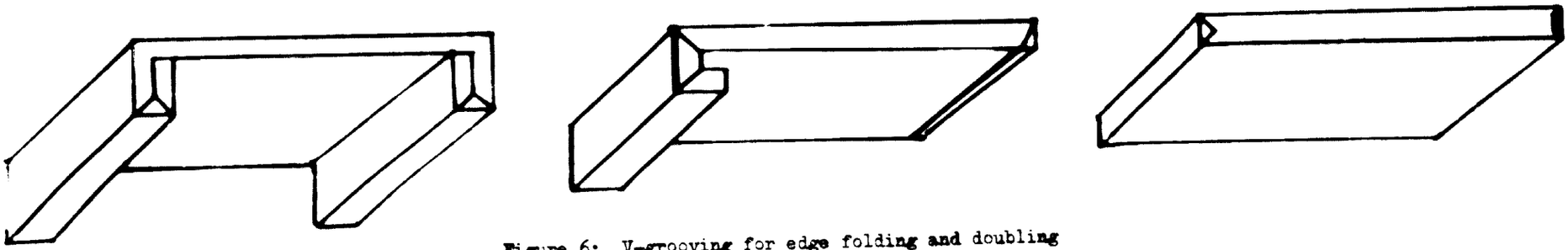


Figure 6: V-grooving for edge folding and doubling

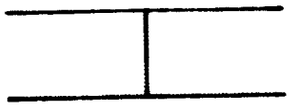
Jointing

Two of the desirable characteristics which particle board possesses are that of its non-directional grain and its gluing qualities. Pieces can be cut from a board in the most convenient and economic way irrespective of their orientation in the board. Furthermore, because the chips lay in a random pattern consistently good gluing surface can be obtained from a saw cut irrespective of the direction or angle of the cut. For the majority of situations glued joints are the most appropriate and economic. They take full advantage of the characteristics of the material and make more complicated mechanical methods unnecessary. There are many ways of detailing board to board joints. The selection of a particular method will largely depend upon the finished appearance required and the equipment and facilities available. Where boards are to be painted, laminated or veneered a plain butt joint is normally suitable. If the edges have been cleanly cut, planing will not be necessary. Both edges should be liberally coated with adhesive and pressure applied and maintained until the adhesive has set.

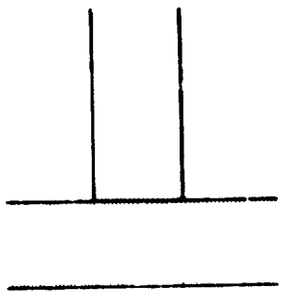
With care in the design and selection of joints, wood particle board is well suited to carcass construction. Simple glued joints are characteristic of the use of the material for this purpose and one of the main reasons for its widespread application in the mass production of furniture. The gluing qualities of particle board are good in all planes and full advantage should be taken of this in the design of joints. Provided that edges have been cleanly cut a plain butt joint provides adequate strength for many situations and is economic. At vertical corner junctions a plain mitred joint can be successfully used. Some means of ensuring accurate location of the components to be joined is often of practical advantage in assembly; for example, a loose tongue may be incorporated in a mitred joint. There are various other ways in which such provision can be made and some of these are indicated in Figure 7

Carcase Joints

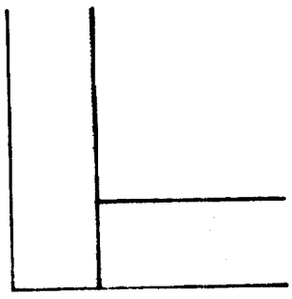
edges must be accurately machined, a gap-filling adhesive used and boards held rigid while adhesive sets



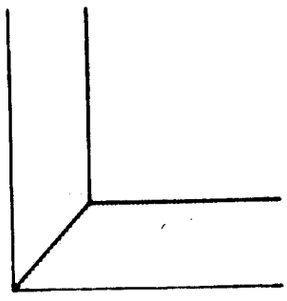
1a Butt joint



2a Butt joint

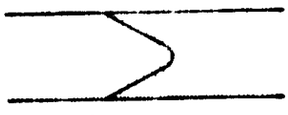


3a Butt joint

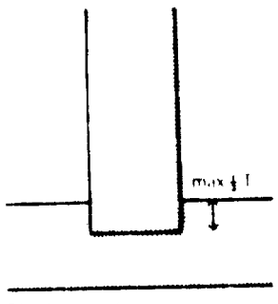


4a Mitre joint

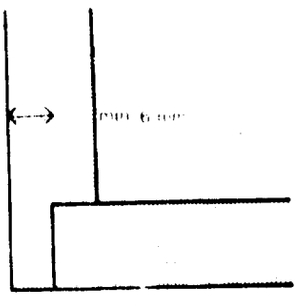
an increase in contact area improves the joint strength but rebates can weaken the cut member if too deep



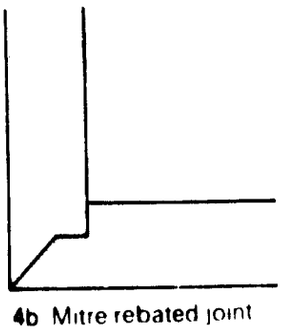
1b Profile joint



2b Housed joint

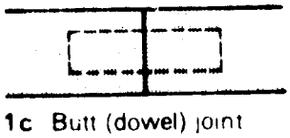


3b Butt rebated joint

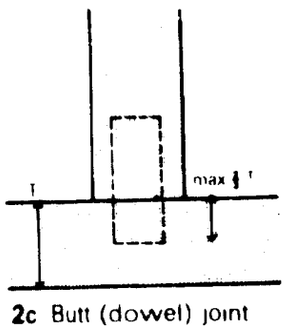


4b Mitre rebated joint

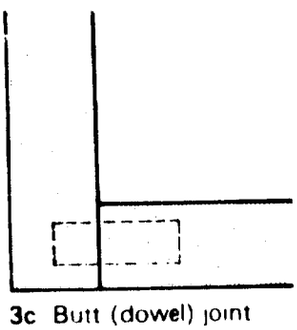
dowels at 100 to 200 mm c/cs will help accurate positioning of boards



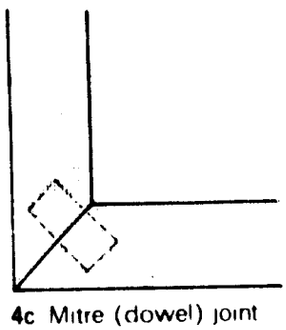
1c Butt (dowel) joint



2c Butt (dowel) joint

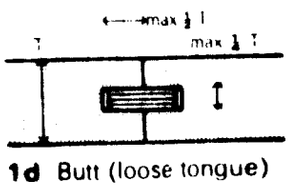


3c Butt (dowel) joint

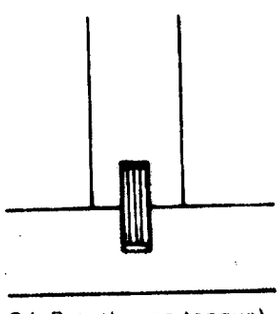


4c Mitre (dowel) joint

tongue will ensure accurate positioning of tee boards

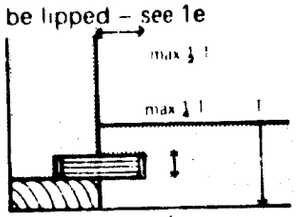


1d Butt (loose tongue) joint

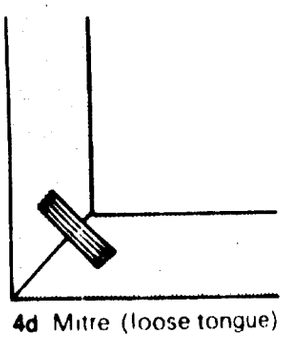


2d Butt (loose tongue) joint

because the rebate is closer than 12 mm to end of board it must be lipped – see 1e

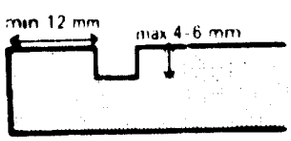


3d Butt (loose tongue) joint



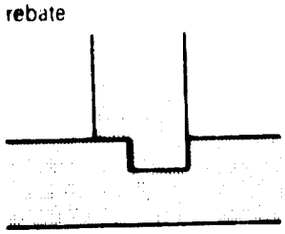
4d Mitre (loose tongue) joint

rebates must be a min. distance from the edges of chipboard to avoid shearing off of the rib



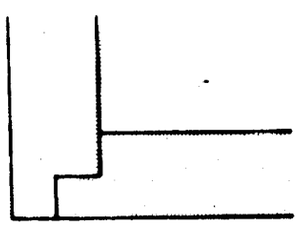
1e Edge rebates

a development of 2b which reduces size of rebate

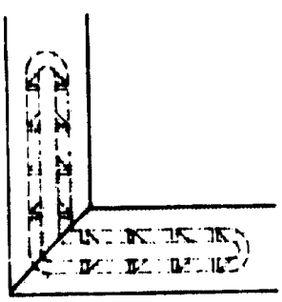


2e Rebated housing

a development of 3b to reduce size of rebate



3e Butt double rebated joint



4e Mitre (nylon 'L' dowel) joint

Figure 7: Jointing

Edge Banding

Particle board may be edged or lipped in a variety of ways. Edges can be veneered easily to provide a matching finnish to the surface. Provided that a clean saw cut has been made, further treatment of the edge surface is unnecessary. Veneers can be applied by hand or machine and the use of a ureaformaldehyde adhesive is suitable for most situations. An alternative edge detail is to use a plastic strip with a toothed tongue on the back face which is pressed into a thin groove out in the edge of the board. Solid wood lippings of any suitable width can be satisfactorily glued with a plain butt joint direct to a cleanly cut edge of particle board. While the use of a tongue and groove detail may be used it only serves to facilitate accurate location, but when it is used the groove should be in the particle board edge.

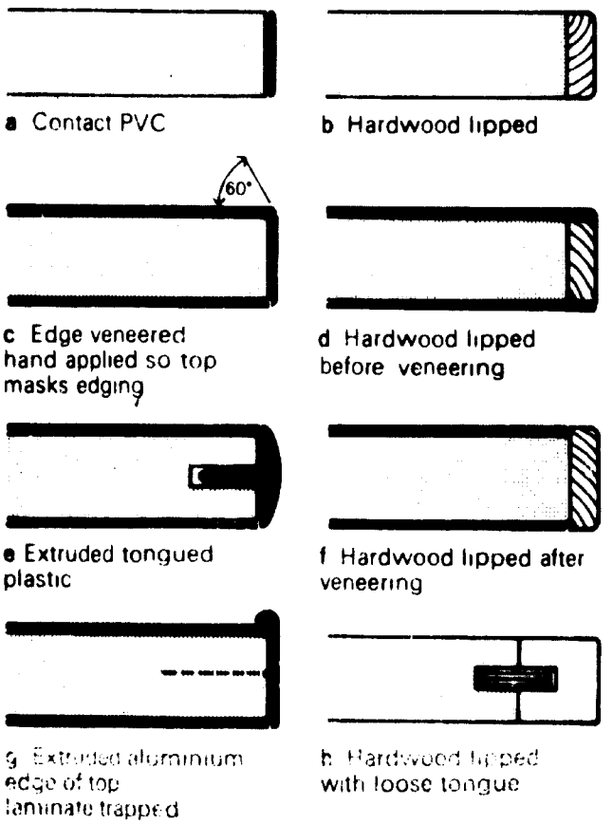
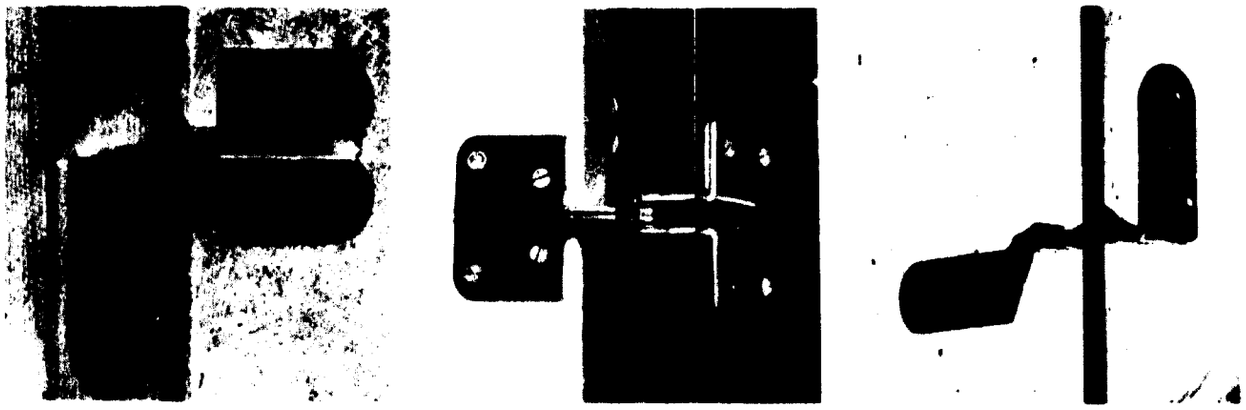


Figure 8: Edge banding and lipping

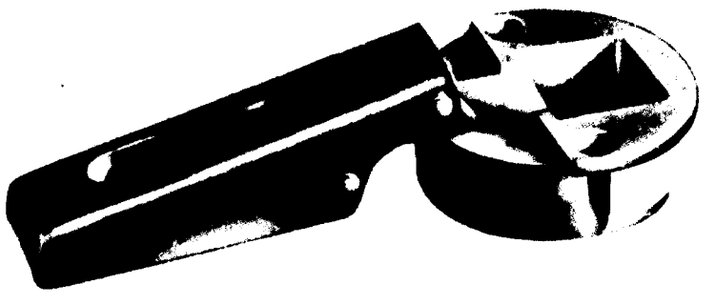
Use of nails, screws or fittings

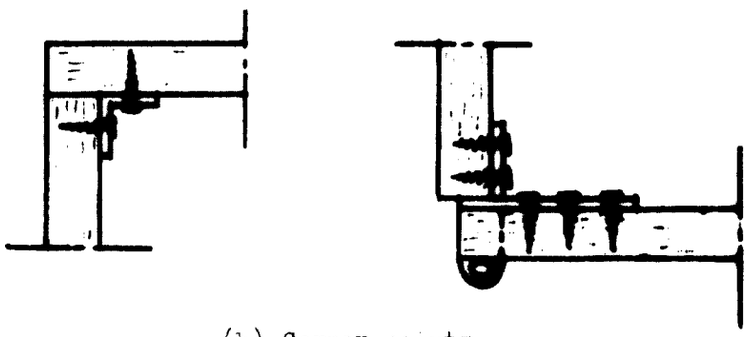
Although nails and screws may be used in particle board, nailing into the board edges should be avoided. Special particle board screws with deeper threading than that of ordinary wood screws, are available. These screws require a bored hole. The hole diameter must be about the "inner diameter" of the screw (measured from the bottom of the threading). Dipping the screws into PVA-glue before driving improves their withdrawal resistence. See Figure 9. Furthermore it is recommended that fittings and structures particularly suited for the purpose should be used as indicated in Figure 10. As regards the use of hinges, the more modern type requires a bored hole on the door panel which is very practical because boring is the simplest of all machining methods. The other side of the hinge is fixed with screws directly on the inside surface of the cabinet side panel. When applying fixings to particle board only those of a permanent nature should be applied directly into the board. Where demountability and reassembly will be required, the use of special inserts or "knock-down" fastenings is advised. There are three groups of "knock-down" or assembly fastenings, namely the concealed, surface and flush type.

Figure 9: Particle board screw.

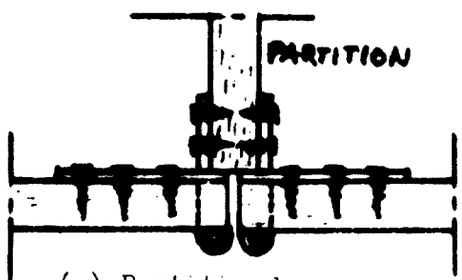


(a)

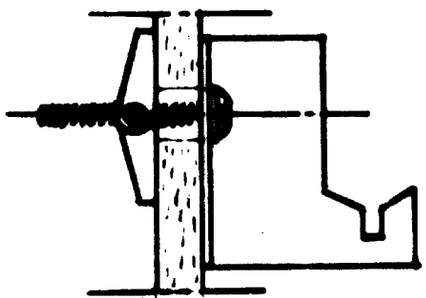




(b) Corner joints



(c) Partition braces



(d) Toggle bolt

Figure 10: Some metallic hardware suitable for use with particle board

Surface treatment of particle board

Particle board can be painted or lacquered in the ordinary way. At first, however, the porous surface must be filled with an appropriate filler. Coating with wood veneer or plastic foil is also frequently done since particle board is a suitable core material for this purpose. The wide-spread use of wood veneered particle board in the furniture industry gives some indication of the suitability and economy of the material for this purpose. There is no difficulty in applying wood veneers provided that a board with a good smooth surface is used. A hard-wearing, scratch-resistant and easily cleanable surface is obtained by the application of melamine based plastic laminates to wood particle board and it is used extensively in the furniture industry, particularly for kitchen units and work surfaces. Soft plastic sheet coverings are also being made use of by the furniture industry as they can be readily applied to the board, besides which they are cheaper than the melamine plastic laminates but still provide a wear-resistent and easily cleanable surface.

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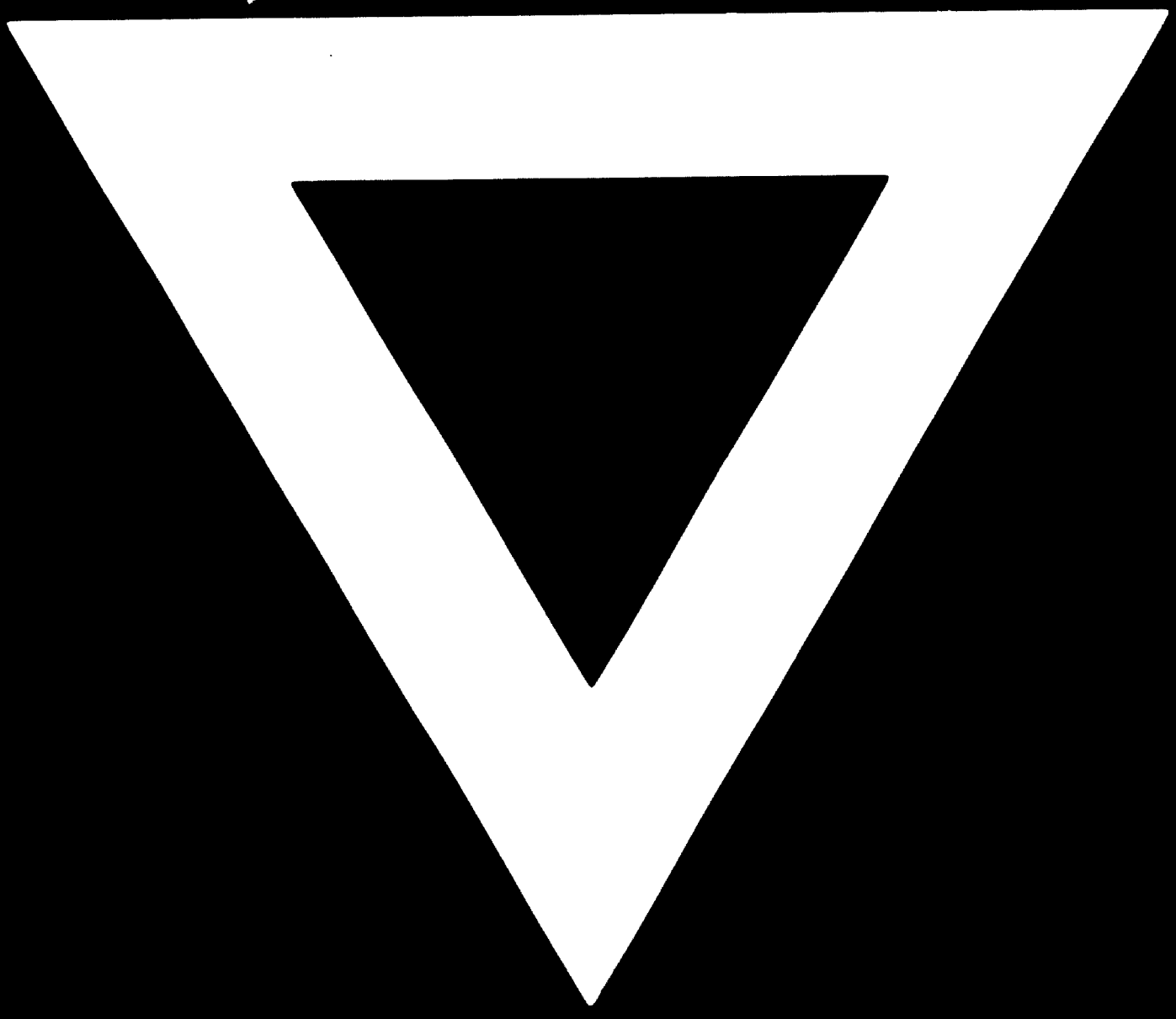

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