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PROPERTIES AND USAGE OF PAPER BASED DECORATIVE PLASTIC LAMINATE BOARDS[1/]

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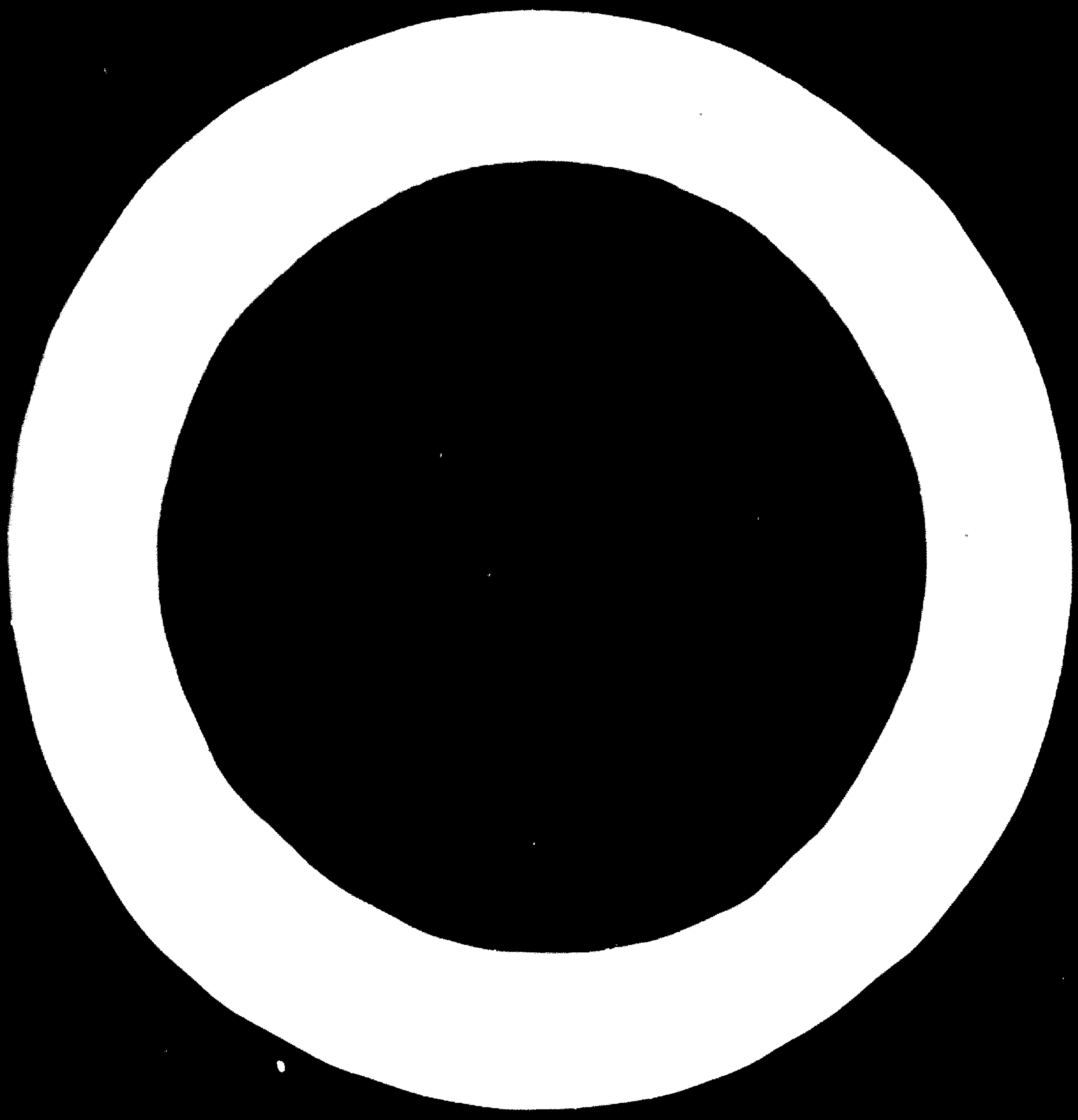


PROPERTIES AND USAGE OF PAPER BASED DECORATIVE LAMINATE BOARDS

Simo Hyvärinen

Nowadays many plastic materials are used as interior linings, such as imitation leather, plastic-covered textiles, plastic films, and to a very large extent, laminate boards.

Paper based decorative plastic laminate boards,(in short decorative laminates or laminate boards), are manufactured, as the name suggests, from paper and plastic. Plastic impregnated papers are pressed at an elevated temperature under particularly high pressure (100 kp/cm^2 , i.e. 1400 p.s.i.) between steel plates into a homogenous board. Decorative laminate contains two different types of plastic and three types of paper. The core part consists of kraft paper and phenolic formaldehyde resin, and the visible surface part consists of patterned or unicoloured paper and a completely transparent overlay. Both of these papers have been impregnated with melamine formaldehyde resin, which is a hard clear substance highly resistant to heat.

Decorative laminate boards with melamine resin surface have been industrially manufactured in several countries since the 1940's The best-known trade marks are Formica in Anglo-Saxon countries Resopal in Western Germany, Perstorp in Sweden, and IKI-board in Finland, and several others in various countries. World production is over 200 million m^2 per year (2000 million sq feet per year).The main producer countries are the U.S.A., Italy, Japan, Western Germany, France, England, and Sweden. The largest factory units manufacture over 10 million m^2 a year, and the middle-sized units about 2 to 3 million m^2 a year. The minium economic size of laminate plant is depending on the local circumstances, but 1 million m^2 a year will in many cases be the smallest possible. This production is achieved by one machine line.

According to European statistics, decorative laminate is mostly used for kitchen furniture, about 42 per cent, for other furniture, about 35 per cent, for passenger transport vechiles, such as ships, buses and trains 7 per cent, for doors and wall coverings 12 per cent, and for other purposes 4 per cent. The figures vary noticeably in different countries, e.g. in Scandinavia, the proportion of vehicles has been 17 per cent. The most typical and oldest use of laminate is still for table tops in kitchens, shops and cafés; the use has then been extended to vertical surfaces of kitchen cabinets, doors, bathrooms, hotel interiors, furniture and cabin walls of passenger ships, buses and trains. For example, about 50.000 m^2 of decorative laminate is needed for one de luxe cruiser.

The appearance of laminate board depends on the decor paper and surface finish. As I mentioned, the decorative paper may be patterned or unicoloured. Printed patterns are divided into three main groups, i.e. woodgrain imitations, textile imitations and fantasy patterns. The printing cylinders are made by photogravure method; thus, it is possible, for example, to make the woodgrains look genuine. However, the diameter of the cylinder is usually only about 30 cm (1 foot), which means that the same pattern is repeated at spaces of one metre. The largest factories have their own printing machines and pattern collections, the middle-sized and small ones buy their printed papers from the same subcontractors. Thus, exactly the same patterns are included in the collections of several different producers. It is also possible to buy sole rights for a certain cylinder, and in this way get an individual pattern in the collection.

Unicoloured decor papers are thoroughly coloured already in the paper machine of the paper factory. The result of this is that it is not worth while manufacturing very small quantities of

some separately chosen colour.
Attempts must be made to explain to architects - althoughit is very difficult - that it is easier to harmonize the paints according to the laminate, than to find a laminate to match a certain shade of paint.

It is also possible to affect the appearance of the board by the surface finish, which is normally either glossy, semimatt or matt.
Recently, the marketing of so called three-dimensional surfaces has been started. Perhaps the most popular of them is the wood-grain imitation with porous finish, in other words, the surface is more wood-like than before. The third dimension has also been employed in the textile imitations, in order to obtain textured surfaces.
If the decorative paper and overlay of the laminate are omitted, the product is called industrial laminate or technical laminate. It is mainly used in machine parts, and in furniture, e.g. on the reverse side of table tops to give sufficient homogeneity to the construction.
By changing the amount of core paper in the laminate it is possible to vary the thickness considerably. As a curiosity, it is possible to make even board of 50 mm (2 inches) thickness.
The thinnest qualities for sale are 0.5 mm. The most common thicknesses on the market are: 1.6, 1.4, 1.0, 0.8 and 0.7 mm. Generally, the manufacturers aim at thicknesses from 1.6 to 1.0 mm, because it is difficult to handle the thin qualities in large sheet sizes. They are inclined to break and crack, thus, the result is no cheaper than if thicker boards are used. Boards between 1.6 and 1.0 mm are mainly used for horizontal surfaces, and thin qualities (from 1.0 to 0.7 mm) for vertical surfaces. They do not require especially high resistance to abrasion, and the overlay can thus be omitted, especially when unicoloured boards are concerned. As a result, the hardness and simultaneous fragility of the board is decreased.

The thickness tolerance is usually ± 10 per cent.
The size of the boards varies considerably with different manufacturers. The length normally varies between 245 and 360 cm (8 feet and 12 feet), and the width between 125 and 180 cm (4 feet and 6 feet); the usual dimensions are 125 x 245 cm (4' x 8') and 125 x 305 cm (4' x 10'). By far the most common width is between 122 and 127 cm, as two kitchen table widths can be obtained from it. Because the product is sold cut to certain sizes, and not for example in rolls, waste occurs in both length and width.

Decorative laminate is very resistant to wear and abrasion.
Another important advantage is that it tolerates a temperature over 100 degrees Celsius (212°F). A kettle filled with boiling water can easily be placed on laminate board, and even a burning cigarette may remain on it for two minutes, without damaging the surface. These good properties are mainly due to the melamine resin which is hard and transparent. In boards for horizontal surfaces, this property is increased by an overlay with particularly high resin content.

Decorative laminate also has certain disadvantages, because it contains three different materials: paper, phenolic resin, and melamine resin. All these substances have their own physical and chemical characteristics differing from each other. When these materials are laminated, the core and surface parts behave in different ways. Variations in temperature and humidity cause tensions between the layers, and this may result in delamination and warping. The characteristics of the paper cause most of the negative effects, and because 60 per cent of the laminate consists of paper, the resins are unable to eliminate the effects completely.

However, paper fibres are able to absorb moisture from the air - they expand, and in dry circumstances again give out water, and they shrink. The result of this is that the dimensions of the board change little with the relative humidity of the air, i.e. when the laminate is kept in great humidity it expands, and in dry circumstances it shrinks. For example, if the laminate, taken from cold and moist storage, is glued on chipboard, and is later kept in dry circumstances, it will shrink; however, when glued it only stretches, and causes heavy tension. If the chipboard is not firmly fixed it will bend, and in extreme circumstances the laminate will crack. This danger is avoided by gluing the laminate in normal circumstances not particularly moist or dry. The disadvantages are thus partly eliminated. The paper also causes the strength of the board, and abovementioned dimensional stability, to be different in cross and longitudinal directions. The paper fibres are more oriented in the longitudinal direction, the same characteristic is also apparent in the laminate. The result is that the board swells and shrinks in cross direction more than in longitudinal direction. Swelling from bone dry to tropical moist may be 0.8 per cent in cross direction, and 0.3 per cent in longitudinal direction, or the tension may correspond to this. The same difference also appears in tensile strength and modulus of elasticity, which are greater in longitudinal than in cross direction. Although paper causes the above disadvantage, it will, on the other hand, reinforce the board. It is also easy to print various imitation patterns on paper.

In quality control of laminate boards NEMA standards (National Electrical Manufacturers' Association, NY) are mostly used. Some other standards could also be mentioned, such as DIN in Germany, British Standards, and SIS in Scandinavia.

The tests and their numbers used for measuring the most usual properties are given in the table 5.1.

As a general rule, the majority of machines used in joinery production are suitable for the machining of laminate board. Nevertheless, for constant use it is advantageous to provide machines with tungsten carbide bits, as their lasting sharpness facilitates the finishing of the board edges, and speeds up the manufacturing process.

When laminate boards are sawn into sizes corresponding to those of the base material,the board must be placed against the saw-blade so that it will cut the decor side first.

In factory processing, straight cuts are made by circular saws, and curved cuts by band-saws.

Laminate board is fixed by gluing on the framework which is usually of wooden board, such as chipboard, block- or laminboard, and plywood. Metal and stone base may also be used.

There are general rules for the application of wood glues, such as urea glue, PVA, and those based on phenol, and in special cases, contact glues and hot-melting glues. The following rules can be applied on the basis of the particular instance and the means for pressing available:

1. PVA glue when good resistance to heat and moisture is not essential
2. Cold-curing urea glues, if ample pressing capacity is available and no special powers of resistance to moisture.
3. Hot-curing urea glues, if the framework material is sufficiently sturdy to preclude the effects of tension resulting from thermal expansion
4. Phenol and resorcine glues when special resistance to moisture is required.
5. Contact glues when no press is available, or its use is not practical
6. Epoxy glues or two-component-contact glue for instance when laminate boards are to be attached to metal surfaces
7. Hot-melting glues are used for edging of table tops and other edged panels. The glue manufacturer's instructions should be observed during gluing.

Wood, metal and plastic are suitable materials for edging strips.
Wood and plastic strips with groove should be attached by gluing. When metal strips are used, they should be firmly attached to the framework with screws set as closely together as is expedient.
Laminate board can be used as edging material simply by gluing it on the framework, and by rounding off or planing the joining edges.
On vertical surfaces laminate can also be attached with strips. Either link strips or capping strips, which may be of aluminium, plastic or wood, are used. In addition to strips, also elastic glue may be used in the middle part of the board.
This installation method is used e.g. in kitchens for covering the wall between cupboards, in bathrooms and toilets, ships and trains.
Decorative laminates have recently been introduced also for exterior wall coverings, but the experiences of their usability for this purpose are still insufficient. Great requirements are also made upon the resistance to light in these cases. Laminate for exterior walls has usually large patterns, and the thickness is about 3 mm.
There are a few modifications of laminate boards, of which three could be mentioned.

1. Postforming laminates
2. Fireproof laminates
3. Low pressure laminates, in other words direct laminated chip boards.

In principle, postforming laminates are manufactured in the same way as ordinary laminates. The resin has been modified so that it is possible once more to soften it, and thus to bend the board two-dimensionally. As a result, curved corners can be made. The prerequisite for this is that the user of the board has the equipment for heating the board up to 160°C, and bending it as desired.

Fireproof boards are used in ships. In these boards, certain substances have been added to the resin or paper, which prevent the board from burning. It is possible to make the board selfextinguishing, and unable to burn futher. However, the laminate is charred in circumstances corresponding to those at fire. Direct laminated boards differ mostly from ordinary laminate. They are made by pressing decorative paper straight on the chipboard surface. Thus, the pressure of only 15 kp/cm^2 can be used,in order to prevent the chipboard from becoming compressed.

Direct laminated chipboard is used for inner surfaces of kitchen furniture, but not for table tops. It is, of course, less durable than actual laminate, but cheaper, because lamination and "gluing" are carried out at the same stage. The use of laminate has continuously increased in the whole world; in Western Europe the increase has been about ten per cent a year. This is mainly because laminate makes it possible to obtain durable, beautiful and hygienic surfaces.

Table 5.1 TESTING METHODS FOR DECORATIVE PLASTIC LAMINATE BOARDS

	NEMA	SIS	DIN	BS
Abrasion resistance	LD 1-2.01	-		
Resistance to boiling water	LD 1-2.02	R 70 50 02	53799	3794
Resistance to high temperature	LD 1-2.03	24 58 03	53799	
Resistance to burning cigarettes	LD 1-2.04	-	53799	
Stain resistance	LD 1-2.05	24 58 05	53799	
Resistance to light	LD 1-2.06	24 58 05	53799	
Wetting resistance	LD 1-2.07	24 58 01		2782
Dimensional stability	LD 1-2.08	24 58 06	53799	
Flexural strength	LD 1-2.09			3794
Modulus of elasticity	LD 1-2.09			3794
Deflection at rupture	LD 1-2.09			3794
Inspection for appearance	LD 1-2.10			3794
Tensile strength	LD 1-2.14		53455	
Impact strength	LD 1-2.15			
Scratch resistance by pencils	-	18 41 87		
Water vapour transmission	-		53122	
Thermal expansion	-			
Thermal conductivity	-			

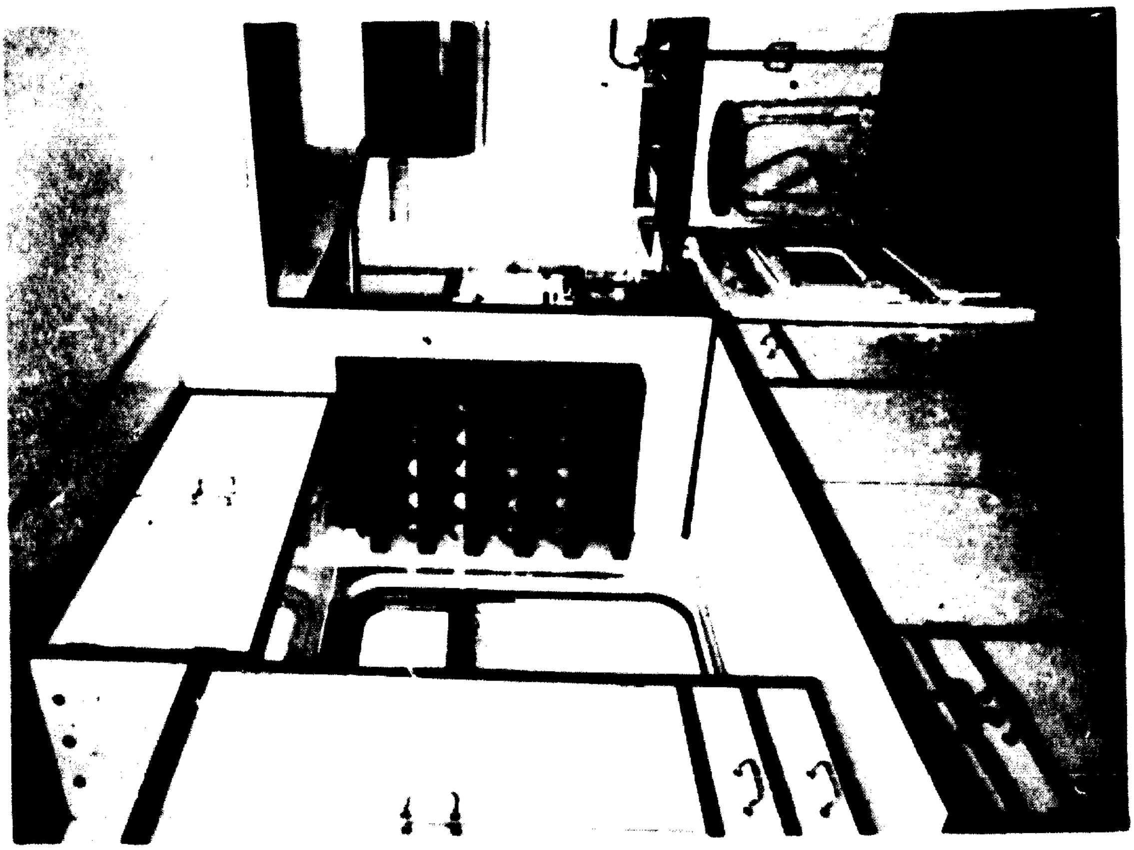


Fig.1. Kitchen of a train; laminate surfaces.

Fig.2. Cabin of a ship; laminate surfaces.

Fig.3. Lunchroom of a school.

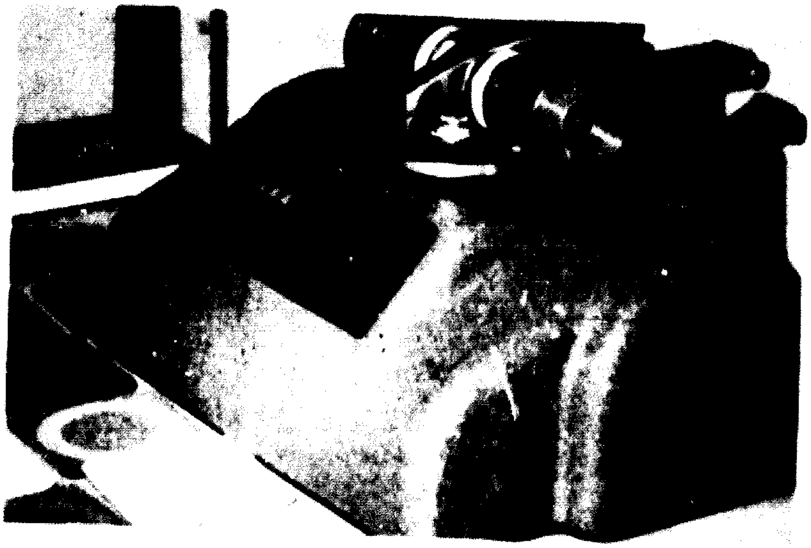


Fig.4. Taber abrasion tester, showing tested and untested specimens.

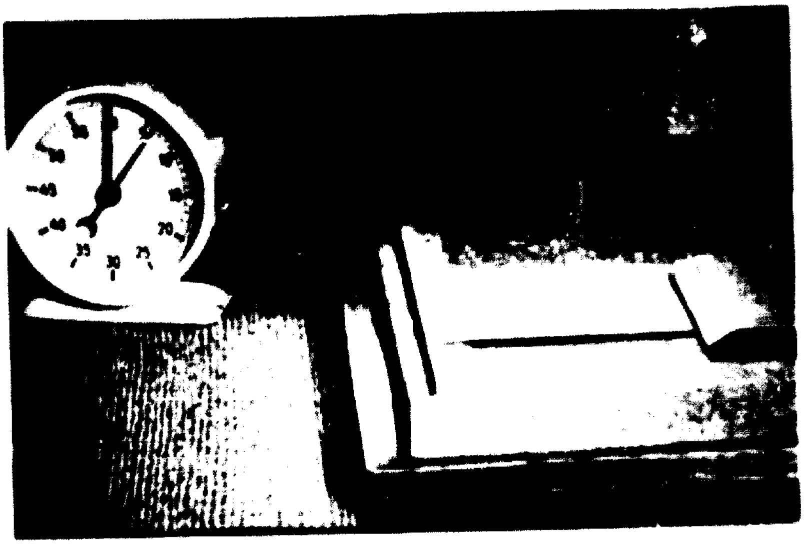


Fig.5. Testing resistance to light. One half of the board is covered with a metal plate, the other is exposed to light.

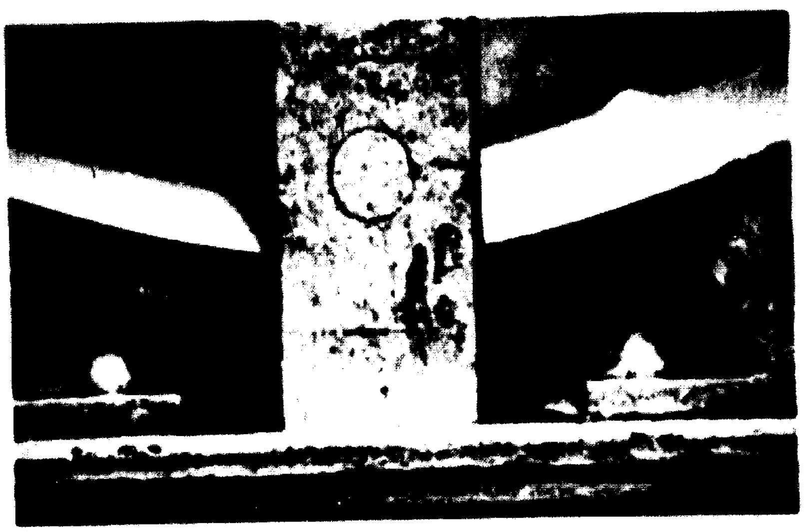


Fig.6. Measuring the flexural strength of a laminate board; the middle part is pressed until the board breaks.

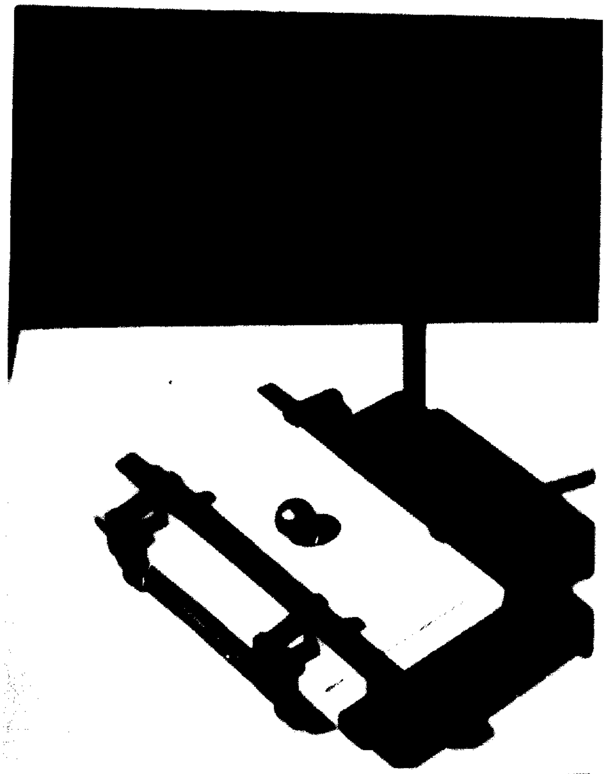
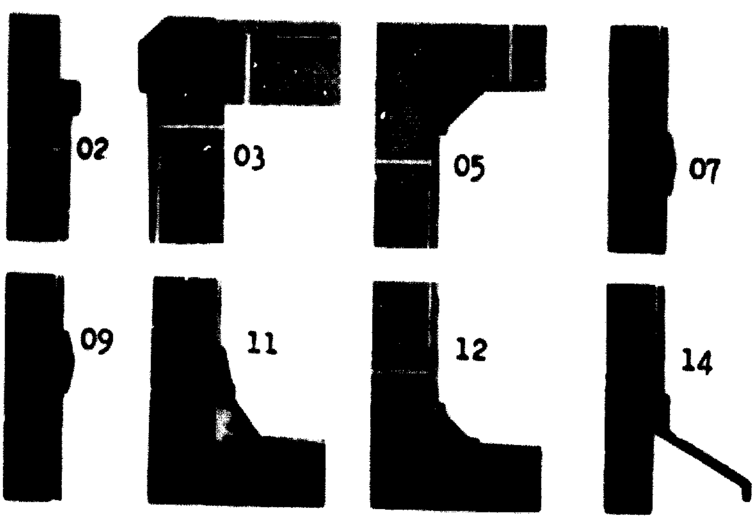


Fig.7. Impact tester; a metal ball is dropped on the board from a height of 90 cm (36 inches).



02 End joint
03 Outer corner joint
05 Inner corner joint
07 Seam joint, 1-side
09 Seam joint, 2-sides
11 Skirting board joint
12 Corner joint
14 "Bathtub" joint

Fig.8. Groove strips for the attachment of laminates

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