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PRODUCTION OF VENEER, PLYWOOD (INCLUDING CORE PLYWOOD) IN DEVELOPING COUNTRIES: AN ANALYSIS OF ALTERNATIVES 1/

by

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1/ The views and opinions expressed in this paper are those of the author and do not necessarily reflect the views of the Secretariat of UNIDO. This paper has been re-issued to incorporate the points raised in the discussion of this topic during the Workshop. This document has been reproduced without formal editing.

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Contents

1) Introduction

Before going into details of definition, raw materials, markets, production methods and costs, it must be stated that plywood still represents one of the major forest products in world trade. While originally mainly logs were shipped from those countries with forest resources to those areas where high technology and labour skill allowed for the production and the coverage of the local market, costs have since risen so much that the production of plywood, veneer and blockboard was largely transferred to the developing countries.

But before going into such details and giving the reasons for such a shifting process, it might be necessary to give a clear determination of the products first.

a) Characteristics of plywood

Originally plywood was designed to provide the market with a more stable product than naturally grown timber.

Based on the technological knowledge that timber swells or shrinks much more in tangential direction than in radial or longitudinal direction, veneer was cut and glued together in cross bands to equalise the shrinkage or swelling tendencies of the single layers. Today everything is called plywood which is a multilayer combination of veneer sheets. Such plywood sheets are usually produced in standard sizes, but sometimes for special purposes also in very small or very large dimensions. While the smallest are just in the range of post-card size, there are large plywood sheets produced up to a size of 9' x 50' or 2.70 m x 15.00 m.

Also the range of thicknesses varies very much. While the thinnest plywood was usually for special purposes such as the production of aeroplanes, today's thinnest plywood seems to be used for the purpose of business cards being not thicker and sometimes even thinner than ordinary paper. The range of thicknesses goes usually up to 1" or 25 mm, but for special purposes also much thicker plywood can be obtained.

b) Characteristics of veneer

The determination of veneer is a thin piece of wood, which might be either peeled by a rotary lathe or might be sliced by a veneer slicer. Also sawn veneer is still in use for certain special purposes.

Peeled veneer is sold as a semi-product, but is usually used for plywood production or to cover the core of blockboards.

Sliced fancy veneer is used mainly for decorative purposes, which means to cover any other wooden boards or panels to give them a beautiful surface.

The thickness of sliced veneer begins with the very thin material, which is used for special purposes mainly in Japan and which has a thickness of 0.1 mm or less, while ordinary fancy plywood is mainly produced in the thickness range between 0.3 and 0.8 mm. Veneer in Asia is generally produced in thicknesses from 0.25 - 0.6 mm. Europe generally produces 0.55 - 0.9 mm.

c) Characteristics of blockboard

The origin of blockboard comes from a time, where ordinary wooden planks have been glued together to form a block of approximately 0.50 m height and 0.50 m width. This block was then sent through a gang saw. The single slices were composed together after the gang saw and were covered by cross band veneer in a hot press.

This process is too expensive to be used today and for this reason the blockboard core is manufactured out of wood waste which is cut into strips and composed together to the core layer.

As a special product some companies still produce so-called laminboard, where instead of the formerly used wooden planks, peeled veneer is glued together to large blocks and cut to slices, thus forming the core layer of such blockboard. Such laminboard today represents the most stable product in board form.

Blockboard is mainly produced in standard sizes of 4' x 8' or 1.25 m x 2.50 m. In central Europe however the standard size for blockboard is larger and usually in the range of 6' x 17' or 1.83 m x 5.10 m.

The thickness of blockboard usually ranges between 12 and 25 mm (1/2" to 1").

2) Review and Projections

a) Uses of plywood and blockboard in various areas

In the United States and Canada plywood is widely used in the construction industry. The ordinary American house consists of a wooden frame work, which is covered with softwood plywood on both sides. This design represents the walls of the house. The softwood plywood usually will be protected on the outside by either asphalt paper, asbestos-cement plates or other protecting materials. The inside of the walls will be decorated by means of hardwood plywood or formerly gypsum board and wall paper. Besides for those standard houses plywood is also widely used in offices for wall partitioning or simply decoration of the walls.

Another country with a very large consumption of plywood is Japan.

In Europe, plywood has been partly replaced by the cheaper chipboard as long as it was used for the manufacturing of furniture. In the construction business and for other special purposes plywood is still largely in use and hard to be replaced. For wall decoration plywood has even an increasing market and demand.

In developing countries plywood is very often used for all kinds of construction and furniture making, because it is a flat material providing very stable characteristics.

b) Demands of plywood and blockboard in various areas

In the United States' plywood market two different types have to be distinguished: softwood plywood and hardwood plywood. Softwood plywood accounts for about 75% of total consumption. It is totally supplied by domestic production. The bulk of softwood plywood is used in housing construction.

The softwood plywood is, however, mainly manufactured from local raw materials and, therefore, not of considerable interest for this working paper, which considers the production of plywood in developing countries. The remaining 25% of total plywood consumption in the United States is, however, of hardwood. This is a plywood type produced in developing countries. Hardwood plywood is mainly used for interior decoration.

During the last twenty years the US hardwood plywood market underwent significant structural changes. Originally, most hardwood plywood was manufactures domestically from either local hardwood species or large quantities of imported logs. Imports of the final product were negligible.

Various factors made local production cost rise steeply. As a result, hardwood log imports declined sharply while imports of finished plywood rose. Total hardwood plywood consumption increased at a rate of 7.5% p.a. in the 1960 - 1970 period.

The domestic hardwood plywood production, which in 1968 had reached almost double the volume of output of 1960, declined since then. Imports captured most of the expanding market and accounted by 1970 for about 55% of total United States' hardwood plywood consumption. Asian countries supplied more than 90% of all hardwood plywood imported by USA.

When Asian suppliers started to take over the US hardwood plywood imports, only Japan had production capacities capable of keeping pace. Later the Philippine and Taiwan shares became substantial. But by the end-sixties the Republic of Korea surpassed all of them, even Japan.

In 1970, Korea and the Philippines supplied most of the US hardwood plywood imports. The share of Japan, which ceased to participate in the market's growth, had fallen to about 15%.

During the period from 1961 to 1970 the US hardwood plywood imports had grown by an average of about 15% p.a. This is double the rate of increase in hardwood plywood consumption (7.5%) in the same period of time. Most recent observations have shown that the increase in hardwood plywood imports is beginning to level off somewhat earlier than expected (from 1973 onward). Therefore, former projections of the main components of the US hardwood plywood market have been revised.

The future expansion rate is estimated on the basis of the following assumptions:

- Until 1972, US hardwood plywood consumption increased by 7.5% p.a. From 1973 on the average annual growth rate will be 2.3% (until 1985).
- Due to rising log and production costs, domestic production will fall by 5% annually from 1970 to 1985.
- US exports being rather negligible will remain at the 1968-level.

As a result the share of US hardwood plywood imports in total hardwood plywood consumption will keep on growing. Figures on the US hardwood plywood market in the past, at present and in the future are compiled in tables 1 and 2.

Table 1:

The Hardwood Plywood Market in the USA 1960-1970

Year	Production	Imports	Exports	Consumption 1/	Consumption per 1 000 capita m³
	(in '000 of m³)				
1960	976	633	3	1 606	8.89
1961	1 155	644	4	1 795	9.77
1962	1 342	789	3	2 128	11.40
1963	1 490	828	1	2 317	12.23
1964	1 693	921	3	2 611	13.59
1965	1 814	927	6	2 735	14.05
1966	1 838	1 110	8	2 940	14.93
1967	1 696	1 101	7	2 790	14.01
1968	1 778	1 670	12	3 436	17.08
1969	1 621	1 865	14	3 472	17.09
1970	1 540	1 812	51	3 301	16.07

1/ Consumption = Production plus Imports minus Exports

Source: US Department of Agriculture, Forest Service.

Table 2:

Projected Demand for Hardwood Plywood and for Imported Hardwood Plywood in the USA 1960-1985 (in '000s of m^3)

	1970 (actual)	1975	1980	1985
1. Total Demand 1/	3 301	4 084	4 576	5 126
2. Exports 2/	51	12	12	12
3. Production 3/	1 540	1 192	922	713
4. Demand for Hardwood Plywood Imports 4/	1 812	2 904	3 666	4 425

1/ 1970-1972 growth rate 7.5% p.a.
1973-1985 growth rate 2.3% p.a.

2/ From 1972 on exports maintain 1968-volume

3/ From 1970 on annual rate of decrease 5%

4/ Line 4. = 1. + 2. - 3.

Source: US Department of Agriculture, Forest Service.

The Japanese Plywood Market

In 1969, Japan accounted for 21% of the world's total plywood consumption. This share is considerably larger than that of the EC and of the United Kingdom combined. It makes Japan the only Asian country with a significant part of the world's plywood demand.

Similarly important is the size of the Japanese plywood industry. By 1970 there were more than 600 plants many of which were rather small, indeed. The industry's record shows an impressive 17% - average annual rate of increase in production during the 1960s.

In the fifties a major part of Japan's plywood was exported mainly to the United States. When exports declined, because of Korea's growing competitiveness in the early sixties, the industry could keep on expanding at a rapid pace due to a steep rise in domestic demand: local consumption rose by 20% p.a. in that period of time. In 1970 less than 5% of total production were exported as against 25% ten years ago. One of the main factors weakening Japan's export competitiveness was the sharp increase in raw material prices: between 1965 and 1970 prices of imported logs marked an increase of about 30%.

Like in the United States most of the plywood is used in housing construction including prefabricated parts, temporary structures and scaffolding (about 40 to 50%). Furniture accounts for a particularly high share in plywood use (30%). This may explain the high plywood consumption per 1 000 capita of Japan as compared to other industrialized countries. In Europe, however, plywood formerly used for furniture has been substituted by chipboards to a large extent.

Logs, which in the early sixties were supplied mainly by the Philippines, have been purchased more and more from East Malaysia and from Indonesia (Kalimantan). Since 1972, Indonesian Borneo is the main raw material source of Japan's plywood industry.

Estimates of future demand have been based on the following assumptions:

- Local consumption will increase by 7.5% p.a. from 1970 to 1975, and by 2.3% p.a. from 1976 to 1985, thus growing at the same pace as the US hardwood plywood market.

- Domestic production will neither rise nor fall.

- Exports are expected to recess further by 0.9% annually for the whole period 1970 to 1985.

Tables 3 and 4 give a quantitative summary of Japan's plywood production, trade and consumption in the period until 1985.

Table 3:

Japan's Plywood Market 1960-1970

Year	Production	Imports	Exports	Consumption 1/	Consumption per 1 000 capita m^3
	(in '000s of m^3)				
1960	1 403	-	355	1 048	11.2
1961	1 666	-	346	1 320	14.0
1962	1 833	-	357	1 476	15.6
1963	2 073	-	341	1 732	18.1
1964	2 453	-	361	2 092	21.6
1965	2 627	-	385	2 242	22.9
1966	3 101	2	375	2 728	27.6
1967	3 778	21	295	3 504	35.1
1968	4 743	4	418	4 329	42.9
1969	5 893	27	340	5 580	54.6
1970	6 924	27	297	6 654	64.4

1/ Consumption = Production plus Imports minus Exports.

Source: Asian Industrial Survey Team collected data.

Table 4:

Projected Demand for Plywood and for Imported Plywood in Japan 1970-1985 (in '000s of m^3)

	1970 (actual)	1975	1980	1985
1. Total Demand 1/	6 654	9 553	10 703	11 992
2. Imports 2/	297	284	271	259
3. Production 3/	6 924	8 122	8 122	8 122
4. Demand for Imported Plywood 4/	27	1 715	2 852	4 189

1/ 1970-1975 annual growth rate 7.5%
1975-1985 annual growth rate 2.3%

2/ 1970-1985 annual rate of decrease 0.9%

3/ From 1971 constant local production output (8 122 000m^3)

4/ 4. = 1. + 2. - 3.

The European Plywood and Blockboard Market

By the end of the sixties aggregate European plywood consumption was about 4.5 mil m^3. Out of the total market, the EC accounted for 43% and the United Kingdom for 22%. Growth of consumption was rather uneven among Europe's sub-regions. Whereas the area as a whole recorded an average annual increase of about 5%, the Southern European market expanded by almost 10%; consumption in the United Kingdom rose by about 8% p.a. and in the Common market by only 4%.

Comparing the levels of Gross Domestic Product per capita and of plywood consumption per 1 000 capita, Europe's figures look rather low with respect to Asian countries. The main reason for this is the development of the European chipboard industry, which has taken over the bulk of the furniture market as well as important segments in construction and interior decoration. Imported raw materials from Africa made production cost of plywood producers rise considerably while the chipboard industry based on local low-quality and hence lower-cost raw materials become increasingly competitive.

Local production covered 84% of total consumption. Imports of finished plywood accounted for 42% of the region's aggregate demand the remainder of 26 indicating the volume of exports (intra-European trade included). Finland is the largest plywood exporter (some than 50% of total European exports) and Great Britain the main importer of finished plywood products (again more than half of total imports). Imports from South East Asian countries were less than 10% of total imports by 1969. Asian log supplies played, equally, no important role in Europe's plywood industry. This was true even for Britain, which buys only negligible quantities from Asian Commonwealth countries. The European market, in general, was determined by special preferences regarding the type of product, which have favoured particularly African supplies either of logs or of finished plywood, so far. Moreover, cheaper substitutes are frequently available.

With a certain time lag similar structural changes are about to take place in the European plywood industry as occurred in the United States some ten years ago. As production costs rose considerably during the last five years, there is now a substantial advantage to import tropical hardwood plywood in large quantities. In 1971 and 1972 many plywood mills closed down in Central Europe. Their markets were covered partly by the chipboard industry and by increased imports of finished plywood.

In order to estimate the future market size in Europe, the following assumptions have been made:

- Consumption in Europe will grow at a rate of 2.6% annually from 1970 to 1985.
- Exports are expected to increase annually by 5% until 1975 and by 2.5% from 1976 to 1980. They will be stable from 1981 to 1985.
- From 1970 to 1975 production keeps at the 1969-level of output. It will decrease at an annual rate of 5% from 1976 to 1985.

As a result imports will rise. The quantitative data on Europe's plywood market are compiled in tables 5 and 6 for the period from 1960 to 1985.

Table 5:

The European Plywood Market 1960-1970 (in '000s of m^3)

Year	Production	Imports	Exports	Consumption
1960	2 661	863	640	2 884
1961	2 724	817	610	2 931
1962	2 919	895	635	3 179
1963	3 229	1 009	705	3 533
1964	3 231	1 215	810	3 635
1965	3 303	1 268	865	3 706
1966	3 338	1 250	865	3 723
1967	3 373	1 507	926	3 954
1968	3 588	1 723	1 032	4 279
1969	3 818	1 787	1 122	4 483
1970	3 940	1 958	1 202	4 596

Sources: FAO Yearbook 1963-1970, Rome

Table 6:

Projected Demand for Plywood and for Imported Plywood in Europe 1970-1985 (in '000s of m^3)

	1970 (actual)	1975	1980	1985
1. Total Demand 1/	[illegible] 696	5 339	6 070	6 900
2. Exports 2/	1 202	1 534	1 735	1 735
3. Production 3/	3 940	3 940	3 048	2 359
4. Demand for Imported Plywood 4/	1 958	2 933	4 757	6 276

1/ 1970-1985 annual growth rate 2.6%

2/ 1970-1975 annual growth rate 5.0%
1975-1980 annual growth rate 2.5%
1980-1985 stable exports on 1980-level

3/ 1970-1975 stable on 1970-level
1975-1985 annual rate of decrease 5%

4/ 4. = 1. + 2. - 3.

c) Major uses for hardwood plywood

Hardwood plywood can be used for

- furniture, either as major material in areas where seasoned lumber is not available, or as decorative coverage of a wooden frame structure,
- decorative plywood such as interior cladding, door skins, moulded plywood,
- construction plywood such as concrete shuttering, plywood box beams, exterior cladding, building components (the latest edition of American Plywood Standard P.S. 1 - 74 approves the use of certain Asian species in the production of plywood which would qualify under their published load bearing and design specification.)

d) Trends of plywood and blockboard contra chipboard

The tendency to use chipboard (particle board) instead of plywood is always based on economical and not on technological reasons. In Europe, for example, where the plywood industry was widely replaced by chipboard producing companies, this process was only possible, because the costs for raw material for chipboard are just about 15% of the costs for raw material for the production of plywood. An additional problem is the different recovery, which made it possible to sell chipboard at prices of 25 to 30% of the prices of locally produced plywood. Even compared with imported plywood, chipboard prices are still as low as just 40%. This makes it most natural that chipboard is now used, whereever it is possible to replace plywood.

The chipboard tendency, however, will be limited towards this direction, because only in certain areas in the world, such as Europe, the United States, Australia and South Africa, such a cheap material is available, which enables the cheap production of chipboard as a competition of plywood. In other parts of the world and mainly in the developing countries with large forest resources the production of plywood is still much cheaper than any chipboard could be made.

e) Uses and demand of veneer

Consumption and demand of veneer is directly related to the fluctuations of fashion. Generally veneer provides a natural wood surface to a large range of wooden products, such as furniture parts, flush doors, wall paneling and partition etc. Depending on the everchanging fashion in those articles the demand of single species varies as much as the total demand of veneer altogether.

In this respect veneer must only be considered as the sliced or fancy type of veneer, because any peeled veneer is only a semi-product for the plywood production and is considered under the section on plywood.

Sliced veneer was usually produced in developed countries, but also in this part of the woodworking industry the shifting process has started many years ago and more and more of the veneer is already produced in developing countries.

f) Plywood and veneer production in developing countries

In the following table No. 7 a comparison is shown for the different countries demonstrating their production output in relation to the number of producing factories.

Table II

Plywood and Veneer Production in Developing Countries

Country	Year	Production Plywood	Production Veneer	Factories Plywood	Factories Veneer
AFRICA					
Algeria	1971	23 000 m^3			
Angola	1971	5 700 m^3			
Cameroon	1971	10 000 m^3			
Congo (Brazzaville)	1972		87 352 m^3		4
Ethiopia	1972	2 500 m^3		2	
Gabon	1971	75 000 m^3			
Ghana	1972	46 761 m^3	667 m^3	5	1
Guinea	1971	2 000 m^3			
Ivory Coast	1972	29 000 m^3	55 000 m^3	3	5
Kenya	1972	15 236 m^3		2	
Malawi	1973	1 000 m^3			
Mozambique	1971	7 100 m^3			
Morocco	1972	22 000 m^3	900 m^3	3	2
Nigeria	1972	39 000 m^3	11 323 m^3	3	4
Swaziland	1971	3 700 m^3			
Tanzania	1972	1 110 000 m^2		2	
Tunisia	1972	650 m^3		1	
Uganda	1971	5 600 m^3			
Zaire	1971	20 000 m^3			
ASIA					
Burma	1971	10 000 m^3			
Cambodia	1971	4 000 m^3			
People's Rep. of China	1971	904 000 m^3			
Hongkong	1971	10 000 m^3			
India	1971	110 000 m^3			
Indonesia	1971	6 600 m^3			
Iran	1971	14 000 m^3	10 000 m^3		
Israel	1971	107 700 m^3			
South Korea				14	
Laos	1973	11 900 m^3	11 900 m^3	1	1

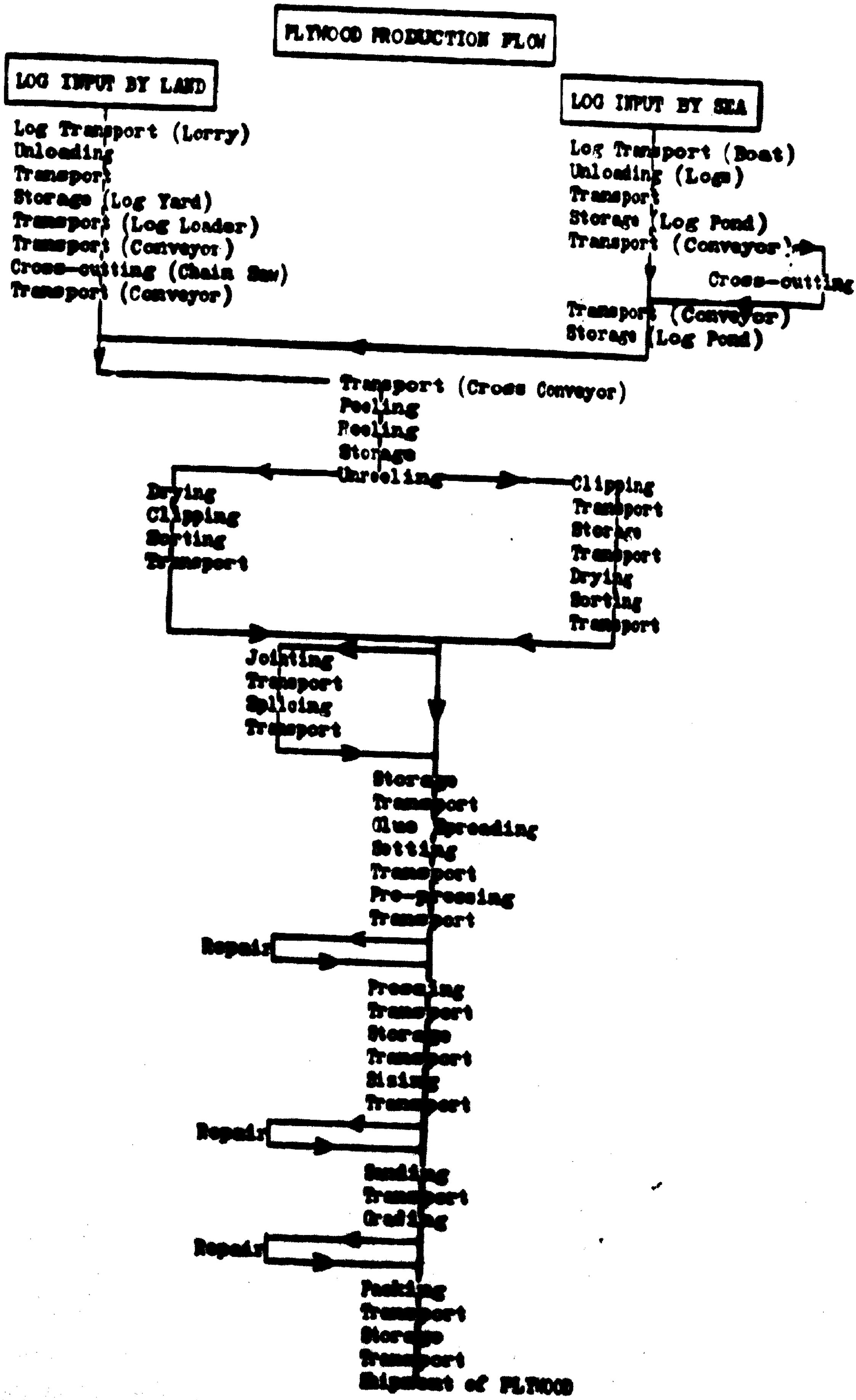
Country	Year	Production Plywood	Production Veneer	Factories Plywood	Factories Veneer
ASIA					
Lebanon	1971	33 700 m^3			
Sabah	1973	ca. 25 266 m^3	ca. 28 068 m^3	3	2
Sarawak	1972	3 034 000 m^2	1 213 000 m^2	2	
West Malaysia	1972	67 080 063 m^2	80 [illegible]26 461 m^2	35	
Mongolia	1971	3 000 m^3			
Pakistan	1971	6 000 m^3			
Rep. of the Philippines	1972	73 037 829 m^2	1 803 755 m^3	24	23
Ryukyu Islands (Okinawa)	1971	60 000 m^3			
Singapore	1972	68 579 000 m^2	22 099 000 m^2	13	
Sri Lanka (Ceylon)	1972	2 780 608 m^2	44 934 m^2	2	
Syria	1971	11 900 m^3			
Thailand	1972	65 761 m^3	13 134 m^3	2	5
Turkey	1971	53 000 m^3			
Rep. of (South) Vietnam	1972	10 100 m^3	10 750 m^3	1	
LATIN AMERICA					
Argentina	1972	56 000 m^3	5 000 m^3	33	18
Bolivia	1972	1 500 m^3		1	
Brasil	1971	336 000 m^3	377 000 m^3		
Chile	1971	10 500 m^3			
Colombia	1973	68 000 m^3			
Costa Rica	1972	31 520 m^3	3 189 m^3	2	1
Cuba	1971	2 000 m^3			
Ecuador	1971	19 000 m^3			
Guatemala	1971	3 000 m^3			
Honduras	1972	11 585 m^3		2	
Mexico	1971	99 400 m^3			
Nicaragua	1971	16 500 m^3			
Panama	1971	12 300 m^3			
Paraguay	1971	6 800 m^3			
Peru	1971	21 500 m^3			
Surinam	1972	19 800 m^3		1	
Uruguay	1972	5 027 m^3		7	3
Venezuela	1971	40 000 m^3			

Country	Year	Production Plywood	Production Veneer	Factories Plywood	Factories Veneer
OCEANIA					
Fiji	1972		1 022 m^3		1
Papua New Guinea	1971	18 400 m^3		1	
Western Samoa	1972		1 700 m^3		1

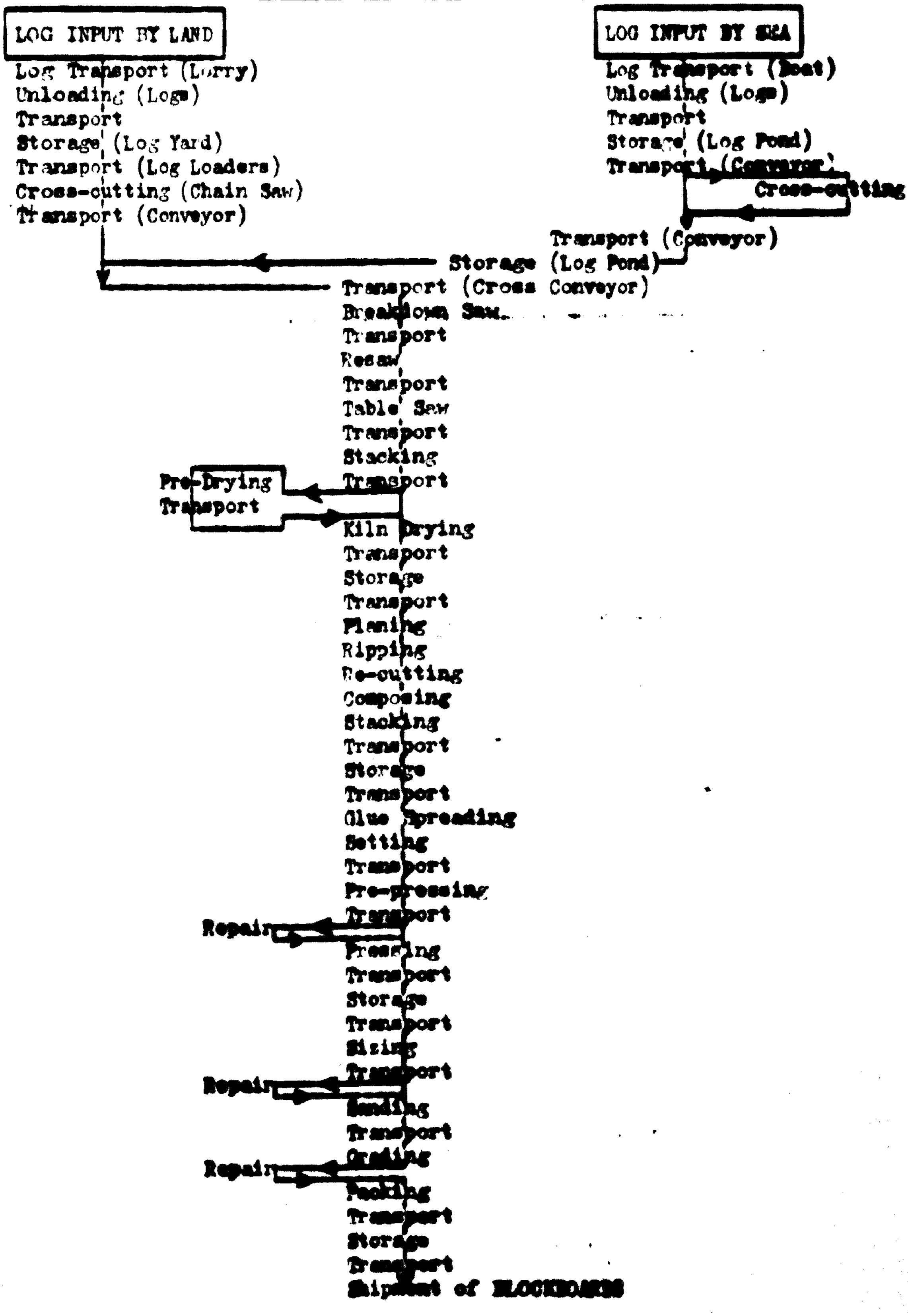
Source: World Wood Magazine.

3) Production Flow

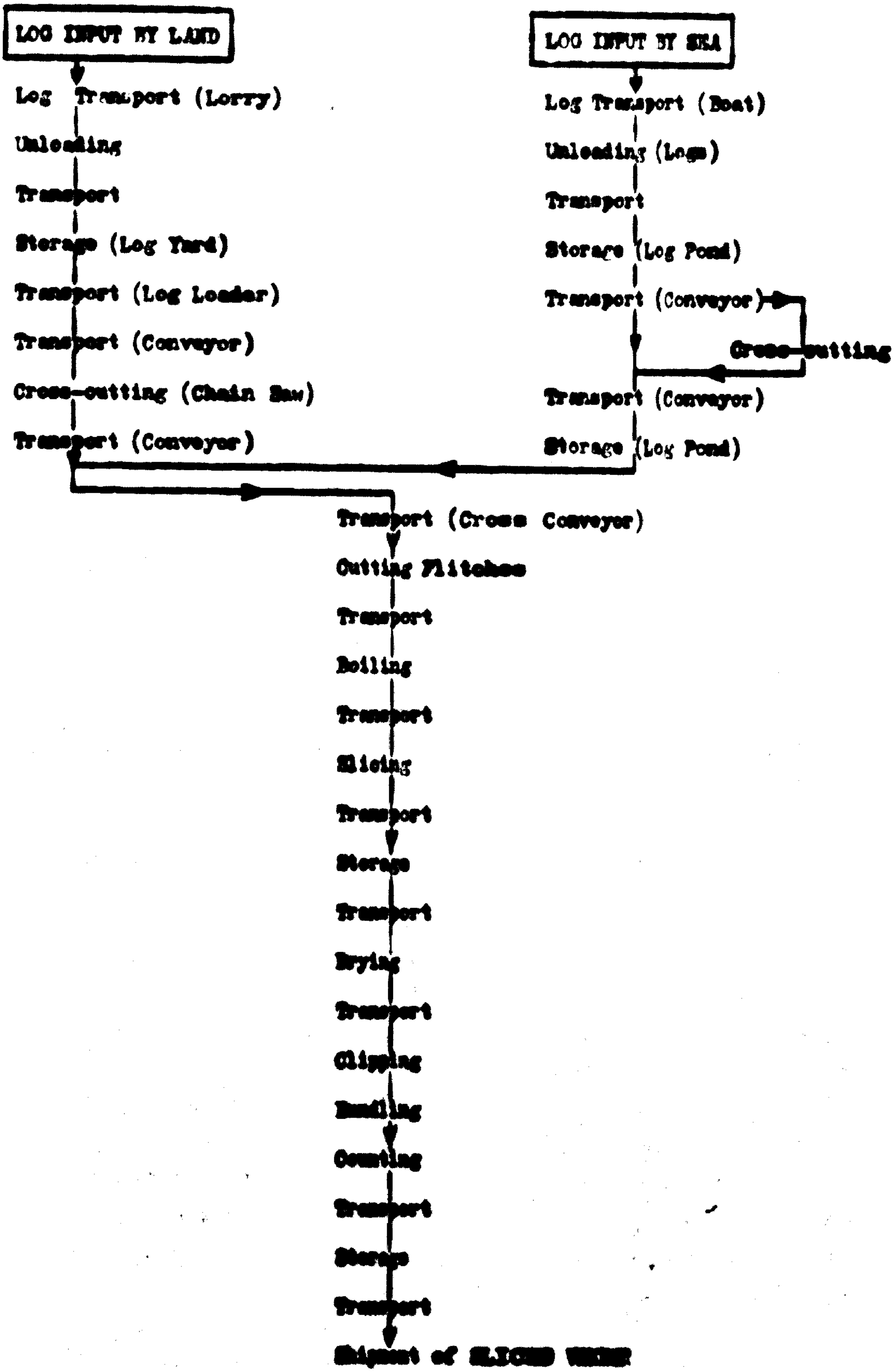
In the following production flow charts the different steps of production are demonstrated between the input of raw material and the output of the finished product. The annexed tables are self-explanatory and details of the various production systems in connection with each different production step are given in chapter 4).


PLYWOOD PRODUCTION FLOW
LOG INPUT BY LAND
Log Transport (Lorry)
Unloading
Transport
Storage (Log Yard)
Transport (Log Loader)
Transport (Conveyor)
Cross-cutting (Chain Saw)
Transport (Conveyor)
LOG INPUT BY SEA
Log Transport (Boat)
Unloading (Logs)
Transport
Storage (Log Pond)
Transport (Conveyor)
Cross-cutting
Transport (Conveyor)
Storage (Log Pond)
Transport (Cross Conveyor)
Peeling
Reeling
Storage
Unreeling
Drying
Clipping
Sorting
Transport
Clipping
Transport
Storage
Transport
Drying
Sorting
Transport
Jointing
Transport
Splicing
Transport
Storage
Transport
Glue Spreading
Setting
Transport
Pre-pressing
Transport
Repair
Pressing
Transport
Storage
Transport
Sizing
Transport
Repair
Sanding
Transport
Grading
Repair
Packing
Transport
Storage
Transport
Shipment of PLYWOOD

BLOCKBOARD PRODUCTION FLOW



SLICED VENEER PRODUCTION FLOW



4) Production Systems

4 A) Plywood

a) Log handling for plywood

As far as log handling is concerned it usually starts with the delivery of the logs at the factory site. Such a delivery might be done by boat with unloading from the vessel directly into the company's own log pond, but it might also be realised by means of lorries carrying the logs directly into the factory area and unloading at the log yard or log pond. In certain areas logs are also delivered to the factory site by the railway with again direct unloading into the factory's log yard or log pond. Dry land storage often results in insect and fungus attack. This can be prevented through chemicals added to the water spraying system (in some areas men equipped with a back-pack spraying device even treat the logs in the forest immediately after felling).

Storage of the logs at the factory site differs greatly and depends mainly on the local conditions. Wherever it is possible in tropical areas the logs will be stored in a log pond, which might also be a fenced part of the sea or of a river bed. The reason for such a storage of the logs in a log pond is mainly for green peeling, which means that the logs will be taken out of the log pond directly into the rotary lathe for the peeling operation.

In non-tropical countries it might be necessary to heat the water during the cold season to avoid freezing of the log pond and the logs. Wherever such a natural log pond is not available or an artificial log pond might be too expensive, logs will be stored in the log yard. The same happens for sinker logs, for which storage in the water is impossible. Dry land storage often causes splitting of log ends with the result of a lower recovery. It is very important to take any measures to reduce splitting. Some protection is available through petroleum spraying and "S"-hooks (metal or better plastic) or the more effective metal spike anti-splitting plates.

Handling of the logs in the log pond or at the log yard usually starts with grading, which means that the logs after the unloading will be selected and graded according to further production requirements.

From the storage area the graded logs will then be brought by means of cranes, conveyors or sometimes manually to a cross cut saw, where the log ends will be cut away and where the logs will be cut to the required size for further operation. Cutting of the logs by means of a portable chain saw is wasting material, because the cut will never be rectangular to the length of the log, which means that a considerable percentage of the raw material will be wasted at the next machine. It is, therefore, advisable to have a stationary chain saw for the cutting process installed. Wherever conveyor lines for the log might be too expensive or too sophisticated, the logs should at least be carried on a railway lorry, whereby again it is decisive that the stationary chain saw is perfectly rectangularly installed to the railway line. If the lorries are equipped with V-shaped layers for the logs the maximum provision is made to get rectangular cuts.

Important part of the log handling before operation is also the debarking process. Wherever labour is cheap debarking might be much more economical to be done manually with simple debarking irons, whereas countries with higher costs for labour will prefer to install conveyers and a mechanical debarking system. Debarking of the logs may be done in the log yard or in the forest, conditions will vary by species and country.

Small diameter logs will usually be sent through rotary debarkers, while large diameter logs will be debarked in machines rotating the log underneath a travelling debarking head. Further transportation of the logs to the peeling operation can be either manual or mechanical, whereby the decision will always depend on the number of logs required per hour and lower costs for log handling. Generally, it can be said that operating on small log diameters requires always a large number of logs to be operated per hour to get a certain factory output guaranteed, which again must be in a certain relation to the investment. For this reason plywood factories working on small diameter logs will usually have a fully mechanised system for the log handling including cutting to size and debarking.

b) Peeling - drying

Particularly in this section of the production flow it is decisive to select the machines and the production system in accordance with the diameter of the logs being available. As mentioned before it is generally necessary to have a certain output in a plywood factory to keep the capital costs for depreciation and interests in a certain range, which will be considered in a later section. To keep the capital costs low it is necessary to have a certain high output from the factory, which again requires a very different number of logs to be peeled for either small or large diameters. On very small diameters, such as in Finland or the Southern Pine plywood industry in the United States it is necessary to peel as much as 200 to 400 logs per hour to get the necessary output figure, whereby in factories operating on tropical timber it might be acceptable to peel only 6 to 8 logs per hours. The large difference in the number of logs to be peeled per hour demonstrates the difference in handling of the logs and the veneer. If, for example, small diameter logs will have to be peeled in large numbers, it is obligatory to have the transportation of the logs from the log yard to the rotary lathe completely mechanized. Also centering of the logs and charging into the rotary lathe will be completely mechanized and partly automatic. This automation goes that far that in the United States sometimes the rotary lathes will not even be stopped for taking out the peeler core and charging the fresh log into the machines, but the spindles will continue rotating during this automated process.

On such operations with small diameter logs, the best method has proved to be a tray system installed after the rotary lathe, where the short veneer ribbon is sent into the different decks. Peeling of the logs will always be done in rotary lathes being equipped with telescopic spindles to enable a maximum of output and recovery out of the small-size logs. On the other end of such a tray system it is common practice to cut the veneer to the required size and, depending on quality requirements, to cut out defects before the veneer will be sent to a roller veneer dryer. Loading of this roller dryer might be manual or mechanized by means of an automatic loading system. At the outfeed side of the roller dryer the veneer will usually be graded according to size and quality, which might be done strictly manually or on a grading conveyor or rotating table.

When operating on logs with larger diameters, such as 500 mm or 20" up, the machinery being selected for peeling and drying is usually a different one. Logs might also be brought to the rotary lathe on conveyors and might also be mechanically centered and charged into the machine, however, it is not obligatory to do so. In the other case usually simple hoists are being used to carry the logs near to the machine. At this position the centering will be done manually by simply measuring the diameter crosswise and fixing the center point. Loading into the machine will then be realized by the same hoist, which will lift the log into the machine. The labour force must arrange for the centralized clamping of the log in the machine. Naturally, this operation takes more time, which must be considered as a loss of time, because during this period the machine cannot produce any veneer. For this reason a rotary lathe being equipped with a centering and charging device will be producing approximately 40% more veneer than a machine being operated manually.

The rotary lathe itself should preferably also be equipped with telescopic spindles allowing for smaller diameters of the peeler cores being waste. Modern machines also provide for high revolutions in the range of 200 to 300 rpm and variable speed drives. The drives should be over-powered to allow for the slow turning of the lathe when starting. The quality at the veneer peel is very important and depends to a great extent on lathe settings. Literature is [illegible] available regarding the peeling of hardwoods, refer "Veneer Species of the World" as published by the Forest Products Laboratory, Madison, Wisconsin, USA, on behalf of IUFRO, also from the Centre Technique du Bois of Paris, France.

When operating on large diameter logs, the veneer ribbon is much longer than it is on small diameter logs. Additionally, it is normally the fact that small diameter logs will be peeled for construction plywood and the veneer thickness is in the range of 2 or 3 mm, thus giving again a very short veneer ribbon out of the small diameter log. Contrary on the large diameter logs the product is mostly thinner plywood for decoration or other similar purposes, whereby the veneer thickness is just 0.6 mm. In such a case the veneer ribbon being peeled off a log with 1 m diameter might be several hundred meters long. On such long veneer ribbons it is not practicable to have a tray system in operation, because such a tray would have to be of a tremendous length. For this reason the reeling system has been developed and particularly for thin veneer it is necessary to use the fully synchronized reeling system. In this case the speed of the surface of the rotating log will be electrically or electronically determined and will be synchronized to the surface speed of the reeling system. This happens fully automatically and the rotary lathe operator has usually only one additional handle, where he can control the reeling operation by just arranging for some minus or some plus tendency to the synchronization.

On such an operation it is desirable, but not necessary to have a chain conveyor in front of the rotary lathe for the removal of the peeler cores and a waste conveyor after the rotary lathe for the removal of the peeling waste.

The round-ups are generally a problem in this system, because they cannot be reeled (without very expensive and not very common equipment) and must be taken out of the line. This happens either manually by selecting those round-ups on little carriages or mechanically by installing a rubber conveyor, which will carry the round-ups out of the production line on another carriage, from where the round-ups will be taken to the round-up clippers.

Drying of such veneer, which is peeled from large diameter logs can either be done continuously or in a roller dryer.

In the continuous drying system the veneer will be stored in reeled condition in the reeling magazine until it is brought to the unreeling station. A synchronizing device at the unreeling system provides for sufficient, but not too much veneer to be sent into the continuous veneer dryer. In this kind of a dryer the veneer will be dried as a ribbon and the design of the dryer must provide for giving the veneer sufficient possibility for shrinkage to avoid any cracking or splitting before it leaves the dryer. The unsplit and uncut veneer ribbon will then be sent to the clipper, where defects will be cut out and the other veneer will be cut to the required size. Directly after the clipper usually a conveyor is installed, from which the veneer will be graded according to quality and size.

This system of continuous veneer drying provides the advantage of saving some 3 to 6% of material, because no allowance for an uncertain shrinkage must be given to any precut veneer sheet. Instead the veneer will first shrink in the veneer dryer and the cutting after drying can be done very precisely just considering the minimum of oversize for the further production.

The other system provides also for a reeling storage in which the reel veneer will be stored for a certain period. Usually this storage is much smaller, because the cutting of the veneer in green condition can be done with a continuous change of thin or thick veneer (for either face and back or core), whereby the different veneer thicknesses will just be stacked on different veneer stacks. In the continuous veneer drying operation it is, however, necessary to provide sufficient veneer reeling storage to operate the dryer for a certain period on the same veneer thickness. When changing the veneer thickness the drying time will be different and such a change requires always that the dryer must first be emptied before the change can be done. This again represents a certain loss of time, if it is done every hour. For this reason the continuous veneer drying system usually provides for sufficient storing space for the reeled veneer to make it possible that long periods of the same veneer thickness can be dried in the dryer. Also the dryers are usually equipped with more than one deck and the decks are having a separate drive making it possible to utilize one deck for thin and another deck for thick veneer mainly.

Back again to the so-called "wet clipping system" the veneer will also be brought to an unreeling station, which, however, requires no synchronisation system, but just a simple drive. The veneer ribbon will be sent through a green clipper and veneer defects will be cut out and the cut veneer will be cut to the required size. This veneer, which will be cut to the required size must be given a considerable shrinkage allowance, which might be unnecessary. Practice has shown that the shrinkage factor for a certain veneer species theoretically is a fixed figure, which, however, does not apply in the practical operation. In such an operation it depends very much on the initial and final moisture content as well as on a number of other drying conditions. According to such conditions the shrinkage of one species and veneer thickness might vary considerably between, for example, 6 and 12%. In such a case, which can easily be demonstrated at any dryer, it is necessary to give the green veneer sheet generally an allowance of 12% for shrinkage. The dry veneer will, however, show that the actual shrinkage only sometimes was as high as 12%, but in other cases as low as only 6%. In this case a considerable oversize has been wasted, because it cannot be used anymore. This, actually, demonstrates the economical advantage of the continuous veneer drying system.

It is, however, not always possible to install only continuous veneer dryers, because these require a mass production, whereby a production, which provides for a large range of sizes and thicknesses (and probably also wood species) will not be very practicable in the continuous veneer drying system. Additionally comes the fact that all round-ups must be cut to size in green condition. For this quantity of veneer, which usually represents some 20% of the total, the continuous veneer drying system is impossible. For this reason and for the reason of providing sufficient flexibility to a plywood mill the practice has shown that it is most advantageous to combine both systems in a way that a certain part of the veneer will be dried in a continuous dryer and all the rest passes through a roller dryer.

At the end of this paragraph the Finnish system must be mentioned, which also includes a fully mechanized centering and charging system for the rotary lathe. This machine will usually be installed in a very high position. The veneer ribbon will then be sent via conveyors overhead of the continuously operating veneer dryer, which will be fed from the opposite side. The veneer will pass through the veneer dryer in various S-lines and will leave the veneer dryer on the opposite side again being fed straight into the dry clipper. This system works without any tray system or reeling system and the missing storage of the green veneer will be equalized by the fact that the rotary lathe operator can see the veneer ribbon and can speed-up his peeling machine as long as the new ribbon reaches the last one. Only then he will slow down his machine to the drying speed. It is naturally necessary with this system to arrange for very fast loading of the rotary lathe to avoid any empty zones in the veneer dryer. This system, however, is only desirable for small diameter logs.

c) Jointing and splicing

This is the section of the production where all veneer which was not produced in full suze will be handled. The operation of this section and the equipment being used will very much depend on quantity and quality requirements of the production, but in the same range also on the quality of the raw material. In Japan, for example, a mass product such as door skins will be produced on fast operating continuous veneer dryers with following rotary veneer clippers cutting permanently all veneer into the same size. The quality of the selected raw material is good enough to allow for the same quantity of lower quality back veneer sheets as higher quality face veneer sheets in the production. Also the quality of the logs for the core veneer is still high enough to allow the same system.

As an opposite case, the production of softwood plywood in the United States can be considered. Quality requirements are there so low that no defects have to be cut out and all veneer can also be cut into full size sheets not considering any defects.

But those two examples are the extreme outsiders, whereas the wide range of normal production conditions requires handling of a considerable quantity of veneer, which is not cut to full required size.

The handling of this veneer has got also a very wide range. In simple operation those veneer strips are neither jointed nor spliced together, but will usually be sent through the glue spreader in the small form and will just be laid together at the setting stack as long as the full width of the required veneer size is reached. Any oversize will then not be cut, but simply torn away. Such a production usually also allows for patching of the core veneer, which saves cutting into smaller strips and keeps full size veneer sheets together, just patching out the defects.

When it comes to higher quality requirement, jointing and splicing of the veneer strips will be necessary. The same is required, if it comes to high production figures, which do not allow for the time consuming setting of unspliced core veneer.

The jointing of the veneer strips is done on travelling head jointers, on jointing machines where the head is stationary and the veneer travels overhead of it, and on simple guillotines. Some of these machines provide also the glue application in one operation, while others require glue application afterwards.

For the splicing also a wide range of machines is available ranging between the old taping machines, which are now mainly replaced by Zig-Zag or spot glue splicers. All those splicing machines operate in fibre direction. Also splicers providing a close glue splicing of the veneer sheets are available and very successfully in operation. Also those ones operate in fibre direction.

There are also cross feed splicers on the market, whereby the glueing of the veneer sheets is either done in a pressing operation or during the passage of the veneer through the machine under a certain feeding pressure in connection with heat supply. All those cross feed splicers are also equipped with clippers cutting the endless veneer ribbons into veneer sheets of the required size.

Under simple conditions and particularly, where the labour costs are low, it is naturally possible to do the splicing operation manually by means of manual tape application. In some factories the hardening of the glue will be assisted by the usage of irons.

A new development was made in Japan a number of years ago, where jointing and splicing is done in one machine. The veneer strips will be fed into the machine across the fibre direction. A knife will first cut the veneer and provide a straight edge. This veneer will then be forwarded against the opposite straight edge of the last veneer and at the time, when both edges join together either spot glue or spot taping will be provided from the top. At the same moment the spliced veneer will be fed out of the machine and the same knife, which is used for the jointing operation, cuts the veneer sheets also to the required size. The veneer sheet will be automatically fed out of the machine and stacked after the machine. This system is very advantageous with respect to the requirement of labour, but is has the disadvantage that it does not provide a glue line between the veneer sheets, which is definitely required for certain plywood qualities.

At the end of this section all veneer is available in full size as it is required for the further production. Usually this section also includes a careful repairing of the veneer sheets and the grading and setting. In the grading operation not only face and back qualities will be separated, but also the different qualities according to the grading rules.

In the setting operation it is quite common to have one face and one back veneer always laid together for the easier setting of the veneer stack after the glue spreader. This applies, however, mainly in such factories, where pre-pressing is in use.

d) Pressing

The pressing section usually begins with the glue spreader, where the core veneer is sent through and is glued on both sides. Other forms of glue application are by hand in very simple operations (which is not advisable because the quantity of glue application is very uneven) and by means of curtain coating or spraying machines. The latter, however, provide only one side glue layer, whereby the ordinary glue spreader will apply glue on both sides of the core veneer at the same.

Depending on the production method sometimes the plywood will then be laid together in single sheets, meaning that only the number of layers will be laid together which are required for one plywood sheet. This method is mainly used where pre-pressing does not exist and where coils or tablets are available for the loading of the hot press.

In modern operations, however, it is common to set veneer stacks of a height up to 1 m after the glue spreader, whereby always one face, one core and one back veneer are set on top of each other and always one sheet following the next until the stack height is reached. Such a set stack will then be taken via a roller conveyor into the cold press, where it will remain for some 12 to 15 minutes time for pre-pressing. This pre-pressing does not actually shorten the pressing time and a technological effect can hardly be shown, but it is mainly used to allow the veneer sheets to stick better together and to allow the easier handling of the pre-pressed plywood, when sending it to the hot press. This applies in the same way for manual loading of the hot press as it applies for automatic loading equipment.

Between the cold press and the hot pressing operation usually a quality control is done to repair any possible overlapping, which may have happened during the pre-pressing operation. This is another advantage of pre-pressing, because this overlapping may otherwise happen in the hot press and may not be repairable.

When deciding about a hot press it is always worthwhile to consider whether this one should be loaded manually or by means of an automatic loading device.

The practice has shown that hot presses up to 15 openings can be loaded and unloaded manually relatively fast, so it is not necessary to have any automatic equipment for it. Also from the economical point of view it is not advisable to have an automatic loading and unloading device for such hot presses, because this equipment might cost nearly as much as a second hot press and might improve the cycle time by not more than just 20 to 30%. However, it is imperative that when using manually loaded presses the period of time between the loading of the first panel and the application of the full pressure should not exceed one minute to prevent pre-curing of the glue.

When it comes to higher production figures and a certain mass production, which means that the fluctuation of thicknesses, sizes, and species is not very big, it is advisable to install hot presses with more than 15 openings and automatic loading and unloading equipment. Pricewise it was demonstrated by the manufacturers that a hot press with 30 openings will not cost very much more than such one with just 20 openings. For this reason it is usually practicable to decide whether one hot press with 30 or more openings should be installed with automatic loading and unloading device or whether a number of 10 or 15-opening hot presses should be set up for manual loading and unloading.

The decision, which kind of hot press has to be taken, is not only depending on the production quantities, but naturally also on the costs of the labour and the relation between output and investment costs.

Usually only one sheet of plywood is loaded into one opening of the hot press, but there are also presses available, where the plywood will be manufactured in double-size or where two sheets of plywood will be loaded into one opening either one besides the other or one on top of the other.

There are also single opening hot presses available particularly for larger size of plywood. The largest of these single opening hot presses for plywood is operating in Australia since many years and produces a final plywood size of 50' x 9'. Otherwise single opening hot presses are mainly in use for laminating of plywood or blockboard with fancy veneer or melamine paper.

Reason for any pressing faults are mainly precuring or incorrect moisture conditions. Precuring is one of the reasons why presses with more than 15 openings should not be loaded manually. Even with a very trained and skilled crew it is almost impossible to reduce the loading time of plywood into the hot press per openings below 4 seconds. But even under such ideal conditions it takes already one minute between loading of the first sheet into the hot press and the end of the loading operation, which means the beginning of the closing operation of the hot press. The first plywood sheet is, therefore, under the influence of the heat of the hot press for one minute without being pressed together. The glue must be mixed in a certain way to allow for such a long time under heat influence without any precuring effect. Otherwise this will be a defected plywood sheet, which has to be rejected afterwards. But the adjustment of the glue cannot simply be done towards too long pot life, because this would also extend the time being required for the pressing operation. In this case the cycle time of the whole pressing operation would be too long and the output too low.

For this reason the practice has shown that it is advisable to have a maximum of 15 daylight openings, if manual loading of the hot press is considered.

Other pressing defects may result out of moisture problems. If veneer is too dry, the water of the glue will be absorbed into the veneer to increase the wood moisture content and will not be available for the distribution of the glue and the hardening process. On the opposite side too wet veneer will cause too much development of steam in the hot press, which may result in glue bubbles or even explosions when the hot press is suddenly opened.

It is advisable to check the moisture content of the veneer first if any pressing defects are realized. Quality control must be very strict to avoid a high percentage of rejects due to such reasons.

g) Sizing - sanding

In the ordinary operation the plywood will be stacked after the hot press before being sent to sizing and sanding operations. Such a stacking and any further storage of the pressed plywood is not technologically required, but is mainly advisable, if the range of sizes and thicknesses in the production is large and the machines for sizing and sanding must be continuously adjusted. In such a case it is better to collect a larger number of plywood stacks of the same size and thickness before sending the material through sizing and sanding operation.

In a mass production it is, however, possible without any technological problems to unload the hot press directly into the feeding conveyor of the sizing machine and to continue with such plywood sheets being sent directly through sanding and grading afterwards. Also so-called cooling wheels, where the plywood sheets have been turned 180 degrees in a large wheel, while being blown with fresh air, have proved unnecessary and have mostly been disassembled again.

When considering sanding it is also important to determine what the sanding operation is supposed to do. On Asia's mass production plywood factories, for example, it is very common to operate with one bottom wide belt sander for calibrating the plywood and providing a rough sanding at the plywood back. Here usually an eighty-grit sanding paper is used.

The second sanding machine is then a 3-head top wide belt sander. The first head usually is a contact roller with an eighty-grit sanding paper. The second and the third head are usually equipped with cushions and the paper is 150 and 250-grit. The grit of the sanding paper naturally depends very much on the required quality, but also on the wood species being used.

Technologically seen under such an operation the bottom sander provides for the main calibrating, while the first top head also gives a certain calibrating effect. The second and the third top heads, however, provide only polishing of the plywood surface.

The end of the production line is mostly seen with grading of the plywood and repairing any defects. Quality control in this section is most important, because right after this operation the plywood will be stacked and packed for delivery.

f) Quality control

Quality control is the key to all steps of plywood production from the lathe (smoothness and thickness tolerance) through the dryer (moisture content) through splicing (close joints) through the pressing section (glue mix and even spread, assembly, press time and core overlapping and gaps) and ending with the cutting and sanding tolerances and the grading process.

g) Recovery

Normal expected recovery would approximate 50% of round logs input for large diameter logs. The following defines the average losses at the different production stages:

round log input	=	100.0 %
wet waste	=	12.0 %
peeler cores	=	8.0 %
= wet veneer	=	80.0 %
shrinkage	=	8.0 %
= dry veneer	=	72.0 %
dry waste	=	7.0 %
= spliced veneer	=	65.0 %
pressing loss (volume)	=	1.0 %
= pressed plywood	=	64.0 %
dry waste	=	7.0 %
sanding dust	=	6.0 %
rejected plywood	=	1.0 %
= marketable plywood	=	50.0 %

4 B) Fancy Sliced Veneer

a) Log cutting for veneer

For the production of sliced veneer there is always the first decision to be made, whether complete logs or cut to size flitches should be steamed or boiled. Whereas the steaming of logs reduces the danger of end cracking, the steaming of flitches has become more common, because the steam pits can be filled with larger quantities and the steaming happens faster due to the faster heat transfer.

In the usual operation it is, therefore, common to send the logs to the band saw first, where they will be cut to flitches. Those flitches will then be taken to the steam pits and out of the steam pits straight to the slicer. Since it is most important to have the flitches as hot as possible in the slicing machine, they will usually be left in the steam pits right until being taken into the slicing machine.

b) Steaming - boiling

The question whether any wood species must be steamed or boiled cannot be answered generally, but must be found out by experience. The fact is that boiling keeps the flitches in the water and the moisture content of the wood will rather be increased than decreased.

Steaming is used more extensively but some species must be boiled to protect the colour or maintain a smooth surface if the species has interlocked grain.

In the steaming operation, however, the decrease of moisture content is unavoidable, since pressure cannot be applied and even under ideal conditions of 100°C. and 100% relative air humidity the wood moisture equilibrium is just around 28%. Any higher wood moisture content in the flitches will, therefore, be trying to transfer the water from the wood into the surrounding hot air. This drying effect causes cracking and splitting particularly, if the heating capacity of the steam pit is very high and the heating-up process of the flitches is very fast. Then not only the difference between actual wood moisture content and wood moisture equilibrium of the surrounding air, but also expansion tensions will cause such a splitting. It is, therefore, advisable to arrange for a slow heating-up process of the material to be steamed in the pits.

The question, whether direct or indirect steaming should be arranged, is easy to be answered, because the direct steaming results in a large loss of water, while most of the steam can be returned to the boiler as condensed water in the indirect steaming system. But not the loss of water only is important, but the fact that any softening and degassing device for the boiler must be much larger, if great quantities of water are continuously lost in a direct steaming operation.

The required time for steaming or boiling of the flitches is also a matter, which usually is found out by experience. Altogether it can be said that steaming and boiling of wood is still the most unknown part of the production with regard to technological questions. But even without a scientific technological background, it can be stated that the influence of the heat is the decisive one and much more important than the influence of the moisture, which is not even given, when steaming is done.

c) Slicing

After steaming or boiling the flitches will be sent quickly to the slicing machine. There are three different kinds of slicers available in the market, horizontal ones, slanting ones and vertical ones. Generally it can be said that horizontal ones are providing the maximum of accuracy, while the vertical ones are the fastest operating machines.

The latest development has been when slicing and drying operations were combined into one continuous production flow. This is so far only possible with vertical and slanting machines. The veneer will be guided by means of converyors out of the machine and into the direction of the dryer. On its way between the slicing machine and the dryer the space between the single veneer sheets will be reduced to almost zero to allow a maximum of coverage of the drying space in the dryer.

In slicing it is essential to have machines where the knife angle and pressure bar opening can be adjusted according to the requirement of the species.

d) Drying

When the continuous process is used, the veneer sheets will enter the dryer on the end, which is next to the slicing machine. In at least three decks in S-form the veneer will pass through the veneer dryer and will leave the dryer on the opposite end, where mostly an automatic stacking device is installed.

This automatic system is applicable only for certain veneer species, whereas others such as Aformosia require a storage period between slicing and drying. If such a period is required, it is necessary to stack the veneer after slicing operation and to keep the stacks in storage for a certain period of time. Afterwards feeding of the dryer is mainly done manually and the dryers being used are mainly two-deck dryers with the same drying direction of both decks. Unloading of the dryers is then again done manually and the number of sheets will

will be counted to have the single packets ready for cutting at the guillotines and bundling. Such before-mentioned two-deck dryers can also be equipped with automatic loading and automatic stacking devices. There are mechanical handling problems when drying very thin veneers. Such veneers (0.3 mm and less) are generally air dried.

e) Guillotining

Those packets of 15, 20 or more veneer sheets of always more or less the same veneer grain will then be sent to the guillotine, where they will be cut on all four ends. The next step of operation is then bundling, which can either be done manually or by means of a machine. Also the recording of the production can be done manually by simply measuring width and length and multiplying it by the number of sheets or by small computers, which do the measuring and counting automatically and provide immediately complete lists giving surface and all the other data in one step of operation.

If a veneer factory produces not only for its own consumption or for laminating of its own plywood, it is most advisable to have a large final storage building available, which serves at the time as sales building. It is most common that buyers want to see a large range of products and want to select the qualities they require. For this reason such a large storage building is very necessary and advisable.

f) Quality control

Quality control concerns mainly thickness tolerance and moisture content. European standards allow thickness tolerances of ± 0.03 mm and moisture contents between 8 - 14% depending on the species.

g) Recovery

Normal expected recovery would approximate 50% of round log input. The following defines the average losses in different production stages:

round log input	= 100 %
log off-cuts, saw dust	= 23 - 28 %
flitches	= 77 - 72 %
slicing waste	= 9 %
green veneer	= 68 - 63 %
shrinkage	= 5 %
dry veneer	= 63 - 58 %
trim waste	= 13 %
marketable veneer	= 45 - 50 %

4 C) Blockboard

a) Blockboard core material

The production of blockboard in independent factories is mainly known in central Europe, while in developing countries it is most common to add a manufacturing line for blockboard to a plywood factory to make use of the peeler cores and some lower class logs.

Under such conditions usually the peeler cores will be collected after the rotary lathes and will then be sent to a band or gang saw, where they will be just cut into 1" planks. Those planks will be stacked and prepared for drying.

In a plywood factory with one or two rotary lathes the recovery on the logs is already so good and the volume of the remaining peeler cores already so small that one core composer cannot be fed only with the material from the peeler cores. For this reason it is advisable to utilise also lower class logs for blockboard production rather than for low class plywood. It is a fact that the prices for blockboard are almost as high as for plywood of the same thickness, whereas plywood requires high class veneer layers and glue lines in between, while blockboard is made out of a one-layer core with only two glue lines and very little glue for the glueing of the strips together.

If a saw mill is existing, it is also very common to utilise the waste of the saw mill and the low class planks from the outside of the logs for the production of blockboard.

b) Drying

The 1"-planks coming from the saw or saw mill will not be square edged, but will be stacked in raw condition. If the moisture content is high, air drying is always an advantage, whereas it is also possible to put the stacks directly into the dry kilns.

Kiln drying is always necessary, since the glueing process requires a wood moisture content which is not obtainable from air drying only.

c) Core composing

The stacks with the kiln dried planks will usually be brought directly to the multiple rip saw, where they will be passed through. After the multiple rip saw a selecting process is necessary, whereby all those strips having not four sharp cut edges will be selected and recut on little circular saws to utilise the remaining good part.

These strips will be brought to the core composing machine, where a spot glue line will be applied to the side and under heat and feeding pressure the strips will be glued together.

There are other systems in use and have been in use before, where no glue is applied between the single strips and which will be held together by means of strings being pressed into a small groove, which will be cut across the fibre direction over the full width of the board. The system, however, does not provide for the glueing between the single strips and therefore each strip can move according to its moisture condition. This of course will not give a good product, because any warping of the final boards, due to moisture changes in the single strips, cannot be avoided. If the strips, however, are properly glued together, the tendency of one strip will be easier balanced by the opposite tendency of the next strip, thus causing a certain tension, but not allowing for such a warping of the final boards.

d) Blockboard production

When the core is prepared it will be brought to the glue spreader, however, not the core will usually be sent through the glue spreader, but the covering veneer layers. To utilize the two-side effect of the glue spreading operation, it is common practice to send two veneer layers through the glue spreader at one time to get one side each applied with glue.

When cold presses are available for the production of blockboard, it is very easy because the same system can be used as for the production of plywood by forming large stacks and sending them into the cold press first, before loading the single sheets into the hot press.

If this is not the case, it is neccessary to use either cauls for the carrying of the layed-sheets or to have a fully mechanised and converyorized system, which avoids any shifting of the single layers. Such a mechanized system is almost unavoidable, if large size blockboard is produced in 6' x 17' size.

There is a fully mechanized and endless system or the production of blockboard existing, which must be mentioned here, too. Under this system all three layers of the blockboard will be formed at the time and directly before the hot press. The smaller or wider sheets of veneer will just be layed into conveyors to be brought into the hot press. The lower veneer, which is endlessly glued together, carries at the time the core layer, which will be composed, while the whole system moves into the hot press. Setting of the core layer is just laying one strip next to the other and filling the whole area with such strips without any glueing process between the strips. All the strength of the board is only provided by the glue layers between the core and the covering veneer sheets.

The hot press is a single opening hot press, which is installed on wheels and which moves slowly forward while it is closed for pressing.

After opening it moves back fast and closes again with a certain overlapping range to avoid any pressing defect.

After pressing the sheets will be cut into the required size and stacked for grading and shipment.

This system provides an endless belt of blockboard, however, it does not provide glueing between the single strips.

2) Costs-Price Structure

a) World market price based

To determine a costs-price structure is very difficult, because not only prices of the products are fluctuating very steeply, but also the costs are a matter of a certain fluctuation. This is particularly the case, because the logs as raw material represent the major and decisive cost factor.

Based on the last high price period a calculation could be drafted as shown in the annexed table No. 11. Those conditions may represent an average between many other more extreme conditions.

As shown in this calculation the logs as raw material represent 46.5% costs out of the sales price. If under certain conditions, such as in Europe or Japan, the transportation of logs is very expensive, the costs for the logs in the factory may easily be double. In such a case the raw materials costs alone would increase the calculation by another 100.-US$. Such a tremendous increase of the log costs cannot be balanced by savings at the labour side nor at the depreciation or overheads costing factors. In such a case it is, therefore, necessary to increase the sales price considerably. This again, can only be done provided the local industry is protected by import restrictions. Otherwise the local industry will have to give up its own production and the import of plywood must cover the demand.

Naturally there are other areas available in the world, where the raw material costs are much lower than shown in Table 11. In such a case the profit margin might be considerably higher. But it is often the case that under such conditions people do not really care about the maximum of possible production, but their output is much lower than shown in the Table No. 11. In this case all the fixed costs, such as labour, depreciation and overheads will influence the calculation and balance a part of the advantage of the low raw material cost.

Table 11a

Average Calculation of Plywood

logs = 50.- US\$/m^3 : 0.5 recovery	= 100.00 US\$/m^3 = 46.5 %
glue 0.35 kg/m^2 x 250 m^2/m^3 x 0.40 US\$/kg	= 35.00 US\$/m^3 = 16.3 %
labour = 30 hrs/m^3 x 0.40 US\$/hr	= 12.00 US\$/m^3 = 0.5 %
depreciation and interests = 4 000 000.— US\$: 5 years : 36 000 m^3/year (10 000 sheets/day) x 1.6 (incl. interests)	= 35.00 US\$/m^3 = 16.3 %
	= 182.00 US\$/m^3 = 84.6 %
+ 10 % overheads and sales costs	= 18.20 US\$/m^3 = 8.4 %
total costs	= 200.20 US\$/m^3 = 93.0 %
+ profit before tax	= 15.00 US\$/m^3 = 7.0 %
= sales price (80.- US\$/1000 sq.ft.)	= 215.20 US\$/m^3 = 100.0 %

6) Summary

a) Shipping

The products should be adequately protected from shipping damage. Generally strong plywood or lumber crates are used. Currently no experience is available on the possible benefits of shrink-wrapping methods.

b) Balancing of machines

When producing plywood, veneer or blockboard in developing countries it is most decisive to have the machines properly balanced in accordance with the local conditions and one against the other. As mentioned before the right system has to be selected for each single step of production and the capacities of the single machines have to be properly balanced with each other. This means that the capacity should not be fixed in accordance with the availability of raw material and the prospects of the market alone, but also in accord with the main machines. In the practical operation it simply means that the dryers should be big enough to dry all the peeled veneer in the same time of operation as the rotary lathe operates and the jointing and splicing section again should be well equipped to cover the demand of jointing and splicing for all the dried veneer. Furthermore, pressing capacity should again be balanced to press all the available veneer into plywood also in the same time of operation as the other part of the factory works.

It sounds very simple, but the practice shows that it is far from the case in such factories in many countries in the world, but the machinery of a factory is not properly balanced if the rotary lathe works only one shift a day and the veneer dryer has to be in operation 24 hours a day plus Saturdays and Sundays.

Part of such a proper balancing is also to provide not too much, but sufficient allowance for production fluctuations. If, for example, a factory is designed for an average production of 4 mm plywood and it must then shift to a longer period of producing just door skins, the conditions will be quite different. There will be ample drying capacity, but the capacity of the rotary lathe might be insufficient.

Under such conditions it will be wise to consider overtime for the rotary lathe section and to work on ordinary production times with the other sections of the factory.

In the opposite, when such a factory is suddenly getting large orders in 25 mm shuttering boards the drying capacity might be rather small and insufficient. In such a case it will be advisable to have certain allowance considered in the drying capacity from the very beginning to avoid much overtime in this section.

Most important, however, is to get the machines working on maximum possible output. Here it is most important to compare with other factories and to collect figures from colleagues or competitors about their machinery output. If, moreover, a set of machines is operated on 50% of the nominal capacity only over longer periods, all the fixed costs for labour, depreciation and interests and overheads will immediately double and influence the calculations very negatively.

c) Optimum machinery selection

The second main important item will be the proper selection of machines. Here the paragraphs of this paper might be quite useful to determine, whether the one of the other machine is better for the local conditions. Not only the system must be evaluated, when machines are selected, but also the quality requirements must be taken into consideration. Cheap copies of precision machines or equipment, which is based on tremendous know-how, such as the veneer dryers, can simply not provide sufficient quality of the products. Very often it is possible to start a production with second-hand or home-made machines much cheaper than if buying expensive machinery from reputable companies, but after trial operation it must be realized that high quality standard simply cannot be obtained with such machines. For this reason it is most important to determine the quality requirements before final decisions baout machineries are made.

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PRODUCTION OF VENEER, PLYWOOD (INCLUDING CORE PLYWOOD) IN DEVELOPING COUNTRIES: AN ANALYSIS OF ALTERNATIVES 1/

by

Gotthard P. Heilborn *

SUMMARY

Plywood is a multilayer combination of veneer sheets making up a sheet or panel material useful for a large variety of products, especially furniture and building construction. It has very high strength-to-weight properties and is less influenced by economies of scale in production than other wood-based panel products. Veneer is both a raw material for plywood, when peeled, and (as here considered) a decorative and strength-giving surface finishing for panel products when sliced or sawn. Its thickness can range from 0.1 mm or even less to 0.3 mm and 0.8 mm. Blockboard is composed of strips of wood glued together and surfaced with veneer. Most hardwood plywood is used in furniture production and interior decoration while, especially in North America, softwood plywood is a common construction material.

Much hardwood plywood production has shifted from the developed to the developing countries, particularly in the Far East. The preference for particleboard over plywood is based on economical rather than technological arguments in any given situation - the two being competing materials in many applications.

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Great care must be exercised in selecting suitable storage, peeling, drying and internal handling equipment to permit maximum flexibility and efficient operation. In balanced production, an overcapacity for peeling and especially drying should be designed. Full synchronization of the peeling, drying and jointing and pressing operations must be maintained. Shrinkage is also a critical control parameter.

Loading time must be carefully controlled when using multi-opening hot presses, since precuring of the early-loaded sheets in each cycle can reduce the quality of finished plywood considerably.

Regarding plywood costs, raw material can represent up to almost [illegible] per cent of the sales price and its price fluctuations can seriously affect the world market.

It is important to select only high quality machinery, since the apparent cost savings of investing in cheap copies of well-known makes, or in poorly maintained second-hand machinery, are usually more than offset by subsequent problems.

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