OCCASION

This publication has been made available to the public on the occasion of the 50th anniversary of the United Nations Industrial Development Organisation.

DISCLAIMER

FAIR USE POLICY

CONTACT

Please contact publications@unido.org for further information concerning UNIDO publications.

For more information about UNIDO, please visit us at www.unido.org

UNITED NATIONS INDUSTRIAL DEVELOPMENT ORGANIZATION
Vienna International Centre, P.O. Box 300, 1400 Vienna, Austria
Tel: (+43-1) 26026-0 · www.unido.org · unido@unido.org

3.2 Sawing

Before selecting the head rig, it is necessary to prepare the log conversion plan which includes: species available, maximum diameter (here the average diameter has a minor importance) and above all whether the species are one or more, with different characteristics: finally, which are the specifications for sawn lumber (boards, beams, railway ties, etc.).

Another lecture during this course covers more details about feeds and speeds and tooth shape for log break down. Here we recall the problem of internal stresses. It is necessary to carefully study the most advantageous solution out of the following three:

a) perform the sawing in parallel boards (sandwich sawing) leaving the boards free to open in the centre;

b) make use of a frame saw with two blades in order to eliminate four off-cuts (or slabs) passing the log twice through the frame. The wane edged timber will then pass gang frame saw;

c) use band head rigs with two circular sawing units to edge the board simultaneously or for center rip cuts to eliminate to loose stresses.

The circular saws are adjusted perpendicular to the sawing plane of the band saw and can also cut out the brittle heart, when required.

Resinous wood species will be sawn with a spray system which sprays a solvent to the blade, avoiding sticky spots on the tool. Finally, the use of a scratch-brush or a similar device is recommended to remove the adhering sawdust from the sawn surface.

Board cross cutting or trimming is done by circular saws with special teeth shapes and set suitable cross cutting operations. The present trend is to use inserted teeth made of wolfram carbide plates, especially when hard and abrasive woods with mineral particles have to be worked.

In wood industries where wood with toxic extratives have to be machined causing trouble to the workers, it is recommended to install a chip and dust exhaust plant (workers should wear a mask on mouth and nose and wear gloves).

It is also very important to study the material flow in the saw mill, to decide on conveying and transport equipment for lumber and waste material (viz: slabs, edgings, trimmings, offcutsets which should be hogged and stored in silos.)

3.3 Peeling and Slicing

The dimensions of the logs are the factors which determine the power requirement for operating the lifting units at the peeling and slicing machines. On the other hand, the cutters, the kilns, glue spreading machines, presses and sanding machines must fit to the dimensions of the finished product.

Since there is the possibility of having to face some "brittle hearts" the peeling machines must be built in such way as to be able to use jaws with different diameters.

Steaming vats have to be adjusted to any quality of wood, both from the point of view of steam temperature and of the length of treatment: it is very difficult to establish general rules for wood species which are known insufficiently. In this case collect applied experienced data for setting rules.

3.4 Milling (planing, shaping, turning, boring, recessing).

The easy performance of all these operations is strictly connected with the wood density, the grain direction of the fibers, the resin content and silicon inclusions. The concept of the required machines is not influenced by these elements, which are on the contrary essential for applying the correct tool geometry with the appropriate tool steel.

In a large plywood factory the recovery and use of waste in form of pre peelers, or peeler cores is an operation of great technical and economical importance which neither cannot be neglected nor undervalued; it is therefore recommended to observe the factors already from the start up of the production.

3.5 Glueing, lacquering and finishing.

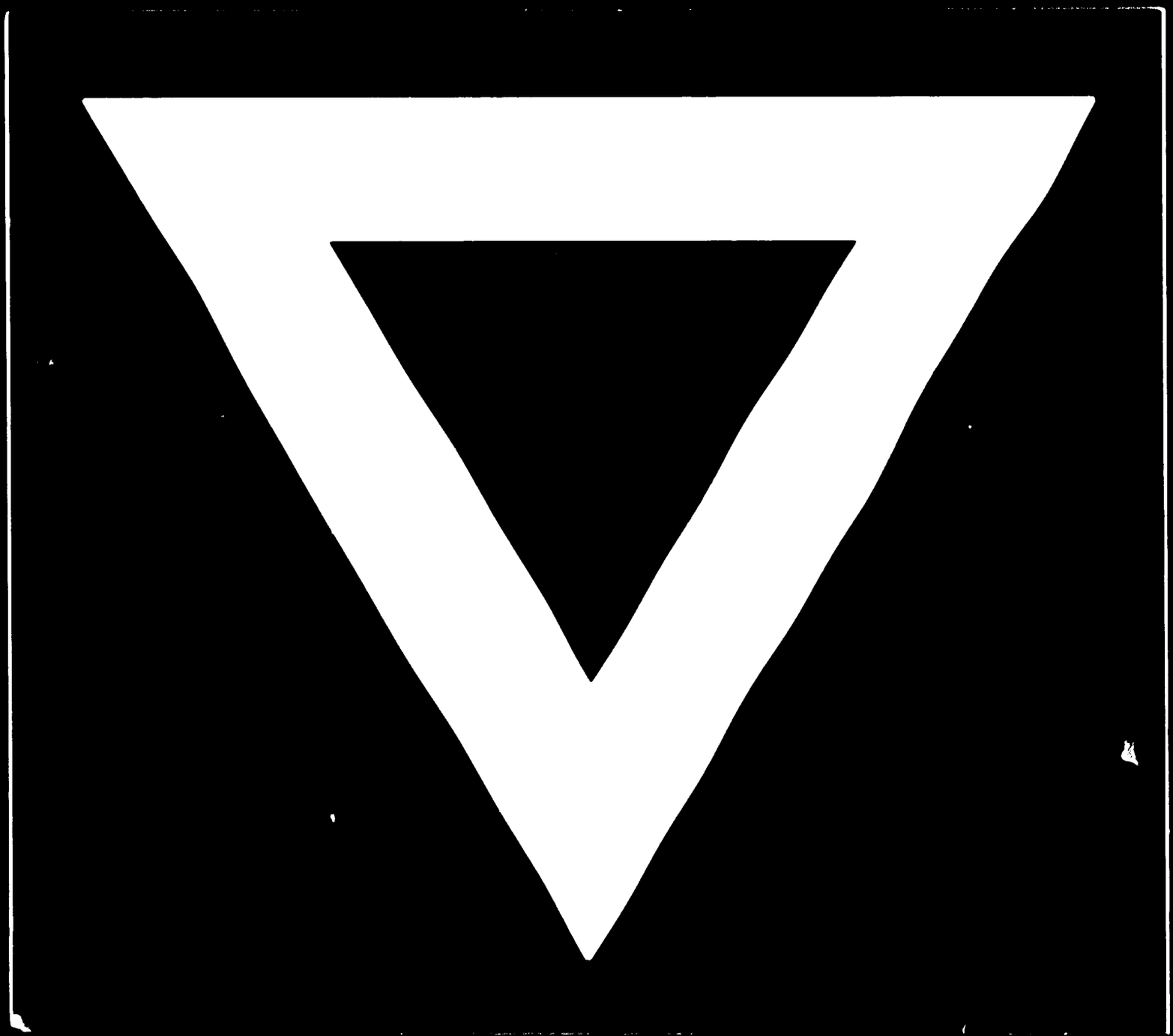
Here it is necessary to repeat some analogous considerations, that is to say that the required equipment is equally used both for tropical

or non tropical woods with the only difference that for oily or greasy woods, such as Iroko and Teak, it will be necessary to add to the production line a preliminary phase destined for eliminating from the surfaces all the substances causing problems in bonding and coating operations.

3.6 Kiln drying

Here we do not want to discuss the selection of the drying kilns from the point of view of the system to be adopted, but recall that, under the influence of steam and heat, tropical wood species, very rich in extractives, release some substances which are corrosive for plates, pipes and for the equipment at all. This feature should carefully be considered when selecting kiln with hot air systems.

C-665



78.11.06

08017

United Nations Industrial Development Organization

Distr.
LIMITED

ID/WG.277/1
19 April 1978

ENGLISH

Technical Course on Criteria
Selection of Woodworking Mach
Milan, Italy, May 1978

WOOD CHARACTERISTICS INFLUENCING THE SELECTION OF EQUIPMENT AND MACHINING OPERATIONS*

by

G. Giordano **

* 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 document has been reproduced without formal editing.

** Professor of Wood Technology and Forest Utilization, University of Florence, Italy.

id.78-2111

CONTENTS

1. Introduction

Having to select a machine tool it is necessary to consider first of all the characteristics of the raw material to be worked, in this case the wood. However, the wood is not a homogeneous material with constant characteristics: there are many parameters which interfere to modify the hardness, the resistance to tool progress and wear, etc. Among these paramenters the most important are the volumetric mass, moisture percentage, direction of cutting for logs also the diameter.

In woodworking industries utilizing timber from countries with temperate climate, machines have to be installed appropriate to these features and remain unchanged during the entire life of the machine, thus calculations can be made and the machines can be tuned to the machining operation. Considerung for instance coniferous logs to be cut for joinery works the wood to be machined has a density in green conditions of 700 to 900 kg/cu.m; with a moisture content below 60 per cent and diameters varying between 25 and 50 cm. Well established working conditions are based on many years of experience which allows to evaluate the influence of varying conditions of log breakdown on the head saw, viz: shape of tooth, feed of carriage, cutting speed, power required. These basic parameters will then lead to qualified selection of equipment.

But in countries where conditions are changing very often which is the case in tropical countries because of the wide variety of wood species and large dimensions of the logs one has to consider average measures.

As all technical experts participating in this course have to select the machines suitable for working tropical woods, it seems necessary to draw the attention on the characteristics of tropical wood species which can influence sawing, planing, peeling, slicing operations when working with different tools, when applying different glues, lacquers and finishing materials; kiln drying operations will be discussed under item 3.6 .

2. Peculiar Characteristics of Tropical Woods

Here we have to rise the question: which are the differences between wood species grown in tropical or temperate regions ? There is no clear boundary at all because "Natura non facit saltus" (the nature does not jump) but the frequency of certain characteristics

2.1 Dimension of Trees

Trees grown on a suitable soil in view of ecology, either for tropical or for temperate forests, much larger dimensions will grow in tropical regions. Everybody knows the marvels of Nature represented by the Sequoias and the Douglas Firs of North America or by the Eucalyptus of Australia, which are both Temperate Regions. However, when considering at all the trees exploited in specific ountries, and not the single tree, we come to the conclusion that the average tree size in Tropical regions is surely larger than the one grown in Temperate regions. As a matter of fact, in the forests of Europe and North America which are rationally managed, a tree is considered mature when its diameter is between 40 and 60 cm at breast height: under easy loading and transport conditions, also the trees which reach a diameter between 2 and 15 cm can find their market. In tropical forests, selection is based on high quality species often connected with difficulties in logging operations: Trees selected for felling are those of high volumn, first grade quality, primary species which cover best all expenses for felling, logging, transport, yard handling, etc. Trees to be considered in here are all in the large diameter category: ranging from 50 to 60 cm minimum to 1.50 up to 2 meters maximum.

While in the past trees were cut in to saw logs and peelerlogs of reduced length, the present trend is to bring the longest possible dimensions, which can be handled by cranes on tractors, fork lifts, trucks and other power units, notwithstanding both weight and dimension limits of the logs to be moved.

2.2 Internal Stresses

Few foresters and technicians are aware of this subject which is extremely important because of perplexing consequences due to the forces in the standing tree and which break out after the felling operation or in

of conversion. The phenomena which is visibly caused by stress forces can be observed more often in tropical wood species than in logs grown in temperate climates, viz: beech, oak, eucalyptus and some fast growing poplars, compared with species of tropical countries: Africa, Akatio, Arbo, Azobe, Ekmer, Ilomba, Limbali, Makoré, African Mahogany, Ossoko, Sipo, etc.; Asia, Balau, Bintangor, Durian, Geronggang, Irzia, Kapong, Kapur, Kerning, Lauan, Mayapis, Mangkulang, Meranti or Seraya, Merawan, Rosewoods, Sal, Terap, etc.

The internal stresses, the theory of which is too complicated and long to be explained here, mark themselves - in the standing tree - through a stress at the stock periphery and a compression in the internal part, close to the pith. When the tree is felled and cut all these forces loosen and consequently the periphery tends to shorten, the internal part to lengthen and the final result are cracks, in the shape of crow's feet, starting from the pith. It often happens that these cracks reach the periphery and really open the log into 4 or 5 independent sectors, out of which it is not any more possible to take any profit. However, even if there are not such large cracks, at the sawing time the boards are under stressed at their ends and open or undergo a strong deformation. The internal stresses are often accompanied in the tropical species by the so-called "brittle heart" which is a central wooden area devoid of any fibrousness and with lower mechanical resistance; along the entire brittle heart area it is also possible to see a succession of cross cracks in the wood in the internal side of the log, which can just be perceived by an unskilled eye; it is evident that this wood cannot be used for any building or joinery use.

3.3 Extractives and Inclusions

Walls of wood cells are composed of three groups of structural substances, namely cellulose, hemicellulose, lignin, common for all woods but the percentage of composition is different. However, these are not the only constituents of the wood, because in the ligneous tissues it is possible to find two other categories of substances deposited in the cell sap. First the soluble substances, called "extracts" and insoluble materials.

The extractives can vary from one specie to another and, consequently, determine in the woods specific and peculiar characteristics.

Several tropical species, especially the dark-colored ones have a remarkable content of extratives: these compounds (e.g. tannins) can increase the wood resistance against biological deterioration and thus be protectively useful, other compounds can, on the contrary, etch the tool steel kiln fittings, stain steamed wood, or cause troubles to the workers exposed by dust generated during machining and sanding operations.

A rubber resin or tacky substance can be troublesome for sawing and milling operations because of resin particles on the tool; this is not a specific peculiarity of tropical woods, however it can cause real troubles when working certain species of woods. However, the most prejudicial cases are due to the presence of insoluble mineral substances in the wooden tissue with high hardness characteristics. These substances (usually phosphates, carbonates or silicates) can produce some agglomerate which appear like irregular stones, even as large as a fist, disseminated in the wood (e.g. species like Iroko or some Meranti) or compound materials in internal cracks and fractures of the log (e.g. Doussié).

These compound materials inevitably cause gullet cracking in the saw blades or in the cutting edges of the tools. Instead of aggregating to a certain volume, the insoluble substances can sometimes be scattered in crystals or granules of smaller diameter (1/50 to 1/20 of mm) inside the cell cavity; the wooden tissues look perfectly normal but when sawing an increased load is noticed causing fast teeth wear. Even though the secrystals are not always of silica only, the wood species are called "siliceous".

The forest administrators and sawyers are much afraid of these woods because machinability is difficult and expensive. Tropical wood species known for their troublesome characterstics when machining are: Akatio, Makoré, Azobé, Movingui, Mukulungu, Aielié, Abiurana, some Lauan and Meranti, the Geronggang, Kapur, Keruing, Mengkulang, Mersawa, etc. It is again necessary to underline that the presence of certain substances of toxic

nature in extractives can cause inconvenience to the workers' health; this is for instance the case of Beté. Obviously, this has nothing to do with the power or type of machine to choose, but it requires a very accurate study of the removal systems for sawn offcuts and saw dust.

2.4 Deviation of Fibers and Tissues

The tropical woods, more frequently than those of the temperate regions, have the fiber direction which is not oriented parallel to the log axis.

The result is a marked counterlip which makes sawing, planing and sanding difficult, but can at the same time, if the fibers are divided into narrow and parallel bands or follow certain arrangements, increase the value of the woods for decoration. This is the case of Sapelli, Sipo, American Mahoganies, Ipe Tabaco, Afrormosia, red Luans, etc. Finally, after discussing the general characteristics of wood, we will follow the operations of log conversion and lumber remanufacturing.

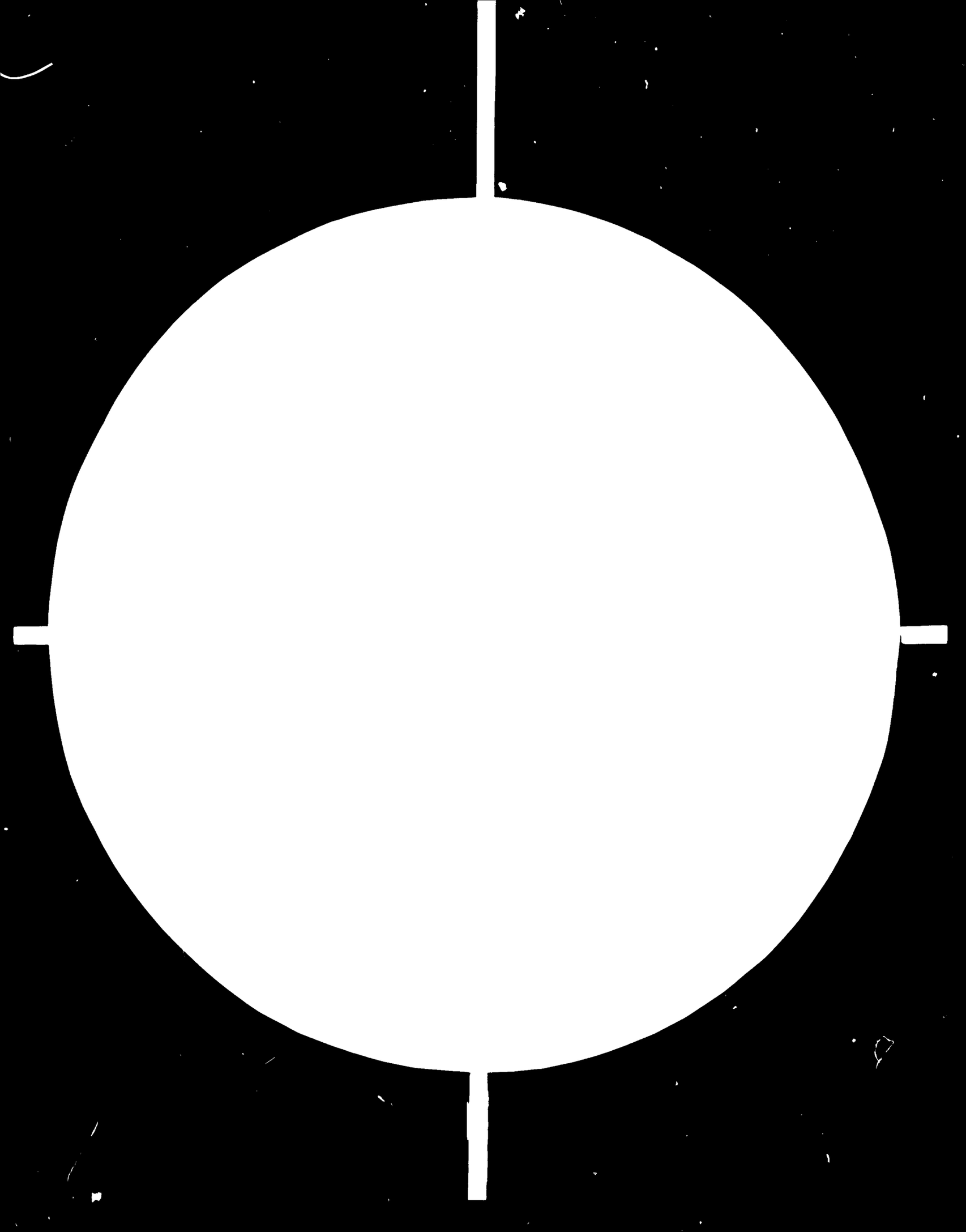
3. Notes about log and lumber conversion

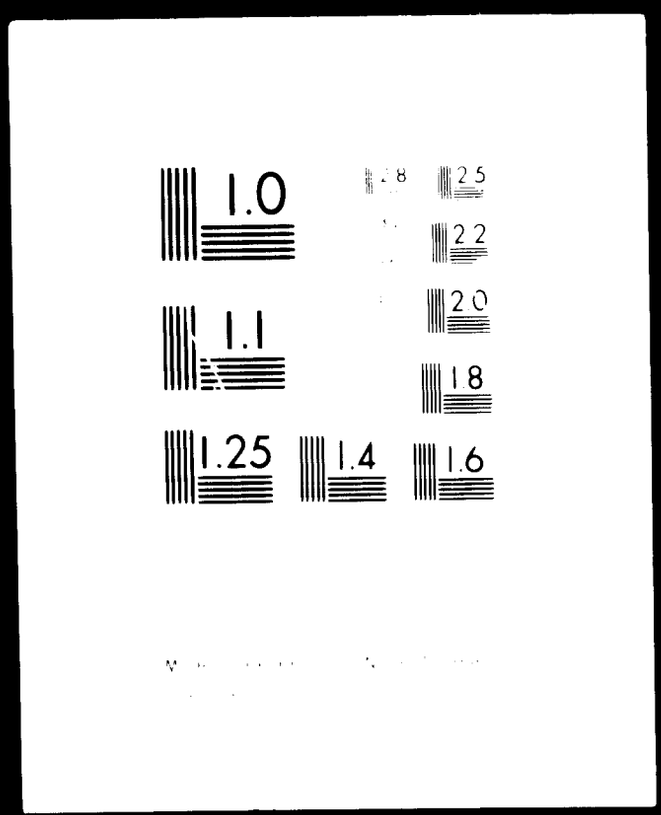
3.1 Log yard operations

Log handling equipment for lifting and transport has to be rigid and high powered and must be of large flexibility in operation. If log storage cannot be done in log ponds it will be necessary to install wprinkler systems to keep moisture content in the wood, thus avoiding the drying cracks and reducing the damages caused by wood-borers, insects and fungi.

The log storage shed must be provided with a set of appropriate cross-cutting saws; the ones actually used are practically always the chain saws of great length, which can be easily moved manually or are mounted on very low carts; it will also be necessary to have some metal brushes and monitors to clean properly the logs before sawing.

In regions where it is possible that the trunks include metal splinters (areas where some fighting or guerilla war took place) it is recommended to operate with metal detectors to locate hidden metal splinters.





such as slabs, edgings, trim ends,offcuts, etc. which should be chipped and stored in silos.

3.3 Peeling and Slicing

The dimension of the logs is a factor which determines the power requirement for operating the lifting units at the peeling and slicing machines. On the other hand, the cutters, the kilns, glue spreading machines, presses and sanding machines must accommodate the dimensions of the finished product.

Since there is the possibility of having to face some "brittle hearts" the peeling machines must be constructed in such way as to be able to use jaws with different diameters.

Steaming vats have to be adjusted to any quality of wood, both from the point of view of steam temperature and of the length of treatment: it is very difficult to establish general rules for wood species which are known insufficiently. In this case collect applied research and experienced data for the establishing of rules.

3.4 Milling (planing, shaping, turning, boring, recessing).

The workability of all these operations is based on the wood density, the grain direction of the fibers, the resin content and silicon inclusions. The concept of the required machines is not influenced by these elements, which are on the contrary essential for applying the correct tool geometry with the appropriate tool steel.

In a large plywood factory the recovery and use of waste in the form of pre-peelers, or peeler cores is an operation of great technical and economical importance which cannot be treated lightly and it is therefore recommended to recognize the various factors right from the start-up of the production.

3.5 Glueing, lacquering and finishing.

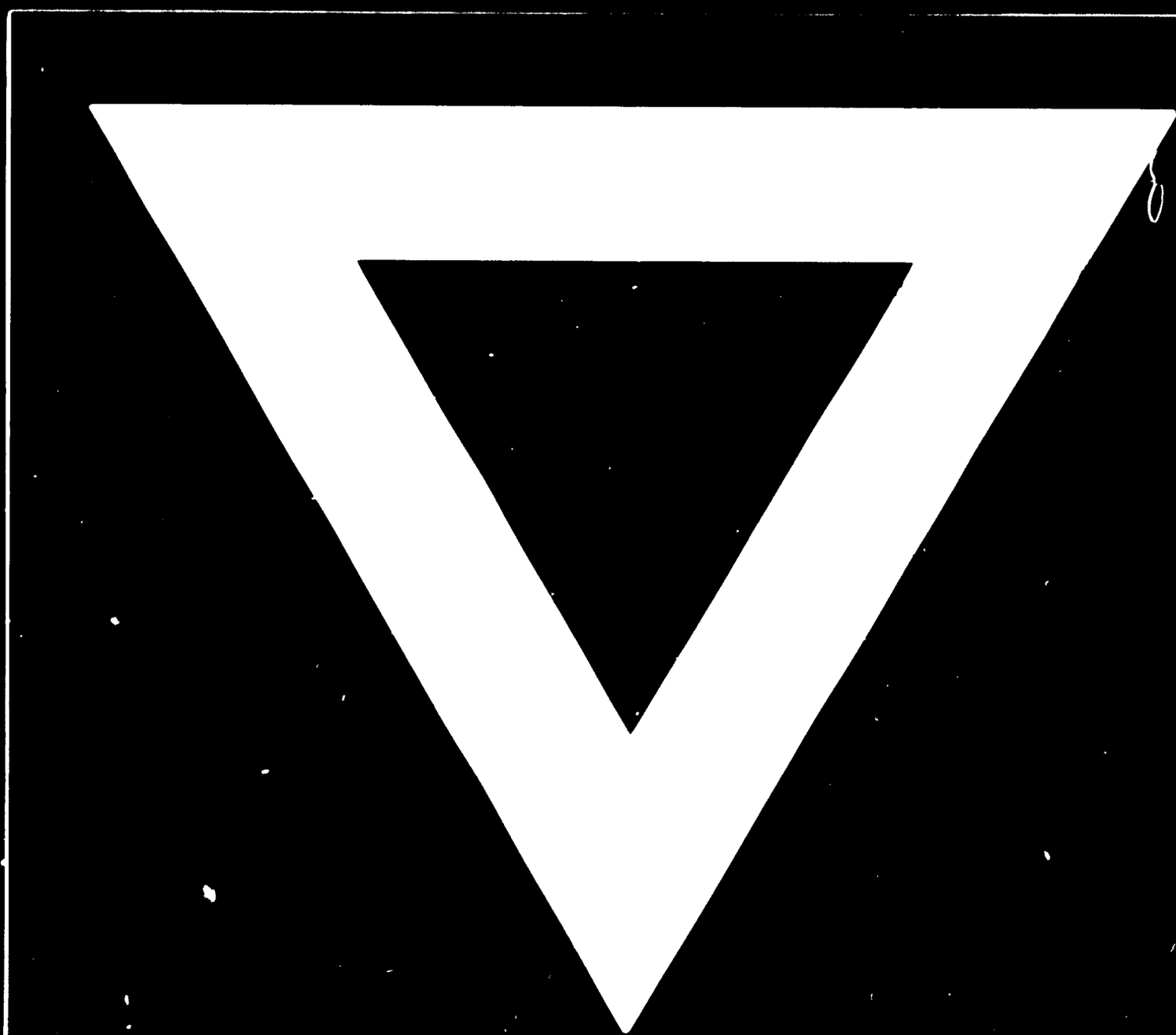
Here it is necessary to repeat some analogous considerations, that is to say that the required equipment is equally used both for tropical or non-tropical woods with the only difference being that for oily or

greasy woods, such as Iroko and Teak, where it will be necessary to add to the production line a preliminary phase destined for eliminating from the surfaces all the substances causing problems in bonding and coating operations.

3.6 Kiln drying

For the reason that another paper will be presented to deal exclusively with drying of timber products this report will not attempt to examine the selection of dry kilns but again wishes to make mention of the fact that under the influence of steam and heat, tropical wood species, very rich in extractives, release some substances which are corrosive for plates, pipes and for the equipment in general. This feature should therefore be borne in mind when selecting kilns with hot air systems.

C-13



79.11.15

08017

Distr.
LIMITED

ID/WG.277/1/Rev.1
14 November 1978

ENGLISH

United Nations Industrial Development Organization

Technical Course on Criteria for the
Selection of Woodworking Machinery

Milan, Italy, 8 - 19 May 1978

WOOD CHARACTERISTICS INFLUENCING THE SELECTION OF EQUIPMENT AND MACHINING OPERATIONS*

by

G. Giordano **

* 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 document has been reproduced without formal editing.

** Professor of Wood Technology and Forest Utilization, University of Florence, Italy.

id.78-7926

CONTENTS

1. Introduction

Having to select a machine tool it is necessary to consider first of all the characteristics of the raw material to be worked which in this case is wood. However, wood is not a homogeneous material with constant characteristics there are many parameters which interfere to modify the hardness, the resistance to tool progress and wear, etc. Among these parameters the most important are the volumetric mass, moisture content, direction of cutting for logs, as well as the diameter.

In woodworking industries utilizing timber from countries with temperate climate, machines have to be installed which will meet these features and remain unchanged during the life of the machines, thus calculations can be made and the machines can be tuned to the machining operation. Consider for instance coniferous logs to be processed for joinery material where the wood to be machined has a density in green form of 700 to 900 kg/cu.m; with a moisture content below 60 per cent and diameters varying between 25 and 50 cm. Well established working conditions are based on many years of experience which allows for evaluating the effect of varying conditions for log breakdown on the h ad saw, such as shape of tooth, feed of carriage, cutting speed, power requirements, etc. These basic parameters will then lead to qualified selection of equipment. However, in countries where conditions are changing very often which is the case in tropical countries because of the wide variety of wood species and large dimension of the logs, one has to consider average measures.

As most technical experts participating in this course have a part in the selection of machines suitable for working tropical woods, it seems necessary to draw attention to the characteristics of tropical wood species which can influence sawing, planing, peeling or slicing operations when working with different tools, applying different glues, lacquers and finishing materials; kiln drying operations will be covered under item 3.6.

2. Peculiar Characteristics of Tropical Woods

2.1 Dimension of Trees

It is known that in the growing of trees, either in tropical or temperate forests, much larger dimensions will develop in tropical regions. There is no secret about the marvels of nature represented by the Sequoias and the Douglas Firs of North America, or by the Eucalyptus of Australia, which are both temperate regions. However, when taking into account all the trees exploited in specific countries, and not just the single tree, we come to the conclusion that the average tree size in tropical regions is indeed larger than the one grown in temperate regions. As a matter of fact, in the forests of Europe and North America which are rationally managed, a tree is considered mature when its diameter is between 40 and 60 cm at breast height, also the trees which reach a diameter between 12 and 15 cm are being extracted from the forests. In tropical forests, selection is based on high quality species which however at times present problems in logging operations. Trees selected for felling are those of high volume, first grade quality and primary species, which bring the maximum return in expense for felling, logging, transport, yard handling, etc. Trees to be considered in this category, are all in the large diameter class, ranging from 50 to 60 cm minimum to 1.50 up to 2 meters maximum.

While in the past, trees were cut into reduced lengths for use as saw logs and peeler logs, the present trend is to bring in the longest possible lengths which can be handled by mobile or stationary cranes, fork lifts, trucks and other powered units, notwithstanding the weight or dimension limits of the material to be transported.

2.2 Internal Stresses

Few foresters and technicians are aware of this subject which is extremely important because of perplexing consequences due to the forces in the standing tree and which break out following the felling operation or in log conversion. The phenomena which is visibly caused by stress forces can be observed more often in tropical wood species than in logs grown in temperate climates, such as beech, oak, eucalyptus and some fast growing

poplars; compared with species of tropical countries, some of which are Akatio, Agba, Azobé, Emien, Ilomba, Limbali, Makoré, African Mahogany, Ossoko, Sipo, etc.; Asia, Balau, Bintangor, Durian, Geronggang, Inzia, Kapong, Kapur, Keruing, Lauan, Mayapis, Mangkulang, Meranti or Seraya, Merawan, Rosewoods, Sao, Terap, etc.

The internal stresses, the theory of which is too complicated and long to be explained here, mark themselves - in the standing tree - through a stress at the stock periphery and a compression in the internal part, close to the pith. When the tree is felled and cut all these forces lossen and consequently the periphery tends to shorten, the internal part to lengthen and the final result is cracks, in the shape of crow's feet, starting from the pith. It often happens that these cracks reach the periphery and really open the log into 4 or 5 independent sectors, out of which it is not possible to produce a profit. However, even if there are not such large cracks, at the sawing time the boards are under stresses at their ends and open or undergo a strong deformation. The internal stresses are often accompanied in the tropical species by the so-called "brittle heart" which is a central wooden area devoid of any fibrousness and with lower mechanical resistance; along the entire brittle heart area it is also possible to find a succession of cross cracks in the wood on the internal side of the log; it is evident that this wood cannot be used for any building or joinery work.

2.3 Extractives and Inclusions

Walls of wood cells are composed of three groups of structural substances, namely cellulose, hemicellulose, lignin, common for all woods but the percentage of composition is different. However, these are not the only constituents of the wood, because in the ligneous tissues it is possible to find two other categories of substances deposited in the cell sap. First the soluble substances, called "extracts" and insoluble materials.

The extractives can vary from one specie to another and, consequently, determine in the woods specific and peculiar characteristics.

Several tropical species, especially the dark-colored ones, have a remarkable content of extractives: these compounds (tannins) can increase the wood resistance against biological deterioration and thus be

protectively useful, while other compounds can, on the contrary, damage the tool steel kiln fittings, stain steamed wood, or cause troubles to the workers exposed by dust generated during machining and sanding operations.

A rubber resin or sticky substance can be troublesome for sawing and milling operations because of resin particles on the tool; this is not a common peculiarity of tropical woods, however it can be a problem when working certain species of woods. However, the more serious cases are caused by the presence of insoluble mineral substances in the wooden tissue with high hardness characteristics. These substances (usually phosphates, carbonates or silicates) can produce some agglomerate which appear like irregular stones, even as large as one's first, disseminated in the wood of certain species, such as Iroko or some Meranti, or even compound materials in internal cracks and fractures of a log, as in the specie Doussié.

These compound materials inevitably cause gullet cracking in the saw blades, or in the cutting edge of the tools. Instead of aggregating to a certain volume, the insoluble substances can sometimes be scattered in crystals or granules of smaller diameter (1/50 to 1/20 of mm) inside the cell cavity; the wooden tissues look perfectly normal but when sawing an increased load is noticed causing fast teeth wear. Even though the se crystals are not always entirely of silica, the wood species are called "siliceous".

Forest officials and sawyers are concerned with these woods because machinability is both difficult and expensive. Tropical wood species known for their troublesome characteristics when machining are: Akatio, Makoré, Azobé, Movingui, Mukulungu, Aielié, Abiurana, some Lauan and Meranti, the Geronggang, Kapur, Keruing, Mengkulang, Mersawa, etc. It is again necessary to underline that the presence of certain substances of toxic nature in extractives can cause problems with the workers' health; this is so in the case of Beté. Admittedly, this has nothing to do with the power or type of machine to select, but it requires a very careful study of the removal systems for sawn offcuts and saw dust.

2.4 Deviation of Fibers and Tissues

The tropical woods, more frequently than those of the temperate regions, have the fiber direction which is not oriented parallel to the log axis. The result is a marked counterlip which makes sawing, planing and sanding difficult, but can at the same time, if the fibers are divided into narrow and parallel bands or follow certain arrangements, increase the value of the woods for decoration. This is the case of Sapelli, Sipo, American Mahoganies, Ipe Tabaco, Afrormosia, Red Luans, etc. Finally, having covered the general characteristics of wood, we will follow the operations of log conversion and lumber processing.

3. Notes about log and lumber conversion

3.1 Log yard operations

Log handling equipment for lifting and transporting logs has to be rigid and high powered, besides being very flexible in operation. If log storage cannot be accomplished in log ponds it then becomes necessary to create a log concentration yard which nowadays is a common thing as it allows for easier handling of the logs which when brought in from the forest are sorted and stacked in piles which are covered by sprinkler systems to protect against end checking, splitting, insect damage, etc. In using the sprinkler system it also affords protection against fire damage or loss in cases of extreme hot and dry weather.

The log storage must be provided with a set of appropriate cross-cutting saws; the ones normally used are of the chain saw type, which can be easily moved either manually or are mounted on very low carts; it is also necessary to have some metal brushes and monitors to properly clean and inspect the logs before sawing. Additionally, in regions where it is possible that the logs include metal splinters (areas where some fighting or guerilla war took place) it is recommended to use metal detectors to locate any hidden metal splinters, or other similar foreign body which might be present.

3.2 Sawing

Before selecting the head rig, it is necessary to prepare the log conversion plan which includes: species available, maximum diameter (here

the average diameter is of minor importance) and above all whether the species are one or more, with different characteristics; finally, which are the specifications for sawn lumber (boards, beams, railway ties, etc.).

While this paper is not going to examine the sawing techniques such as feeds, speeds, shape of teeth, etc. for breakdown of the log it does wish to dwell somewhat on the problem of internal stresses and in this connection believe it is worth the effort to study the most advantageous solution out of the following three:

a) perform the sawing in parallel boards (sandwich sawing) leaving the boards free to open in the centre;

b) make use of a frame saw with two blades in order to eliminate four off-cuts (or slabs) passing the log twice through the frame. The wane edged timber will then pass through a gang frame saw;

c) use band head-rigs with two circular sawing units to edge the board simultaneously or for center rip cuts to eliminate or loosen stresses.

The circular saws are adjusted perpendicular to the sawing plane of the band saw and can also cut out the brittle heart, when required.

Resinous wood species will be sawn with a spray system which sprays a solvent to the blade, avoiding sticky spots on the tool. Finally, the use of a scratch-brush or a similar device is recommended to remove the caked sawdust from the sawn surface.

Board cross cutting or trimming is done by circular saws with special teeth shapes and suitably set cross cutting operations. The present trend is to use inserted teeth made of solfram carbide plantes, especially when hard and abrasive woods with mineral particles have to be worked.

In wood industries where wood with toxic extractives has to be machined, causing problems to the workers' health, it is recommended to install a chip and dust exhaust unit, besides which the workers should use protective items such as masks and gloves.

It is also important to study the material flow in the saw mill, to decide on conveying and transport equipment for lumber and refuse material