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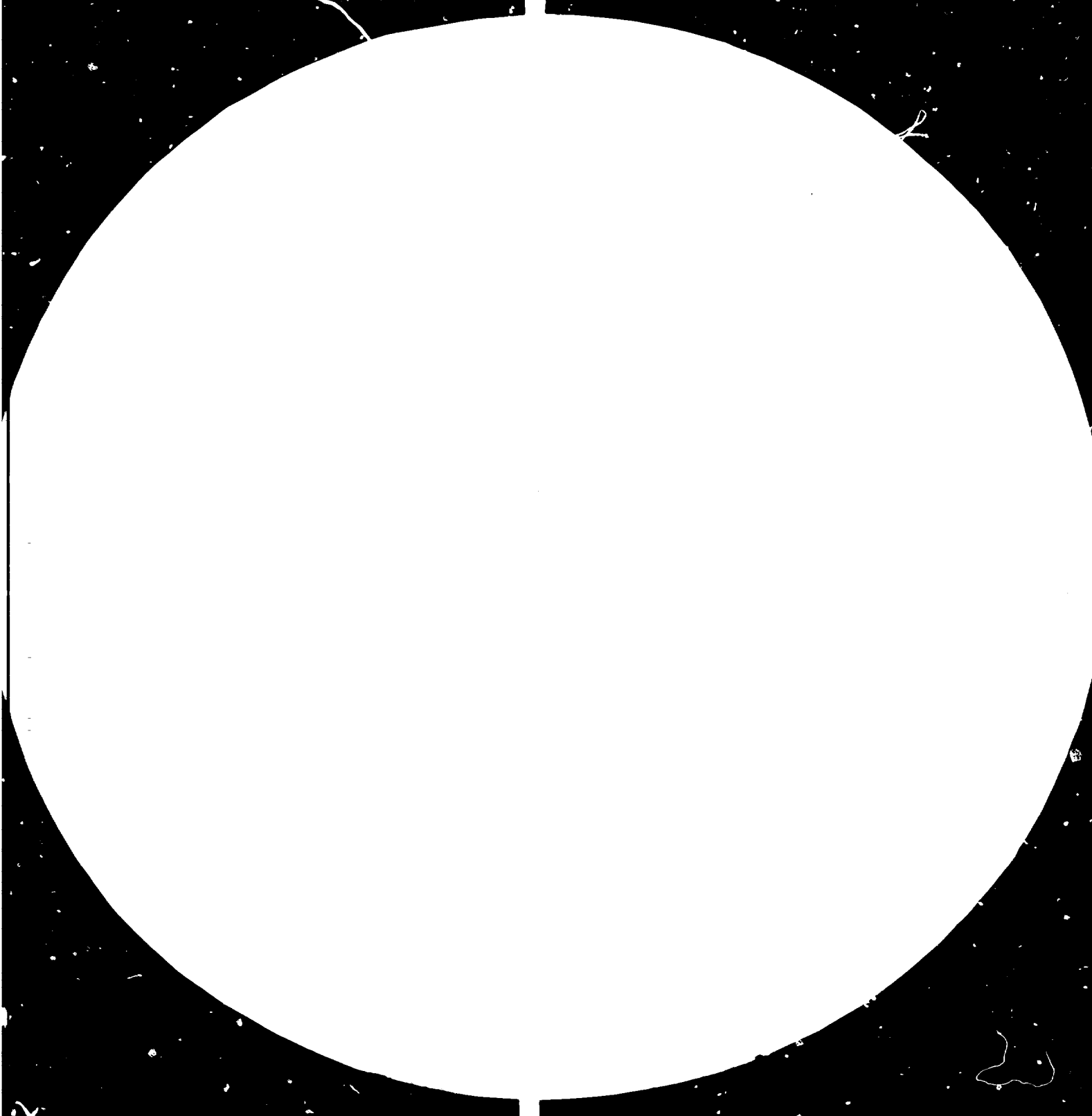

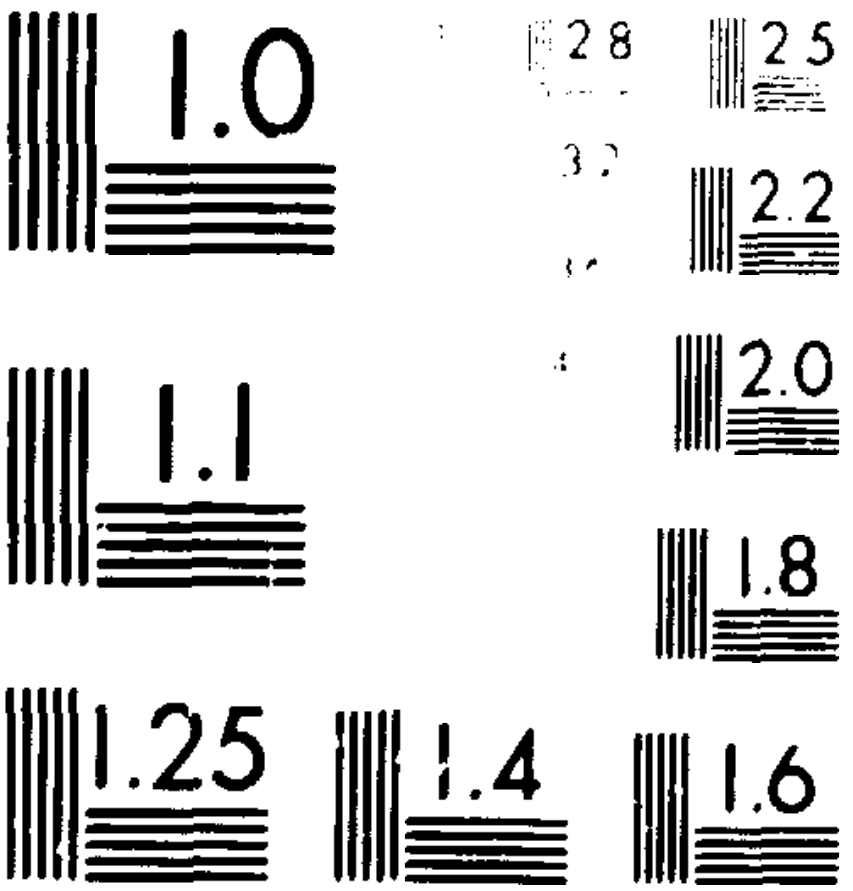
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ECONOMIC CONSIDERATIONS FOR THE CHOICE OF PLANT AND MACHINES FOR THE PRODUCTION OF PARTICLE BOARD *

by

T.F. Slodyk **

2229

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INTRODUCTION

Apart from general previsions regarding the growth or crisis of the particle board worldwide market, which will be examined afterwards, the subject will be studied with regard to the real needs and possibilities of all countries, under the following aspects:

A. General considerations

B. Determination of plant total capacity, size and type of board.

C. Choice of machinery

A. GENERAL CONSIDERATIONS

1. Evaluation of the Choice of Building a Plant for Particle Board of Common Usage

Three main considerations generally affect the choice of producing particle board:

1.1 Social needs: development of the building trade, the furniture industry, as well as special requirements in the packaging and plywood industries;

1.2 Amount of raw material available (wood and by-products);

1.3 Home and export market potential.

Unfortunately, in spite of the strong social needs, local markets may sometimes not be large enough to justify even a very low production level (about 30 m^3/day of 22 hours), unless the market is official and supported by government authorities.

It is also most important to know in which measure power and technology are available, and/or whether the possibility to acquire them exists.

The three considerations mentioned above are closely related; that is why they must be examined both separately, and with regard to each other

In case the social needs, such as town planning, furniture, etc. are restrained by the lack of raw material, a country rich in natural resources could consider the advantage of purcahsing a plant by importing wood for various uses and utilizing just a part of its

wastes; otherwise, this country could import poor quality wood, choice or even boards, thus avoiding investment in a plant for wooden materials.

As for the raw materials, one must also consider the amount of glue available which, when dry, represents about ten percent of dry product, as well as the availability of other additives. The same rules must be adopted when facing the need for industrial boards with regard to the packaging industry and the building trade for instance (though considering that social claims are always connected with industry).

In case wood is available and other packaging materials are lacking, the production of a particle board plant could solve problems concerned with export and agricultural production, by converting wood wastes into a material suited for this purpose. In this case, part of the material could be used for social/industrial purposes (building and furniture) and the rest for packaging and plywood.

As for the above mentioned usages, the prospect of placing the product on the home market, and possibly abroad either directly (raw board) or indirectly (processed board), represents another very important subject when examining the advantage of realising one's own production. Employment problems are also to be taken into due consideration in making a decision.

2. CHOICE OF OUTPUT

After having clarified the above situations, output will have to comply with:

a) the number of factories of the same type, existing in the country;

b) the real urgent needs;

c) the previsions for future needs and development;

d) in any case, the amount of raw material available (wood, wood wastes, annual plants, bagasse, hemp and linen production wastes).

For all the cases mentioned above, and not considering problems of power and water, raw material to be used must be at a reasonable distance from the factory. Availability of skilled and unskilled labour is another most important factor affecting choice of the type of plant (automated or not), its capacity, and, as a consequence, the size of the investment. The type of board, wood, wooden materials and/or their wastes, defines the type and price of machinery; on the other hand, the availability of skilled or unskilled labour affects the choice of plant operation which can be manual, semi- or fully automated. The last case is especially sensitive to spare parts' shortages and/or production stoppages which can reduce productivity and make an automatic plant unprofitable.

All the data available about wood based products on the worldwide market in the last years can be helpful in deciding on whether or not to set up a plant.

3. Some Data about the Productive Situation of Particle Board and Other Woodbased Panels (F.A.O. Data)

The following data are characteristic of the last thirty years:

3.1 Growth of world-wide production of particle board, in million cubic meters:

	1950	1960	1970	1973	1976	1977	1970-78	1978 Percentage of total world production
DEVELOPED ECONOMIES	0.02	2.6	14.7	26.2	26.1	26.8	26.2	73 percent
- Northern America	0.01	0.6	3.4	6.9	6.1	6.5	7.5	19 percent
- Western Europe	0.01	1.9	10.5	16.9	18.3	18.5	18.9	49 percent
- Oceania	-	-	0.3	0.5	0.6	0.6	0.6	2 percent
- Others	-	0.1	0.5	0.9	1.1	1.2	1.2	3 percent
DEVELOPING ECONOMIES	-	0.1	0.6	1.1	1.5	1.7	1.7	5 percent
- Africa	-	-	-	-	0.1	0.1	0.1	--
- South America	-	-	0.4	0.7	0.9	1.0	1.0	3 percent
- Asia	-	-	0.2	0.4	0.5	0.6	0.6	2 percent
CENTRALLY PLANNED ECONOMIES	-	0.4	3.8	5.7	7.4	8.2	8.6	22 percent
WORLD TOTAL FIGURES	0.02	3.1	19.1	32.0	35.0	36.7	38.5	100 percent

3.2 World production of other wood-based panels in the years 1950/1980

	1950	1960	1970	1973	1976	1977	1978
Face-veneered	-	1.2	3.2	3.8	4.2	4.3	4.4
Plywood	6.1	15.3	33.1	42.2	38.8	41.3	41.6
Particle Board	0.02	3.1	18.1	32.0	35.0	36.7	38.5
Fibreboard :	5.4	11.0	14.4	17.4	17.7	17.8	18.0
Total boards derived from wood	11.5	30.6	69.8	95.4	95.7	100.1	102.5
Sawnwood	265	344	413	422	431	439	444

The production of wood-based panels (without sawnwood) from 1950 to 1970, has increased from 30 to 102 million cubic meters, i.e. it has more than doubled in a decade. For 1980, a production ranging from 140 to 200 million cubic meters, and for 2000 a production between 170 and 350 million cubic meters is foreseen.

These four cases are shown in Table I below:

Table 1. Development Forecast (FAO)

Wood-based panels (stated in million cubic meters per year)

1961 1965 Average values	1974 1976 Average values	Real consumption 1978	Forecast for 1980	1990	2000
39	87	105	109	141	169

Since 38 million cubic meters of particle boards are included in 1978, real consumption figure (103 million m^3/year), it is possible to assume that their growth will be the same, at least, during next years; therefore, in 1990 their consumption would reach 56 million cubic meters.

3.3 European Situation according to FESYP data

From 1972 to 1978, the board manufacturing situation in the European countries was the following, in thousand cubic meters:

	1972	1978	Course + or -	Difference + or -
Particle board	14,245	17,793	+24.9%	+3,548
Plywood	3,400	2,420	-29.2%	-1,000
Hard fibreboard	1,960	1,530	-21.9%	- 430
Insulating board	1,045	760	-27.2%	- 285

This means that the average increase in production for particle board is 6 percent. A similar increase has occurred in other countries.

3.4 Distribution of productive capacity in Western Europe

		Number of plants
0 to 20.000 m^3/year	about 11.0%	27
20 to 50.000 m^3/year	about 23.0%	55
50 to 100.000 m^3/year	about 30.5%	74
100 to 200.000 m^3/year	about 21.0%	51
more than 200.000 m^3/year	about 14.5%	34

Productive capacity about 23,000,000 m^3

Real output about 18,000,000 m^3

Extra capacity margin: 27 percent

Just 11 percent of the existing plants produce about 60 m^3/day or less, based on 300 work-days, while a higher percentage have a capacity of about 350 m^3/day. As to choosing plant capacity, this data is most significant. In fact, plants having small capacities are rather old and, in most cases, cannot produce at all, or, if they can, are close to bigger plants and, under normal conditions, are no longer profitable.

3.5 Situation in the United States of America, Japan and Indonesia

In the United States of America, productive capacity has changed from 7,500,000 cubic meters in 1972 to 9,500,000 cubic meters in 1978, for an increase of 26.6 percent: production of 5,490,000 cubic meters in 1972, became 7,600.000 cubic meters in 1978, for an increase of 38.4 percent equal to 6.5 percent per year; the number of factories changed from 58 to 85.

In the last six years, particle board production in Japan has more then doubled. Worldwide particle board production reached 38,000,000 cubic meters in 1978, against 3,100,000 cubic meters in 1960.

What concerns European countries, as analysed above, it is likely that this increase will not reoccur, since wood is not as readily available as before, and costs of raw material, power and labour rise higher and higher.

In this case, those countries rich in wood and exporting large quantities of unprocessed wood, should really provide for its full exploitation; on the other hand, those countries importing wood for processing into plywood, should urgently provide for the exploitation of wastes. Indonesia, Malaysia, the Philippines and Papua New Guinea, which currently export logs (about 40 million cubic meters per year, almost half of which goes to Japan, Korea and China, as per table 2), could become in the near future, important plywood and particle board manufacturers and pave the way for new plants and investments.

Table 2, Destination of Indonesian Exports (FAO Data)

	Log volume (thousand m^3)	Percentage
Japan	9,365	49.5
Republic of Korea	5,218	27.6
China Province of Taiwan	3,112	16.5
Singapore	916	4.8
Hong Kong	61	0.3
Thailand	46	0.2
CEE	136	0.7
Australia	13	0.1
Egype	35	0.2
	18,702	99,9

Export figures above represent almost half of the total Indonesian exports (about 40,000,000 m^3/ year)

Assuming a 50 percent conversion factor, at best, for plywood and sawnwood, an amount of some 20,000,000 cubic meters per year could be recovered. Since the price of wood has doubled in one and a half years, both for coniferous and non-coniferous species (from 55 to 60 US$/m^3 to 105-120 US$/m^3 in 1980), it is obvious that full exploitation of wood must be achieved by a programme of wood conversion and investments in suitable technologies.

Considering that the production of wood to be processed in Indonesia, Sabah, Sarawak and the Philippines as well as other countries of the region is about 35 - 40,000,000 cubic meters per year, and that market demand (Japan, Korea, China, Europe) is almost the same (35,000,000 cubic meters per year), and comparing the production of these countries with the percentage of their particle board production, only two percent of the total world production, it becomes obvious that the possibilities of setting up plants of various capacities in that region must be investigated.

3.6 Plant and investment alternatives

An accurate study of what is mentioned above, with regard to the different markets in the world, can be helpful in choosing the most economic plant for investment.

Considering that the average growth rate in wood-based panel production (9 percent from 1970-1978) will be halved for various reasons in the next ten years; the current production of 103,000,000 m^3 (Table I) will grow to only about 140,000,000 m^3 by 1990. If particle-board production maintains its 40 percent share of the total, this indicates a level of 55 to 65 million cubic meters for particle board production or an increase of 1.7 to 2.2 million cubic meters per year.

In Europe, which accounts for about 49 percent of world particle board production, market demand should rise at least 1,000,000 m^3/year; i.e. in 1990, European production should become about 28 to 30 million cubic meters.

The low current per capita consumption in some countries, such as Portugal, Spain and Italy will probably rise to account for this increase in production surplus. This increase can most probably be covered in countries which are major consumers, with the full exploitation of plant production capacities (plants now exploiting only 80 percent of their capacity), or merely by modifying or modernising the existing plants.

This is the proper way to make investments and purchase machinery, so that relatively small expenditures can increase plant capacities by 30 percent or more.

The situation is different in Oceania, Asia, Africa and Latin America, where growth will no doubt be much greater, because of their rate of development and the abundance of forests.

B. DETERMINATION OF PLANT CAPACITY

4. Productive Capacity and Board Type

4.1 Industrialized countries

Rules defining plant capacity are always the same, since prices of wood, power and finished products are more or less alike in all countries (except in the United States of America and Finland). If manpower remains constant, it is obvious that by doubling production, from, say, 150 m^3 to 300 m^3 per day, labour costs and other expenses will be reduced.

Some examples of cost calculations, in percentage are found in table 3 below. Aside from production costs, plant site costs will also have to be considered. The ease of access to the plant (roads, etc.) can be vital when deciding to set-up a new plant or to increase the production of an existing one. In any case, a plant should be studied for the utilization of different types of wood, wastes and annual plants.

Table 3, Production Cost Breakdown in Italy (actual examples showing percentages by input)

Inputs	Case I Board thickness 18mm Sp. gr. 0.65	Case II Board thickness 14.5mm Sp. gr. 0.68	Case III Board thickness 15.5 mm Sp. gr. 0.64
Wood 11-12.8 q/m^3 5000-7000 Lit/q	47.2	49.2	44.4
Glue: 100-110 kg/m^3 290-300 Lit/kg.	23.9	18.8	17.6
Labour	4.8 54 men total	7.4 26 men total	8.1 20 men total
Fuel (burners, driers, transporters, heating)	7.2	3.2	4.5
Electric power (about150kW/m^3) lighting, heating, etc.	4.6	4.5	7.2
Various working consumptions (abrasive materials,knives,etc.)	3.9	6.2	0.9
Maintenance and repairs	5.2		1.8
Overheads	2.9	9.8	1.8
Depreciation	2.6	1.7	3.6
Production	300 m^3/day	120 m^3/day	140 m^3/day

Lit = Italian Lira q = quintal = 100 kgs

4.1.2 Type and size of board

These mainly depend on the market situation, the board's end uses, the consumers' requirements, the climate in the country, as well as international standards and building regulations.

4.2 Developing Countries

In developing countries, plant capacity must be analysed case by case. Countries rich in wood but lacking facilities should chose plants of rather small capacities and located near the sources of supply. Countries having much unskilled labour, should choose small-sized, manual plants.

Assuming that wood and manpower are relatively cheap, the total cost of boards should not be high. In any case, the possibility of selling wood on the local or international markets at high prices will have to be considered. Investment will, in such a case, depend only on local demand for boards, and on the care taken to recover and exploit all wastes of the raw wood exported. In fact, any type of waste, when turned into boards, always represents a form of capital (if it cannot be used as an energy source). With this in mind, it would be better to choose small plants, with the possibility of modifying them in order to increase production in the future.

4.2.1 Main Features of Boards

As far as developing countries are concerned, the subject is rather complex: in fact, in the case of small and plain plants, the board's size is: 1220 x 2440 mm, which are more or less the standard dimensions for plywood. On the other hand, if the intention is to export, these measurements do not comply with European markets very well.

Besides, the type of board to be manufactured depends on the ambient conditions (resistance to humidity, mould and/or insects). Note also that the more simple and manual a plant is, the more difficult it is to obtain a three-layer board with faces suitable for lamination.

The above-mentioned considerations are vital in the choice of investment and plant. A good quality board is always an advantage, so purchasing good quality machines is normally profitable.

C. CHOICE OF MACHINERY

5. Machinery corresponding to the capacity required

5.1 Plant diagram (see annex I)

a) General scheme for single opening plant: This type of automated plant, with a press size of 2000 x 11600 mm, can produce about 160 cubic meters in 22 hours, with a board thickness of 20 mm. A similar plant with a press size of 1220 x 2440 mm will produce about 23 cubic meters in 22 hours.

b) For daily outputs of 25 and 30 cubic meters, although the plant's flow-sheet is similar to the one having an output of 160 cubic meters, the machinery set-up is wholly different.

A plant producing 25-30 cubic meters, should be designed for the future extension of its capacity up to 55 to 60 cubic meters. A small-size plant can be almost entirely manually operated, while a medium-size plant (160-400 cubic meters) must definitely be automated. Annex I, all parts marked in black represent those components of the plant that can be removed from the line of 160 cubic meters per day.

5.2 Comparative investments

The following table gives approximate values for 1220 x 2440 x 19 mm (A and B) and 2000 x 11600 x 19 mm (C):

	A: 20-25m^3 per day	B: 45-50m^3 per day	C:150-160 m^3 per day
Output (300 days/year)	6,750 m^3	13,500 m^3	40,000 m^3
Imported machinery including all expenses, transport and insurance	1,250,000	1,500,000	5,400,000
Local supplies	100,000	250,000	1,400,000
Assembly, foundations, vehicles	350,000	350,000	1 300,000
Others	100,000	100,000	
Totals	1,000,000	2,200,000	8,100,000

Economies of scale play a very important role and total production costs can vary according to production increases, approximately as follows:

- from 25 m^3 to 150 m^3 per day: decrease of about 30 %
- from 25 m^3 to 50 m^3 per day: decrease of about 21-25 %
- from 50 m^3 to 150 m^3 per day: decrease of about 6 - 9 %

Considering rough production costs in plants for 25 to 50 and 150 cubic meters per day, the resulting returns on investment have been reported as follows:

	25 m^3/day	50 m^3/day	150 m^3/day
Cost in US$/$m^3$	145	(115)1/-(135)	105
Selling price	170	170	170
Excess	25	35	65
Return on capital per year (gross)	6,750m^3x25 = 168,500	13,500m^3x35 = 472,500	40,000m^3x65 =2,600,000
Investment (machines only) percentage	1,800,000 (9.3%)	2,200,000 (21.5%)	8,100,000 (32%)

1/ In particularly favourable conditions

Leaving out all general expenses, the conclusions drawn from figures showing the return on capital, in yearly percentages, are obvious, and from the economic point of view, according to the approximate calculations above, there should be no perplexity as to choice of plant capacity.

For plants with capacities ranging from about 150 m^3/day to 500 m^3/day, proportions do not change so much: therefore the main factor is the amount of wood available. For developing countries, the principles can be completely different. Where capital is lacking, local consumption is low and labour is largely unskilled, a small-size plant (25-30 m^3), designed to be extensible, can definitely be justified.

Some components of plants with capacities as above are shown hereunder which indicate whether small and medium-size plants are profitable:

1. Glueing plant see table no. 4
2. Flaking and refining machines see table no. 5
3. Sifter see table no. 6
4. Drier see table no. 7
5. Presses

Table 4: Glueing plant

Daily capa ity/m^3	25 - 30	50-60	100-120	200 - 25 and more
Glue spreading machine lateral type - and electric plant	Lit. 38.000.000	Lit. 12.000.000	Lit. 15.000.000 (1machine)	Lit. 30.000.000 (2machines)
Setting unit of five components bonding mixture - pumps	6.000.000	8.000.000	8.000.000	15.000.000 (automatic)
Dosing: feeding screw of glue spreading machine discontinuous balance	10.000.000	14.000.000	14.000.000	46.000.000 (2 electronic dosing)
Total	24.000.000	34.000.000	37.000.000 1/	98.000.000

1/ In case of two glue spreading machines, add: + 15.000.000 for glue spreading machine
+ 14.000.000 for dosing

Table 5

CENTRIFUGAL FLAKER

Capacity	25 m^3/day	50 m^3/day	100 m^3/day	150 m^3/day	200 m^3/day
Model	80/30	100/30	120/45	2 units 100/30	2 units 120/45
Power	180 HP + 15 HP	220 HP + 25 HP	140 HP + 30 HP		
Price(Lit.)	60.000.000	75.000.000	100.000.000		

FLAKING MACHINE

Capacity	25 m^3/day	50 m3/day	100 m^3/day	150 m^3/day	200 m^3/day
Model	150/Dm	150/DMS	180/DMS	2 units150/DMS	2 units 180/DMS
Power	180 HP	220 HP	340 HP		
Price(Lit.)	120.000.000	130.000.000	170.000.000		

REFINER

Capacity	25 m^3/day	[illegible] m^3/day	100 m^3/day	150 m^3/day	200 m^3/day
Model	STL/800	[illegible]000	STL/1000	STL/1002	STL/1500
Power	75 HP	[illegible]0 HP	150 HP	220 HP	270 HP
Price(Lit.)	11.100.000	19.500.000	19.500.000	30.500.000	41.000.000

Table 6, SIFTER

Capacity	Grading quantities	Dimension	Power	Price (Lit.)
3.500 kg/h dry	4	2 x 4 x 1.60 m	4.5 kW	10.000.000
7.000 kg/h dry	4	2.5 x 5 x 2 m	5.5 kW	15.000.000

Table 7, DRIER

Production, kg/h of dry raw material	kg/h of water evaporated	Power	Burner kg. fuel 1/	Price (Lit.) (including control and fuel burner, excluding dust burner)
1.500	1.250	60 kW	200 kg/h	70.000.000
3.000	2.500	95 kW	300 kg/h	105.000.000
4.500	4.000	135 kW	500 kg/h	175.000.000
8.000	7.000	168 kW	750 kg/h max.about 1 lt.= 840 Kcal.	240.000.000
10.000	8.500	180 kW	900 kg/h max.	280.000.000

1/ It can work even with a share of dry wood dust

NOTE: For 1 m^3 of exhaust air, dust content is 150 mg.

5.3 Suggestions for Economic Choices

When choosing machines, appart from their cost and size, the most important thing is quality. In the woodworking industries, all machines are generally good; nevertheless, if they are particularly cheap, there will be a risk of shorter machine life, of frequent halts in the course of production, and of further extension of assembling time. Besides, if local repair and maintenance are particularly difficult and spare parts scarcely available, it would be worthwhile to spend a little more, in order to assure continuity in operation, to avoid production losses and lost revenue.

All plants must be well kept, and small problems should not be neglected, since they might endanger future operations. Any plant, though expensive, eventually becomes profitable if it can assure an easy production, without problems, a good safety level for the operators, as well as good quality products On the other hand, a simple and cheap plant might become unprofitable from the economic viewpoint, if at least part of the production must be of a better quality for lamination and export to industrialized countries.

6. Considerations on investment advantages

6.1 General

Japan, Korea, the China Province of Taiwan, which lack wood resources and aim at saving as much as possible, should increase their particle board production in the years to come. So investments in new plants will be not only justified, but also profitable. In the above mentioned countries, the daily output of plants should never be lower than 150 m^3 (if possible plants should be always extensible to larger capacities).

6.2 Developing countries, wood producers

These countries, lacking pecuniary resources and facilities, but normally having ample unskilled manpower, should set-up small size plants. From the economic point of view, plant output should never be lower than 50 cubic meters per day; plants should have the possibility to achieve at least this output and an even greater one in the

future. Meanwhile, it should be necessary to provide operator training so that skilled technicians will be available in the near future.

6.3 Industrialized countries

Those industrialized countries which, according to global development expectations (see table 1), could exploit the whole capacity of their plants, should modify the plants themselves (when possible) in order to increase their productive capacity. Another possibility would be to set-up new plants with a daily output not lower than 150 cubic meters - board thickness: 19 mm.

Another very important subject is the advantage of exploiting wood wastes and board finishing dust either as energy sources or as raw material for the production of new boards. It is advisable that dust under 0.15 mm mesh should not be used or reused since glue consumption will increase (even with the addition of a third glueing machine), the board's mechanical properties will be reduced and the tools used will wear out faster (depending on the amount of glue added and on the baord's thickness).

The above mentioned use will be justified in case energy is very cheap, and wood and panels are very expensive, as in oil-rich countries. As for the utilization of dust as an energy source, the dust heat value at different moisture content percentages must always be considered as shown below:

W O O D		Kg-cal/Kg wood	Kg-cal/kg fuel oil
% dry wood	% wet wood		
50	50	2100	about 10,500
70	30	3200	
90	10	4300	

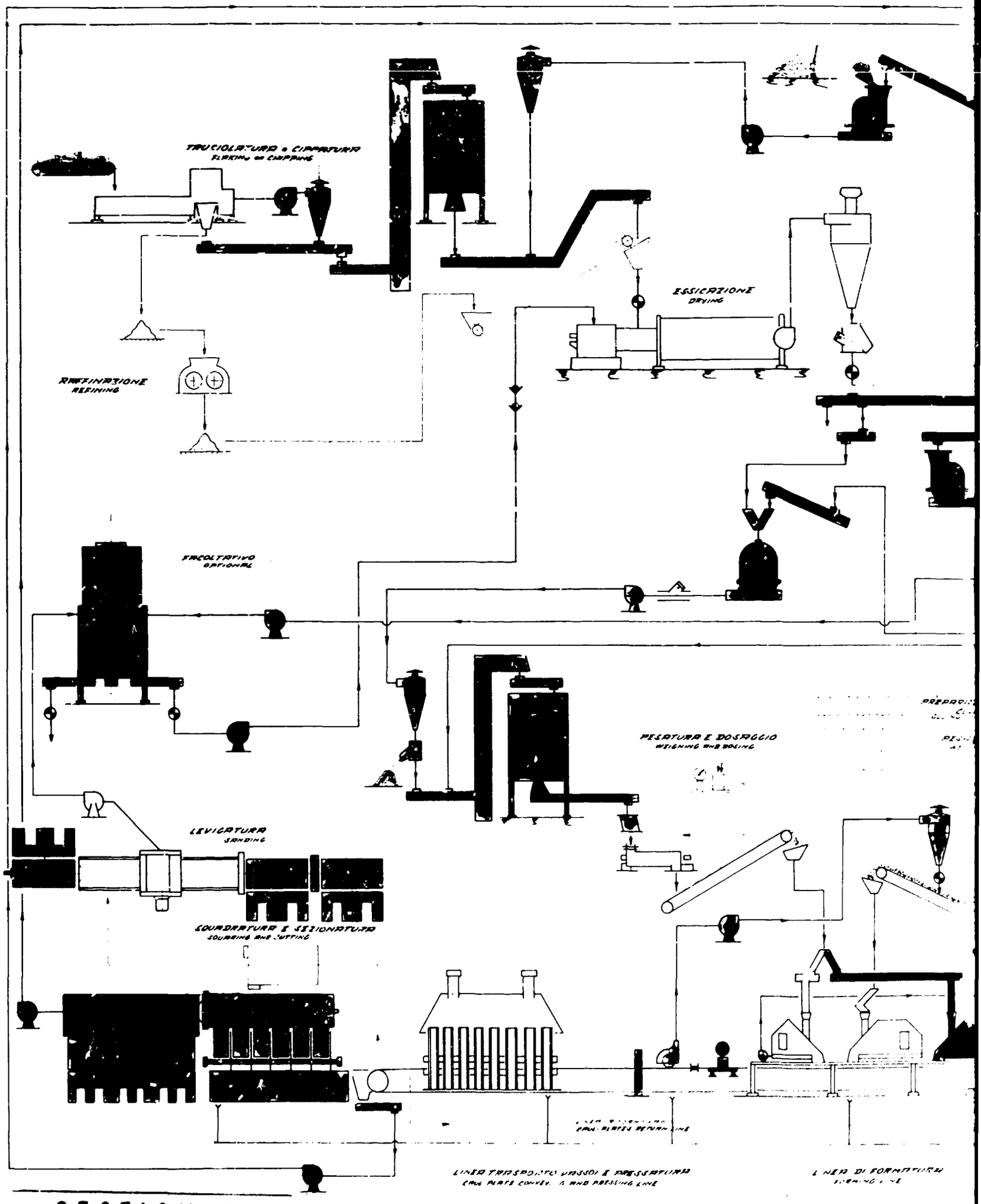
In most countries (except the oil-rich countries), it is profitable to use wood waste as an energy source. Wastes should be as dry as possible. In order to dry them solar energy could be used or, failing

that, a plant for dust drying could be set-up; thus allowing the prompt utilization of dust in boilers and/or particle driers.

In case the dust to be dried is wet, and considering all heat losses, about 900 kg-cal will be required per one kilogram of evaporated water. For this operation too, it would be preferable to utilize wood dust from wastes.

The above considerations refer to small and medium-size plants for the production of particle boards. They have nothing to do with plants of a capacity above 500 cubic meters.

What is stated above will help in deciding what plant is best suited to a specific region - considering the output capacity and the quality of the machinery from the economic and social points of view, be it in the private or in the state industry sector. But, the final decision should be taken with the manufacturing firm after weighing pros and cons mentioned in this report.


TRUCIOLATURA e CIPPATURA
FLAKING and CHIPPING
ESSICAZIONE
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PESATURA E DOSAGGIO
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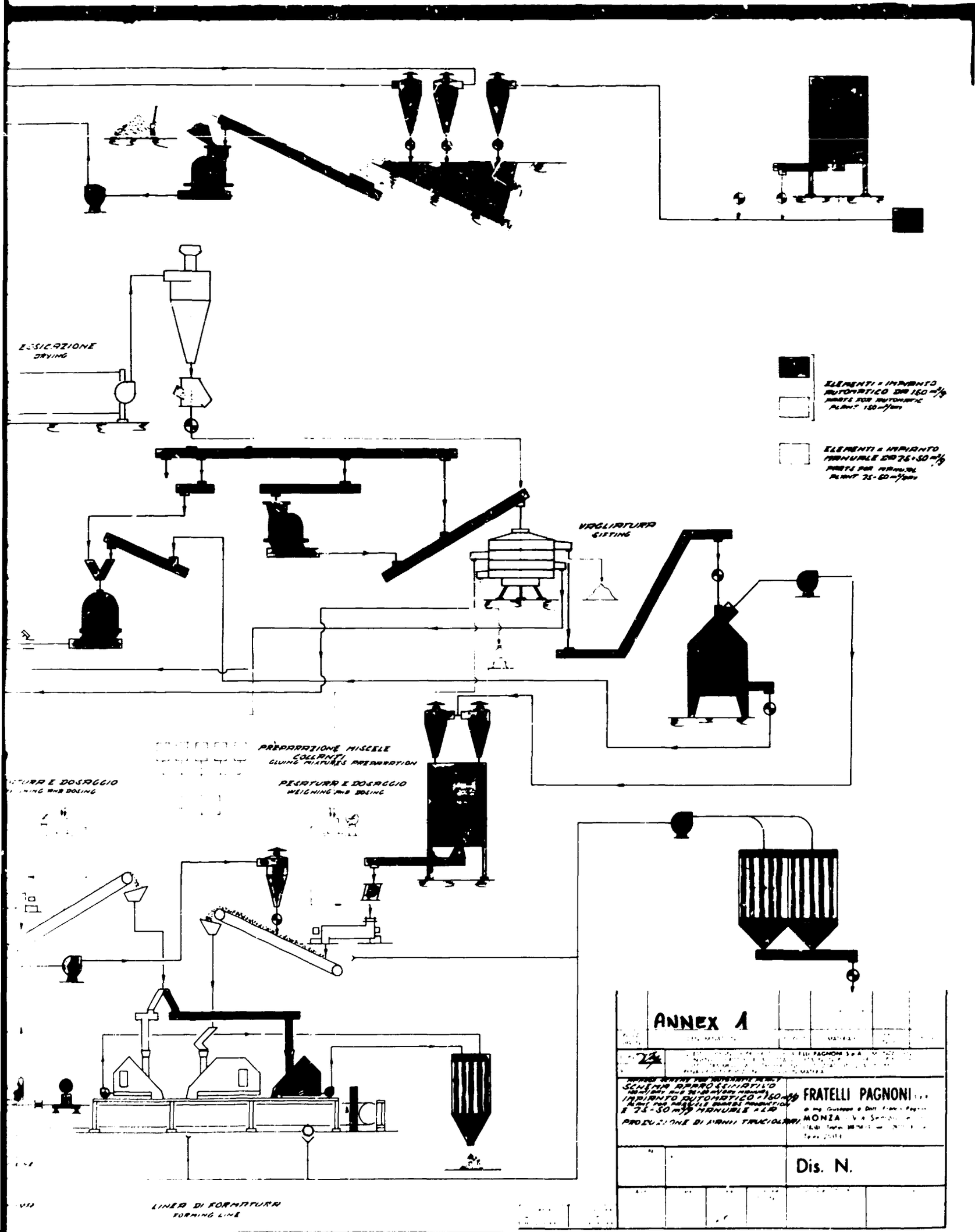
SQUADRATURA E SEZIONATURA
SQUARING and CUTTING

SECTION 1


ESSICAZIONE
DRYING
ELEMENTI A IMPIANTO AUTOMATICO DA 150 m³/g
PARTS FOR AUTOMATIC PLANT 150 m³/gm
ELEMENTI A IMPIANTO MANUALE DA 75÷50 m³/g
PARTS FOR MANUAL PLANT 75÷50 m³/gm
VAGLIATURA
SIFTING
PREPARAZIONE MISCELE COLLANTI
GLUING MIXTURES PREPARATION
PESATURA E DOSAGGIO
WEIGHING AND DOSING
LINEA DI FORMATURA
FORMING LINE
ANNEX 1
FRATELLI PAGNONI
Dis. N.

SECTION 2