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TECHNO-ECONOMIC INVESTMENT PROFILE

ON

MELAMINE FORMALDEHYDE LAMINATES

JUNE 1991

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TECHNO-ECONOMIC INVESTMENT PROFILE ON

MELAMINE-FORMALDEHYDE LAMINATES

1.0 EXECUTIVE SUMMARY

The Gulf Organization for Industrial Consulting (GOIC) has requested UNIDO to assist in the preparation of a number of technical economic investment project profiles. The manufacture of melamine-formaldehyde laminates is one of them.

Melamine formaldehyde laminates are rigid plastic panels which are decoratively coloured and patterned. They are heat and dirt resistant and lend themselves to use in products for which considerations of hygiene are important, such as kitchen surfaces.

The panels are manufactured by applying heat and pressure to multiple layers of paper which have previously been impregnated with the melamine formaldehyde resin.

The proposed plant capacity is 500,000 panels per year which would require two presses and two impregnation lines, working a 120 hour week for 48 weeks per year. The estimated annual turnover would be US$7.1 million, yielding an annual gross profit before depreciation and financing charges of US$1.6 million.

The cost of the equipment inclusive of installation and commissioning, is estimated at US$7 million.

The above projections are entirely dependant upon price and demand for the product in the GOIC region, and must take cognizance of the current European over-capacity.

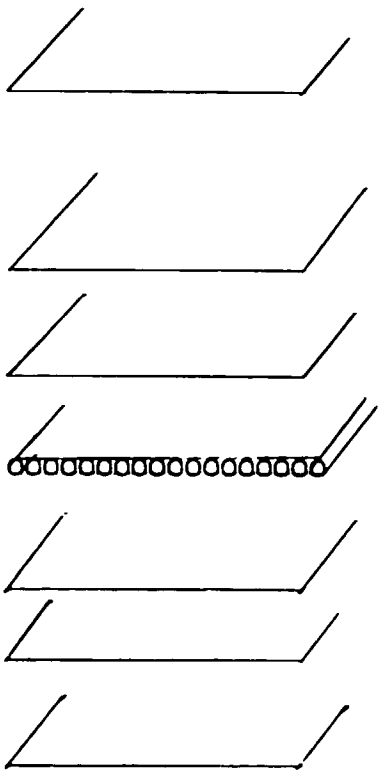
2.0 PRODUCT DEFINITION

Melamine formaldehyde (MF) laminates are a product of the plastics industry and fall within the category of thermosets. These plastics require heat to form a hard and rigid product which will not soften on exposure to further heat.

Melamine is a pure chemical which has the property of forming resins with formaldehyde (another pure chemical), under suitable and accurately controlled conditions.

Melamine formaldehyde laminates are manufactured as rigid panels. The composition of typical panels is shown in figures 1a and 1b.

Figure 1a - Self Supporting Laminated Sheet



Transparent surface layer of melamine formaldehyde (MF) paper sheet to protect patterned layer.

Patterned layer of MF paper sheet.

Pigmented 'barrier' layer of MF paper sheet.

Core layers, PF (phenol-formaldehyde) paper typically 4-17 sheets

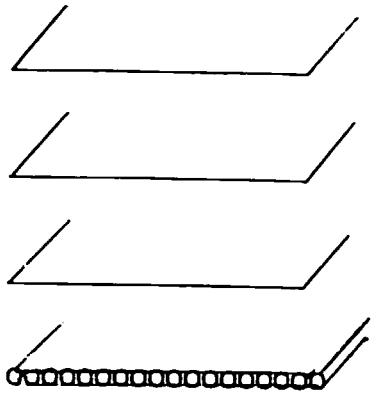
Pigmented 'barrier' layer of MF paper sheet.

Patterned layer of MF paper sheet.

Transparent surface layer of MF paper sheet to protect patterned layer.

Figure 1b - Laminated Sheet For Use With Various Substrates

Where the laminate is to be subsequently bonded to a backing material such as plywood, the PF material: is applied to one side of the MF layers:-



Transparent surface layer of MF paper sheet to protect patterned layer.

Patterned layer of MF paper sheet.

Pigmented 'barrier' layer of MF paper sheet.

'Bottom' layers, PF paper - typically 4-17 sheets.

The panels are manufactured by loading sheets of paper impregnated with melamine formaldehyde resin into a press and applying heat and high pressure to bond the layers of paper into a rigid panel typically 1.8 to 3.0 metres long; 1.2 metres wide and in thickness ranging from 0.8mm to 3.2mm.

The middle or "core" paper sheets are typically phenol formaldehyde resin impregnated paper because phenol formaldehyde is cheaper than melamine formaldehyde but has a dull opaque appearance which has no decorative use. Three sheets of melamine formaldehyde paper are then used to cover the core as shown in figures 1a and 1b. The first sheet is coloured, the second sheet is patterned and the final sheet is transparent so that the finished panel appears to be coloured ar d patterned as required.

While some markets require the laminates as self supporting panels, most laminates are sold in a form which permits others manufacturers to subsequently bond them to a suitable substrate. Such substrates can be chip board, hard board, plywood or aluminium sheet.

The desired properties of melamine formaldehyde panels are decoration, combined with a resistance to heat (upto 180°C), scratching and staining. These panels are widely used in areas where hygiene is of importance, such as kitchen furniture, table mats, door

panels and laboratory surfaces.

These laminates are made at pressures of about 15 mpa (150kgf/cm^2), and can be free standing at about 2mm or thicker, or can be bonded to other substrates at 0.8 to 1.3mm thickness.

There is an alternative but similar process whereby impregnated papers arranged as 1b above, are bonded directly on to the substrate such as chip-board. These laminates are produced at lower pressures, but give inferior impact properties compared with the high-pressure skins bonded to similar substrates, and could give slower cycles. Unless 50% or more of production is of the lower pressure laminations, there is no advantage in considering this option.

The final product is normally manufactured to internationally recognised specifications, such as: BS3794, 1982 and BS4965, 1983, 'Decorative Laminated Plastics Sheet'. These cover four classes of amino plastic faced phenolic laminated sheet, having coloured and/or patterned surfaces, and which may incorporate metal foils in the lamination. The mechanical properties and resistance to chemicals abrasion are likewise specified.

Comparable specifications include: German, DIN 53799/16926, and International, ISO 4586.

3.0 TECHNOLOGY REVIEW

3.1 Review of Technological Options

There are two principal manufacturing routes:-

a) Batch Production

STAGE 1 - Prepare resin impregnated papers.

STAGE 2 - Batch production of panels by manual or semi automatic loading of a press.

b) Continuous Production

STAGE 1 - Prepare resin impregnated papers (identical to stage 1 of a) above).

STAGE 2 - Continuous production of panels, whereby rolls of resin impregnated paper are fed between polished steel rolls to produce continuous lengths of panel which are subsequently cut to length.

3.2 Review of Production Scale and Ranges

Economic production levels depend upon the sales price which can be achieved in the region. At the moment, there are about 5 to 8 major producers in Europe, and it is believed that all have spare capacity. It is considered that a reasonable minimum output would be about 2,000 panels of equal numbers of 1.3 and 1.0mm thickness of size 2.4 x 1.2m (10 tonnes) per single shift per week. If 50% were 1.1m x 0.9m then production would fall to about 1,740 panels (8.3 tonnes) from a single press. The suggested colour range would be 50% white and beige with the balance in other colours. On a yearly basis but 3 shifts for 5 days per week and 48 working weeks, with 2 presses, production should just reach 500,000 panels.

A typical production scenario based on production cost of 2.4m x 1.2m x 1.3mm panels white or beige, at $13.26, and selling price of $16.87 would be:
45% panels are 1.3mm thick, of which 50% are 8' x 4' and 50% 7' x 3'
45% panels are 1.0mm thick, of which 50% are 8' x 4' and 50% 7' x 3'
10% panels are 3.0mm thick, of which 50% are 8' x 4' and 50% 7' x 3'

In Europe, a manufacturer would sell to wholesalers who would in turn supply retail outlets.

Popular products would be manufactured for stock, but special patterns and thickness would be manufactured to order, in minimum batches of 1 to 5 tonnes. For a start-up project, batch production using a single press is preferable to continuous production. This would provide the flexibility desirable for a developing market by virtue of its lower capital cost, more economic short runs and shorter installation time.

There is some merit in the importation of finished resin impregnated paper to obviate the first stage of paper preparation.

This would reduce the financial commitment and start up time whilst establishing markets, setting standards and concentrating the technical effort and training on a single press operation. Bought-in impregnated paper is more expensive than paper impregnated 'in house'.

3.3 Sources of Technology

There are three possibilities for setting up the plant and commissioning it:

(i) to obtain a license from an existing manufacturer, thus obtaining direct assistance in both the design of the plant and subsequent operations.

(ii) to employ one or more consultants fully familiar with the process, and so design, purchase, erect and commission the plant 'in house'.

(iii) to award a 'turn key' contract to one of the manufacturers of the principal equipment.

Potential Licensors

FORMICA LTD
Coast Road
North Shields
Tyne and Weir NE29 8RE
UK
Tel: 091 259 3000

RESOPAL WERKE AG
Hans - Bockleerastrasse 4
11 - 20 D6114 Gross-Umstadt
Tel: 06078 801

PERSTORP-WARERITE LTD
Dycliffe Industrial Estate
Darlington
County Durham DL5 6EF
UK
Tel: 0325 315141

ISOLA WERKE AG
Isola Strasse 2
10095
D-5160 Duren
Tel: 02421 808 0

Possible Plant Suppliers

Impregnation Machines

T H DIXON & COMPANY
Dixon House, Works Road, Letchworth, Hertfordshire, UK
Tel: 0462 685101

VITS MASCHINENBAU GMBH
Winkelweg 172, Postfach 86, D4018, Langenfeld, West Germany
Tel: 02173 7980 Fax: 02173 798244

BABCOCK-BSH AG
Aug-Gottlieb Strasse 5, Postfach 266, Bad Hersfeld, West Germany
Tel 06621 810 Fax 06621 81613

Laminating Presses

SIEMPELKAMP GMBH & COMPANY
Siempelkampstrasse 75, Postfach 2580, D-4150, Krefeld, West Germany
Tel: 2151 898240 Fax: 2151 898604

Drying Ovens

JENCO MATERIALS HANDLING
208 Maybank Road, South Woodford, London E18 1ET, UK
Tel: 081 504 6565 Tlx: 898379

WERNER & PLFEIDERER (UK) LIMITED
117 Stockport Road, Marple, Cheshire, UK
Tel: 061 427 7041 Tlx: 667814 WAPUK

Impregnated Paper Suppliers

PRIMCO LTD
Spring Street
Grimshaw Lane
Middleton
Manchester M24 2AA
Tel: 061 653 4876 Fax: 061 655 3073

4.0 THE PRODUCTION PROCESS

4.1 Outline of the Process (See Figure 2)

Impregnation of Paper

Rolls of suitable grades of paper of a width slightly greater than the finished laminate, are impregnated with the relevant resins in solution and passed through drying ovens to evaporate the solvent and to partially cure the resin. The treated paper is cut into lengths slightly longer than the finished sheet, and stacked in 'paper packs' between two steel plates according to the required finished thickness.

Pressing

A hydraulic press is used to compress and bond the individual sheets together in each pack. Up to eight complete paper packs can be stacked and loaded into one of the 'daylights' on the press. A press is normally loaded with eight 'daylights' so that with panels 1.0 - 1.3mm thick, 64 laminations can be pressed simultaneously at a cycle of about 76 minutes. This will give about 2,000 panels per 5 day week (one shift/one press). The weight of laminate is 1.35 to 1.5 tonnes per cubic metre, depending upon its composition.

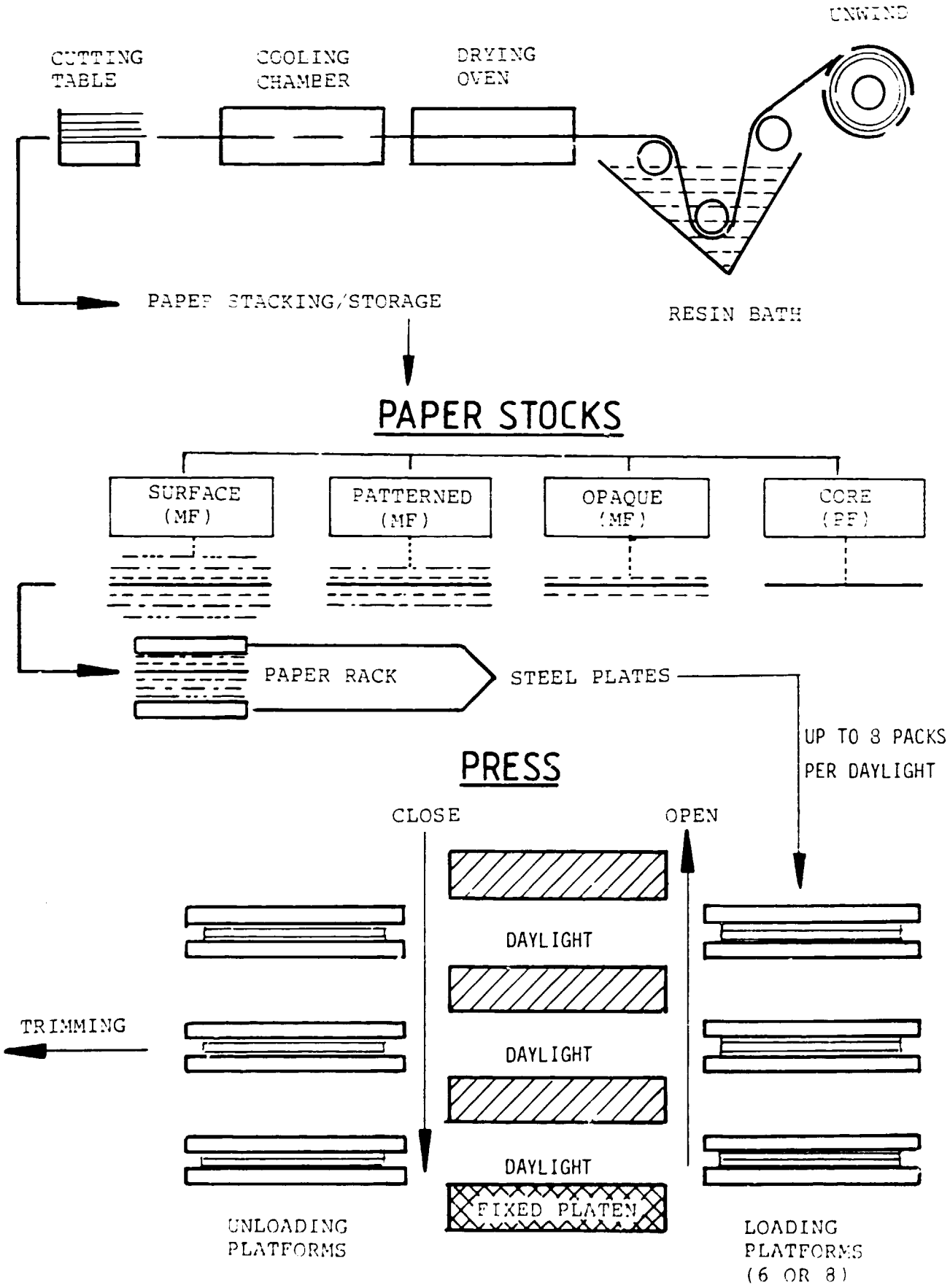
The packs are subjected to heat and pressure to affect the cure of the laminate. The platens are then cooled to avoid internal and surface defects and the press unloaded. The action of loading and unloading is synchronized by continuous chains, so that the fresh packs are dragged on to the platens as the cured ones are transferred to the unloading platforms.

Trimming and Packing

After pressing, the edges of the panels are rough and the sheets must therefore be trimmed to size by passing beneath a group of circular saws. After inspection, the panels are stacked with a protective interlayer of kraft paper to prevent surface damage, banded and boxed ready for dispatch.

FIGURE 2

SCHEMATIC DIAGRAM



A schematic layout for the proposed plant is given at Appendix I. Photographs of an impregnation line, assembly packs, steel sheets and loading the press are shown in Appendices 2 - 5.

Production Output

The most economical way of using the installed plant is to operate it continuously, 24 hours a day. However,it is envisaged that initially, demand for the product will not be great enough. Operation on a single shift per day basis will probably allow initial demand to be met.

The output rate is determined by the rate at which the laminates are moulded. These can vary according to a number of factors. A conservative initial typical cycle consists of:

a)	Loading assemblies between platens	5 mins
b)	Mould close	1 min
c)	Cure time at 135°C	60 mins
d)	Cooling to 60°C	20 mins
e)	Mould opening	1 min
f)	Re-heat platens	9 mins
g)	Unloading platens takes place at the same time as the loading	0 mins
Total time		**96 mins**

Output of a typical eight hour shift is therefore likely to be 5 batches of up to 64 panels per batch. Later, with experience, it may be possible to reduce the cycle time of 96 minutes by up to 20 minutes especially with thin panels, thus permitting 6 batches to be completed per shift.

Packaging

Panels are stacked on returnable pallets, alternately face-to-face with a sheet of paper to stop scuffing, and back-to-back. The whole is covered with polyethylene film held by polypropylene tensioned bands. Capital and running costs are very low compared with the value of the pack.

Early Years' Production

Depending upon the demand, the first year's production, based on 5 days per week and 48 weeks per year, should be 250,000 panels rising to 500,000 at full production in Year 3, on a three shift basis.

Construction Period

Since the machinery would be made to order, manufacture and delivery of the press would take 4-6 months; and the impregnating machine 6-9 months. The construction of the building and the manufacture of other equipment would be made within these periods. Installation and commissioning would take another 3-6 months. The total lead time to initial production is therefore approximately 12-18 months.

4.2 Outline List of Equipment and Machinery

It is possible that all units could be bought individually and combined to form a complete plant, but it is preferable, in the region concerned, to purchase the whole plant on a 'turn key' basis, where design, procurement, delivery, erection and commissioning of the complete plant, (with the possible exception of the laminating press) is the responsibility of one company.

Item 1	Silos for the storage of melamine-formaldehyde resin.
Item 2	Tanks for the storage of water to mix with solid resin.
Item 3	Weighing machines for powder resin and water.
Item 4	Mixing unit to dissolve the resin in the water.
Item 5	Impregnation, drying and reeling unit.
Item 6	Unit to take the prepared paper cut to length ready for pressing.
Item 7	Tables on which packs of papers can be stacked between polished steel plates ready to be loaded on to the platens for pressing.
Item 8	A 6 or 8-daylight hydraulic press capable of 1500-2000 lbs/sq in on the projected area of the laminates.
Item 9	Table on which to separate the plates and laminates.
Item 10	Conveyor to take the panels for inspection and to the trimming area.
Item 11	Conveyor to take the steel plates for re-loading, or for re-polishing.

Item 12 Saw bench to trim away the rough edges and cut to width and length.

Item 13 Table to inspect, interleave and pack ready for dispatch.

Item 14 40-50 stainless steel plates polished on both sides.

Item 15 10-20 stainless steel plates polished on one side.

Item 16 Polishing machine to keep a high finish on the steel plates.

Item 17 Saws with tungsten carbide or other wear resisting teeth.

Item 18 Sharpening machine for the saws.

Item 19 Water or solvent recovery plant from the drying unit.

Item 20 Fume extraction unit around and above the press.

Item 21 Crane for lifting reels of paper (3 ton capacity).

Item 22 Fork-lift truck to handle steel sheets (2.5 metre x 1.3 metre).

Item 23 Industrial vacuum cleaning equipment to minimise the risk of dirt particles becoming embedded in the panels.

4.2.2 Various services would also be needed, but these may be available if the plant is erected on an existing manufacturing site. These would include:

a) Cooling water.

b) Steam for platen heating. This could give faster cycles than electrical resistance heating.

c) Machine maintenance shop.

4.2.3 A laboratory is essential for the maintenance of quality, and the testing of raw materials, intermediates, and finished products. It would be the source of developments and initial training of personnel and would be one of the first installations on the site.

The laboratory equipment should include:

a) Weighing machine (1 kilo capacity).

b) Paper micrometers.

c) Mixer for making resin solutions.

d) Tray for impregnating paper.

e) Guillotine for cutting paper.

f) Drying oven.

APPENDIX V

g) Small hydraulic press 100-150 ton fitted with temperature sensors and recorders.

h) 10 stainless steel plates, 14" x 14" (350mm x 350mm), highly polished on one side.

4.3 Budget Costs for Machinery and Equipment (ex Europe)

Budget costs - extended plant (based on 1990 quotes):

	No Impregnation	Including Impregnation
Impregnation plant	NIL	US$ 3,500,000
Presses (2)	US$ 1,575,000	US$ 1,575,000
160 (2 sided) plates	US$ 0,280,000	US$ 0,280,000
60 (1 sided) plates	US$ 0,084,000	US$ 0,084,000
Ancillary plant (includes laboratory and maintenance shop)	US$ 0,250,000	US$ 0,250,000
TOTALS	US$ 2,189,000	US$ 5,689,000

Note 1. No transport equipment outside the plant has been included.

Note 2. It was assumed that steam would be available. If not, a separate oil fired steam boiler to serve two presses would cost about US$ 20,000. This would include: oil tank, water softener, steam separator, and 10 metre free-standing chimney.

Carriage at 8%:-	US$ 0,175,000	US$ 0,455,000

4.4 Budget Cost for Erection of Machinery

The respective installation costs are estimated at 9.5% of the ex-works capital cost viz: US$ 0.208.000 US$ 0,540.000

4.5 Cost of Training, Commissioning, etc

Much would depend upon the arrangements made with the equipment suppliers. It is suggested that a sum of US $131.250 be set aside.

4.6 Site Requirements

The floor areas for some of the more important individual units are given below. and a possible layout of the site covering an area of about 30 metres x 36 metres is shown in Appendix 1.

Impregnation plant	Length: 30m	Width: 8m	Height: 15m
Compression plant	Length: 13m	Width: 16m	Height: 10m
Steel repolishing shop	About 150 square metres		
Saw sharpening shop	About 100 square metres		
Laboratory	About 50 square metres		

The first two items of plant require a high building, and this would allow a second level to be built over the other areas to provide storage space.

4.7 Buildings and Civil Works

The site should have access to good main roads. The foundations must be level and adequate for the weight of the plant, particularly the compression press which may be subject to some vibration in addition to its weight. Since the plant covers an area of about 30 x 36 metres, the site area should be about 40 x 45 metres. If expansion is contemplated, then an area of about 45 x 55 metres should be provided. There needs to be adequate supplies of electricity (240 volts), water, and sewage treatment. The office and dispatch sections should have direct or easy access to the site road and hence to main roads.

4.8 Raw Materials

4.8.1. Specifications

For the raw materials. specifications have to be agreed with the suppliers. Guide lines for these are given below:-

Resins

Although laminates can be made from melamine-formaldehyde resins alone. it is normal to have a PF (Phenol-formaldehyde) core, as these panels are tougher and cheaper. Melamine-formaldehyde resin would be imported in powder form and mixed with water to allow the impregnation of the papers. The PF resin can be imported as resin. but initially at least. could be bought in as ready impregnated paper.

Typical tests would be:-

a) Moisture content;

b) pH

c) Processability - tested by making a small laminate and subjecting it to relevant tests. as given in BS3794 and others that might be relevant for use in tropical climates.

Papers

Four types of paper are needed:

1. Sulphite for the transparent layer.
2. Coloured and/or printed with a pattern.
3. Highly pigmented (normally white) to give an opaque layer.
4. Core paper, normally PF impregnated kraft.

It is recommended that, initially at least, the printed paper is imported printed and/or coloured to minimise the variables that have to be evaluated at the commissioning of production.

Typical tests would be:-

a) Moisture content (possibly to BS3433)

b) pH

c) Thickness and uniformity (thickness could be to BS3983)

d) Weight per unit area

e) Fibre clumps and black spots

f) Resin content (PF paper only)

g) Colour, ash content, nature of ash (opaque barrier paper only)

h) Colour, quality of pattern, light and heat fastness (patterned paper)

i) Absorbency - to BS2916, freedom from alum (surface paper only)

Lacquers

These can be coated on to the final surface of the PF paper, to allow two laminates of the asymmetric type to be made between one pair of stainless plates.

4.8.2 Raw Material Inputs

Typical inputs per panel based on 2.4m x 1.2m panel 1.3mm thick, white, for use with substrates:

			Complete Processing (in kg)	Ready Impregnated Paper (in kg)
MF Resins	-		0.307	—
Paper	-	Overlay	0.062	0.124
	-	Barrier	0.245	0.490
Pre Treated	-	PF Layers x 1	4.900	4.900
			-------	-------
		TOTAL	5.514	5.514
			(Weight trimmed	5.183kg)

4.9 Prices of Raw Materials & Consumables

4.9.1 There are two possibilities for initial recommended production:

i) Ready Impregnated Paper

To buy in ready impregnated papers, needing only pressing;

ii) Complete Processing

To buy the papers which need MF resin impregnation, cutting to length, and pressing but buy in the PF paper ready impregnated.

The following costs are prices quoted for export, and are 10 - 15% higher than those available to European manufacturers buying in reasonably large quantities.

(i) Typical costs of ready impregnated paper:-

Type	Thickness	Cost
Overlay paper	20 gm	US$ 0.70/m
Overlay paper	25 gm	US$ 0.88/m
Patterned paper	80 gm	US$ 1.40/m
Patterned paper	100 gm	US$ 1.47/m*
Barrier paper	80 gm	US$ 1.02/m
Barrier paper	120 gm	US$ 1.23/m
PF paper	160 gm	US$ 0.40/m

* - (range of US$0.52/m to US$1.5/m depending on design).

(ii) Typical raw material prices for complete processing:-

		Cost Per Tonne FOB
Resin	Melamine formaldehyde	US$ 2,275
Papers	Overlay	US$ 5,950
	Patterned	US$ 3,010 - 8,750
	Barrier - 80 gm	US$ 6,125
	Barrier - 120 gm	US$ 7,675
	Phenol-formaldehyde impregnated	US$ 1,400

4.10 Utility Requirements

Steam is the preferred medium for the heating of the platens, as it gives rapid but controlled heating. The consumption would be equivalent to 30 kilowatts per hour, for a production of 200 kg of panels. (These figures include contingency for small power and lighting).

Cooling water consumption would be about 60.000 litres per hour.

4.11 Maintenance Costs

The main costs would be the sharpening and replacement of the saw blades. Two men could carry out this task and combine it with plate repolishing. Replacement costs depend upon a number of factors but would be of the order of US $35,000 per year.

Press maintenance would consist mainly of replacing the glands on the hydraulic cylinders. This should be nil the first year, and thereafter cost about US$ 10,000 per year. Moulding plates should need no replacement for the first year at least; after this about 4 per year would require replacement, at a total cost of about US$ 14,000.

Note that the above excludes 1st year start up and commissioning spares which are included in the initial capital cost of the presses.

4.12 Manpower Requirements

Indirect Labour (daywork only)

1	Production manager	-	skilled
1	Production engineer	-	skilled
3	Office staff	-	semi-skilled
5	TOTAL PER DAY		

Direct Labour (per shift)

1	Foreman or charge-hand.	-	skilled
8	for the impregnating machine.	-	semi-skilled
8	for assembling paper packs.	-	semi-skilled

4	to operate the press and oversee the loading and unloading.	-	skilled
8	for trimming the panels.	-	semi-skilled
2	for inspection and handling the panels.	-	skilled
1	for packing and taking to despatch stores.	-	semi-skilled
1	for the raw material and maintenance stores.	-	semi-skilled
2	for plate and saw care.	-	skilled
2	for general maintenance.	-	skilled
2	for cleaning and general duties.	-	un-skilled

39	**TOTAL PER SHIFT**		

4.13 Environmental Aspects

The atmosphere within the operating plant must be clean for the sake of the quality of the product. There would be some discharge of formaldehyde fumes but these would be removed by fume extractors. The edge trimmings are completely scrap, with little likelihood of disposal other than by dumping, as the material burns only with difficulty. However, since the material is essentially inert and not degradable, disposal by dumping as landfill does not pose problems.

5.0 EUROPEAN PRODUCTION COSTS

The estimated production costs for a typical 2.4m x 1.2m x 1.3mm thick. white. for use with substrates panel is at about 2,000 panels per five day week (one shift/one press):

	US $
Raw Materials	9.18
Direct Labour	2.08
Overheads	2.00
TOTAL	13.26

6.0 INTERNATIONAL PRICES

The following table is indicative of European manufacturing costs and sales prices of 2.4m x 1.2m panels in white (the cheapest), and of an average priced colour product.

	Production Cost		Selling Price (Ex Works)	
Thickness	White	Coloured	White	Coloured
0.8mm	$ 6.47	$12.30	$ 7.77	$14.77
1.3mm	$13.26	$20.38	$16.87	$24.45
3.0mm	$32.81	$37.67	$39.37	$45.22

APPENDICES I - V

APPENDIX I — PLANT LAYOUT

APPENDIX II — IMPREGNATION PLANT (horizontal type).
Vertical is more economic for floor area.

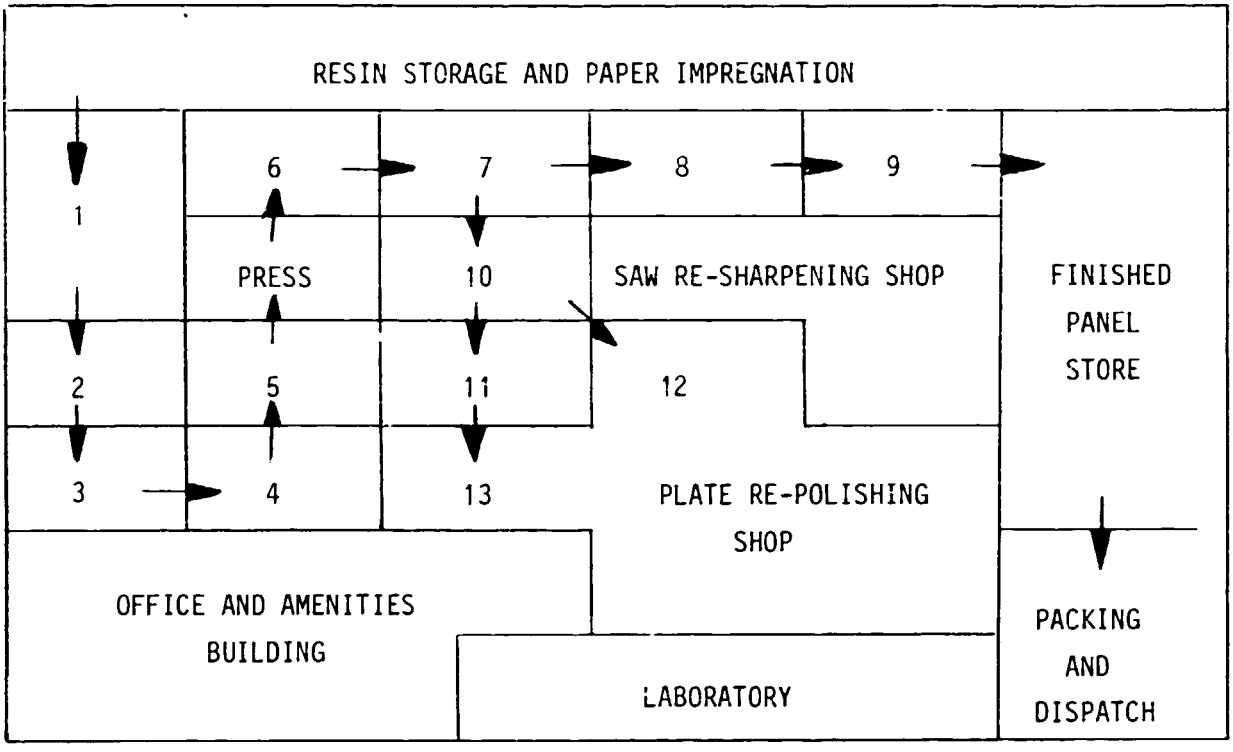
APPENDIX III — ASSEMBLING PACKS OF PAPERS.

APPENDIX IV — STEEL SHEET ON TOP OF PACK, READY TO PASS TO LOADING STATION.

APPENDIX V — VIEW OF PRESS
- right side last loading pack being fed into loading platform.
- centre (background) press.
- left side unloading platform.

APPENDIX I

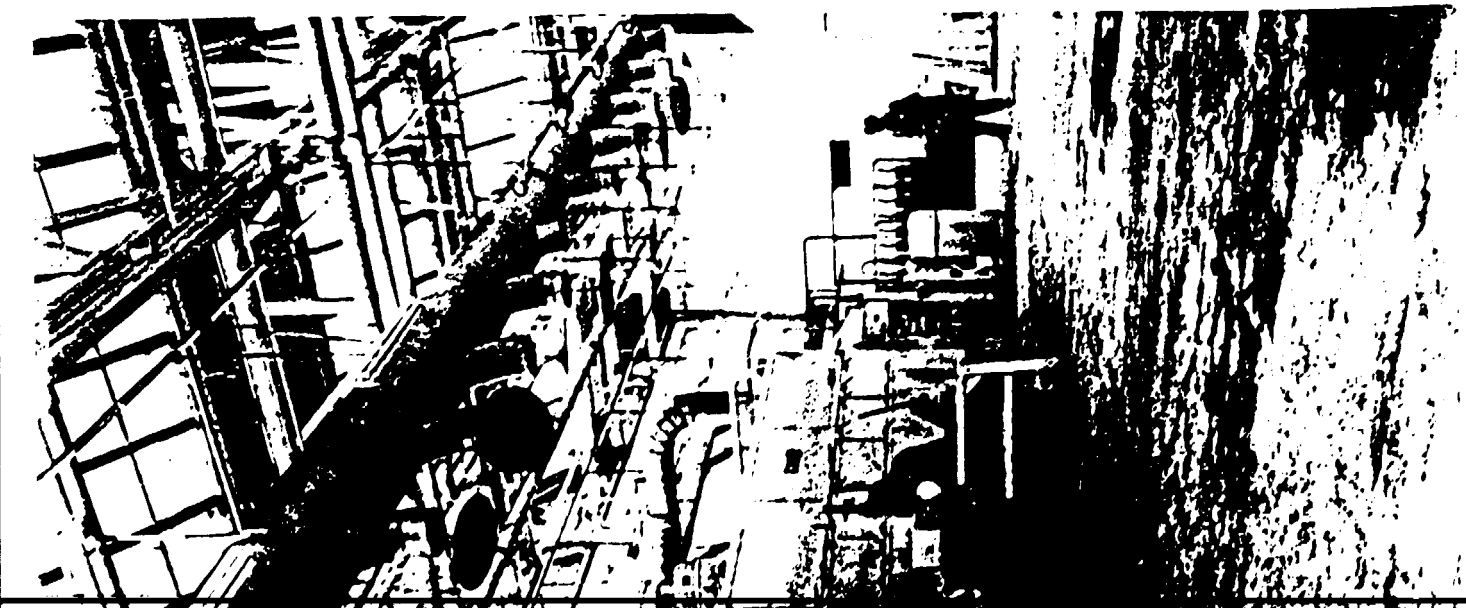
Possible layout of the plant -

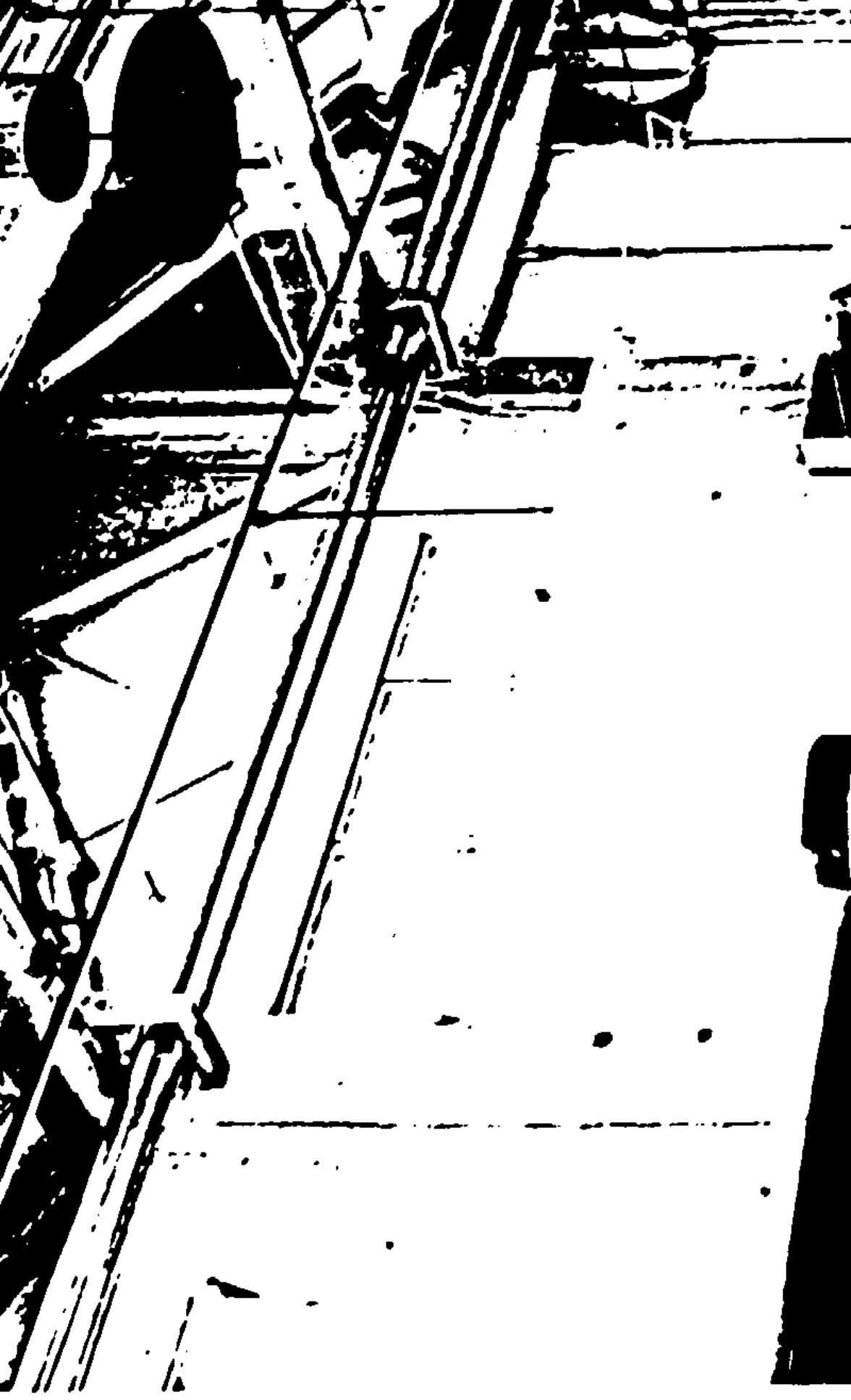


Index of numbered locations

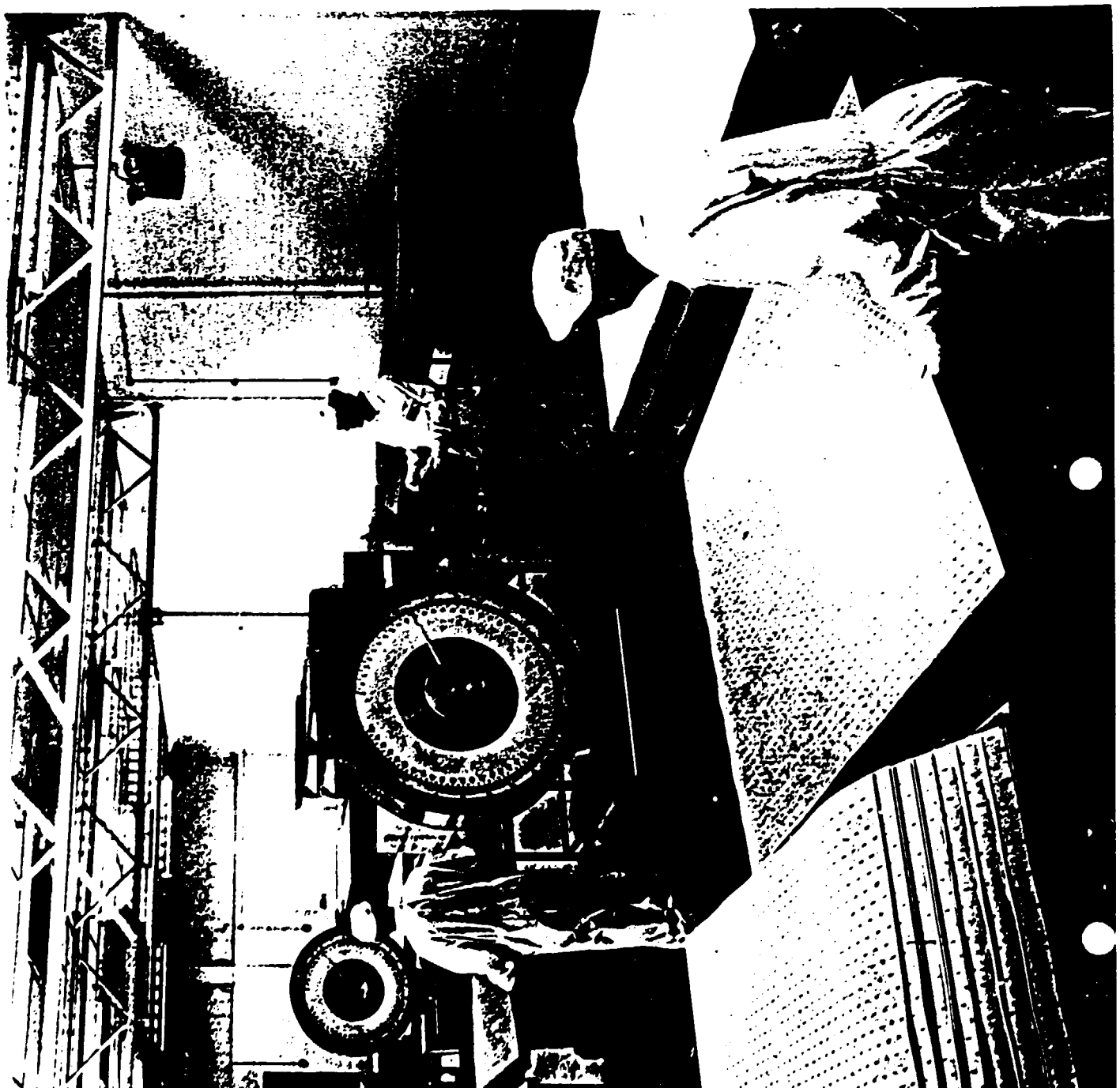
1)	Cut paper Stock	2)	Pack Assembly	3)	Plate Rack
4)	Plate Store	5)	Loading Platform	6)	UnloadingPlatform
7)	Unpacking Panels	8)	Panel trimming	9)	Panel Inspection
10)	Used Press Plates	11)	Good Plates	12)	Rejected Plates
13)	Good Plate Store				

APPENDIX II





APPENDIX III



APPENDIX IV