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PLANT LAYOUT ^{1/}

by

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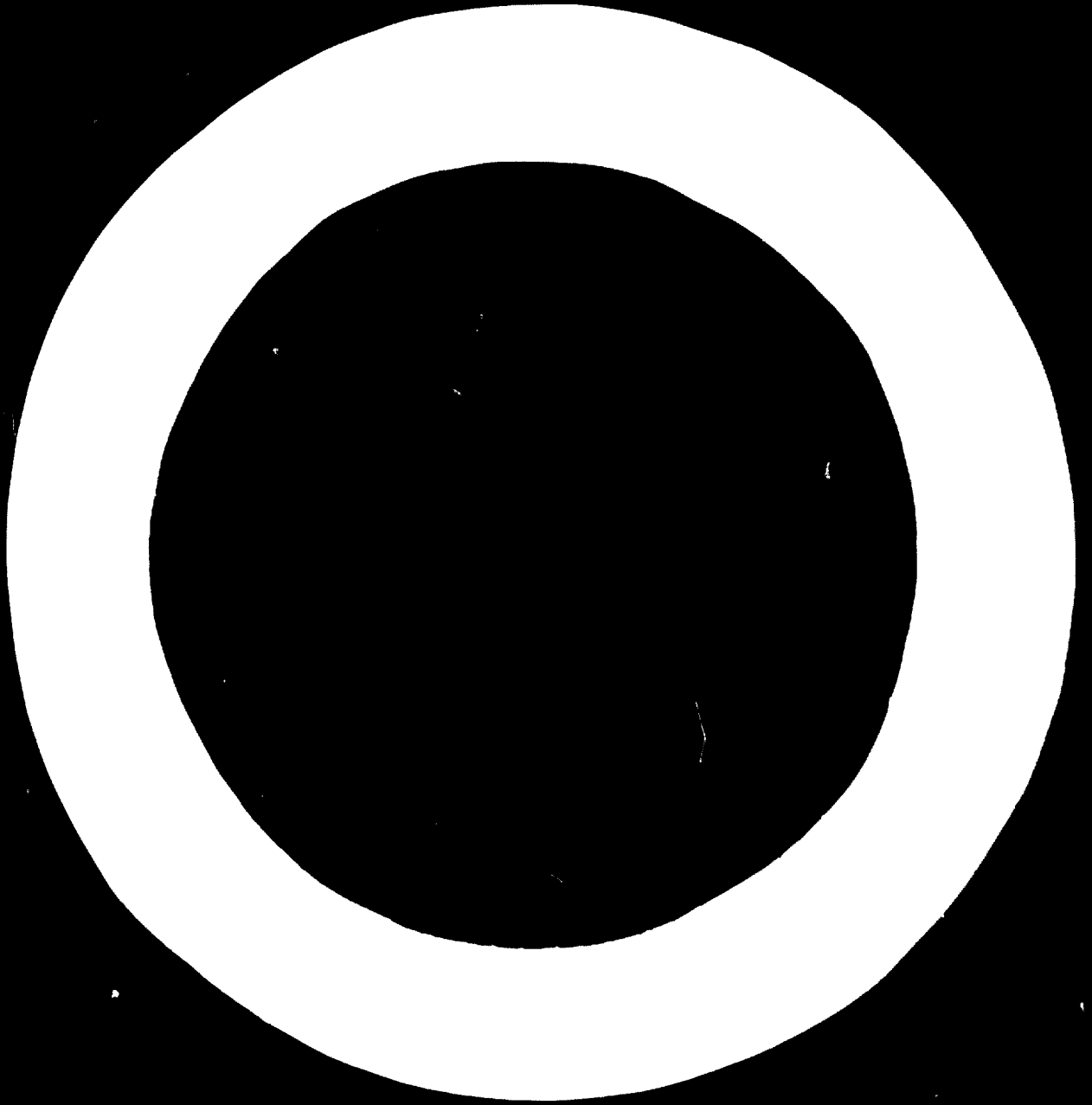
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1. General

By the term PLANT LAYOUT is meant the general organization of production, placing of machines, equipment and working places as well as planning of internal transportations and factory building in the way that offers the manufacturing process as advantageous conditions as possible.

Following grades of plant layout can be distinguished in respect of comprehension of task.

- Complete planning of new plant
- Necessary plant layout when moving into another, already existing factory building
- Rearrangement of factory within a total plan
- Small arrangements on different sections of plant

The principles of plant layout presented in the following are independent of the branch of industry and so far generally applicable to any kind of plant or establishment (e.g. service station, farm, kitchen, photographic laboratory etc.).

Plant layout must not be understood only as one time process but rather as continuous activity which is necessary to maintain the enterprise's ability to compete.

2. Objects of plant layout

The main objects of plant layout can be divided into following groups:

- Working methods and places
- Their placing into process

- Planning of machine groups and sections
- Locating different sections at proper places
- Designing factory building around machines and process
- Electric installations, pipe networks (water, heating, steam, sewage disposal, compressed air, chip and dust extraction etc.)
- Power plant (or supply)
- Handling of waste
- **Factory area**

3. Starting point for plant layout

The basic information necessary for layout planning is in first place:

- Planned selection of products (production programme) now and in future
- Type, construction and materials of products
- Desired quality standard
- Desired production capacity

4. Special characteristics of production in furniture and joinery industries

Important viewpoints having effect upon layout planning are:

Furniture industry

- Assortment of products is usually large
- Number of similar items in one batch is often quite small
- Life of designs is short
- Continuous production of same models is seldom possible
- In addition to solid wood or timber, many wood-based semi-manufactures as well as plastics and metals are used for raw materials

Joinery industry

- Assortment of products is considerably limited as compared with furniture industry (product size is variable as in

doors and windows)

- Many products are standardized (in Finland)
- Continuous manufacturing of standard products is possible
- Life of products is long (e.g. flush doors)
- Solid wood is the principal raw material

In regard to plant layout a joinery factory is often easier to design because of standardized products.

5. Arrangement of production

Following principles of arrangement can be distinguished (fig. 1):

- Stationary working places (e.g. manufacture of fixtures)
- Arrangement according to manufacturing method (e.g. basic woodworking machines in furniture industry)
- Production lines
 - separate working places (e.g. machines) in line according to successive work stages
 - working in chain (e.g. furniture assembly)
 - semi-automated or automated production lines (sequential automation common in furniture and joinery industry)

6. Production capacity

- In conventional production using separate woodworking machines and equipment the machining or manufacturing capacity is determined by the bottleneck (fig. 2). **Bottlenecks**

form when 100 % of the capacity of a certain machine, machine group or ^{piece of} equipment is utilized. The estimation of machine need can be based on the amount of required machining hours/year at different machines with a certain production programme or on the average wood handling capacity in m³/year of woodworking machines to be used (table 1).

- The capacity of an automated line is the same throughout the entire line.

7. Production flow

Following principles can be distinguished in respect of flow

path direction

- Straight flow
- Zig-zag flow
- U-shaped flow
- Ring flow
- Odd-angle flow (fig.3)

8. Means and facilities for plant layout

These are in first place:

- Internal standardization
 - products, materials, working methods
 - parts of factory building
 - factory equipment and fixtures
(e.g. transportation pallets, storage shelves, working tables, tool cabinets etc.)
- Operation process charts, machine operation charts etc. schemes and drawings (fig. 4 and 4a)
- Miniature scale models (fig. 5)

9. Plant layout in practice

The recommended method is to begin the layout planning on "white paper" from the placing of machines, equipment, conveyors, passages, working places, storage areas etc. appropriately independent of the limiting effect of walls, pillars and other construction details. This is done best by the aid of scale models (scale of building drawings is usually 1:50) using e.g. soft fibre board, covered with millimetric scale paper, as base material. The scale models can be cut from coloured cardboard and fixed on base board with pins. In case three-dimensional models are necessary such can be made of soft wood (e.g. Balsa) or lightweight polystyrene.

In many cases the production of a factory can be divided into two distinct parts or lines:

- Solid wood line (chairs, legs, rails, drawers etc.)
- Panel line (cabinet parts, table tops etc. details made

of semi-manufactured boards)

A common practice which has shown to be advantageous is to place machines of similar function (in respect of working principle) into groups as follows:

- Cross-cutting saw + edging saw
 - Planing machines
 - Tenoning machines
 - Mortising and boring machines
 - Vertical spindle moulders + routers
 - Sanding machines
 - Veneering machines
- etc.

In furniture industry the internal transportation is mostly carried out by pallets + hand-operated lift trucks. This system is very flexible and therefore well suited to furniture manufacture. In addition to this system, roller tables and motor operated fork lift trucks are used in joinery industry. The conveyors used in surface finishing shops are usually of special type and therefore not suited to other stages of production. Today's tendency, especially in furniture industry, is to do the surface finishing before assembly.

The direction of load transportation (on pallets) must continuously follow the same direction on factory passages. Opposite and crossing traffic must be avoided (fig. 6).

The factory area necessary for different storages is always noticeably large in furniture and joinery factories (roughly one half of total factory area in many plants). Two kinds of storage areas are needed for components and products under manufacture:

- Intermediate storages between different work stages
(free floor area between machines or other work places)
- Proper storage areas between main manufacturing stages
(for machined parts, assembled products, finished parts, finished products etc.)

Storage is further needed for the following items.

- Kiln dried timber
- Veneers

- Semi-manufactured boards, plywood, plastic laminates etc.
- Glues
- Fittings and hardware, sanding materials etc.
- Packing materials

The storage shall be easily accessible from the factory side by workers and from outside by lorries or railway. Too centrally located storages cause much wasted time due to long walking distances from the ends of plant to the centre of building. Therefore it is more rational to place the storages near to the points where materials in question are needed (fig. 7).

The electric installations and pipe networks are generally positioned in the upper space of the factory building above machines and equipment to facilitate later rearrangements.

In all details of plant layout the viewpoints of safety must be taken into consideration.

11. Factory building

The principal characteristics of modern factory buildings in furniture and joinery industry are:

- Buildings are in one level. This results in avoidance of vertical transportation, cheaper foundations and easier enlargement in future
- Rectangular building form. In large buildings illumination by natural light is possible through roof windows. In practice, however, electric illumination is decisive
- Partition walls between sections are avoided (surface finishing section is an exception). Especially for this reason factories are provided with S p r i n k l e r networks
- Pillars are avoided whenever possible
- Number of corners must be at the minimum (fig. 8)
- Future enlargements (Stage I, Stage II etc.) are preliminary planned in advance (fig. 9)

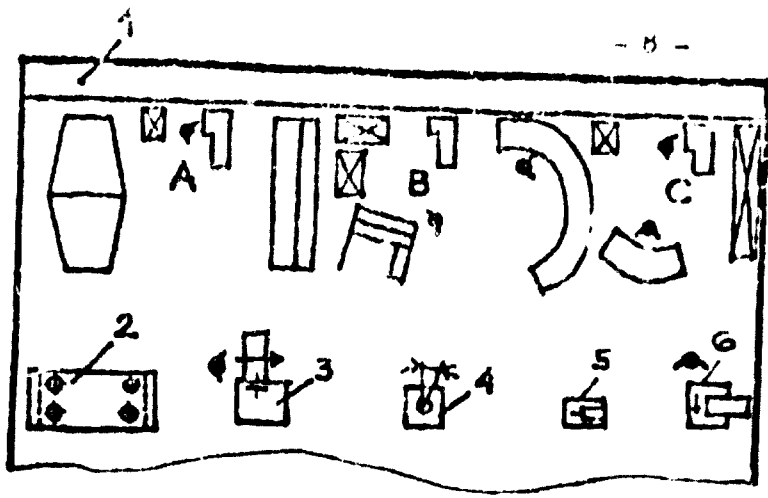
12. Factory area

The planning of the factory area includes among other things considering of following details:

- Positioning of factory building on the lot in that way that future enlargements are possible. It is advantageous if the starting point of production can be maintained in its position in spite of enlargements
- Placing of timber yard and outer storages taking easy transportation into consideration
- Traffic plan within factory area (people, raw materials in, finished products out etc.)
- Office (in connection with the factory or as separate building).

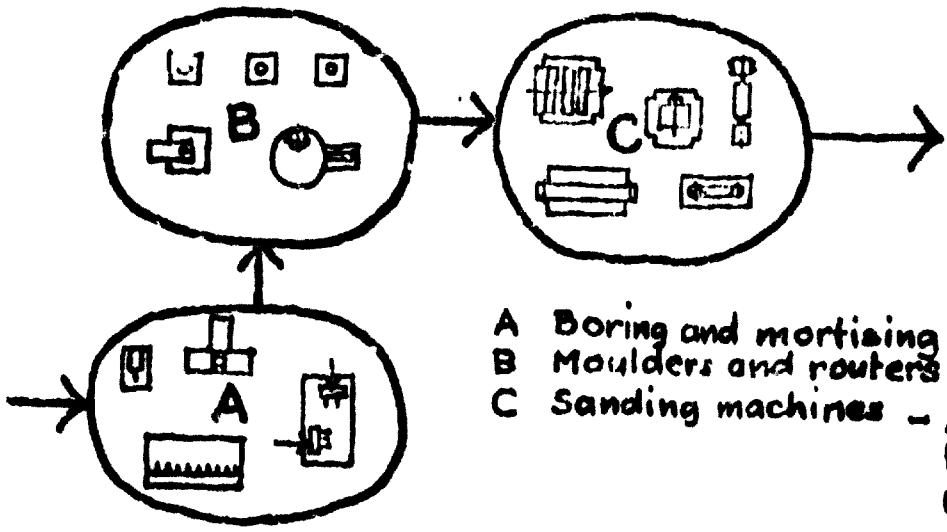
(fig.9) .

Fig. 10 shows an example of a typical layout for the surface finishing shop of a small furniture factory.

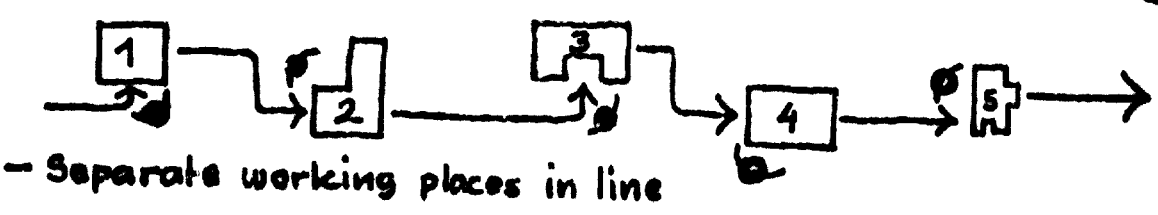


- 1 Drafting and plan table
- 2 Single-opening press
- 3 Circular saw with feed table
- 4 Vertical spindle moulder with tilting table
- 5 Horizontal boring machine
- 6 Band saw

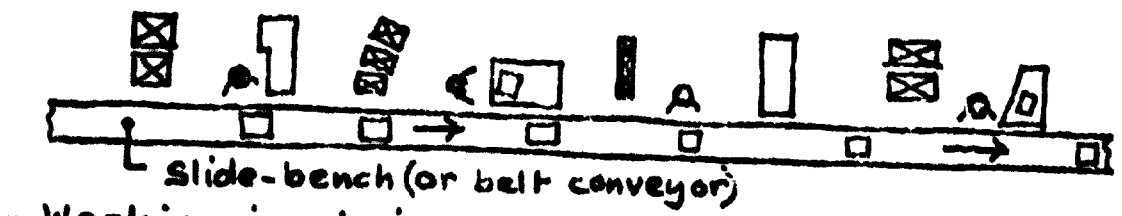
-- Stationary working places



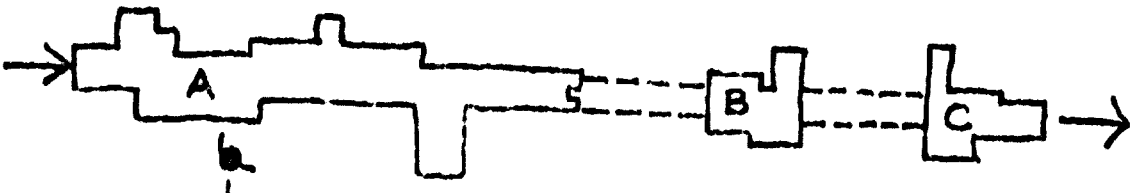
- A Boring and mortising machines
 - B Moulders and routers
 - C Sanding machines
- Arrangement according to manufacturing method



- Separate working places in line



- Working in chain

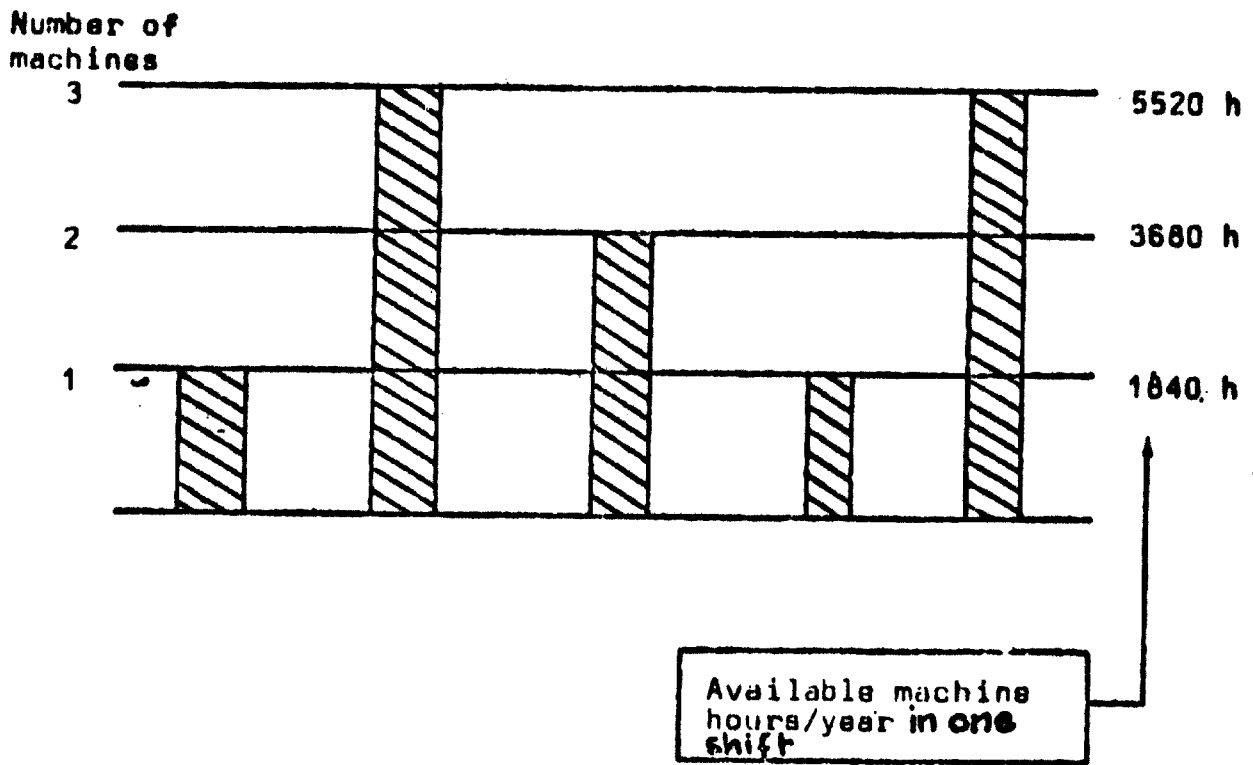
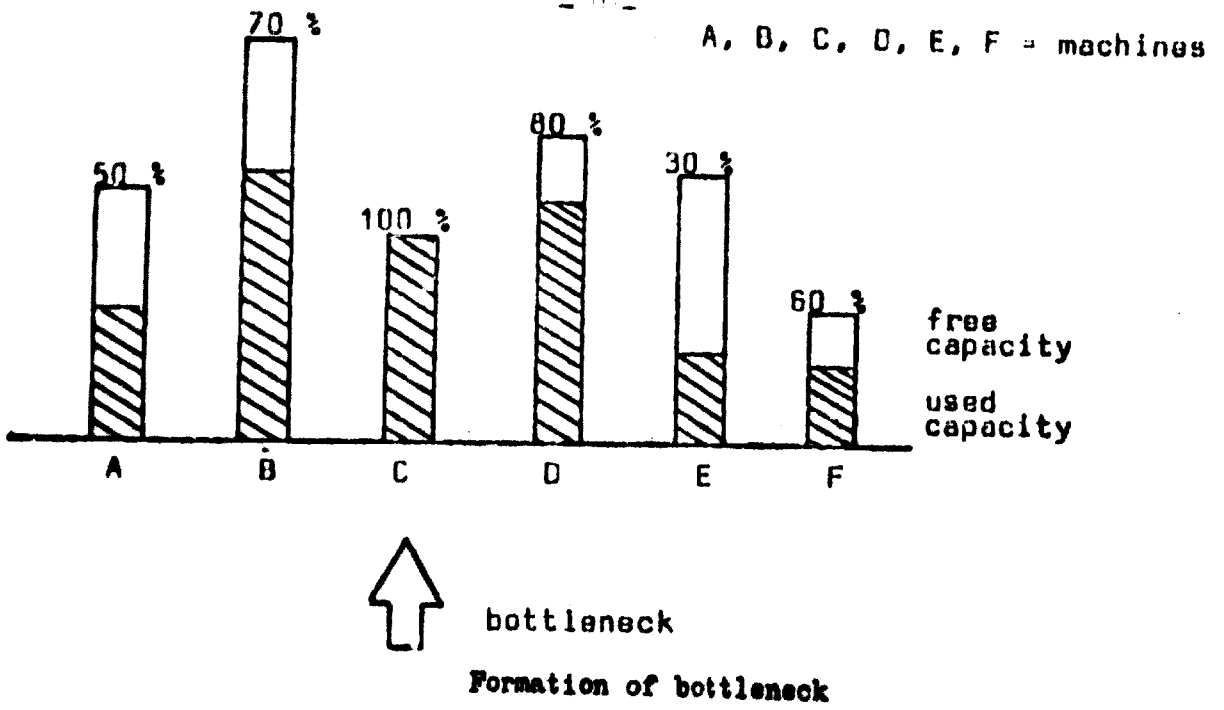


Controls machines A, B and C

- Semi-automated or automated production line

Production lines

FIG. 1. Arrangement of production



Capacity of machines can be increased only as multiples of single machines

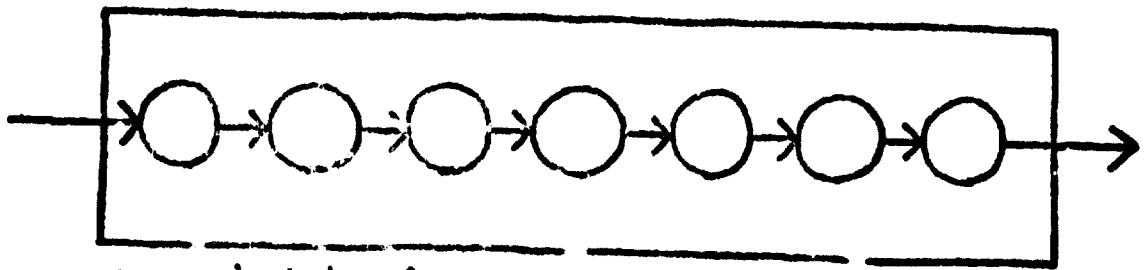
FIG. 2. Capacity and formation of bottleneck

Table 1.

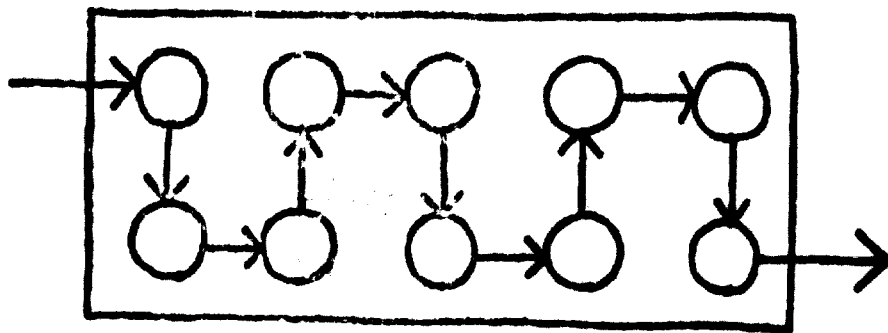
AVERAGE CAPACITIES OF SOME BASIC WOODWORKING MACHINES

	Cubic metres/year
Cross-cut saw	2300
Edging saw, chain feed	2300
Surface planer	1400
Thickness planer	4,7/mm in width
4-side moulder	2300...4700
Trimming saw, single-blade	1400...1900
Trimming saw, double blade	2800...3700
Band saw	2300...4700
Vertical spindle moulder	700...1400
Router	2300
Chisel mortising machines	1400...1900
Horizontal belt sanding M.	1900...2800

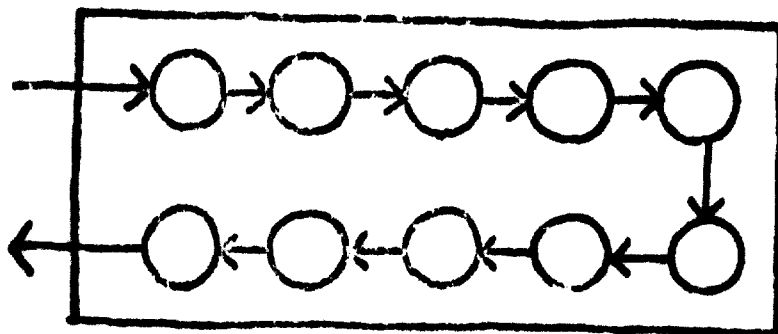
The values are valid in average furniture production where different kinds of furniture are manufactured of solid wood in one shift.



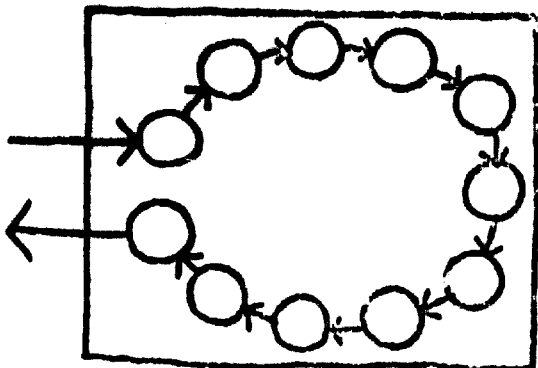
Straight flow



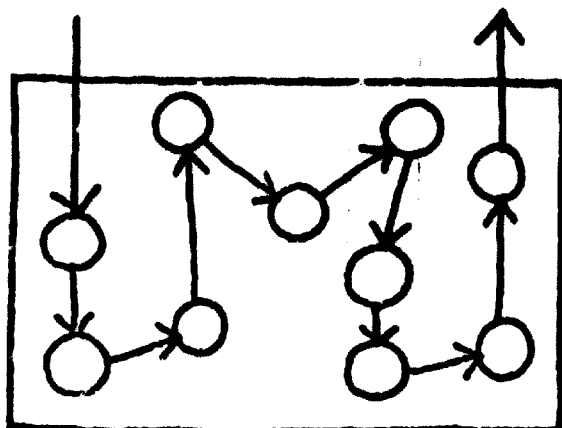
Zig-zag flow



U-shaped flow



Ring flow

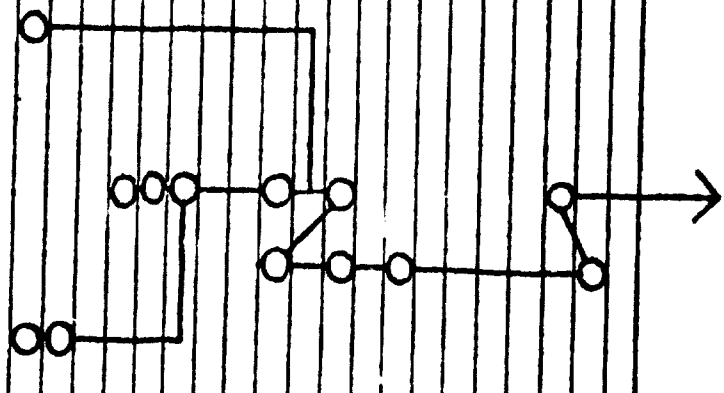


Odd-angle flow

FIG. 3. Production flow

FIG. 4. Machine operation chart

MACHINE / DEVICE		MACHINE OPERATIONS			
Machine No.		TOP PANEL ① SURFACE VENEER PARTICLE BOARD CORE	LEG ②	SIDE RAIL ③	END RAIL ④
1	Cross-cut saw				
2	Vertical saw				
3	Surface planer				
4	Thickness planer				
11	Glue spreader				
12	Solid wood panel gl. press				
13	Veneer saw				
14	Veneer jointer				
15	Panel saw				
16	Glue spreader				
17	Panel veneering press				
2.1	Sickle-blade saw bench				
2.2	Double-blade trimming saw				
18	Edge veneering				
9	Vertical spindle moulder				
10.1	Multi-spindle boring mach.				
10.2	Form sanding machine				
10.1	Horizontal belt sand. mach.				
10.2	Vertical " " " "				
10.2	Form sanding machine				



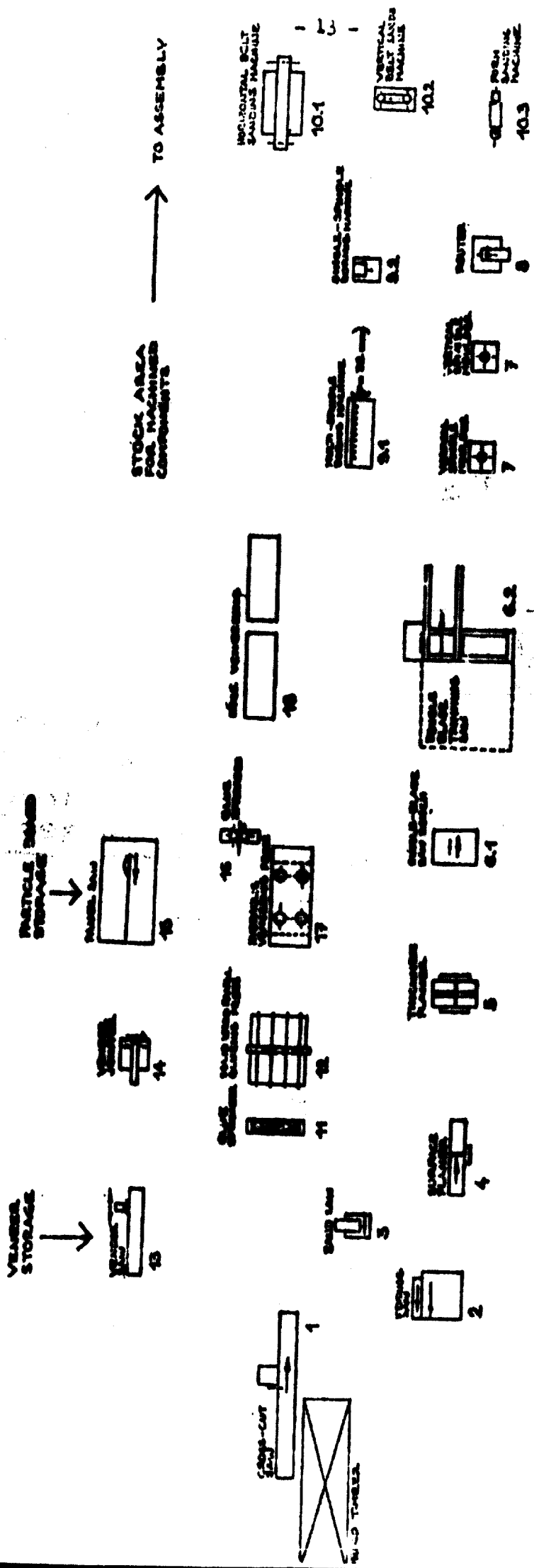


FIG. 4a Machining section of small furniture factory

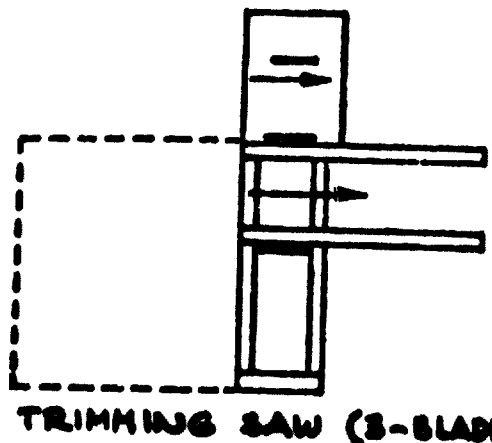
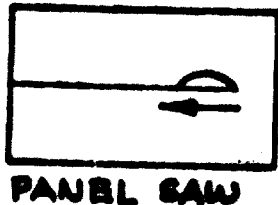
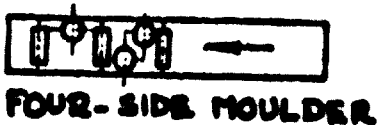
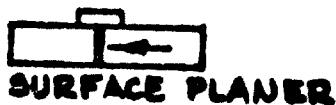
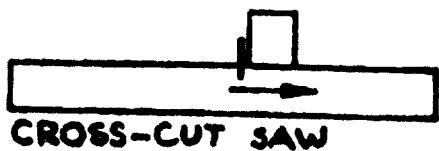


FIG. 5. Scale models 1:100

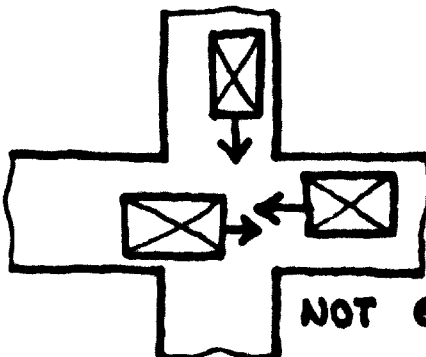
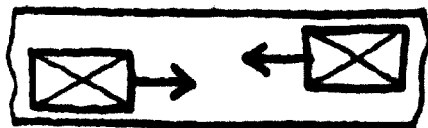


FIG. 6. Pallet transportation on factory passages

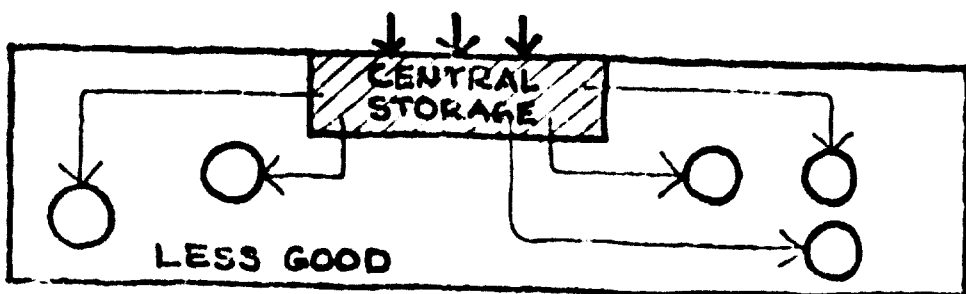
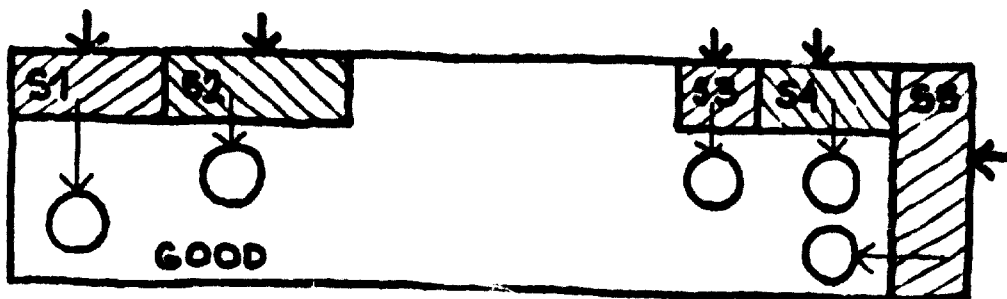
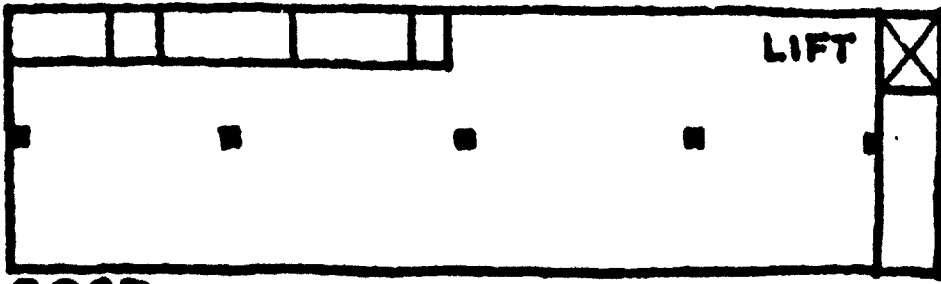
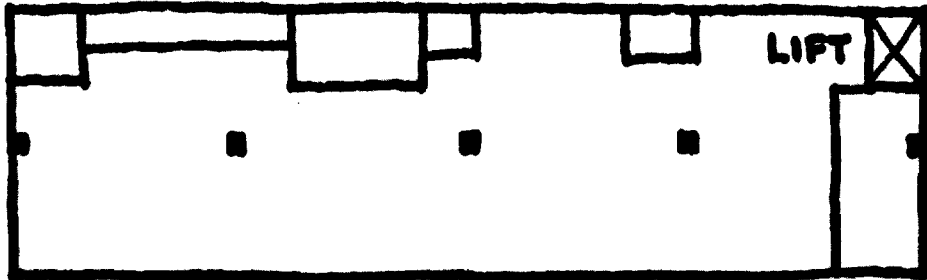


FIG. 7. Locating storage space



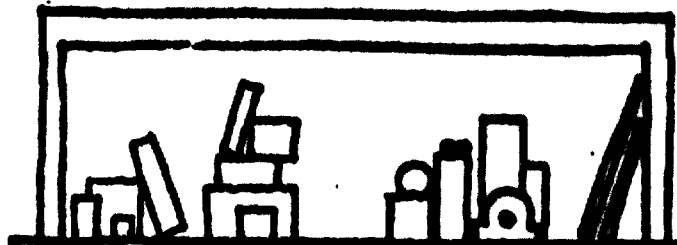
GOOD



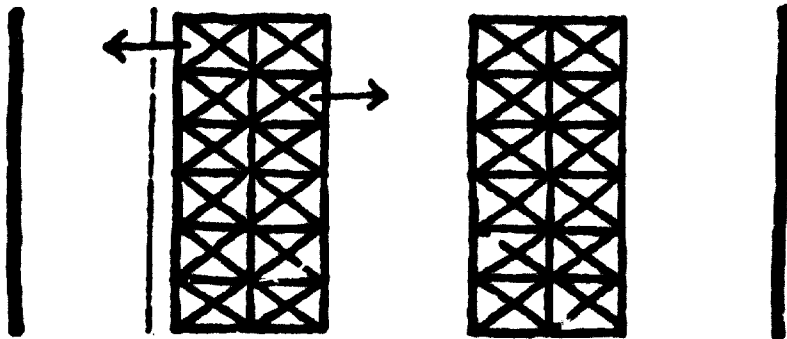
TOO MANY CORNERS



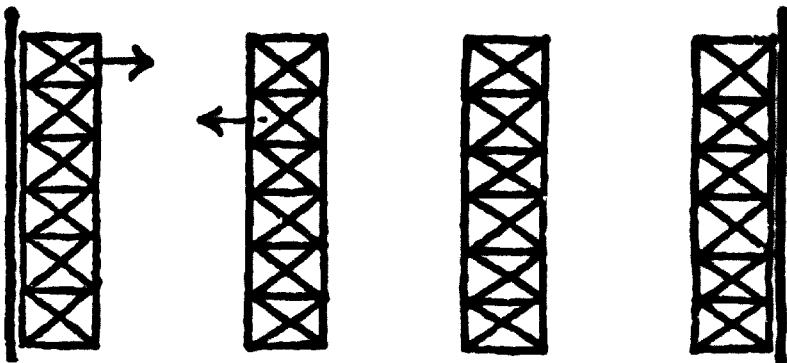
GOOD



NOT GOOD

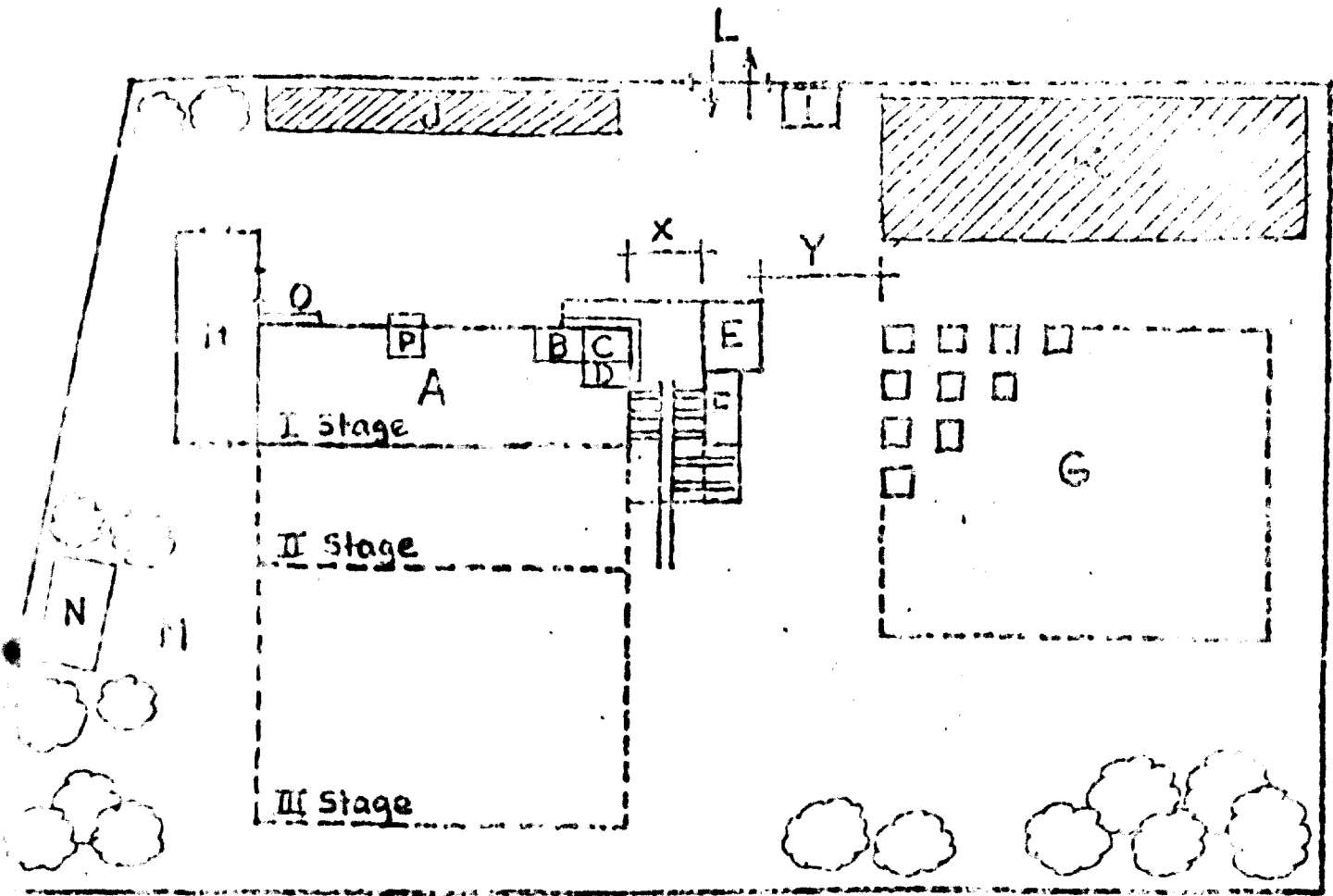


GOOD
Free walls



LESS GOOD
Pallet loads
against walls

Fig. 8. Use of factory area



- A Factory building
 - B Panel storage
 - C veneer storage
 - D storage for kiln-dried timber
 - E Heat centre
 - F Drying-kilns
 - G Timber yard
 - H Office building
 - I Gate-keeper
 - J Car parking for office staff and visitors
 - K " " " " workers
 - L Gate
 - M Lawn
 - N Ball game
 - O Finished products out
 - P Storage for fittings & hardware etc.
- Allowable distance between
 X Heat centre and factory
 Y Heat centre and timber

FIG. 9 Plan for factory area

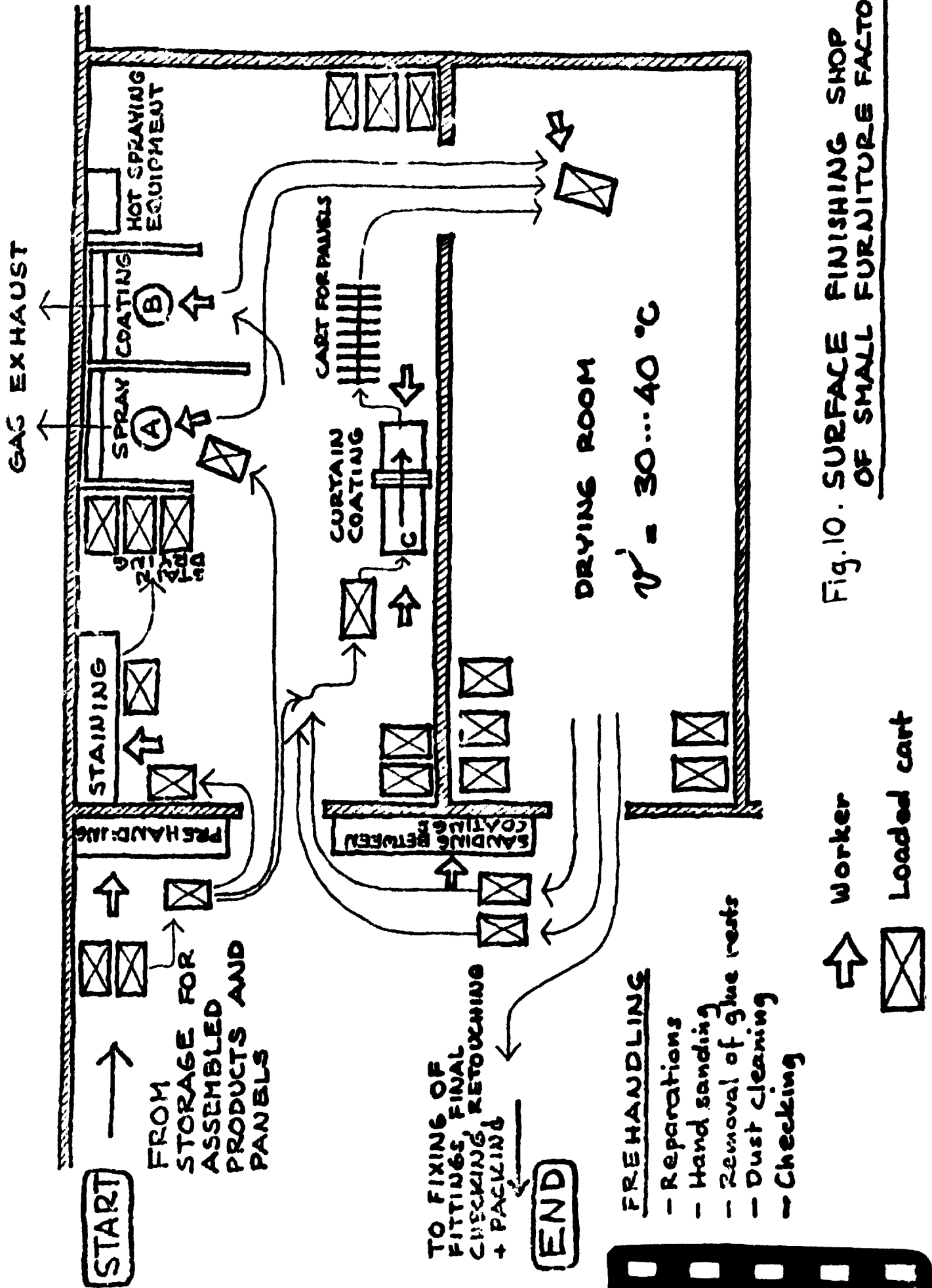


Fig. 10. SURFACE FINISHING SHOP OF SMALL FURNITURE FACTORY



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