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WOOD BASED PANELS: GENERAL CONSIDERATIONS AND GUIDE FOR PLANT IMPLEMENTATION, SELECTION OF MACHINES AND EQUIPMENT*

by

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1. Introduction

While thisreport deals mainly with plant and machinery for the production of those particular groups of wood based panels which are currently of more industrial importance, it is nevertheless considered opportune to refer to all types of panel, to the main differences in their structural characteristics and to their end use.

As regards end use, bonded wood panels may be subdivided into two categories: those which are mainly used for furniture, furnishing components and door wings and those which are made specifically for use in building, both for industrially made components and for total or partial prefabrication of buildings of various types. There are also direct applications in building yards in the form of substitutes of other less convenient or less rational materials.

First category:

a) Particleboards bonded with synthetic resin, not very humidity or water resistant.

The process begins by transforming wood into chips of a given length and thickness. The chips are then mechanically broken into particles of the required size and dried. A certain percentage of synthetic resin binder, and other complementary substances, are then added. With the correct amount of uniformly distributed particles thus obtained, the panels are formed, compacted and highly bonded in heated presses.

The resins, used in the majority of cases to produce this type of panel, are urea and formaldehyde based and are thermosetting, a property greatly intensified by the addition of suitable catalysts.

Besides resin and catalyst, a small quantity of water-repellent material is generally added to the particles (fossil wax in emulsified form or molten) to give the panels a limited amount of waterproofing to avoid any trouble which might arise with an end product either during manufacture or use.

For furniture, and other products, delivered to countries where wood is subject to parasitic attacks (particularly by xylophagous insects), the preparation of the particles can be completed by adding a suitable protective agent to the mix.

With modern plants these panels can be made very large, of the order of several tens of square metres, and also by a continuous process without limitations lengthwise. Large panels, and continuously produced panels, obviously simplify any marketing problems; they are simply cut to size according to requirements.

Thickness can be from 2.5 to 40 mm and therefore satisfy the most varied needs. Weight, also according to needs and depending on raw materials used, production method and panel thickness, can vary from 350 kg/m^3 (very light panels, made from wood or other cellulosic materials of low specific gravity, with thickness usually not less than 15 mm) to 800 kg/m^3.

Elastic-mechanical characteristics are good, not differing greatly from the better qualities of plywood and particleboards.

They are becoming applicable for general use throughout the world for making modern furniture, furniture components and panelling, sliding partitions, solid and flush door wings, etc. and applications can be extended to all those cases where there is no danger of high ambient humidity, contact with water or exposure to several weather conditions.

b) **Medium density fibreboards manufactured by a dry process**

These are a recent alternative to type a) panels even if, for the time being, their industrial importance is very much less. The manufacturing process is very similar, the main difference being that the wood is initially transformed into fibres, thereby creating an absolutely compact and uniform structure (also thicknesswise) which ensures satisfactory workability in depth and along the edges.

Thicknees are normally from 6 to 30 mm with weight being from 600 to 700 kg/m^3. They can be produced in very large sizes, and are easily divided up, but so far no continuous production plants have been made. Elastic-mechanical characteristics are similar to those for particleboard. Due to the greater amount of energy required to defiber the wood, more raw material used for a given thickness and otherreasons, these panels are considerably more expensive than those previously described. They are very convenient to use and even become a necessity when they have to be carved, countersunk, accurately shaped, etc.

c) **Hard and semi-hard fibreboards**

Defibering of the wood is also required for these boards and they can be manufactured by both wet and dry processes.

For the wet process, substances already oontained in wood (lignin) are used as binders with the addition of limited amounts of synthetic resins. With the dry process, fibres are bonded exclusively with synthetic resins similar to those used for chipboard.

Particularly with the dry process it is possible to make very large hard and semi-hard boards, but as far as is known no continuous plants for their production have been built. Minimum thickness is usually 2.5 mm and never exoeeds 7-8 mm. The weight is greater than that of an equally thiok normal type (chipboard) particle board.

Plants are more or less similar to those for the two types of boards previously described and, naturally, the range of thicknesses is the same.

Second category:

d) Mineralized wood-wool boards

The ingredients for bonding are: Portland type or magnesian cement and a relatively soft mass of wood wool or shavings from which panels of limited dimensions are made with thicknesses from 20 to 100 mm. They are extremely porous and therefore fairly light; weight from 360 to 570 kg/m^3. Good heat and sound insulation are their main features but mechanical strength is obviously low. The "mineralization" of the wood is suoh that the panels, while being very permeable to air and not subject to attack from mildew, fungus, bacteria and insects, behave well in the presence of high humidity and also in the oase of fire. They are only used in certain sectors of the building industry such as temporary buildings, small modest type dwellings, rural buildings, or as heat insulation inside masonry walls or for false ceilings or lining garrets.

e) Concrete-wood boards

Relatively large wood particles are prepared for this product. They are only partially dried and after undergoing a "mineralising" treatment they are mixed with Portland type cement and a suitable quantity of water.

Panels of limited dimensions are made with this mixture (usually not much over 1 m^2), thioknesses being from 20 to 80 mm. To obtain disoreet mechanical characteristics, weight reaches from 500 to 700 kg/m^3 for finished panels brought to a commercial humidity level. Mechanical strength is higher and the field of applications wider than for mineralised wood wool panels. In particular, surfaces are not porous, even if not very flat, and they lend themselves to plastering. They are easy to work, hold nails reasonably well and may be joined together without difficulty with special, but simple, metal fittings. Heat and sound insulation are excellent and weatherproof and fireproof characteristios are very satisfactory.

These properties make the panels highly suitable for "built-in" shuttering, which are left in position for subsequent finishing, for insulation of load-bearing concrete and reinforced concrete casts. They are also suitable for forming floors, and in this case also remaining in position (as false ceilings), for floor foundations, for internal and external facing on perimeter walls, for internal partition walls etc.

f) Particleboards bonded with synthetic resins having high resistance to humidity and water.

Except for the nature of the bonding synthetic resins and complementary substances added (together with them or separately) to give the panels the required characteristics, their structure and the plant required to produce them are identical to those of the boards described in a).

The resins used are phenol and formaldehyde based or belong to the melamine group. Thermosetting resins which may be catalyzed are always involved, but once they have reached polymerisation they are absolutely insensitive to cold and hot water. Other synthetic resins have recently been studied, with which panels of this same type can be made, but they are still in an experimental stage and only some small industrial applications have so far been made.

Logically it would not be sufficient merely to use a water-resistant resin to make a panel suitable for applications under the severe conditions found in the building industry. It is necessary to limit, as far as possible, the swelling of the wood particles (and therefore of the panels) by adding suitable water-repellent substances to the mix and other special treatments. It is furthermore necessary to prevent parasitic attacks, particularly from mildew and fungus, which could rapidly degrade the material, this being done by adding defensive agents.

Finally, another necessity for all materials involved in building work is that of fireproofing, to prevent the starting and spreading of fires with all their serious consequences to human beings. Except for particular cases, panels intended for use in buildings receive fireproofing treatment during manufacture.

g) **Particleboards bonded with lyes of lignin bisulphite**

This type of board is of relatively recent production. Manufacturing plants can justify their existence if, at a conveniently economical distance, there are cellulose factories or paper mills able to supply their by-products (i.e. lignin lyes) for concentration into a syrupy substance for use as binders.

Plant and production cycles are analogous to those for types a) and f) boards the main difference being at the pressing stage, the time required being necessarily longer than for other types of panel. This negative production factor can be partially remedied by adding to the lyes a percentage of thermosetting phenolic resin, or similar, and by speeding up the heating of the panels while under pressure by applying high frequency electric equipment to the press.

For an equal weight of wood particles, the amount of lignin added is much greater than the amount of synthetic resin used for the other types of particleboards. The weight

is therefore much higher, this being of no great inconvenience if the panels are for the building industry. Resistance to humidity and water of these lignin bisulphite boards is very high and values for swelling by absorption are extremely low.

h) High density cement-bonded boards

This is another type which has only recently gone into production. It has already met with success and is of great interest for its possibilities in modern and rational building applications.

Its industrial cost is less than that of f) and g) type panels, manufacture is easier and weatherproofing excellent. Durability is more than adequate as, in this case, the wood particles are also "mineralized" and there are virtually no problems of parasitic attacks or degradation. Stabilization of the wood also determines very low values of dimensional variation which are proportional to the humidity level. Fireproof qualities are also good.

On the other hand, elastic-mechanical characteristics are, for the time being, a good deal lower than those boards bonded with synthetic resins and weight is higher (always over 1000 kg/m^3).

Sizes are relatively large and usually correspond to modular building elements. Lenghts are usually over 3 m, widths vary from 1.25 to 1.83 m while thicknesses are between 7 and 40 mm.

At the pressing stage, specific loads reached are of the same order as those for the production of ordinary particleboard. All mechanical characteristics are good, surfaces are smooth and uniform and therefore distemper, paint, wallpaper, and any other type of finish, are easily applied.

In spite of a high cement content, operations such as sawing, drilling or countersinking, using suitable tools, are very much the same as for normal particleboard. The panels are highly suitable for all kinds of building components, floor foundations, false ceilings, partition and perimeter walls (combined with other materials) etc., due to their excellent resistance to fire, humidity, atmospheric agents, mildew, fungus, insects and chemicals.

Sound deadening properties are high and, although inferior to those of normal panels, heat insulation is satisfactory.

For these reasons, and other features already mentioned, advantageous applications are for built-in shuttering for normal concrete and reinforced concrete casts used for main structural members, slabs and load bearing walls.

High density cement-bonded boards can also be used to make fire barrier doors, industrial and agricultural silos, agricultural buildings, etc.

i) Insulating fibre-boards

As in the case of b) and c) type boards the raw material (wood) must be defibered and bonded by wet processes mainly with natural ligneous substances.

Due to low mechanical strength, large panels cannot be marketed. Generally, thicknesses are not below 8 mm and can reach 35 mm or more.

Their main advantage is that of good heat insulation and they are used for all those building applications where rigid insulating and easily erected materials are required.

j) Fibre-boards bonded with mineral substances

The binders used are calcium sulphate or magnesian cement. The panels are substantially insulating types, both heat and sound (especially reflected sound if surfaces have been suitably prepared with carving, holes, decorative high relief etc.).

Compared with type i) panels they are more durable and have better fire-proof properties.

2. PRINCIPLES AND GUIDE FOR THE STUDY OF AN INDUSTRIAL PROGRAMME FOR THE PRODUCTION OF WOOD BASED PANELS

There are two basic factors which must first be considered :

- possible and predominating applications for the panels, due to need or as alternatives to those existing on the market, or applications foreseen;
- availability of wood (or other cellulosic materials such as agricultural by-products or from other sources), their physical and technological characteristics and suitability for the processing required to produce a given type of panel, as well as annual quantities available at a convenient distance from the factory so that transportation costs may be held to a minimum.

The first factor applies mainly to group a), b) and c) boards rather than d), e), f), g), h) and i). Having established product application, bearing in mind the specific needs of the market, the manufacture of one rather than another type of board in the same group will be made possible, or more convenient, by the nature of the raw material.

For example, wood with a high content of tannin or oily substances is not suitable for synthetic resin bonded boards. For cement bonded boards it is not advisable to use wood containing a certain percentage of saccharine substances. It is possible to produce mineralized wood-wool boards only if wood is available in rounds with diameters not less than 7 or 8 cm. It is furthermore to be borne in mind that any limitations in raw material supplies determine corresponding limitations in the productive capacity of any projected plant.

Among the three types of panel considered above in the group of materials to be mainly used for furniture and furnishing components a distinction can be made between thin panels (between 2.5 and 6 or 7 mm) and medium to very thick. With the former, particleboards and hard and semi-hard fibre boards may be considered as alternatives. With the latter, the alternative is between particleboards and medium density fibre boards; cheaper than the former types but with some limitation in workability. While the others are absolutely compact and homogeneous, and therefore suitable for any work their industrial cost is much higher.

Among the six types of panel which are mainly used in building work, characteristics are more differentiated and the choice of one rather than another of the respective production plants depends, besides on what has already been pointed out, on the type of buildings involved (conventional, partially prefabricated, totally prefabricated), the principles followed in the design and the specific use to which the panels are to be put (for built-in shuttering, for integrating other materials such as auxiliary elements and as actual building material).

For purposes of brevity, among all the possible types of bonded wood panels, only particleboards will be examined in the succeeding paragraphs. Due importance will be given, however, to the differences in technological characteristics of the binders used (various kinds of synthetic resin, lyes of lignin-bisulphite, cement) and, consequently, suitability and specific utilization.

It should be emphasized that. while in principle it is possible to produce every type of bonded boards (with all the various synthetic resins now available) with the same plant (suitably flanked by complementary equipment), it is vital to know the end use, or uses, of the material before studying the plant, thus avoiding the choice of machines not suitable for the job and not possessing the correct requirements for operative adaptability.

It should also be pointed out that normal plants are capable of producing panels of any thickness, but if the main interest is for thin panels, it is worth while considering a much less costly type of plant for this specific purpose.

3. - MACHINES AND EQUIPMENT FOR EACH SECTOR OF A PARTICLE BOARD PRODUCTION PLANT : PRINCIPLES OF DETERMINING THE SELECTION

Sectors common to all types of plant are:

- raw material storage (wood or other cellulosic material);
- particle production (mechanical);
- particle drying;
- preparation of bonding materials and their mixing with or application to particles;
- mat forming and pressing;
- panel finishing.

3.1.- Raw material storage

The designing of a particleboard factory should begin with the allocation of space for raw material and an estimate of the equipment required for unloading, stacking and withdrawal for production.

Raw material can be of only one type or consist of different materials to be used simultaneously, in constant ratios, for the first operation. Only in the case of one of these material which is sawdust, from other operations, can storage in silos be convenient. All other raw materials are normally stored in the open.

To establish the maximum storage area required, besides pathways and space left free for security reasons (especially for fire prevention involving low humidity materials in particular), consideration must be given to the frequency with which raw material could arrive as well as the anticipated productive capacity.

In order to be able to face any unforeseen circumstances, even in situations where supplies are plentiful, stock should never reach levels lower than those required to cover 40-50 working days. Where regular deliveries cannot be made, or materials are available seasonally, stocks should be kept at an adequately high level.

In calculating area requirements, the dry weight of raw material required for each cubic metre of panels produced should be taken into account, as well as its corresponding apparent volume in the state in which it can arrive at the factory, the most convenient height for piles, if the wood is relatively large and evenly sized, or average height of heaps if material is already chipped.

For the latter type of material, problems of conservation can arise (if storage is long term) as regards avoidance of degradation determined by biological factors, mildew and fungus and especially if climatic conditions are unfavourable. Particular cases are for wood purchased in the form of chips or for agricultural by-products delivered in bulk. . .

As already mentioned, the only convenient method of storing these materials is in the open and they are therefore fully exposed to the elements.

Weatherproofing and prevention of degradation, with the advantage of providing some preliminary reduction of humidity, is done with a ventilation system, inside the heaps, which also maintains a certain pressure level to prevent the ingress of rain-water. It consists of rudimentary parallel ducting (in galvanized iron or cement), with suitable vent holes, which is simply placed on the storage area and connected to a manifold into which a fan blows warm air, at low pressure, mixed with combustion products to create inside the heaps an environment unfavourable to parasitic attack.

The ventilation system can be arranged so that it functions automatically when climatic conditions make it necessary.

For raw material in the form of small rounds or branches stacking is normally done by vehicle mounted grabs with hydraulic jaws. Maneuverability is simplified by keeping piles at a maximum height of 4 m. (Fig. 1)

The same facilities serve for faggots and off-cuts in bundles with suitable adaptation of the hydraulic jaws.

This lifting equipment is also used for withdrawing material from the piles, with trolleys running on rails, or tractor-drawn trailers being used for transport to the factory. (Fig. 2)

In the case of stocks not covering a large area (suitable for withdrawals which may be safely carried out continuously) and situated close to the factory, a chain conveyor system could be advantageous.

For piling raw material which is in small pieces, or in bulk, mechanical loading shovels may be used, but if the material is sufficiently small and uniform, belt conveyors (bucket or hydraulic types) may be used for transport to the factory.

Regarding silos containing sawdust and relative mechanical withdrawal systems, details are given later.

For reasons of brevity, consideration is not given here to situations where materials contain foreign matter (sand and rubble, nails, wire, iron splinters etc.) which must be removed to prevent damage to production machinery.

Consideration is neither given to by-products of plants from which textile fibres have already been extracted (hemp stalks, flax straw etc.) and from which all fibrous residuals must be removed mechanically.

In these cases each group of material is stored separately with their own handling gear for conveyance to the production line.

It should be pointed out that, for the production of panels having three or more clearly differentiated layers, the process begins with different woods to obtain particles for the external and internal layers; at least different in shape even if of the same species.

In this way, for example, rounds not yet debarked can be used for external layer particles , while lower grade assortments such as branches or faggots are used for internal layer particles.

3.2 - Mechanical processing of raw materials : breakers and chippers, flakers, mills.

As already mentioned, modern particleboards either have three or more layers or the particles are suitably distributed (particle size decreasing from centre to surface) when the panels are being formed. In both cases the aim is to obtain panels with external layers made only of fine and uniform particles to give an even and compact surface, thereby easing the finishing operations. Two different types of machine must therefore be considered for the preparation of normal and fine particles; these initial phases being common to all types of particleboard panels in whatever manner they are bonded.

Particles are produced in two or three successive phases. When it is preferable to prepare all the wood in a broken up form, because its characteristics make it advisable or because most of it is purchased in chip form, the wood which arrives at the factory in another form is also brought to this state to unify the processing. This production of relatively coarse material is done with bladed breakers or chippers. (Fig. 5 and 6)

For small logs (rounds) or saw mill by-products (slabs and off-cuts) disc type chippers can be used, the material being conveyed, with a certain inclination, to a rotating disc fitted with a series of blades which cut the material into lengths varying from 20 to 40 mm. Disc diameter varies from 1000 to 2000 mm and production can exceed 150 m^3/h.

However, the drum type chipper is more advisable, particularly because it is more universal in its capability of handling different woods. It is in fact also suitable for veneer off-cuts, for small diameter brushwood or annuals which could not be used in disc type chippers. Very robust blades are mounted on the drum and, in a direction perpendicular to its axis and on a higher plane than its generatrix, the wood is fed towards the drum by a conveyor belt followed by a set of toothed rollers, the lower ones being fixed and the upper ones oscillating to adapt to the thickness of material involved.

Important requirements for chippers are robustness and simplicity as well as wear resistance of the more highly stressed parts. Details worthy of careful attention are those relative to the upper oscillating roller system of the feed system which, on the more rational types of machine, is controlled hydraulically. A safety device stops the feed as soon as the conveyor belt becomes overloaded with wood.

If there is a possibility of metal foreign matter in the wood (e.g. iron wire used to tie up bundles of saw mill by-products) it is advisable to install a metal detector over the conveyor belt to stop it even in the presence of minute metal objects. The length of chips obtainable depends on the rotational speed of the drum, the number of blades on it and the feed rate of the wood; values normally arranged to produce chips about 30 mm long. It is useful, however, to have a machine which, in case of need, can easily be adapted to modify this dimension.

As a contrasting element to the action of the blades, chippers are fitted with a fixed counterblade (the most rational type is useable on the four edges as they have inserts of high wear resisting alloy and its position can therefore be changed four times before sharpening becomes necessary).

The arrangement of the counter-blade relative to the characteristics of the drum and its blades is important. Cutting, which must be done at an angle, depending on the properties of the wood, must ensure minimum energy absorption and best chip quality. Another important point is the system used to fix the counter-blade. Frequent and heavy impacts can damage it and make fixing uncertain and dismantling difficult. The wedge system is the most advisable.

The drum is made of steel elements welded together and the manufacturers must guarantee that it has been stress relieved; otherwise deformation and even breakage could occur. Another important factor is accurate dynamic balancing to avoid vibrations which, due to the drum's considerable mass, could prejudice the duration of its bearings. (Fig. 7)

The drum is driven through a V belt. The driven pulley, consisting of a flywheel coaxial to the drum, helps to absorb peak loads.

The blades are fixed to the drum with bolts and domed lock washers. The bolts, which must be impossible to loosen during the operation of the machine, are arranged so that blades may be rapidly substituted.

Blade projection must be accurately set. The preferred system is that which allows setting to be done externally by means of adjusting screws.

With all types of chipper, including the drum type, it is practically impossible to avoid the presence of a certain percentage of excessively large splinters. A rational machine must prevent these moving forward with the regular sized chips which are made to pass through a robust screen. A cross member fixed inside the carter acts as a second counter-blade and the splinters are cut until reduced to regular chip size. Passage of chips through the screen is helped by air suction. The outlet point is connected to ducting which carries the material to a fan and then to a cyclone separator.

The inevitable presence of dust on all moving parts, and the impossibility of keeping this kind of machine clean, makes lubrication problematical. For this reason, among all the systems for driving the conveyor belt and the feed rollers, that with a hermetically sealed oil-bath gear box is to be preferred and the drive is absolutely smooth with consequent dimensional uniformity of chips. Quite different, for example, from chain drive systems where links, which stretch with use, are difficult to keep correctly tensioned.

Ball and roller bearing housings must also be fitted with very efficient packing rings to avoid infiltration of dust.

Principles for the choice of a chipper must therefore be based on its being guaranteed to produce chips of uniform shape and size. It must have the greatest flexibility to allow for handling many different kinds of wood, it must be solidly built throughout and require minimum maintenance, it must have minimum down times for blade substitution and, finally, it must have high hourly output of chips expressed in dry weight and ratio of output to effective energy absorbed in its operation.

Still on the subject of chippers, two particular types can be mentioned the so called "blade" type (the operating element still being a drum but with material fed directly from above; advisable for processing very short pieces of plank off-cuts or veneer edging and trimming and that for breaking up material packed in bales (agricultural by-products). (Fig. 9 and 10)

In this latter machine a horizontal feeder pushes the bales against a cutter drum which operates on their entire front area. The diameter of the drum can be from 800 to 1600 mm according to the sizes of the bales

The principal machines for the first process in particle making are flakers. The uniformity of the flakes produced by them largely influences the uniformity of the particles obtained by crushing and, consequently, the uniformity of panels.

Flakers may be grouped into two categories: those which operate on chips (purchased in this form or prepared on the machines previously described), or on already broken up material, and those which operate only on relatively long pieces even if of small cross section.

In the first category there are flakers with a rotating blade-holder cage, the double flow type being the one most recommended, schematically composed of an internal vane type rotor and external coaxial cage rotating in opposite directions. Material is fed in continuously and proportioned in the centre of the rotor which throws it on to the inside surface of the cage from which the blades project. The flakes produced are sucked through the spaces between the cutting edges and the counter-blades. Blades and counter-blades are mounted and fixed from outside the cage. The thickness of the flakes produced depends on the internal projection of the cutting edges and the distance between them and the edges of the counter-blades. Projection and distance must be capable of easy and accurate adjustment. Extremely hard steel wear plates are fixed, to the extremities of the internal rotor vanes, in such a way as to facilitate their projection adjustment and removal for sharpening and substitution. These plates must be adjusted so that their edges skim the cutting edges of the blades in the cage to ensure that the material is flaked. (Fig. 11 and 12)

The cage shaft is tubular and the rotor shaft passes through it. The front part of the machine is therefore free of supports and, being mounted on hinges, access to the interior is facilitated. The cage is generally chain driven from a motor and reduction gear. The rotor is driven from a second motor through a reinforced V belt which provides a certain degree of elasticity.

The two opposite directions of rotation make it easier for the flakes to be ejected even in the case of very humid material. The base is airtight and is connected by a hopper to ducting which directs the flakes to a fan and a cyclone separator.

Rugged construction and reliability of bearings and rotating elements must be borne in mind when choosing a cage type flaker. Also of importance is wear resistance of all those parts coming into contact with the material to be flaked, beginning with the rotor vane plates, the internal surface of the cage and the counter-blades, which must be made of suitable steels to avoid the necessity of substitution or the need for grinding after a relatively short period of use.

One of the most important factors in a flaking machine is the quality of the blades as even if top grade materials are used, sharpening is necessarily frequent if the characteristics of the flakes are to be maintained and energy losses avoided. Rapid changing of blades, with consequent limiting of down time, is therefore an important factor.

Flakers on which the entire rotor hae to be dismantled to change the blades are not recommended. Those machines on which each blade and counter-blade unit is interchangeable, and can be removed and replaced through an opening in the periphery of the casing, are more practical.

Frequency of sharpening is influenced by the accuracy of inclination of the blades, their cutting angle and the shape of the blade holder which allows easy flow and extraction of flakes. Blade wear and replacement have a considerable influence on production costs and therefore blades should be capable of being sharpened many times and be utilized even when greatly reduced in width. In a good flaker the blades should still be usable even after having been reduced by 65-70 mm with successive sharpenings.

If the arrangement for inserting the blade unit and blade holder in the cage is rationally designed, replacement is rapid and positional adjustment not required. Push-button controlled hydraulic systems are recommended where each depression of the button corresponds to a rotation of the cage equal to the interval between two blade units, and to the simultaneous release of the spring which blocks the unit. With this system, loosening screws or bolts is not necessary and replacement takes only 8 to 12 minutes according to the size of the machine and the number of blades on the cage. (Fig. 13)

Highly recommendable are those flakers having the internal surface of the cage lined with hard steel wear plates fixed into the side so as to be easily withdrawn for grinding or, if really necessary, for substitution.

A very useful accessory on cage type flakers is an electromagnetic device to simplify setting and fixing the blades on the interchangeable units. The magnet holds the blade and its fixing plate firmly while an electric screwer tightens the fixing bolts. A lamp illuminates a reference line which corresponds to the pre-set position for the cutting edge.(Fig.14)

In the second category of flakers (suitable for all kinds of wood in larger sizes) are the vertical or horizontal disc types which, in principle, should be able to produce more uniform flakes due to their being cut on the flat. They are only suitable, however, for round wood, which must first be reduced to pieces not longer than 50 cm., and their productive capacity is r latively low.

For this reason their use is diminishing, universal flakers with cutter head being preferred. They consist of a loading channel with an articulated metal element mat, a hydraulic system for holding the wood during the cutting operation and a slide moving transversally to the axis of the machine, on which the main motor and the cutter head are mounted. (Fig. 15)

The characteristics of this head represent the most important qualitative aspects of the machine. On the most rational types the blades, whose width corresponds to the length of the flakes, are aligned hyperbolically on the cylinder of the head so as to ensure maximum continuity of cutting. The blades are screwed to the blade holders which are fixed to the cylinder without screws. The surface of the cylinder is composed of wear plates which can easily and rapidly be substituted. Adjustment of blade projection, according to required flake thickness, is by means of a precision automatic circumferential system. (Fig. 16)

By substituting the blades it is possible to vary flake length from 20 to 30 mm. The power of the hydraulic pressure device, which holds the wood during cutting, prevents the formation of splinters and vibrations which could prejudice product quality.

These machines are able to process wood of any section, and productivity is considerable. Power required varies from 90 to 250 kW and, with the latter power, productive capacity is of the order of 5-6000 kg/h of flakes 0.4 - 0.5 mm thick (dry weight).

Crushing of flakes to produce particles of sizes according to the layer of the panel they are to occupy is done by mills, the choice of type being determined by the particle size required.

For normal particles (middle layers) a hammer mill is recommended. It has articulated rotating plates, which throw the flakes against fixed contrast elements to cause crushing. The hammer profiles can vary according to the nature of the raw material. A screen with holes or slots determines the particle size (Fig. 17).

According to the capacity of the machine, the rotor diameter varies from 400 to 800 mm and its length from 500 to 1200 mm.

In cases where flakes have medium or low humidity it is possible to use a hammer-cross mill for crushing a rotor with vanes throwing the material against a fixed basket type screen on which contrast elements can also be fixed to ease crushing . Particle size is determined by the size and shape of the holes in the screen (Fig. 18).

Based upon their capacity the inside diameter of these mills varies from 600 to 1200 mm and screen width from 200 to 600 mm.

For producing very fine particles, and in cases where flakes are already dried, it is possible to use a special type of this mill in which the screen, instead of being fixed, rotates in the opposite direction to the rotor (as with a cage type flaker) and which has contrast elements alternating with drilled ones (Fig. 20).

Finally, if the flakes have to be really defibered which may be the requirement in the case of boards with extremely compact outer layers, it is necessary to use a refining mill in which the material is made to pass between two profiled segmental discs, one fixed and one rotating, their distance apart being adjustable to the particle size required. Disc diameter varies from 400 to 1200 mm. (Fig. 21 to 25)

3.3 - Driers

In the particle preparation cycle this sector is extremely delicate due to difficulties caused by non-rationally designed driers and especially by fires and explosions which occur when the processing rate is not kept scrupulously within the pre-established limits.

Also from the point of view of wear and maintenance, some types of drier, which have been widely used in plants up to a few years ago, must now be eliminated on the basis of experience acquired.

When the raw material has a high humidity content there is some difficulty in maintaining constant with crushing of the flakes (for a given type of mill and setting, the particle size obviously varies with flake humidity) and in ensuring the correct functioning of the driers. It is therefore possible to install a pre - drier which, independently of the initial humidity content, keeps the flakes at around 50-60% before they enter the mills and main driers.

In this connection the mills are inserted between the pre-drier and the main driers with particle preparation taking place under optimum and constant humidity conditions. Furthermore, drier potential is increased and a final particle humidity can be assured which corresponds exactly to that called for by successive operations.

The vertical tube type of pre -drier is the most common; working temperature is relatively low and evaporation potential is proportional to the length of the tube.

The main drier which has proved to be the most functional, being currently used in the majority of cases, is the type with a rotating horizontal cylindrical body consisting of three concentric solidly united cylinders giving three passes, in alternate directions, to the particles before they are ejected. Heat exchange therefore takes place in equal flow movement of the particles is determined in part by the mechanical rotating action of the cylindrical body and by the effect of the hot gases passing through it (Fig. 27, 28, 29).

A counter flow gravity separator is usually arranged after the drier to eliminate any unwanted foreign particles heavier than those of the wood. A high efficiency fan, made of wear resisting material, conveys the particles into a cyclone.

The silos in which the dried particles are stored must be equipped with very sensitive fire prevention devices capable of causing automatic intervention of safety equipment immediately in case of need.

The hot gases for drying are produced by burning liquid fuels (petroleum, naphtha, diesel oil) or gases (propane, butane, natural gas) and, in a separate burner, all the wood dust produced during the various processes such as sanding of the panels.

The first furnace is completely self-regulating according to the temperature of the gases produced and flake humidity. All ducts connected to the driers are equipped with fire prevention devices and the ratio of carbon dioxide to oxygen is continuously metered, and kept at a safe level, to avoid the risk of fire or explosions.

In estimating the productive capacity of dried particles in kg/h it is advisable to establish the amount of moisture to be evaporated on the basis of humidity limits.

Normal driers are capable of evaporating moisture at the rate of 2000 to 10000 kg/h.

3.4 - Silos

A certain number of silos must be provided for each production line for the preparation of particles forming the various layers (in the case of multi-layer boards), or for the single line where progressivley graded particles are involved (mixture of fine and relatively large particles distributed so that the fine ones constitute external layers). These silos ensure a sufficient reserve of material to give flexibility to the plant and cover down-times during tool changing, maintenance, etc.

The shape of the silos(square, rectangular or cylindrical) and, above all, the system for metering the material extracted, depend on the state of the material.

Square or rectangular types are preferable for chips and for storing humid materials and those in the early stages of processing (e.g. agricultural by-products after separation of unusable residuals). The most suitable extraction method is by means of hydraulic thrusters, arranged in parallel on the bottom of the silos, with transverse screw feeders.(Fig. 30, 31)

Extraction in cylindrical silos is by means of a hydraulic rotor system, on the bottom of the silo, driven by a motor-reduction gear situated externally. (Fig. 32)

Framework and plating should preferably be in steel (silos can also be in reinforced concrete), galvanized and treated to avoid oxidation and corrosion, especially when they have to contain humid materials. The inside must be perfectly smooth, and free from projections, to avoid all possibilities for the formation of "bridges". If necessary this can be prevented by extending the rotor spindle upwards and fitting special arms to it.

Auxiliary, but essential, elements, for safe working of silos are the fire prevention devices already mentioned, rapid opening anti-explosion doors, ultrasonic level indicators.

3.5 - <u>Particle grading</u>

After drying, fine particles must be separated from the larger ones which are added to those for forming internal layers (and vice versa). The dust which, if left with the particles would cause a lowering of panel quality, is also separated as well as excessively large particles which are passed to a refining mill. As already mentioned, the dust is used as fuel in the driers together with that from sanding the panels.

Grading can be done both by multi-sieve graders and by air blast separators. Best results are obtained by combining the two systems.

Graders can be oscillating, vibrating or orbital (rotating in a plane round an eccentric axis). The latter system is preferred for wood particles because it gives them continuous circular sliding movement on the sieves, easing separation and preventing particles of elongated form from entering the mesh endwise.

Graders can be rectangular or circular and the surface area of each sieve does not usually exceed 7 to 8 m^2 which gives a total area of 21 to 24 m^2 in a three-sieve grader.

Eccentricity in orbital graders is of 35 mm. which gives a horizontal rotational excursion of 70 mm; speed of rotation 220 to 250 rpm. (Fig. 33)

In air blast separators the particles are made to fall in measured quantities evenly spread over the whole width of the separator. A horizontal air blast blows the particles to a distance diminishing with their increasing size; the dust being blown farthest. (Fig. 33 BIS)

The main difference between the two systems (graders and air blast separators) is that the former separates particles according to their surface area (independently of thickness) while the latter separates according to mass (particle volume).

3.6 -Preparation of binding agents and their application to particles

For the production of synthetic resin bonded boards (urea, phenol or melamine based) it is necessary to prepare carefully measured mixtures of five components. In the simplest type of product the components are: synthetic resin, catalyst (or hardener), emulsified fossil wax (which gives the board a certain amount of waterproofing) and a complementary product which regulates the rate of hardening of the resin according to the temperature reached by the board at the pressing stage and to fix the formaldehyde which is liberated at this stage; a product which for urea resins can be a solution of ammonia. The fifth component is water for dilution.

Plants for the automatic preparation of binders are therefore designed for volumetric metering of five liquid components.

For the production of boards having special characteristics (e.g. treated with anti-parasitic products), additional components for the mixture can be dissolved in the dilution water.

Particular features of a good plant are: functional simplicity as well as guaranteed minimum quantitative tolerances for component metering, safety in operation, visual and acoustic signalling for any functional irregularity and automatic stopping in the event of lack of inflow of any one component, possibility of periodic and efficacious washing and practicability of any maintenance foreseen. (Fig. 34, 35, 36)

After the automatic metering device there is a rapid mixer to homogenize the mixture which is then conveyed to a tank, made of stainless steel or other material not subject to attack by the chemical products in the mixture, having a capacity adequate for the production involved.

Normal metering and mixing plants are made to supply up to 6 to 7000 kg/h of mixture.

For plants producing cement bonded boards, the cement is put into the mixers dry and liquid metering involves only the preparation of the special mineralizing solutions which, at the beginning of mixing, must be sprayed onto the particles.

It should be pointed out that, both for synthetic resin bonded boards (multi-layer) and for the treatment of the finer particles in boards with progressive grading, the bonding mixture required for these particles is different from the mixture used for the particles composing the internal part of the boards. Two distinct metering and mixing plants are therefore required.

Particles, as well as bonding materials, must be accurately and continuously metered before being fed into the machine which unites them.

Liquid products and particle bonding mixtures are fed to these machines by variable speed precision rotary metering pumps. Particles and solid products (cement) are continuously weighed by self-regulating belt type weighing machines. (Fig. 40)

For these machines to function well it is essential that their weighing elements do not come into contact with the material to be metered and that they are fully dust proof. Furthermore, they must be relatively insensitive to brief power supply fluctuations and allow a reasonably high belt loading to reduce to a minimum.

As regards continuous glueing machines, the tendency is to use high turbulence types, the mixture, which enters through the hollow shaft, being projected centrifugally onto the particles through rotating nozzles on the shaft.

Besides uniform binder distribution, features of these machines are: high productivity (over 30 T/h of treated particles) notwithstanding their limited dimensions, working safety and ease of maintenance.

The particles, entering at one end of the machine through a hopper connected to the belt type metering weigher, travel axially in the form of an annular layer adhering to the internal cylindrical wall of the machine. The blender consists of a hollow shaft on which three sets of arms are mounted. The first set consists of adjustable elements holding inclined blades which centrifugally thrust forward the incoming particles. The second set (where the binder is applied) is connected to the inside of the shaft by holes through which the mixture flows to nozzles. The third set (the so called "post-glueing" section consists of very robust specially shaped arms which spread the particles against the walls to ensure even distribution of the mixture.

The length of the arms of the second set is differentiated to give varying depths of penetration of the ozzles into the annular layer. As the particles are distributed at distances from the rotational axis depending on their mass, it is possible to adapt each nozzle so that binder is applied in quantities optimized for each particle size.

Due to the amount of friction during operation which, being transformed into heat, would overheat the machine and harden the mixture, the cylindrical body is double-walled and cooling water is circulated in the hollow space. Cooling water is also fed into the hollow shaft, in the part opposite to that in which the mixture flows, and made to circulate in the shaft and in the arm cavities in the "post-glueing" section.

Maintaining a constant working temperature ensures uniformity of application and distribution conditions for the mixture.

In glueing machines for fine particles, both the first and third sets of arms are fitted with pointed elements which, acting as combs, prevent clotting of the material.

The cylindrical body is divided into two parts on an axial plane and hinged so that the whole machine can be opened for easy cleaning and maintenance. (Fig. 41)

Even though relatively simple in construction, glueing machines oall for special care in manufacture. They must ensure scrupulous distribution of mixture to particles, economize on binder (which depends on suitable nozzles and on their distance from the shaft as well as on their efficiency), provide all rotating parts with self-cleaning properties for minimizing binder adhesion and ensure uniformity of working temperature.

Other essential characteristics are : perfect dynamic balancing of the shaft possibility of accurate adjustment of the distance between the extremity of each set of arms and the internal wall and the inclination of the blades of the first set, wear resistance of all parts subjected to friction and their interchangeability, robustness and tightness of bearings.(Fig.42)

Drive to the shaft, usually by V belts, is from a motor whose power (from 7 to 80-90 kW) normally varies according to the capacity of the machine.

Glueing machines incorporated in plants for the production of high density cement bonded boards are not dissimilar in construction to those for synthetic resin bonded boards , but their working principle is different. As already stated, the cement is fed into the machine in the dry state. The rotating nozzles are used to distribute the mineralizing solution which, in a first sector, is applied to the particles and, successively, to introduce water for the mixture. The spreading or friction effect is not used at all and therefore there is no need for cooling.

Due to the abrasive action of cement, abrasion resistance of the extremities of the arms and the internal wall of the cylindrical body is essential.

3.7 - Matforming lines

In most plants, boards are formed on a mechanical conveyor belt, whose width corresponds to that of the boards (or with joined sections corresponding to boards length), made of high temperature resisting synthetic fibre fabric.

Steel and fabric advantages and disadvantages and choice depends on the characteristics of the forming and pressing section type of board to be produced as regards thickness, structure and binder.

Advantages of metal belts are heat conductivity and longer life. Disadvantages are: possibility of deformation, a certain amount of thermal inertia, impermeability to vapour and difficulty of repair in the event of fire.

Fabric belts have no thermal expansion and permit faster closing of the heated presses. They have negligible heat absorption and the vapour produced during pressing can be dissipated through the weft. These features can be important for producing thin boards with pressing cycles lasting less than a minute and little possibility of dissipating vapour through the boards Although it is easy to substitute worn or damaged sections, fabric belts have the disadvantage of a much shorter life than metal ones.

Forming machines are used to distribute evenly, over the entire surface of the belt, the quantity of particles required for the thickness of board involved. Functional reliability is essential to produce boards with optimum characteristics and also reduce scrap if it is necessary to size them after pressing or, if sizing is not done as often happens with thin boards if the panels must have thicknesses as uniform as possible and corresponding the nominal value. (Fig. 43)

Forming machines can remain still, if the belt moves underneath them, or can have reciprocating motion if the belt remains still during particle distribution.

For graded particle boards one forming machine is sufficient which, with a mechanical or air blast distribution system (or a combination of the two), causes the particles to fall at a greater or less distance according to size to achieve progressive distribution throughout the thickness of the board.

Multi-layer boards require a distributor for each layer or a single machine can combine a group of distributors.

Control of the specific gravity of the particles forming the board, both for total value and exact distribution, is done with a double system; volumetric and weighing. Another automatic system using Gamma rays, from a radicisotope, can standardize the forming process.

3.8. Mat Pressing

3.8.1. Preliminary Pressing

The installation of a preliminary press for compacting particles is undoubtedly a considerable advantage, even if it constitutes a complication for the plant and an increase in its cost. It is always advisable in an important installation. (Fig. 44)

Besides giving the required compactness to the particle "mattress" and avoiding crumbling, specially at the edges during the movement towards and introduction into the main press, the purposes of preliminary pressing are to improve the particle location, to release much of the air remaining between them and to reduce considerably the thickness of the "mattress" in order to speed up the closure of the main press.

Preliminary presses for synthetic resin bonded boards were initially made without any heating, but recently mild heating, around 60 - 70°C, differentiated between upper and lower platens, has been adopted. This heating improves pre bonding of the particles and reduces the final pressing cycle time, while the temperature difference between the two platens compensates for the asymmetrical heat exchange determined, in the successive press, by the panel forming and conveyor belt. This asymmetry, especially in small and medium thickness boards tends to cause them to warp due to stresses brought about by polymerization of the resin.

If the main press is a multi-platen type, the preliminary press must be able to supply a sufficient number of boards in the time corresponding to a main pressing cycle.

Specific pressure recommended is around 20 kg/cm^2 even though good results can be obtained with lower values.

There are also the calender type preliminary presses (which cannot be heated), the rolls being covered with double tough rubberized canvas. While this particular type is more economical and faster than platen presses, the specific pressures they can exert are relatively low and their use is limited to compacting. Two fundamental categories exist: the continuous production type, with no board length limitations, and the intermittent type where maximum length of boards corresponds to length of platens. (Fig. 45)

It must however be mentioned that there is a specially equipped single chamber press which premits two consecutive operations on the extremity of the formed boards thereby obtaining one board of unlimited length if formation takes place with a normal succession of opening, closing and pressing phases.

In recent times manufacture has begun of some very special continuous presses, but experience gained so far is not sufficient to establish whether, in future, they will provide the best system for pressing bonded wood boards.

On the other hand, for those boards for normal use, bonded with ordinary synthetic resins (with thicknesses between 2.5 and 7 mm), continuous calender presses are without doubt advantageous as far as productivity is concerned. (Fig. 49 and 49 BIS)

With these presses the board is formed on a steel belt and then, without preliminary pressing, wound around an internally heated main drum which is brought to the temperature required for rapid polymerization of the resin. The necessary pressure is applied by rolls which compress the belt and mass of particles against the main drum. The rolls are also heated internally thereby permitting operation under conditions of thermal symmetry.

These rolls are followed by non-heated calibration rolls which, operating on boards still in a relatively plastic state, are able to keep thickness tolerances within satisfactory limits (usually of the order of 0.2 mm).

The forming belt then separates itself from the boards passing over guide rollers and stretchers, returns to the forming station while the board is sent by other guide rollers to a track on which it slides forward to the finishing operation.

Feed rate is adjustable and varies between 3.5 and 21 m/min. according to board thickness and characteristics of the resin mixture. Drum and pressure roll heating is by circulation of thermic oil brought to the required temperature by a boiler situated near the plant. The temperature in each element is suitably regulated by independent devices.

Drum diameter is 3000 mm and belt width allows production of boards of 2500 mm and over. Productive capacity of a calender press (with max. width of boards reach 150 m^3 per day).

Presses with heated platens, for the production of synthetic resin bonded boards can be single-chamber in which case they are very large (30 m long and over and 2.65 m wide) to give high productivity, even though pressing only one panel at a time. These presses may also be multi-chamber but necessarily equipped with automatic board loading and unloading (Fig. 46, 47, 48).

While modern technology makes it possible to build large heated platens, and still ensure very accurate working, there is a tendency nowadays to prefer plants having single-chamber presses which are undoubtedly simpler and easier to operate. Multi-chamber presses, besides the need for automatic loading and unloading, require devices for simultaneous closing of the platens and present difficult problems regarding thickness control and uniform temperature regulation of all the platens (Fig. 50).

Fundamental elements of platen presses are: specific working pressure (which it is convenient to limit to at least 30 kg/cm^2), closing speed, accurate distribution of hydraulic pressure, structural reggedness (whether steel plate or column type), thickness of platens (which is usually not below 80 mm to ensure adequate rigidity and thermal inertia), devices for board thickness control.

Also of prime importance is the machining accuracy of the platen surfaces, the system and precision of holes for circulation of heating fluid (superheated water or, preferably, thermic oil) as even a few degrees centigrade difference between one point and another on the platens can cause irregularity of thickness and technological characteristics of boards, heat insulation between platens and the press structure to avoid all heat transmission which would cause expansion and distortion.

All these measures and the high platen temperature (normally over 200°C) allow a reduction in pressing time of the order of 10s per mm of board thickness (100s for 10 mm boards and permits over-thickness (even with large boards which is eliminated by the final smoothing and calibration operation, to be kept within 0.4 mm or slightly over.

In the production of cement bonded boards, the press has the sole function of bringing them to the required degree of compactness, the setting of the binder being obtained in a successive phase in a chamber kept at a suitable temperature and humidity. Therefore these presses do not have heated platens and feature a very wide opening through which the boards are introduced for pressing in stacks and supported on steel sheets.

3.9 - Checking and operations immediately following board pressing.

In order to control all the preparatory operations in the production of synthetic resin bonded boards immediately after the main press there are thickness gauges, at various points, and weight checking units. This apparatus is automatic and, besides providing graphs of all results, gives immediate warning of any irregularities arising.

In order to avoid boards being stacked when they are still hot, which could cause degrading and distortion due to internal stresses, they must be adequately cooled. The simplest and most rational system is the rotating rack in which boards are arranged radially and cooling is effected equally on both faces and during a complete rotation of the unit. (Fig. 51). Prior to being sanded the boards are usually stored in a temporary area (Fig. 52).

4. Board Finishing

Finishing consists substantially of squaring off (if they are of normal size when they come off the press) or of simultaneous squaring off and sawing if they are very large and have therefore to be reduced. The subsequent operation is equalizing and smoothing.

Among the most rational trimming saws are those on which panels move continuously and are sawn simultaneously on all four sides.

Circular saw blades with inserted tungsten carbide teeth are used, thereby considerably reducing the frequency of sharpening. Transverse sawing is done by a blade mounted on a slide table which moves at an angle so that the result of the two feeds (panel feed and table cross feed) is square with the longitudinal axis.

The same principle is used for the panel saws.

In the case of plants with calender presses for producing thin and medium thickness boards, the trimming saw and the transverse saw for cross cutting are located immediately after the press and all the processing phases, from forming onwards, are carried out simultaneously.

With other plants having platen presses, squaring off and any other work required, sawing can be carried out with other types of machines which operate, on packs, thereby resulting in higher capacity.

Sanding is indispensable if surfaces have to be finished accurately enough for undergoing further operations when they are put to use, and if boards are to have thicknesses as close as possible to nominal (thickness tolerance) with extremely limited differences from one part to another of the same board.

Sanding machines which are now generally used for particle boards are the so-called "contact type" operating at high speed and giving excellent results. The use of other types of machines and, in particular, the bobbin type, is being increasingly discontinued (Fig. 53 and 54).

On the "contact type" machine the flexible abrasive element consists of an endless belt mounted on a pair of cylinders, one of which (motor driven) is in contact with the panel while the other acts as a stretcher. The devices are arranged in opposed pairs so that both faces of a panel can be finished simultaneously and two or three pairs are located to operate in succession. The first pair, having coarse grain abrasive, is used for equalizing while successive pairs have fine grain abrasives for sanding.

As already stated, working speed is high and, with thin panels requiring limited stock removal, it can reach 30 m/min. Each cylinder is driven by a motor with power around 30 kW.

5. Technical Data on Various Plants and Special Types of Particle Board: Considerations on their characteristics

To complete this report an indication is given below of technical data on plants with calender presses for continuous production of particle boards (synthetic resin bonded) as well as on plants for cement bonded boards.

5.1 Plants for continuous production of thin particle boards

As previously mentioned, thin boards are understood to be those with thicknesses between 2.5 and 7 mm.

Normal plants are able to produce boards from 1300 to 2500 mm wide. Daily production, all other conditions being equal, is proportional to length, and the output corresponding to the above two thicknesses is respectively 80 m^3 and 150 m^3.

Both energy consumption and labour required per m^3 produced, diminish with increasing plant production capacity; in particular:

- electric energy requirements vary from 205 kWh/m^3 in small plants to 150 kWh/m^3 in larger plants;
- correspondingly, heat requirements vary from 600,000 $kCal/m^3$ to 800,000 $kCal/m^3$;
- incidence of labour from 2.9 to 1.5 working hours per m^3.

On the other hand, the following remain substantially the same:

- fuel: around 90 kg of heavy oil per m^3;
- cooling water: 4.5 m^3 per m^3;
- compressed air (intake volume): 25 - 30 m^3 per m^3 of boards produced.

To ensure adequate elastic-mechanical characteristics of the boards the synthetic resin binder content must be kept a little higher than that required with conventional plants using platen presses. With urea formaldehyde resins their total percentage, of the relative hardener and of the paraffin added to give a certain amount of water repellence, is 12% (expressed in dry substance).

Panel weight must also be rather high and, according to thickness, normally runs from 700 kg/m^3 upwards.

Bending strength varies from 220 - 240 kg/cm^2 for 2.5 mm thickness to 280 - 300 kg/cm^2 for 7 mm.

Tensile strength perpendicular to panel faces (transverse) is practically independent of thickness and is between 6 and 8 kg/cm^2.

Swelling (soaking in water) averages 6% after 2 hours and 15% after 24 hours.

With a plant accurately set up, thickness tolerance from the press can be kept within ± 0.2 mm.

Major applications for thin boards for making flush doors (as a base for veneers or platic coatings), furniture manufacture, such as back panels and drawer bottoms etc., particle board manufacture (as a coating layer instead of ply), the packing industry etc.

Production of thin particle boards is increasing continuously throughout the world at a greater rate than that of thicker types. However, they are not without their disadvantages and those about to build a new plant must concentrate their efforts on limiting or eliminating them. The most common disadvantages are :

- a certain tendency to bulge, which depends on the conditions under which they are pressed by the calender system. This inconvenience could be negligible if the panels are used for small elements but is problematical with larger sizes;
- fragility due to limited flexibility;
- irregularity of surface absorption when painted, varnished or glued, due to resin distribution not being homogeneous.

Qualitative requirements are growing because these panels are being increasingly used with surface finishes in hard plastic materials or very thin laminates. It is generally considered that a more careful study of particle size and shape, binders, constructional details of glue spreaders, could lead to considerable improvements.

5.2 - Plant for the production of high density cement bonded boards

Thickness is normally from 6 to 40 mm and the most common sizes 125 x 280 cm, 125 x 320 cm or 183 x 360 cm corresponding to modules adopted by technicians for building projects.

On the basis of a 21 hour day of three 7 hour shifts, plant productive capacity is 50 m^3 per day minimum to 200 m^3 per day maximum.

Weight is proportional to thickness and can reach 1400 kg/m^3 for small sizes and drop to 1100 kg/m^3 for very thick types. Production technology is in the process of development to reduce these values considerably and, at the same time, improve heat insulation.

The type of cement commonly used is that defined in German specifications as PZ 450 F but it is likely that, in the near future, special cements will be produced having better bonding properties and more rapid setting.

Indicative energy requirements for production are :

- electrical: 190 - 200 kWh per m^3 produced;
- heat: 380,000 to 390,000 kCal per m^3 produced.

The incidence of labour, as is to be expected, falls with increased productive capacity and consequently drops from 5 to 4 working hours per m^3 produced.

Raw material requirements are approximately:

- 280 kg (dry weight) of wood per m^3;
- 770 kg of cement per m^3;
- 50 kg of special chemical products (for particle treatment) per m^3;
- 500 l of water per m^3.

Bending strength, depending on thickness and weight, is between 120 and 180 kg/cm^2; compression strength approx. 150 kg/cm^2 and tensile strength, perpendicular to panel faces, from 6 to 9 kg/cm^2. These values are of the same order as those for synthetic resin bonded panels.

A very interesting point is the low value for swelling (soaking in water): from 0.2 to 0.6% after 2 hours and from 0.6 to 1.2% after 24 hours.

Heat conductivity is 0.155 kCal/m/h/°C.

Nail and screw holding (18 mm penetration) is respectively 50 and 140 kg (nail diameter 2.5 mm, screw diameter 3.5 mm).

Weatherproofing is excellent (even in freezing conditions) as also is fire resistance and possibility of parasitic attacks non existent. These features make the panels particularly suitable for building applications.

Surfaces are smooth and compact and ideal for all types of finish whether water based paints, varnish or any other kind of coating material.

Due to heterogeneous structure and fairly high weight, sound deadening properties are satisfactory. Sound absorption , for 12 mm panels, is 32 dB.

The coefficient of diffusion is 22.6 - 22.8 and this is a favourable factor in the case of applications involving the building of external walls. Permeability to air is 1.32 l/min/m^2/10 mm of mercury.

Main applications are: built-in shuttering, false ceilings, all types of floor foundation, cellar doors or wherever panels are exposed to high humidity, rural buildings, road hoardings,etc.

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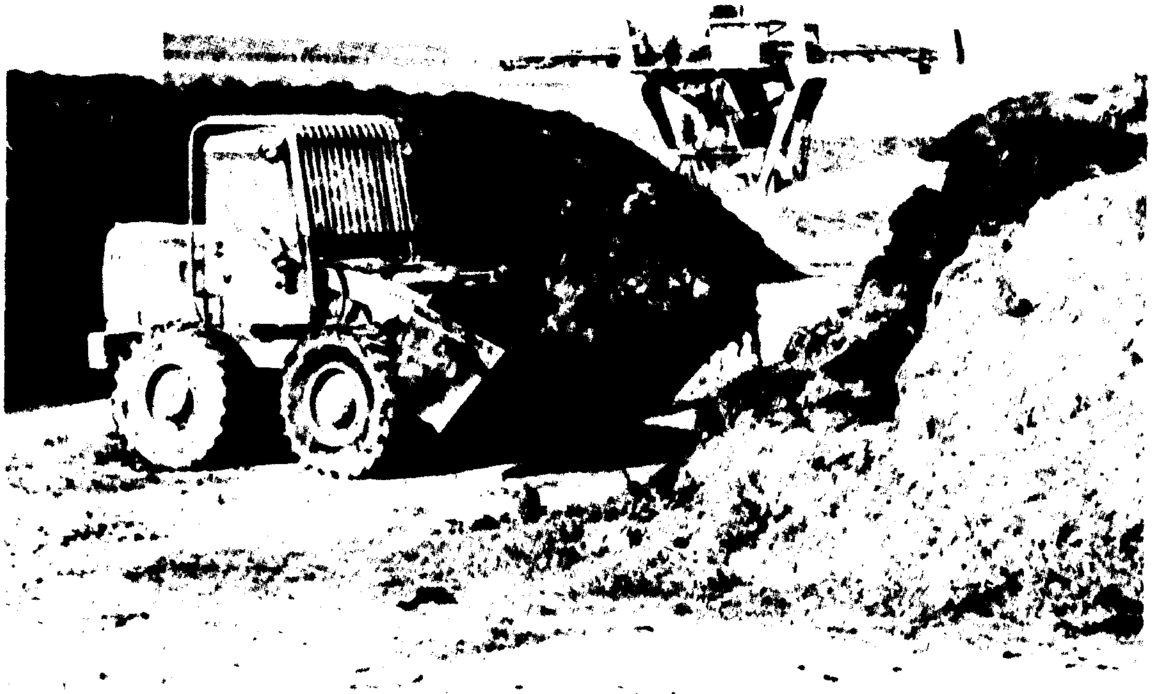
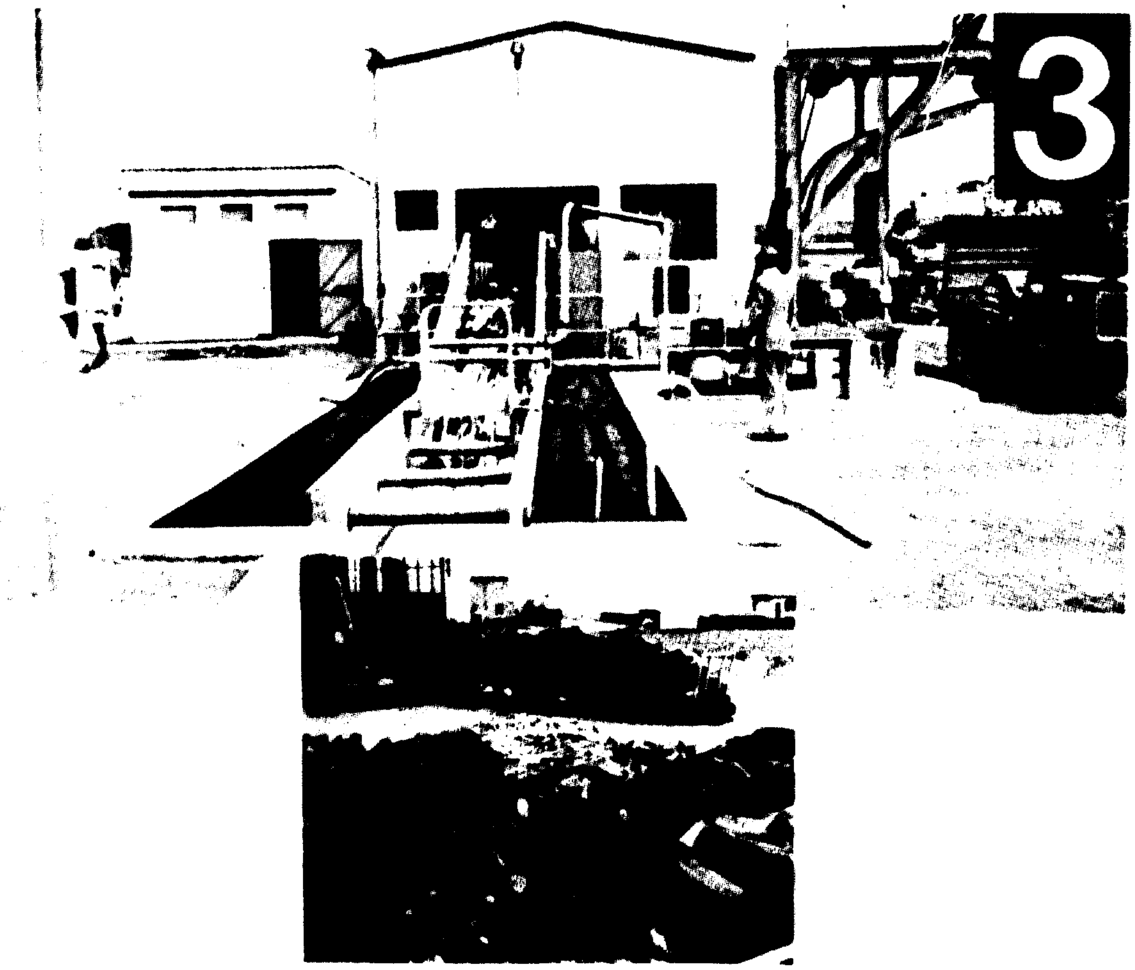


Equipment for receiving, storing and despatching raw materials at plant site.



Feeding assorted specie of raw materials to obtain a variety of external and/or internal layer particles.

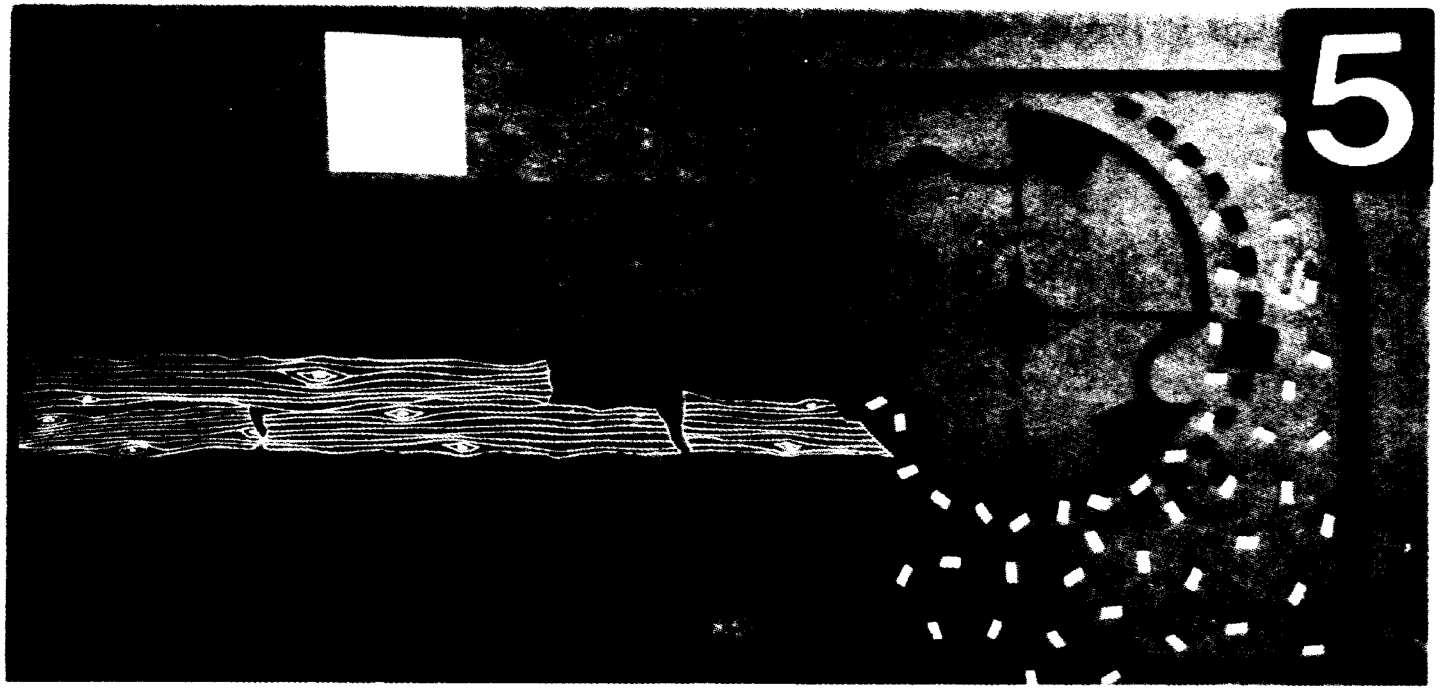


Fig. 5 and 6: Processing coarse raw material with heavy duty bladed chippers.

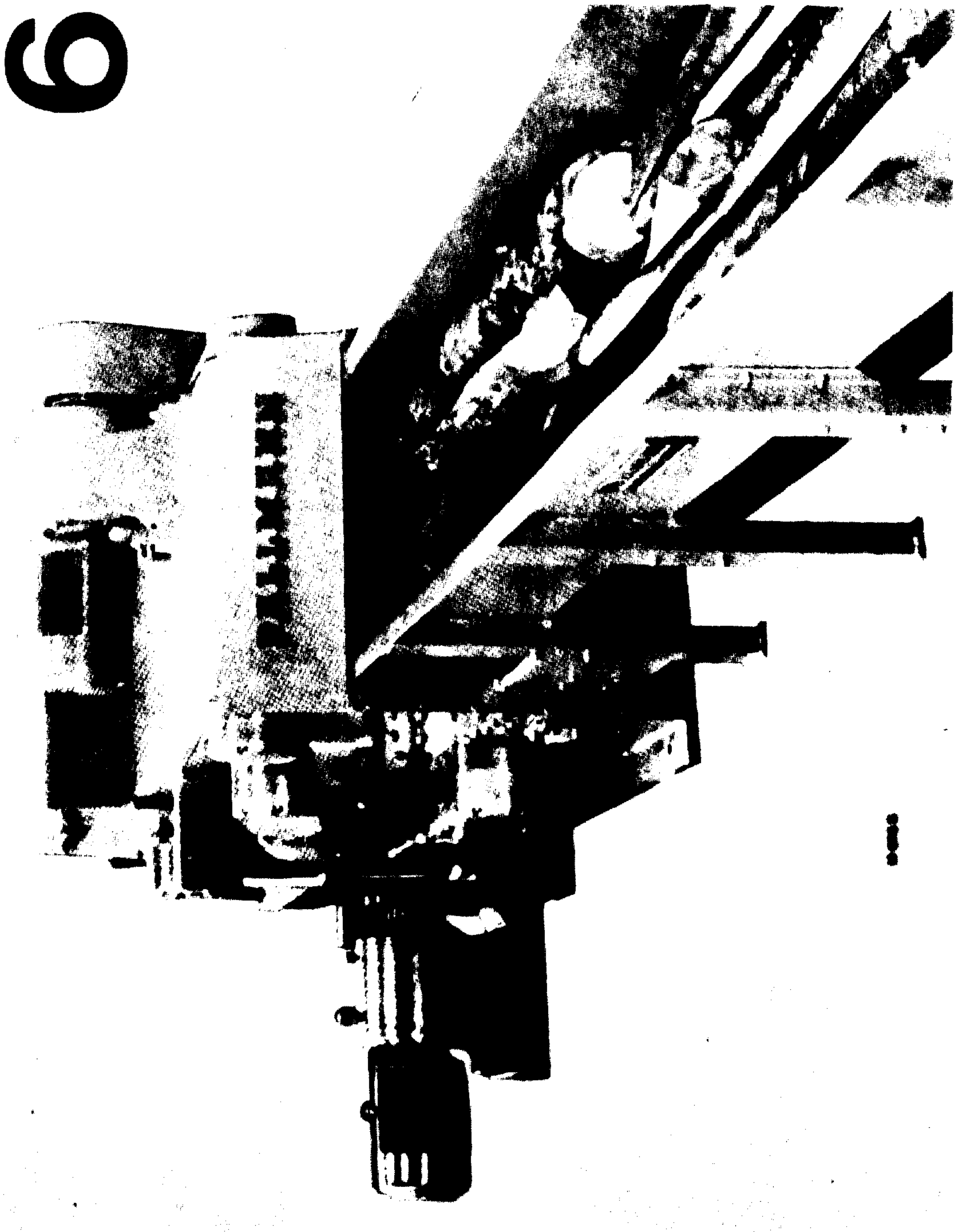
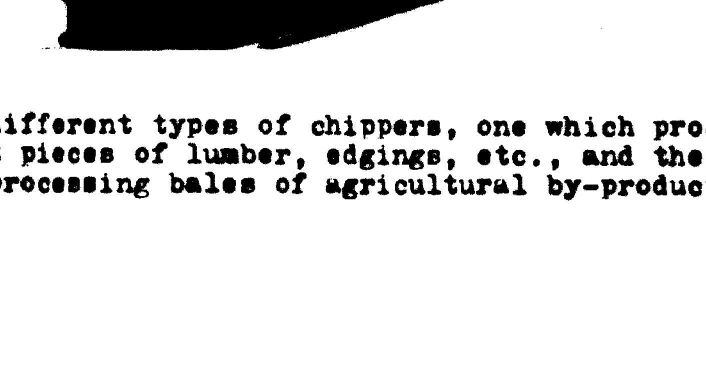
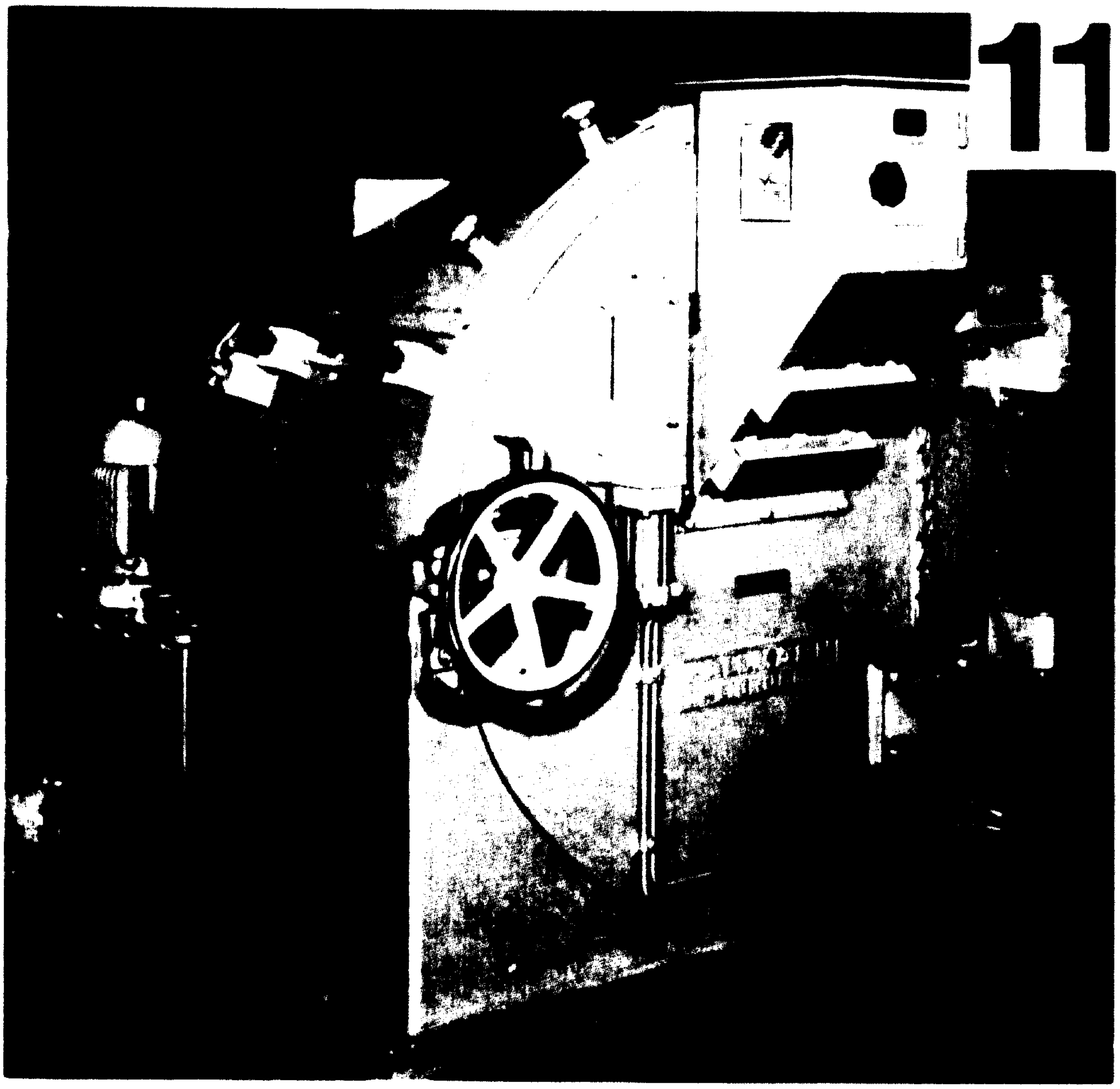


Fig.7: Steel drum for wedge system of chipping
Fig.8: Setting blade externally by means of screw adjustment



Two different types of chippers, one which processes short pieces of lumber, edgings, etc., and the other for processing bales of agricultural by-products.



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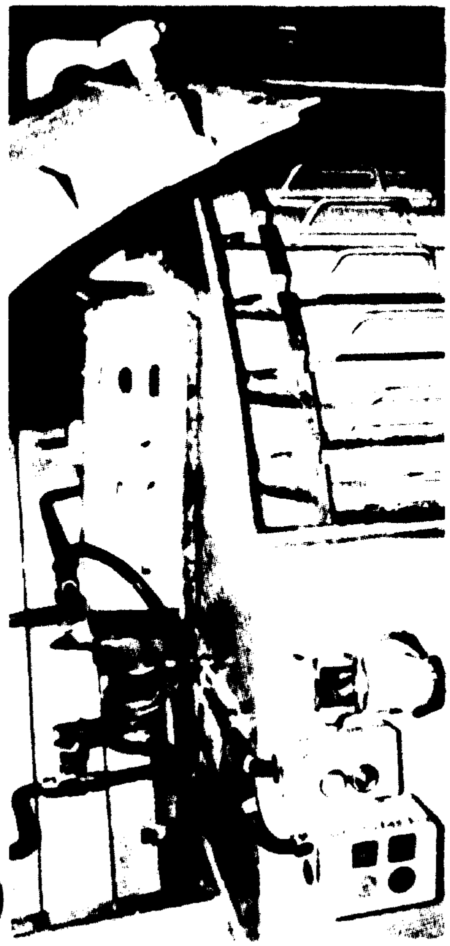
Outline of equipment for making flakes.



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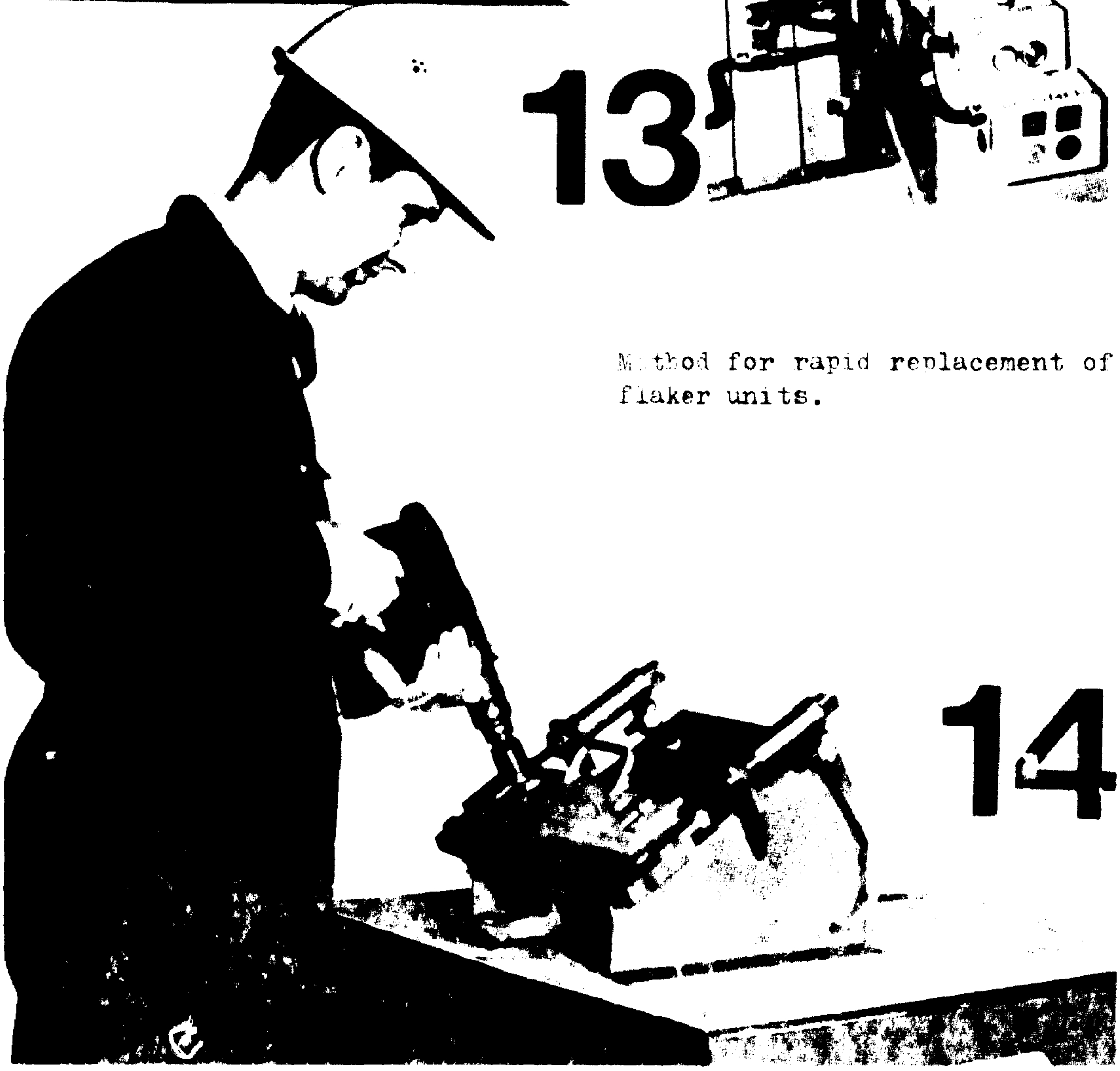

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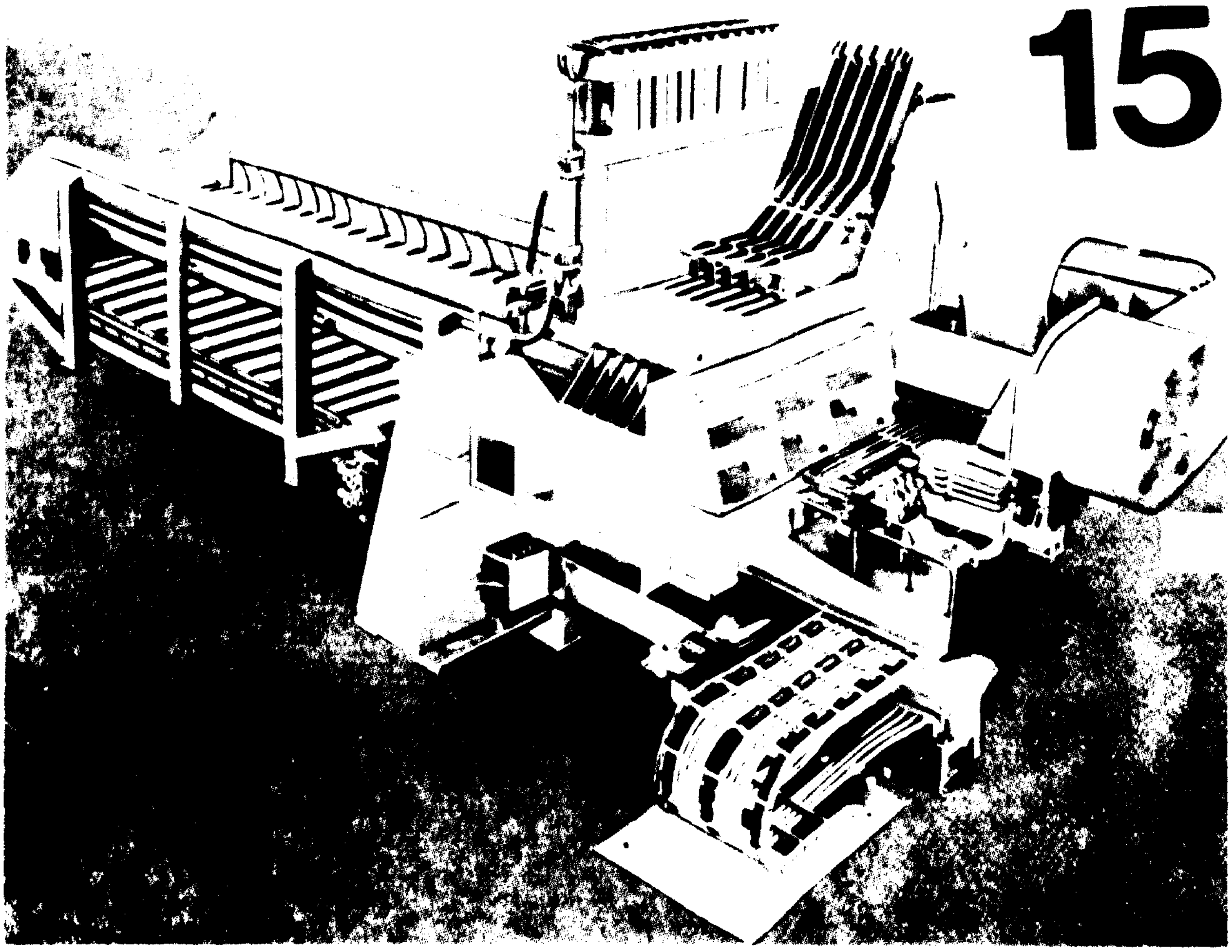
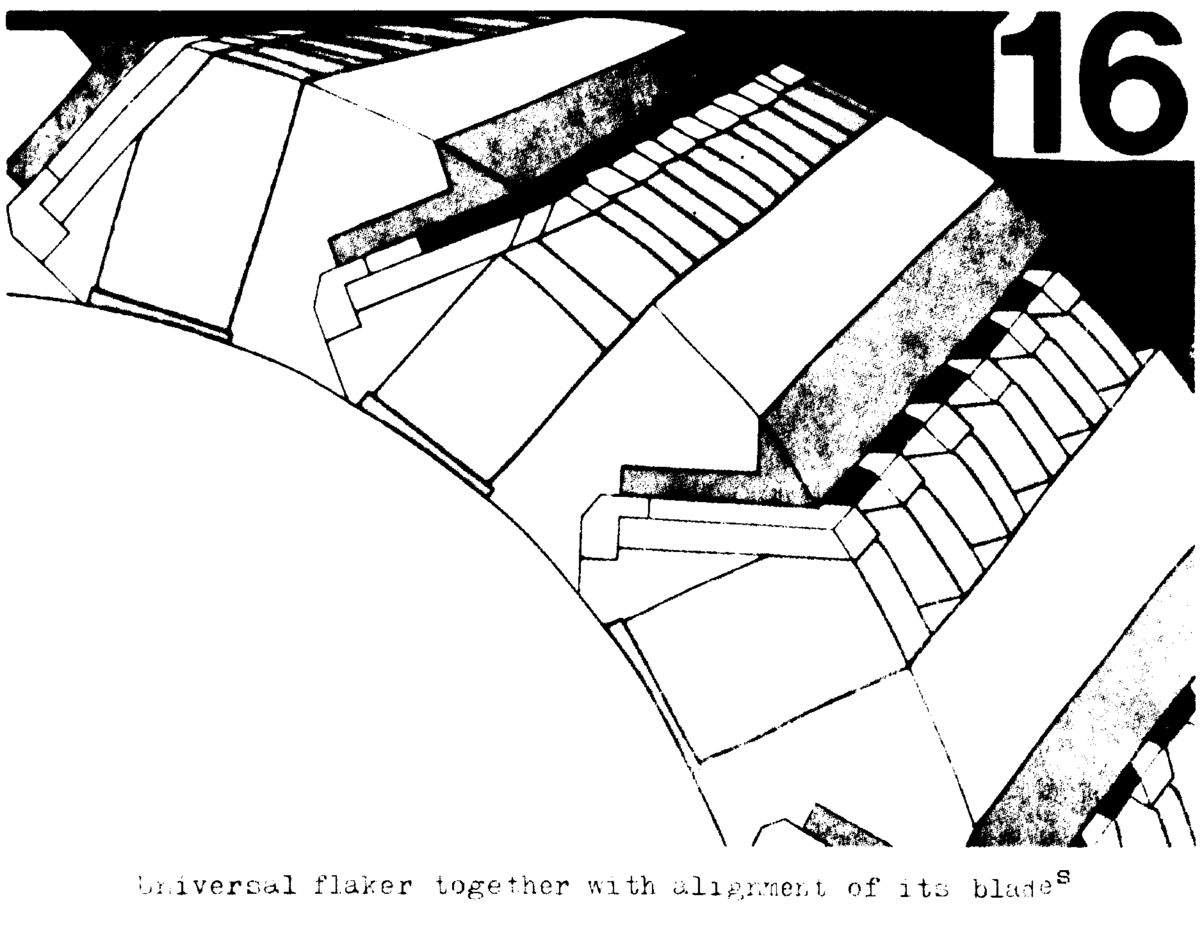
Method for rapid replacement of flaker units.





Universal flaker together with alignment of its blades

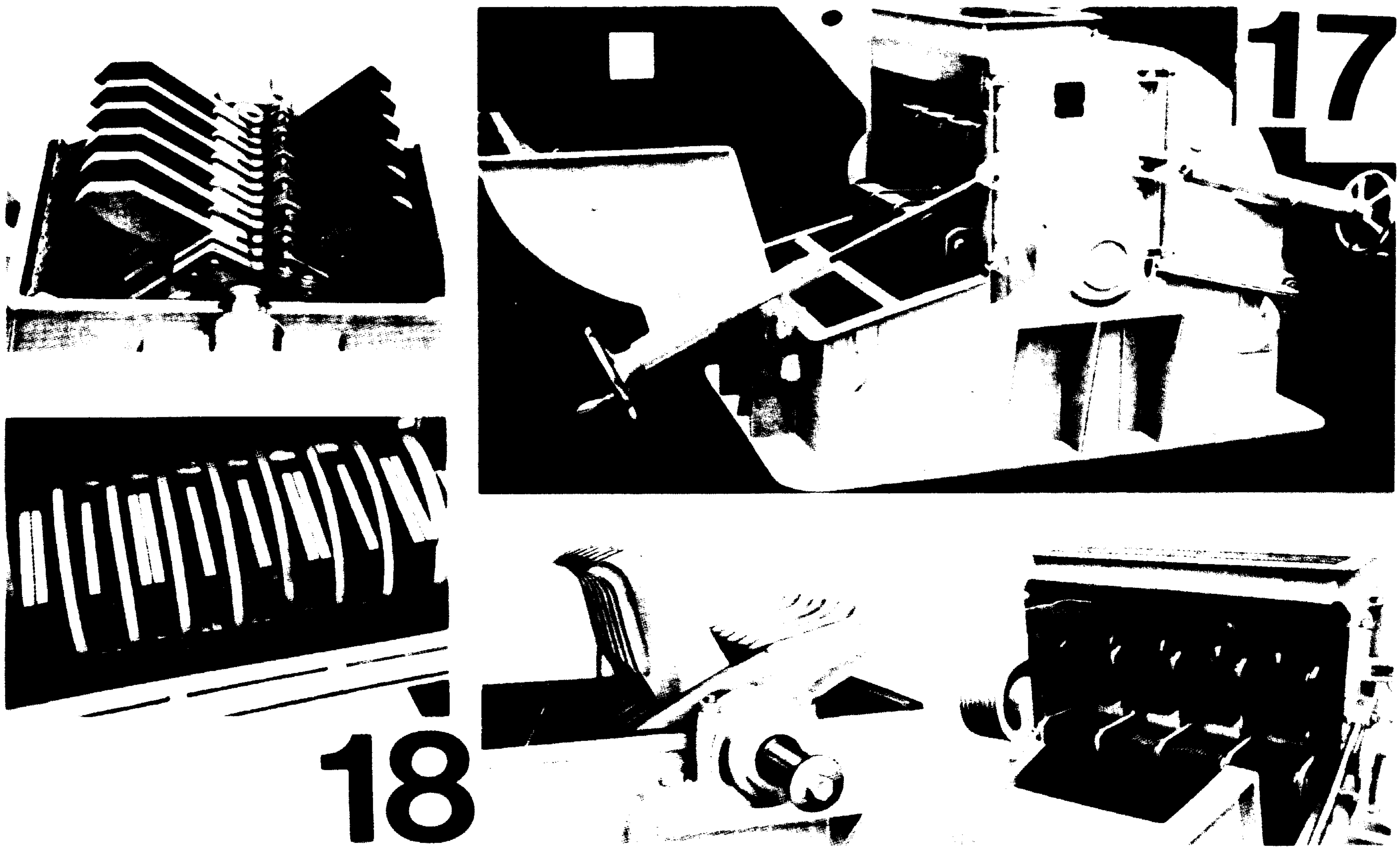


Fig.17 and 18: Make-up of both a hammer and hammer-cross mill

Final Product

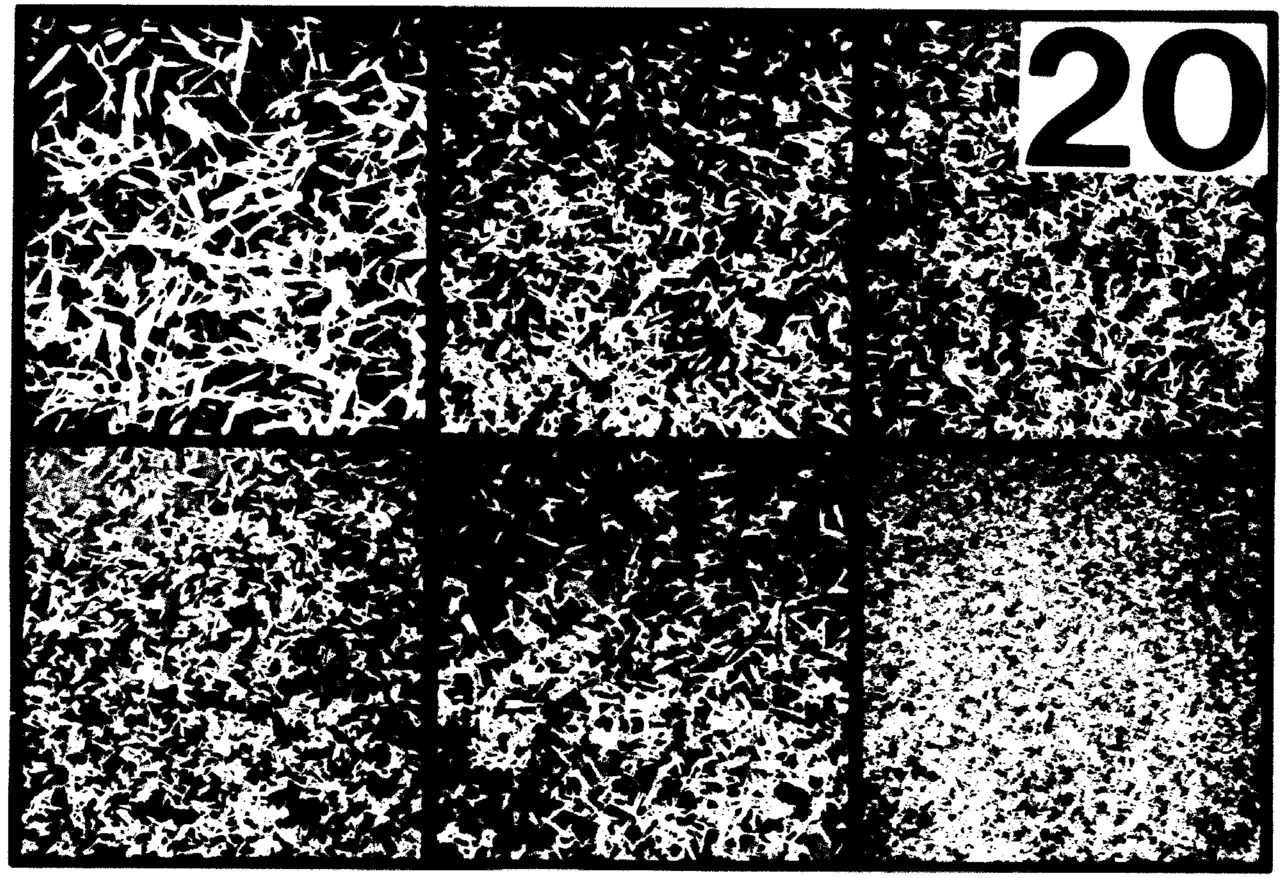


Fig.20: Display of the final product from extra fine particles

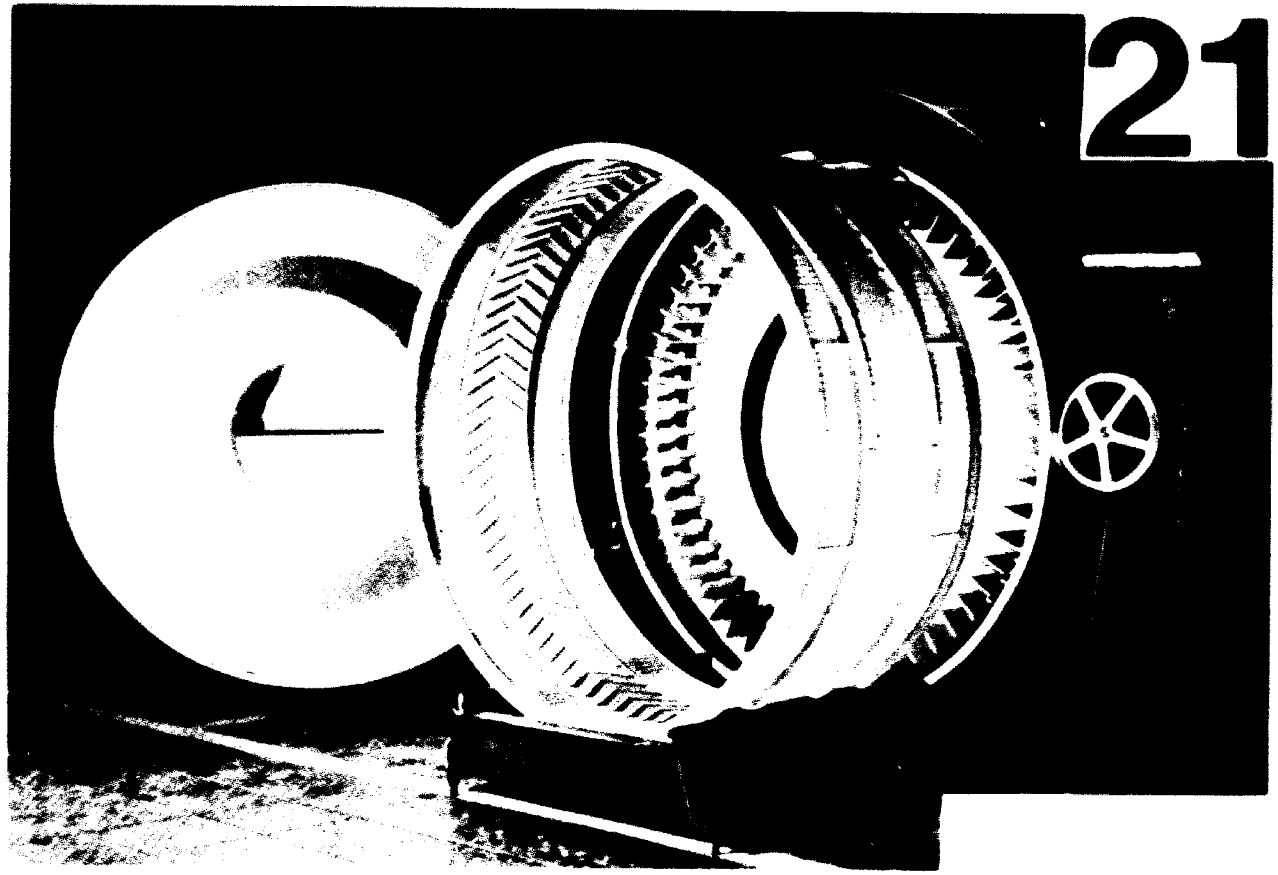
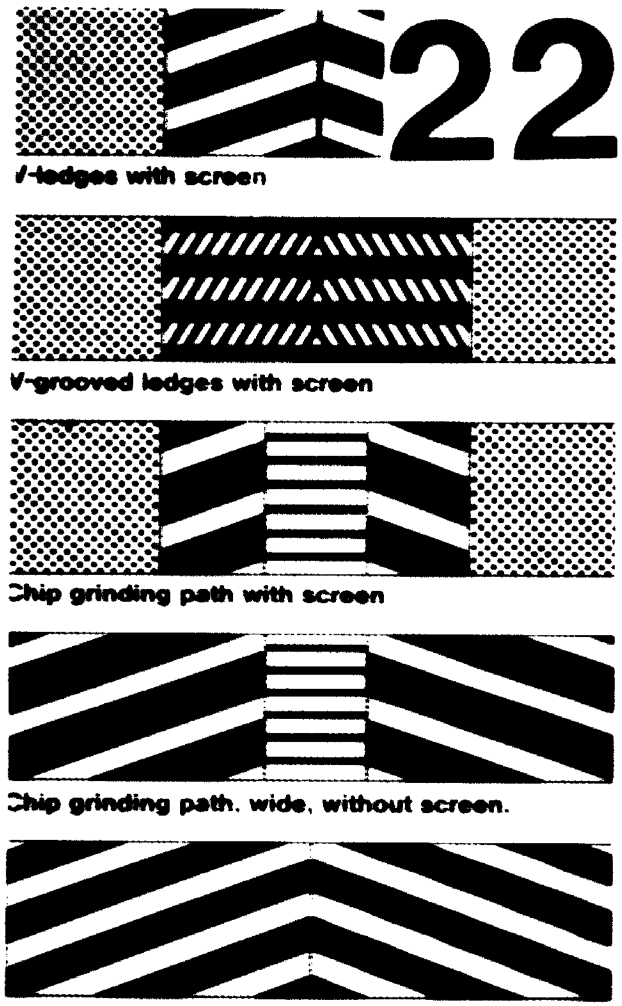


Fig.21-25 inclusive: Components of a refining mill

22



V-ledges with screen

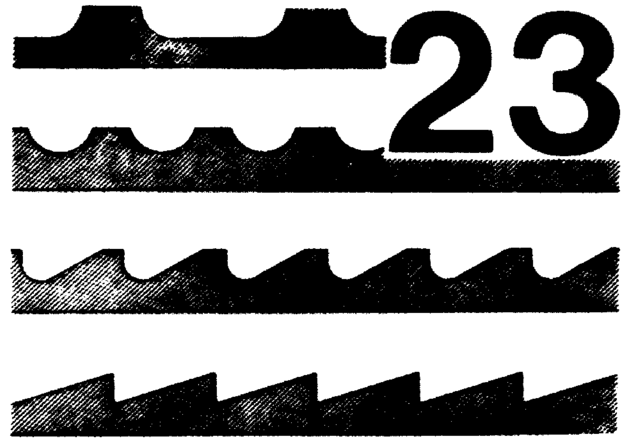
V-grooved ledges with screen

Chip grinding path with screen

Chip grinding path, wide, without screen.

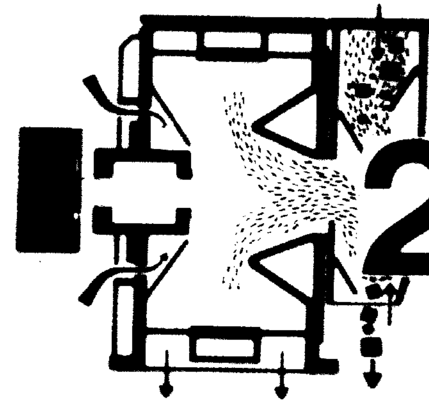
V-ledge grinding path, wide, without screen.

23

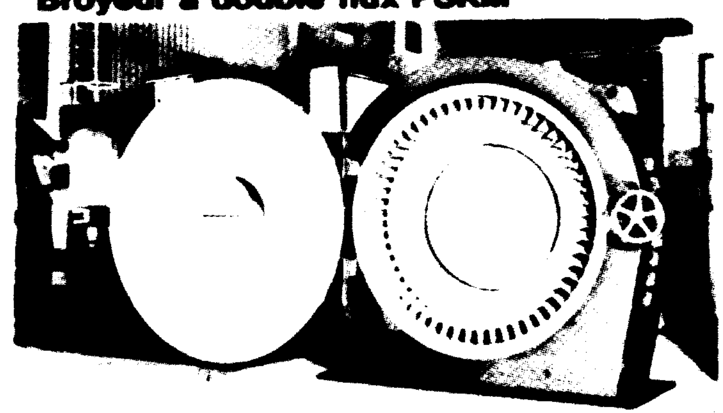


Different Grinding-Profiles
Depending on Requirement

24



Broyeur à double flux PSKM



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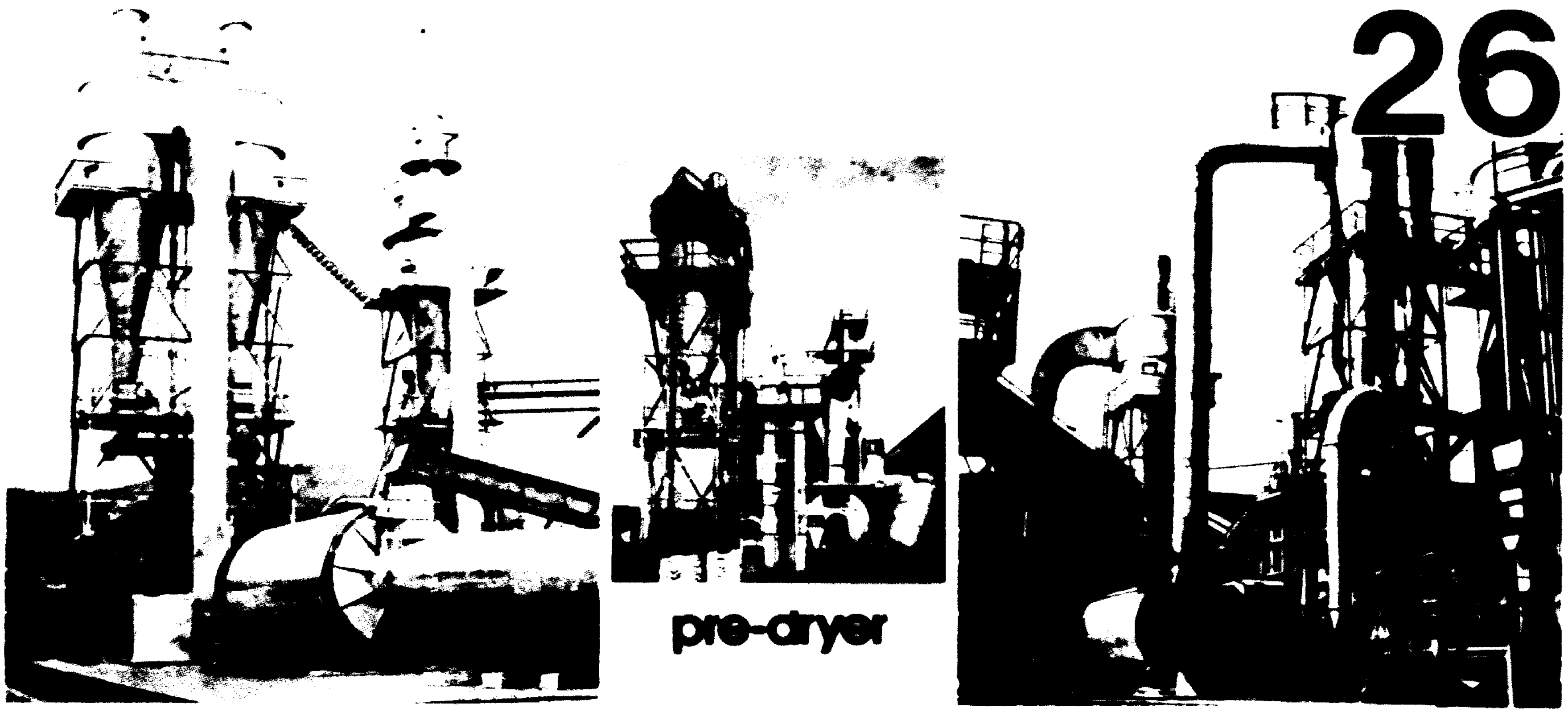
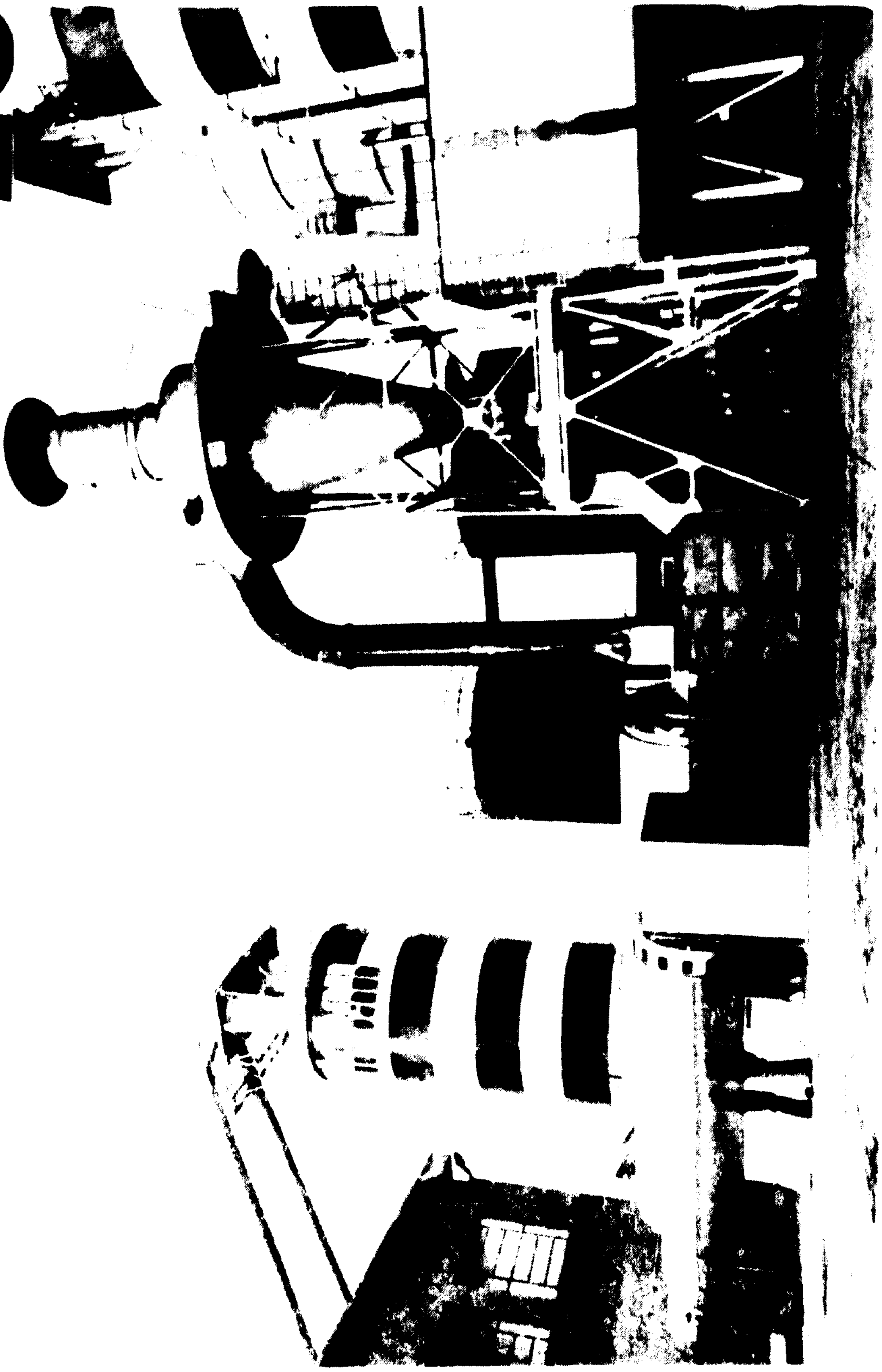


Fig.26–29 inclusive: A pre-drier unit arrangement

27

28

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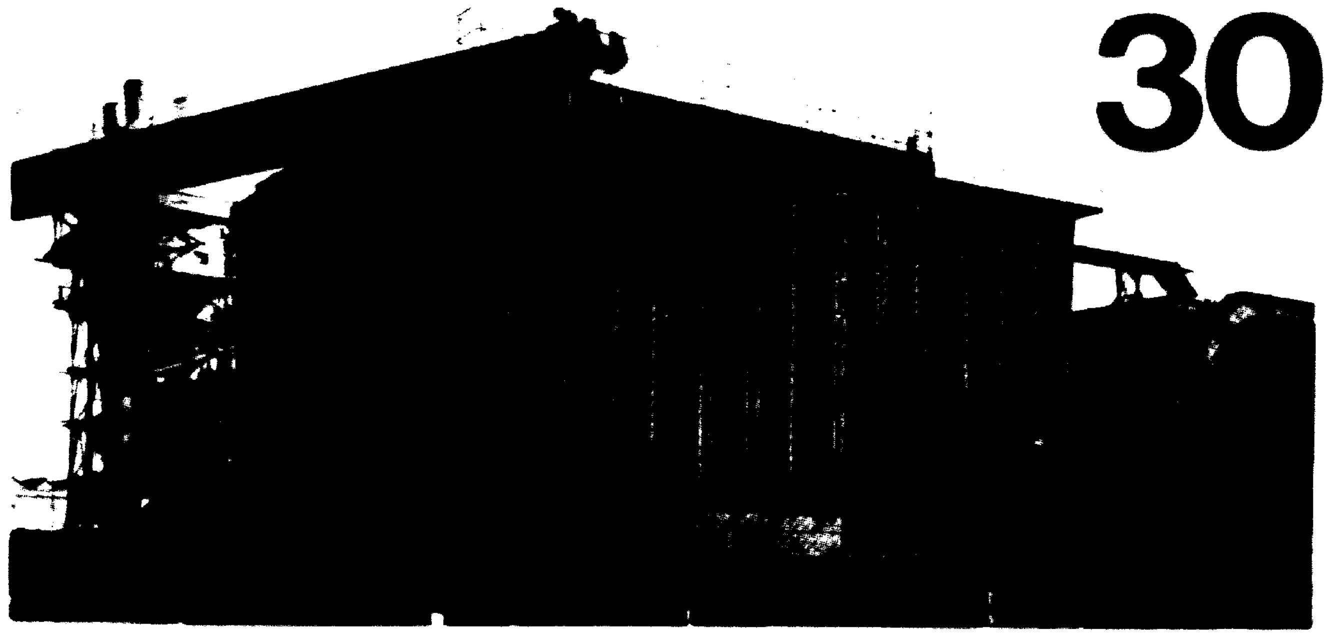
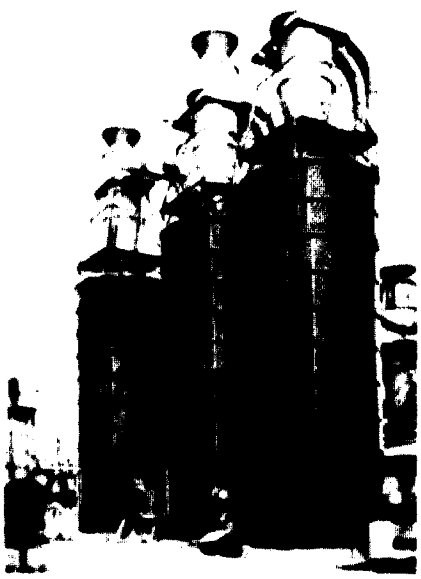
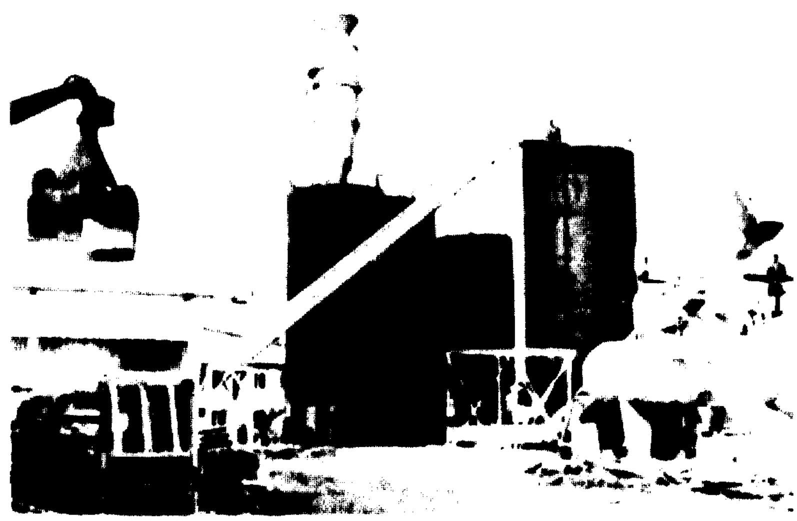
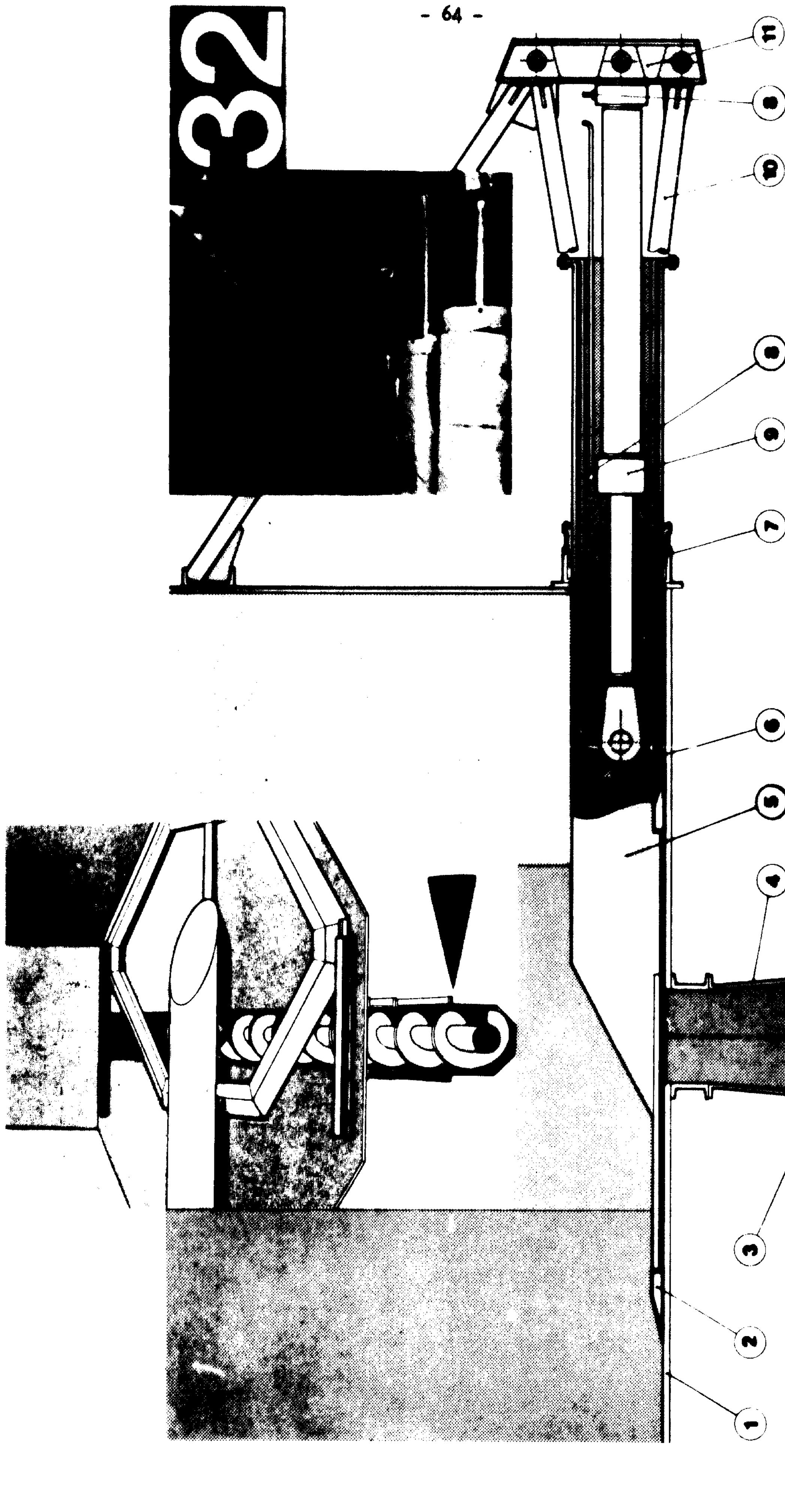


Fig.30-32 inclusive: Silos used for storage of assorted particle sizes

31



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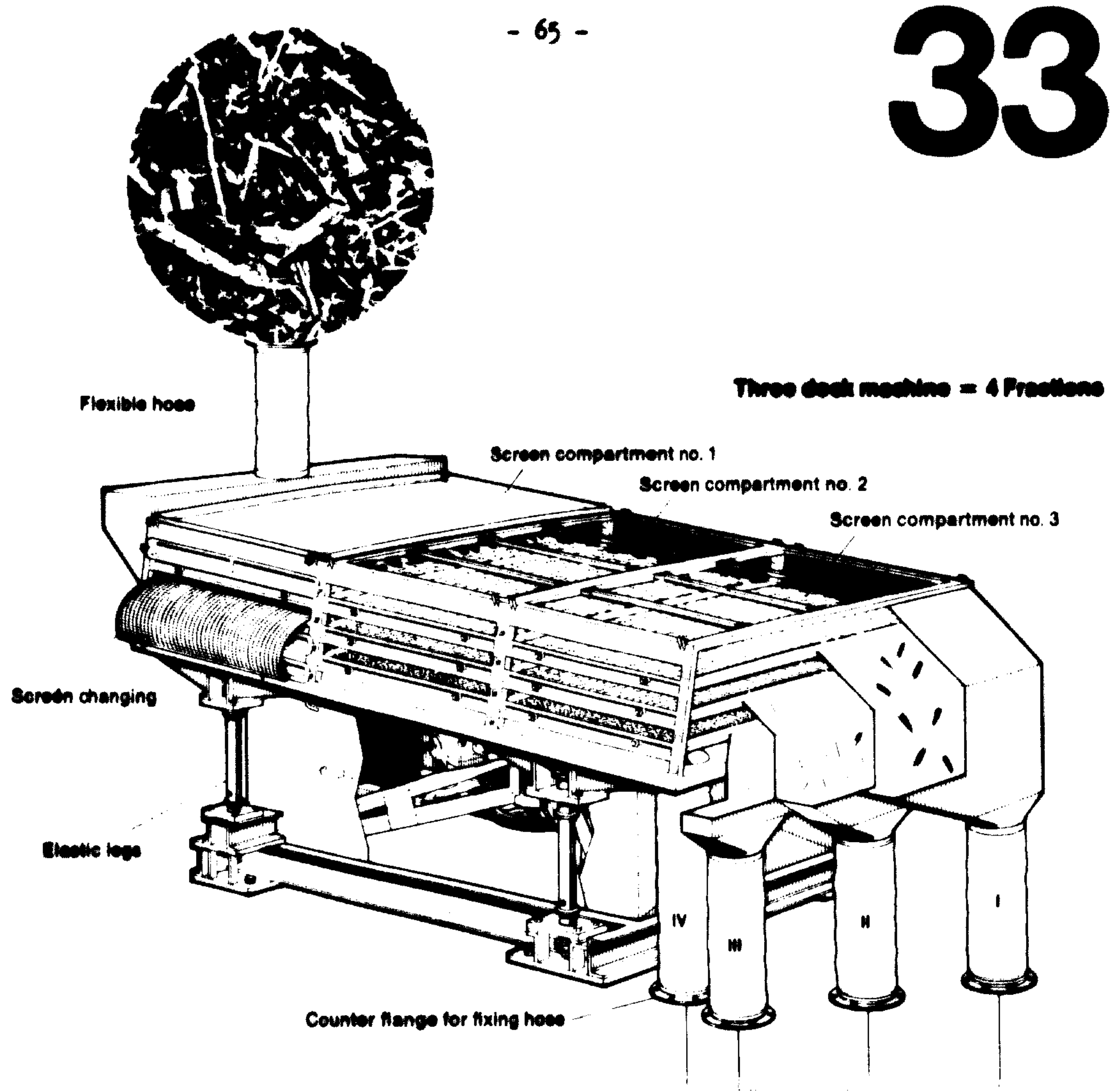


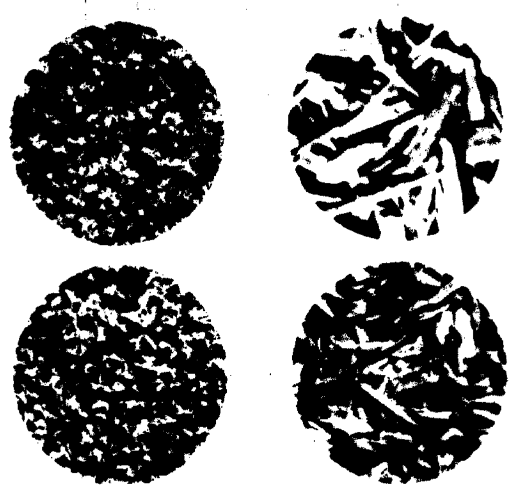
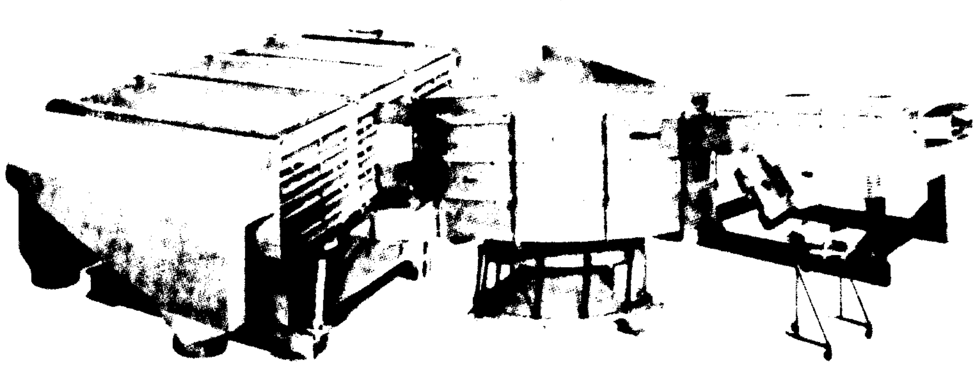


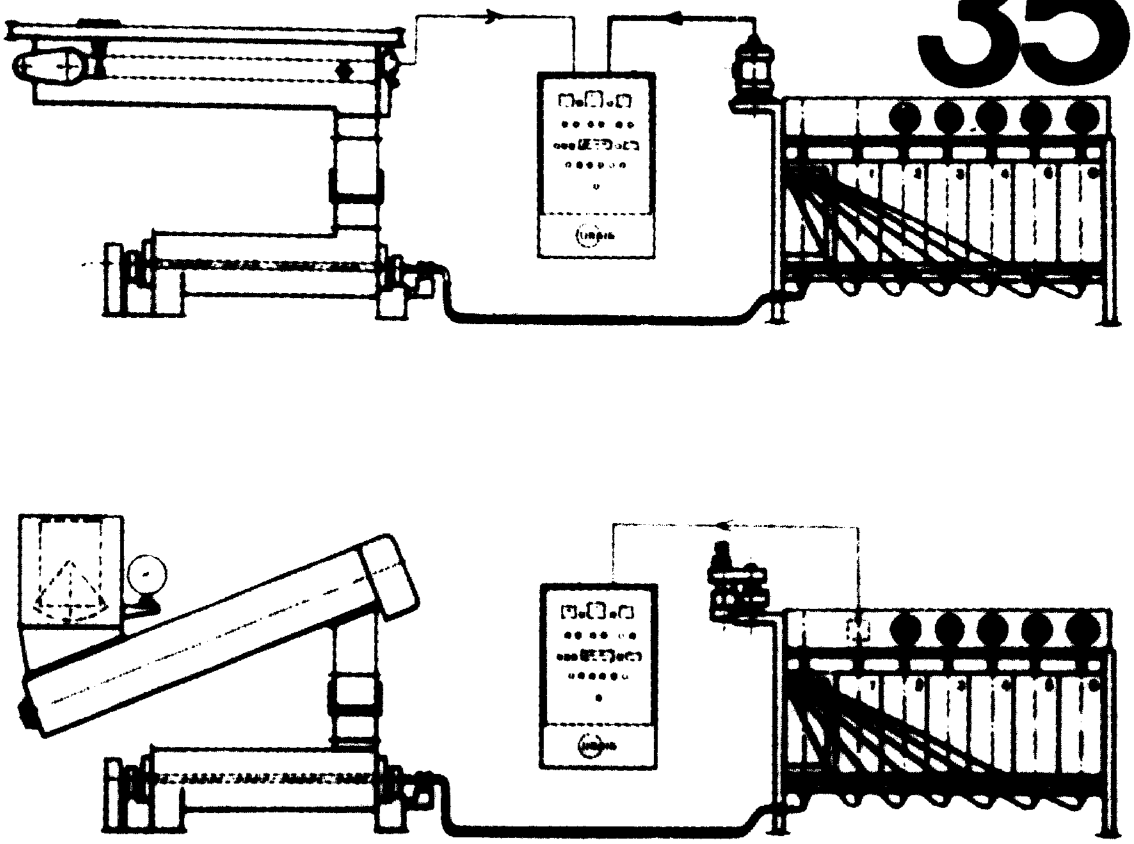
Fig. 33 and 33 BIS -
The orbital type chip grader.



33 BIS

Fig.34-36 inclusive: Plant and arrangement for automatic preparation of binders

35



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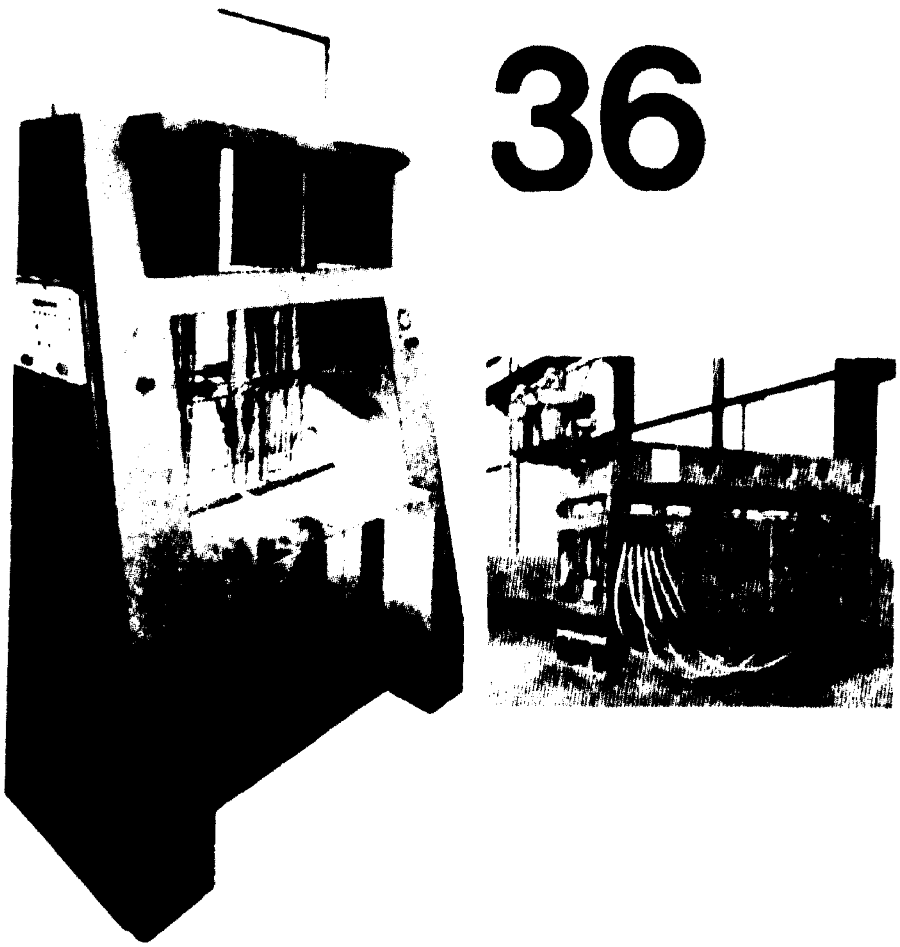

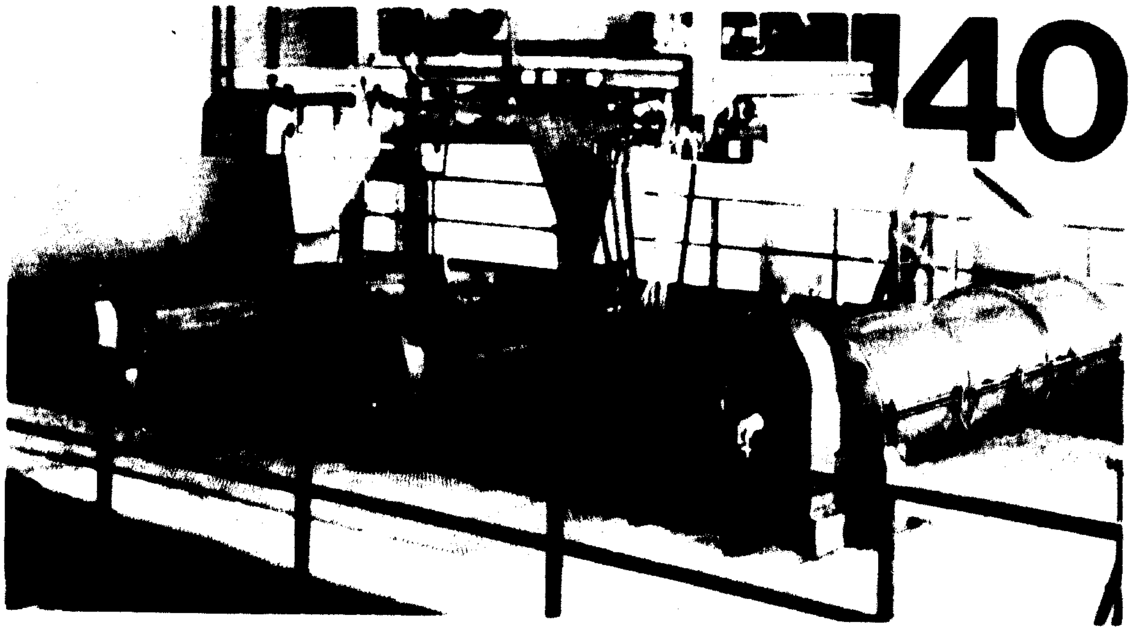

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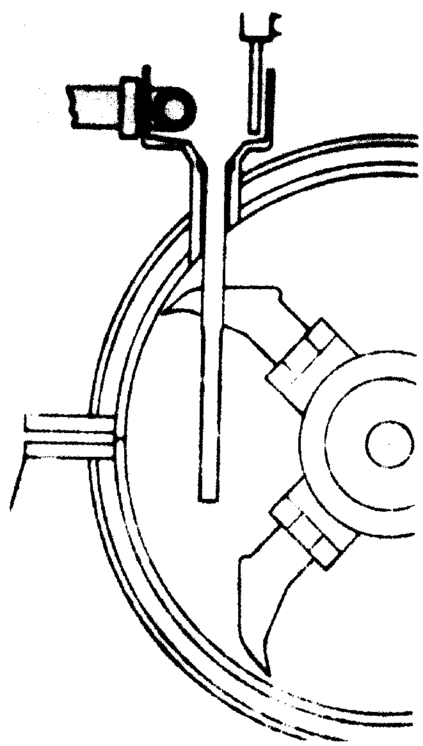
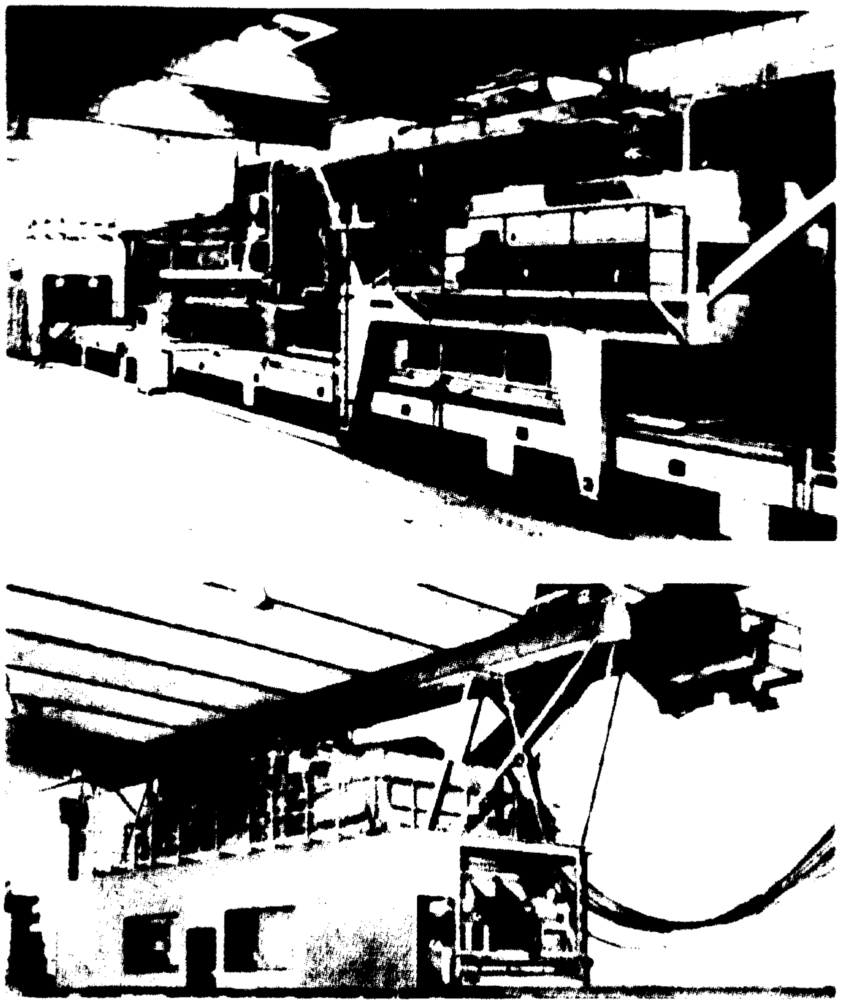


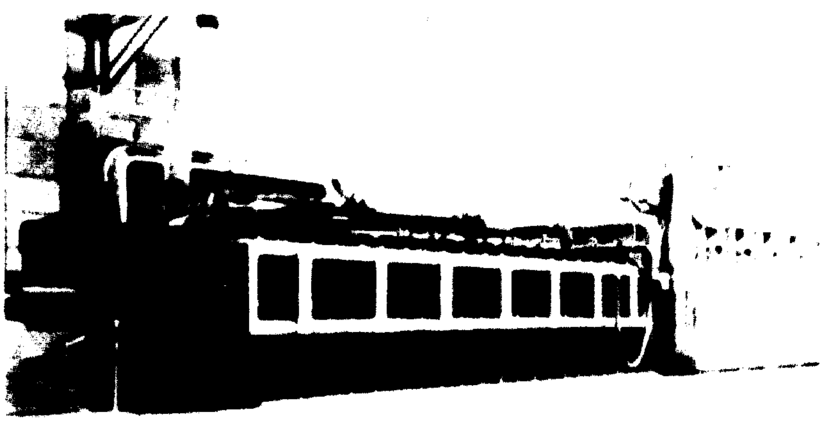
42

Fig. No. 40 to 42 inclusive - System for applying binders.



43

Fig. No. 43 - Forming machine used for spreading particles for board thickness.

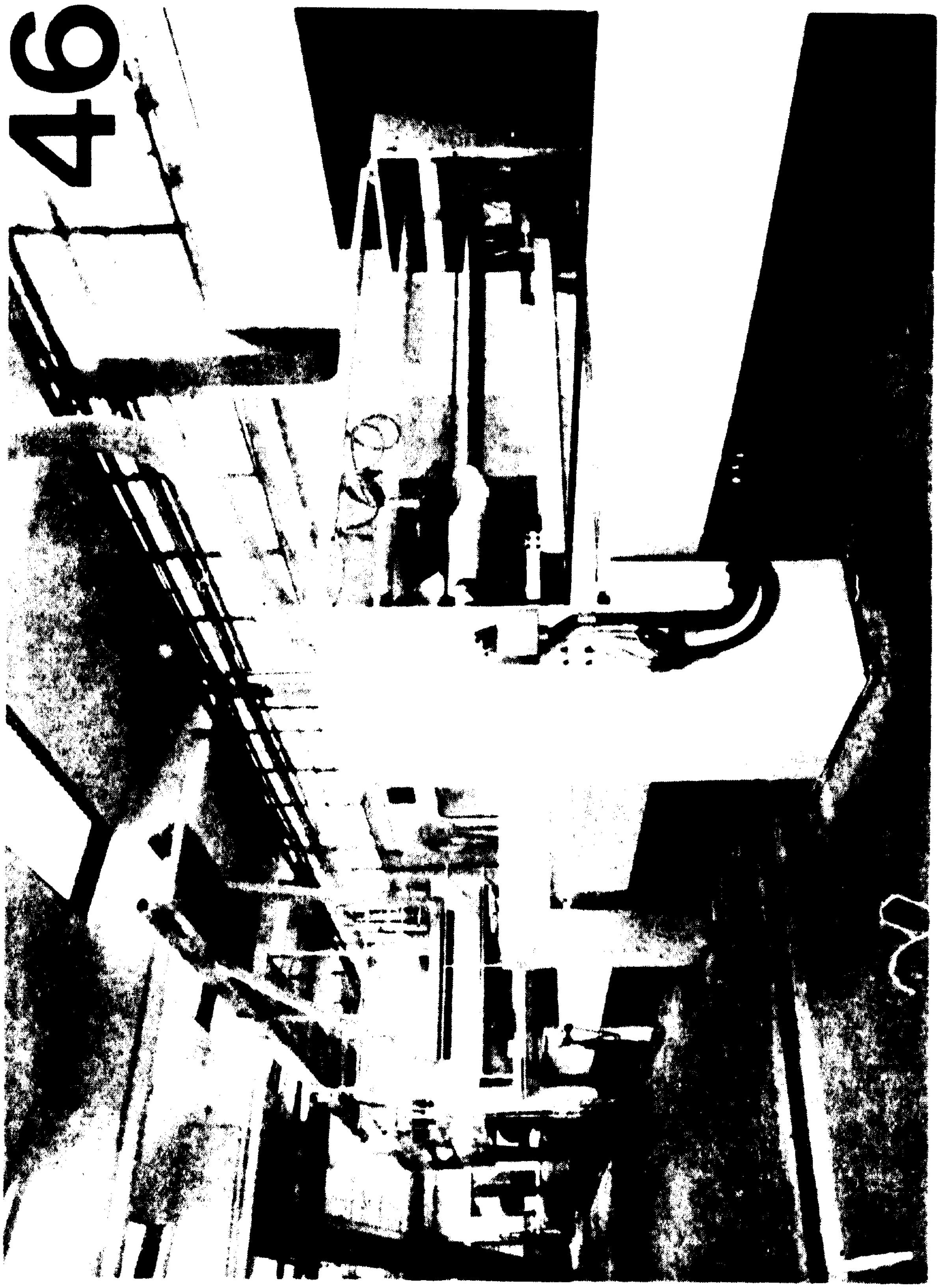


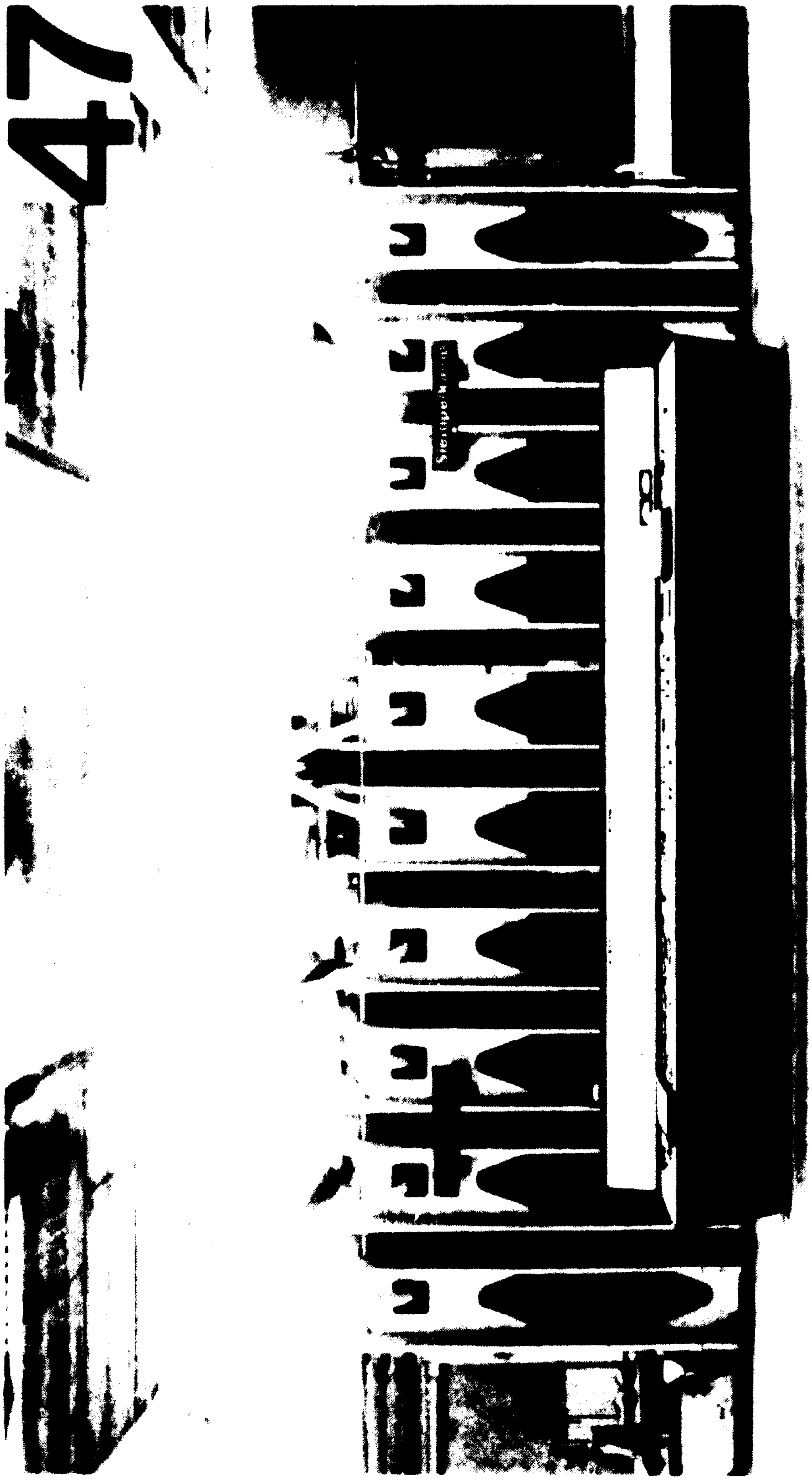
44

Fig. No. 44 - Preliminary pressing unit used to compact particles.

45

Fig. 45 - Calender type preliminary presser


46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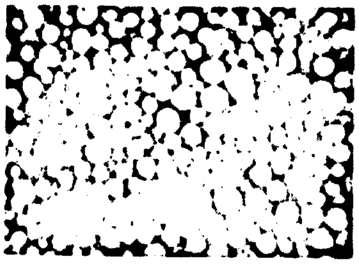
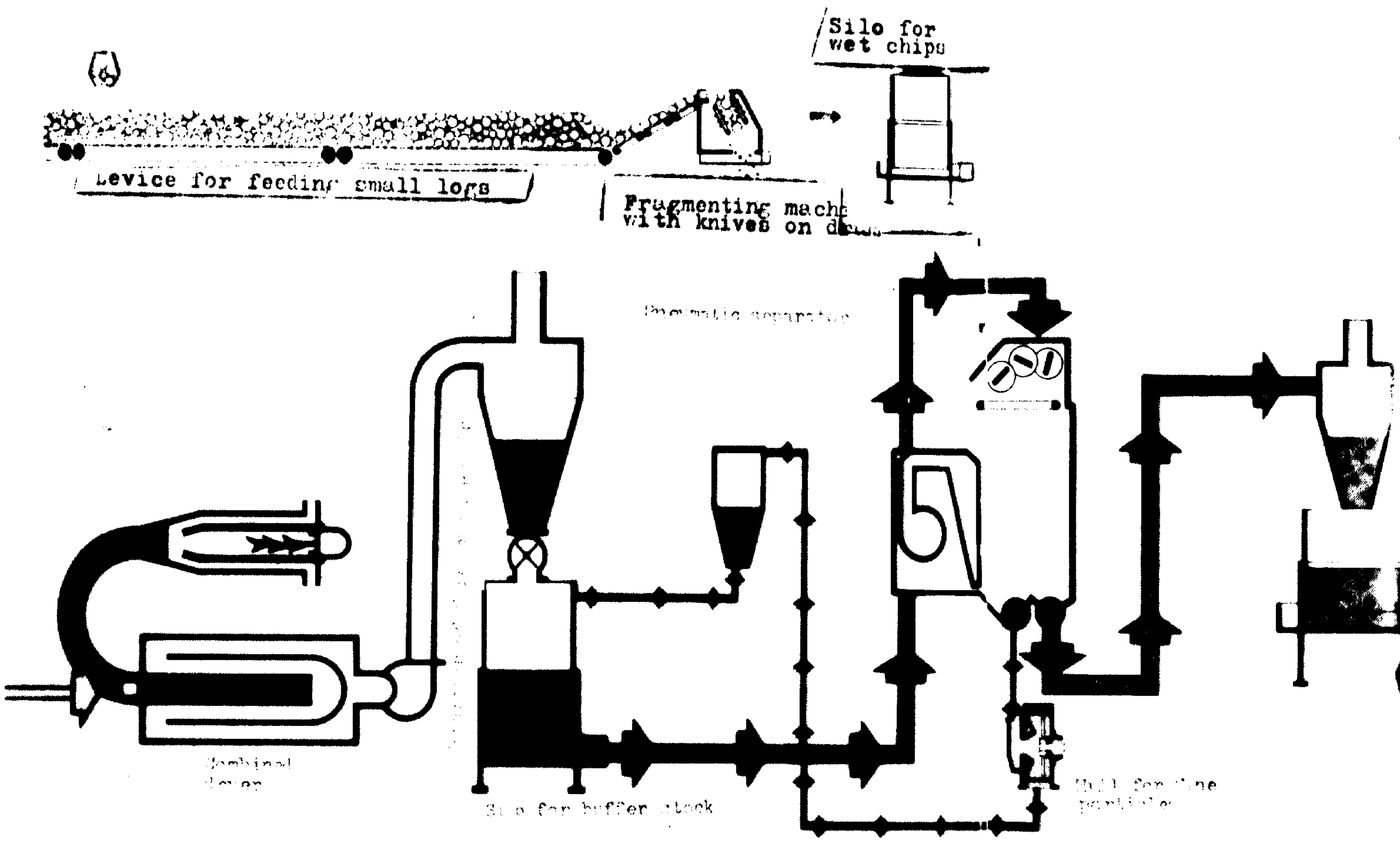




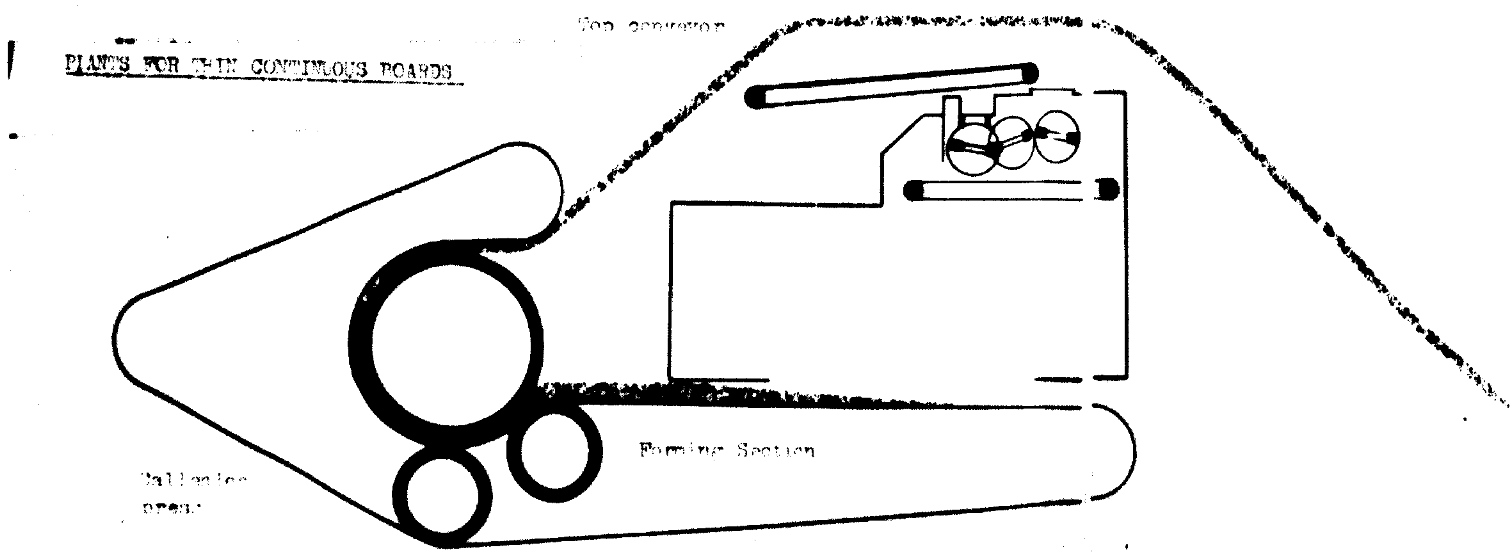


Fig. No. 49 and 49 B

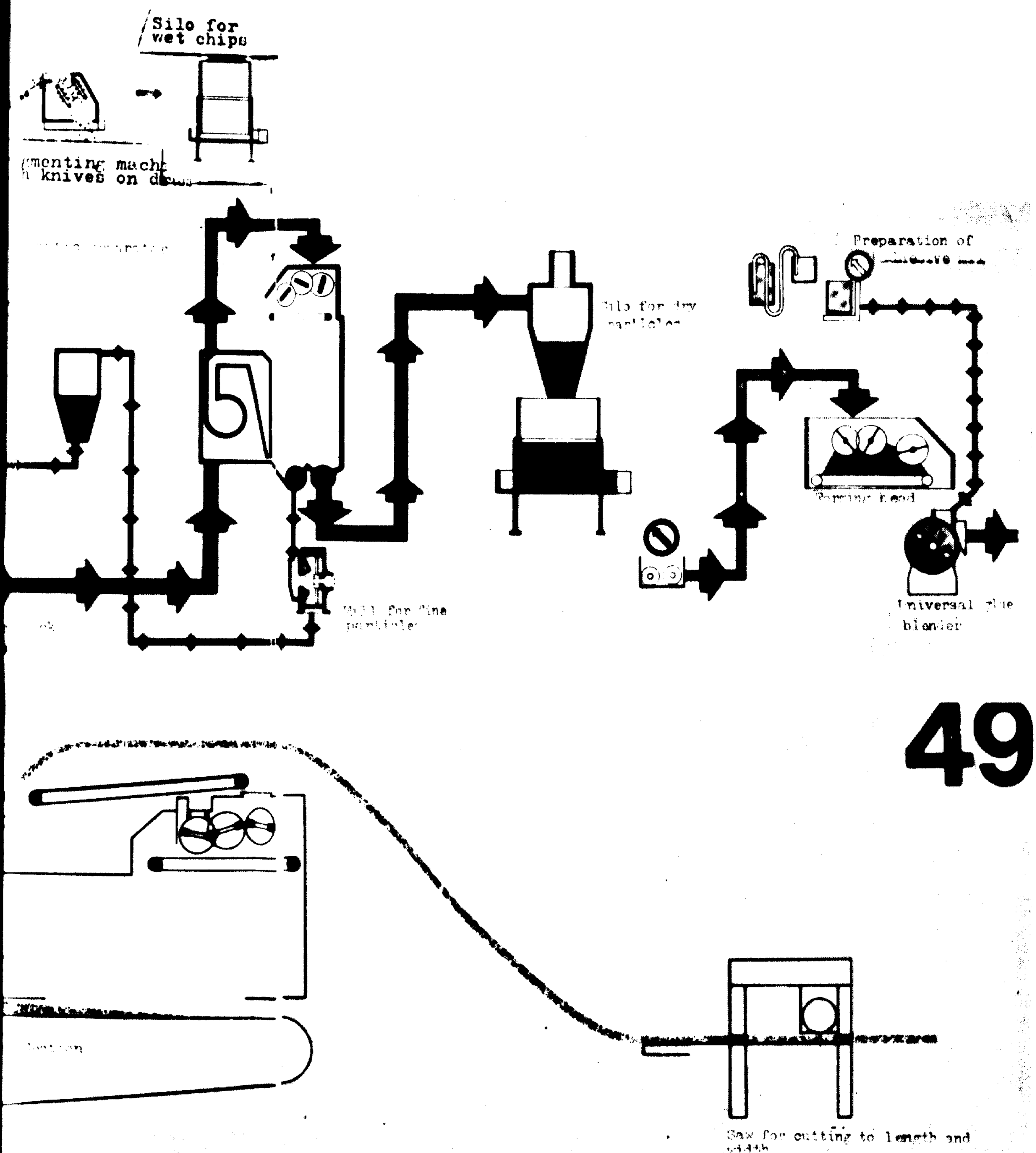
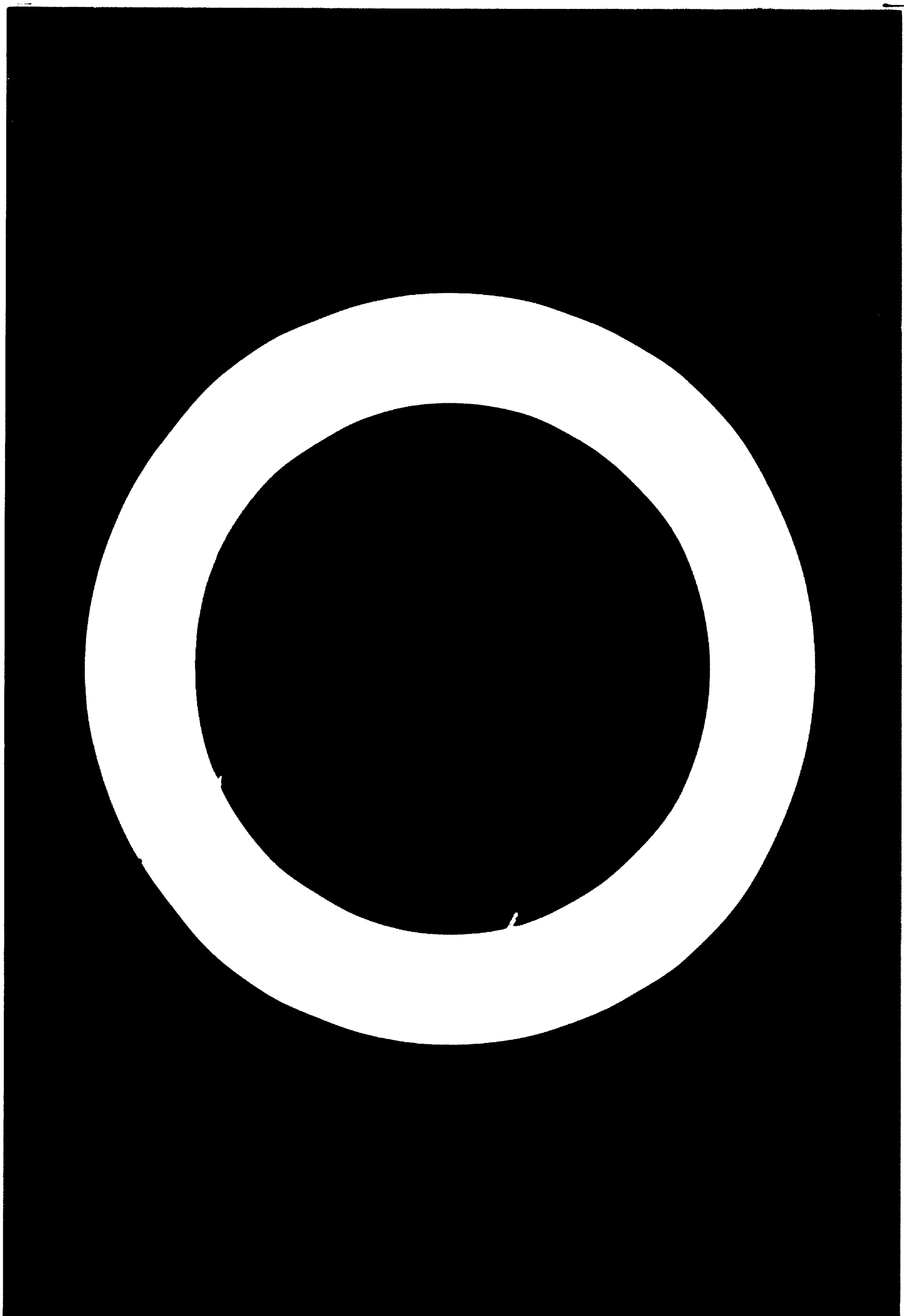
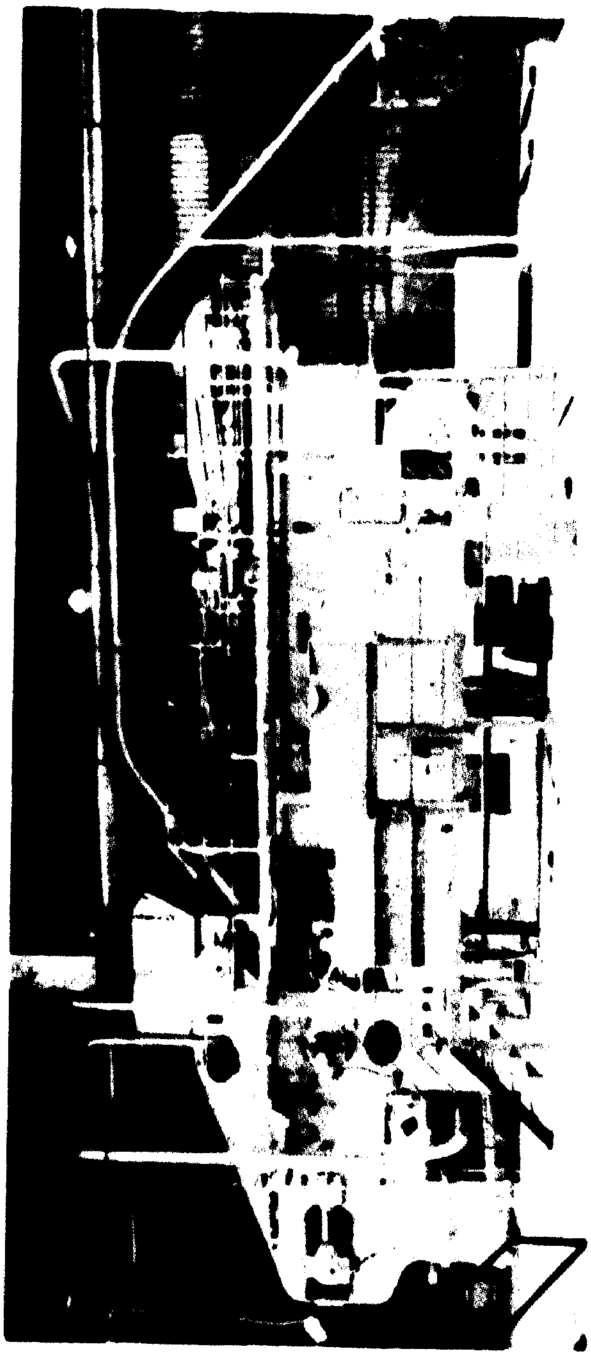


Fig. No. 49 and 49 BIS - Continuous Calender type presses.





49 BIS

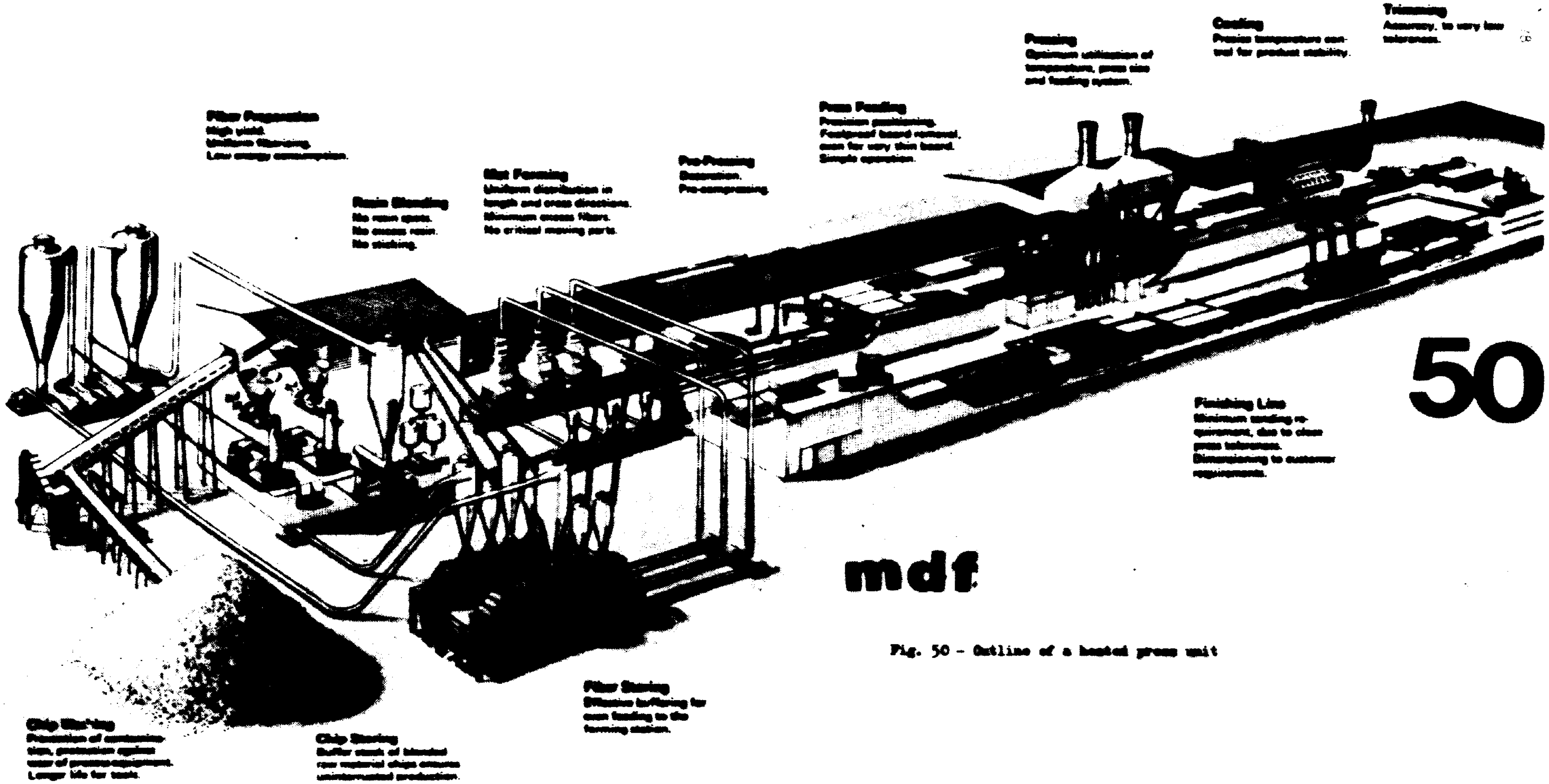
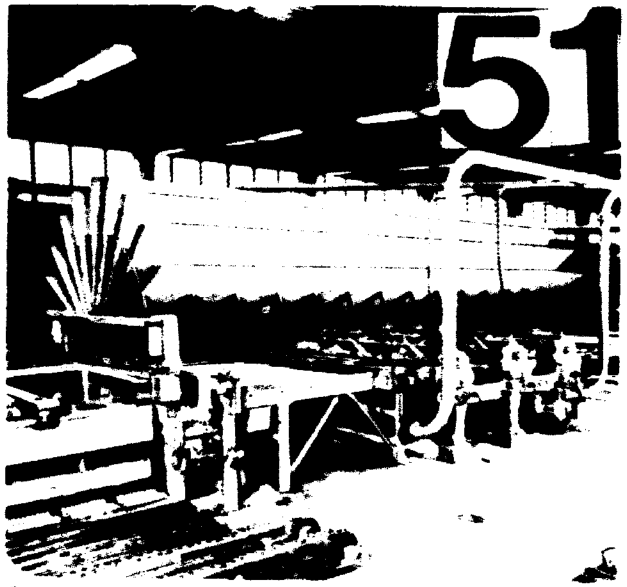


Fig. 50 - Outline of a heated press unit



Cooling section after the press

Intermediate storage prior to sanding

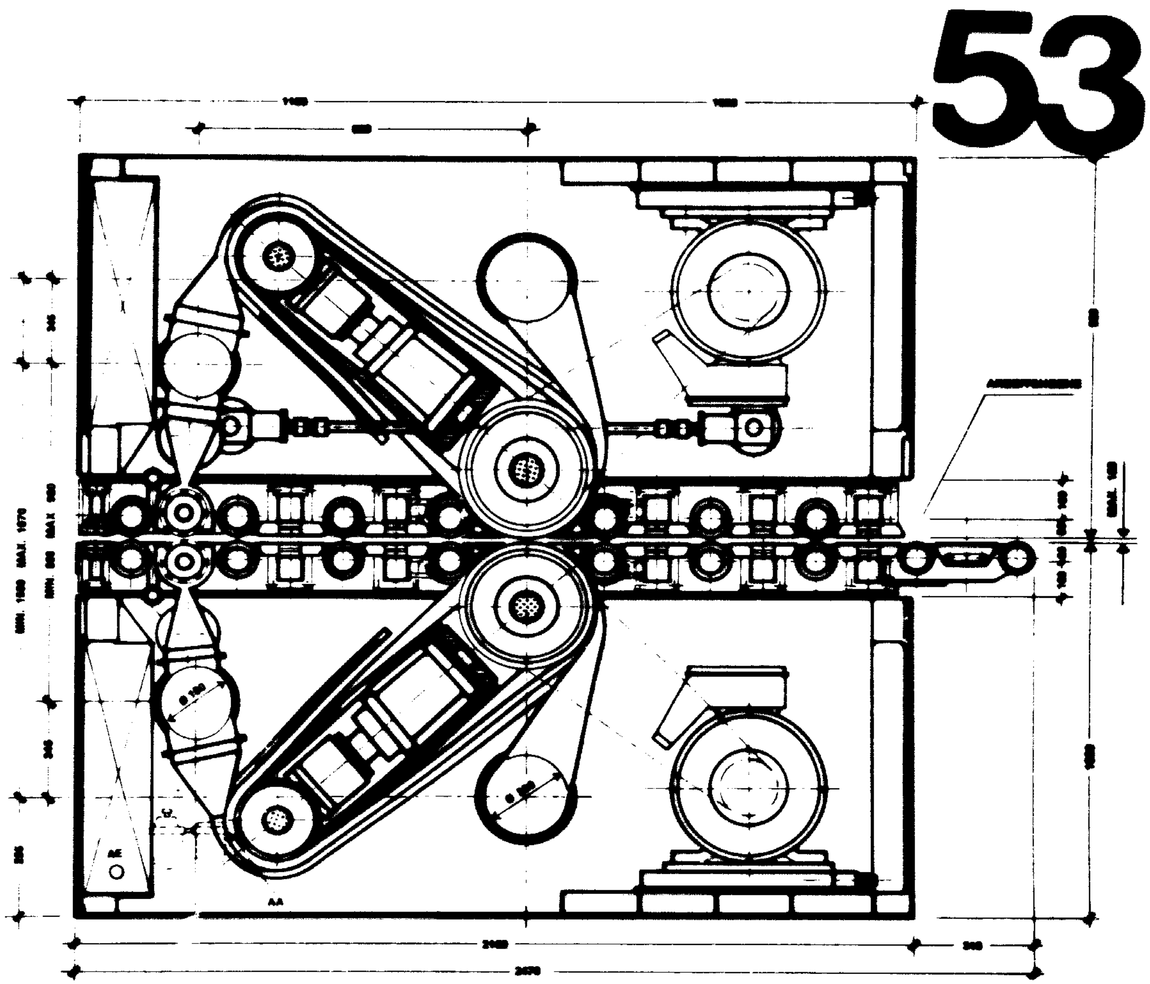
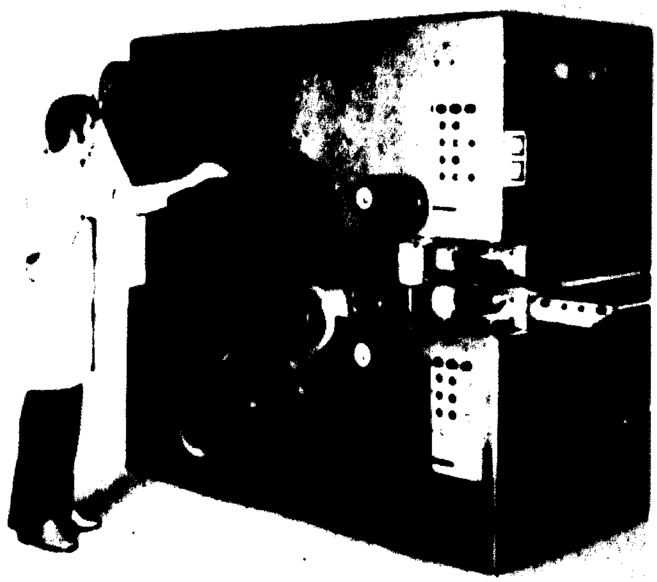


Fig.51: Cooling boards by the rotating rack system
Fig.52: Storage of boards prior to being sanded
Fig.53 and 54: Sanding machines used for surfacing the boards



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C-13

79.11.15