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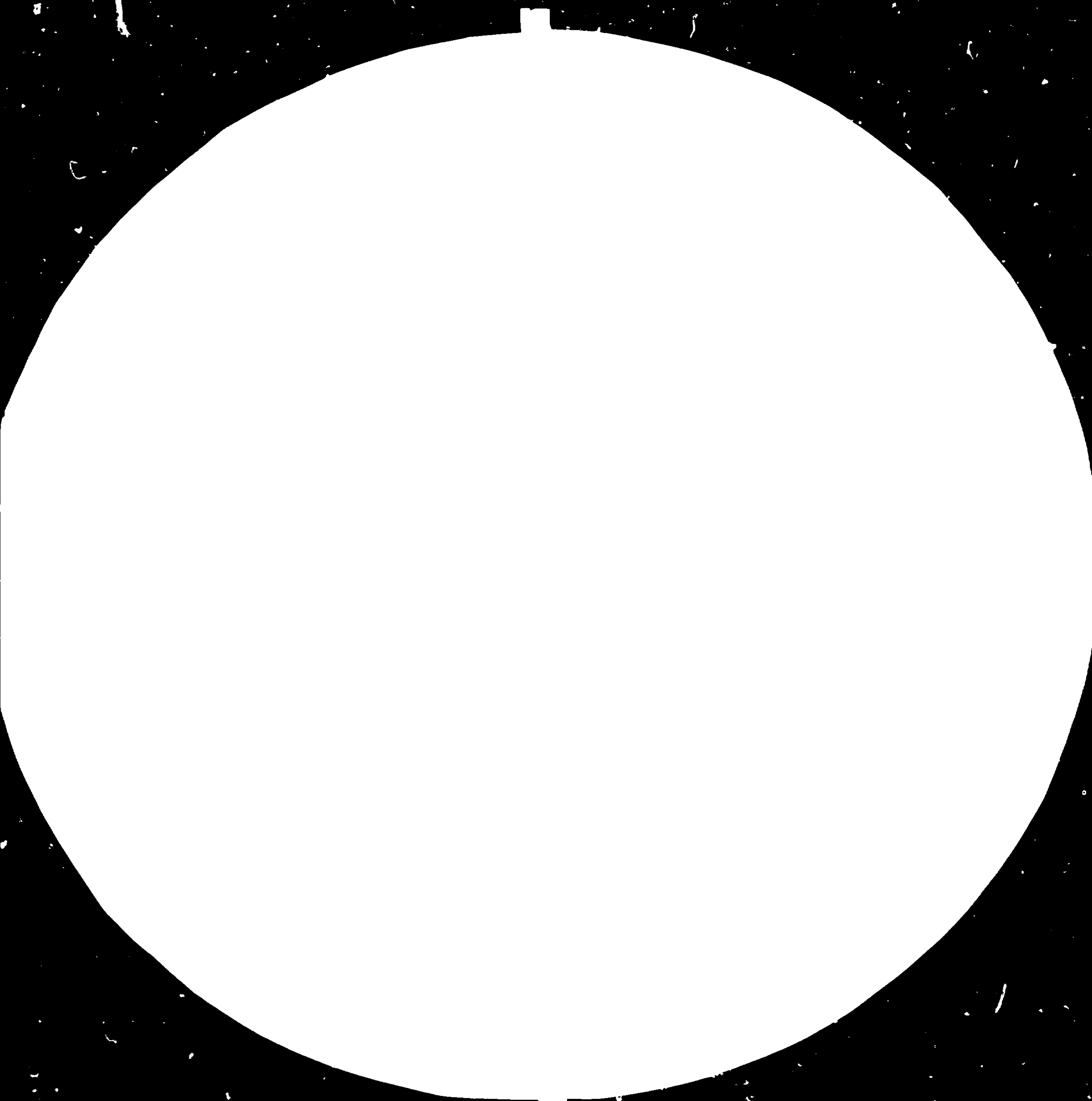

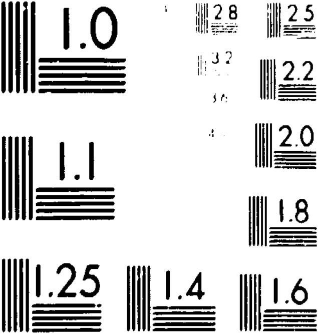

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WASTE AND DUST EXTRACTION SYSTEMS*

by

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1064

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Introduction

In the modern woodworking industry, particular attention is paid to the problem of dust and waste extraction. Sawing, squaring, planing, polishing machines, etc., produce waste of various kinds, chips, shavings and dust, which must be removed both from the machine and from the work environment and should later be recovered, hopefully, for industrial or energy purposes. Today, priority is no longer given to the machine which, however, should be kept clean in order to ensure a smooth operation and prevent damage that may possibly involve delicate automatisms, but - reasonably enough - to man and to the ways in which he may be enabled to work in an environment as clean and as healthy as possible.

In order to achieve this goal, one must:

1) extract the waste from where it has originated;
2) convey it through a conduct system;
3) deposit it in a suitable place.

These operations give rise to a suction plant and this is also the topic of this lecture.

Suction plant

A waste suction plant (or extraction system) is, basically, composed of:

1) a fan;
2) pipelines;
3) a material collection bin,

as shown in figure 1.

Its working principle is based on the action of the fan, which, in fact constitutes the core of any suction plant. A fan is a rotary blade machine that continuously supplies power to the air passing through it. The action of the fan is twofold:

1) it sucks both air and waste through a pipe network which is connected to the woodworking machines;

2) It blows the mixture (air and waste) toward the pre-established point of collection; this action is also performed through a pipe (figure 2).

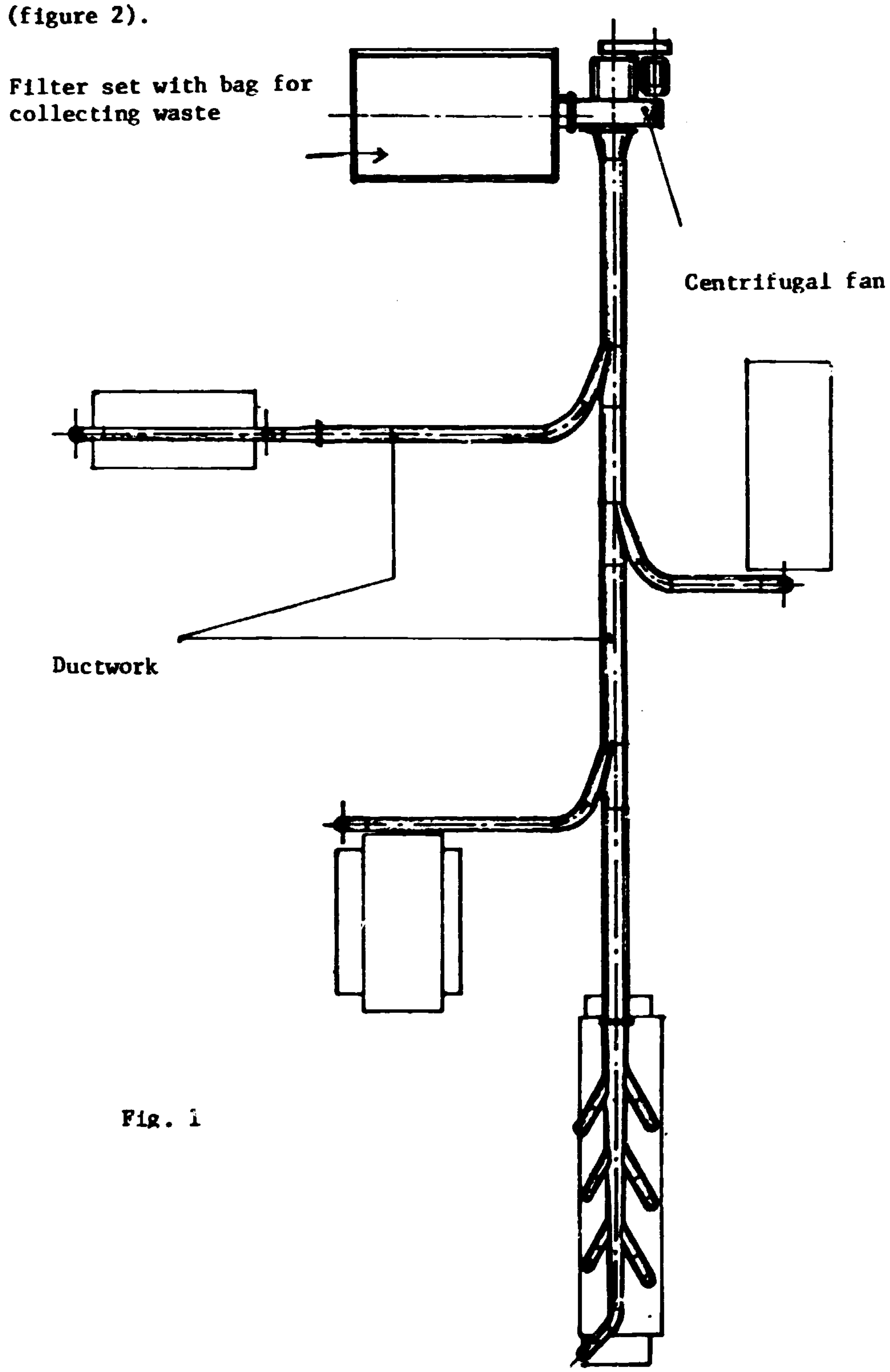


Fig. 1

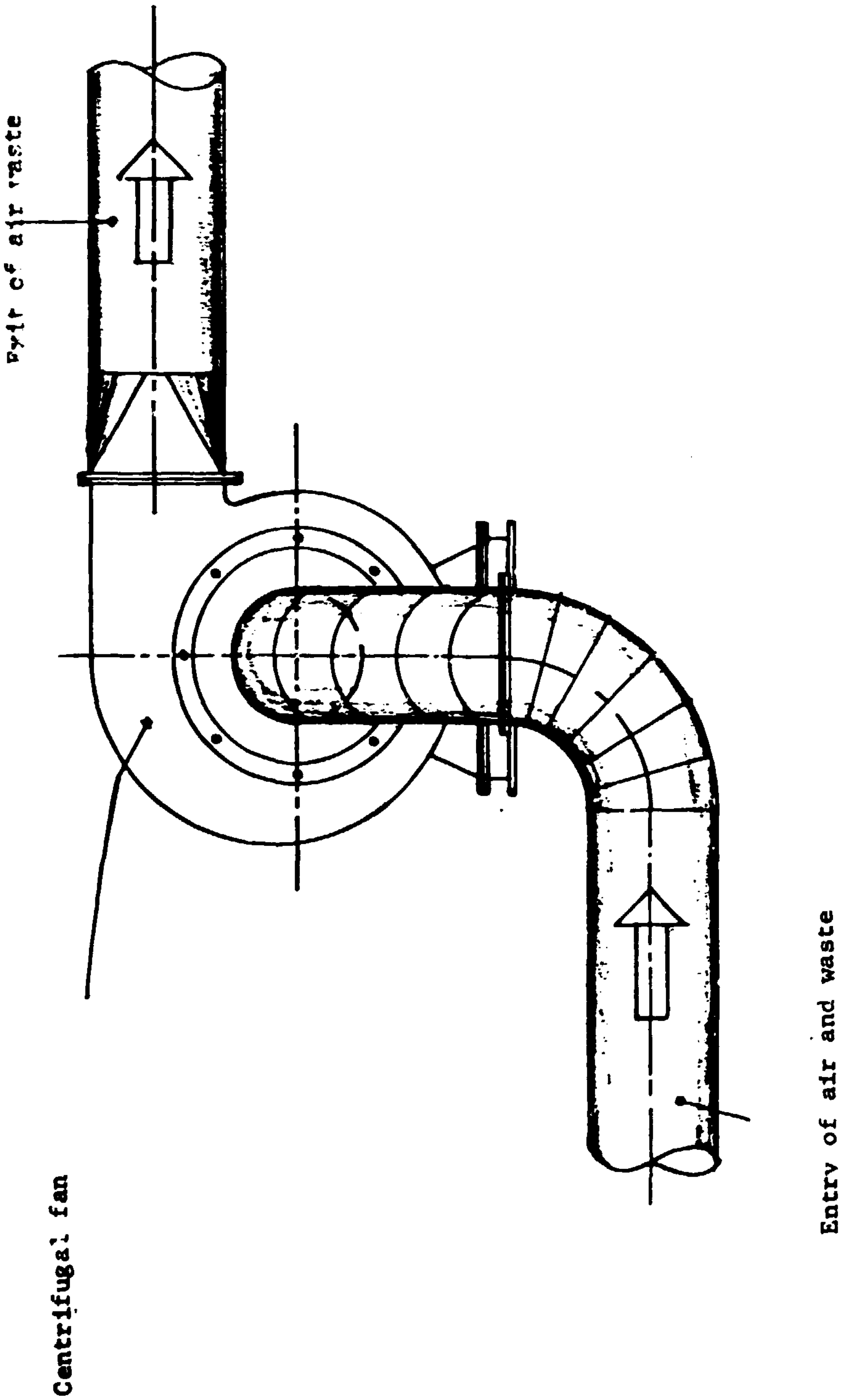


Fig. 2: Centrifugal fan

This is simply a schematic outline, our starting point for an examination of the type of suction plant which should actually be adopted, also in view of modern aeromechanical technology. A correct choice must be based on the size of the factory in which the suction plant is to be installed and on the number and type of woodworking machines. Thus, if the size of the factory premises is rather limited with simple, unautomated equipment and without on-line machining requirements, small standard units can be installed - either fixed or trailer-mounted - possibly connecting them to each of the machines operating in accordance with one's specific requirements. Normally, this occurs when the machines installed exceed the number of workers employed for processing and operate with a low degree of contemporaneity.

These standard units come packed in assembly cases which include the fan and the filter, and are connected to the relevant machines by means of flexible plastic pipes (see figures 3 and 4).

If, on the other hand, the business is of an industrial type, hence characterized by scheduled on-line processing operations with a considerable number of machines, including automatic ones, and with a high degree of operating contemporaneity, then a centralized system must be designed, capable of connecting each of the machines to the waste collection area via a suitable pipe network. Figure 5 shows the layout of an industrial plant.

Each machine is normally equipped with one or more suction mouths. The size of the latter is calculated as a function of the amount of air normally required in order to ensure the effective intake of the waste material produced.

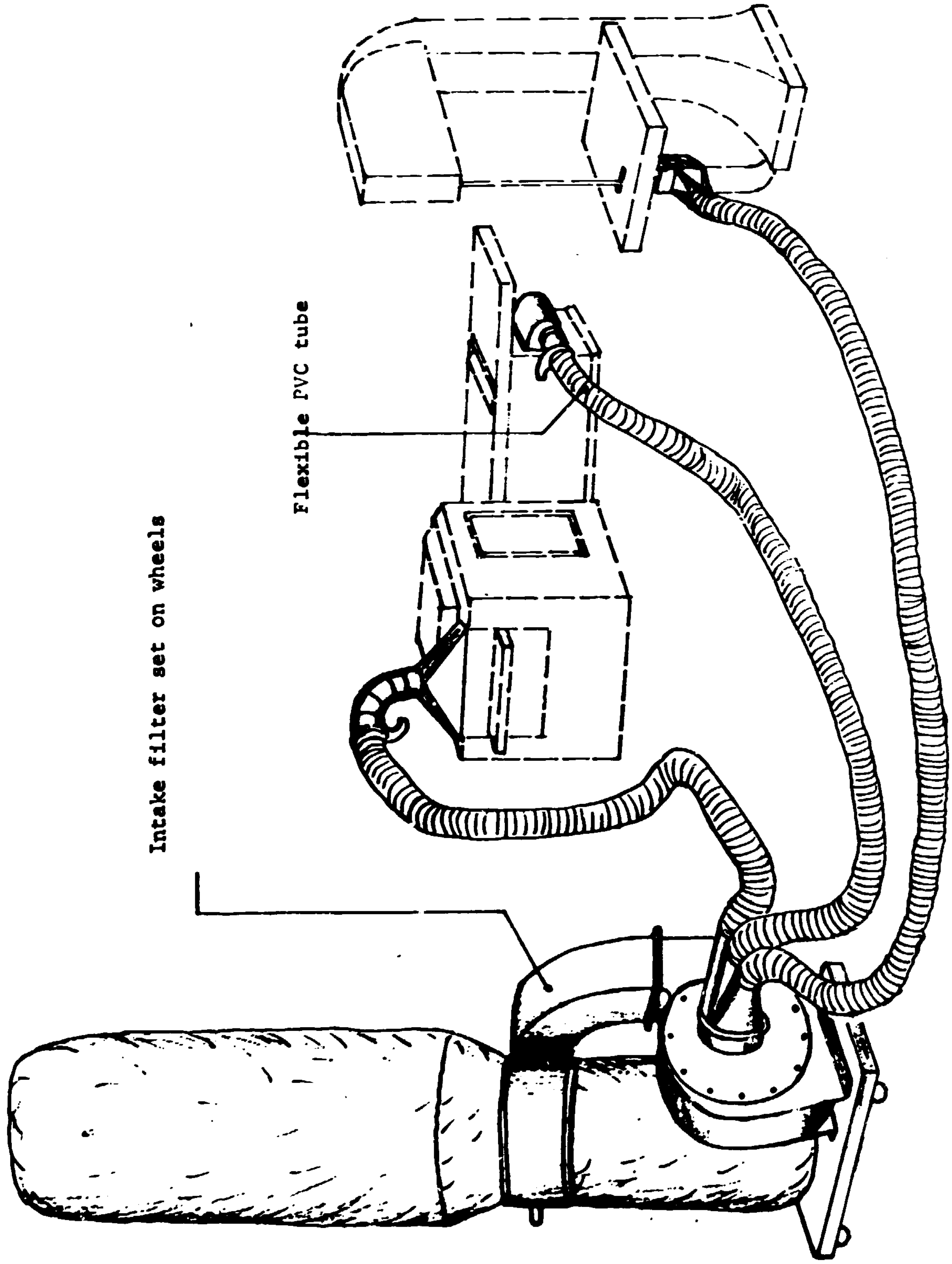


Fig. 3: Intake filter set on wheels

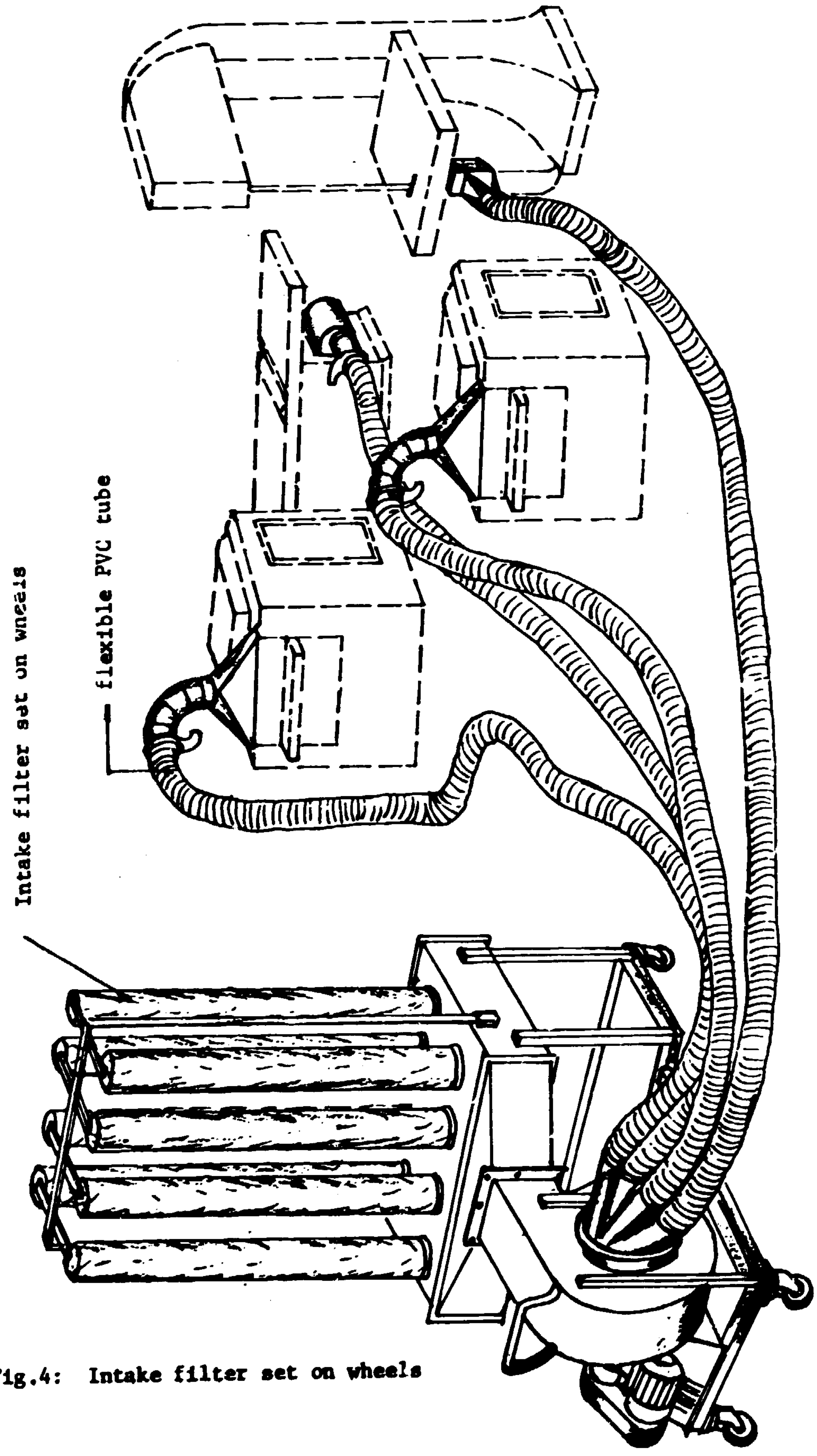


Fig.4: Intake filter set on wheels

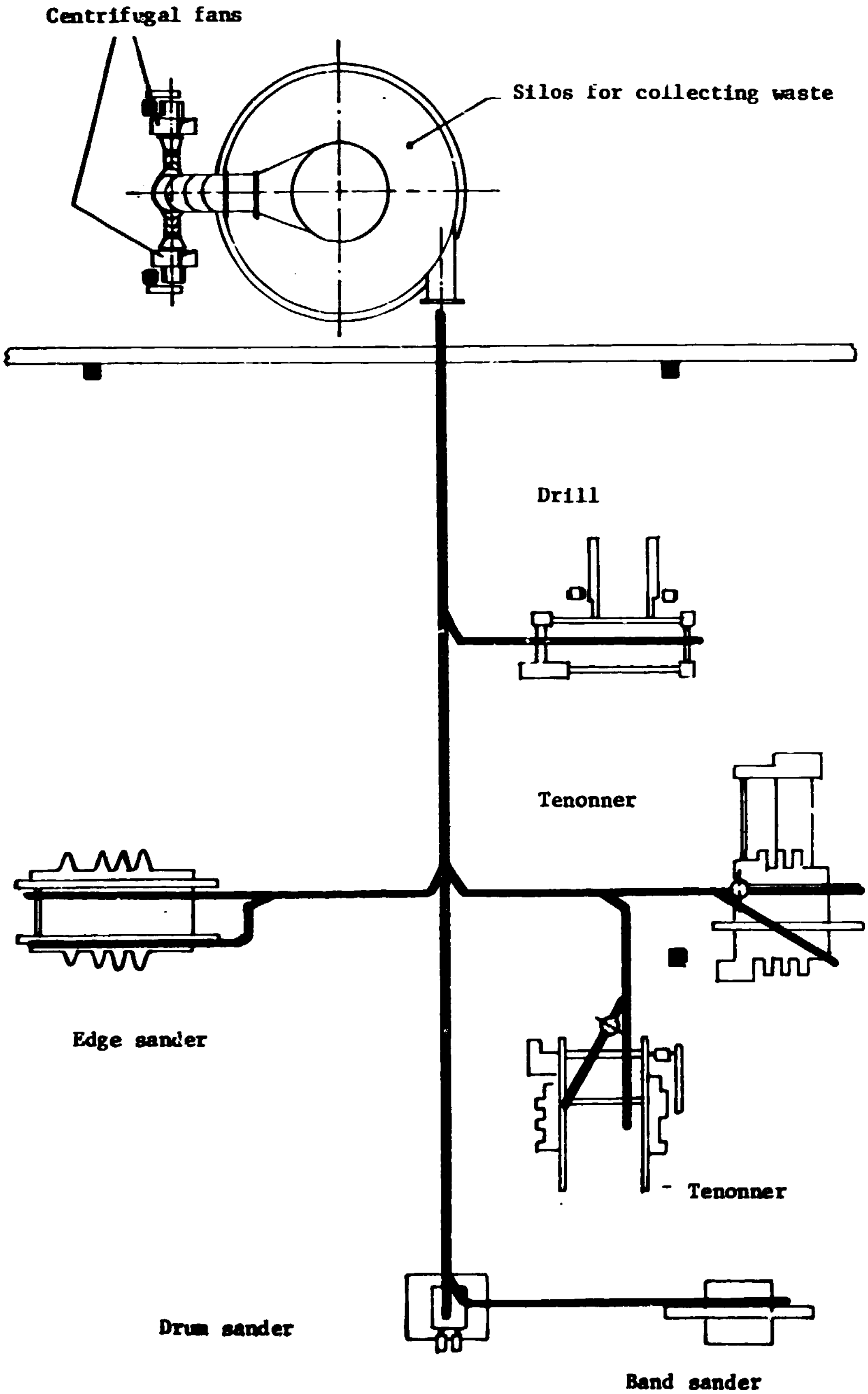


Fig. 5: Plan of a waste intake installation.

Since each machine is to be connected to the pipe network of the suction plant, it follows that the fan must be capable of sucking in an amount of air equal to the sum of the quantities specified for each of the machines. The air, which thus becomes the vehicle for conveying the waste material, must run across the whole suction network at a given speed in order to prevent the chips, shavings and dust from settling along the conduits and to make sure they reach the collection pan regularly. In order to do this, the electric motor driving the fan must have sufficient power to win the resistance offered by the air and waste mixture present in the network.

We have thus established that a suction plant must have a quantity of air (expressed as cubic meters/hour), a force to transport the waste (expressed as millimeter of a water column) and a given power (expressed in Horsepower). The choice of one fan rather than another is, therefore, crucial also for limiting energy consumption (electric power). We are not concerned here to discussing the planning of a suction system in any detail; thus, the formula for obtaining the power of an electric motor of a centrifugal fan is given merely as an indication. Knowing the rate of flow (m^3/sec.), the total head (Ht as mm of a water column) and the efficiency of the selected fan (η), said power shall be expressed through the formula:

$$HP = \frac{m^3/\text{sec.} \times Ht}{75 \times \eta}$$

The efficiency of a fan is important because the greater its efficiency the less power is required.

Each fan has a specific "identity card" expressed through a characteristic curve which is a function of the various relevant parameters: efficiency appears to be satisfactory only for a limited portion of it.

Figure 6 shows the characteristic curves of two "high efficiency" fans; curve A relates to wing-blade fans, while curve B relates to a straight blade fan. The peak efficiency sectors are shown in the

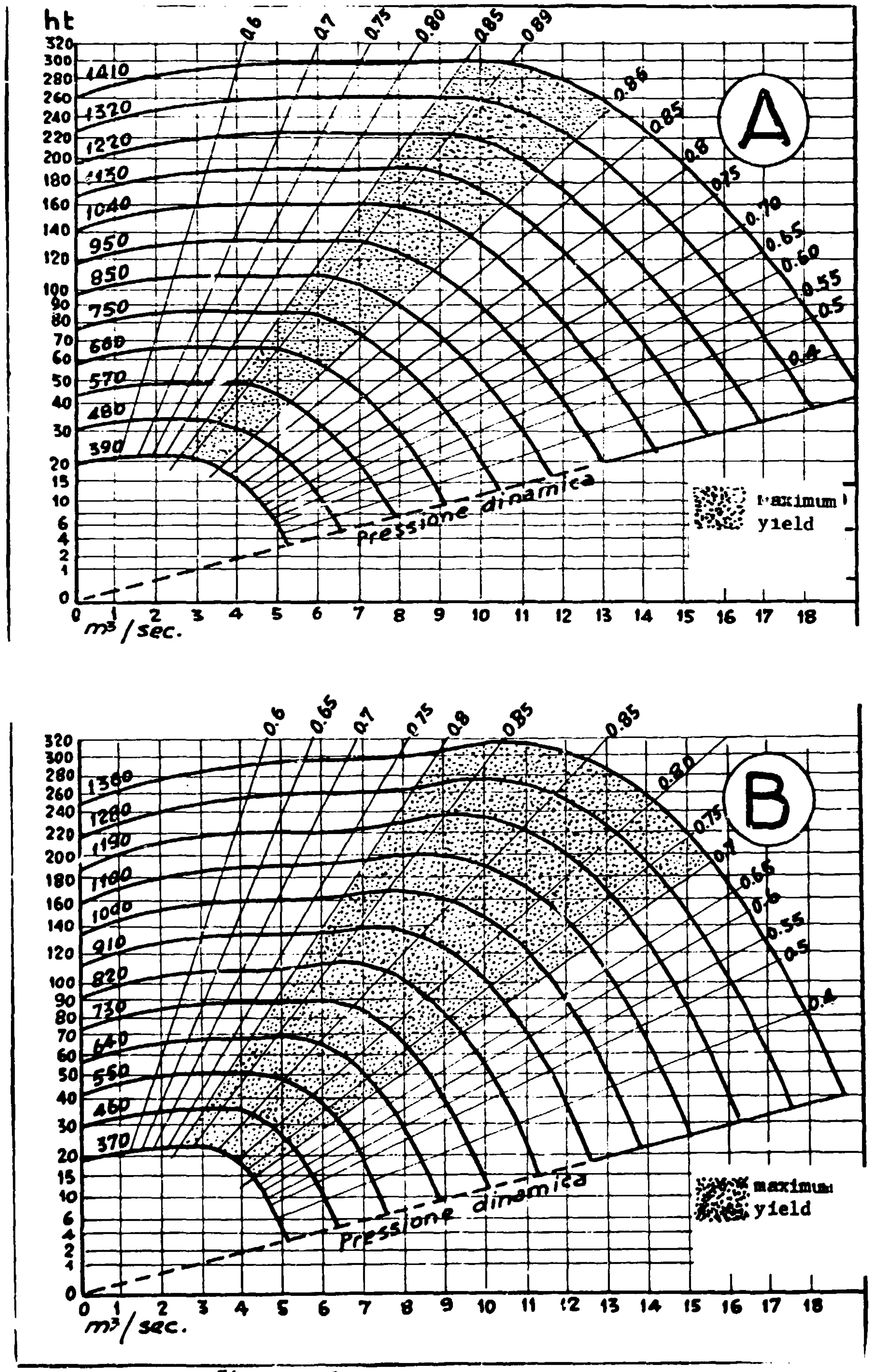


Fig. 6: Fan capacity

shaded area and fan performance should be selected in this area only.

Due to their very features, these types of fans must be installed on systems in which a filter is fitted before the fan; namely, the waste does not pass through the system because the impact with foreign bodies could damage it and, in the long run, the fan wheel could go off balance - just as the wheels of a motor car can be off balance. Figure 7 gives a schematic view of a system of this type, where a separator is placed between the waste-generating machine and the fan. Hence the fan operates only with clean air.

Figure 8, on the other hand, relates to a system where the filter is placed after the fan. Here the waste runs through the fan because the latter is placed between the machine and the collection pan. Due to the strength of the fan wheel and of the fan itself, this type of plant requires a "conveying" fan fitted with suitably thick radial blades. The handicap of these fans is their low efficiency and the fact that they require high-power motors; thus, in order to reach similar performance levels, they need a greater amount of electric energy than the high-efficiency ones described hereabove. A schematic view of a "radial blade" conveying fan is shown in figures 9 and 10.

With very few exceptions, manufacturers in the wood-processing sector have been designing suction plants of the former type for many years.

When designing a suction plant, it is very important to identify the best possible route for the pipe network. It should be the most economic in terms of power and, therefore, as aerodynamic as possible, whilst being compatible with the structure of the factory. This is why any new plan for a woodworking industry should take this important detail into account, avoiding exceedingly long and winding pipe installations and, if possible, positioning the collection bin at the very centre of the suction system.

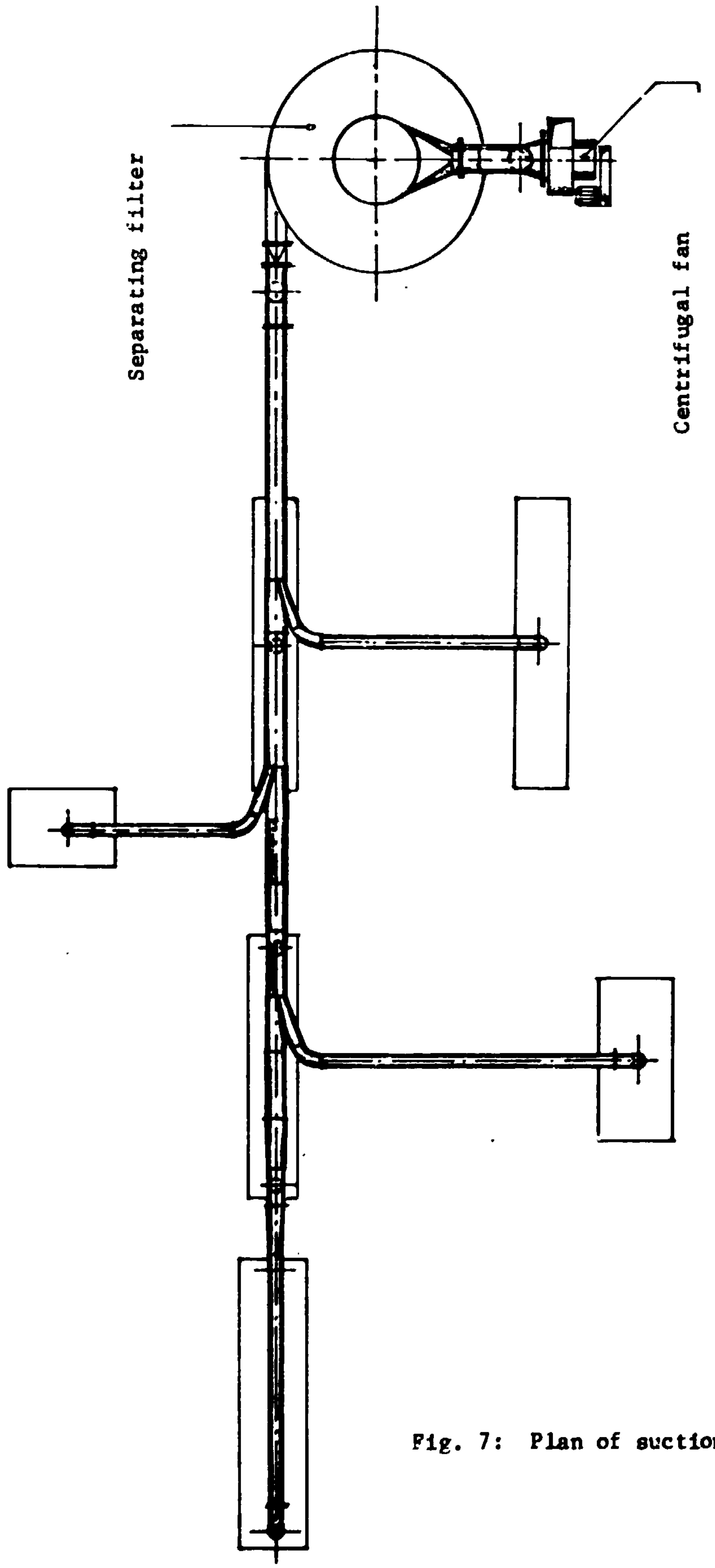


Fig. 7: Plan of suction system

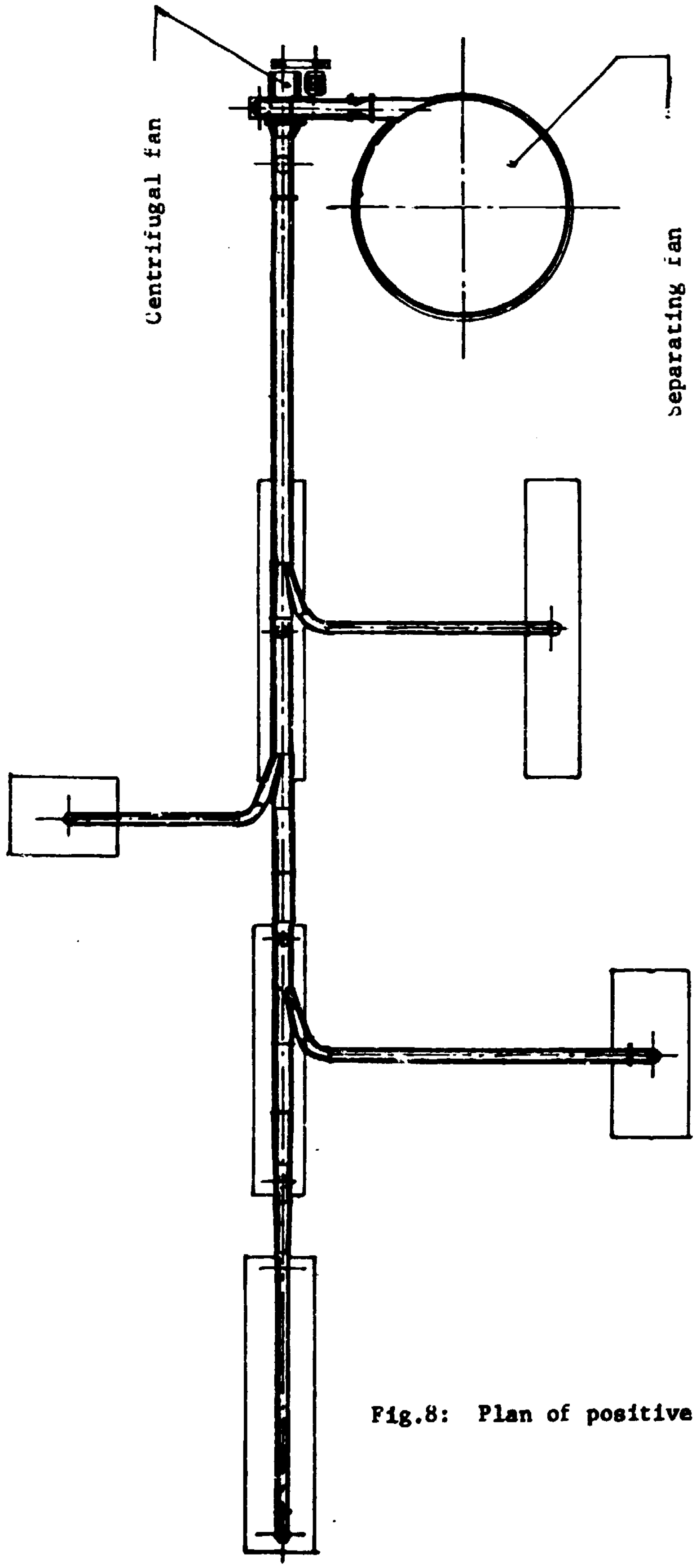


Fig.8: Plan of positive pressure system

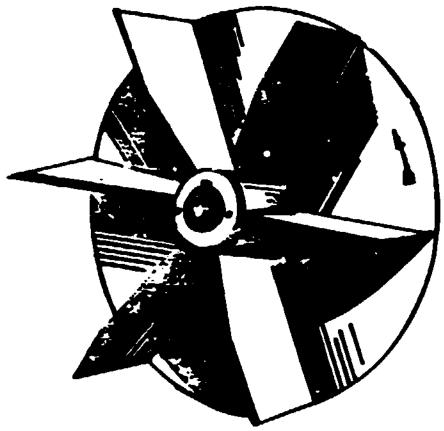


Fig. 9: Radial blade

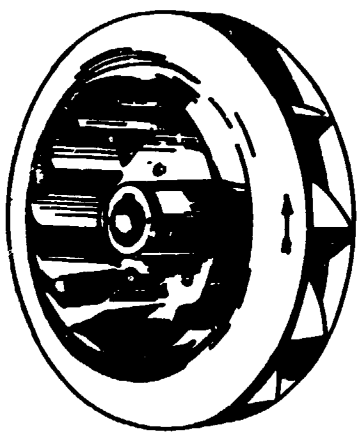


Fig. 10: Radial blade

A plant, such as the one shown in figure 11, entails higher operating costs than the one shown in figure 12, due to the longer distance between the waste collection area and some machines.

Through a schematic outline of its main components, the way in which a suction plant is composed is now examined. Starting from the machines, the components are as follows (see also figure 13):

1) machine coupling or suction inlet;
2) vertical connection pipe;
3) minor horizontal branches;
4) main header;
5) waste pan;
6) centrifugal fan.

All these elements are harmonic parts of a well-balanced unit designed to ensure effective suction on different machines having, furthermore, different requirements. The actual plan of a medium-sized industry is shown in figure 14; it is worth considering in some detail so as to identify the above-mentioned components as well as other elements which, altogether, define the project as a whole.

A centralized system can be subdivided into subsystems through the adoption of suction and filtering substations. Normally, this occurs when, following the development of the company, the system requires enlarging and when such development had not been foreseen in the designing stage.

Some groups of machines shall, then, lead to a given substation where the waste is gathered and hence sucked in by the centralized system (figure 15).

The advantage is obvious. If the system is not capable of sucking in the waste of machines A, B, C, D, E which, for instance, jointly require 10.000 m^3/h, it is able, however to take in as much as 1,500 m^3/h - i.e. the amount required for carrying the material discharged by the substation.

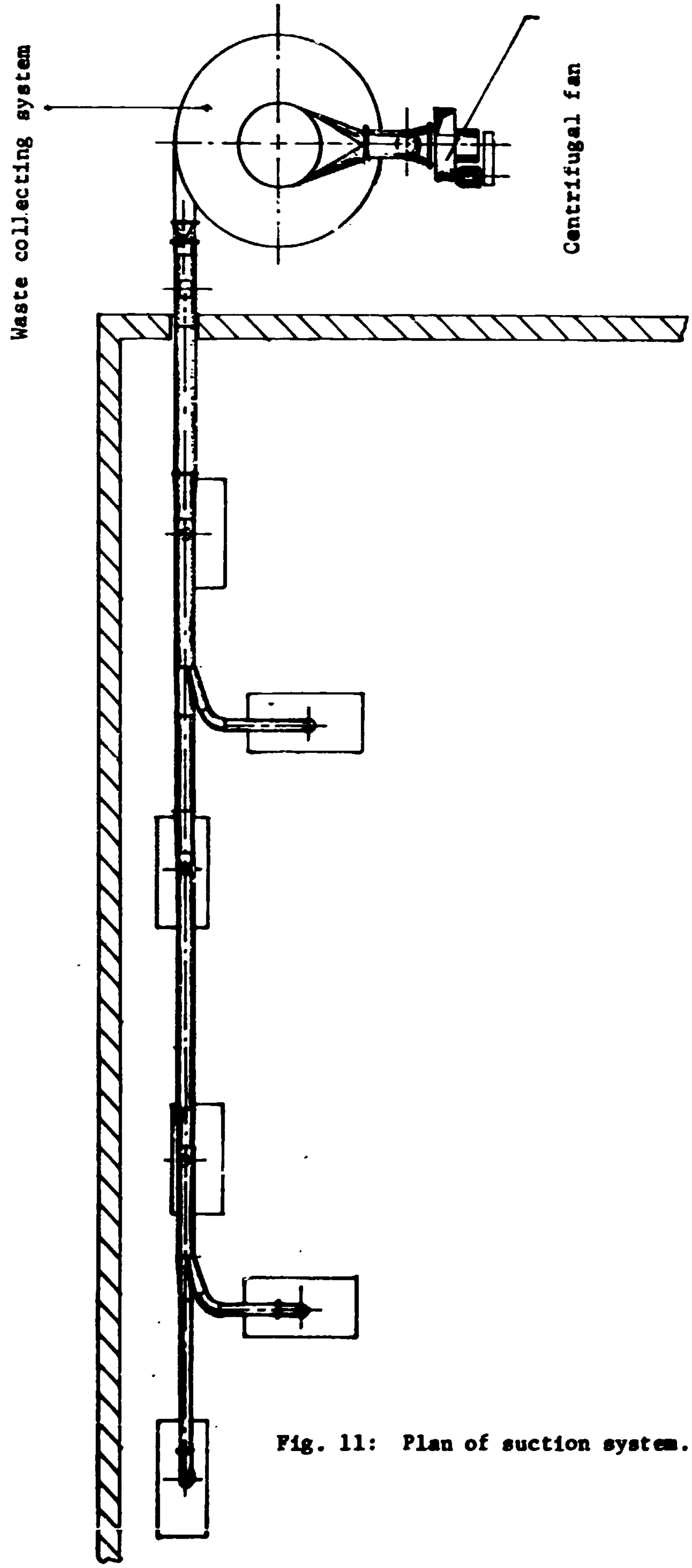


Fig. 11: Plan of suction system.

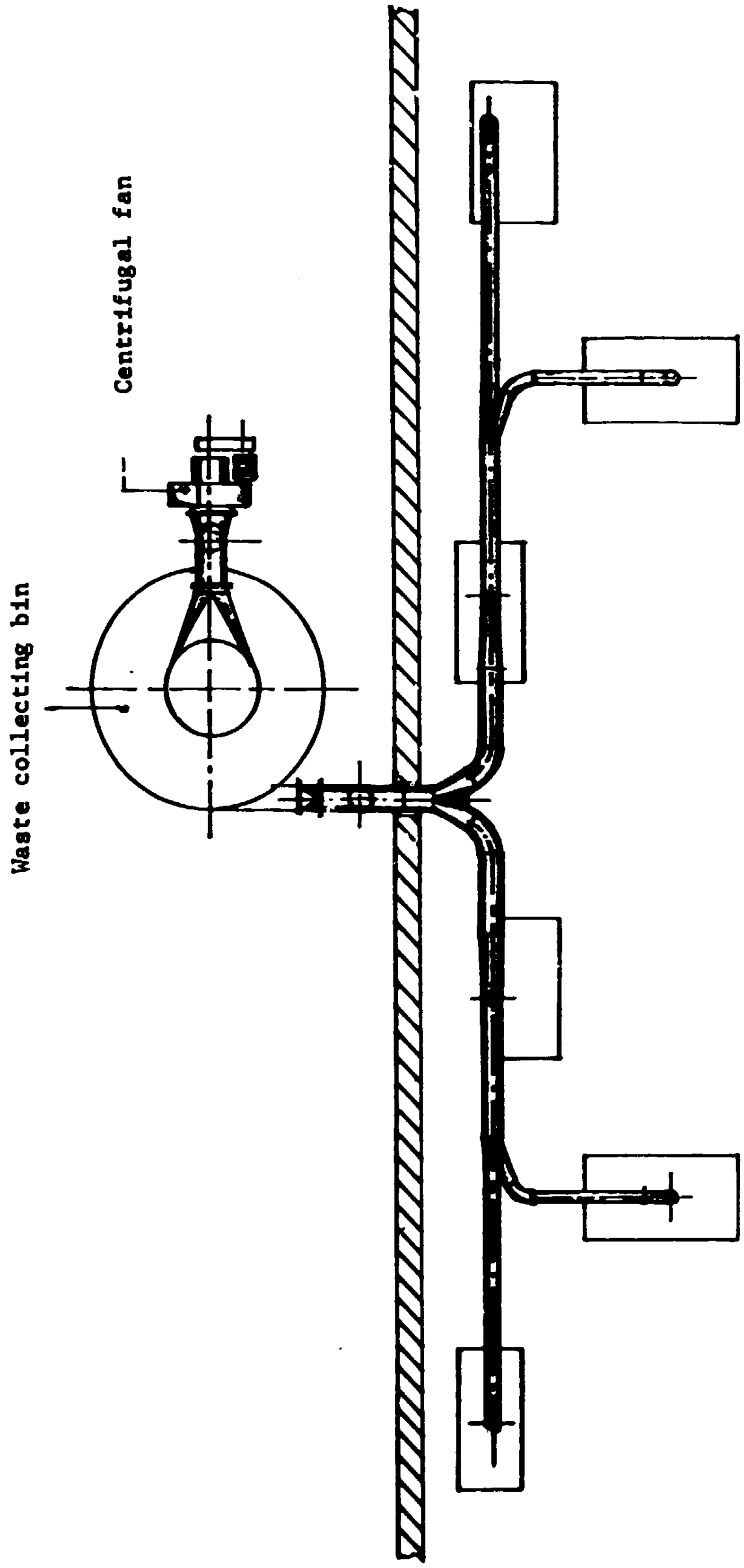
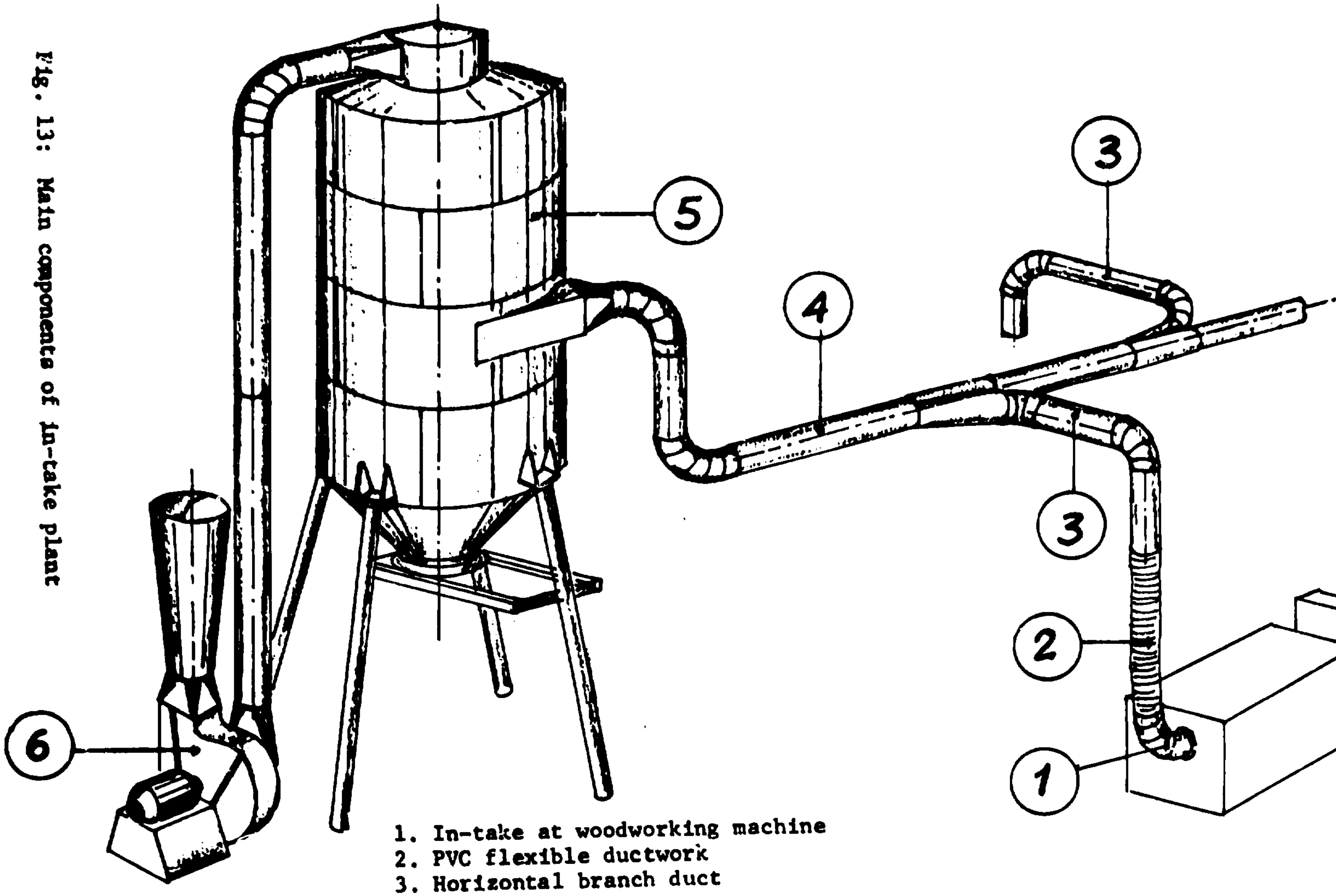
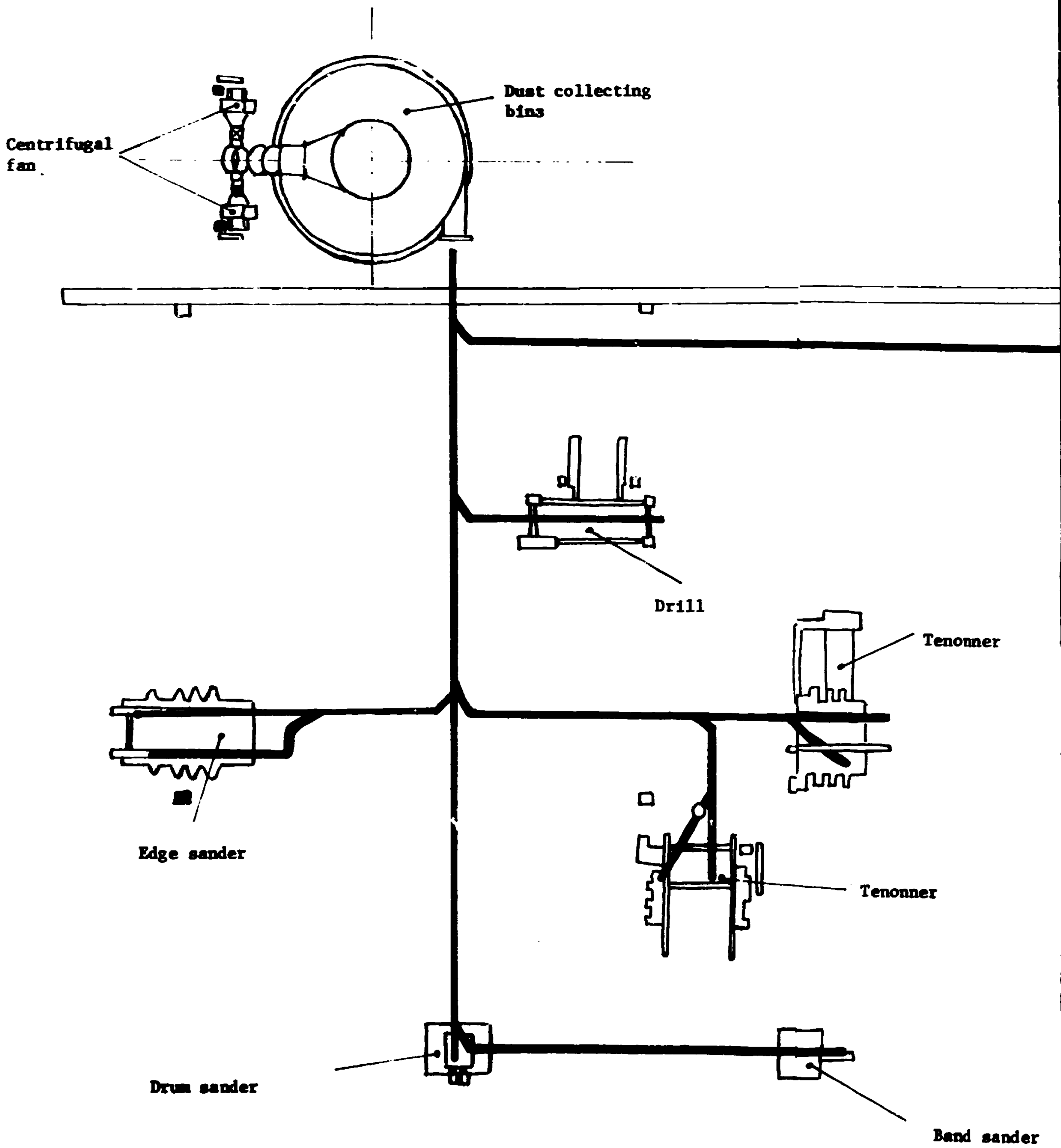


Fig. 12: Plan of gravity extraction system



1. In-take at woodworking machine
2. PVC flexible ductwork
3. Horizontal branch duct
4. Main collector
5. Waste collecting cyclone
6. Centrifugal fan.

Fig. 13: Main components of in-take plant


Centrifugal fan
Dust collecting bins
Drill
Tenonner
Edge sander
Tenonner
Drum sander
Band sander

SECTION 1

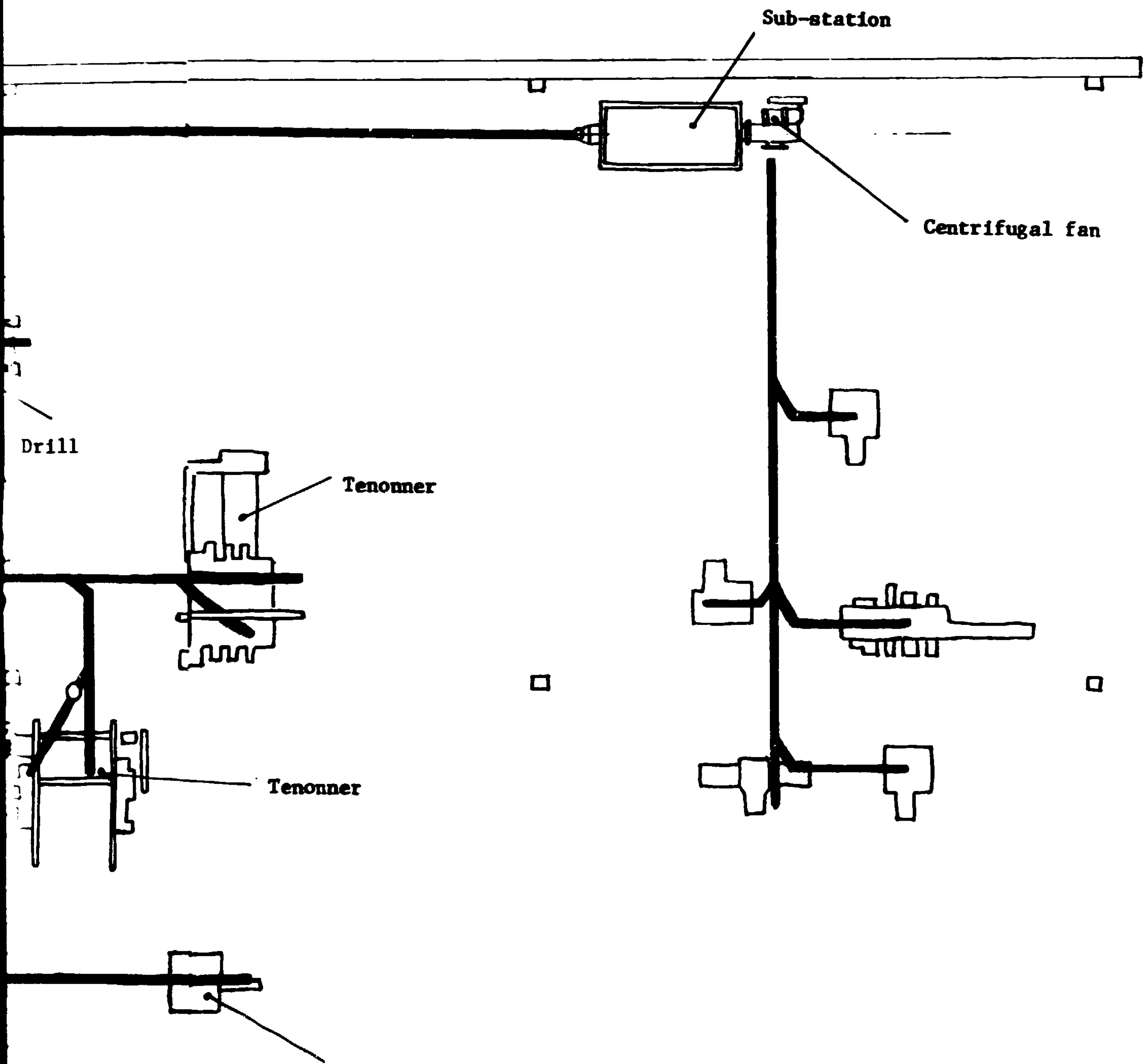


Fig. 14: Plan of wood-waste and dust extraction system.

SECTION 2

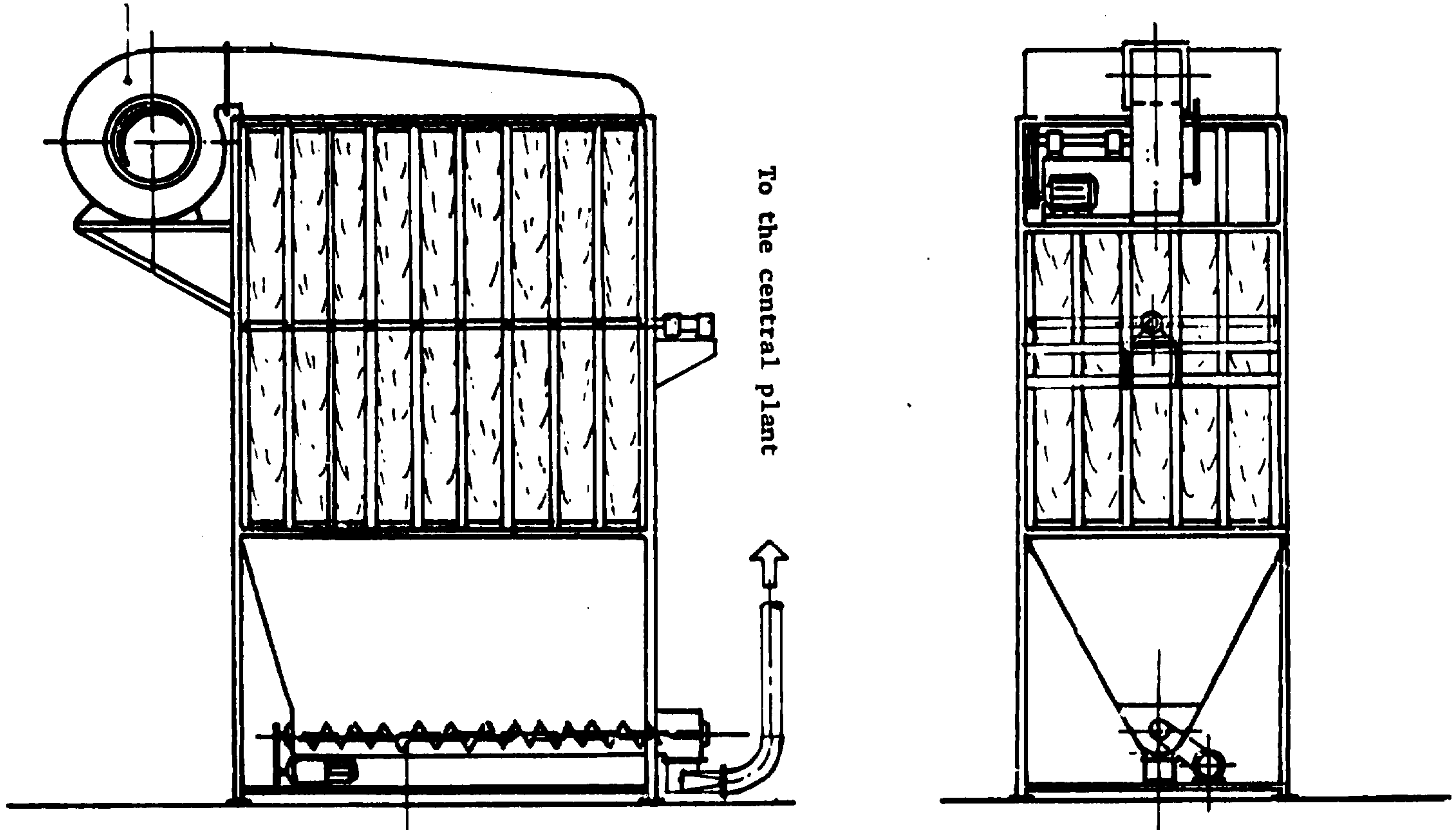


Fig. 15: Sub-station.

All the 10.000 m^3/h of air needed shall be treated by the substation. Obviously, the latter shall have to be equipped with a controlled exhaust or discharge system. A single plant can also include a number of substations (see figure 16).

In the overall appraisal of a suction plant, if one takes the machine and its intakes as the starting point, one comes across several important components.

Suction hoods or intakes

Advanced wood-processing machines are usually equipped with intakes. The latter are not always designed correctly, from an aerodynamic point of view; in this case, they should be modified so as to achieve the best possible results.

Pipes

The machine is connected to the system through a rigid coupling unless it is provided with mobile parts, in which case the connection is to be made through a flexible pipe. The latter should be made of abrasion-resistant material, especially for some types of machines, in order to prevent damage of same. Pipes should be made of galvanized sheet iron and their diameter shall depend on the requirements of the machine: by way of example, refer to the table which expresses the diameter of the pipe for connection to the machine through the rate of flow (cubic meter per hour) corresponding to a speed of 25 m/sec. The data concerning recommended thickness are supplied by the data in figure 17.

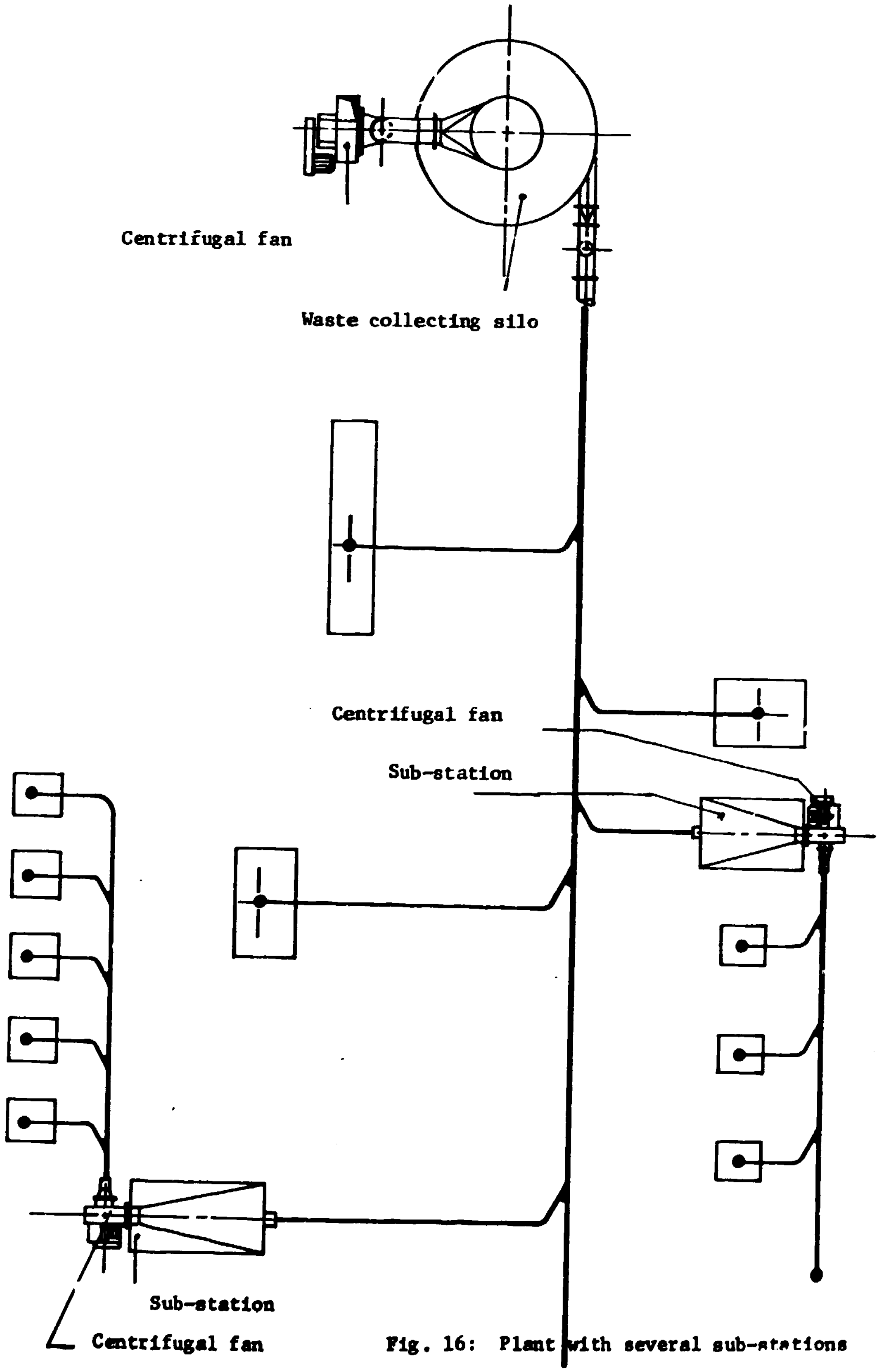


Fig. 16: Plant with several sub-stations

PIPE THICKNESS	Ø of PIPE
8/10	100
	125
	150
	175
	200
	225
	250
	275
	300
	325
	350
10/10	375
	400
	425
	450
	475
	500
	525
	550
	575
	600
12/10	625
	650
	675
	700
	725
	750
	775
	800
	850
	900
15/10	950
	1000
	1050
	1100
	1150
	1200
	1300

Fig. 17: Table of tube wall thickness

As the various minor branches meet in the main header, the latter must grow in diameter so as to enable the air sucked in to flow in growing quantities, while keeping a virtually constant speed: the cross-section area of the header at a given point must at least be equal to the sum of the cross section areas of the pipes reaching the header before such point. For example: where two pipes each having a diameter of 200 mm (hence each with a cross-section area of 31.416 mm^2) meet, the header shall have a diameter of 283 mm (cross-section area 62.902 mm^2).

Bend pipes

Bend pipes shall be made of galvanized sheet steel and shall be thicker than the straight pipes having the same diameter because they are subject to severer wear due to the living force of the waste material: by hitting the wall of the elbow, the chips etc. cause considerable abrasion.

Branches

Branches are connections between pipes having equal or different diameters, which meet in a single header (see figure 18). They should be made in such a way so as to enable the air to run freely across them without being obstructed either by obstacles or by narrow necks. Therefore, they should be aerodynamic in shape.

Locks

Locks are cutoff devices which are designed to disconnect one or more machines from the system if the machine is out of use or temporarily out of order for maintenance.

Filter separators

Whatever the waste-conveying system chosen for carrying the material from where it has originated to the chip pan, one must

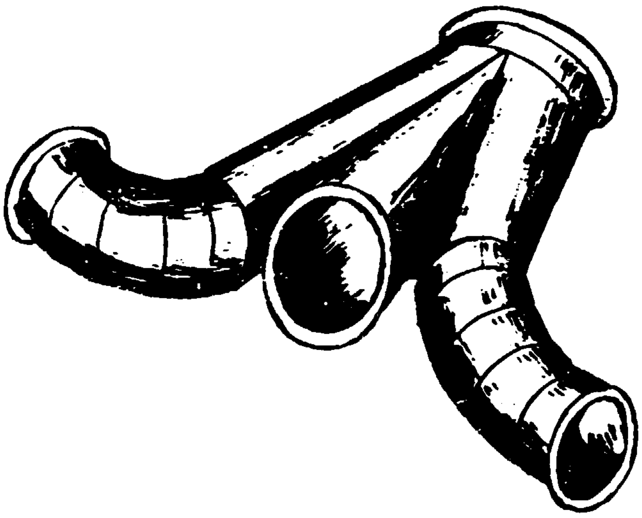


Fig. 18: Three-way connector

separate the waste from the air before stocking. Thus, once the air has fulfilled its function as a waste-conveying vehicle, it must be separated from the waste itself. There are two standard systems for doing this: cyclones and filters.

A cyclone is a gravity separator which, due to its conical/ cylindrical shape, reduces the speed of the material contained in the conveying air as a result of the friction they undergo when penetrating the apparatus tangentially (cyclone). The air is led out through the top while the waste which, compared to the air, is heavier, settles on the bottom. Cyclones vary in performance. They should be selected on the basis of the specific nature of the waste (powdery, fine coarse, moist) and of its volume weight (see figure 19).

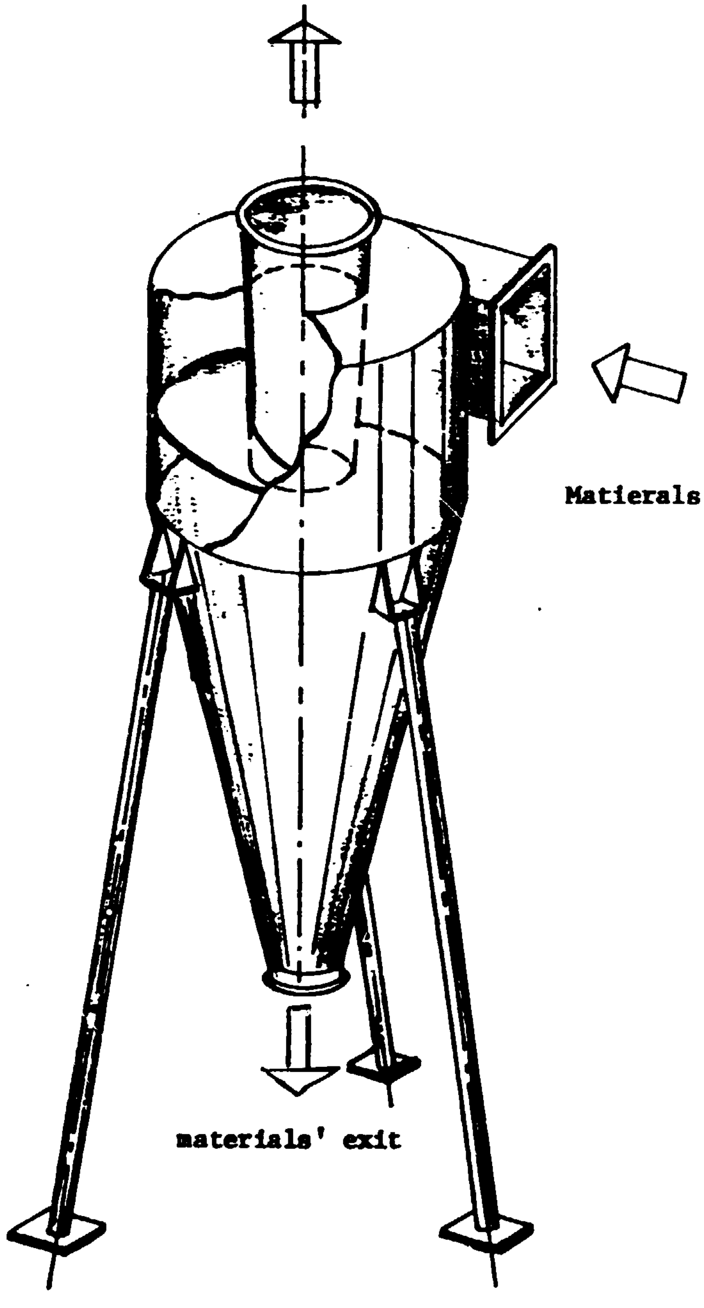


Fig. 19: separating cyclone

A filter is a system supplied with an intermediate element designed to stop the waste while letting the air through. The type normally adopted in the woodworking industry is composed of a large metal housing containing a number of cloth sleeves (cotton, flax-wool, polyester, nylon, etc.) each characterized by a different degree of perviousness to air and filtering efficiency.

It is very important to keep these elements clean in order to ensure constant efficiency of the filter.

There are two methods generally adopted for doing this: mechanical shaking and compressed air counter-current. The two methods are shown in figures 20 and 21 respectively. The choice between the two systems depends on the nature of the waste.

Silo

Silos are the actual containers of the waste produced by the machines and conveyed by the suction plant. Their size should be calculated on the basis of the amount of waste produced. They may be constructed of brickwork, reinforced concrete or steel. For many years industries have been using mostly steel-made prefabricated and sectional silos, because it is possible to move them, if necessary,and to alter their capacity fy fitting one or two sectors or rings.

Silos may be equipped with automatic extractors or simply with openings for discharging the waste directly through gravity (see figures 22 and 23). The extractor-equipped version is adopted when the waste must be utilized in order to obtain heat energy or when it must be made compact, through special machines, so as to reduce the cost of transport.

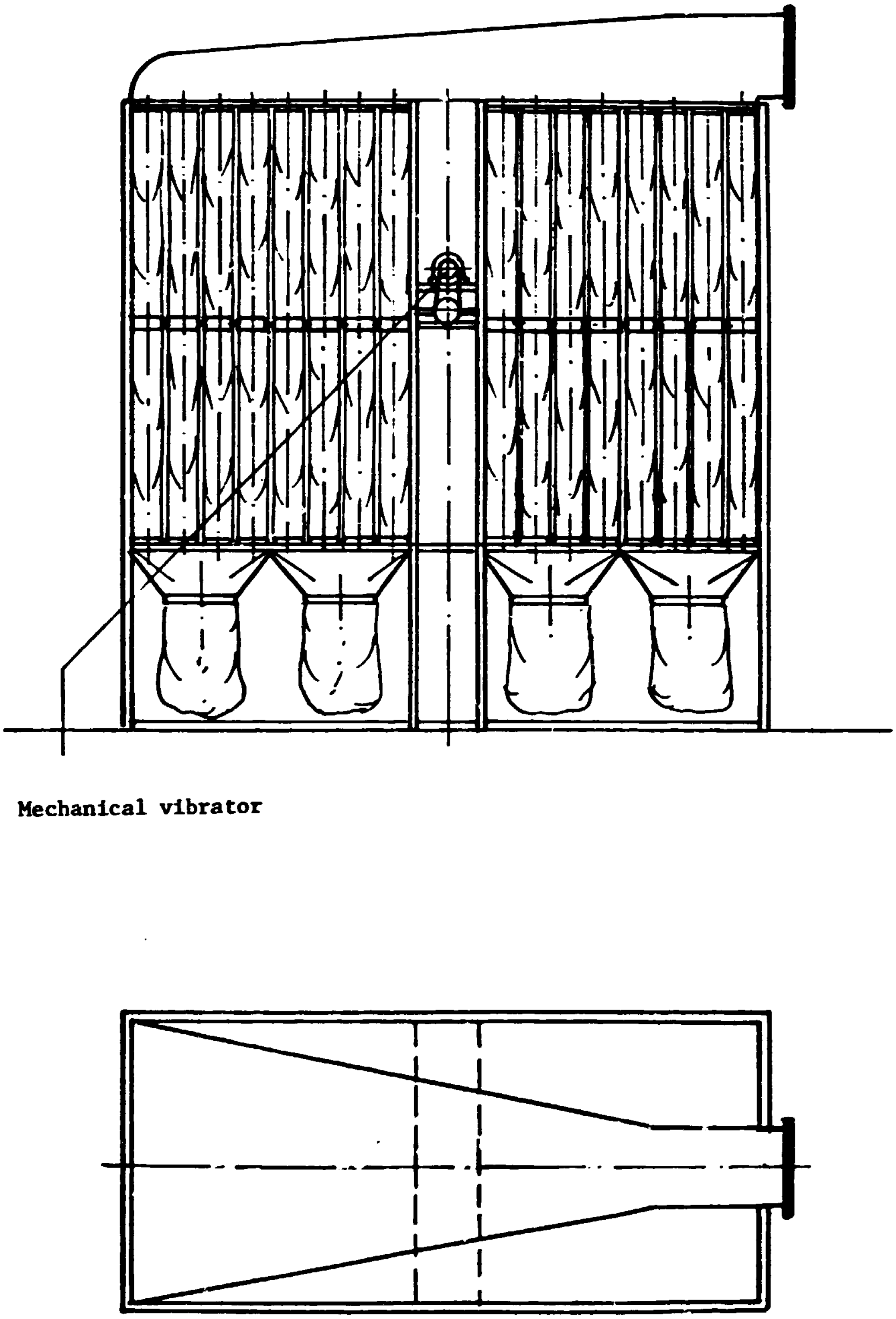


Fig. 20: Filter with mechanical vibrator

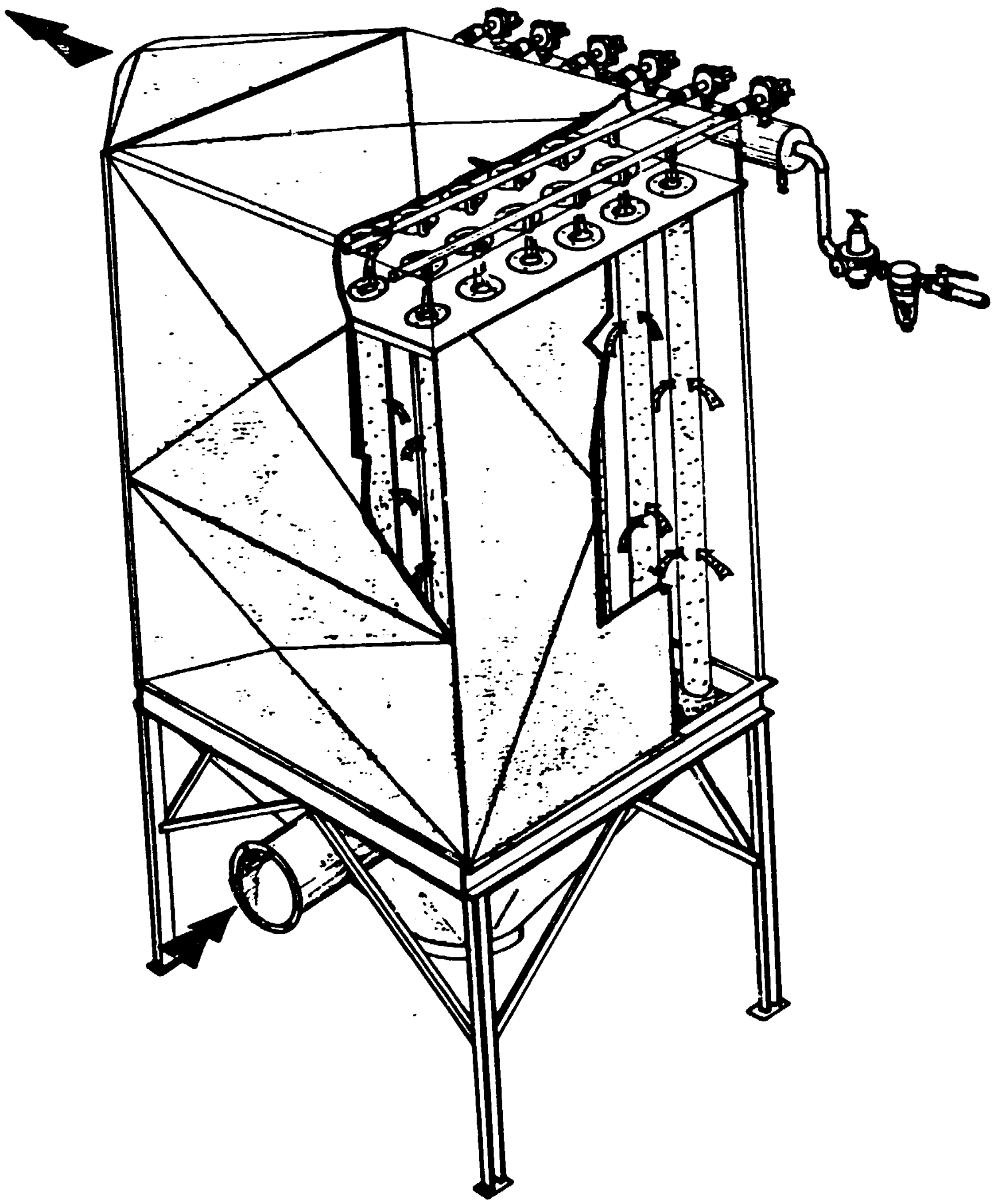


Fig. 21: Filter with counter-current compressed air cleaning

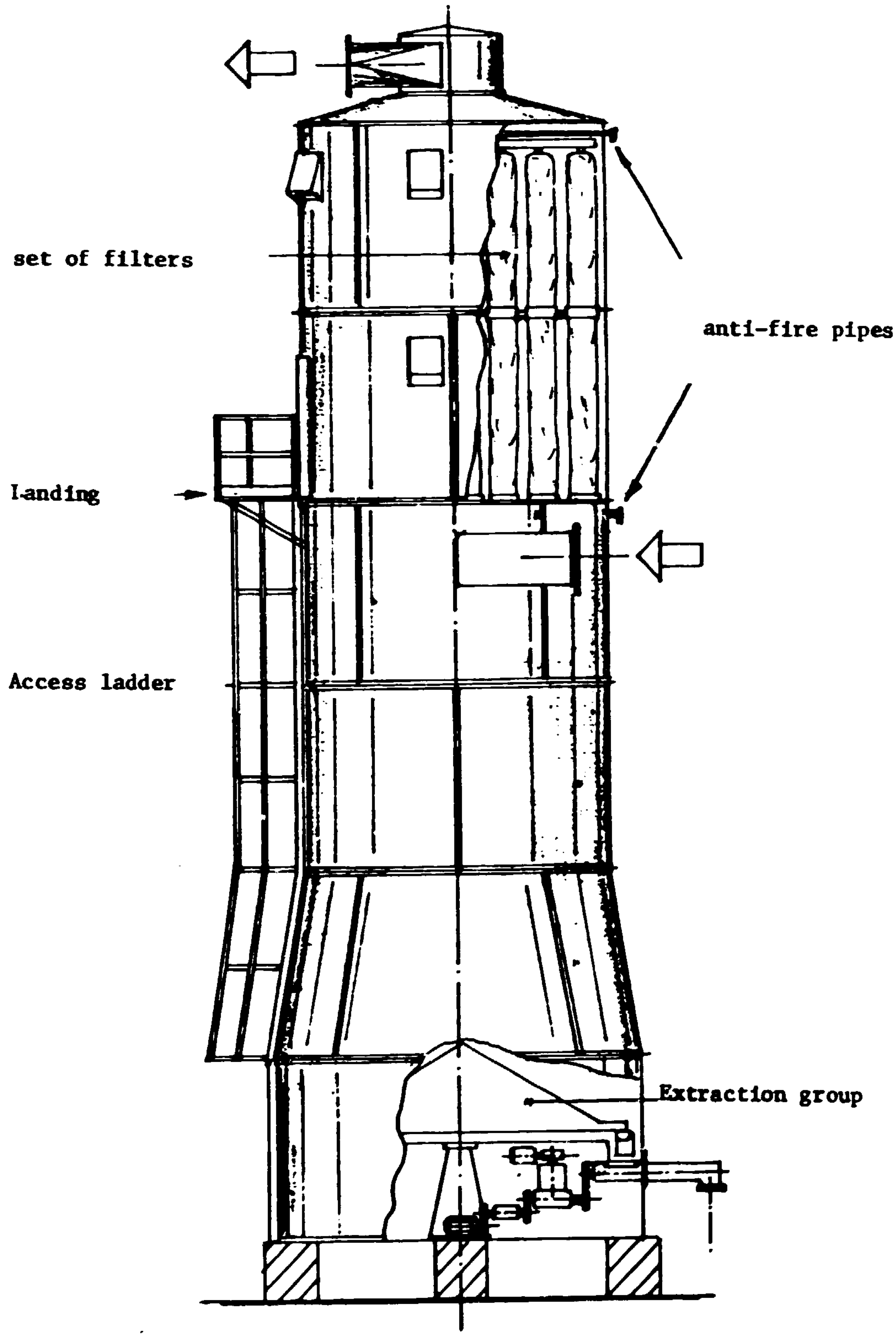


Fig. 22: Metal silo with extractor

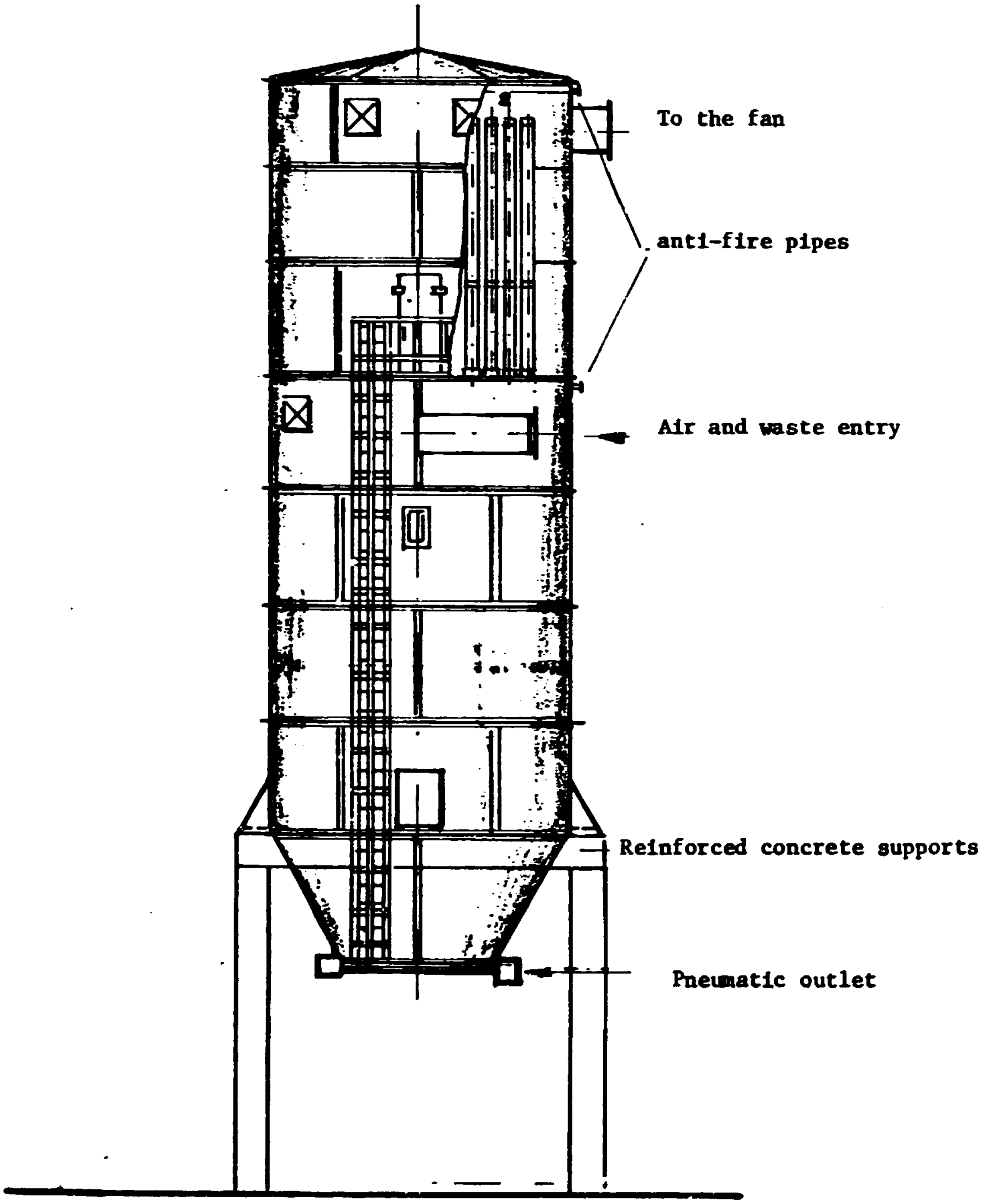


Fig. 23: Metal silo on recinforced concrete supports.

The silo of any modern plant is, therefore, made up of three main parts:

1) the filter;
2) the container;
3) the automatic extractor.

There are, however, other important fittings, such as: explosion-proof doors, sprinkler system, inspection doors, stairways, platforms, level indicators, etc. Cylinder-shaped silos are preferable in order to reduce friction, whereas polygonal or square structures enhance it.

Extractors

There are a number of different models available on the market, each having specific features. Normally, each extractor is equipped with mechanical units designed to perform the relevant operation (cochleas, chains, leaf springs or any combination thereof). Figures 24, 25 and 26 show extractors. All models perform well enough.

There is only one model which does not make use of the above mechanisms for extraction of waste. This model is characterized by the rotative, power-driven motion of the floor itself of the storage depot, and it deserves particular attention especially for the aspects connected with energy savings: this may be of interest to those countries where the cost of traditional fuels has reached extremely high levels. The possibility was mentioned earlier of recovering waste because it supplies good fuel; therefore, the problem of fire prevention in the silos must also be dealt with since the latter is a reservoir of solid fuel (see figure 27).

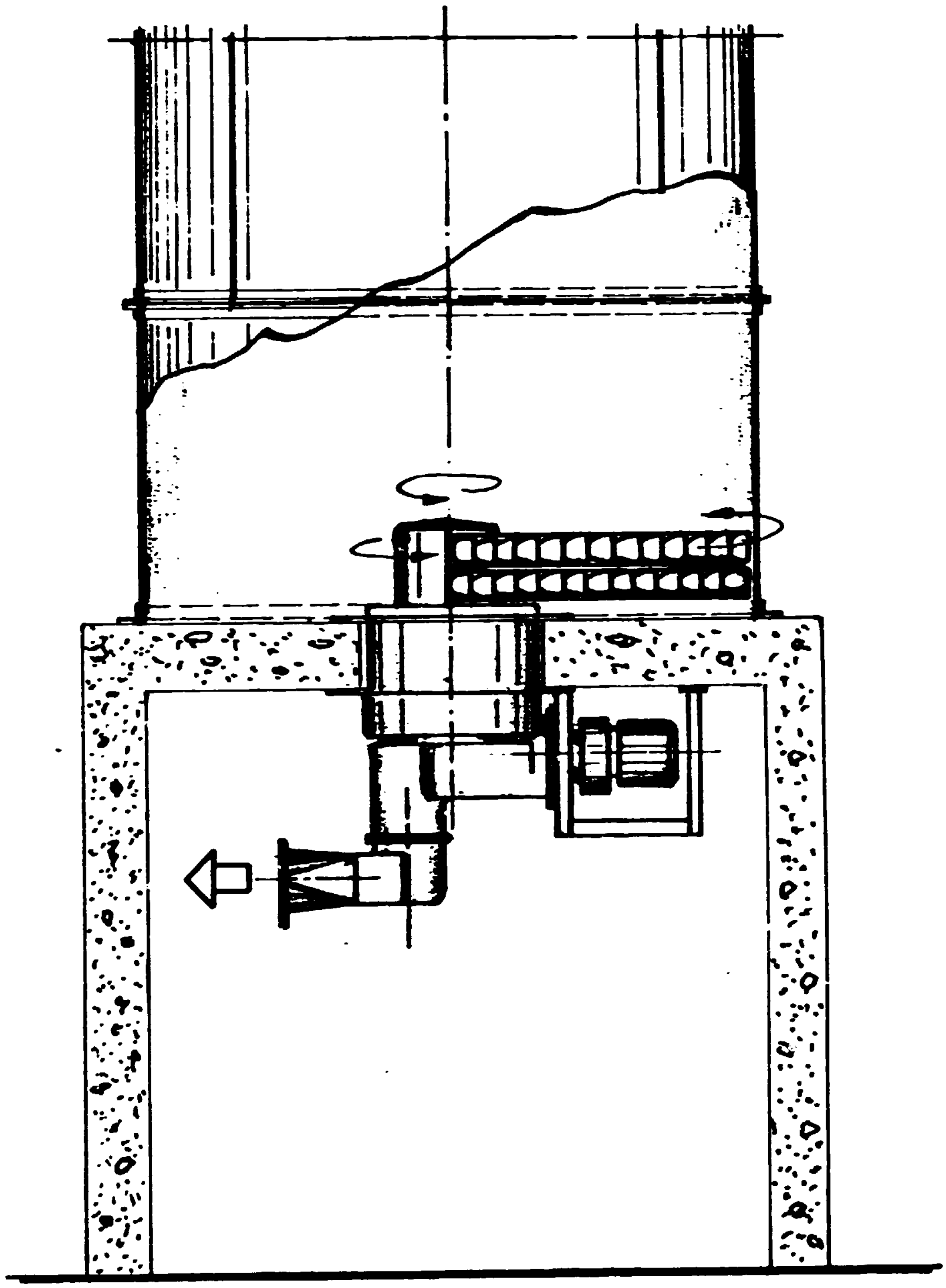


Fig. 24: automatic extractor

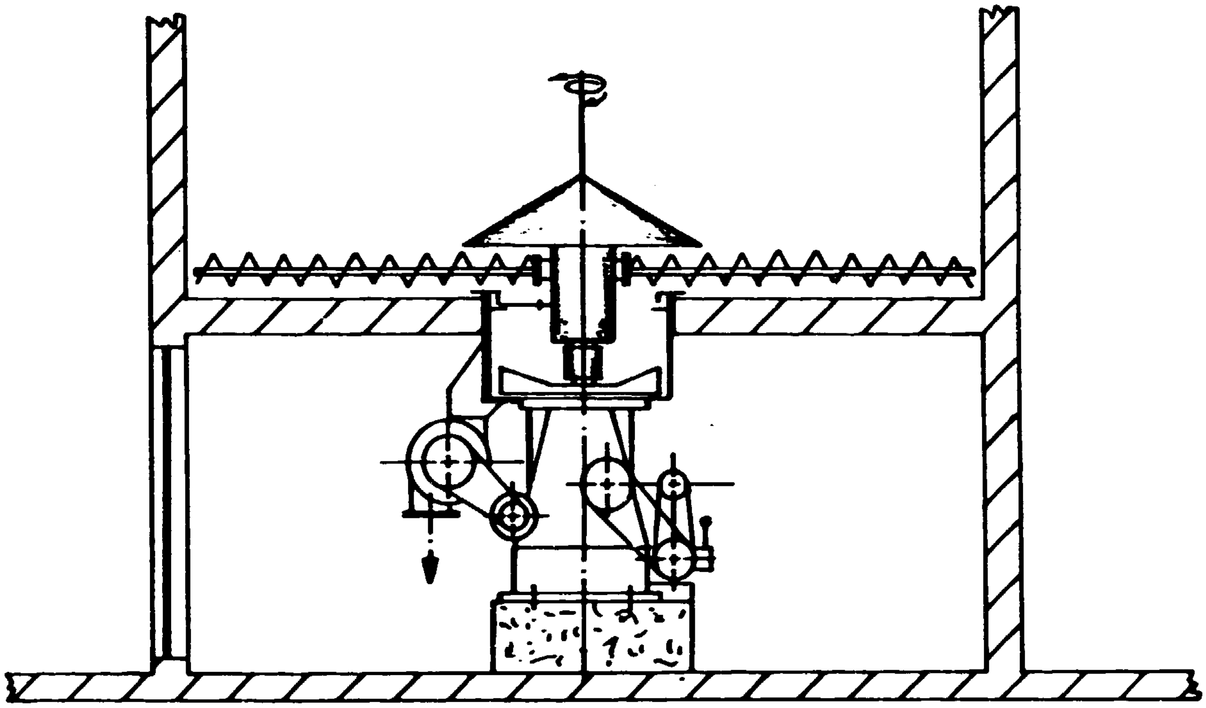


Fig. 25: automatic extractor

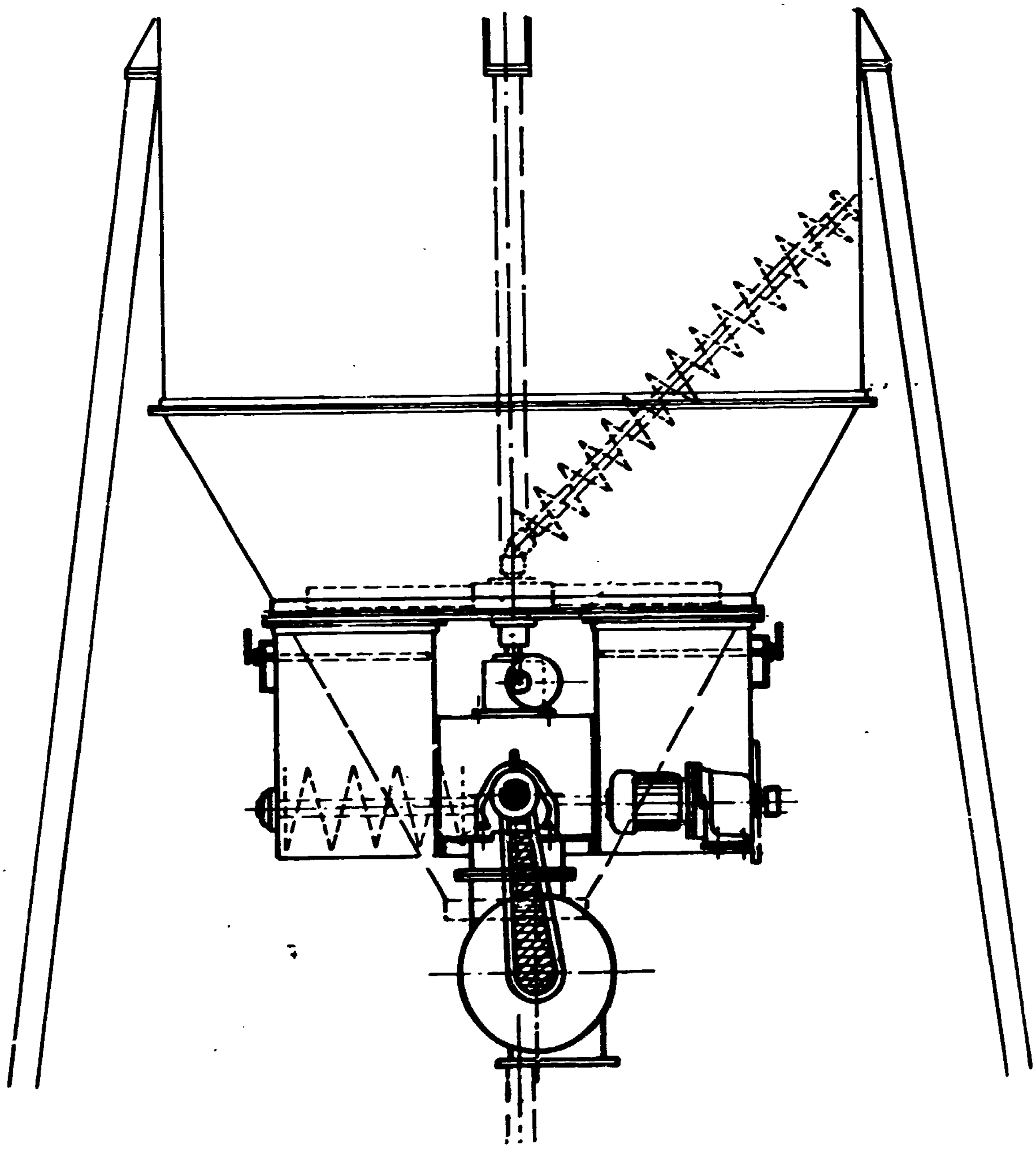


Fig. 26: Automatic extractor

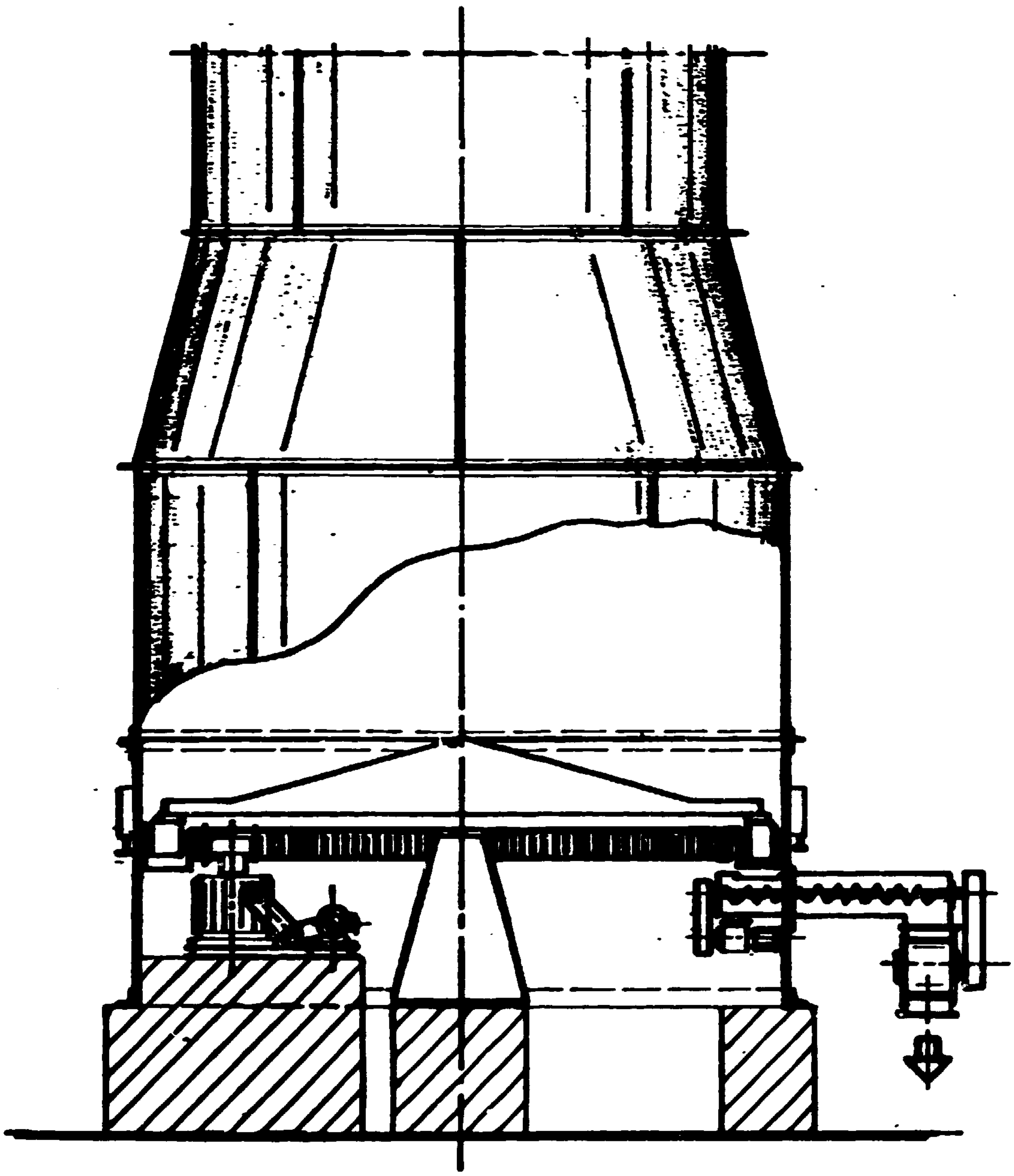


Fig. 27: Automatic extractor (Balducci)

Silos are normally provided with pipes that are able to extinguish, through rain, manual or automatic systems, any fire which may develop inside them. One system, however, is capable of actually preventing fire itself. This system is supplied with spark or flame detectors, sensitive to infrared rays, which send an impulse to a sprinkler system working with water or some other fire-extinguishing product: the system extinguishes the spark or flame in the main header, before they reach the silo. One example of installation of the system is shown in figure 28.

There are many other things which need to be described and many of the ones dealt with here should be examined in greater detail.

1. Collecting bins
2. Suction plant
3. Woodworking machines
4. Tube section with spark detecting device
5. Extinguishing device (with 6 and 7)
6. Electric valve
7. Spraying nozzle
8. Hydraulic device
9. Stabilized feeder for spark detector
10. Alarm (audio- or visual)

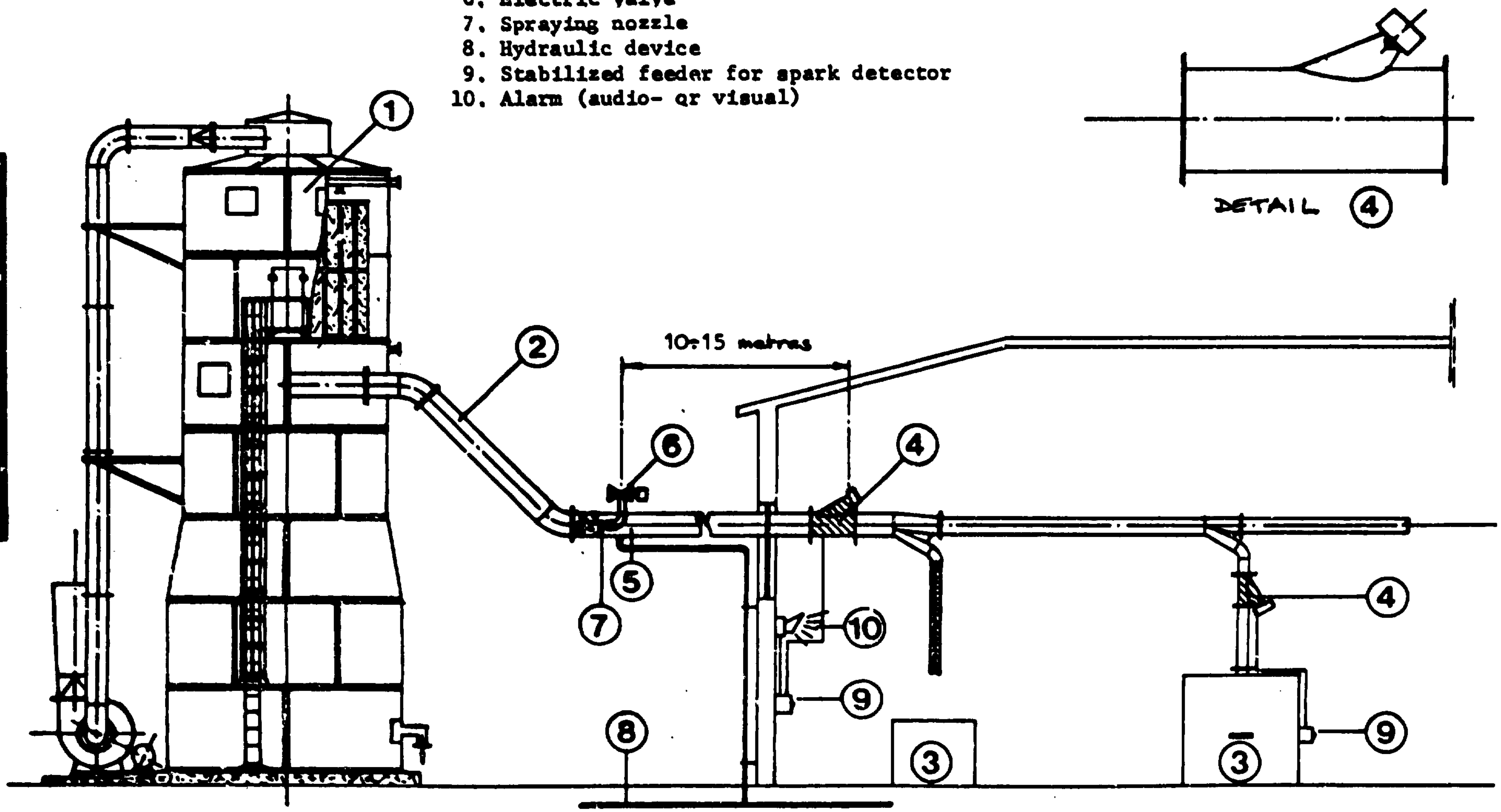


Fig. 28: Plan of an installation with one or more spark detector(s) with automatic extinguishers.