THE FIGHT AGAINST AIR POLLUTION IN THE FERRO-ALLOY INDUSTRY

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SYNOPSIS

Dust Emissions in Ferro-Alloy Plants, and the way of controlling them

- Raw material
- Finished goods
- Furnace

Furnace Dust Control

- Relation between hooding, temperature, cooling
- Choice of filter type: - reverse flow, shaker, jet
  - glass, Nomex, polyester

Optimization of a Bag House Operation

Energy saving - pressure drop - filter area, bag cleaning efficiency
Maintenance costs - bag life - valving

Dust Disposal

Hopper discharge - conveying - pelletizing

This paper contributes to the sound choice of methods of controlling dust emissions in a ferro-alloy plant, mainly on furnaces.

It finds a compromise between investment costs and operating costs of the filtration equipment.

1. DUST EMISSIONS IN FERRO-ALLOY PLANTS

There are many sources of dust emissions in ferro-alloy plants. The raw material handling equipment like crushers, conveyers, railroad car unloading, screens, silos, are typical sources of dust.

Also handling finished goods with crushers, screens, etc., and storing creates some pollution problems.

These are relatively easy to solve because the dust concentration is low and the temperatures are ambient.

Classical filters cleaned by shaking, reverse-flow, or compressed air, and using polyester filter media are suitable.

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Furnace

Solving the pollution problems created by the furnace stack emissions is more complicated.

First, you have to have a good capture of the fumes and the hood must be large enough.

Then the gases, after an eventual cooling, have to be conveyed into a filter.

Fans usually operate at high temperature.

The filter itself is critical in its design and the life of its components.

To take the dust out of the filter and remove it or even resell it, is also a problem.

We will mainly concentrate our study on the furnace dust control problems.

2. FURNACE DUST CONTROL

2.1 Hoods (See figure 1)

The users of the furnace will always want to have large opened hoods, in order to easily control what happens in the furnace. This allows big amounts of ambient air to mix with the fumes and reduce the final filter inlet temperature.

Closing the hoods will sharply increase the final fume temperatures, reducing the amount of Nm3/H of gas to be filtered but requesting means of cooling, in order to reduce the temperatures to values acceptable by the filters.

Working with closed hoods brings additional problems to the furnace, such as roof cooling (steam pipe leakages), cable protection, insufficient air (formation of CO).

Also in case of problems on the heat-exchanger or on the cooler, the filter must be by-passed.

Choice of filter type and filter cloth

Reasonable inlet temperatures compatible with different filter cloth are:

- 290°C	Fiber glass
- 200°C	Nomex
- 135°C	Polyester

The first type of cloth exists only in woven form, the two others can be used in form of woven cloths or felts.

The price ratio is:

- Fiber glass:	1 (cloth)	
- Nomex:	2.5 (cloth)	4/5 (felt)
- Polyester:	1 (cloth)	2.5 (felt)

Most of the ferro-alloy furnaces contain charges having sulphur, which induces SO_2 and SO_3 into the fumes.

Nomex and polyester fibers are not resisting very long to sulphuric acid when frequently starting and stopping the bag houses.

It has not yet been seen a bag house with Nomex cloth or felt having bag lives above 18 months in presence of furnace gases containing SO2/SO3. The same remark is true for polyester.

But: Fiberglass bags have been in operation for more then 8 years in bag houses with or without SO2/SO3, as long as some precautions mentioned in 3.21 had been respected.

In the long range, fiber glass bag houses are the best choice because of:

- Very long life of the bags (5 to 10 years)
- Relatively low price of replacements (see price ratio)
- High temperature safety (290°C continuous, no acid dew points)
- High temperature = good dust extraction

The use of jet type filters (pulsed compressed air) looks modern and apparently cheaper during the investment phase.

However, because of the choice of the bag material (polyester or Nomex), the operating temperatures have to stay low, and the bags are very sensitive to chemical attack.

The evolution of the filter pressure during the time is also questionable. By heavily reducing the filtration area or increasing the air to cloth ratio, even with pulse-jet cleaning, the pressure drop rises to 400 mm WG after a few months of operation.

It has been tried to reduce investment costs by using Nomex in bag houses and shaking systems to clean the Nomex bags, this allowing slightly higher filtration ratio (or reducing filtration area) than more conventional reverse flow system.

Here again, in the long range, the maintenance costs of replacing Nomex bags every 18 months and of maintaining the shaking mechanisms in operation have soared very high.

This is not the best solution when looking a price of investment and maintenance over 10 years.

THE TABLE BELOW SUMMARIZES THE DIFFERENT POSSIBILITIES:

Pressure Drop mmWG	CLOTH NATURE	FILTER TYPE	MAXI INLET TEMP	Price of Bags	Filtration velocity	COMMENTS (see above)
180	FIBER GLASS	reverse flow	290° C	1	1cm/s	Life = 5 to 10 years
280/300	NOMEX cloth	reverse flow	200° C	2,7	1cm/s	Life = problems
180	NOMEX cloth	shaking	200° C	2,5	1,3cm/s	shaking mechanism problematic. Poor life of bags (SO2)
180	POLYEST. cl.	reverse flow	140° C	1	1cm/s	
300/500	POLYEST. felt	pulse jet	140° C	2	2 to 3cm/s	
300/500	NOMEX felt	pulse jet	200° C	4	3 to 4cm/s	Pressure drop out of control. No resistance to SO2
180/250	NOMEX felt	pulse jet	200° C	4	2cm/s	Pressure drop correct

3. OPTIMIZATION OF A BAG HOUSE OPERATION

3.1 Energy

You can save energy by watching the fan operation (meaning that you need the most efficient fan), and by watching the filter pressure drop (meaning that you have to keep it as low as possible).

3.11 Fan operation

You can vary the volume and pressure of the fan with 3 basic systems:

- Variable inlet vanes,
- Variable speed motors (direct current),
- Variable speed fan using hydraulic coupling.

The volume of fume emission on a typical ferro-alloy furnace is variable during the time, and the fan output must follow these variations. Figure 2 shows the comparison between different performance curves. The straight flat damper volume control system is the worst concerning energy.

Second comes the variable inlet vane system.

Third the hydraulic coupling using variable speed.

And best is variable speed direct current motor.

If you have one filter for one furnace only, the volume fluctuation stays between 70 and 100% of the nominal volume. Therefore the power consumption difference between the 3 systems (variable inlet vanes, hydraulic coupling and variable speed motor) is very low.

On the other hand, if you have 2 or more furnaces on one single filter, and one furnace is shut down, the volume variation can go between 40 and 100% of the nominal design volume and then the power consumption difference between variable inlet vanes, variable speed, hydraulic or electrical, is very important.

This curve shows also that in no way it is recommended to use straight restriction dampers at the inlet or the outlet of the fan or any place in the piping system.

3.12 Filter pressure drop

The filter pressure drop is influenced by the total filtration area, the pressure drop through the cloth, the back-flow rings spacing, the cleaning sequence and the valving system.

Filtration area

It is obvious that the more filtration area you have, the less pressure drop you will have in your filter.

It is always interesting to have one spare compartment which you can shut off and do some maintenance work on, while the others are working. A typical filter having 12 compartments can have one in cleaning and one in repair, meaning that you work on a net filtration area of 10 compartments.

Cloth quality

The choice of the cloth quality is also critical for keeping the pressure drop as low as possible. Some very low permeability fiberglass cloths have been used with 2 by 2 binding and a permeability of 10 CFM.

This is not suitable for ferro-alloy application.

One can also improve the permeability of cloth during operation by having a good silicone finish including a hydro-repellent finish avoiding humidity to stick on the fibers.

Spacer rings

It is well known that the huge fiberglass bag houses are usually fitted with filterbags having spacer rings. Originally, these spacer rings were installed at equal distances all over the filterbag length.

A much more interesting spacing pattern is shown on figure 3: the bottom rings are much closer one to each other as the top rings. This keeps the bottom of the bag much more open during reverse flow, allowing more dust to go through the bottom of the bag and avoiding some abrasion problems.

Also, since the suction inside the bag is quite higher at the bottom than at the top, the fabric tension is better balanced with decreasing spacing from top to bottom.

Cleaning sequence

The cleaning sequence must be designed in a way that the bags do not collapse too quickly.

It has been proved that multiple collapses during one single cleaning sequence can decrease the overall pressure drop of filter of about 10 to 30 mm WG.

Efficient valving system (See figure 4)

The puppet valves have very long control rods which can bend during operation. Also the flat disc seating happens to leak after some time.

The butterfly valves with contact rips are dangerous to use because of dust build-up against the rips, which forbids the valve to close totally and creates leakages.

To our knowledge, the best solution is an angle seating valve, which, when open, gives a practical passage totally free of gas and dust and gives a good tightness when it is closed.

It is absolutely necessary to keep the valving system in good operation and check the adjustment of the valves whatever type they are, so that they always close.

The most critical are the repressure valves.

On a 10 compartment filter, if you have only one valve leaking on the repressure system, the total repressure system is bad.

There is an easy way to check if a valving system is efficient on a baghouse: you must verify if the gas flow inverts during repressuring, meaning that the suction in the hopper is below 0, and, when all valves of 1 compartment are "closed", the pressure in the hopper must be exactly zero.

We would recommend 50 mm WG negative pressure during repressuring of a compartment.

3.13 Conclusion on energy

By saving 10 mm WG pressure drop on a bag house, handling 100 m3/s of fumes, you save about 20 000 French Francs over a year or about 5 000 U.S. Dollars. This gas volume of 100 m3/s corresponds to the volume necessary for a furnace of 16 to 18 MW producing FeSi 75 % (based on KWH price of 0,2 FF).

3.2 Maintenance Costs

There is always a tendency from people who purchase a bag house to squeeze the invested amount for such equipment.

One apparent saving is done by reducing the bags spacing (see figure 5). If you install the bags very close one to the other, the dimension of the single compartment is smaller, the overall dimension of the bag house is smaller and the initial cost of the bag house is smaller.

But after 1 or 2 years, when you have to replace 2 bags in one compartment and the bags are located out of reach, you lose time to replace the bags and you also destroy the bag's surrounding a broken bag.

The best bag lay out is 2 bags-one walk way-2 bags-one walk way a.s.o., which gives the easiest access to each bag.

3.21 Bag life

An interesting way of saving money on maintenance cost is to have a very long bag life.

The factors influencing bag life are:

- Pressure drop

It is obvious that if you work with a pressure drop of 300 to 400 mm WG, the cloth and the sewing are very quickly destroyed (see the previous paragraph, how to reduce the pressure drop). The lower the pressure drop, the longer the bag life.

A well designed filter should work with 180 mm WG pressure drop, and the expected bag life will be above 5 years.

- Sewing:

The quality of the threads used in manufacturing the bag, the reliability of the workers, the maintenance of the machines have much influence. The way the back flow rings are mounted and are tightly sewn on the bag has also an influence on the life.

Some cheap bag manufacturers install carbon steel back flow rings which rust after a few months and create abrasion on glass or/and Nomex.

- Cloth quality:

Although the fiber glass cloth quality is almost regular all over the world now, there are still some big differences in the treatments of these fiber glass cloths. A good silicone-graphite-teflon-hydro-repellent finish is excellent for bag life.

One must be careful when using teflon finishes because above 250^{o}C operating temperature, there is a tendency for the teflon to lose its qualities and destroy the total finish.

- Condensation:

This point is very important and has created a lot of problems all over Europe and USA.

We have found that on completely closed type baghouses like reverse jet filters, or reverse-flow closed filters, there is a heavy problem of condensation at the bottom of the bags.

We also found condensation problems in open pressure bag houses where the metal sheeting around the bags did not allow any ventilation during shutdown. These shutdowns on open bag house filters, when having very good bottom ventilation, will have no influence on bag lives (5 to 10 years for fiber glass bags).

- Electrostatic discharge:

On some bag houses, the structural beams are so close to the bags that there is a continuously electrostatic discharge between the bag rings and the structure. This creates holes in the cloth and destroys the cloth after a few months of operation.

4. DUST DISPOSAL

4.1 - Get the dust out of the hoppers:

Some of the users of filter bag pollution control systems in the ferro-alloy industry have found it very hard to get the dust out of the hoppers.

This is mainly due to 2 reasons:

The opening at the bottom of the hopper has always been too small.

Some people install rotary airlocks of only 100 x 100 mm cross section, which is in theory sufficient to discharge the dust collected by the filter.

Some others go up to 300 but it is still insufficient.

The best solution is the use of 400 x 400 mm rotary airlocks.

Another important point is to continuously extract the dust while it is still hot.

It is always difficult, in the morning, to start up a conveying system with cold dust.

If this cannot be avoided, we would recommend some high pressure air-blasts to break the bridges above the openings.

4.2 - Convey dust into the silo:

There are 3 possible systems:

- High pressure pneumatic conveying,
- Low pressure pneumatic conveying,
- Mechanical conveying (screw conveyers, lockets, elevators, etc.).

We are in favour of low pressure pneumatic conveying usine conveying pipes of 300 mm diameter.

There is much less chance of plugging such a big diameter pipe than if you use only 100 mm diameter pipes, or even lower, as used in high pressure pneumatic system.

4.3 - Pelletizer: See figure 6

The best known pelletizer up to now has been the plate-type pelletizer (rotating disc).

We have introduced a new type of pelletizer which we call a screw-type pelletizer.

The dust comes into a tube where a first screw section pushes the dust into a humidifying section and then pins, arranged in a spiral form, make the pellets and push them toward the outlet.

The humidity of the pellets is controlled by a variable water injection and the amount of water is permanently controlled by the power absorbed by the motor.

The size of such a screw-type pelletizer is 0.4 x 0.4 x 2.5 meters, which means it is very small and has a capacity of 5 to 8 T/H. You can easily see the advantage of such a pelletizer:

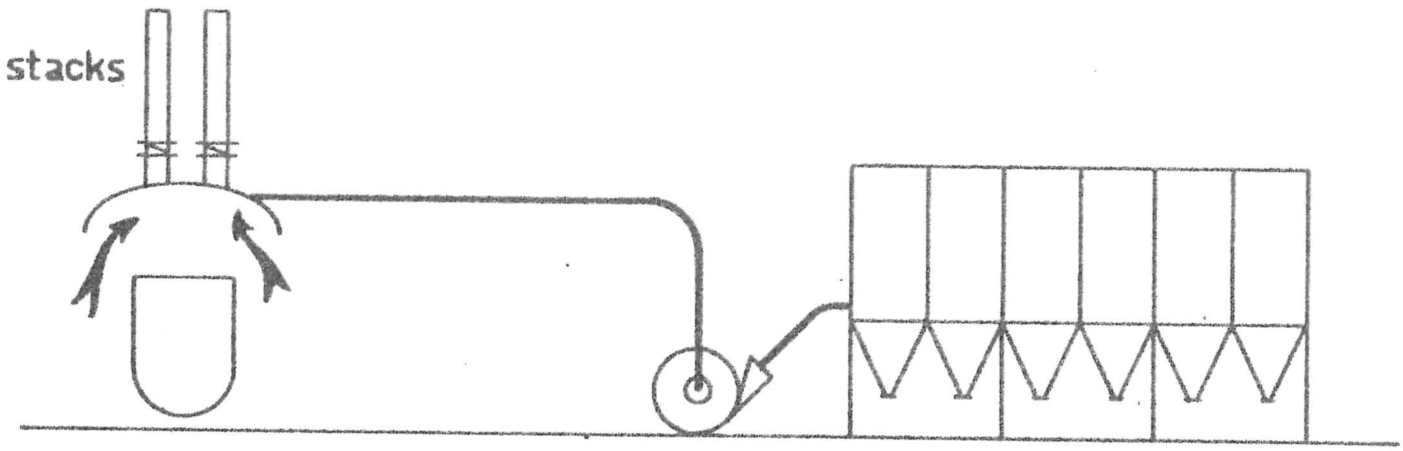
- it is cheaper than a conventional pelletizer,
- it can be installed directly under a silo and unload directly into a truck or any type of storage system.

5. CONCLUSION

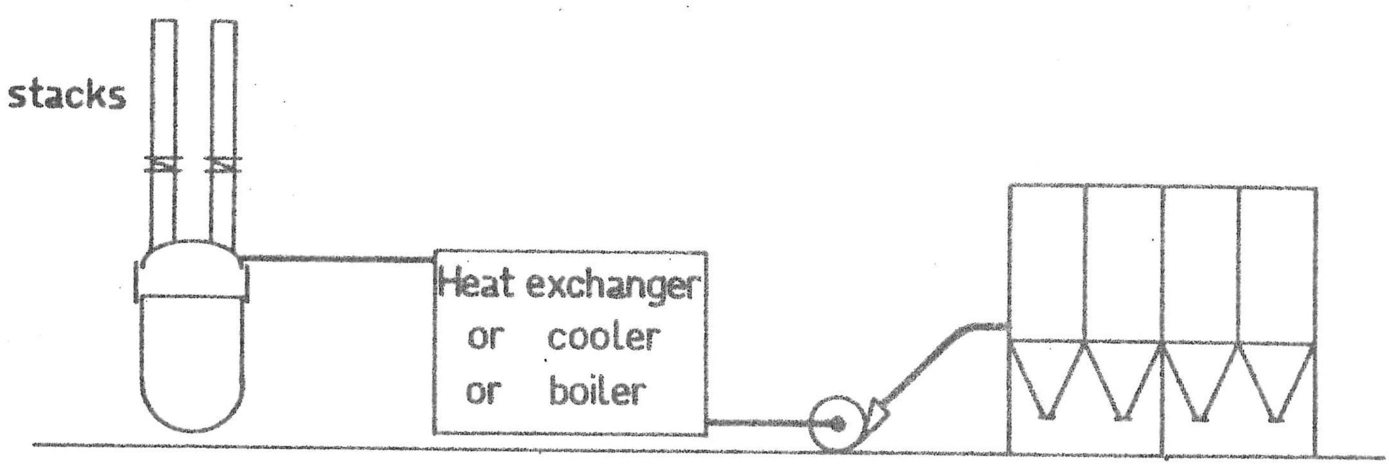
Since having energy and saving maintenance costs are at least as important as saving initial investment costs, we have tried to give you a few tips on how to follow that idea.

FURNACE DUST CONTROL

OPEN FURNACE



ALMOST CLOSED



INFACON 80	FILTER MEDIA LYON - FRANCE	fig: 1

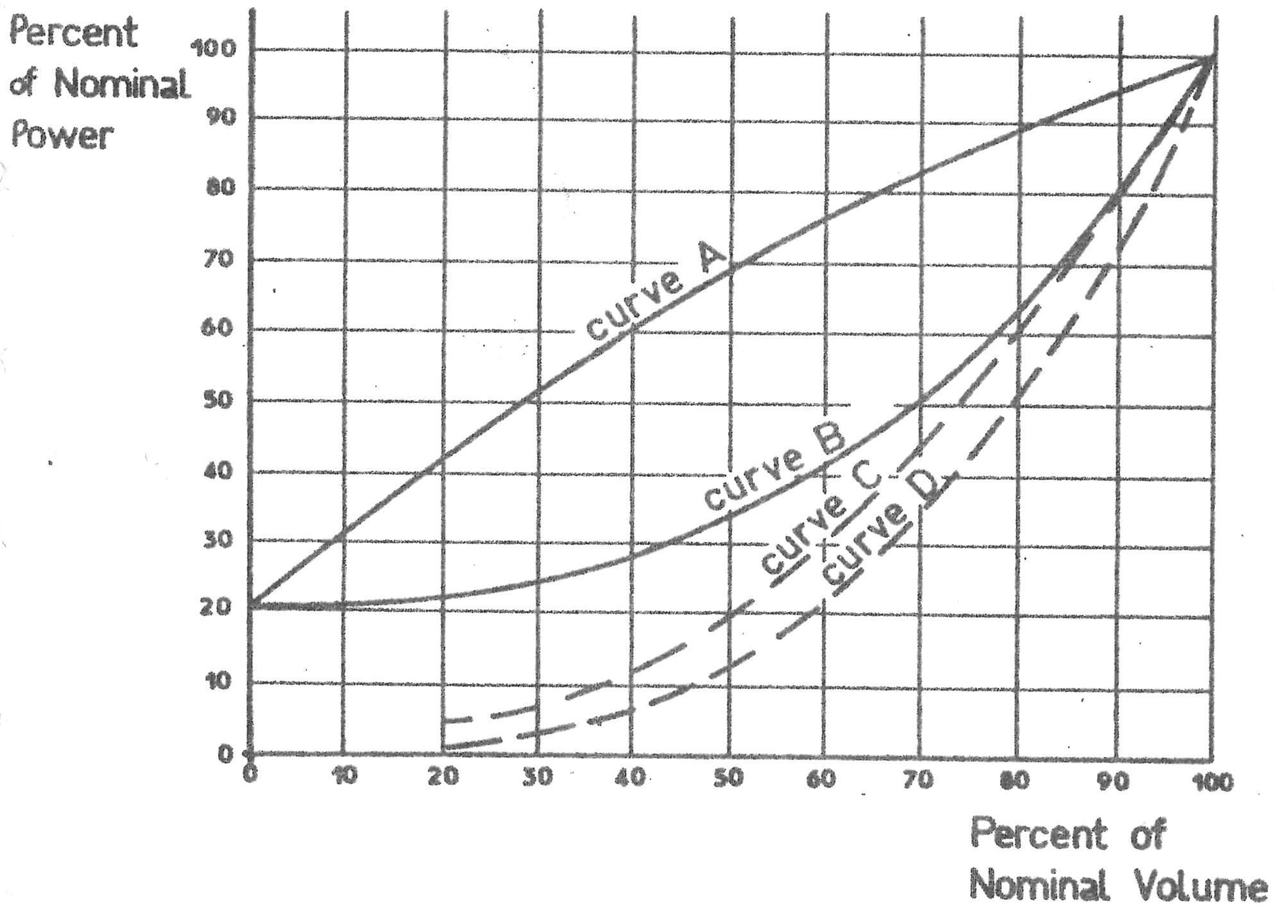
FAN VOLUME CONTROLS

curve A : straight damper

curve B : variable inlet vanes

curve C : hydraulic coupler

curve D : variable speed d.c. motor



FILTER BAG SPACER RINGS

SHAPE OF BAG WHEN CLEANED BY REVERSE FLOW

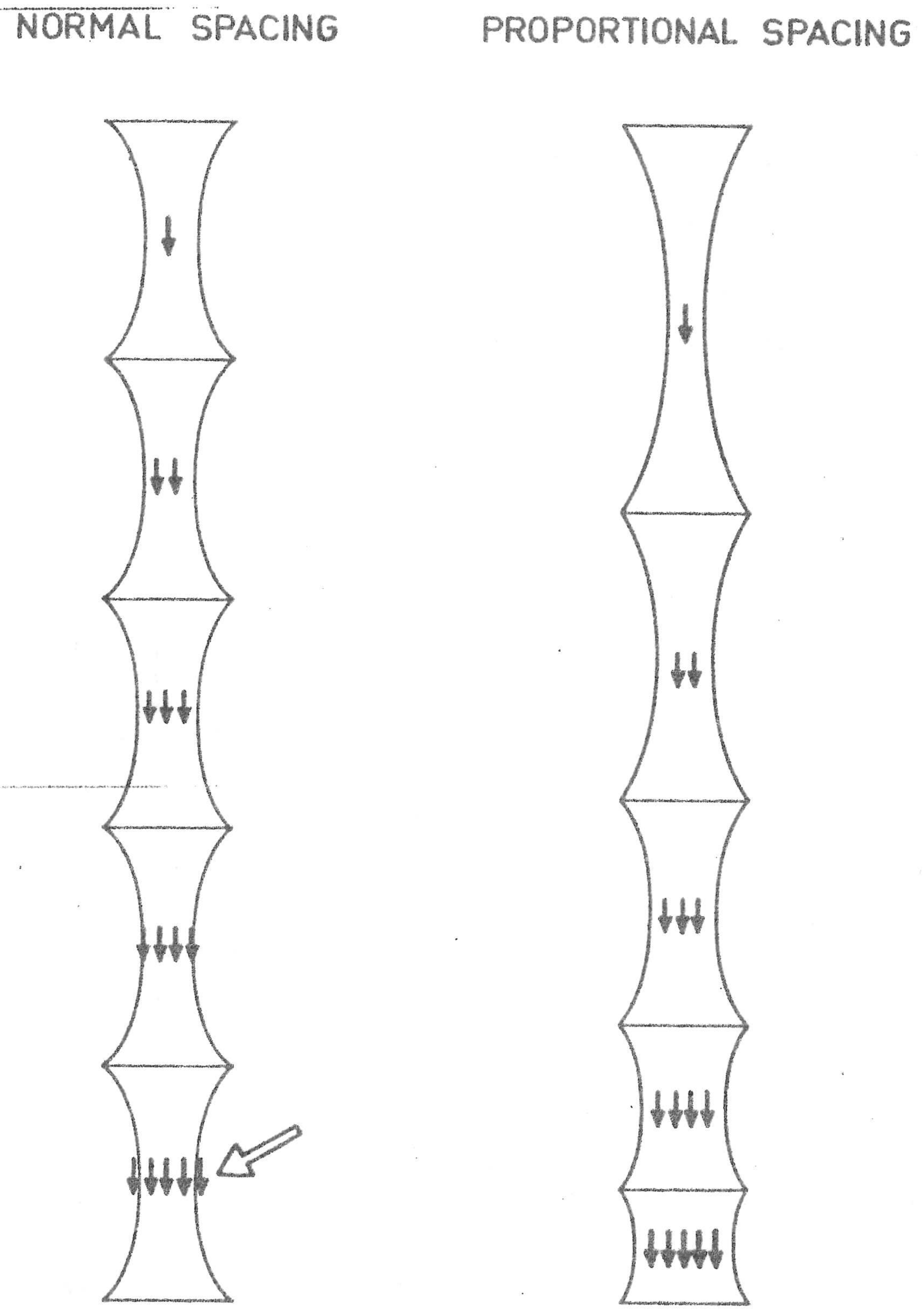
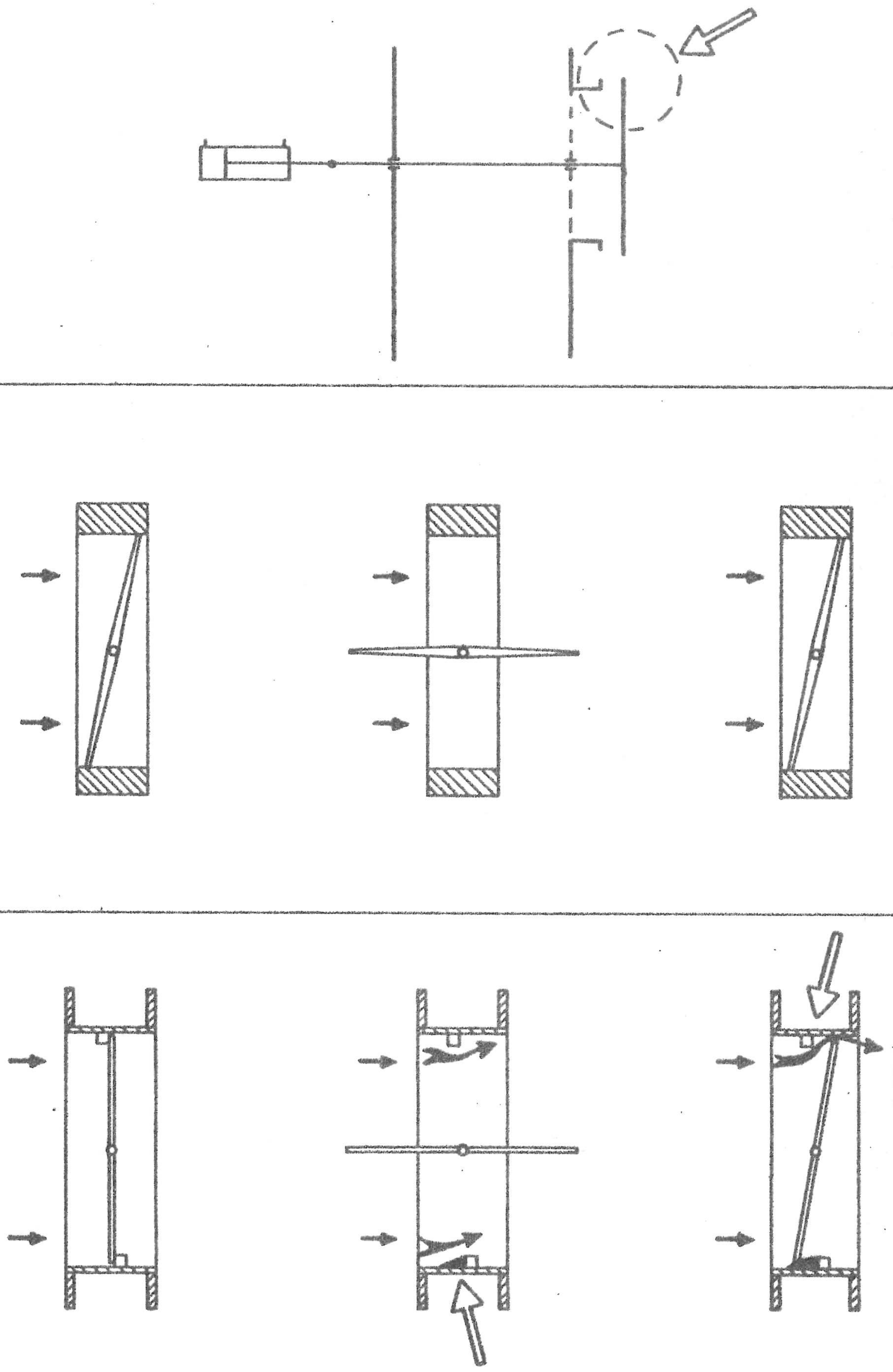


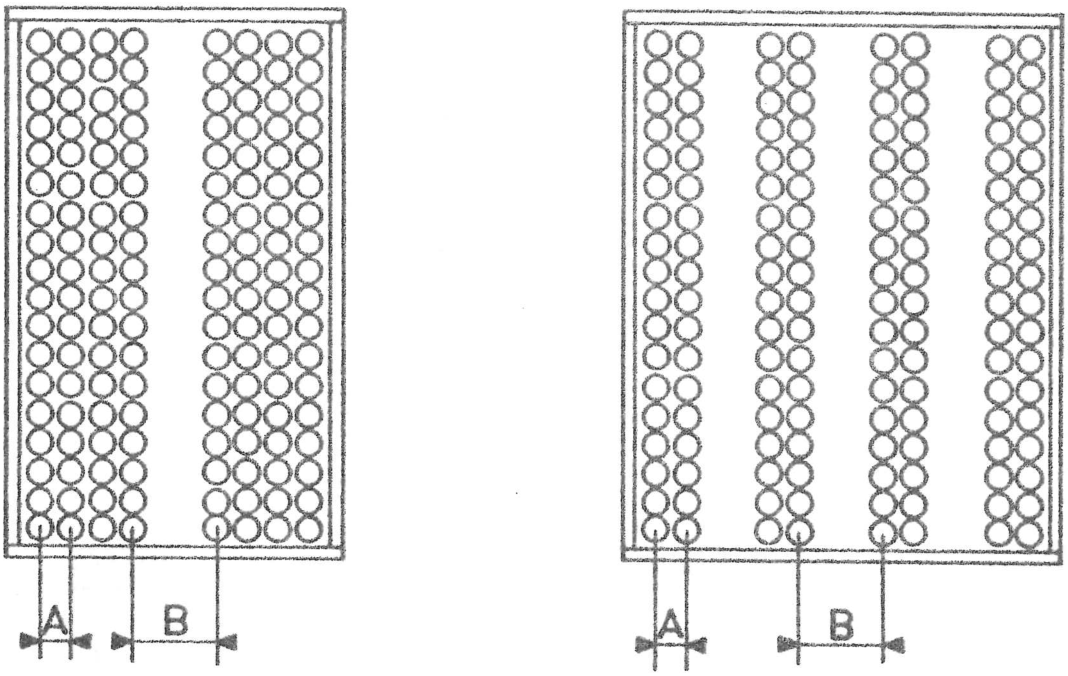
fig: 3

VALVES

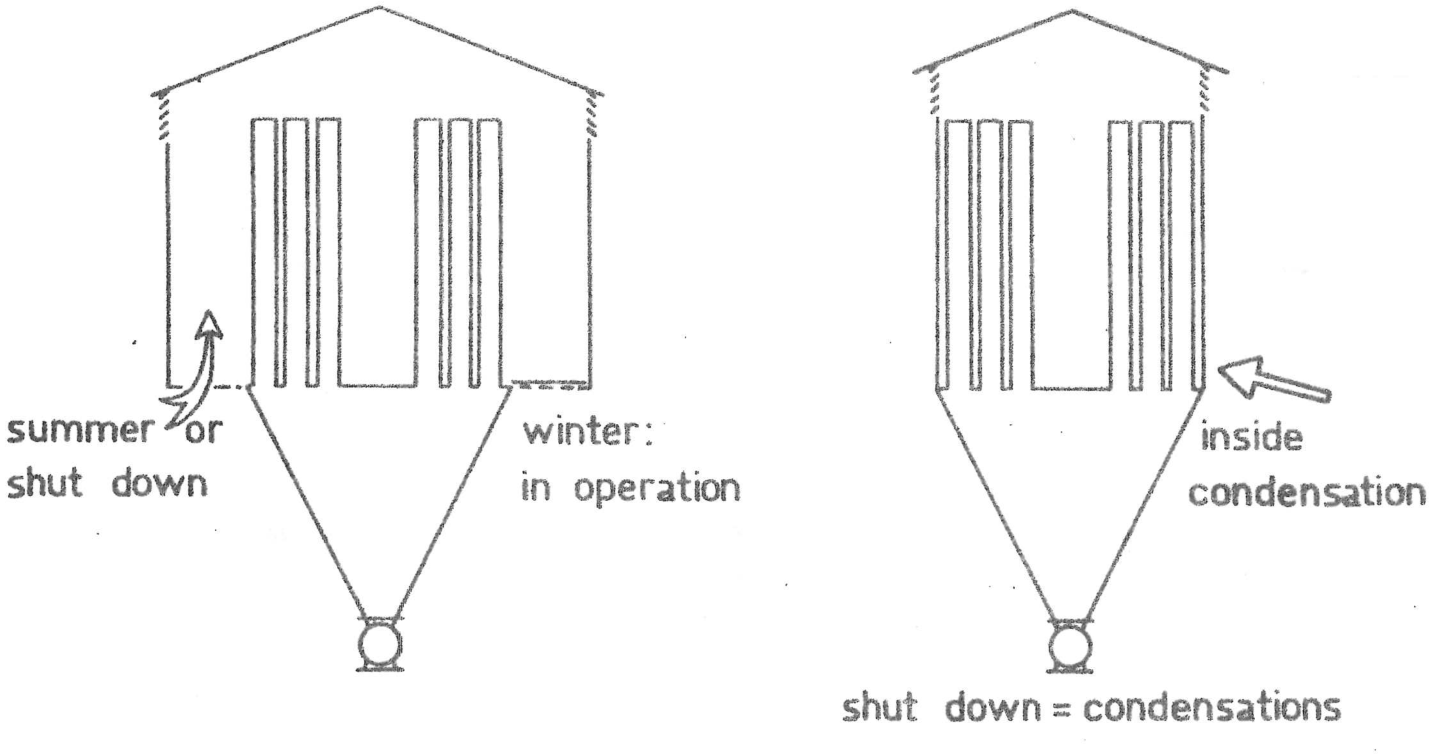


BAG HOUSE DESIGNS

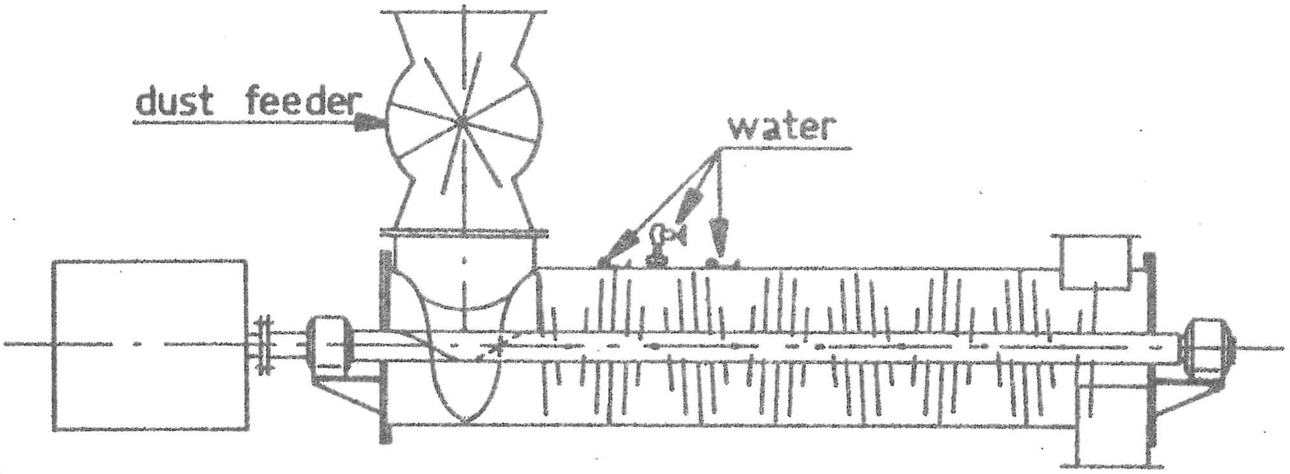
FLOOR LAY OUT



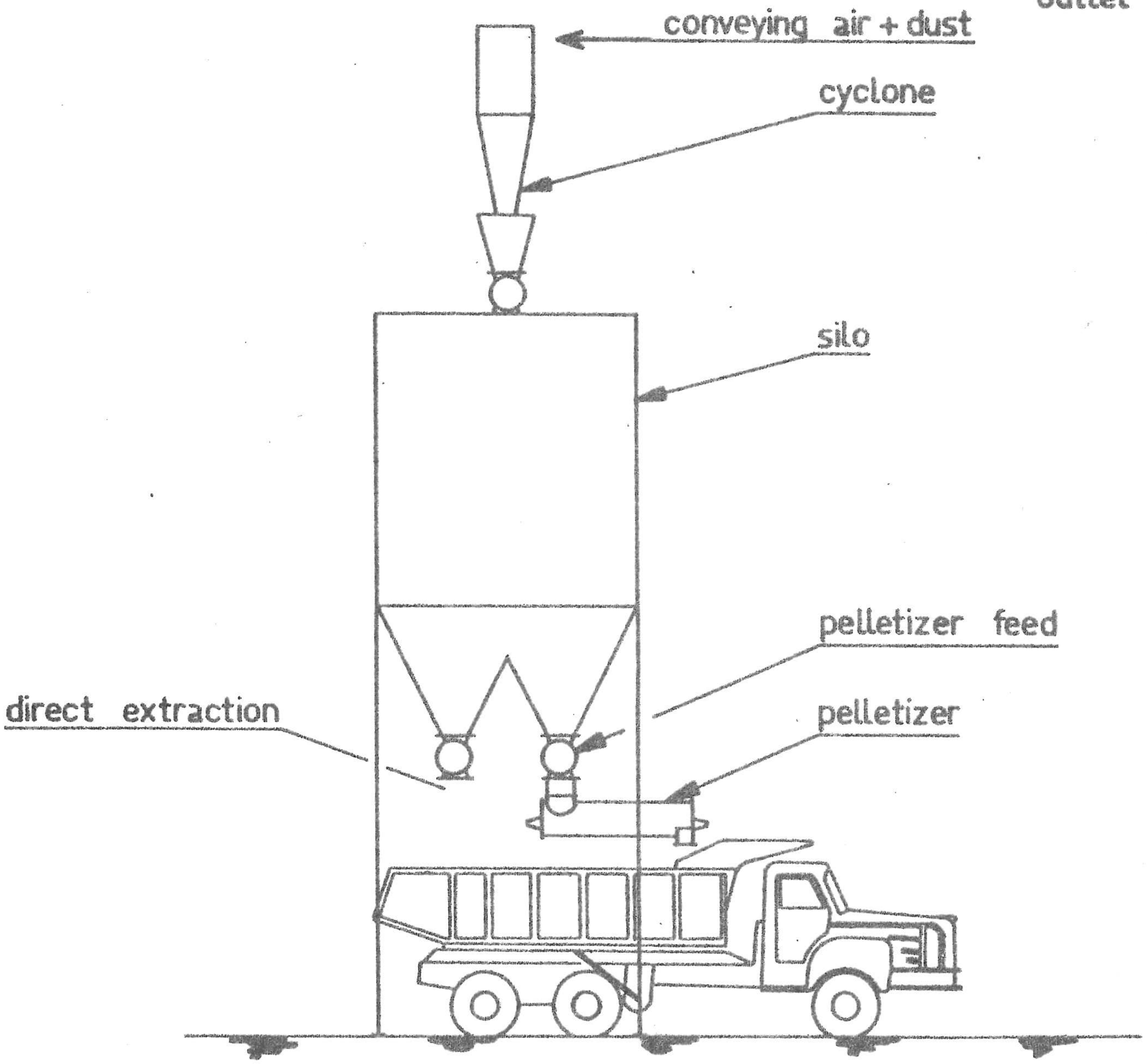
FILTER VENTILATION



DUST REMOVAL: CONVEY - STORE - PELLETIZE



SCREW TYPE PELLETIZER



INFACON 80	FILTER MEDIA LYON - FRANCE	fig: 6

DISCUSSION

Mr. H. Wittstruck*

I have one question regarding the pelletizer. What is the shape of the pellet that exists in the truck?

Mr. F. Schmitt:

The pellet is not as the nice round ball you find under disc pelletizer. Also the size is not as regular as in the disc pelletizer. It varies between 3 and 8 mm. You have a distribution of sizes, but its consistency is equivalent to disc pelletizer, and its strength is the same.

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