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FISH MEAL PRODUCTION[1]

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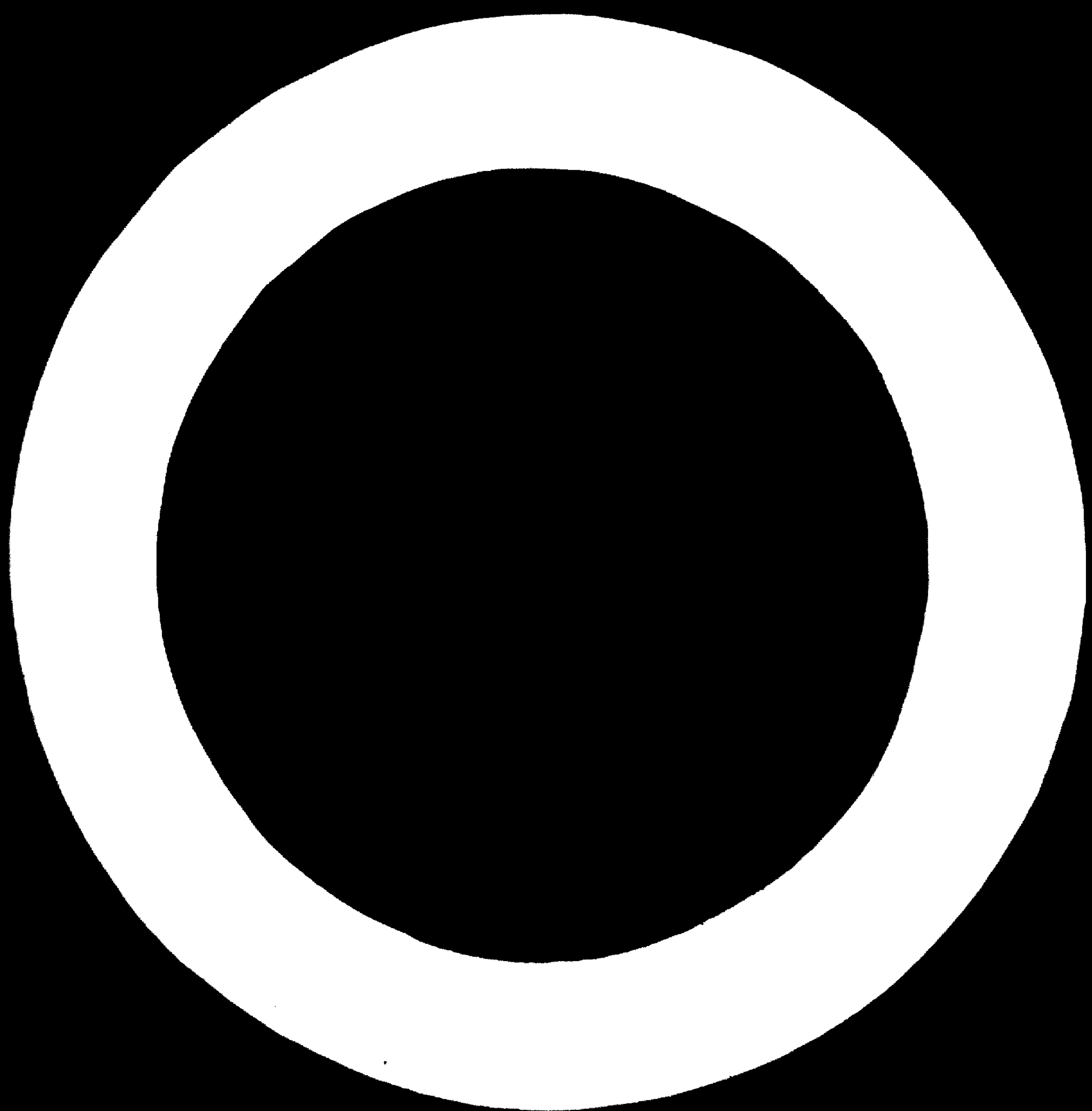


It is often considered to be a waste of valuable raw material if fish is converted into meal to be fed to chickens and pigs instead of using the fish for human consumption.

This is not true, however, as there are many species of fish which are not suitable for human consumption, but which are excellent raw material for fish meal production. Furthermore, when fish are caught for direct human consumption, as a rule both trash fish and fish waste are obtained. These types of raw material can also be used for fish meal production.

In this connection I wish to quote the following from an interim report on the FAO Technical Conference on Fishery Products held in Tokyo December 1973.

> "Participants showed a great deal of interest in the Session dealing with fish protein, fish meal and fish oil. The Conference concluded that where fish cannot be gainfully used for direct human consumption, it should be converted into meal and oil thereby making constructive use of resources which would otherwise be neglected or underexploited or perhaps not fished at all. In the discussion of this topic it was pointed out that fish meal and oil made valuable contributions to human well-being through use for animal feed and for medical and industrial purposes. Another favourable factor was that the fish meal industry frequently plays an important part in bringing about development of fishery industry, especially in developing countries."

Why is fish meal so valuable? I will not go into detail concerning the composition of the fish itself but can mention that fish in general contain about 15 - 20 % fatfree dry substance and a certain amount of oil, 2 - 25 %, dependent on type of fish. The balance is water.

The meal produced from the dry substance contains 60 - 70 % of protein, of which about 90 % are digestible. This protein contains all the essential aminoacids that are required to build up the body and is thus an ideal additive to animal feed. The meal also contains an unidentified growth factor, UGF. This means that chicken and pigs fed with fodder containing fish meal grow faster than if they are fed with another type of fodder, even if this fodder has the same composition as far as proteins are concerned.

The meal also contains a small amount of oil (4 - 10 %). The oil content should be as low as possible, as a high oil content may reduce the storage ability and also possibly affect the taste of the chicken and pigs fed with the meal.

The oil in the fish is also a valuable product. After refining and hardening it can be used for the production of margarine or used for industrial purposes, such as paints, leather treating agents, fatty acids to name but a few.

The quantity of fish meal produced each year in the world is about five million tons and the quantity of fish oil about one million tons. The quantity of raw material used for this production is 20 - 25 million tons. This is somewhat more than 35 % of the total fish catch in the world which amounts to 65 - 70 million tons.

Prices of the meal and oil fluctuate, of course, in relation to supply and demand. At the moment, the price of meal containing 65 % protein is about 400 US dollars per metric ton and the price of oil about 600 US dollars per metric ton.

When considering whether or not a fish meal plant should be installed in a certain area it is necessary first to make a market study. Factors that should be investigated are for example:

- the supply of fish and fish waste
- which species are available
- maximum and minimum quantities caught daily
- number of working days per year.

If the conclusion is reached that a fish meal plant is a profitable investment, the next step is to decide on the type of plant that would be the most suitable one.

If the raw material is lean, i.e. if it can be established already beforehand that the meal will have a sufficiently low oil content without removal of the oil (and that oily fish will never be used as raw material in the future) a plant for drying the raw material only can be installed. If, however, which is normally the case, the fish contains so much oil that a de-oiling has to take place, a complete fish meal and fish oil plant has to be used.

For this application, several types of plants are available, most of which work according to the same principle and can be classified as conventional plants.

By this expression I refer to a plant consisting of a steam-heated cooker, a screw press, a drier, decanters and separators for press liquid, separators for the fish oil and possibly also an evaporation plant. See figure 1.

The cooking process is an extremely important stage in a fish meal factory, as the raw material must be cooked properly to make the protein coagulate and to burst the oil-containing cells. The steam cookers are intended for direct steam injection, indirect steam heating or - which is most common - for both direct and indirect steam heating.

The next important step is the removel of solids from the liquid after cooking. A screw press is used for this purpose in conventional plants.

The effectiveness of the screw press is, however, dependent on the quantity and the consistence of the cooked fish mash. If the quantity varies, the press portion or the number of revolutions of the press has to be adjusted. Corresponding adjustments must also be made if the consistency of the cooked fish mash varies.

The drying of the solids coming from the press is nowadays normally carried out in a steam drier.

The liquid phase from the press is treated in a decanter centrifuge for the removal of suspended solids and then treated in a separator to recover the oil. The oil is purified in a special separator.

The water phase leaving the press liquid separator contains dissolved solids which can be recovered by first concentrating the stick water in a multiple-effect evaporator and then drying the concentrate together with the solids from the press and the solids from the decanter.

Another type of fish meal and fish oil plant which differs from the conventional plants in several fundamental aspects is shown on figure 2.

The raw material, including the blood water, is fed to a mincer, where the raw material is evenly cut up. This is then pumped or transported from a hopper after the mincer by a screw conveyor to the cooker. By varying the speed of the pump or screw conveyor at the inlet of the cooker it is possible to adjust the capacity of the plant.

The cooked fish mash is pumped to the decanter where it is separated into a liquid phase and a solid phase. The solid phase is transported to the drier.

The liquid phase is pumped to a solids-ejecting separator, where the liquid is separated into three phases, an oil phase, a water phase and a solid phase.

The solid phase is intermittently shot out from the separator and fed back to the cooker. The intervals between the shootings are regulated by a preset programme.

The oil phase is either pumped direct to the storage tank or "polished" in a special separator.

The water phase, which contains dissolved solids, is concentrated in an evaporator plant to about 35 - 40 % dry substance. In some plants the concentrate is separated in a special separator in order to remove the oil, which may have been freed during the heat treatment in the evaporator plant.

The concentrate from the evaporator plant is mixed with the solids from the decanter before being fed into the drier, where it is dried into meal.

After the drier, the meal can be milled, cooled, pelleted or pressed to bricks according to the requirements of the customer.

The most important difference between the above type of plant and the conventional type is that a decanter is used instead of a press.

A decanter, see figure 3, consists of a drumlike rotor containing a screw conveyor, both rotating at a high but slightly different speed. The cooked fish mash is fed through a hollow shaft into the rotor. By means of the centrifugal force the solids are thrown out to the rotor wall, where, due to the speed differential, the flights of the conveyor move the solids continuously to the outlet ports at one end. The liquid, which is lighter than the solids forms an inner layer and leaves the decanter continuously through outlet ports at the opposite end.

By introducing decanters, centrifugal force replaces the mechanical force used in screw presses.

The introduction of centrifugal force for removing the solids from the liquid in cooked fish mash has proved to give many advantages, for example:

The decanter is far less sensitive to the kind of raw material treated than a screw press. It is thus not necessary to drain off any blood water from the fish before feeding the raw material into the plant.

The machine needs no adjustment when the quantity or the consistency of the cooked fish mash is changed.

When treating soft raw material, which is difficult or impossible to treat in conventional plants, the dry substance is separated out and continuously discharged from the decanter.

The decanter has a better de-oiling effect than a screw press which results in a fish meal with lower fat content.

The decanter gives a higher meal yield than a press.

The decanter gives a very fluffy and uniform solid phase which is easy to dry.

The spongy state of the solid phase facilitates the absorption of stick water concentrate if whole meal is produced.

The cooker and drier system also differs from that of conventional plants. In the plant just described no steam is required for cooking.

The cooker and drier are in principle of the same design, see figure 4.

They consist of a slowly rotating cylinder inside a stationary, insulated jacket. The cylinder is fitted with longitudinal tubes attached to the end plates.

The heating medium is flue gas generated by burning oil in a heater belonging to the plant.

The flue gases, which have a temperature of about 400°C at the inlet of the cooker and drier, heat the longitudinal tubes as well as the side and end plates. These surfaces transfer the heat to the material to be cooked or dried. There is, consequently, no risk for any direct contact between flue gases and the material.

The flue gas, which is sucked through cooker and drier, is recirculated to the flue gas generator and mixed there with the out-going gases so that a steady temperature at the outlet is maintained.

A temperature of about 400°C may seem to be very high. However, the material to be cooked and dried is not exposed to this temperature as there is no direct contact between the flue gases and the material. The temperature of importance for the treatment of the substance is that of the heating surfaces which due to the low heat transmission coefficient of the flue gases will be low.

As can be seen from the graph in figure 5 the temperature of the heating surfaces in the cooker is slightly higher than 100°C. The temperature in the fish mash rises to just below 100°C before the material leaves the cooker.

From the graph in figure 6, it can be seen that the temperature of the heating surfaces is about 140°C in the drier and that the temperature of the material to be dried is constant at about 70°C.

The above type of cooker and drier have proved to be very efficient and give better results than conventional ones. This refers especially to the heat economy which is extremely good as no steam is used.

Another advantage of the above cooking and drying system is that an effective deodorizing plant can easily be added to the plant.

Most of the unpleasant odour in a fish meal plant comes from the drier, where the water driven off is absorbed in the form of vapour by ventilation air.

If the ventilation air with its vapours and gases can be prevented from being let out into the air, the main pollution problem is solved.

The deodorizing syetem used in combination with the above type of plant is shown on figure 7.

The ventilation air from the drier is fed through a cyclone to a scrubbing tower, where it is cooled and washed with water. The tower is fitted with inserts which guarantee good contact between the ventilation air and the cooling water, resulting in an effective cooling and condensation.

The cooled ventilation air with the incondensable parts are passed from the scrubbing tower to a moisture trap to remove droplets. The air is then preheated and split up in two streams, one going back to the drier as ventilation air and one going as secondary air to the furnace of the fish meal plant, which has a constant consumption of air. No gas therefore leaves the plant without passing through the burner, where the unpleasant smelling matter is burned.

Some of the advantages of the above type of plant can be gained in a conventional plant if the decanter is used in a more effective way.

The decanter can be used in parallel with the press as shown on figure 8. In this system, the prestrainer between cooker and press is equipped with large holes through which liquid and fine solids are drained off and fed directly to the decanter. In this way material which may be difficult to press is prevented from being fed into the press and is treated in the decanter only.

The decanter can also be used as replacement for the press, see figure 9, i.e. in the same way as described previously for the "unconventional plant".

Comparisons have been made between plants using presses and plants using decanters instead of presses. Some results are shown in figure 10. In this figure, each vertical line with one dot and one x represent a factory where analyses have been made simultaneously. The dots represent the fat content in the meal obtained when operating on decanter only, whereas the x-marks represent the fat content in meal produced in the press-line.

To sum up, I have described a complete fish meal and fish oil plant which differs from conventional plants and which has the following main benefits:

The plant is less sensitive to the type of fish and its condition than other plants.

It can be operated at high capacity even when treating fish of inferior quality.

The meal produced in the plant will have a lower oil content than meal produced in other plants.

No steam is used for cooking and drying, thus no steam boiler is required.

The heat economy is very good, i.e. the fuel oil consumption per ton or raw material is low.

The fresh water consumption is insignificant. An evaporator plant can be added to the plant if the waste water (the stick water) is also to be treated.

A deodorization plant can be added if the plant is to be installed in a populated area.

I have also described how some of the above advantages can be gained in a conventionel plant by using a decanter in a more effective way then is normally the case.

Finally, the last figure shows you the importance of maintaining a plant at high capacity and how the profit decreases rapidly if the capacity is reduced.

In figure 11, the lower horizontal line represents the fixed costs, i.e. depreciation, interest, labour costs, maintenance costs, costs for electric power etc. which are more or less independent of the actual throughput in the plant. The difference between the horizontal line and the sloping, lower line reprsents the costs for raw material, fuel oil, bags etc. which are directly related to the eotuel throughput in the plent. This line, therefore, shows the totel costs for operating the plant at different throughputs, i.e. at different degrees of utilization.

The upper declining line represents the gross income, i.e. the value of the meal and oil produced, which is directly proportional to the rate of production.

The profit is thus represented by the difference between the two upper lines. As can be seen, the profit decreases much faster than the reduction in the degree of utilization. This shows the importance of choosing a plant which can be run at high capacity more or less independently of the kind of raw material treated.

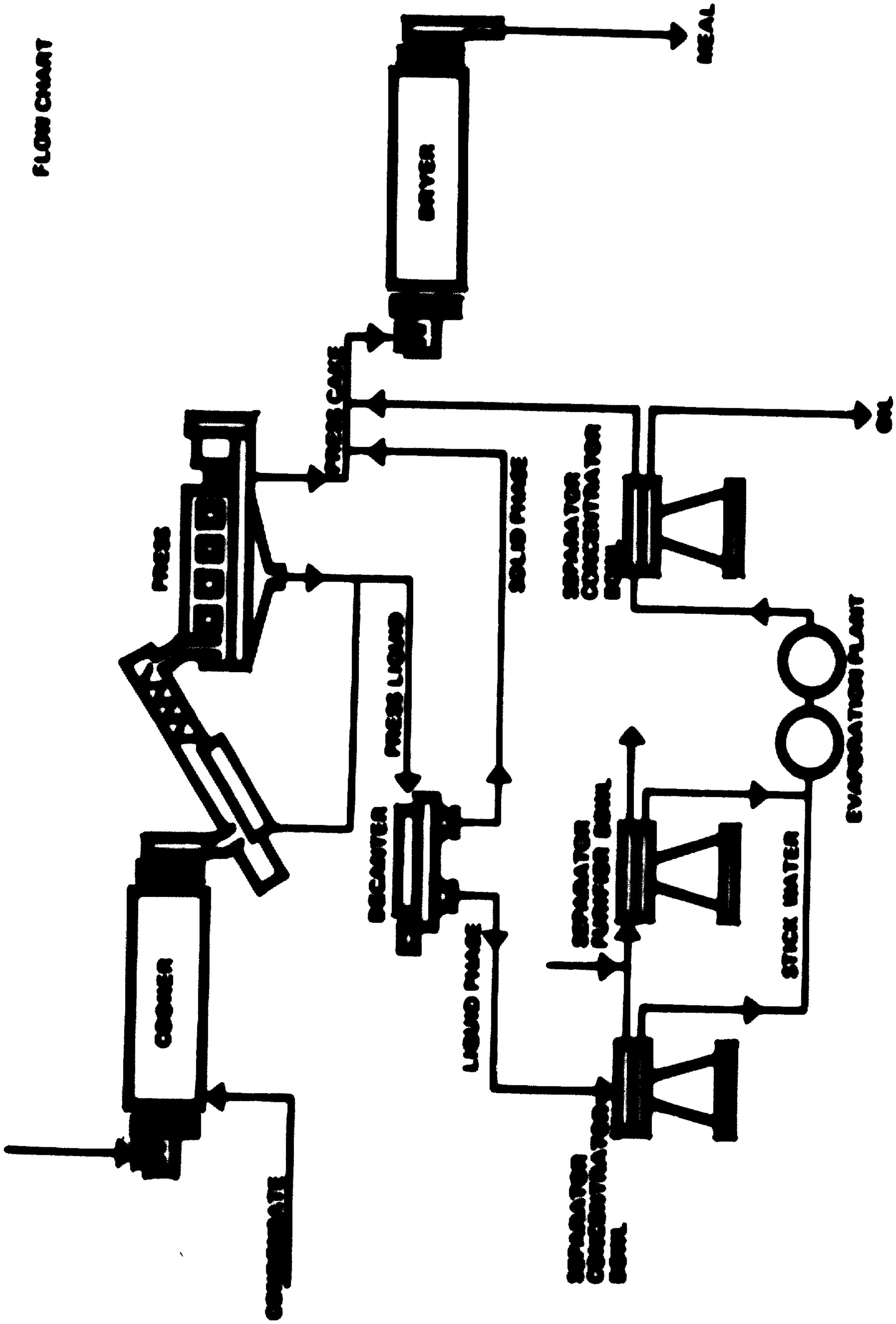

FLOW CHART
RAW MATERIAL
CONDENSATE
COOKER
PRESS
PRESS CAKE
DRYER
MEAL
PRESS LIQUID
DECANTER
SOLID PHASE
LIQUID PHASE
SEPARATOR CONCENTRATION BOWL
SEPARATOR PURIFIER BOWL
STICK WATER
EVAPORATION PLANT
SEPARATOR CONCENTRATION BOWL
OIL

Fig 1

Plant for production of fishmeal and fish oil

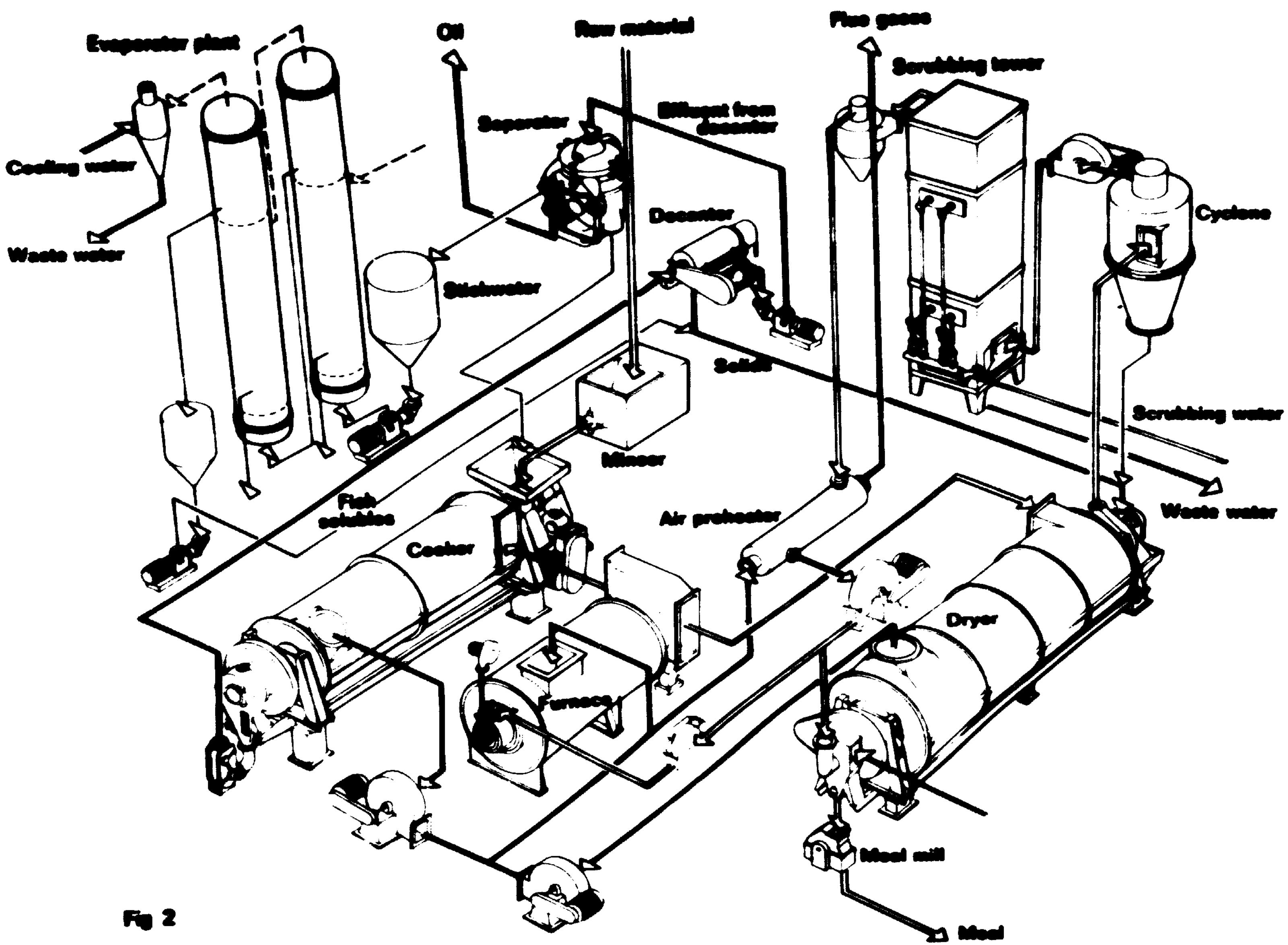


Fig 2

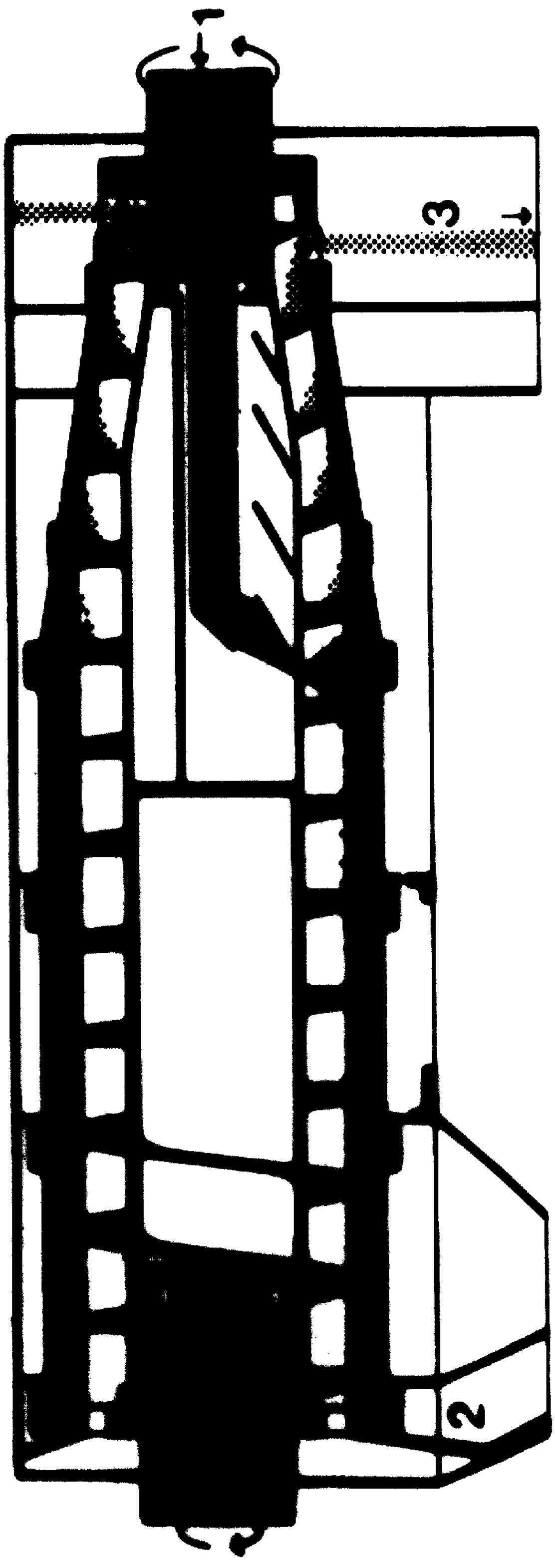
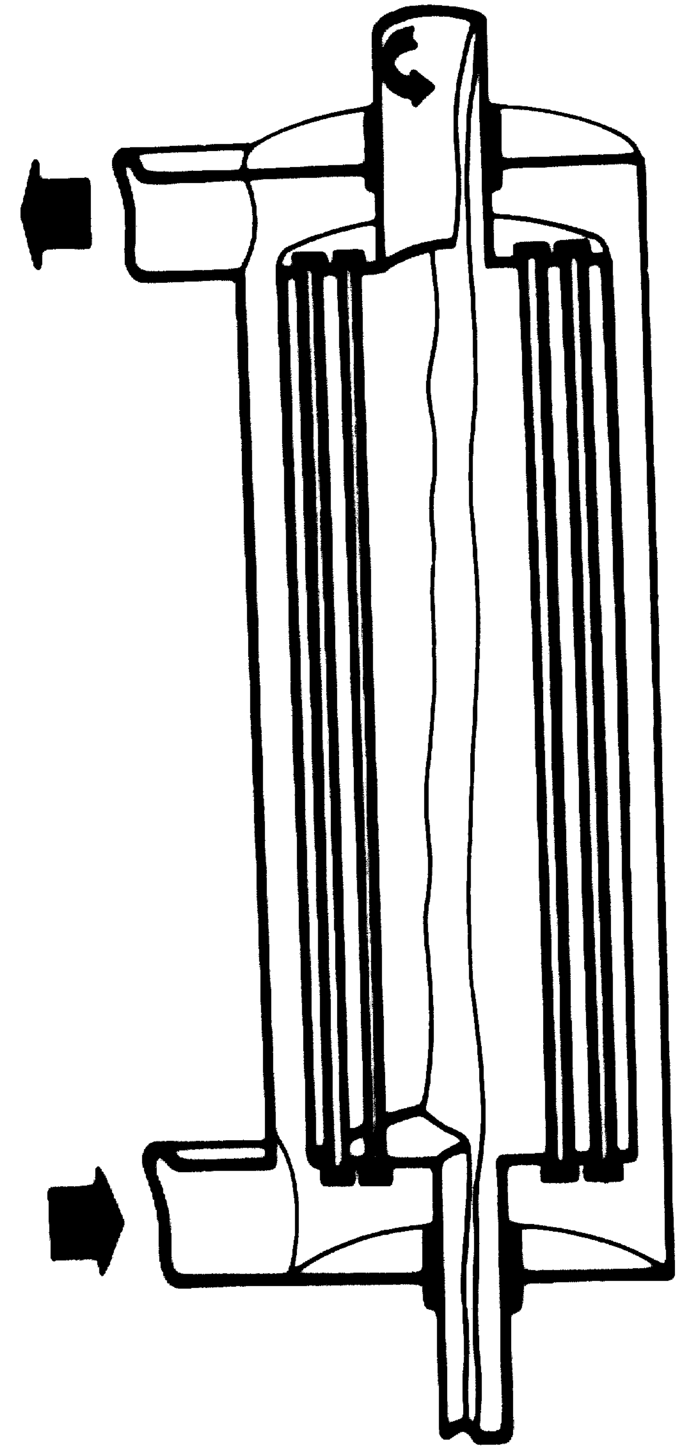


Fig 3



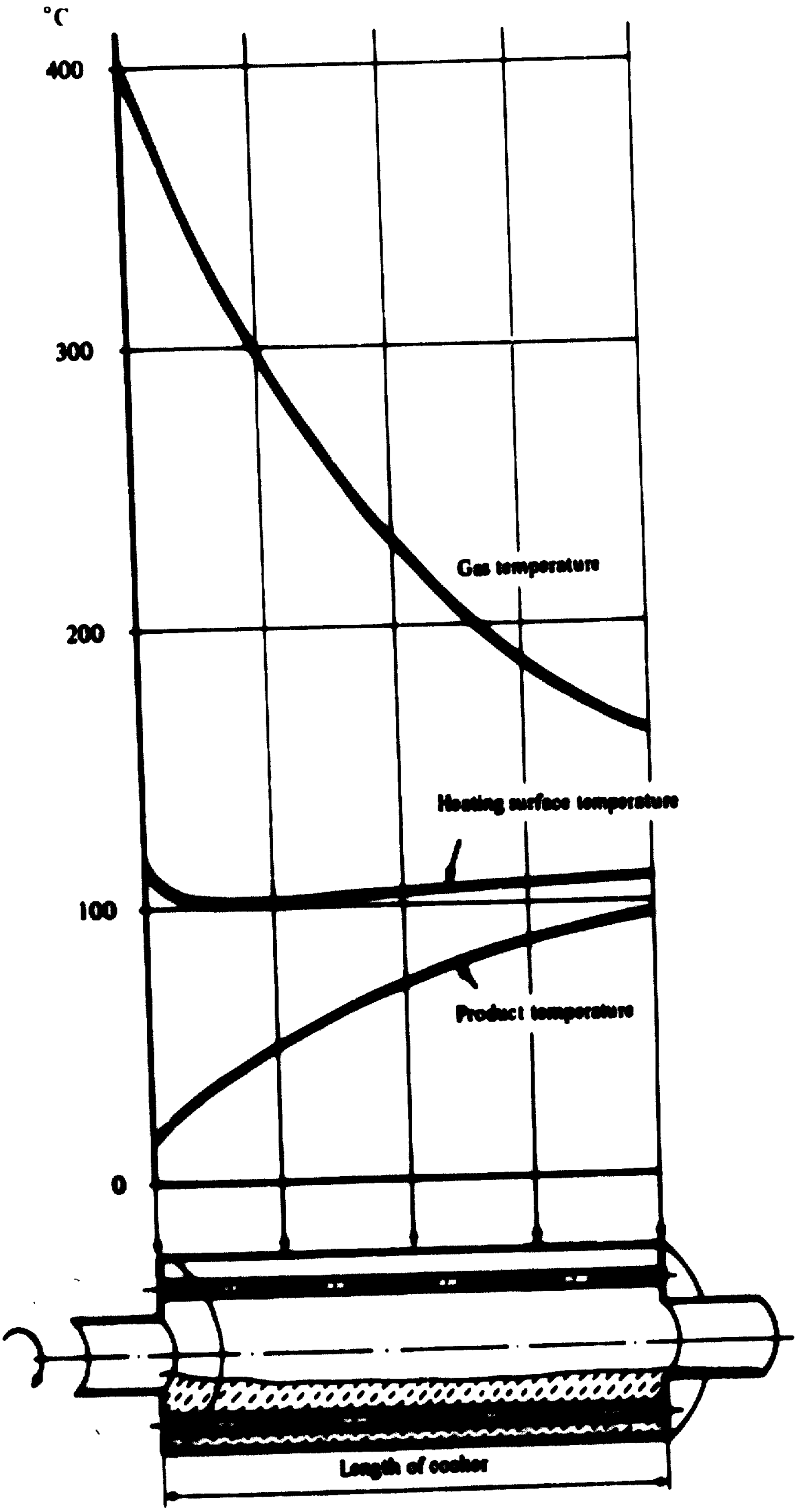

°C
400
300
200
100
0
Gas temperature
Heating surface temperature
Product temperature
Length of cooker

Fig 5

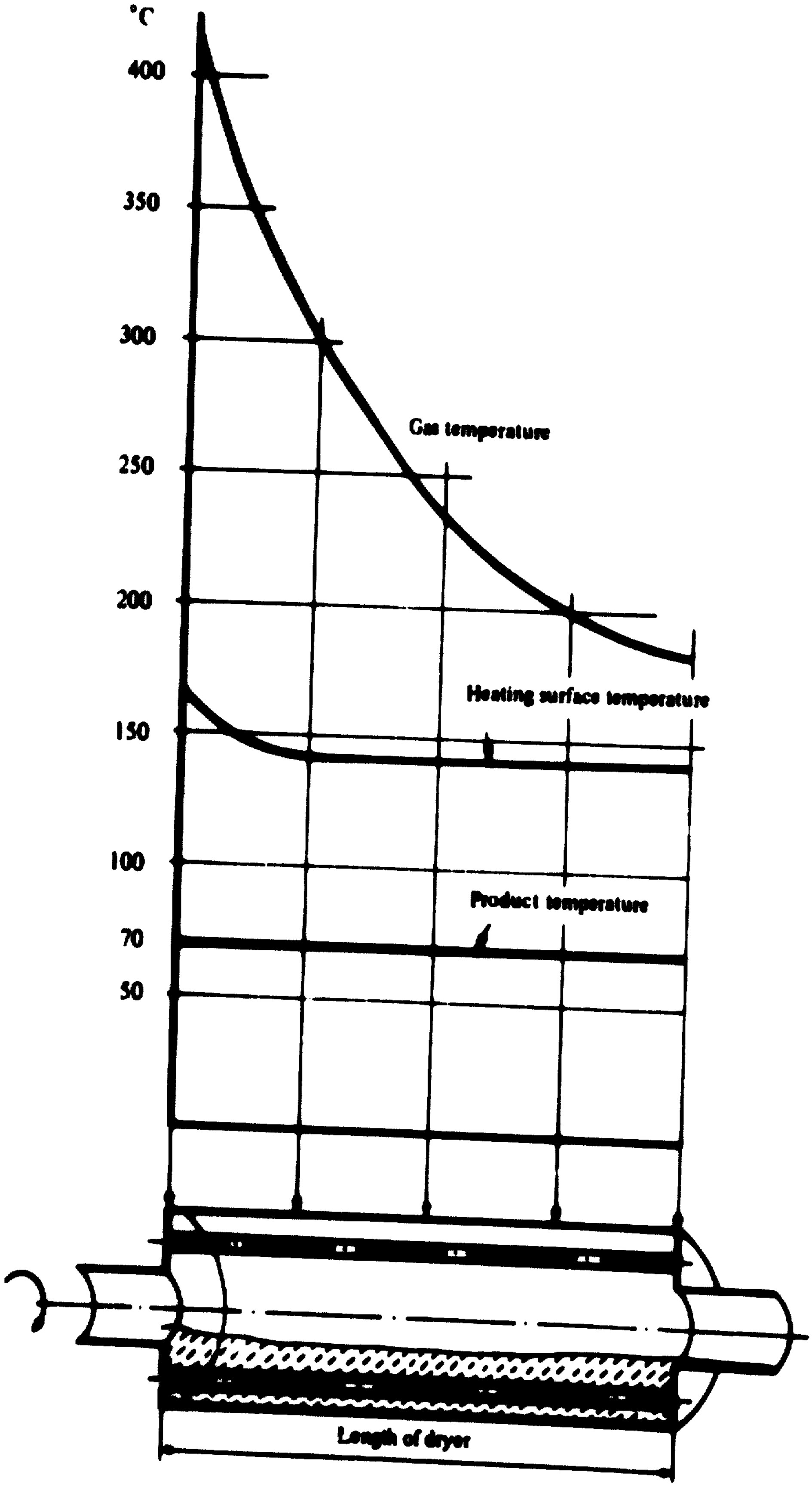

°C
400
350
300
250
200
150
100
70
50
Gas temperature
Heating surface temperature
Product temperature
Length of dryer

Fig 6

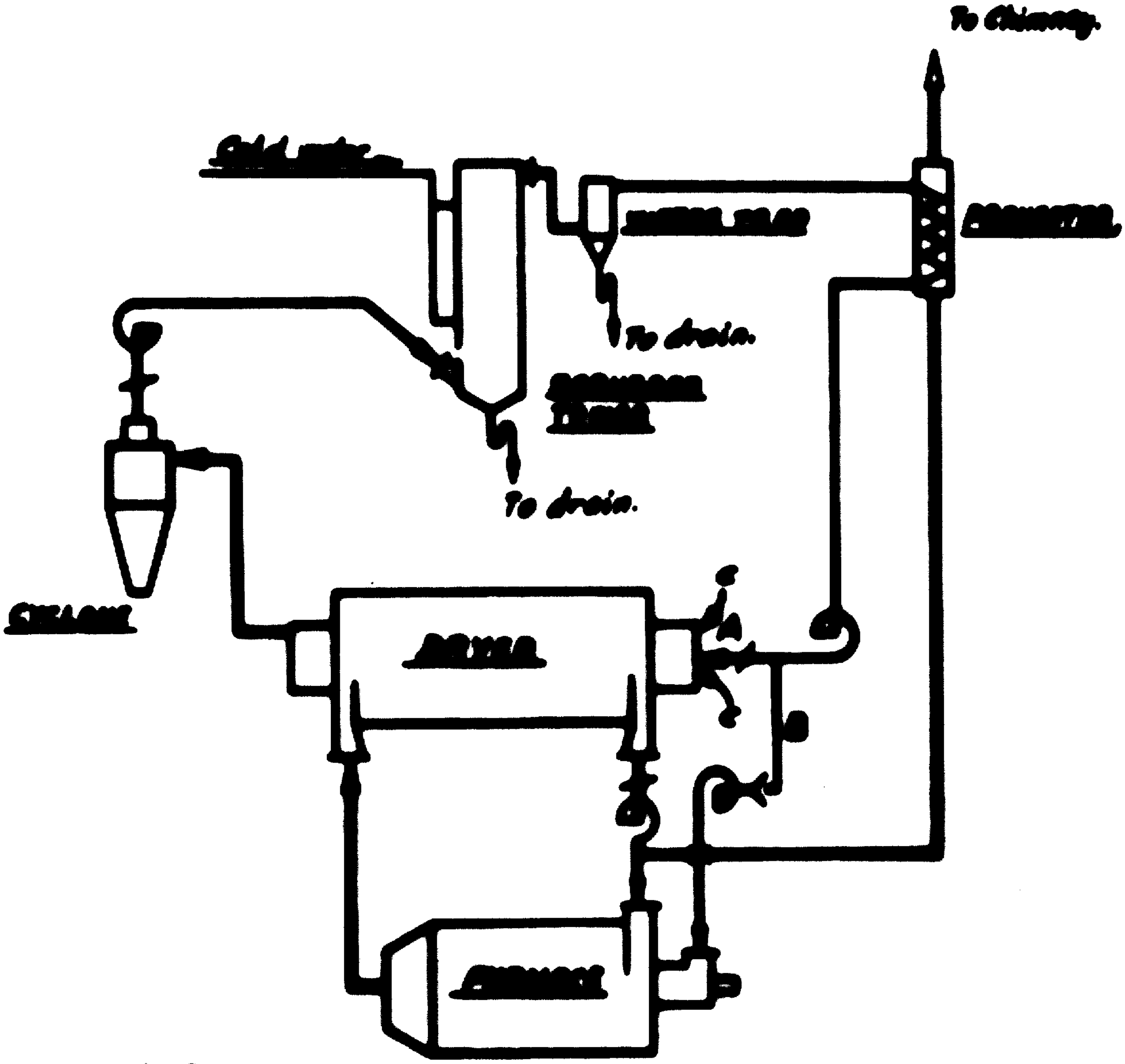


Fig 7

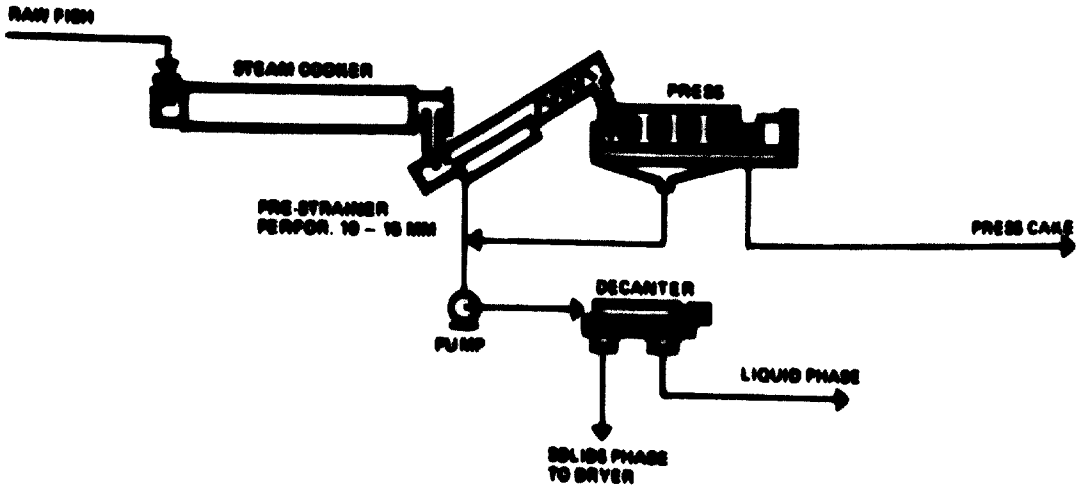

RAW FISH
STEAM COOKER
PRESS
PRE-STRAINER
PRESS CAKE
DECANTER
PUMP
LIQUID PHASE
SOLIDS PHASE
TO DRYER

Fig 8

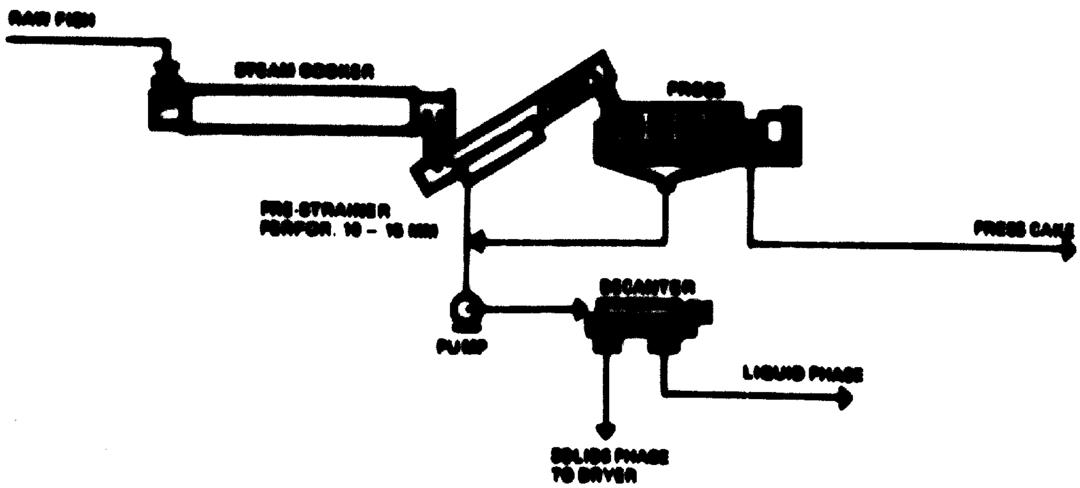

RAW FISH
STEAM COOKER
PRESS
PRE-STRAINER
PRESS CAKE
DECANTER
PUMP
LIQUID PHASE
SOLIDS PHASE
TO DRYER

Fig 9

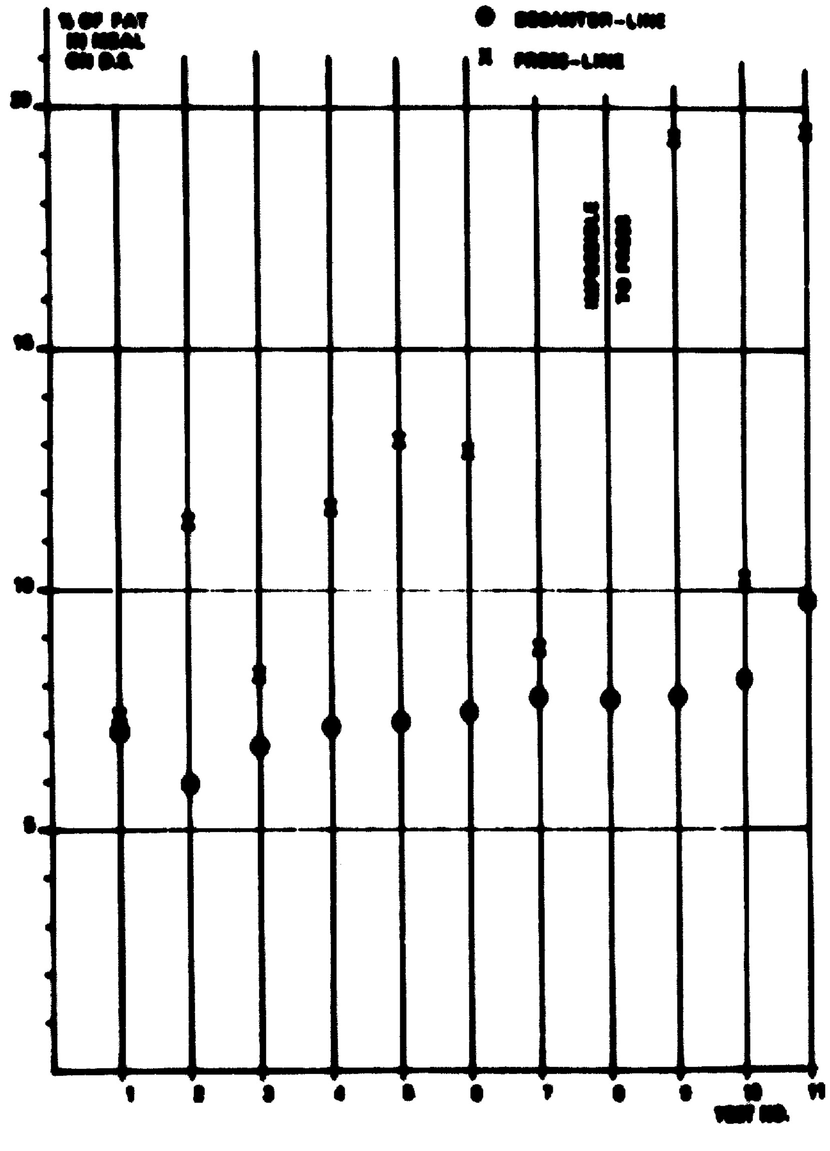
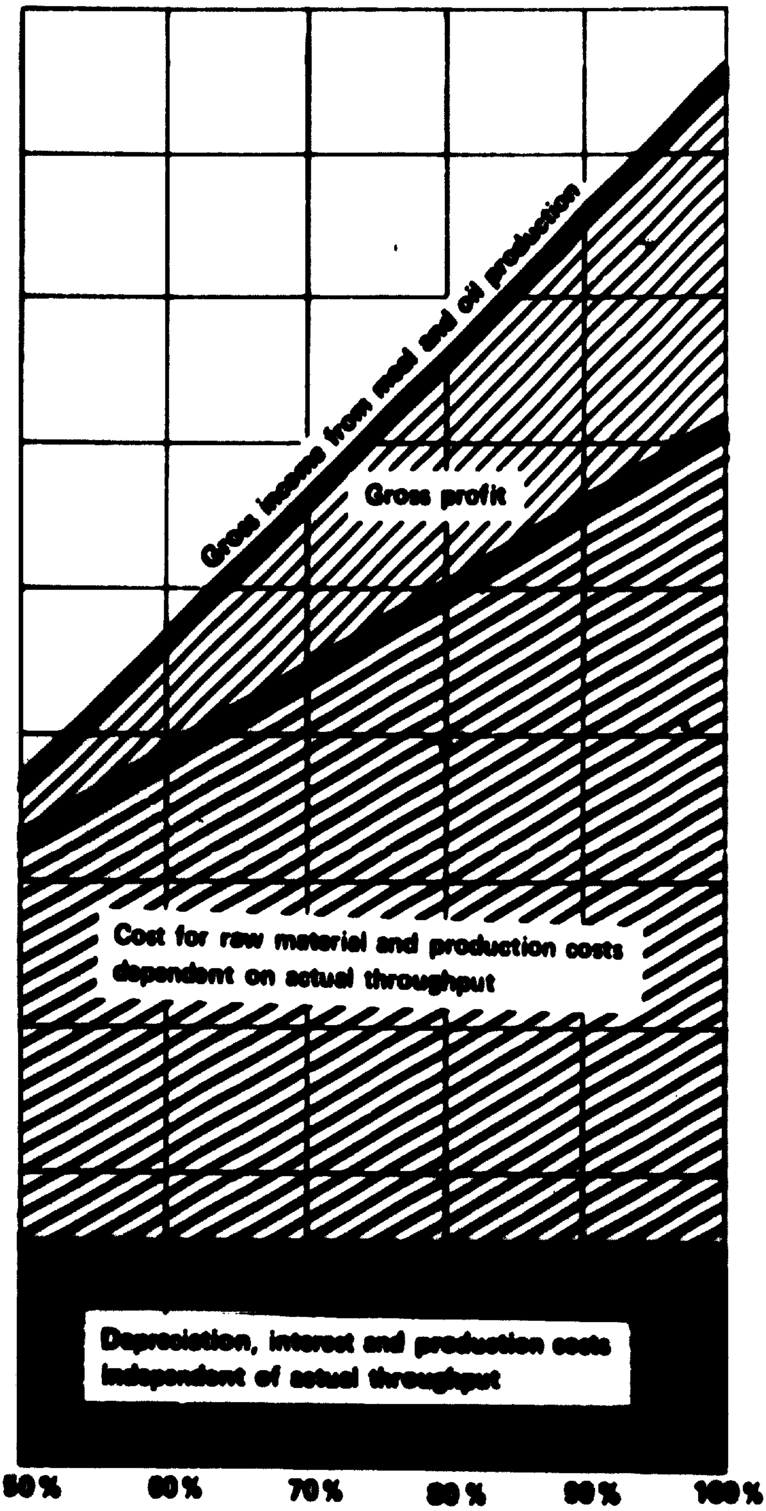


Fig 10

ECONOMICS OF REDUCED CAPACITY OPERATION



Degree of utilization i.e. actual throughput in comparison with rated capacity

Fig 11

74.09.30