

# PILOT-PLANT FISH-MEAL DRYER

By Lynne G. McKee\* and Neva L. Karrick\*\*

## PREFATORY ABSTRACT

This article reports on the design and method of construction of an experimental fish-meal dryer. The device is compact, portable, and makes possible close control of the various processing variables. From 2.5 to 10 pounds of meal can be prepared in the dryer at one time. It has been found satisfactory for processing both tuna viscera and whole herring.

## INTRODUCTION

The development of laboratory methods to determine the relative nutritional quality of fish meals is one of the important projects in the Service's Branch of Commercial Fisheries. Before such methods can be developed, however, the factors causing the differences in quality must be known. Knowledge of these factors

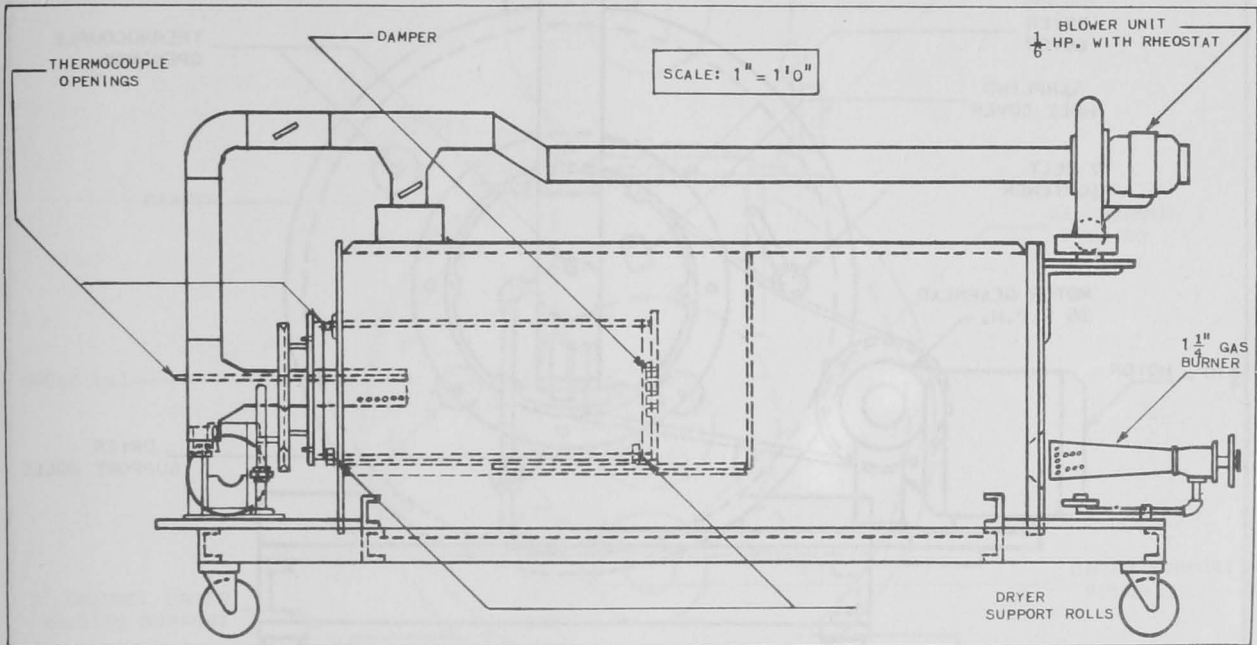


Fig. 1 - Side view of dryer housing.

then can be applied to setting up methods to determine the differences in a quantitative manner and, ultimately, to solving the problem of producing fish meal of uniform quality.

In order that the processing variables that affect the nutritive value of fish meal could be studied, a pilot plant-scale fish-meal dryer was designed and constructed. This dryer was designed in such a manner that the operator would have complete knowledge of the conditions inside of the dryer during different steps of the drying process and would be able to control these conditions. Runs thus could be repeated exactly, and variables could be introduced and controlled exactly.

For convenience and for use in limited space, the meal dryer had to be compact and portable. It had to be a complete unit, with gas and electrical connections being the only separate components needed; and it had to be large enough to hold the amount of raw material necessary to produce  $2\frac{1}{2}$  to 10 pounds of meal, which is about the amount that ordinarily is needed to check the nutritional value of the meal by chemical and biological tests.

\*Fishery Products Technologist  
\*\*Chemist

{ Fishery Technological Laboratory, Branch of Commercial Fisheries,  
U. S. Fish and Wildlife Service, Seattle, Wash.

## DESCRIPTION OF PILOT-PLANT FISH-MEAL DRYER

The essential parts of the fish-meal dryer are as follows: (1) a rotating inner drum with parallel flights (vanes) to distribute and tumble the meal while it is drying; (2) a stationary drum or housing to confine and direct the hot gasses around the rotating drum; (3) a nozzle-type gas-burner heat source; and (4) accessories--

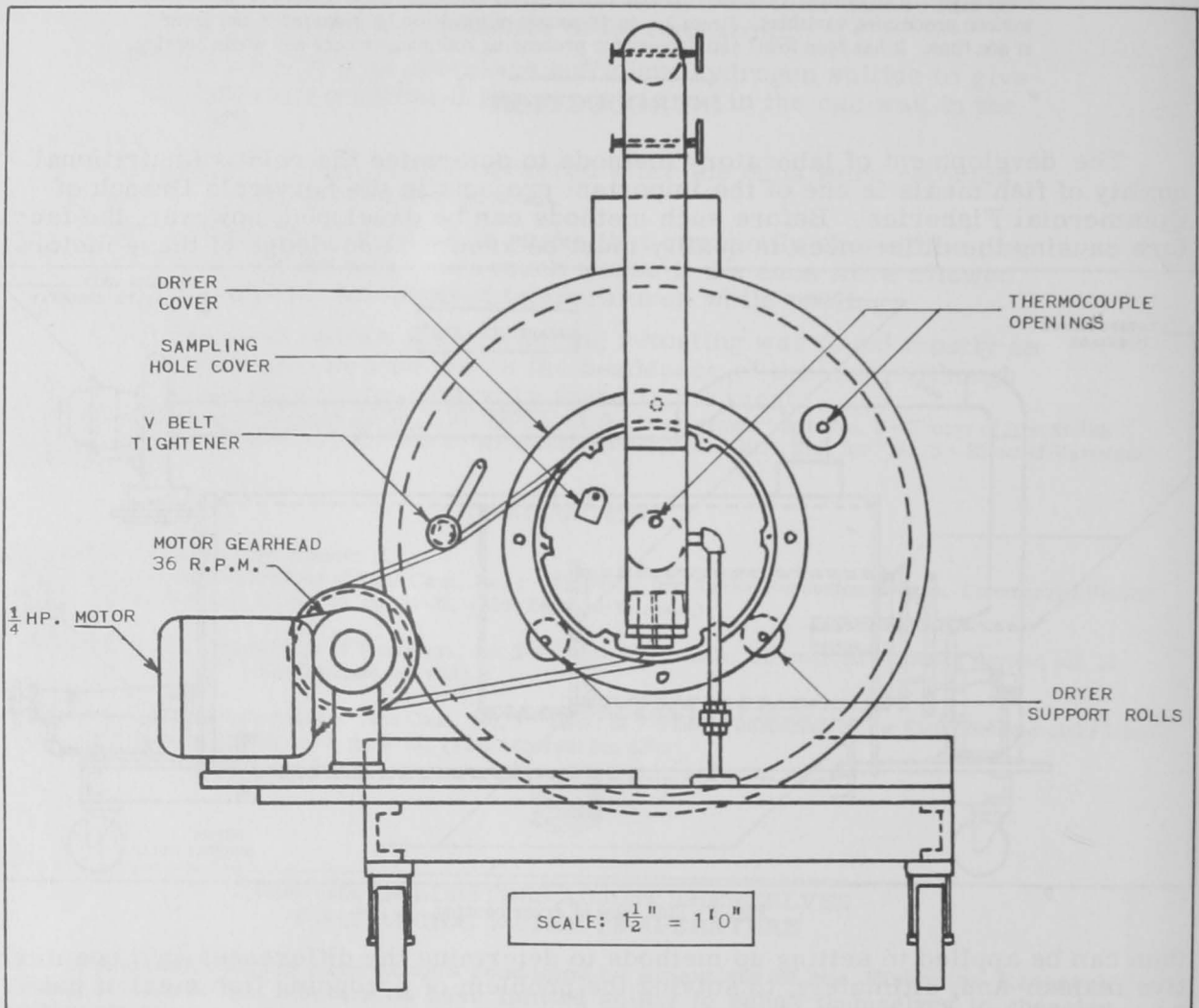


Fig. 2 - Front view of dryer housing.

drum motor, exhaust fan, thermocouples, and air ducts. Because the exact conditions used to dry the meal must be known, it was necessary to have knowledge and control of (1) the gas-air combination needed to obtain particular heating conditions, (2) the temperatures in the jacket and in the drum, (3) the regulation of the draft, and (4) the speed of rotation of the drum.

The housing of the dryer (fig. 1) was rolled from 10-gauge black sheet steel into a cylinder 24 inches in diameter and 60 inches in length. The rotating drum (the inner cylinder) was rolled from the same material and was 12 inches in diameter and 30 inches in length. All end plates and baffles were cut from the 10-gauge black sheet steel. (A lighter gauge would warp under the heat, and the inner cylinder would be distorted sufficiently to interfere with rotation; a heavier gauge would be harder to work and would make the assembly unduly heavy.) The circular disks used for end plates were cut 2 inches larger in diameter than were the respective

cylinder diameters in order to make it possible to attach the end plates to the cylinders with lugs and stove bolts. On the smaller cylinder, an iron ring made from 1-inch by 1-inch by  $\frac{1}{8}$ -inch angle iron was pressed over the ends of the cylinder, and the end plates were secured to these rings. Angle-iron lugs were welded, at intervals, to the edge of the large cylinder, and the end plates were bolted to the lugs.

The assembly (fig. 2) was mounted upon a 3-inch channel-iron frame, which was 24 inches by 84 inches and was fitted with 4-inch rubber-tired casters at the corners. The 24-inch cylinder was mounted on saddle blocks cut from 3-inch

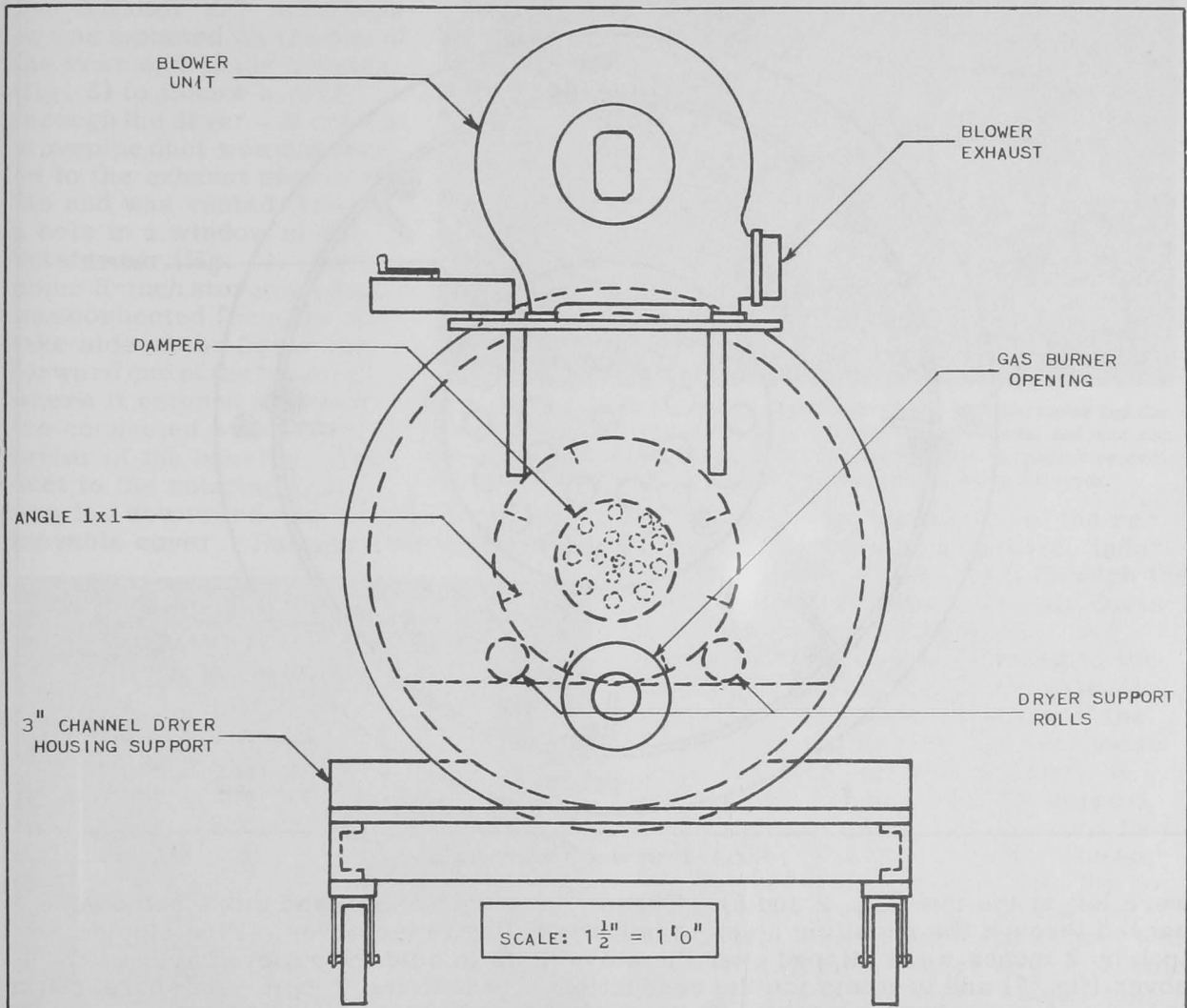


Fig. 3 - Rear view of dryer housing.

channel iron and was placed across each end of the channel-iron frame. Blocks of 85-percent magnesia were used to insulate the sides and rear of the dryer. (The front end plate was not insulated because the free space on it was too limited for the use of insulation to be practical.) The insulating blocks were covered with cotton duck in the usual manner, and the entire assembly was painted with heat-resistant aluminum paint.

The front end of the rotating drum was supported by two rollers attached to the front end plate of the housing of the dryer. The rear end of the rotating drum was

supported by two rollers on the interior of the housing (fig. 3) and was attached to an angle-iron frame welded to the inner surface of the housing. Lubrication was supplied to the rear rollers by means of two  $\frac{1}{4}$ -inch copper tubes extending through the front housing.

A 12-inch V-pulley was attached to the front cover plate to drive the rotating drum. In order that the middle area of the cover could be left free for other attachments, the hub and spokes of the V-pulley were cut away, and only short lugs

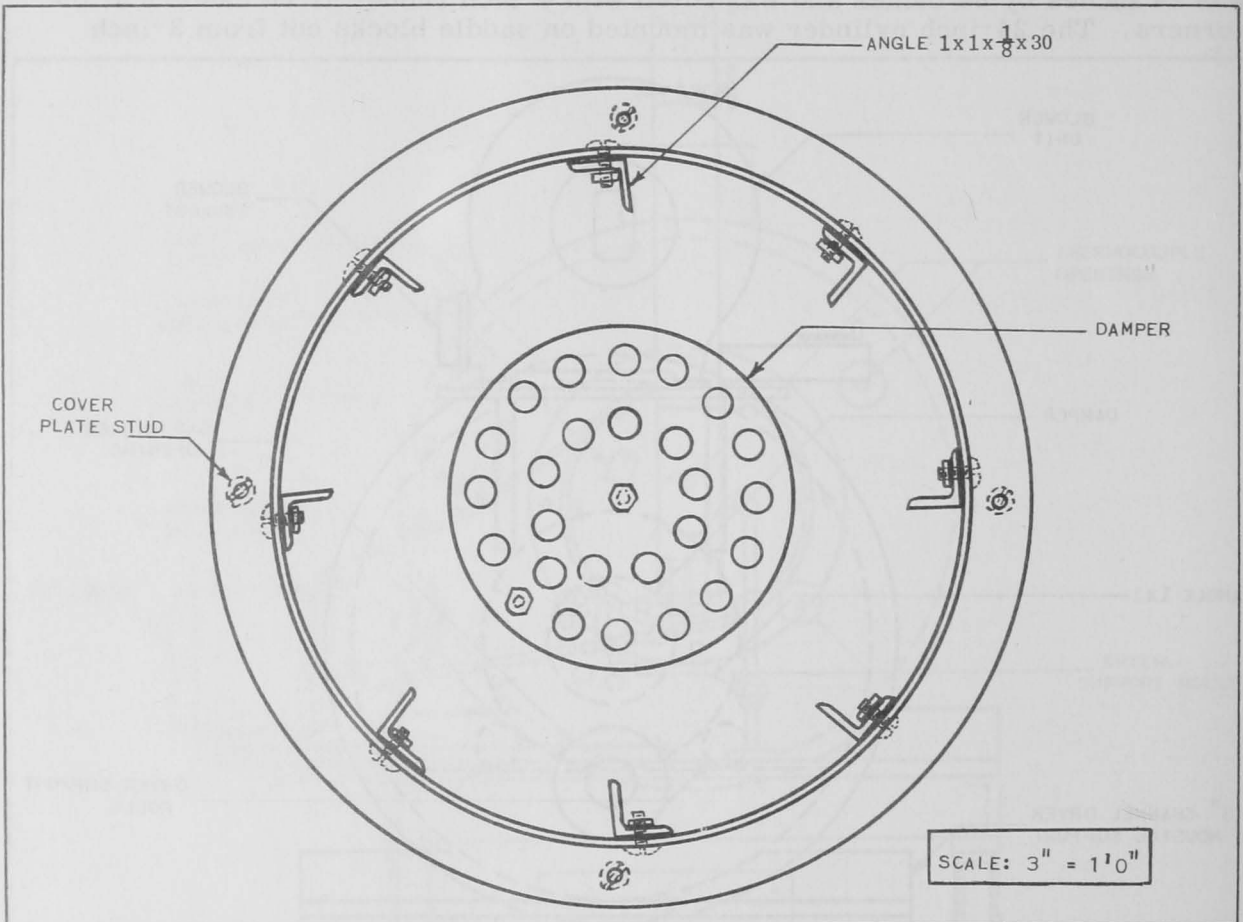


Fig. 4 - Front view of rotary drum.

were left at the rim (fig. 2 and 5). These lugs were drilled, and stove bolts were passed through the resulting holes to bolt the pulley to the cover. Pipe nipples  $\frac{1}{4}$  inch by 2 inches were slipped over the stove bolts to hold the pulley away from the cover (fig. 7) and to minimize the conduction of heat to the V-belt. A  $\frac{1}{4}$ -horsepower gear-head motor having a take-off speed of 36 revolutions per minute was used to provide power for rotating the drum at a speed of 12 revolutions per minute. An adjustable tightener was used to take up the slack in the V-belt.

The cover plate was attached to the rotating drum by means of four  $\frac{1}{4}$ -inch studs spaced equidistant around the periphery of the drum. Wing nuts were used on the studs to permit the cover plate to be removed quickly. Parallel flights were attached to the inner surface of the drum (fig. 4) to distribute the meal while it is drying. These flights consist of 8 angle-iron sections that are  $\frac{1}{4}$  inch by 1 inch by 1 inch and that are 30 inches in length. The flights were bolted to the under surface of the drum, parallel to its longer axis. The dryer was constructed level so that the meal will not gravitate to one end of the drum when it is rotating.



A damper that is 6 inches in diameter was placed on the rear end plate of the rotating drum to provide for the circulation of air through the drum. Holes  $\frac{1}{2}$  inch in diameter were drilled through the damper and the end plate to provide entrance for hot gases to the drum. The circulation of air can be adjusted by the damper. The drying process thus can be made wholly indirect or can be made semiindirect.

A motor-driven fan blower was mounted on the top of the rear end of the housing (fig. 3) to insure a draft through the dryer. A 3-inch stovepipe duct was connected to the exhaust side of the fan and was vented through a hole in a window to the outside air (fig. 6). Another 3-inch stovepipe duct was connected from the intake side of the fan to the forward end of the housing, where it entered a 3-inch tee connected with the interior of the housing. The duct to the rotating drum was led downward and into the front end of the drum through the center of the removable cover. Dampers were placed in each branch of the duct to provide independent control of the draft through the drum and the housing. The air ducts were made easily detachable. A  $\frac{3}{8}$ -inch pipe support was attached to the horizontal duct entering the drum in order to prevent the vibration of the drum from shaking the air duct loose from the elbow or from the tee. A union at the lower end of the support was adjusted finger tight in order that it could be detached quickly. The horizontal duct was projected into the rotating drum about 6 inches, and the end of the vertical duct was closed with a wooden plug. A series of  $\frac{1}{2}$ -inch holes were drilled in the lower side of the portion of the horizontal duct projecting into the rotary drum in order that the fines falling downward would not accumulate in the end of the duct. During the drying process, moisture condenses within the vertical riser of the exposed air duct. A small hole therefore was provided in the plug closing the 3-inch tee to allow this condensed moisture to escape.

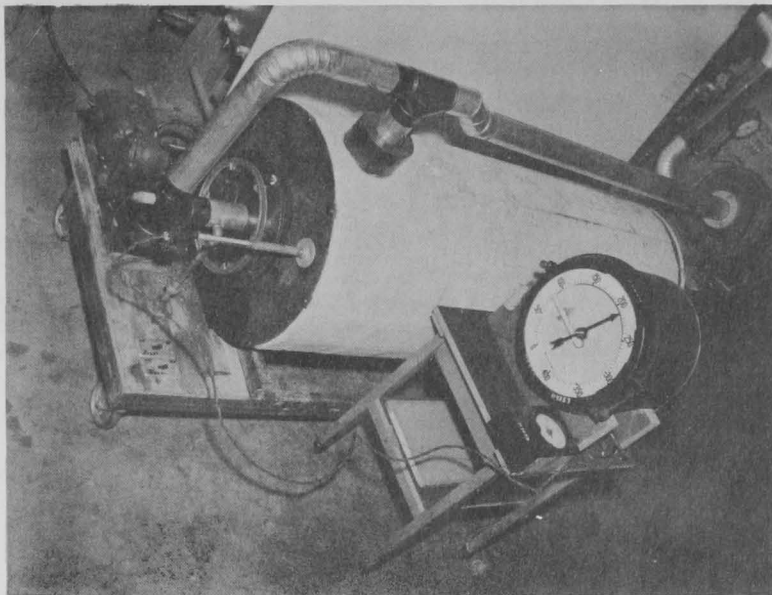


Fig. 5 - General view of laboratory-scale flame dryer. Note the motor and the drive mechanism for rotating the inner meal-containing cylinder and note also the exhaust pipes and the blower at the top. The dial-type instrument records, by means of thermocouples, the temperatures obtained within the dryer.

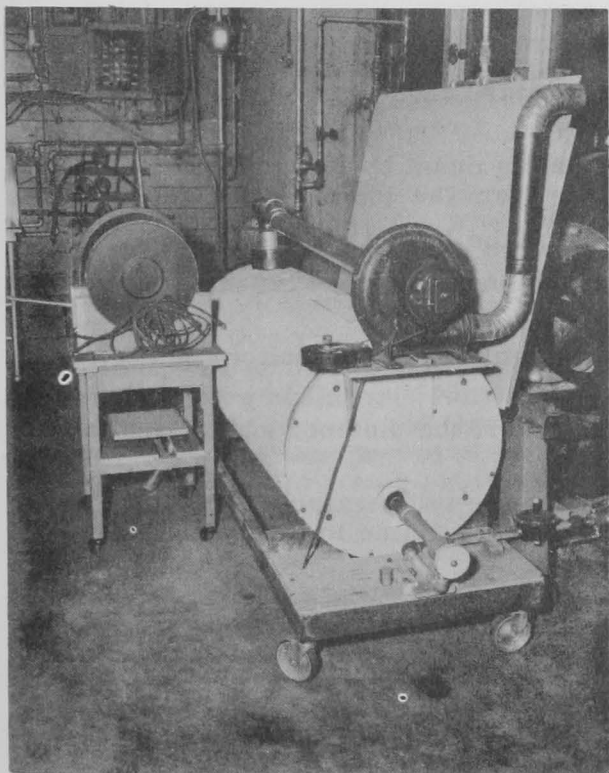


Fig. 6 - Rear view of the laboratory-scale flame dryer. Note the gas burner (near the bottom) and the blower for the discharge of gases at the top of the dryer.

The air ducts were made easily detachable. A  $\frac{3}{8}$ -inch pipe support was attached to the horizontal duct entering the drum in order to prevent the vibration of the drum from shaking the air duct loose from the elbow or from the tee. A union at the lower end of the support was adjusted finger tight in order that it could be detached quickly. The horizontal duct was projected into the rotating drum about 6 inches, and the end of the vertical duct was closed with a wooden plug. A series of  $\frac{1}{2}$ -inch holes were drilled in the lower side of the portion of the horizontal duct projecting into the rotary drum in order that the fines falling downward would not accumulate in the end of the duct. During the drying process, moisture condenses within the vertical riser of the exposed air duct. A small hole therefore was provided in the plug closing the 3-inch tee to allow this condensed moisture to escape.

A  $1\frac{1}{4}$ -inch gas burner with a  $\frac{3}{4}$  inch inlet to the city gas main was used for the source of heat. An indexed dial

was mounted on the stem of the needle valve of the burner to enable the valve settings to be repeated for replicate runs. The rheostat on the fan blower and the handles of the dampers also were indexed to allow reproducible control for replicate runs. One thermocouple was inserted into the housing space of the dryer, adjacent to the rotating drum, through a  $\frac{1}{2}$ -inch by 4-inch pipe nipple in the front end plate. A second thermocouple was inserted into the rotating drum itself by means of a  $\frac{1}{2}$ -inch tube that passes through the horizontal duct and enters the center of the drum.

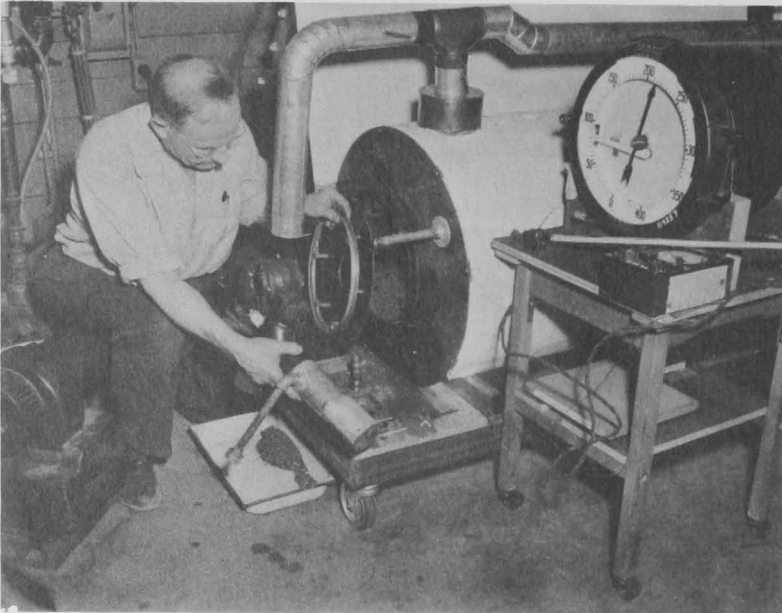


Fig. 7 - Opening the dryer preliminary to removal of the meal.

er. Figure 6 shows the rear of the dryer, with the gas burner, the fan blower, and the exhaust.

The completed dryer is shown in figures 5 and 6. Figure 5 shows the front of the dryer, with the thermocouples, the air ducts to the rotating drum and jacket, the V-belt connection to rotate the drum, and the front cover.

#### OPERATION OF THE DRYER

The dryer is operated as follows:

1. Preheat the dryer until the temperature of the combustion space is about 280° F.
2. Remove the air duct from the rotating drum by loosening the finger-tight union and pulling the duct free from the upper elbow.
3. Slacken the V-belt tightener and run the V-belt off the pulley.
4. Remove the four wing nuts from the studs and take off the cover (fig. 7).
5. Distribute pulverized press cake evenly along the bottom of the drum by means of a scoop.
6. Reassemble the cover and ducts, insert the thermocouples, and start rotating the drum.
7. Since the cold press cake will cause the temperature of the dryer to drop sharply, advance the setting of the gas flame to compensate for this drop.
8. When the dryer is at the correct temperature, which will be reached after about 10 minutes of operation, decrease the flame gradually to the point where an even temperature is maintained as the moisture is evaporated from the press cake.
9. As the press cake dries, cut the flame down gradually to prevent the resulting meal from being scorched. By the end of the run, the burner should be almost closed.

If the speed of the fan is too high, meal fines will be drawn into the horizontal duct and will settle in the lower end of the tee above the plug on the vertical riser of the air duct. Upon the completion of the run, this meal can be recovered by removing the plug at the bottom of the tee. The fan motor should be run at a speed that will maintain a great enough draft for efficient drying but that will not result in the collection of an excessive amount of fines from the rotating drum.

This pilot-plant fish-meal dryer has been operated satisfactorily both with tuna viscera and with whole herring as the raw material. Minor adjustments in operational details are necessary when the raw material is changed. When a precooked material of a light density or small particle size is used, for example, the velocity of the air in the exhaust system must be modified in order to insure that fines are not carried out of the inner drum. The meal does not stick to the side of the drum, indicating that there is adequate tumbling action. The temperature can be varied, and that selected can be maintained closely. In initial tests,  $2\frac{1}{2}$ - to 10-pound batches of meal were dried in 1 to 2 hours at a jacket temperature of 225° to 300° F.

#### ACKNOWLEDGMENT

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#### SEA GETTING WARMER

During the last two or three decades an increase in the temperature of the surface waters of the Atlantic Ocean has been demonstrated. At the sources of the Gulf Stream this rise is less than one degree Centigrade, but further north two-degree increases have been recorded. This rise is not confined to the surface waters entirely, but may extend down to depths of over 100 fathoms.

The warmer temperatures in recent years have decreased the area covered by floating ice in the Arctic, and the thickness of this ice is now reduced some 40 percent. This is important to navigation in opening up new areas and increasing the period of time that vessels may operate in the northern waters.

Owing to this rise in water temperatures the fisheries of the north have also benefited. Extensive banks, formerly too cold, have been made habitable for several species of fishes. Notable among these is cod, which has extended itself in the waters of Iceland and Greenland, and the catch of cod from these waters has increased during this period of higher temperature. Much of this increased production reaches our own tables in the form of frozen fish sticks made from frozen fillet blocks and as frozen fillets.

--Sea Secrets, The Marine Laboratory,  
University of Miami, Coral Gables, Fla.