Project Planning for Small and
Medium Scale Industries No. 16

Fishmeal Manufacturing Plant

October 1986

JAPAN CONSULTING INSTITUTE

This technical brochure was compiled to help in the drafting of a suitable plan for the construction of a Fishmeal Manufacturing Plant.

The production scale and manufacturing process have been described in this brochure on the basis of a typical instance.

The profitability was estimated by fixing certain required conditions, which may differ from country to country.

We hope that the data contained in the brochure will help you to draw up the most suitable plan for the industrialization of your project.

In case a government or public organization requests the Japan Consulting Institute to conduct a feasibility study of the above industry for the purpose of establishing the most suitable plan, it is possible for us to carry this out free of charge.

CONTENTS

1. Introduction

Man takes in animal protein from fish, livestock and poultry. In recent years the demand for meat has increased year by year with the improvement in the eating habits. In connection with this, the demand for fishmeal to feed livestock and poultry has increased, and the production of fishmeal is being expanded. Despite this, the output of fishmeal in the world is still unable to meet the demand.

Fishmeal was first produced in Scandinavia in the second half of the 19th century, when people manufactured fish oil by primitive method of using a board or a stone, and the remnant was used as fertilizer.

Early in the 20th century America, Germany and Britain began putting out fish oil and fishmeal, and they used fishmeal as fertilizer until about 1915.

The other countries followed a similar course.

In 1920 or so fishmeal came to be used as livestock feed, and fish oil used for making edible margarine and bread.

From about 1945 a large-scale fishing method using a purse seine and trawl were adopted. With the development of this new method, a fish catch increased, which helped expand the output of fishmeal.

In the 1950s Peru and Chile, which have the world's three largest fishing grounds, set up huge fishmeal manufacturing plants using anchovy, merluze which is abundantly caught there, and thus, the mass-production of fishmeal was started.

Their main markets were first West Europe and America, and later they extended their markets to other countries.

Fishmeal is not only rich in protein but also contains the essential amino acid which does not exist in vegetable feed. Hence, fishmeal is a very valuable feed.

When a comparison was made between the livestock fed with only vegetable feed and the livestock fed with an assorted feed consisting of both vegetable and fishmeal, it was proved that the latter grew 20% quicker than the former.

This explains that fishmeal contains several kinds of vitamins and minerals which often insufficiently exist in livestock feed.

It has already been proved that the assorted feed, in which fishmeal is appropriately mixed, is the best feed.

Fishmeal can be made from almost any kind of fish. The muscle and part of the intestines of fish are edible, but the remaining parts are not used for making food. The ratio between the edible and inedible parts is reportedly about 50% on an average. As Table 1 indicates, the fish catch in the world in 1984 was 82,770,000 tons, 50% of which amounts to some 41,000,000 tons. This quantity of inedible remnant and small fish are being discharged from the fish processing and canning plants as well as from fish markets. Accordingly, the disposal and utilization of such inedible parts of fish will have great significance from the point of effective use and the maintenance of environmental sanitation.

This brochure will explain an outline of the fishmeal manufacturing plant.

2. Outline of Product

Fishmeal is usually made from the whole part of fish or from the remnant. In the manufacturing process the moisture and oil contained are removed as much as possible. The final product has less than 10% moisture and oil. Fish oil is obtained as by-product in the course of making fishmeal.

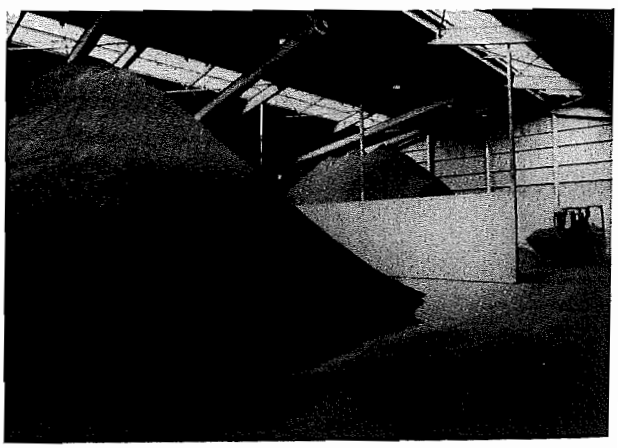


Photo 1. Fishmeal

Table 1. Change in the Fish Catch in the World from 1980 to 1984

(Unit: 1000 tons)

country \ year	1980	1981	1982	1983	1984
Japan	10,436	10,741	10,827	11,255	12,021
U.S.S.R.	9,476	9,546	9,957	9,757	10,593
China	4,235	4,377	4,927	5,213	5,927
U.S.A.	3,635	3,767	3,988	4,143	4,814
Chile	2,817	3,385	3,673	3,981	4,499
Peru	2,739	2,741	3,529	1,568	2,997
India	2,442	2,444	2,367	2,507	2,859
South Korea	2,091	2,366	2,281	2,400	2,477
Norway	2,409	2,552	2,501	2,836	2,456
Thailand	1,792	1,989	2,120	2,250	2,250
Indonesia	1,812	1,907	1,990	2,205	2,217
Philippines	1,557	1,687	1,788	1,978	1,935
Denmark	2,029	1,852	1,927	1,863	1,847
North Korea	1,400	1,500	1,550	1,600	1,650
Iceland	1,515	1,441	789	839	1,535
Spain	1,265	1,257	1,374	1,250	1,268
Canada	1,347	1,417	1,403	1,346	1,221
Mexico	1,222	1,536	1,321	1,064	1,104
Brazil	820	829	829	875	946
Ecuador	643	731	654	307	867
others	16,284	16,785	16,795	17,609	17,287
Total	71,996	74,850	76,590	76,846	82,770

2.1 Kind of Fishmeal

(a) White meal

This is made from such white meat fish as flatfish and cod. As the meal contains a small quantity of neutral fatty substance of muscle and myoglobin, it has a light color.

(b) Brown meal

This is made from such lean fish as sardine and mackerel. As the meal contains such neutral fatty substance and myoglobin, it has a brown color.

(c) Scrap meal

The above (a) and (b) are made from the whole part of fish, while scrap meal is made using the inedible part of fish (refuse). And in distinction from the other meals, it is called scrap meal.

(d) Whole meal

While being cooked and pressed in the fishmeal manufacturing process, much water soluble nutriment is removed from the raw material. Whole meal is made by recovering and concentrating the water soluble part, and by adding it to the pressed cake, and dried. Whole meal, therefore, contains the entire nutriment of the raw material fish.

2.2 Purpose of Fishmeal and Fish Oil

(a) White meal

White meal is higher than brown meal in the effectiveness of feed and in the digestion of protein. In the case of white meal, the nutrition disorder of livestock by oxidation fatty substance is seldom caused. Therefore, white meal is mainly used for fish farming.

(b) Brown meal

The quality of brown meal is graded according to the content of protein. Brown meal is mainly used as part of the assorted feed for raising livestock and poultry.

(c) Scrap meal

Scrap meal is used for the same purpose as brown meal, but inferior scrap meal is used as carrier material for high-quality meal or is used as fertilizer.

(d) Whole meal

The same as brown meal.

(e) Fish oil

Oil extracted from all parts of sardine and mackerel is refined and hydrogenated to be used as shortening oil for cake making

and as raw material of margarine. Fish oil is also used as fuel. Cod-liver oil extracted from the intestines of Alaska pollack is used for making edible oil as is the case with the fish oil.

Liver oil extracted from the intestines of cuttle-fish is used as industrial oil (paints and printing oil) because it is high in the unsaturation degree.

Table 2 shows the percentage of oil being contained in the typical kinds of fish, which are used as raw material for making fishmeal. The oil content differs according to the time of fish catching, age, and seasons.

Table 2. Oil Content of Fish

Kind of fish	Oil content (%)
Herring	10 ~ 25
Anchovy	3 ~ 8
Cod	0 ~ 2
Red fish	6 ~ 10
Flatfish	2 ~ 3
Mackerel	7 ~ 20
Shark	0 ~ 2
Alaska pollack	2 ~ 3

Table 3. Change in the Fishmeal Production in Major Countries from 1981 to 1985

(Unit: 1000 tons)

country \ year	1981	1982	1983	1984	1985
Denmark	330.0	317.4	281.9	316.3	283.8
France	15.9	17.5	18.3	17.0	22.0
Britain	59.7	56.4	54.2	57.6	53.2
West Germany	38.5	36.8	35.8	36.5	36.0
Faeroeisland	20.0	16.3	24.4	37.0	37.5
Iceland	147.9	40.5	67.5	158.0	197.0
Norway	299.5	286.3	346.8	293.0	238.0
Spain	36.7	37.3	29.8	37.0	34.0
Sweden	13.1	13.7	10.4	12.0	12.3
Poland	50.5	38.2	54.3	60.0	67.0
Rumania	10.9	12.4	11.6	10.0	11.0
U.S.S.R.	553.0	600.2	604.1	673.0	685.0
South Africa	154.1	137.9	143.7	115.0	114.0
Canada	76.2	70.0	67.4	63.0	64.0
U.S.A.	281.3	330.3	338.9	328.0	349.0
Mexico	117.2	111.3	60.1	56.0	59.0
Panama	22.0	15.0	26.0	22.0	27.0
Argentine	22.0	21.0	14.0	13.0	12.0
Brazil	25.9	25.0	29.0	28.0	25.0
Chile	687.7	782.2	806.8	999.0	1,121.0
Ecuador	123.3	114.0	21.8	133.0	146.0
Peru	478.2	645.2	219.4	531.0	605.0
South Korea	15.2	24.8	33.0	28.0	29.0
Thailand	186.2	186.2	188.4	207.0	191.0
China	–	–	65.0	53.0	55.0
Japan	884.7	993.9	1,145.0	1,283.4	1,478.6
others	1,039.1	1,068.2	1,238.1	1,329.6	1,032.2
Total	5,688.8	5,998.0	5,936.5	6,896.4	6,986.5

Note: 1. FAO's statistics for 1981 ~ 83. The Soluble is excluded as a rule.
2. The statistics for the year 1984 is from the Oil World, in which the Soluble is included as a rule.

2.3 Change in the Production

Table 3 shows the change in the fishmeal production in major countries from 1981 to 1985.

3. Raw Material

Fishmeal can be made from almost all kinds of fish. Not only the inedible part but also the whole part of all kinds of small fish, that are caught abundantly, are used as raw material.

(a) Inedible part (remnant after being processed)

It consists chiefly of the remnant of Alaska pollack which was used for making the frozen surimi on factory ships or in the plants on the shore as well as the remnants of skipjack, tuna, salmon, trout, mackerel which are discharged from canneries.

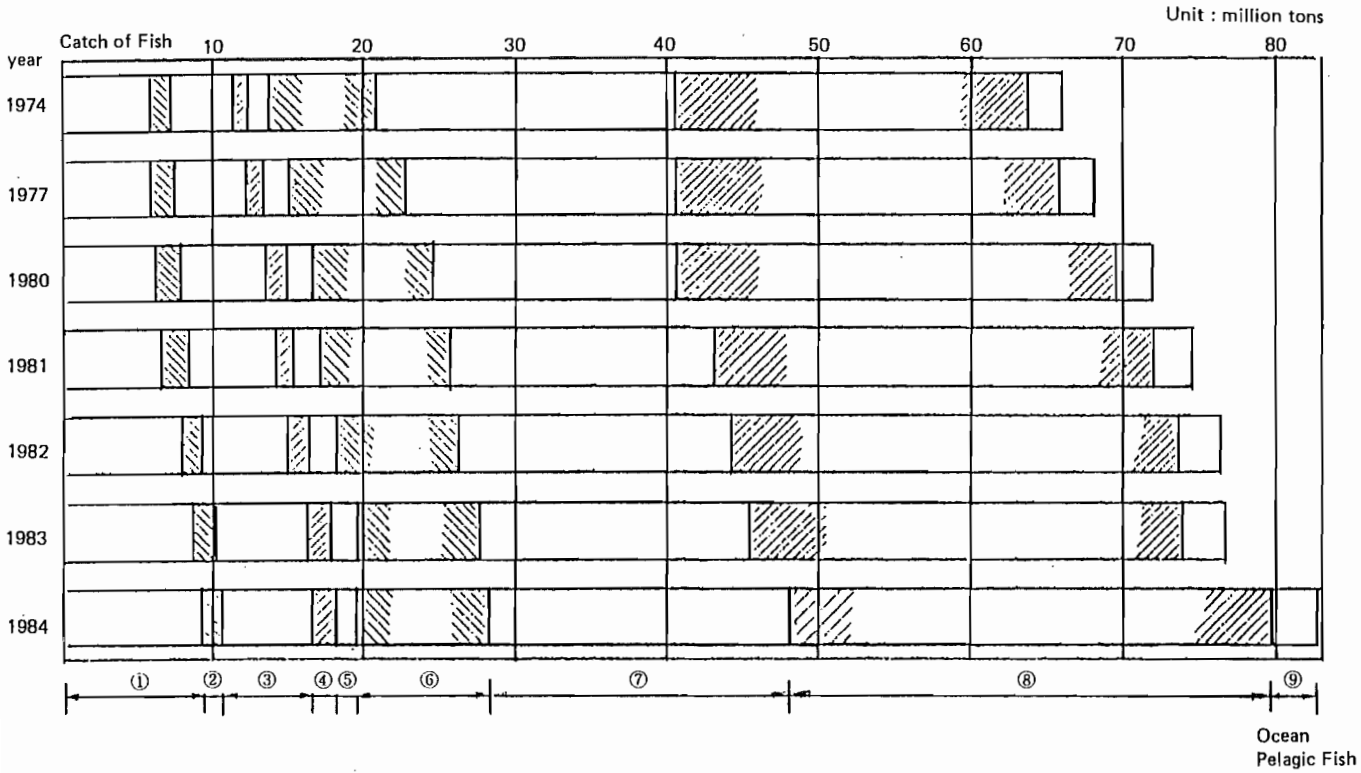
In addition, miscellaneous remnants coming from wholesale markets and fresh fish retainer are used.

(b) Whole part of fish

The fish, the whole part of which is used as raw material, are herring, sardine, Pacific saury, mackerel, anchovy, pilchard, which are caught in large quantities. Besides, small Alaska pollack and flatfish are used.

Table 4 shows the catch of principal fish in the

Table 4. Catch of Principal Fish in the World from 1974 to 1984



Remark : ① Fresh Water Fish
② Salmon Trout, Other Anadoromous Fish
③ Other Marine Animal
④ Cuttle Fish (Squid), Octopus
⑤ Prawns (Shrimps)
⑥ Miscellaneous Fish, Trash Fish
⑦ Flatfish, Bastard Halibut, Cods, Red Meat Fish, Sharks.
⑧ Horse Mackerels, Mackerels, Sardines, Anchovies, Herrings.
⑨ Skipjacks, Tunas.

Note : The Miscellaneous fish and Trash fish in the FAO Yearbook of Fishery Statistics being mainly Demersal fish, they were classified as the Demersal fish.

world from 1974 to 1984.

Protein being an important ingredient as livestock feed, a comparison will be made on its content between vegetable meal and fishmeal in Table 5, referring to herring meal, peanut meal and soybean meal.

Table 5 Comparison of Protein Content (wt%)

	Protein	Fats	Water	Salt	Ash
Herring meal	72	8	9	2	9
Peanut meal	50	7	9	0.1	6
Soybean meal	45	6	10	0.1	6.7

4. Manufacturing Process

Fig. 1 shows an outline of the standard fishmeal manufacturing process, and its gist is explained. Fig. 2 shows the process flow sheet.

① Raw material storage

Concrete storage with an outlet for oil and blood coming from the raw material fish.

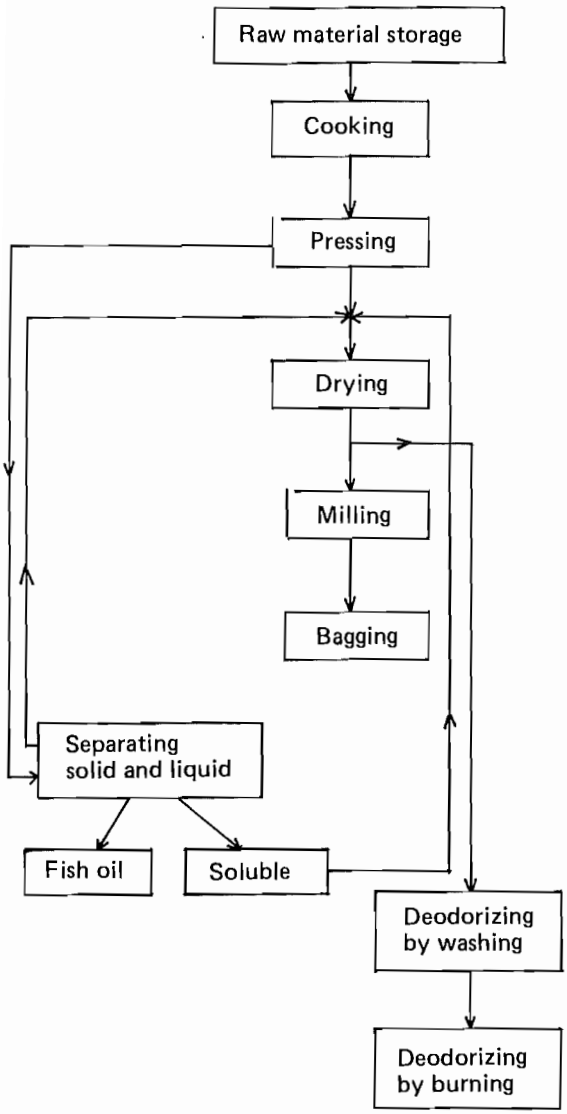


Fig 1. Fishmeal Manufacturing Process

② Cooking

Heating and cooking by steam are made directly or indirectly so as to solidify protein and to easily separate liquid and oil. Pasteurization and disinfection are also made.

③ Pressing

Drying process burden is alleviated by screw press, and fish oil is extracted.

④ Drying

Moisture is reduced down to about 10%.

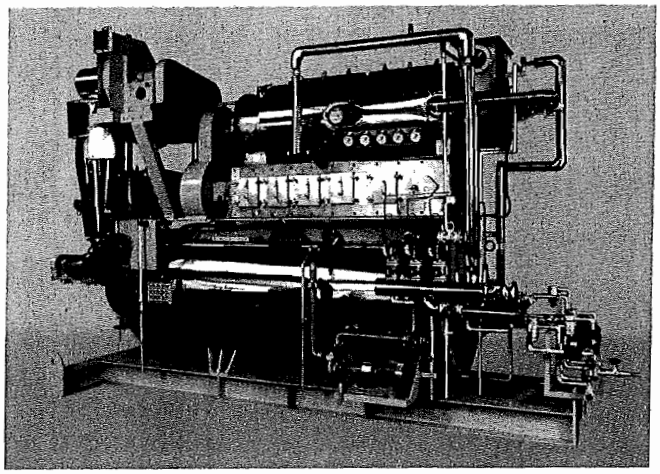


Photo 2. Meal Unit (Cooker, Screw Press, Dryer)

⑤ Milling

To remove iron in the meal, raw material passes through a rotary magnetic iron separator or through a stationary magnet, and is crushed by hammer mill, and then is sent into the cooling air.

⑥ Bagging

Automatically weighed and bagged.

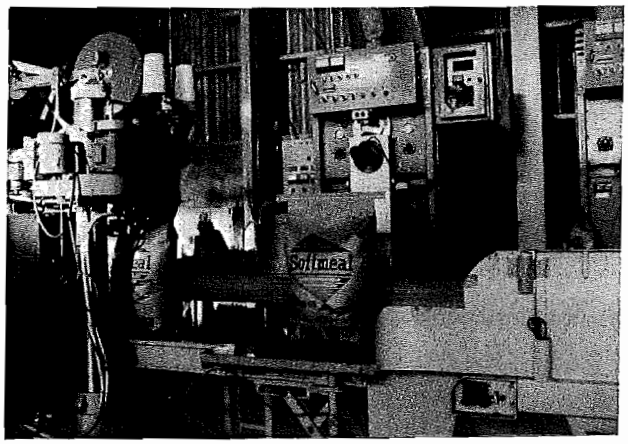


Photo 3. Bagging

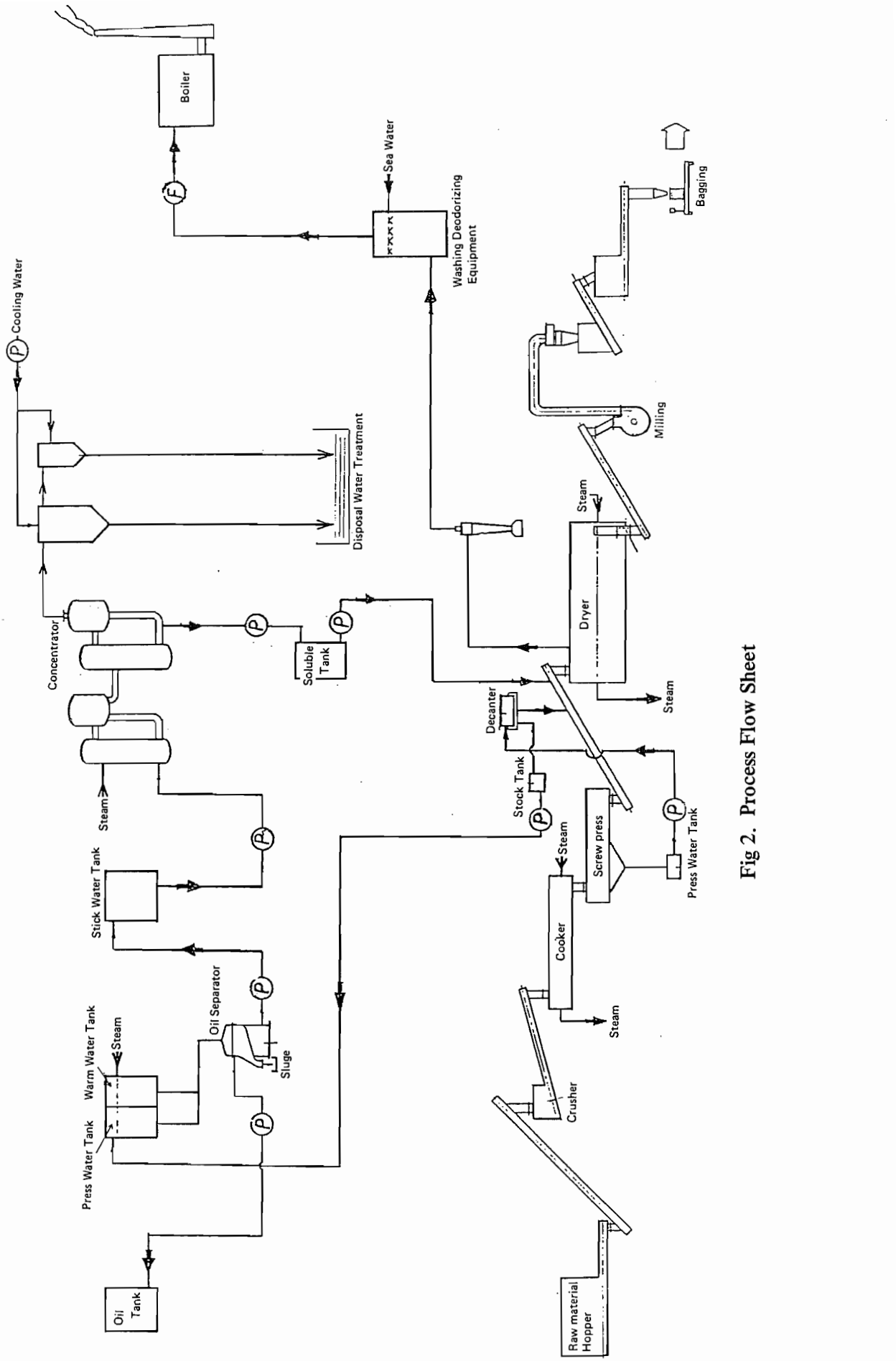


Fig 2. Process Flow Sheet

⑦ Separating solid and liquid

Compressed liquid is separated into solid and liquid by decanter, and the solid is returned to the drying process; and the liquid is separated into fish oil and stick water by decanter.

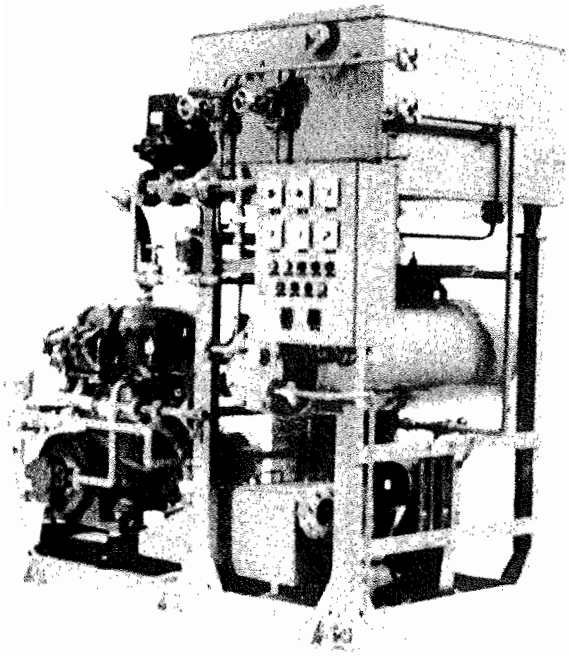


Photo 4. Oil Separator

⑧ Soluble

Stick water is concentrated to 50% moisture to obtain soluble. It is again mixed with the solid in the drying process to make whole meal.

⑨ Deodorizing

The machines (cooker, press, conveyer, dryer, tank, centrifugal separator), which emit bad smell, are of the sealing type. They are connected with an air-duct, and the bad smell is made to pass through a washer by exhaust fan, and then is carried to the boiler burner for deodorizing by burning.

5. Fishmeal Model Plant

In planning a fishmeal manufacturing plant, it is necessary to fully investigate the availability of raw material and utilities, and to select a suitable plant site, and fix a production scale.

Fish oil is usually generated in a fishmeal manufacturing plant as by-product.

5.1 Production Scale

Required quantity of raw material	25 tons/24hrs
Output	5 tons/24hrs
Annual number of working days	300 days
Annual output	
Fishmeal	1,500 tons
Fish oil	375 tons

5.2 Required Quantity of Raw Material

Raw material	7,500 tons/year
Bag (20 kg bag)	75,000 bags

5.3 Utilities

Electricity
63 kWh/hr x 0.75 x 24 hrs x 300 days
= 340,200 kWh

Steam 800 kg/hr

Fuel oil
64 *l*/hr x 24 hrs x 300 days
= 460,800 *l*

Cooling water (Seawater)
20 m³ /hr x 24 hrs x 300 days
= 144,000 m³

Fresh water
0.2 m³ /hr x 24 hrs x 300 days
= 1,440 m³

5.4 Machinery and Equipment Required

The machinery and equipment required are shown in Table 6.

Table 6. Machinery and Equipment Required

No.	Kind of Machine	Quantity
1	Raw material storage (25 m³)	1
2	Raw material hopper, discharging conveyer	1
3	Conveyer carrying raw material to crusher	1
4	Crusher	1
5	Raw material intermediate hopper	1
6	Fixed quantity supply conveyer	1
7	Meal unit	1 unit
8	Milling unit	1 unit
9	Meal intermediate receiving hopper	1
10	Meal conveyer	1
11	Conveyer carrying meal into silo	1
12	Meal silo	1
13	Weighing machine	1
14	Meal bag sewing machine	1
15	Stick water tank	1 unit
16	Oil separator	1 unit
17	Washer	1 unit
18	Concentrator	1 unit
19	Washing deodorizer	1 unit
20	Boiler	1 unit
21	Boiler attachment	1 unit
22	Soft water tank	1
23	Fuel oil tank	1
24	Fish oil tank	1

5.5 Price of Machinery and Equipment

The price of machinery and equipment, which are shown in Table 6, is as follows:

Price of machinery and equipment
US$1,040,000
FOB Japanese port as of 1986

Note: The exchange rate of the U.S. dollar to the Japanese Yen is assumed to be US$1 = ¥180.

5.6 Layout of Plant and Construction of Buildings

(1) Plant area 850 m²

(2) Floor space

Raw material storage	6m x 8m = 48 m²
Machine room	15m x 8m = 120 m²
Product warehouse	15m x 8m = 120 m²
Boiler room	5m x 8m = 40 m²
Administration room	11m x 8m = 88 m²
Total	416 m²

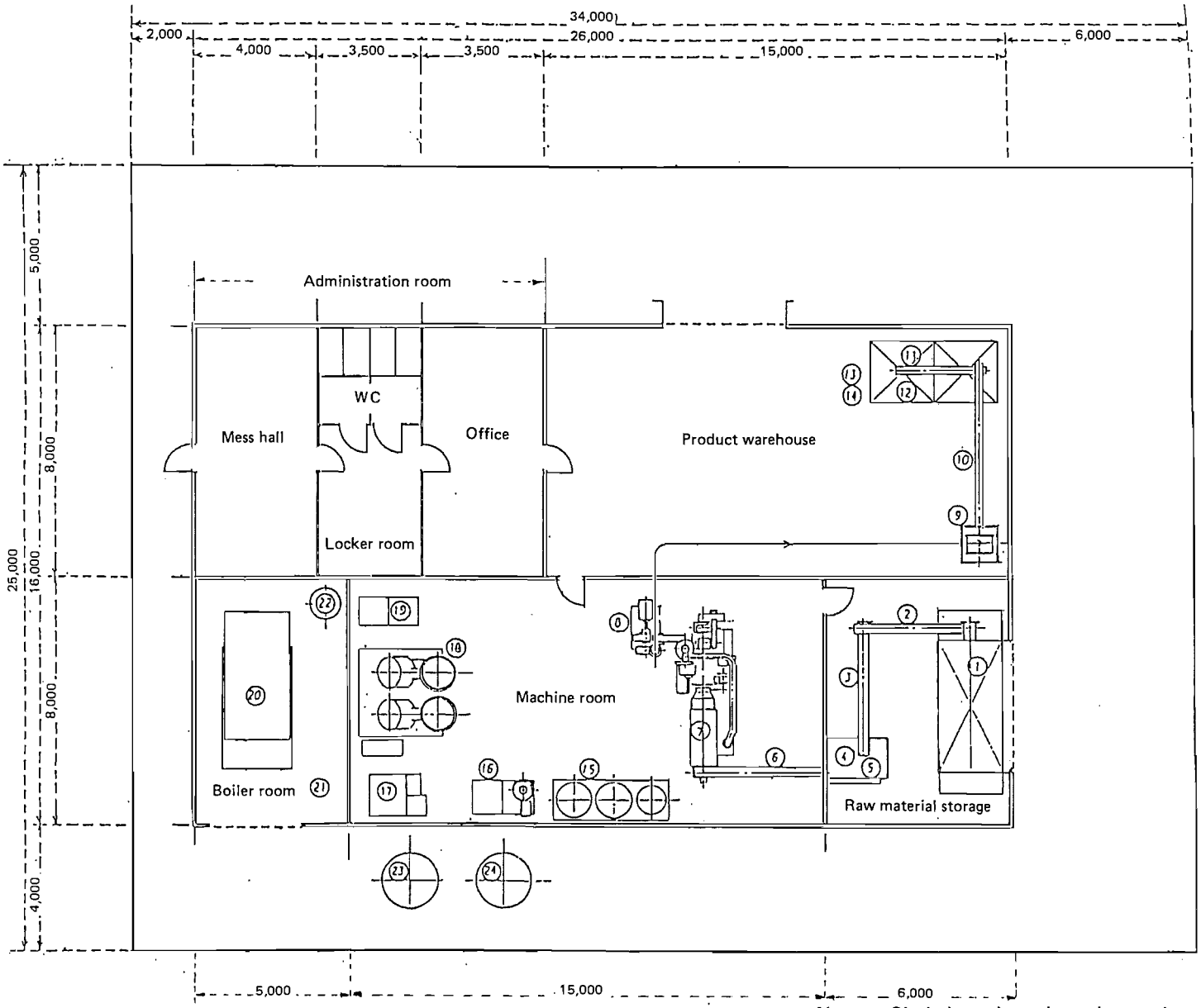
(3) Layout of plant

Fig.3 shows the layout of fishmeal manufacturing plant.

5.7 Labor Required and Placement

Table 8. Labor Required and Placement

Division	Male	Female	Total
Factory manager	1		1
Managerial officer	1		1
Clerk	1	3	4
Engineer	1 x 3		3
Skilled worker	1 x 3		3
Unskilled worker	4 x 3		12
Odd-job man	2 x 3		6
	27	3	30



Note : Circled numbers show the number of machines in Table 6.

Fig 3. Layout of Fishmeal Manufacturing Plant

6. Production Cost and Profitability

The production cost must be calculated according to the conditions of each country concerned. However, it being difficult to do so, the calculation of production cost was made on the following basis in this brochure.

6.1 Basic Conditions for the Calculation of Fixed Capital, Working Capital and Production Cost

(1) Fixed capital

(a) Construction cost of factory, office and warehouse is assumed to be US$250/m². The land price is omitted from calculation.

(b) Machinery and equipment cost is shown by FOB Japanese port as of 1986.

(c) Spare parts cost is assumed to be 10% of the FOB price of machinery and equipment.

(d) Freight and insurance cost is assumed to be 10% of the FOB price of machinery and equipment.

(e) Civil engineering cost for foundation is assumed to be 10% of the FOB price of machinery and equipment (including miscellaneous work).

(f) Erection cost is assumed to be 6% of the FOB price of machinery and equipment.

(g) Supervision cost is assumed to be 6% of the FOB price of machinery and equipment.

(h) Commissioning cost is assumed to be 2% of the FOB price of machinery and equipment.

(i) Training cost is assumed to be 3% of the FOB price of machinery and equipment.

(j) Contingency is assumed to be 10% of the FOB price of machinery and equipment.

(2) Working capital

(a) Raw material cost for one month operation.

(b) Storing of products for one month.

(3) Production cost

(a) Raw material cost

Raw material	US$0.025/kg
Bag	US$0.3/bag

(b) Utilities cost

Electricity	US$0.06/kWh
Water	US$0.40/m³
Fuel oil	US$200/kl

(c) Labor cost

Direct labor cost (per head a year) is assumed to be as follws:

Factory manager	US$12,000
Managerial officer	US$ 6,000
Clerk	US$ 3,000
Engineer	US$ 5,000
Skilled worker	US$ 4,000
Unskilled worker	US$ 3,000
Odd-job man	US$ 500

(d) Maintenance cost

Maintenance cost is assumed to be 3% of the FOB price of machinery and equipment.

(e) Depreciation cost

Straight-line method will be adopted. The depreciation cost of machinery and equipment is as follows:
(Fixed capital-building construction cost) x 7%.
Depreciation cost of buildings is assumed to be 3%.

(f) Insurance cost

Insurance cost is assumed to be 0.5% of the fixed capital.

(g) Interest

One-second of the fixed capital is to be covered by a long-term loan with an annual interest rate of 10%.

(h) Selling and administration expenses

Selling and administration expenses are assumed to be 5% of the sales.

Note: The exchange rate of the U.S. dollar to the Japanese Yen is assumed to be US$1 = ¥180.

6.2 Capital Required

(1) Fixed capital	US$
Plant area: 850m²	—
Floor space of factory and office: 416m²	104,000
Machimery and equipment	1,040,000
Spare parts	104,000
Freight and insurance	104,000
Civil engineering work	104,000
Erection work	62,400
Supervision	62,400
Commissioning	20,800
Training	31,200
Contingency	104,000
Sub-total	US$1,736,800

(2) Working capital	US$
Raw meterial cost for one month	17,500
Storing of products for one month	45,489
Sub-total	US$62,989

(3) Capital required (1) + (2)	US$1,799,789

6.3 Production Cost

(a) Cost of raw material	US$
Raw material	
US$25/ton x 7500 ton	187,500
Bag	
US$0.3/bag x 75,000 bag	22,500
Sub-total	US$210,000

(b) Utilities cost	US$
Electricity	
US$0.06/kWh x 340,200 kWh	20,412
Water	
US$0.40/m³ x 1,440 m³	576
Fuel oil	
US$200/kl x 460.8 kl	92,160
Sub-total	US$113,148

(c) Labor cost	US$
Factory manager	
US$12,000 x 1	12,000
Managerial officer	
US$6,000 x 1	6,000
Clerk	
US$3,000 x 4	12,000
Engineer	
US$5,000 x 3	15,000
Skilled worker	
US$4,000 x 3	12,000
Unskilled worker	
US$3,000 x 12	36,000
Odd-job man	
US$500 x 6	3,000
Sub-total	US$96,000

(d) Maintenance cost	
US$1,040,000 x 3%	US$31,200

(e) Depreciation cost

Machinery and equipment	
US$1,632,800 x 7%	US$114,296
Buildings	
US$104,000 x 3%	US$3,120
Sub-total	US$117,416

(f) Insurance cost

US$1,736,800 x 0.5%	US$8,684

(g) Interest

US$1,736,800 x ½ x 10%	US$86,840

(h) Selling and administration expenses

US$795,000 x 5%	US$39,750
Total for (a) to (h)	US$703,038

The production cost per ton will become US$703,038 ÷ 1,500 tons = US$468/ton.

6.4 Annual sales

It is difficult to fix the price of fishmeal because it depends on the kind of fish to be used, and also the market price sharply fluctuates according to the catch of fish. Hence, the sales was calculated based on the recent average unit price in Japan as below.

Fishmeal	US$480/ton x 1,500 ton = US$720,000
Fish oil	US$200/ton x 375 ton = US$75,000
Total sales	US$795,000

Note: The unit price of fish oil (US$200/ton) does not include the container.

6.5 Profitability

Profitability of the projected model plant will become as follows when calculated according to the conditions cited above.

Annual sales of products	US$795,000
Selling cost	US$703,038
Profit	US$ 91,962

The rate of profit against annual sales
US$91,962 ÷ US$795,000
= 11.5%

The rate of profit against capital
US$91,962 ÷ US$1,799,789
= 5.1%

The profit ratio of sales being 11.5% and the profit ratio of capital 5.1%, the profitability may be comparatively good.

7. Conclusion

In recent years the fishing zone and fishing right problems are getting more and more difficult worldwide. Therefore, the effective use of the limited marine resources is quite important from the point of food supply and demand.

The construction of a fishmeal manufacturing plant, which uses the inedible parts of fish as its raw material, is a significant project when viewed from the current international situation and future trend.

Project Planning for Small and Medium Scale Industries

No. 1 Rice Milling Plant and Rice Bran Oil Manufacturing Plant
No. 2 Plastic Woven Bag Manufacturing Plant
No. 3 Container Board Manufacturing Plant
No. 4 Plastic Blow Bottle Manufacturing Plant
No. 5 Concrete Block Manufacturing Plant
No. 6 Glassware Manufacturing Plant
No. 7 Galvanized Iron Sheet Manufacturing Plant
No. 8 Fishing Net Manufacturing Plant
No. 9 Ice Making, Refrigeration and Cold Storage Plant
No.10 Starch and Syrup Manufacturing Plant
No.11 Instant Noodle Manufacturing Plant
No.12 Surimi and Surimi-Based Food Manufacturing Plant
No.13 Polyethylene Shopping Bag Manufacturing Plant
No.14 Retreading Tire Manufacturing Plant
No.15 Husk Fired Thermal Power Plant
No.16 Fishmeal Manufacturing Plant

Project Planning for Small and Medium Scale Industries No.16

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Edited date: October 1986