

**Project Planning for Small and  
Medium Scale Industries No.30**

**Insulator**

**Manufacturing Plant**

**March 1990**



**JAPAN CONSULTING INSTITUTE**

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

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## 1. Introduction

The insulator being used in electric facilities is so wide in variety that there are tens of types. Moreover, each insulator has its own important role. Once the insulator should lose its function, the electric facilities would become unable to perform their normal operation, which results in cutting off the power supply to households and factories. Thus it may cause a great damage.

Therefore, in manufacturing an insulator, care must be taken that the insulator satisfies the electrical characteristic, mechanical characteristic and thermal resistance that are required for the purpose. As the materials that meet these characteristics, there are porcelain, glass and resin, of which porcelain is being most used.

Porcelain is one of the ceramic wares which are generally called ceramic. In making porcelain, clay or the inorganic matter resembling clay is given plasticity to be formed and dried, which is then fired hard at a sufficiently high temperature that can produce the glass phase for vitrification. Compared with other materials, porcelain has not only good insulation but also remarkably excellent weather resistance and thermal resistance as well as water resistance and chemicals resistance, and seldom changes its shape from mechanical load. Also, the price of porcelain is relatively low. On the other hand, porcelain is weak against impact load and can not be machined after firing.

## 2. Function of the Insulator

### 2.1 What is the Insulator

It is defined that the "insulator is a tool that supports the laid electric wire and prevents the electric current that flows through the electric wire from passing to a strut."

### 2.2 Function of the Insulator

The functions required of the insulator are the following three points, each of which must be fulfilled.

#### ① Mechanical strength

For the purpose of supporting a heavy

wire.

#### ② Electrical insulation

For the purpose of preventing the flow of electric current to a strut.

#### ③ Weather resistance

For the purpose of resisting the climatic change like rain, wind and temperature.

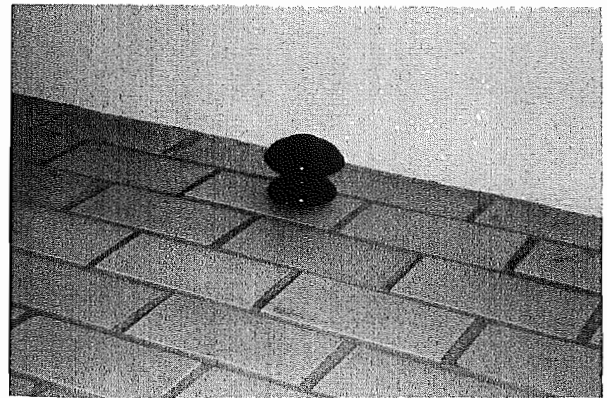


Photo 1. Shackle Insulator

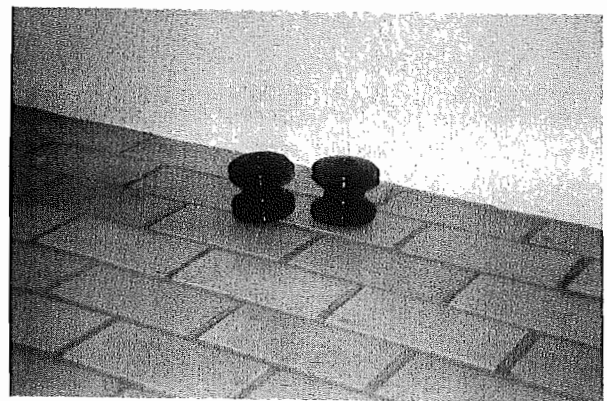


Photo 2. Reel Insulator

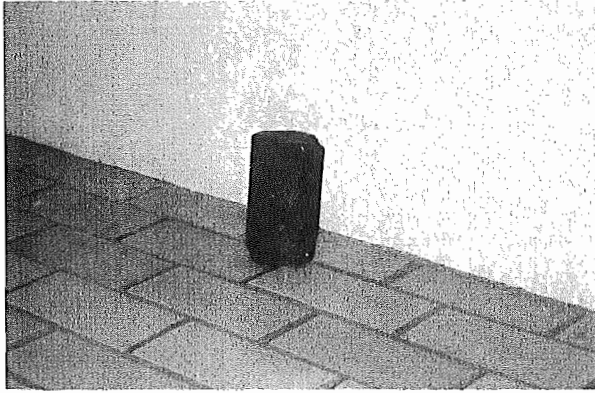


Photo 3. Stay Insulator

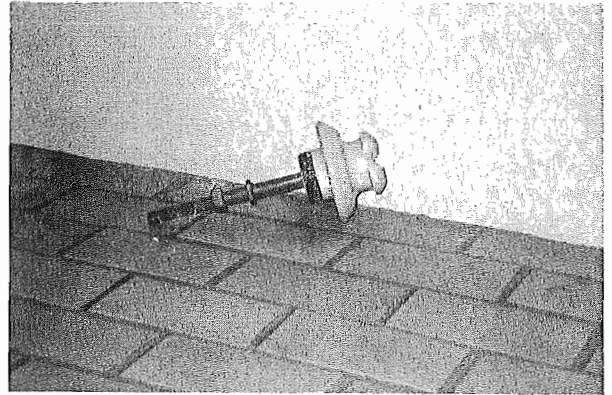
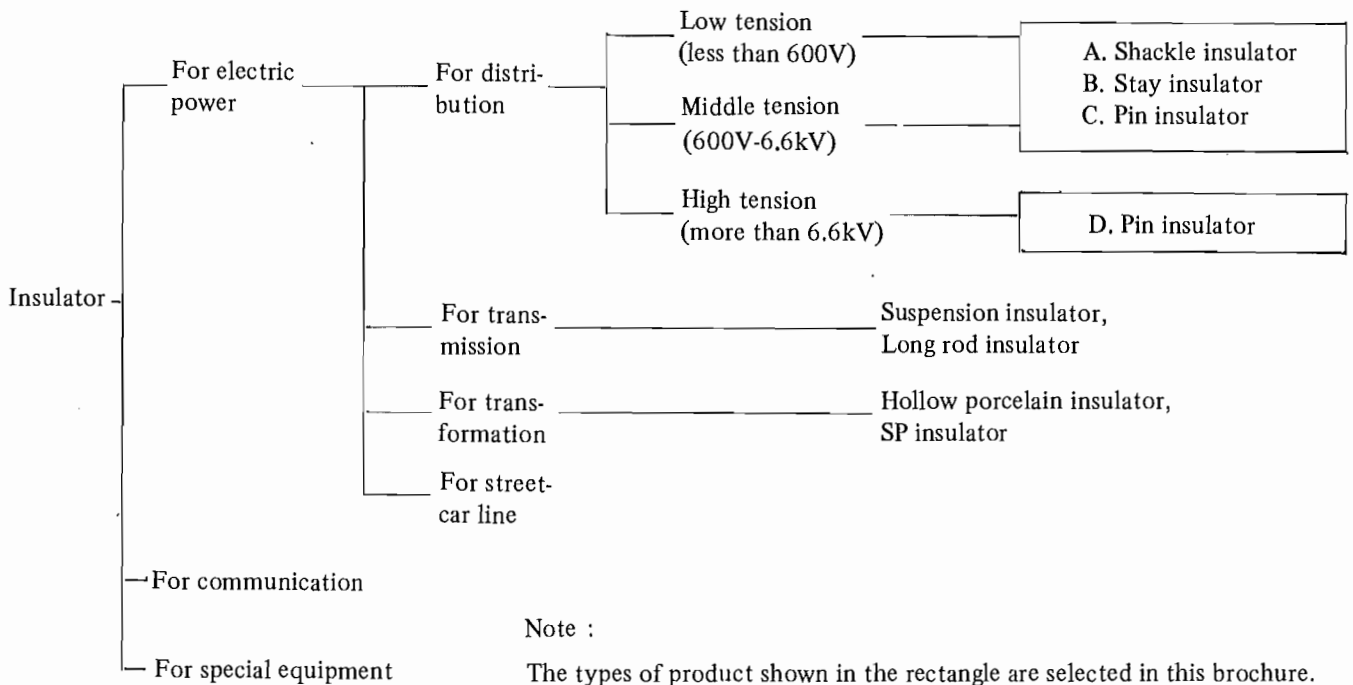


Photo 4. Pin Insulator

### 2.3 Purposes and Types of the Insulator

The insulator can roughly be classified by purpose and type as below.



### 3. Raw Materials

The raw materials of body and glaze which are necessary for the production of insulator porcelain are as follows.

- (1) Silica stone or silica sand
- (2) Feldspar
- (3) Ball clay
- (4) Kaolin (china clay)

In addition to the above, glaze needs the following raw materials.

- (5) Talc
- (6) Dolomite
- (7) Calcite or limestone

The chemical compositions of the raw materials which are used for manufacturing various insulator porcelains are shown in Table 1.

Table 1. Chemical Compositions of Raw Materials

(unit: wt%)

Kind	SiO <sub>2</sub>	TiO <sub>2</sub>	Al <sub>2</sub> O <sub>3</sub>	Fe <sub>2</sub> O <sub>3</sub>	MgO	CaO	K <sub>2</sub> O	Na <sub>2</sub> O	Ig.loss
Silica stone	98.1	—	0.8	0.1	tr	0.1	0.2	0.1	0.7
Feldspar A	79.6	—	12.9	0.1	tr	0.5	0.4	5.9	0.6
Feldspar B	66.8	tr	17.7	0.1	tr	0.4	11.1	3.5	0.7
Ball clay	78.8	tr	14.1	0.7	0.1	0.1	2.7	0.2	3.3
Kaolin A	52.7	0.8	30.1	1.7	0.6	0.4	1.3	0.2	12.1
Kaolin B	49.2	0.8	30.2	1.6	0.3	0.3	0.8	0.2	13.8
Talc	61.6	—	0.3	0.1	31.6	0.4	—	0.1	5.9
Calcite	0.8	tr	0.5	0.1	3.4	51.4	0.1	0.1	43.3
Dolomite	0.1	—	0.1	0.2	18.9	33.5	—	—	47.0

#### 4. Production Process

##### 4.1 Production Process

The production process of insulator porcelain differs according to the use, shape and size. The general production process is shown below. Fig. 1 indicates its flow sheet.

- (1) Body preparation
- (2) Glaze preparation
- (3) Forming
- (4) Drying
- (5) Glazing

(6) Firing

(7) Assembling

(8) Inspection

(9) Plaster moulding

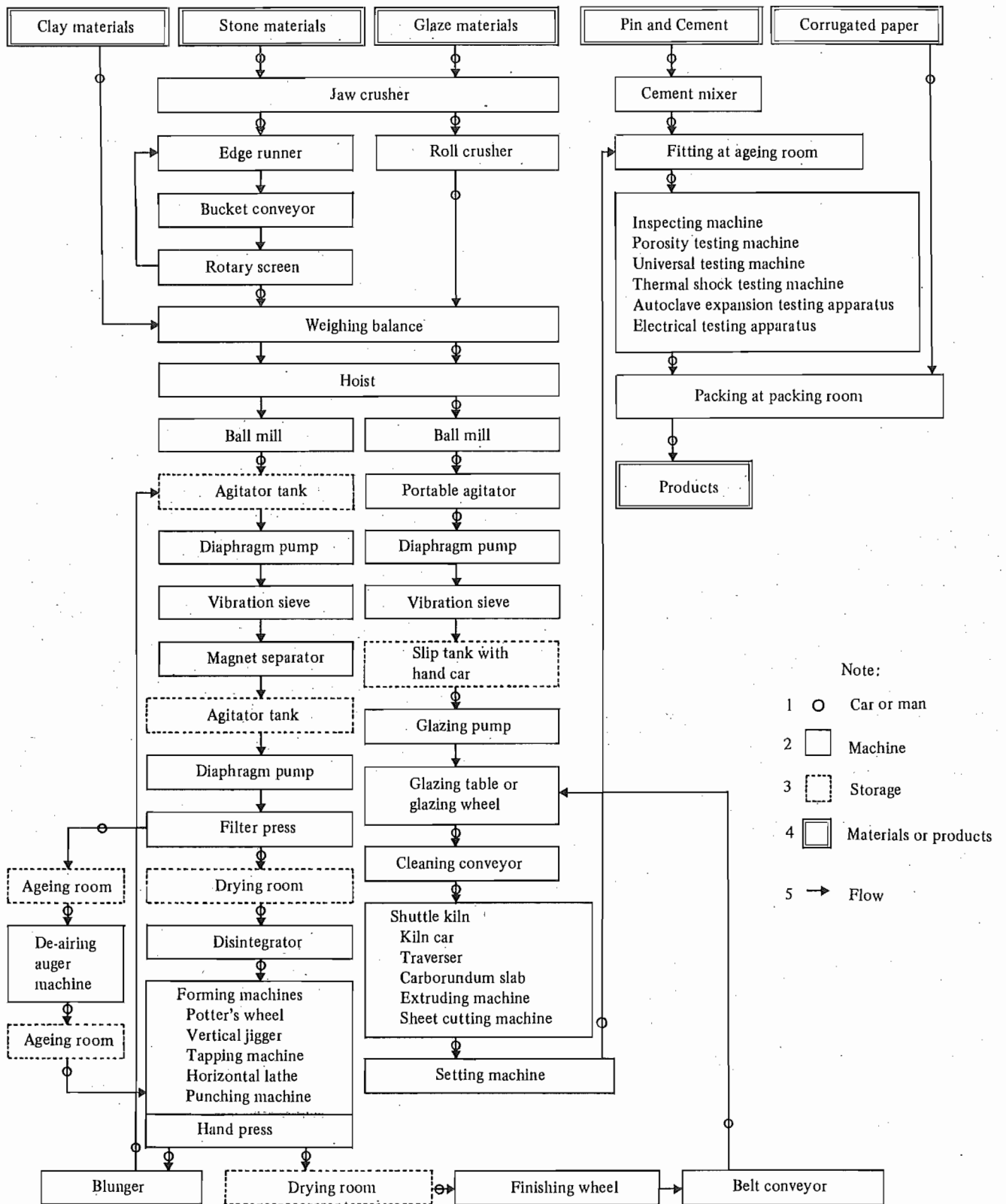


Fig. 1 Flow Sheet of Production Process

## 4.2 Outline of Production Process

### (1) Body preparation

In manufacturing an insulator, it needs stone-like materials as feldspar and silica stone as well as clay-like materials such as ball clay and china clay. The roughly crushed feldspar is mixed with silica stone, ball clay and china clay, and then wet fine grinding and elutriation are made. After that, ageing is made to homogenize the water distribution.

### (2) Glaze preparation

As the glazing raw materials of an insulator, there are feldspar, silica stone and kaolin as well as talc, limestone and dolomite. After they are mixed, they are finely ground to make glaze slip.

### (3) Forming section

The aged body cake are extruded by a de-airing kneader into a shape that makes the forming easy. The body cakes are dried up to the degree (moisture content: 15–18%) that forming can be done easily. After that, forming is made using a forming machine that fits the shape of each insulator.

### (4) Drying section

The formed bodies are carried to a drying chamber by a drying car. The bodies are dried until their moisture content becomes less than 4%.

### (5) Glazing section

The dried bodies are glazed after cleaning. There are two glazing methods, one is water-fall and the other is spray. The glazed bodies are again carried to the firing section by a drying car.

### (6) Firing section

The glazed bodies are piled up on a kiln car. In the kiln the temperature is adjusted in this order: drying, raising of temperature, reduction firing, lowering of temperature. The firing using reduction flame is especially important in the production of porcelain insulators. For firing a temperature of higher than 1,300°C is needed. Of the fired products, pin insulators are carried to the assembling section. And the other products are transferred to the inspection section.

### (7) Assembling section

In the case of pin insulators, metal fittings are set on the fired products. And then cement mortar is poured into to fix the metal fittings. It is necessary to perform the curing for about a week.

### (8) Inspection section

Testing is made using an inspection method appropriate for each product in order to control the quality level. The following machinery and equipment are used for various tests.

#### (a) Porosity testing apparatus

The moisture absorption of a product is inspected.

#### (b) Mechanical strength testing apparatus

In connection with load resistance and load rupture characteristic of tensile, pressure and bending of the products are inspected.

#### (c) Thermal shock testing apparatus

Insulators are inspected whether any defect is caused by a change in the temperature or not.

(d) Autoclave testing apparatus  
The in-service deterioration of cemented insulators is inspected.

(e) Electrical testing apparatus  
The electrical characteristics of insulators are examined.

① Commercial frequency voltage testing apparatus

This is an apparatus that generates the commercial frequency voltage, whereby the commercial frequency voltage resistance of insulators is inspected.

② High frequency voltage testing apparatus

This is an apparatus that generates the high frequency voltage, whereby the high frequency voltage resistance of insulators is inspected.

③ Impulse voltage testing apparatus

This is an apparatus that generates the impulse voltage, whereby the impulse voltage resistance of insulators is inspected.

(9) Plaster moulding section

This is a section where the moulds for forming pin-insulator are made.

### 4.3 Auxiliary Facilities

The following facilities are generally required for an insulator manufacturing plant.

(1) Laboratory

The function of laboratory is to study the quality control of the products and the production technology so that the operation can be maintained and enhanced. Its concrete role is as below.

① In order to maintain the product quality, the quality of raw materials is checked on each lot received.

② The preparation and firing tests are done on the raw materials that can be obtained cheaply and stably.

③ A study is made for the establishment of production technology of high-tension insulators.

(2) Workshop

This is a section where the maintenance and control of plant facilities are performed.

(3) Electric supply facilities

(4) LPG supply facilities

(5) Water supply facilities

(6) Transportation equipment

## 5. Outline of an Insulator Model Plant

According to use, the insulator is classified into low tension, medium tension and high tension insulators. This brochure will take up mainly the low-tension insulator, and also the production of high-tension pin insulator.

### 5.1 Type of Product and Production Scale

The type of product and the production scale are shown in Table 2.

### 5.2 Plant Operation

The plant will be operated as below. Three shuttle kilns are to be used.

- (1) Operating hours per day: 8 hours
- (2) Operating days per month: 21 days
- (3) Operating days per year: 252 days

**Table 2. Type of Product and Production Scale**

Type of product	Production amount		Weight g/ pc.	Total weight of products	
	pcs. month	pcs. year		tons/ month	tons/ year
1 Shackle insulator	48,000	576,000	417	20	240
2 Reel insulator	70,000	840,000	229	16	192
3 Stay insulator	25,000	300,000	400	10	120
4 Pin insulator	23,200	278,400	602	14	168
Total	166,200	1,994,400	-	60	720

**5.3 Required Quantity of Raw Materials**

The required quantity of raw materials (when a 100% operation is made) is shown in Table 3.

**Table 3. Required Quantity of Raw Materials**

Item	Required quantity	
	tons/month	tons/year
Raw materials for body		
Ball clay	20	240
China clay	25	300
Feldspar	20	240
Silica stone	15	180
Raw materials for glaze		
Talc	0.8	10
Calcite	0.8	10
Dolomite	0.8	10
Plaster of mould	7.5	90
Pin	1.25	15
Cement	10	120

**5.4 Required Quantity of Utilities**

The required quantity of utilities is as follows.

- (1) Electric power: 50,000 kWh/year
- (2) Fuel (L.P.G.): 200 tons/year
- (3) Industrial water: 1,500 tons/year

**5.5 Area of Plant Site**

200 m x 110 m 22,000 m<sup>2</sup>

**5.6 Buildings**

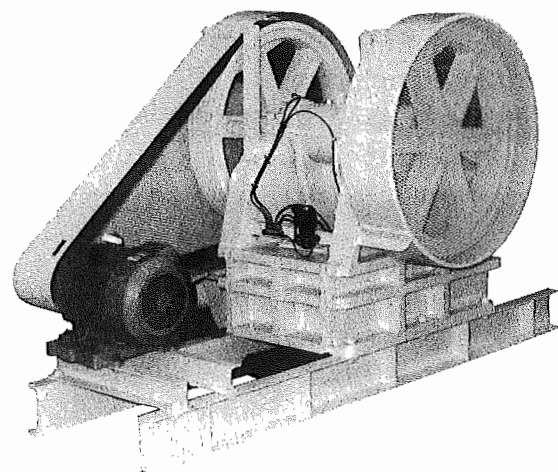
Factory	60 m x 40 m	2,400 m <sup>2</sup>
Warehouse	40 m x 40 m	1,600 m <sup>2</sup>
Office and laboratory	20 m x 40 m	800 m <sup>2</sup>
Total		4,800 m <sup>2</sup>

**5.7 Required Number of Personnel and Placement**

Table 4 shows the number of personnel required and placement

**Table 4. Required Number of Personnel and Placement**

Section	Director	Manager	Worker	Total
Body and glaze preparation		1	10	11
Forming		1	25	26
Glazing		1	30	31
Firing		1	8	9
Assembling		1	10	11
Plaster moulding		1	8	9
Inspection & laboratory		1	10	11
Maintenance		1	5	6
Factory manager	1			1
Total	1	8	106	115



**Photo 5. Jaw Crusher**

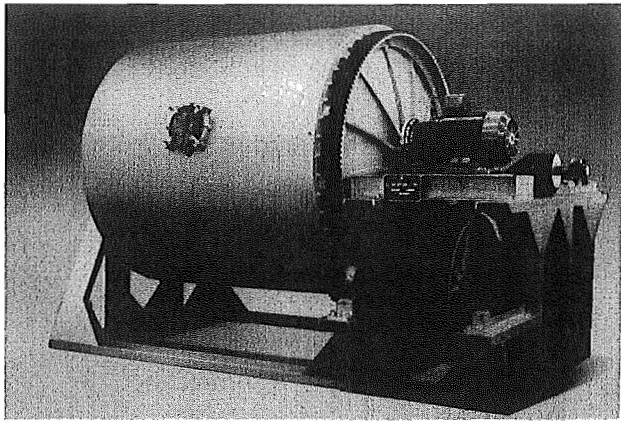


Photo 6. Ball Mill

### 5.8 Machinery and Equipment Required

The following shows a list of machinery and equipment required.

Item	Quantity
<b>(A) Body Preparation Section</b>	
1 Jaw crusher 800 kg/hr	1 set
2 Edge runner 400 kg/hr	1 set
3 Bucket conveyer	1 set
4 Rotary screen	1 set
5 Weighing balance	1 set
6 Hoist	1 set
7 Ball mill 2,000 kg/1 batch	2 sets
8 Agitator for 6 m <sup>3</sup> tank	1 set
9 Diaphragm pump 90 l/min	1 set
10 Vibration sieve	1 set
11 Magnetic separator	1 set
12 Agitator for 10 m <sup>3</sup> tank	1 set
13 Diaphragm pump	2 sets
14 Filter press 525 l/batch	2 sets
15 Hopper car	10 sets
16 Blunger	1 set
<b>(B) Glaze Preparation Section</b>	
1 Roll crusher 300 kg/hr	1 set
2 Ball mill 500 kg/batch	1 set
3 Slip tank 200 l	5 pcs
4 Hand car	5 sets
<b>(C) Forming Section</b>	
1 De-aring auger machine	1 set
2 De-aring auger machine	1 set
3 Potter's wheel	1 set
4 Vertical jigger	2 sets

5 Tapping machine	1 set
6 Finishing machine	2 sets
7 Horizontal lathe	3 sets
8 Horizontal lathe	2 sets
9 Horizontal lathe	2 sets
10 Punching machine	1 set
11 Hand press	2 sets
12 Disintegrator 300 kg/hr	1 set
13 Drying car	30 sets

#### (D) Drying Section

1 Drying chamber	3 sets
2 Electric heater	18 sets
3 Control box for electric heater	1 set

#### (E) Glazing Section

1 Diaphragm pump 16 l/min	1 set
2 Vibration sieve #149 mesh	1 set
3 Slip tank with portable agitator	1 set
4 Glazing pump 6 l/min	1 set
5 Finishing wheel	2 sets
6 Belt conveyer	1 set
7 Glazing table $\phi$ 2,000 mm	1 set
8 Glazing wheel and spray gun	2 sets
9 Air compressor	1 set
10 Washing conveyer 600 Lmm	1 set
11 Dust collector 300 m <sup>3</sup> /min	1 set

#### (F) Firing Section

1 Shuttle kiln 8 m <sup>3</sup>	3 sets
2 Kiln car	5 sets
3 Traverser	1 set
4 Carborundum slabs	1 set
5 Extruding machine	1 set
6 Sheet cutting machine	1 set

#### (G) Assembling Section

1 Cement mixer 10 l	1 set
2 Setting machine for pin insulator	1 set

#### (H) Inspection Section

1 Porosity testing apparatus 250 kgf/cm <sup>2</sup>	1 set
2 Universal testing apparatus 20 tonf	1 set
3 Thermal shock testing apparatus	1 set

4	Autoclave testing apparatus max. 20 kgf/cm <sup>2</sup>	1 set
5	Electrical testing apparatus	1 set
<b>(I) Plaster Mould Section</b>		
1	Vacuum agitator	1 set
2	Potter's wheel	1 set
3	Horizontal lathe	1 set
4	Drying chamber	1 set
<b>(J) Laboratory Equipment</b>		
1	Pot mill	1 set
2	Electric test kiln 27 l, 1,400°C	1 set
3	Extruding machine 50 kg/hr	1 set
4	Balance	1 set
5	Shaking apparatus with standard screen of ISO	1 set
6	Differential balance for moisture control	1 set
7	Particle size analyzer	1 set
8	Heat expansion meter	1 set
9	Bend testing apparatus	1 set
<b>(K) Work Shop</b>		
1	Bench drill	1 set
2	Grinder	
3	Lathe	
4	Welding equipment	
<b>(L) Others</b>		
1	Water supply facilities	1 set
2	Electric supply facilities	
3	LPG supply facilities	
4	Transportation equipment	

## 5.9 Plant Layout

Fig. 2 shows the layout of plant.

## 6. Cost of Machinery and Equipment and Building Construction Cost

The following shows the cost of machinery and equipment and the building construction cost of the plant.

### (1) Machinery and equipment cost

	F.O.B. Japan in US\$
Body preparation section	270,000
Glaze preparation section	60,000
Forming section	600,000
Drying section	140,000
Glazing section	110,000
Firing section	640,000
Assembling section	30,000
Inspection section	220,000
Plaster moulding section	90,000
Laboratory equipment	70,000
Work shop	60,000
Others	210,000
<b>Total</b>	<b>US\$ 2,500,000</b>

### (2) Building construction cost

		US\$
Factory	2,400 m <sup>2</sup>	528,000
Warehouse	1,600 m <sup>2</sup>	352,000
Office, laboratory	800 m <sup>2</sup>	176,000
<b>Total</b>		<b>US\$ 1,056,000</b>

## 7. Profitability

In calculating the production cost, etc., it is necessary to take into consideration the real condition of each country concerned. In this brochure, however, calculation will be made on the following preconditions.

### 7.1 Preconditions

#### (1) Fixed capital

- (a) Unit construction cost of factory and office buildings is supposed to be US\$220/m<sup>2</sup>.
- (b) Price of machinery and equipment is supposed to be FOB Japanese port in 1989.
- (c) Spare parts cost is assumed to be 10% of the FOB price of machinery and equipment.

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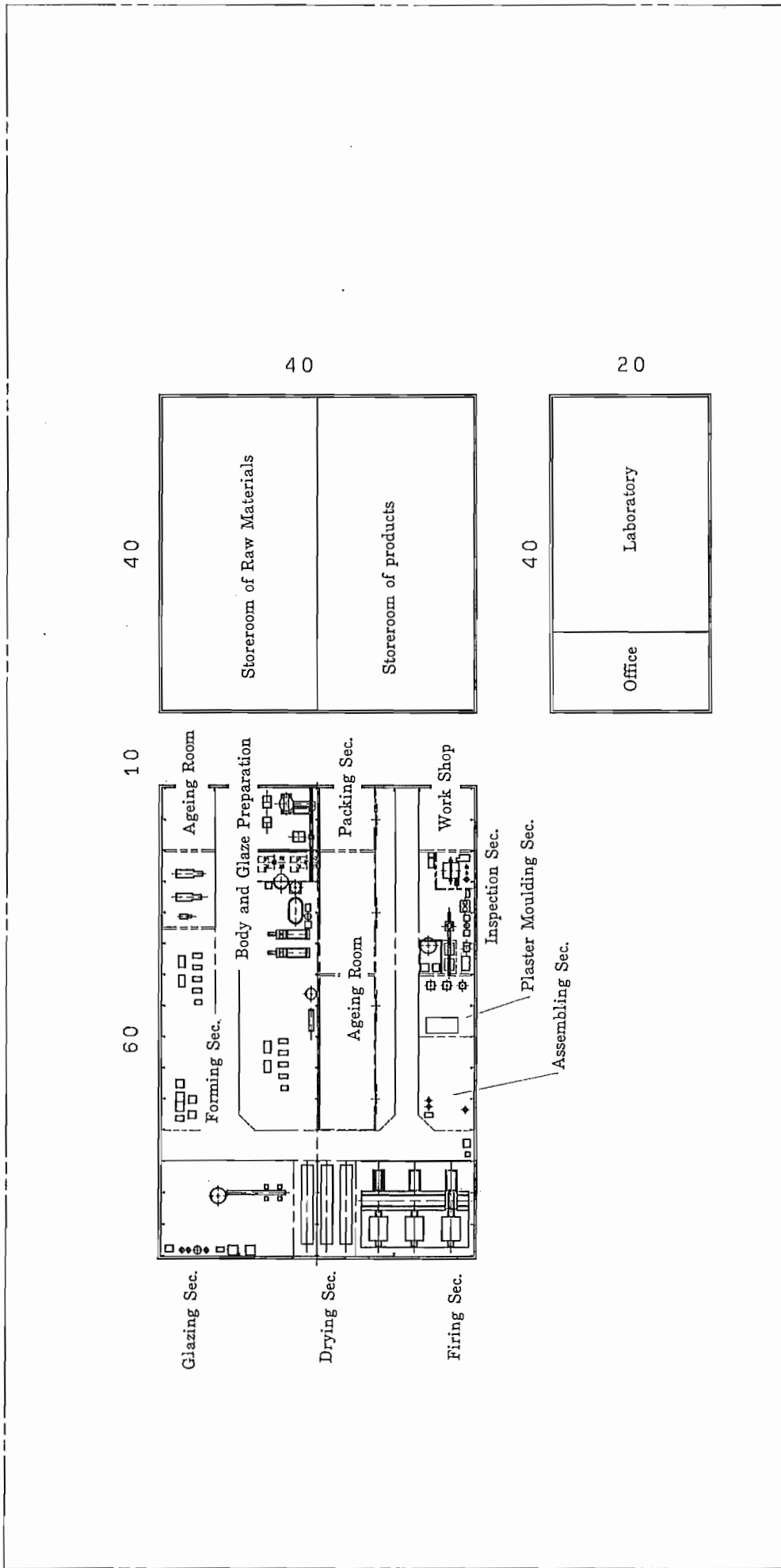


Fig. 2 Plant Layout

- (d) Freight and insurance cost is assumed to be 10% of the FOB price of machinery and equipment.
- (e) Erection cost is assumed to be 5% of the FOB price of machinery and equipment.
- (f) Civil engineering cost for foundation is assumed to be 10% of the FOB price of machinery and equipment.
- (g) Supervision cost is assumed to be 10% of the FOB price of machinery and equipment.
- (h) Commissioning cost is assumed to be 5% of the FOB price of machinery and equipment.
- (i) Training cost is assumed to be 5% 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 two months
- (b) Products inventory for one month

(3) Production cost

(a) Raw material cost

Ball clay	US\$ 170/ton
China clay	US\$ 300/ton
Feldspar	US\$ 300/ton
Silica stone	US\$ 100/ton
Glaze materials	US\$ 400/ton
Plaster	US\$ 400/ton
Pin	US\$6,000/ton
Cement	US\$ 90/ton

(b) Utilities cost

Electric power	US\$ 0.07/kWh
Industrial water	US\$ 0.20/ton
Fuel (LPG)	US\$ 250/ton

(c) Labor cost

Annual labor cost is as follows.

Director	US\$14,000
Manager	US\$ 8,000
Worker	US\$ 4,000

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

(e) Depreciation

Straight-line method will be adopted for depreciation.

Machinery and equipment:

(Fixed capital-building construction cost) x 7%

Buildings: (Building construction cost) x 3%

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

(g) Selling and administration expense is assumed to be 5% of the annual sales.

(h) Interest

A half of the fixed capital is to be covered by a long-term loan and its annual rate of interest is 10%.

(g) Exchange rate

The exchange rate of the U.S. dollar to the Japanese Yen is assumed to be US\$ 1.00=¥140.

## 7.2 Capital Required

### (1) Fixed capital

	US\$
Land price	not included.
Building construction cost	1,056,000
Machinery and equipment cost	2,500,000
Spare parts cost	250,000
Freight and insurance cost	250,000
Erection cost	125,000
Civil engineering cost for foundation	250,000
Supervision cost	250,000
Commissioning cost	125,000
Training cost	125,000
Contingency	250,000
<b>Subtotal</b>	<b>US\$ 5,181,000</b>

### (2) Working capital

Raw material cost for two months:	US\$ 61,600
Products inventory for one month:	US\$ 109,738
<b>Subtotal</b>	<b>US\$ 171,338</b>

### (3) Capital Required

(1) + (2) US\$ 5,352,338

## 7.3 Production Cost

### (a) Raw material cost

	US\$
Ball clay	40,800
China clay	90,000
Feldspar	72,000
Silica stone	18,000
Glaze material	12,000
Plaster	36,000
Pin	90,000
Cement	10,800
<b>Subtotal</b>	<b>US\$ 369,600</b>

### (b) Utilities cost

	US\$
Electric power:	
US\$0.07 x 500,000 kWh	35,000
Industrial water:	
US\$0.2 x 1,500 tons	300
Fuel: US\$250 x 200 tons	50,000
<b>Subtotal</b>	<b>US\$ 85,300</b>

### (c) Labor cost

	US\$
Director:	
US\$14,000 x 1 person	14,000
Manager:	
US\$8,000 x 8 persons	64,000
Worker:	
US\$4,000 x 106 persons	424,000
<b>Subtotal</b>	<b>US\$ 502,000</b>

(d) Maintenance cost : US\$ 75,000

(e) Depreciation: US\$ 320,430

(f) Insurance cost: US\$ 25,905

(g) Selling and administration expense:  
US\$ 118,980

(h) Interest: US\$ 259,050

**Annual production cost US\$ 1,756,265**

## 7.4 Annual Sales

On the basis of the international prices of insulators, the unit price was fixed, whereby the annual sales was estimated.

<u>Item</u>	<u>Unit price</u>	<u>Annual number of insulators sold</u>	<u>Annual sales</u>
1. Shackle insulator	US\$1.2	576,000	US\$ 691,200
2. Reel insulator	US\$0.6	840,000	US\$ 504,000
3. Stay insulator	US\$0.7	300,000	US\$ 210,000
4. Pin insulator	US\$3.5	278,400	US\$ 974,400
<b>Total</b>			<b>US\$ 2,379,600</b>

### 7.5 Profitability

The profitability of this model plant, which is estimated according to the above conditions, will become as below.

Annual sales	US\$ 2,379,600
Annual production cost	US\$ 1,756,265
<b>Profit</b>	<b>US\$ 623,335</b>

Annual profit will become US\$623,335.

This shows that the return on sales is 26.2% and the return on investment is 11.6%. Therefore, the profitability is considered good.

### 8: Conclusion

The living standards have risen in recent years, increasing the demand for electric power year after year. The role of the insulator that supports the electric supply is very important. With an increase of voltage, the higher quality of the insulator porcelain is required.

In constructing an insulator porcelain manufacturing plant, it is necessary to select the type of product after grasping the demand on the market. What is indispensable in this case is to acquire the porcelain manufacturing technology.

## 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
- No.17 Assorted Animal Feed Manufacturing Plant
- No.18 Sanitary Napkin Manufacturing Plant
- No.19 Sanitary Ware Manufacturing Plant
- No.20 Toilet Tissue Manufacturing Plant
- No.21 Powder Milk Manufacturing Plant
- No.22 Mosquito Coils Manufacturing Plant
- No.23 Solar Pond Power Generation Plant
- No.24 Manufacturing Plant of Textile Products for Medical Use
- No.25 Ceramic Tableware Manufacturing Plant
- No.26 Manufacturing Plant of Ethanol for Medical Use
- No.27 Match Manufacturing Plant
- No.28 Wind Power Generation Plant
- No.29 Concrete Pole and Pile Manufacturing Plant
- No.30 Insulator Manufacturing Plant

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Project Planning for Small and Medium Scale Industries No. 30

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### **Japan Consulting Institute (JCI)**

Sumitomo Fudosan Kudanshita Bldg. 3 F  
Kanda-Jinbocho 3-5, Chiyoda-ku Tokyo  
101-0051 Japan

TEL +81-3-3222-8100  
FAX +81-3-3222-8101  
URL : <http://jci-plant.or.jp>

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