As can be seen from Table VII-3, it has been concluded that Halang is most suitable for the installation of alcohol distillery.

3. Process Evaluation

The following are comparative studies of each process.

3-1 Extraction of Sugar

As a method to extract sugar from sugarcane, a comparative study of the following two processes has been made in view of production of alcohol. One is the milling process which has been employed extensively in the past and the other is the diffusion process which is a comparatively new method.

3-1-1 Process description of milling and diffusion processes

(1) Milling process

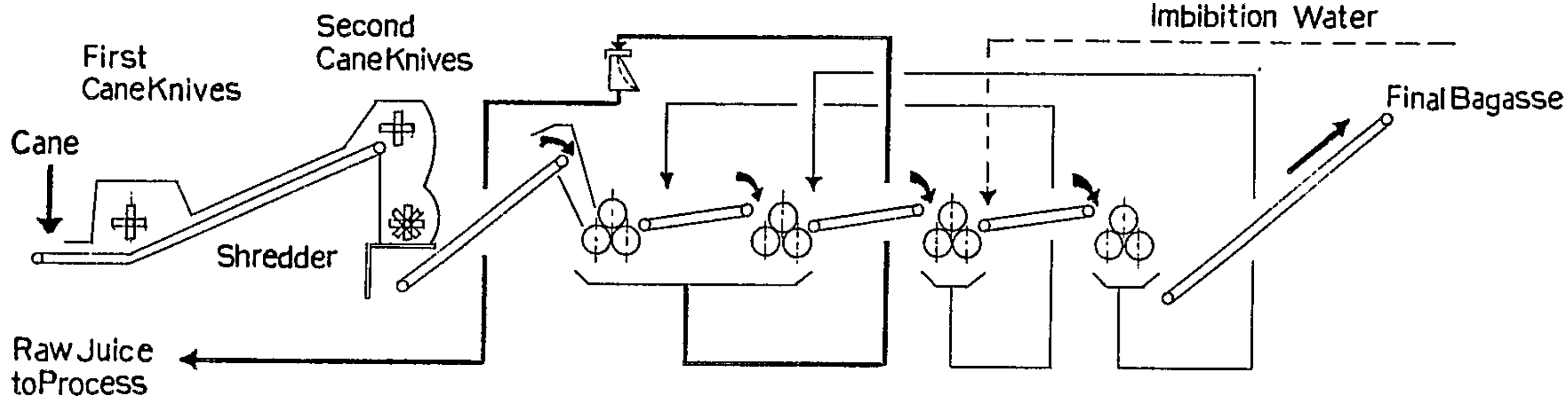
This is a prevailing process being used for a long time as a method for extracting sugar in the production of sugar from sugarcane. The schematic flow diagram is shown in Drawing VII-1.

To make extraction of sugar easier, the preliminary preparation for shearing of cane and cell rapture by means of cutters and a shredder is made, and then the following multi-mill train squeezes out sugar juice sheer- mechanically.

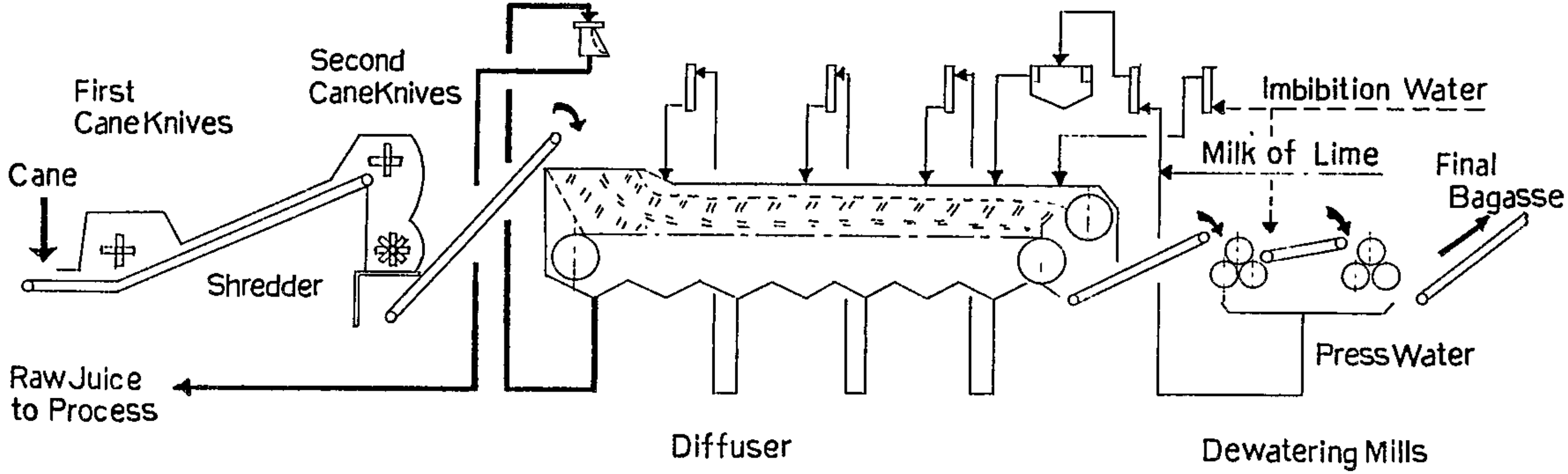
(2) Diffusion process

This is a method which has been employed to lixiviate sugar from sugar beet. Due to its lower capital cost, ease of maintenance, superior economical efficiency in energy balance, high recovery rate of sugar, etc. which are the advantages of the diffusion process, the application of this process for sugarcane has emerged gradually in all

Drawing VII-1 Milling Process



Drawing VII-2 Diffusion Process



over the world following the introduction in Egypt after the World War II. An outline of the process is given in Drawing VII-2.

For effective lixiviation of sugar, the preliminary preparation for shearing of cane and cell rupture is made, and then the ruptured cane and heated extracting solvent (approximately 70°C) are thoroughly contacted in the diffuser, consequently lixiviation effect is accelerated because of the difference of sugar concentration between juice within the cell and imbibition juice on the outside of the cell.

There are at least 9 types of the diffusion processes, such as De Smet, DDS, Silver Ring, BMA, Saturne, Fletcher-Stewart, Buckau-Wolf-Burnett, Suchem and Hulletts. Each process has a slight difference in character due to the structural difference, but the basic principle is identical. Accordingly, the findings of the comparative studies stated below may be considered applicable in any process of the nine types.

3-1-2 Comparison of milling and diffusion process

A comparison of the two processes is described separately by item as follows:

(1) Capital cost

The civil engineering foundation for a diffuser is not required to be so rigid as that for a mill tandem, and therefore the civil engineering cost of the diffusion process is cheaper than that of the milling process. Furthermore, since the diffuser itself can be installed outdoors, the building cost of the diffusion process is cheaper than that of the milling process. In addition, the price of diffuser itself is equivalent to a one and half mills in milling train of the same processing capacity.

In consideration of the aforementioned points, a comparison of the capital cost of the two processes was made as follows: The capital cost of the diffusion process adopted (a diffuser and 2 dewatering mills) will be approximately 80-80% of that of the milling process of the same processing capacity (4 mill train). Further, since the bagasse bed within the diffuser has a combined filtering action of juice, it has a merit that the subsequent clarifier requires shorter retention time and can be made smaller in comparison to that of the milling process.

(2) Operating cost

The operating costs of the two processes were compared from the points of labor cost and utility costs.

1) Labor cost

The diffusion process requires the same preparation equipment (cutters and a shredder) as the milling process and two mills for dewatering of bagasse.

Accordingly, the diffusion process requires almost the same number of operators as the milling process. There is little difference between labor costs for the two processes.

2) Utilities costs

The two processes were evaluated in view of the steam and electric power consumption.

a) Consumption of high-pressure steam

Since the diffusion process (a diffuser and 2 dewatering mills) requires a half number of the mill turbines to be required for the milling process (4 mill train), the consumption of high-pressure steam is approximately 50% of that in the milling process.

b) Consumption of low-pressure steam

In the diffusion process, low-pressure steam is used in order to heat recycling juice and imbibition water. However, as exhaust steam from the back pressure mill-turbine or the back pressure generator turbine is available as the low-pressure steam, there is no need of introducing extra steam from outside source.

c) Electric power consumption

Since the diffusion process employs much more juice pumps than the milling process, it is natural to use much more electric power. The electric power consumption of the diffusion process is approximately 2.2 times that of the milling process.

In view of the aforementioned comparison it is understood that the difference of the operating costs for the processes is mainly derived from the difference of both high-pressure steam and electric power consumption. Calculation of these consumption cost shows that the utilities cost of the diffusion process (a diffuser and 2 dewatering mills) is approximately 55% of that of the milling process (4 mill train).

(3) Maintenance cost

In the case of the milling process, it requires a considerable amount of maintenance cost due to the inherent maintenance requirements, such as wear and tear of mill-rollers. While in the case of the diffuser only, it requires only comparatively simple maintenance, such as wear of impellers. That is why the maintenance cost of the diffuser is much less than that of the mill train. However, since the diffusion process also requires the 2 mills for dewatering, the maintenance cost of mill-rollers is required to a certain extent.

In consideration of the aforementioned difference, the maintenance costs of both processes are evaluated as follows: The maintenance cost of the diffusion process (a diffuser and 2 dewatering mills) will be approximately 75% of that of the milling process (4 mill train).

(4) Performance

The two processes were evaluated with respect to the performance, such as extraction efficiency, clarity of juice and moisture content of bagasse, as follows:

1) Extraction efficiency

Generally speaking, the diffusion process can attain higher extraction efficiency than that of the milling process.

Extraction efficiency of the diffusion process is approximately 95-87% against approximately 93-96% of the milling process. Namely, the diffusion process is possible to obtain some 2% higher extraction.

2) Clarity of juice

Since the bagasse bed within the diffuser has the filtering action, juice obtained has generally higher clarity than that of the milling.

3) Moisture content of bagasse

The moisture content of bagasse to be obtained in the diffusion process is generally some 1-2% higher than that of the milling process. Therefore, efficiency as the boiler fuel is worse than the bagasse obtained from the milling process.

As mentioned above, the diffusion process has a number of superior aspects to the milling process with respect to the performance. However as described below, performance of the diffusion process is easily influenced by the fluctuations in cane quality. In order to overcome this problem, both the manufacturer of the diffuser unit and the users have to get together to establish the most suitable design to meet local conditions. It is absolutely necessary to take into account the item (5) as described below for proper comparison of the diffusion process with the milling process.

(5) Performance stability for fluctuations in cane quality

The milling process is a method to extract juice by means of sheer mechanical process, while the diffusion process is a method to extract juice employing lixiviation effect. Therefore, the performance, such as processing capacity and extraction efficiency, of the diffusion process is governed by the lixiviation speed of the juice through the bagasse bed. Furthermore, the lixiviation speed of the diffuser is greatly influenced by the quality of prepared cane at the inlet, such as 1) fineness and uniformity of cane pieces and 2) the presence of trash and soil attached to cane.

Accordingly, in order to realize and obtain the fullest performance of the diffuser, it is required to plan appropriate countermeasures in the design stage, especially a study of cane preparation to meet local cane conditions as stated below.

1) A thorough investigation should be made on the quality of cane, such as sucrose content, fiber content, toughness of fiber, and permeability of membrane, and the range of its fluctuations. Then, based on the data obtained, an appropriate fineness of cane preparation shall be established which shall be reflected in the design of cane preparation section.

2) Soil and trash in cane shall be removed at the cane preparation stage to prevent them from entering into the diffuser.

As mentioned above, the diffusion process has a special feature that the performance is easily governed by the fluctuations in cane quality as compared with the milling process.

To overcome this weak point of the process, both the manufacturer and the users have to make close cooperation and coordination at the preliminary stage of designing the unit to establish the most suitable system to meet the local conditions. It is again emphasized that this is really an important requirement.

3-1-3 Results of comparative study between milling and diffusion

The aforementioned comparative findings are summarized in Table VII-4. The diffusion process is cheaper than the milling process in view of the capital, operating and maintenance costs. On the contrary, the diffusion process has such a disadvantage that its performance is easily influenced by the fluctuations in cane quality.

Therefore, as the result of overall evaluation in this study, the milling process is adopted because of the facts that it has long commercial experience, higher performance stability and less chance of design error.

However, the diffusion process has no only the potential to make the capital and operating costs lower than the milling process, but also it has a possibility of operating under even higher temperature for the production of alcohol than sugar production, which may even improve the extraction efficiency and may increase the sterilization effect of juice.

Table VII-4 Comparison between Milling and Diffusion

Please note that this comparison is carried out based on a processing capacity of approx. 1000 TCD.

Items \ Process	Milling (4 Mills)	Diffusion (Diffuser & 2 dewatering mills)
Initial Cost Index	100	80 - 85
Operating Cost Index	100	55
Maintenance Cost Index	100	75
Performance	—	Better
Stability of Performance	Better	Relatively difficult to enable long and stable operation
Overall Evaluation	World-wide proven process	Special design consideration is needed for stable operation

Therefore, development of the diffusion process should always be watched and, whenever local conditions are favorable, its adoption should be seriously considered.

3-2 Clarification and Concentration of Sugarcane Juice

In the Interim Report, the clarification process and the concentration process were adopted, but in this final study, it has been decided not to use the concentration process considering the results of detailed study.

3-2-1 Clarification process

The reasons for adopting the clarification process are as follows:

(1) The yeast recycle process has been adopted as the fermentation process.

As described later, the yeast recycle process is the best of all processes commercially proven but this process which re-uses the yeasts by recycling requires clarification to prevent microbial contamination.

(2) Reduced formation of scale in the mash column

The use of the clarification process has a advantage of reducing scale formation in the mash column, requiring less frequent cleaning.

The facility cost of the clarification process is 5,000 (10^3 pesos).

3-2-2 Concentration process

When the Interim Report was prepared, sum of sucrose and invert sugar contents of sugarcane juice was estimated to be relatively low at 11.8% and therefore it was planned to adopt the process to increase sugar content by about 1.6% so that juice with sugar content of 13.4% may be fed to the fermentation tank.

However, as described in VII-1-2, the result of recent analysis on sugarcane composition has shown that the sugar content is about 1.5% higher than previously expected. This means that sugarcane juice of 13.9% sugar content can be obtained without the concentration process.

Namely, such process is not necessary for the purpose of increasing the sugar content of the juice. Such process also serves to make the sugar content more uniform but it has been judged that the cost for adopting the process (about 7,000 x 10^3 pesos) can not be justified.

3-3 Fermentation

For comparative evaluation of the fermentation process, the types of fermentation process available, past experience as commercial application and overall evaluation are discussed in the following.

3-3-1 Types of fermentation process

(1) Batch process

Batch process is roughly divided into the following two types and has been most popular so far.

1) Batch process using large amount of yeasts
2) Batch process with step-wise feeding

(2) Yeast recycle process

This process separates yeasts from fermented mash by centrifuge and separated yeasts are acid-treated and re-used, thus shortening the fermentation time.

(3) Continuous fermentation process

The following are representative continuous fermentation processes, and they are now under research and development stage.

1) Continuous fermentation by A-type immobilized yeasts fermentation process

   In this process, yeasts immobilized by Al-alginate are packed in the fermentation tank and are fluidized by carbon dioxide gas to which sugarcane juice is contacted for continuous fermentation. Drawing VII-3 shows the process flow.

2) Continuous fermentation by P-type immobilized yeasts

   Plate-shaped immobilized yeasts which are made by photo polimerization of a mixture of photosensitive special resin and wet yeasts are packed in the fermentation tank to which sugarcane juice is contacted for continuous fermentation. Drawing VII-4 shows the process flow.

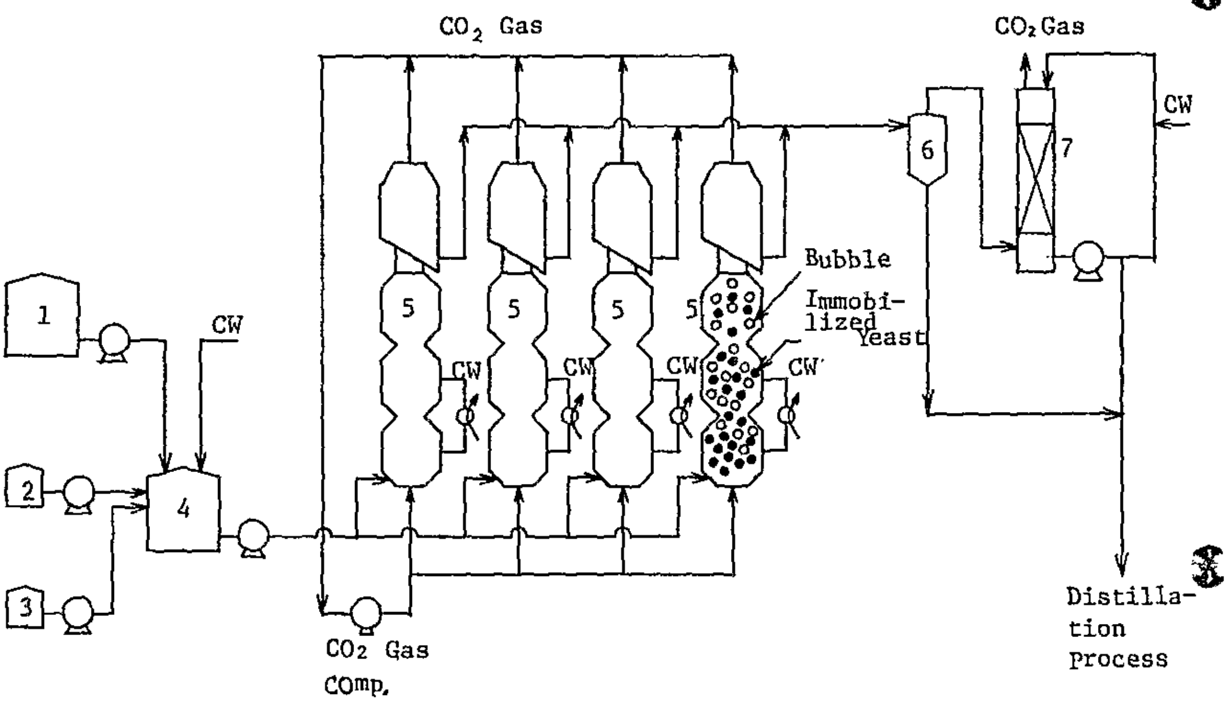
3) Continuous fermentation by K-type immobilized growing yeasts

   Yeasts immobilized by Kappa-carrageenan, an extract from seaweeds, are packed in the fermentation tank to which sugarcane juice is contacted for continuous fermentation.

4) Vacuum fermentation process

   In this process, the fermentation tank is kept at a pressure of about 50 mmHg at 35°C to facilitate ethanol vapor to boil away so that the ethanol concentration is kept below 1 vol. % in the fermenter. This eliminates inhibitive effect of ethanol on yeasts and enables more efficient fermentation. Drawing VII-5 shows the process flow.

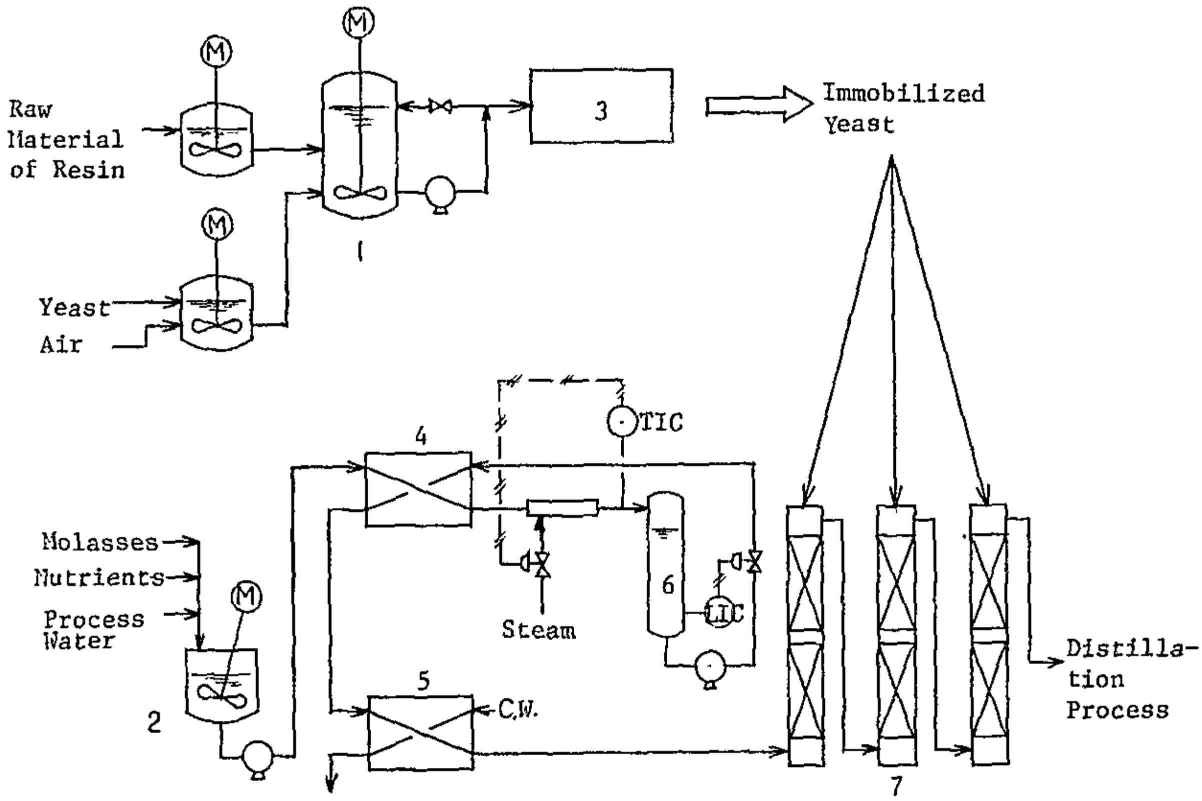
Drawing VII-3 Flow Diagram for Continuous Alcohol Fermentation by Immobilized Growing Yeast Cells-A-type



1. Molasses Tank
2. $Al_2(SO_4)_3$ Tank
3. H_2SO_4 Tank
4. Mixing Tank
5. Bioreactor
6. Gas-Liq. Separator
7. Absorber

Reference Fukushima, Hatakeyama: '81Biotechnol. Eng. Symp.

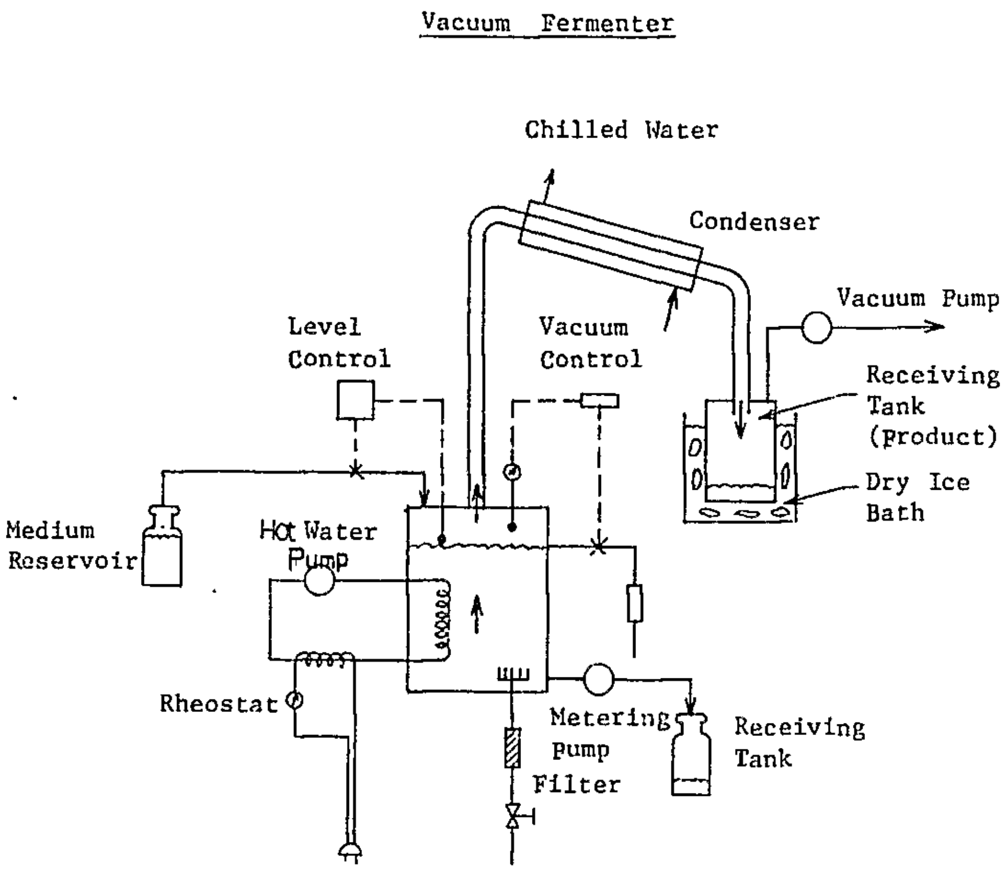
Drawing VII-4 Flow Diagram for Continuous Alcohol Fermentation by Immobilized Growing Yeast Cells-P-type



1. Mixing Tank
2. Mixing Tank
3. Continuous Immobilizing Equipment
4. Heat Exchanger
5. Cooler
6. Sterilizer
7. Continuous Fermenter

Reference : MOL No.8 (1981)

Drawing VII-5 Schematic Diagram of the Complete Vacuum System



Reference G.R. Cysewki, C.R. Wilke ; Biotechnol. Bioeng., 19,1125 (1977)

3-3-2 Comparison of processes

The following types of fermentation processes have been compared.

(1) Batch system using large amount of yeasts.
(2) Yeast recycle system
(3) Continuous fermentation system
   1) Continuous fermentation by A-type immobilized yeasts
   2) Continuous fermentation by P-type immobilized yeasts
   3) Vacuum fermentation process

(1) Comparison of investment cost and operating cost

As the continuous fermentation systems have never been commercially run, evaluation has been made based on the following indices found in literatures.

1) Fermentation efficiency

The fermentation efficiency is not expected to vary much among these processes and range from 90 to 92% against fermentable sugar. High fermentation efficiency is often cited for continuous fermentation process using glucose solution, which may be misleading, but it is not actually so when converted for the same fermentable sugar.

2) Fermenter ethanol productivity

The fermenter ethanol productivity is an index associated with fermenter capacity requirement.

a) Batch system using large amount of yeasts
4 g ethanol/l/h

b) Yeast recycle system 5 to 7 g ethanol/l/h

c) Continuous fermentation system

i) A-type immobilized yeasts	7 to 18 g ethanol/l/h
ii) P-type immobilized yeasts	7 to 18 g ethanol/l/h
iii) Vacuum fermentation process	40 to 82 g ethanol/l/h

3) Fermentation time

a) Batch system using large amount of yeasts 14 to 16 h

b) Yeast recycle system 8 to 14 h

c) Continuous fermentation system

i) A-type immobilized yeasts	5 to 8 h
ii) P-type immobilized yeasts	5 h
iii) Vacuum fermentation process	4 h

4) Ethanol concentration of fermented mash

a) Batch system using large amount of yeasts 8 to 9 vol.%

b) Yeast recycle system 8 to 10

c) Continuous fermentation system

i) A-type immobilized yeasts	8 to 12
ii) P-type immobilized yeasts	8 to 12
iii) Vacuum fermentation process	High

5) Necessity of mash sterilization prior to fermentation

The degree of sterilization of the mash varies from process to process.

a) Batch system using large amount of yeasts

No sterilization

b) Yeast recycle system

Sterilization by penicilin, etc.

c) Continuous fermentation system

Sterilization by steam

Comparison of investment and operating costs in terms of these indices is summarized in Table VII-5. The figures of the continuous fermentation system are those estimated without commercial proof as this system has not yet been run commercially. As for the vacuum fermentation process, no valid quantitative analysis was possible due to insufficient available data.

Table VII-5 Comparison of Investment Cost & Operating Cost

	Batch	Yeast Recycle	Continuous		
			A-Type	P-Type	Vacuum
Investment Cost	100	93	75	75	-
Operating Cost	100	90	70	70	-

(2) Operation

The results of comparison with respect to operation of these processes are as follows:

1) Batch system using large amount of yeasts

No particular problem in operation.

2) Yeast recycle system

Yeast culture process is simplified but the recycle process is added, making it necessary to maintain active yeasts all the time.

This requires skilled operation technique.

3) Continuous fermentation system

a) A-type and P-type immobilized yeasts

The continuous fermentation has to be performed under constant operating conditions, i.e., it requires highly sophisticated instrumentation system and skilled technique for the operation and maintenance.

b) Vacuum fermentation process

The vacuum fermentation has to be kept under constant operating conditions, i.e., it requires highly sophisticated instrumentation system. This combined with the need for keeping the fermenter under vacuum requires very high level of technique for the operation and maintenance.

Table VII-6 summarizes the results of comparison.

Table VII-6 Comparison of Operation

	Batch	Yeast Recycle	Continuous		
			A-Type	P-Type	Vacuum
Operation	Easy	Medium	Difficult	Difficult	Very Difficult

(3) Maintenance

The results of comparison of expected maintenance requirement for these processes are as follows:

1) Batch system using large amount of yeasts

Maintenance is relatively easy as sophisticated equipment is not in use.

2) Yeast recycle system

Maintenance is more difficult than batch system because this system requires centrifuges for separating yeasts which need skilled technique for the maintenance.

3) Continuous fermentation system

a) A-type and P-type immobilized yeasts

Sophisticated instrumentation system requires high level of maintenance work.

b) Vacuum fermentation system

This system requires maintenance of not only the instrumentation system, but also the vacuum system and therefore, as a whole, very high level of maintenance work is required.

The results are summarized in Table VII-7.

Table VII-7 Comparison of Maintenance

	Batch	Yeast Recycle	Continuous		
			A-Type	P-Type	Vacuum
Maintenance	Easy	Medium	Difficult	Difficult	Very Difficult

3-3-3 Experience of commercial operation

Experience of commercial operation of these fermentation processes is as follows.

(1) Batch system using large amount of yeasts

(2) Yeast recycle system

These two systems have been fully proven in commercial operation.

(3) Continuous fermentation system

A-type and P-type processes are now in the stage of development from bench scale to pilot scale.

The vacuum fermentation process is in the stage of laboratory test.

Thus, the continuous fermentation system as a whole is currently in the research and development stage, lacking experience of commercial operation.

The results are summarized in Table VII-8.

Table VII-8 Stage of Development

	Batch	Yeast Recycle	Continuous		
			A-Type	P-Type	Vacuum
Stage of Development	Commercial	Commercial	Bench→Pilot	Bench→Pilot	Lab.

3-3-4 Overall evaluation

The results of comparison of these processes and the experience of commercial operation are summarized in Table VII-9.

Table VII-9 Comparison of Fermentation Process

	Batch	Yeast Recycle	Continuous		
			A-Type	P-Type	Vacuum
Investment Cost Index	100	93	75	75	-
Operating Cost Index	100	90	70	70	-
Operation	Easy	Medium	Difficult	Difficult	Very Difficult
Maintenance	Easy	Medium	Difficult	Difficult	Very Difficult
Stage of Development	Commercial	Commercial	Bench→Pilot	Bench→Pilot	Lab.

As is obvious from above table, the yeast recycle system is superior to the batch system and the continuous system further excels the yeast recycle system. However, the continuous system is currently in the process of research and development and hence can not be adopted for the Alcogas project.

Therefore, it has been concluded that the yeast recycle system that has been well proven in commercial operation and considered as most advanced process as of today is most suitable.

3-3-5 Recent trend of yeast strains

In this study, improved type of yeasts well proven in Brazil have been selected as the basis of study. Recent trend of yeasts are discussed in the following.

(1) Heat-resisting yeasts

Usually, the optimum temperature for yeasts is said to be in the range of 30 to 33°C, but in South East Asia, South America and other regions where cooling water temperature is high, development of heat resisting yeasts is under way.

There are also improved version of conventional types. There is ample literature on yeasts screened in tropical regions.

(2) High active yeasts

High active yeasts have also been reported, but many of them are still being tested on the bench scale, and therefore analysis of commercial operation is necessary for accurate evaluation.

3-4 Distillation

Distillation method, types of dehydrating agent and types of tray have been studied.

3-4-1 Distillation method

In the production of alcohol, the atmospheric pressure distillation system is conventionally adopted but the use of pressurized distillation is recently examined from the viewpoint of energy saving. Also, the use of vacuum distillation system in the dehydration process is examined as this eliminates the azeotropic system. Various distillation system have been compared for overall evaluation.

(1) Process comparison

1) Atomospheric pressure distillation

This system is widely adopted and well proven in actual operation, and does not involve any particular difficulty in operation. From the point of energy consumption, however, energy recovery is difficult as there is only small temperature difference between input and output fluids in the distillation process. This system also cannot take advantage of more efficient energy recovery which is made possible in pressurized distillation by gradually decreasing the pressure from column to column. As the result, this system consumes about 4t of steam (1 to 2 kg/cm^2G pressure) per 1 kl of product alcohol. Drawing VII-6 shows the process flow of this system.

2) Pressurized distillation

There are following two ways of pressurized distillation:

a) Mash column and rectifying column pressurization

b) Dehydrating column and benzene recovery column pressurization

Explanation is given below for the mash column and rectifying column pressurization system which is more popular between the two. The largest advantage of this system is low energy consumptions as evidenced by the steam consumption of about 2.5t of 4 to 5 kg/cm^2G steam to produce 1 kl of product alcohol. This is due to the fact that considerable amount of energy in the pressurized column can be utilized in the following non-pressurized columns.

Additional care should be taken to control the pressure in the operation. The investment cost is low as this system requires smaller diameter of column.

Drawing VII-7 shows the process flow of this system.

3) Vacuum distillation

Depressurization to about 70 mmHg of the dehydrating column eliminates ethanol/water azeotropic distillation and hence dehydrating agent becomes unnecessary. However, the number of trays in the dehydrating column and the column diameter get larger, resulting in higher investment cost. In addition, due to low column top vapor temperature, it requires low temperature cooling water for condensation, purpose and this makes the system not very suitable for use in hot district.

(2) Overall evaluation

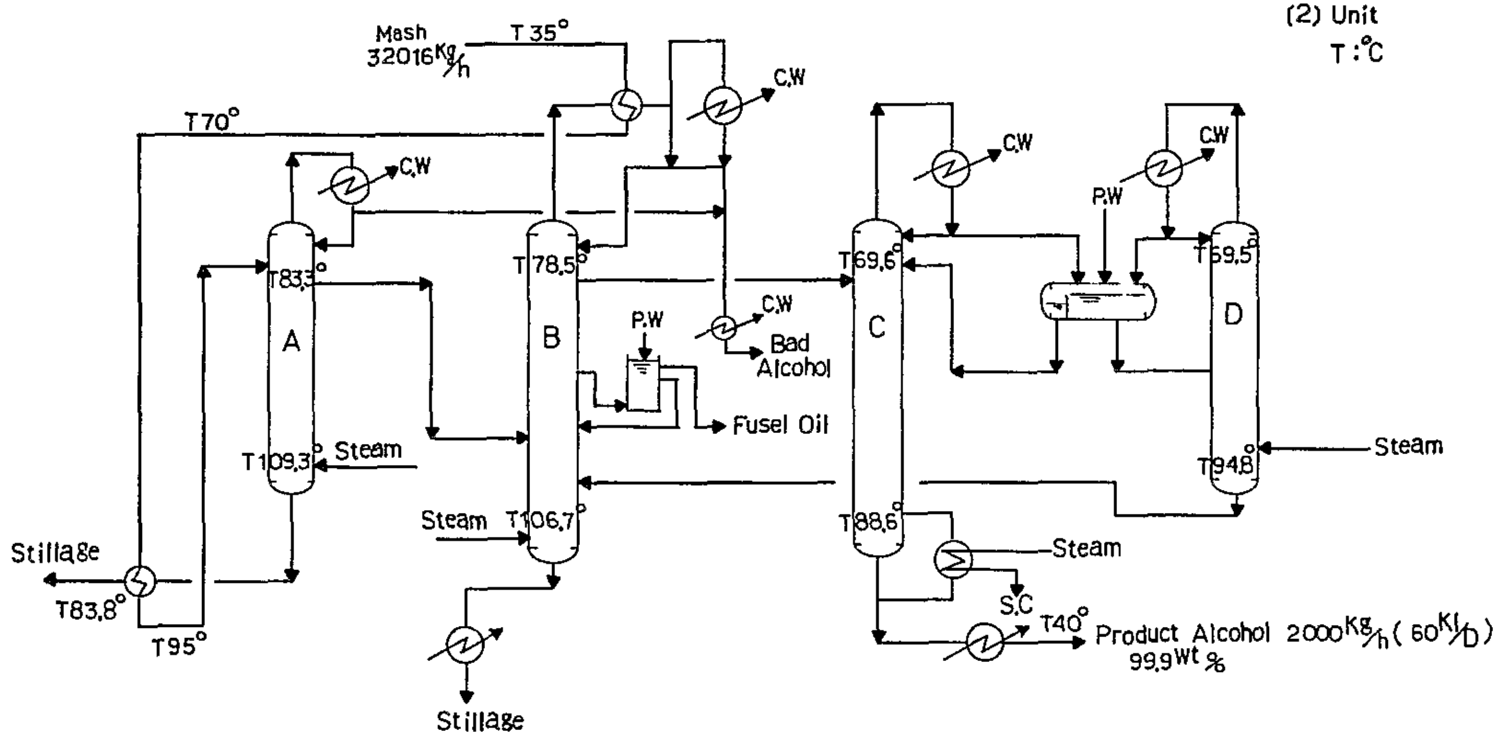
Overall evaluation is shown in Table VII-10.

Table VII-10 Comparison of Distillation Process

	Atmospheric Process	Pressurized Process
Investment Cost Index	100	75
Steam Consumption (t/kl-Alc.)	(1 to 2 k) 4.	(4 to 5 k) 2.5
Operation	Easy	Difficult
Experience	Many	Few

As can be seen from the table, the pressurization system is superior in terms of investment cost and steam consumption. On the other hand, the atmospheric pressure system can utilize exhaust steam from milling or power generator as it operates on steam of pressure as low as 1 to 2 kg/cm^2G.

Drawing VII-6 Atmospheric Azeotropic Distillation Method



Note

(1) Tower

A : Mash Column

B : Rectifying Column

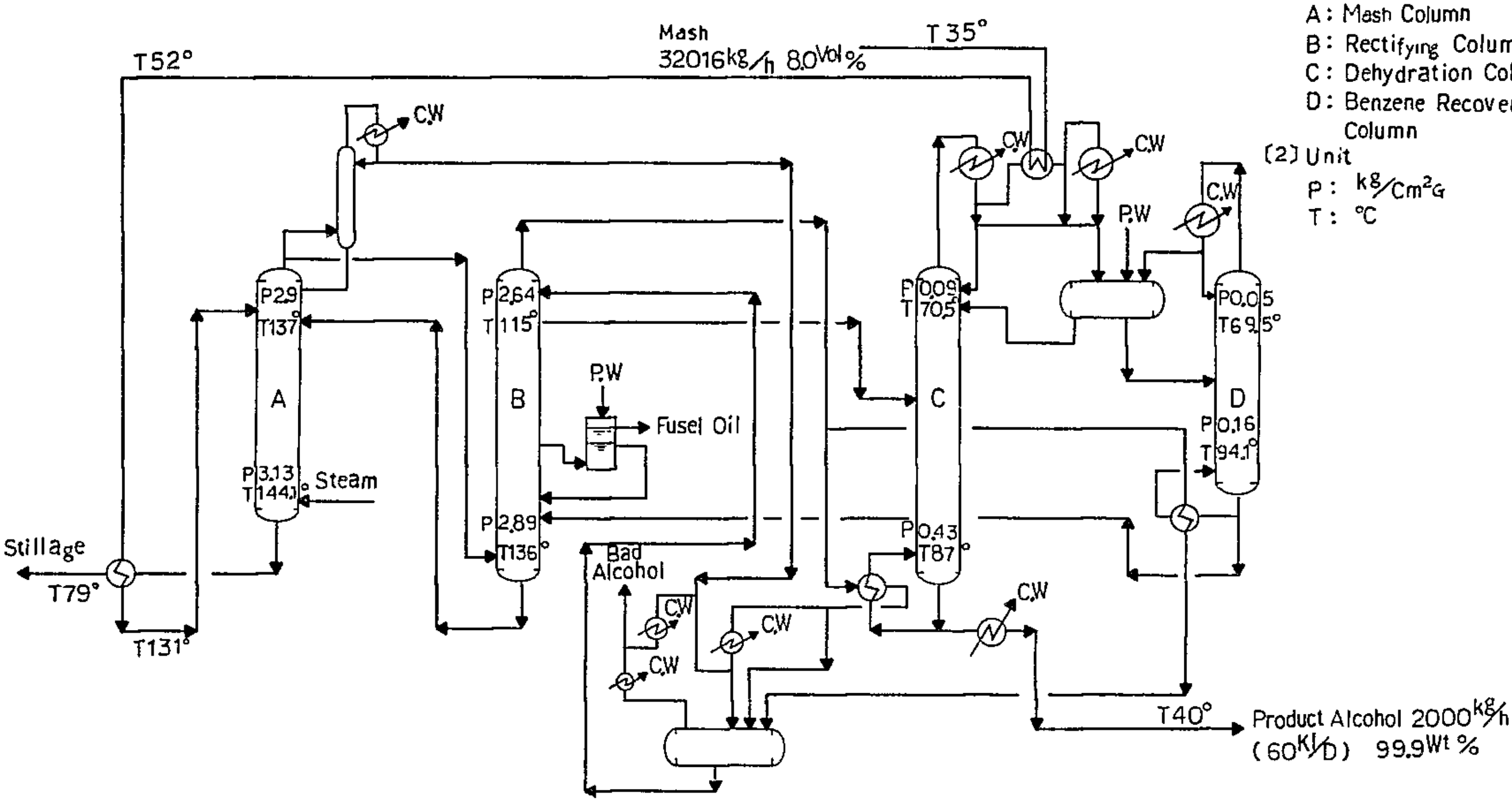
C : Dehydration Column

D : Benzene Recovery Column

(2) Unit

T : °C

Drawing VII-7 Pressurized Distillation Method



Note

(1) Tower

A : Mash Column

B : Rectifying Column

C : Dehydration Column

D : Benzene Recovery Column

(2) Unit

P : kg/Cm²G

T : °C

If this is taken into consideration, energy consumption of the latter as the entire plant system is no more than that of the former. The atmospheric pressure system is, in addition superior in terms of ease of operation and experience in commercial run.

In view of these and due to the fact that the pressurization system has possible problems of column corrosion due to high temperature, scale formation in mash column, decomposition of materials in mash column, etc. yet to be solved, the atmospheric pressure system has been selected.

(3) Technique other than distillation method for dehydration

From the viewpoint of energy saving, use of membrane or super-critial CO_2 gas for ethanol separation in the dehydration process is being studied.

These techniques although in the experimental stage are worth attention.

3-4-2 Dehydrating agent

The dehydrating agents used in azeotropic distillation are substances that are less likely to dissolve in water and form azerotropic mixture with water and alcohol.

Dehydrating agents in common use are listed in Table VII-11.

Table VII-11 Characteristics of Dehydrate Agents

Agents	Boiling Point (°C)	Composition of Azotoropic Mixture (%)		
		Ethanol	Water	Agent
Benzene	80.2	18.5	7.4	74.1
Cyclohexane	80.8	17.0	7.0	76.0
Trichloroethylene	87.0	26.0	5.5	69.0
Carbon Tetrachloride	76.8	9.7	4.3	86.0
Chloroform	61.2	4.0	3.5	92.5

High water content in the azeotropic mixture is an important characteristic of dehydrating agent as it results in smaller consumption of the agent.

From Table VII-11, benzene, cyclohexane and trichloroethylene have been selected for comparison as they have desirable characteristics.

(1) Comparison and overall evaluation

The three materials are compared in Table VII-12.

Table VII-12 Comparison of Dehydrate Agents

	Benzene	Cyclohexane	Trichloroethylene
Unit Consumption Index	100	70	65
Price Index	100	130	140
Characteristics	Poisonous	Less Poisonous	Poisonous

As can be seen from the table, the three materials are nearly of the same performance. Therefore, in view of availability and the use of same material in Japan for production of industrial alcohol, benzene has been selected.

As automotive alcohol is eventually mixed with gasoline, study is recently under way to use gasoline as the dehydrating agent but it has not been adopted here since the study is yet in experimental stage.

3-4-3 Selection of tray system

As for the trays of distillation column, bubble cap tray has been selected for the mash column and the rectifying column because of the wide operating range and high efficiency. For dehydration column and benzene recovery column, sieve trays have been adopted because of high efficiency and low capital cost.

4. Measures Incorporated in Distillery Design

4-1 Measures for Maintenance

As this alcohol distillery is near Metro Manila, it is assumed that the maintenance of large scale or during long shutdown of the distillery is entrusted to outside contractors but that the daily maintenance is undertaken by the engineers stationed at the distillery using the facilities as below.

(1) Maintenance equipment

Lathe, drilling machine, milling machine, welding machine, cutter, bender, etc., are installed.

(2) Maintenance system

o Expert engineer - 3
o Expert worker - 3/shift (3 groups, 3 shifts)

As measures for maintenance, stand-by equipment is installed or spare parts are retained, in principle, for rotating equipment.

4-2 Environment Protection

4-2-1 Measures for waste water

The most important environment problem in the alcohol distillery is the treatment of waste water. The study was conducted for the following four types of treatment methods of waste water aiming class C (See Table VII-13) of the effluent standard of NPCC (National Pollution Control Commission).

i) Lagoon process
ii) Activated sludge process
iii) Anaerobic digestion process
iv) Utilization as irrigation water

Table VII-13 NPCC Water Quality Standard Class C

BOD	Temp.	SS	PH	Oil & Grease
250 ppm	40°C	100 ppm	6-9	100 ppm

Sources of waste water and their treatment methods are studied as follows:

(1) Type of waste water

Waste water from the alcohol distillery was classified in two categories by its source.

i) Process waste water
ii) Sewage

(a) Process waste water

It is mainly stillage from the mash column. Quality of process waste water is as stated below. This process waste water, the volume of which will be approximately 800 m^3/d, requires treatment.

Table VII-14 Process Waste Water Quality

BOD	Temp.	SS	PH	Oil & Grease
10,000 ppm	60°C	2,000 ppm	4.4	500 ppm

(b) Sewage

Waste water from office, canteen, laboratory, etc. will be treated in septic tanks first, and then mixed with process waste water.

(2) Waste water treatment process

The process flow of lagoon process, activated sludge process and anaerobic digestion process are shown in Drawing VII-8 to 10. Each treatment process is outlined as follows:

(a) Lagoon process

Lagoon process is a method to hold waste water in a lagoon for a long time under the conditions close to natural aeration. However, BOD of the stillage is so high that it is difficult to reduce the value down to the effluent standard of NPCC by means of natural aeration only. Therefore a study was made on a lagoon process with surface aeration using simplified aerator.

Advantages and disadvantages of lagoon process:

- o Lower cost of facilities and operation
- o Easy maintenance

- o Longer residence time
- o Larger land area is required

(b) Activated sludge process

This is a process to employ aerators in order to force supply of oxygen into waste water for treatment by means of aerobe.

Advantages and disadvantages of activated sludge process:

- o Shorter residence time
- o Required site is comparatively smaller
- o BOD removal efficiency is high
- o Higher cost of facilities and operation
- o Requirement of high technique in maintenance

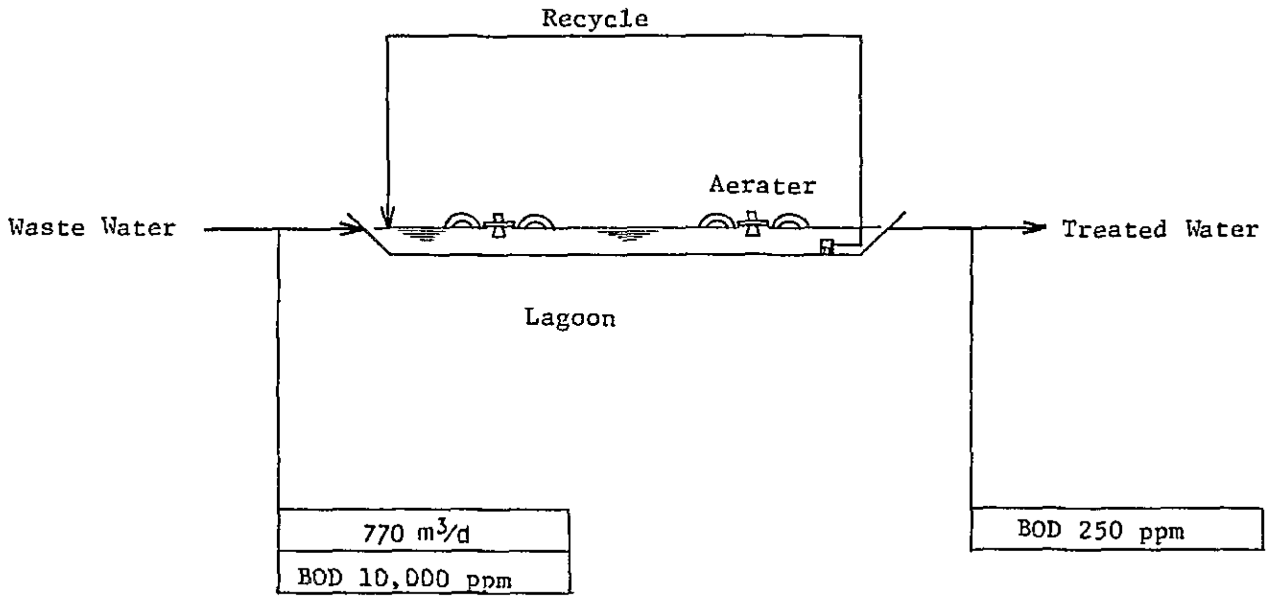
(c) Anaerobic digestion process

This is a process to decompose organic matters in waste water by means of anaerobe. When organic matters are decomposed they generate gas which mainly consists of methane gas. The collected methane gas is utilized as fuel for boilers. However, it is difficult to reduce the BOD down to the NPCC effluent standard only by means of anaerobic digestion, so that the combined use with activated sludge process is required.

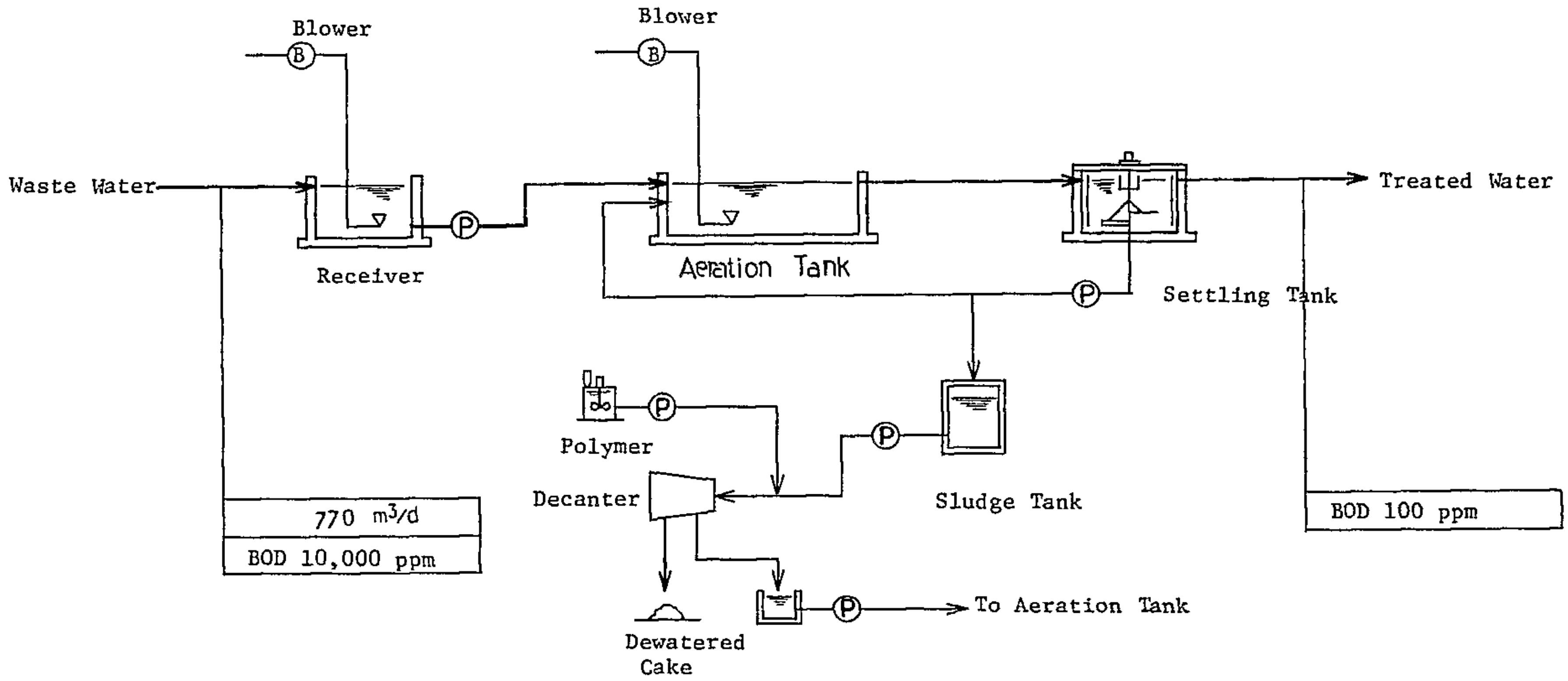
Advantages and disadvantages of anaerobic digestion process:

- o It is difficult to meet the NPCC effluent standard by means of this process only.
- o Generated energy is comparatively less than the cost of the treatment.
- o Generation of bad odor
- o Longer residence time

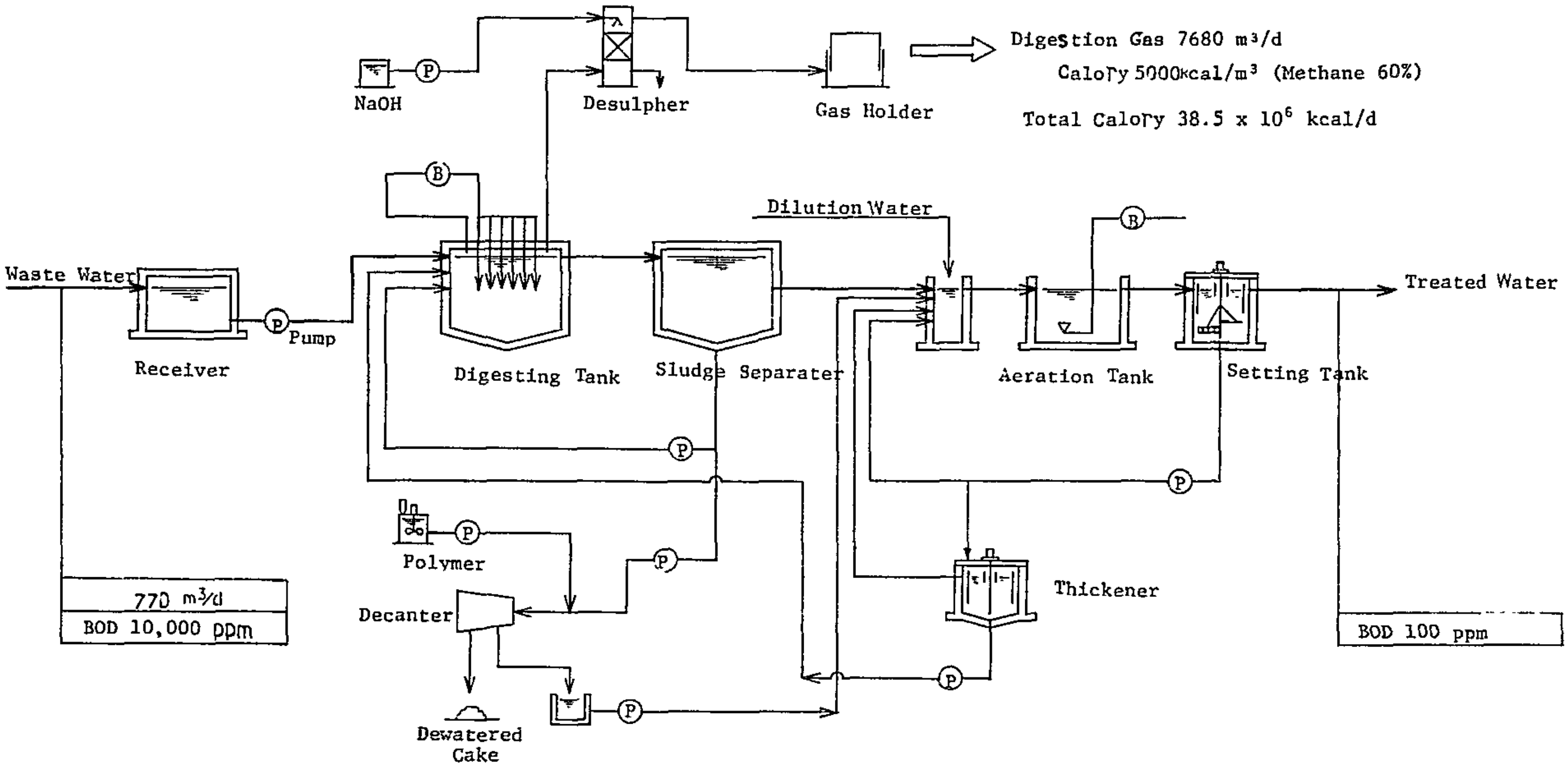
Drawing VII-8 Lagoon Process Flow Sheet



Drawing VII-9 Activated Sludge Process Flow Sheet



Drawing VII-10 Anaerobic Digestion Process Flow Sheet



(d) Utilization is irrigation water

Waste water pit is set up within the battery limits. Both process waste water and sewage will be mixed together and sent to the irrigation water pond outside of the distillery to be utilized as irrigation water for sugarcane fields.

Advantages and disadvantages of utilization as irrigation water:

- o Lower capital and operating costs
- o Higher nutritive value

The findings are shown in Table VII-15. In view of the overall judgement including construction, operation costs, etc., the utilization as irrigation water is the most advantageous treatment of waste water. Accordingly this report recommends the utilization of waste water as irrigation water as a result of the aforementioned studies.

4-2-2 Countermeasures against air, noise and odor pollution

As a possible cause of air pollution, there is a flue gas generated from the steam boiler. Since the distillery is equipped with conventional dust collector, it is considered that the NPCC Air Quality Standards (Table VII-16) can be satisfactorilly maintained. As for the countermeasures against noise and odor pollution, the facilities plan was made in reference to the NPCC standard (C Area). For noise, sound insulation walls are to be installed around the mill turbine and blowers of the boiler. As countermeasures against odor pollution, no problem is expected by continuous flow of waste water to the irrigation water pond instead of leaving it in waste water pit for a long period.

Table VII-15 Study on Treatment Method of Waste Water

Treatment Method	Lagoon Treatment	Activated Sludge Treatment	Anaerobic Digestion Treatment	Irrigation
Waste Water Capacity (t/d)	770	770	770	770 (after dilution 2,160)
Construction Cost ($x10^3$ pesos)	6,500	16,000	20,000	1,170
No. of Operators (man/d)	-	3	3	-
Utilities Requirements				
Electric Poer (KWH/d)	2,800	9,600	2,900	670
Chemicals (Kg/d)	NaOH 12	Polymer 65 NaOH 12	Polymer 47 NaOH 106	-
Fixed Cost ($x10^3$ pesos/y)				
Depreciation & Tax	1,300	3,200	4,000	230
Labor & Maintenance	60	359	439	12
Variable Cost ($x10^3$ pesos/y) Utilities & Chemicals	566	2,576	1,100	140
Energy Recovered ($x10^3$ pesos/y)	-	-	-1,588	-
Annual Cost ($x10^3$ pesos/y)	1,926	6,135	3,951	382

Table VII-16 NPCC Air Quality Standards (1978)

PARAMETERS OF CONCERN	EMISSION STANDARDS (mg/SCM)
Particulates	300 (new sources) - boilers/incinerators
SO_x (sulfur oxides)	250 as SO_2 or where limit cannot be met, control to be by stack height.
NO_x (nitrogen oxides)	
CO (carbon monoxide)	500
H_2S (hydrogen sulfide)	15

4-3 Safety Measures

Basically, safety measures are incorporated in conformity with the Fire Code of the Philippines and Regulations and National Fire Code (U.S.A.). Matters of special consideration are as follows:

(1) Install fire-fighting facilities for facilities handling highly concentrated alcohol, such as distillation facility and storage/loading facilities of product alcohol.

(2) Construct dike around alcohol storage tanks. The tanks are located at non-hazardous area with adequate spacing for safety reasons.

(3) Install lightning rods and fire extinguishers for the overall distillery.

(4) Use explosion proof type electric equipment for the facilities handling highly concentrated alcohol.

4-4 Utilization of By-products

In the course of production of alcohol, various types of by-products will be generated. In this study, utilization of the following by-products are examined.

(1) Bagasse
(2) Carbon dioxide
(3) Yeasts
(4) Others
  1) Filter cake
  2) Fusel oil
  3) Lighter impurities

The findings on each by-product are shown in Table VII-7. Drawing VII-11 & 12 show a flow sheet to manufacture pulp and paper from bagasse; Drawing VII-13 manufacturing flow of liquefied carbon dioxide; and Drawing VII-14 manufacturing flow of dry yeasts.

(1) Bagasse

A study was made to manufacture pulp and paper from bagasse, taking the following points into consideration:

a) Since the excess bagasse is not sufficient, utilization of the entire bagasse to be produced in the milling process was assumed. Timbers have to be obtained as an alternative boiler fuel.

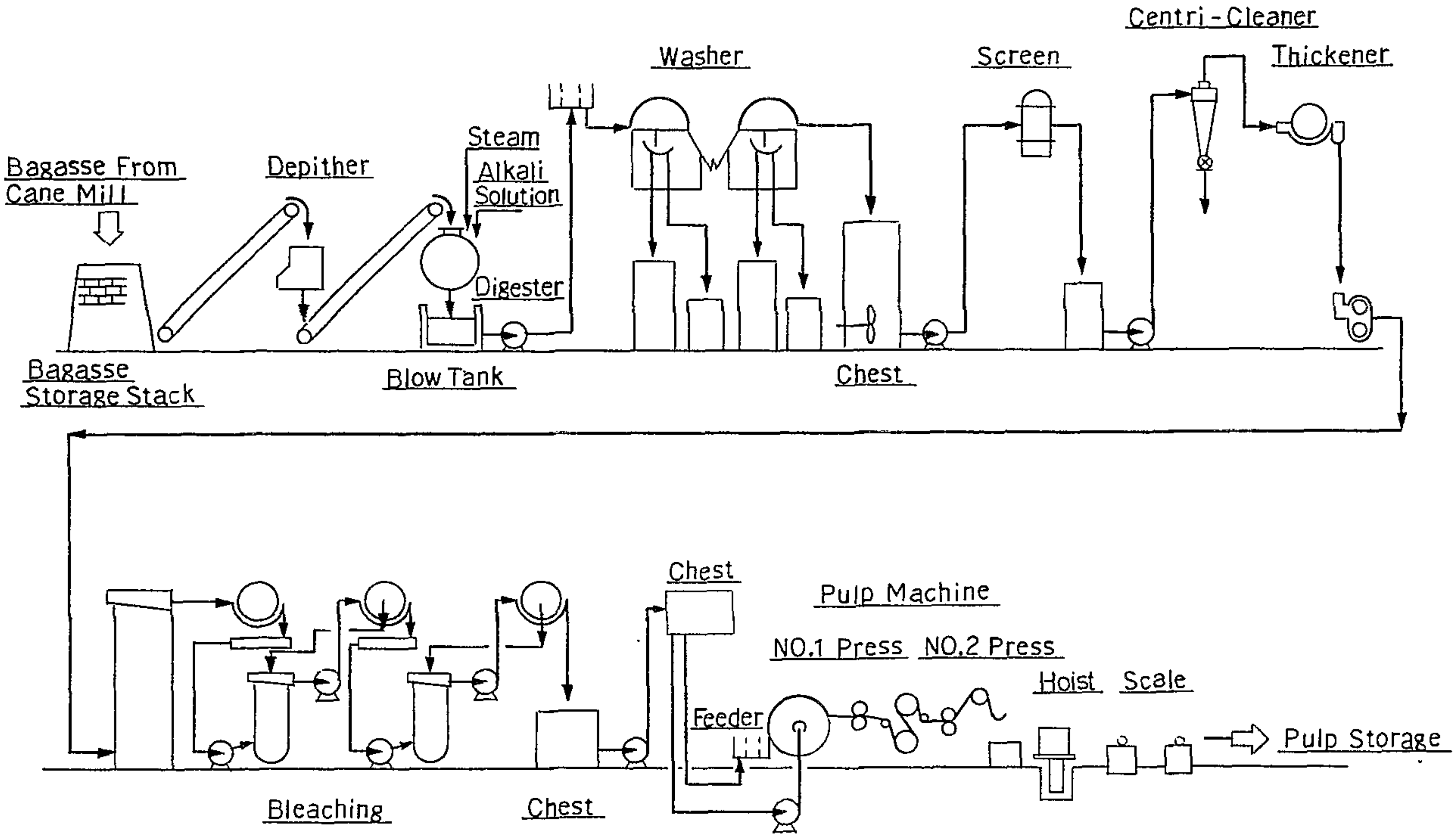
b) As the pulp production method, soda process was adopted, which is suitable for a small scale production.

c) As for paper to be produced, low grade wrapping paper was aimed, because of low construction cost and easy manufacturing. The findings are as follows:

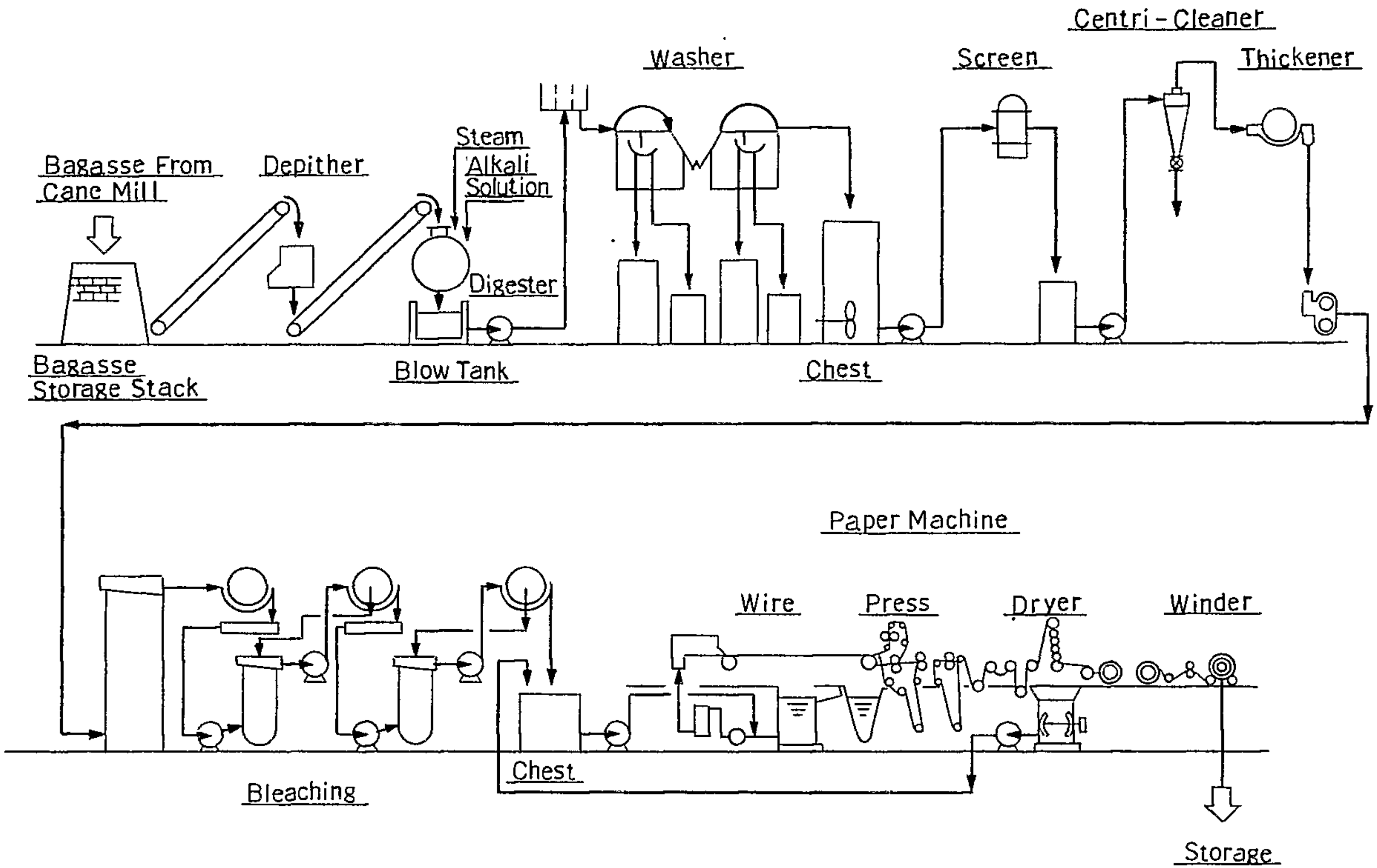
	Pulp	Paper ($x10^3$ pesos)
Yearly Product Sales	27,600	34,650
Yearly Expenditure	36,475	52,115
Fixed Cost	(14,225)	(20,865)
Variable Cost	(22,250)	(31,250)
Profit	-8,875	-17,465

As seen from the above, manufacturing of pulp and paper from bagasse will not be profitable, and therefore it was concluded that bagasse should be utilized as fuel of the distillery.

Drawing VII-11 Flow Sheet of Bagasse Pulp Plant



Drawing VII-12 Flow Sheet of Bagasse Paper Plant



(2) Carbon dioxide

A study in manufacturing liquefied carbon dioxide was conducted in order to utilize carbon dioxide for soft drink. The manufacturing method is shown in Drawing VII-13. The findings are as follows:

Liquefied Carbon dioxide		($x10^3$ pesos/y)
Yearly Product Sales	22,400	
Yearly Expenditure	4,240	
Fixed Cost	(2,680)	
Variable Cost	(1,560)	
Sales Profit	18,160	

Sales profit of about 18,160 x 10^3 pesos/y is expected as a result of manufacturing liquefied carbon dioxide for soft drink. In addition, the field survey revealed the sufficient demand in the soft drink industry, so that possibility of commercialization will be well considered.

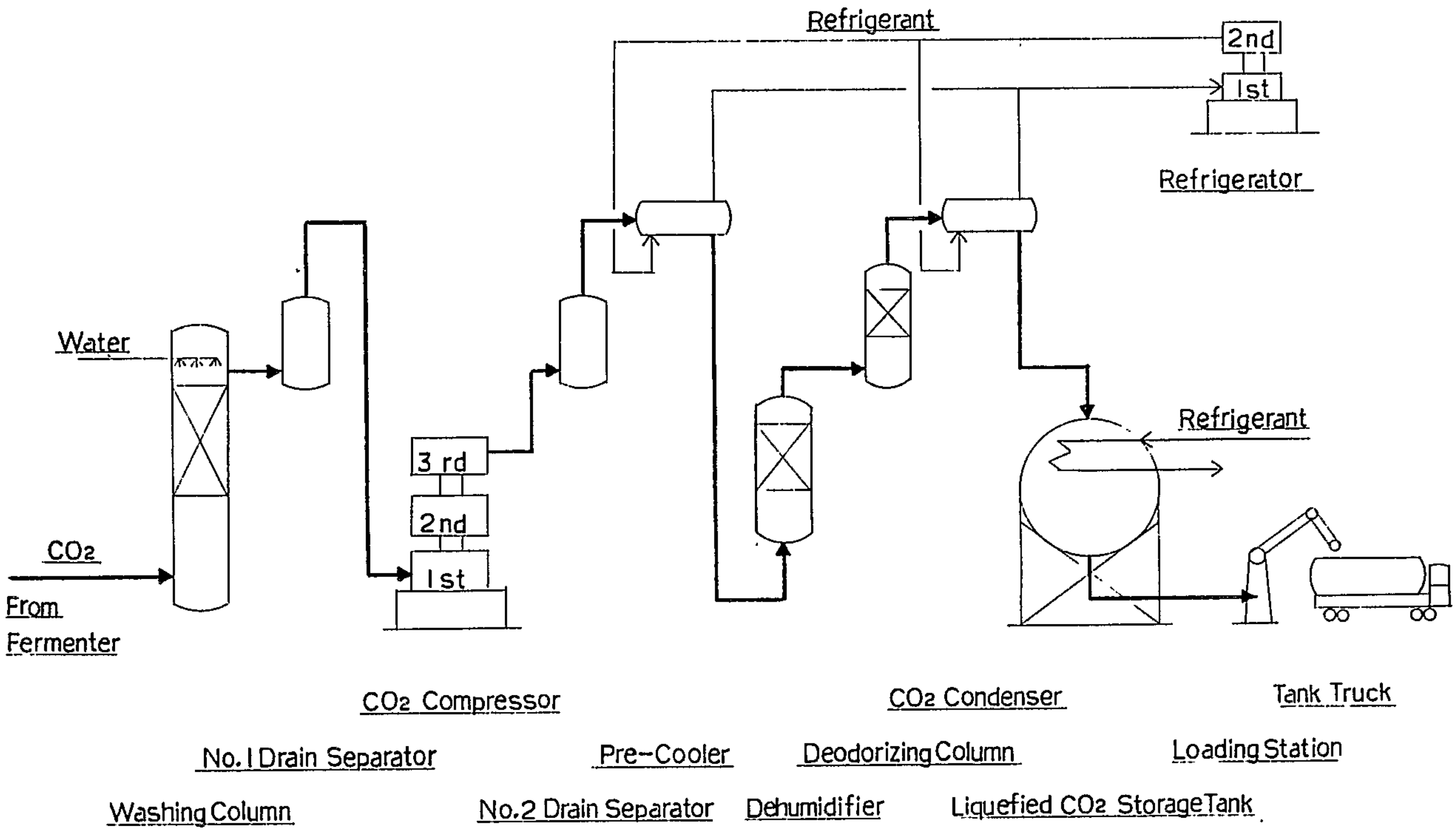
(3) Yeasts

A study was made to use yeasts to be separated in the fermentation process as animal feed. Since this study assumes yeast recycling process, a large portion of yeasts will be reused as active yeasts after pH adjustment and the remaining portion will be drawn, vacuum filtered, and dried to be used as animal feed.

The findings are as follows:

Yearly sales of feed	858	($x10^3$ pesos/y)
Yearly expenditure	990	
Fixed cost	(480)	
Variable cost	(510)	
Sales profit	-132	

Drawing VII-13 Schematic Flow Diagram of Liquefied Carbon Dioxide Plant



Drawing VII-14 Schematic Flow Diagram of Yeast Production

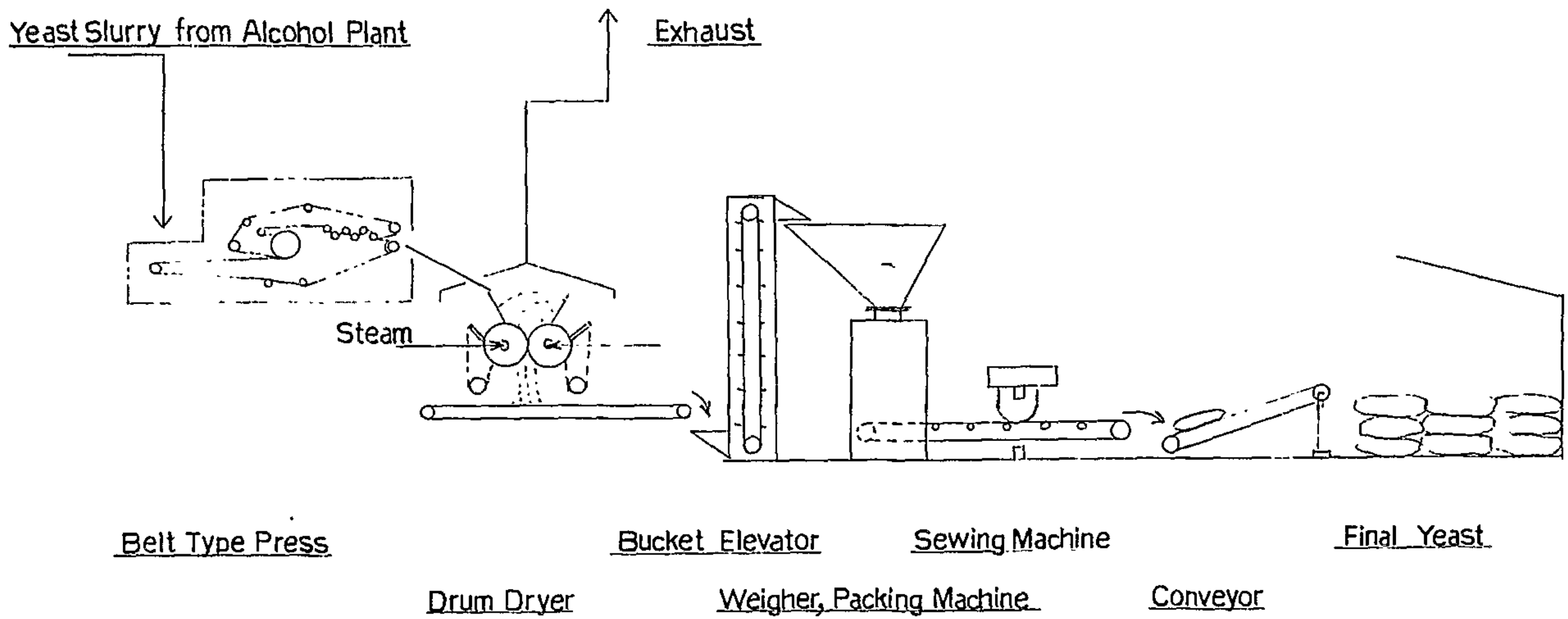


Table VII-17 Study on Ulitiaztion of By-products from Alcohol Distillery

By - Products		Bagasse			Carbon Dioxide	Yeast	Mud Cake	Fusel Oil	Bad Alcohol
Being Utilized as:		Fuel	Pulp	Paper	Soft Drinks	Animal Feed	Fertilizer for Fields	Perfumes	Fuel for Alcohol Distillery
Production Capacity of By-products (t/d)		211 (200 days/y)	23 (300 days/y)	21 (300 days/y)	40	1.65	26	0.24	0.384
Construction cost (x 10^3 pesos)		-	62,000	91,000	12,000	1,650	-	-	-
No. of Operators Required (men/d)		-	45	65	3	9	-	-	-
Utilities Requirements	Electric Power (KWh/d)	-	9,200	26,000	7,800	660	-	-	-
	Water (t/d)	-	2,300	2,300	4,000	-	-	-	-
	Steam (t/d)	-	69	153	-	12.0	-	-	-
	Chemicals (kg/d)	-		NaOH 6,900 $C\ell_2$ 2,300		-		- -	- -
Raw Material Cost (x 10^3 pesos/y)		-	16,250	16,250	-	-	-	-	-
Sales Revenue (x 10^3 pesos/y)		-	27,600	34,650	22,400	858	-	58	-
Fixed Cost (x 10^3 pesos/y)	Depreciation & Tax	-	12,400	18,200	2,400	330	-	-	-
	Labor & Maintenance	-	1,825	2,665	280	150	-	-	-
Variable Cost (x 10^3 pesos/y)	Utilities & Chemicals	-	6,000	15,000	1,560	510	-	-	-
Profit (x 10^3 pesos/y)		16,250	-8,875	-17,465	18,160	-132	-	58	-
Profit/construction cost		-	-	-	1.5	-	-	-	-

Production of animal feed from yeasts shows poor rentability as above, furthermore, the production volume is small and the quality is inferior to that of the imported feed being used. Accordingly, the yeasts discharged from the vacuum filter shall be returned to the sugarcane field as fertilizer.

(4) Others

Filter cake, fusel oil and lighter impurities other than those aforementioned were also studied for possible utilization. Filter cake is separated in the clarification process, while fusel oil and lighter impurities are separated in the distillation process but the separated volume is very little. Filter cake and lighter impurities can be used as fertilizer and fuel respectively, but they have no commercial value. Fusel oil consists largely of amyl alcohol which is useful as perfume. Therefore, this report assumes that it can be sold as raw material of perfume.

4-5 Instrumentation System

A study was made on the instrumentation system taking the following major points into consideration.

i) Necessity and degree of automatic control in view of the characteristics of the process.

ii) Availability of the instruments including spare parts and the prices.

iii) Easy maintenance

iv) Availability of required instrument engineers.

As the result, it was determined to install the following instruments. In addition, miscellaneous instruments, such as temperature gauges and pressure gauges, will be installed when necessary.

(1)	Vehicle weighbridge	(Quantity of incoming raw material and outgoing product)
(2)	Flow integrator	(product alcohol)
(3)	Flow indicator	(Imbibition water)
(4)	Temperature gauges	(Fermenters)
(5)	Flow indicators	(Reflux of columns)
(6)	Flow controllers	(Steam to columns)
(7)	Temperature gauges	(Principal points of columns)
(8)	Level controllers	(Waste water from mash and rectifying columns)
(9)	Level controller	(Bottom of dehydration column)
(10)	Level controller	(Bottom of benzene recovery column)
(11)	Flow controller	(Boiler feed water)
(12)	Pressure controller	(Steam from boiler)
(13)	Level controller	(Steam drum)
(14)	Pressure controller	(Deaerator)
(15)	Level controller	(Deaerator)
(16)	Juice scale	(Raw juice)

4-6 Inland Transportation

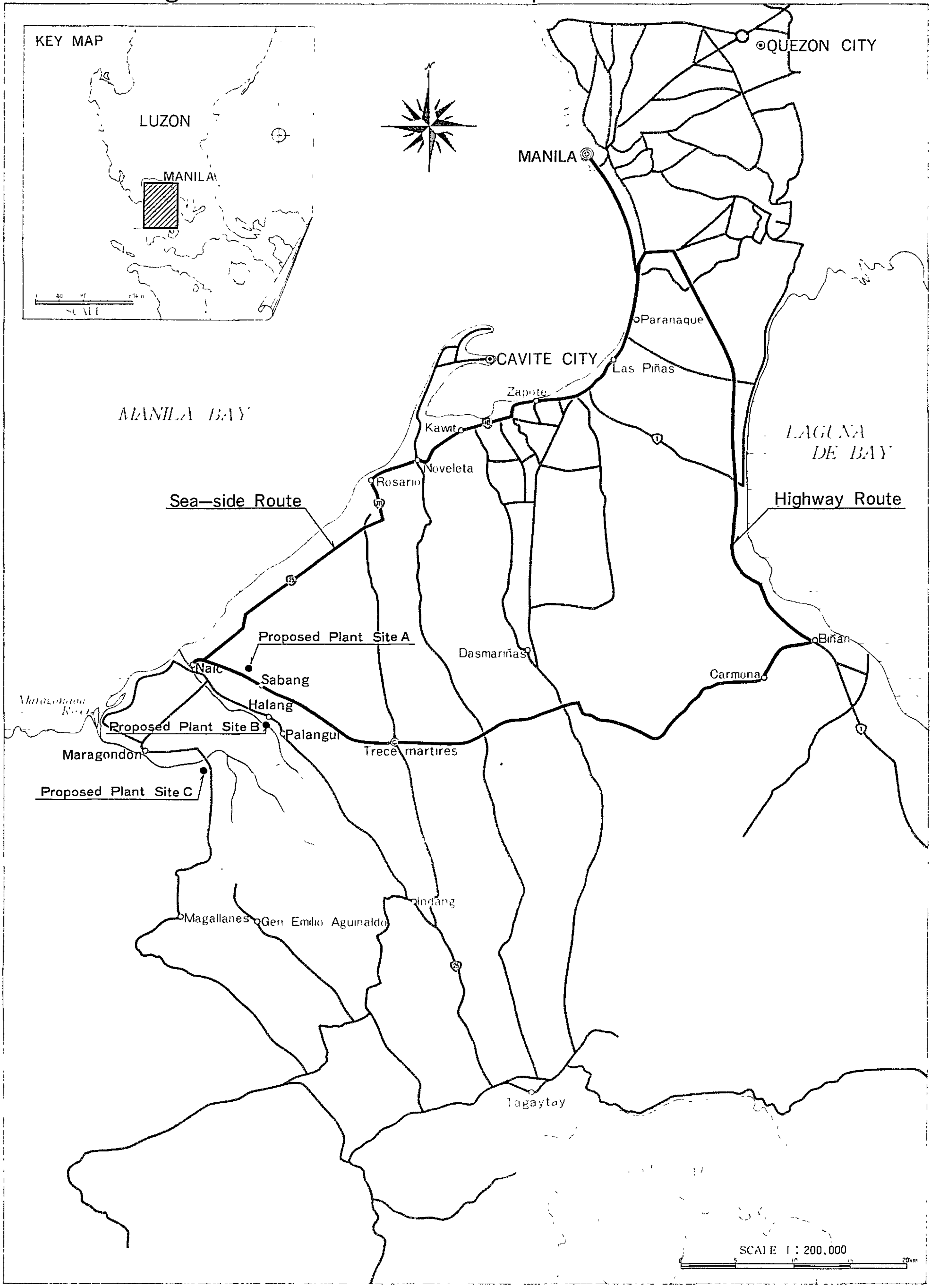
4-6-1 Unloading of imported equipment and materials

Manila Port deals with cargos corresponding to 80% of total import bill and has satisfactory port facilities and unloading facilities. As there are no well-equipped and materials will be unloaded at Manila Port. South harbor of Manila Port has 5 piers accommodating the maximum size of vessel of 200 m length, 30 m width and 45,000 DWT. Unloading facilities include 3- floating crane of 50 t lifting capacity and 6- shore crane of 30 t lifting capacity.

4-6-2 Inland transportation

The dispatch point of inland transportation is Metro Manila, i.e., imported equipment and materials are transported from Manila Port to

Fig. Ⅶ—3 The Route of Transportation



the site, whereas locally manufactured equipment, from manufacturer's factory in Metro Manila to the site.

Transport routes can be either of the two:

(1) Sea-side route (Manila to site, approx. 60 km)
(2) Highway route.

They are indicated in Fig. VII-3. Both routes have traffic limitations for large vehicles (truck ban) when passing through Metro Manila, and the traffic of these large vehicles is suspended during 6 - 9 a.m. and 4 - 8 p.m., a fact which should be noted carefully.

(1) Sea-side route

Sea-side route is Metro Manila → Parañaque → Las Piñas → Zapote → Mabolo → Kawit → Noveleta → Rosario → Naic.

The average width of the street from Metro Manila to Rosario is 8 m or so with many curves, and the traffic is normally heavy. Electric wires hang down to about 4 meters above ground here and there. Most of the bridges are of concrete construction with the arch type or girder-beam type structure.

The following considerations should be given in utilizing the sea-side route.

1) Night transportation should be made in view of the heavy traffic during daytime and many curves within the city.

2) Electric wires must be raised when passing, to avoid contact with cargo.

3) Long equipment such as distillation column should preferably be transported in pieces and assembled or welded at the plant site.

(2) Highway route

Highway route is Metro Manila → Biñan → Carmona → Trece Martires → Naic.

The highway route has height limitations. There are slopes at many places between Biñan and Trece Martires, having the inclination of 7 ∿ 8°.

Short bridges on the way are of concrete construction with arch type, having no problem in tolerating a load, but long bridges are steel suspension bridges which require studies on load tolerance.

5. Conceptual Design of Alcohol Distillery

5-1 Design Basis

Studies were made on production facilities, off-site facilities, plot plan, construction schedule, distillery management plan and construction cost, based on the following design conditions.

Alcohol production capacity	:	60 kl/d
Alcohol content (product)	:	99.5 vol.% or over
Sucrose content (sugarcane)	:	13.5 wt %
Invert sugar content (sugarcane)	:	0.6 wt %
Fiber content (sugarcane)	:	13 wt %
Fermentation process	:	Batch process with yeast recycle
Fermenting temperature	:	37°C
Fermentation cycle time	:	24 hours
Fermentation efficiency	:	90%
Distillation efficiency	:	97.5%
Raw material consumption per kl of alcohol	:	12.87 t/kl-alcohol
Raw material consumption per day	:	772 t/d
Electric power generation	:	In-plant generation

Fuel	:	bagasse
Cooling water temperature	:	28°C

5-2 Production Facilities

5-2-1 Process description

The facilities consist of the following processes:

(1) Raw-material receiving and storage
(2) Milling
(3) Clarification of sugarcane juice
(4) Fermentation
(5) Distillation
(6) Finished-product storage and loading

Each process is described as follows. For the process flow, refer to Drawing VII-15.

(1) Raw material receiving and storage

The raw material brought in by trucks are weighed by the road vehicle weighbridge and transported to the raw material storage yard. As the raw-material must be processed within 24 hours following harvesting, the raw-material storage yard is sized to have a storage capacity for two-day operation.

(2) Milling

The delivered raw-material is unloaded onto the feed table by the yard crane and knifed and shredded. Then, it is crushed by the milling machine to be separated into juice and bagasse. Imbibition water is added to improve the sugar recovery in the milling stage. Following the screening, the juice is fed to the clarification process and the bagasse is fed to the boiler for use as the fuel.

The milling machine consists of four mills, with a crushing capacity of 880 t/d and an extraction efficiency of 94%.

(3) Clarification of sugarcane juice

Following the weighing by the juice scale, the mixed juice has its pH value adjusted to 7.0 by addition of lime. Then, it is heated to approximately 100°C and fed to the clarifier where it is separated into clarified juice and mud. The clarified juice is then screened and cooled to approximately 35°C before it is sent to the fermentation process. The mud sedimented in the clarifier is filtered by the vacuum filter and discharged out of the system.

The quantity of mud generated amounts approximately to 26 t every day and it is recirculated to the sugarcane fields as the fertilizer.

(4) Fermentation

This process, batch fermentation with yeast recycle, takes approximately 24 hours to complete one cycle of feeding, fermentation, discharge and washing.

Upon feeding of the clarified juice obtained in the preceding process and the recycled yeast to the fermenter, the fermentation starts immediately and continues. After the elapse of approximately 14 hours at 37°C, fermented mash with alcohol content of about 8.4 vol. % is obtained. In the initial stage of fermentation, a required amount of ammonium sulfate and phosphoric acid are added as the nutrients.

The fermented mash is fed to the yeast separator and the yeasts recovered in this separator have their pH adjusted before re-use as the seed for next batch.

The separated mash is sent to the distillation process. Of the yeasts recovered, excessive ones are discharged out of the system and dewatered to be returned to the sugarcane fields as the fertilizer.

To prevent decrease of activity of the recycles yeasts, the fresh yeasts cultured in the seed vessel are added once in one or two months.

(5) Distillation

The fermented mash with alcohol content of about 8.4 vol. % is preheated to about 95°C by the vapor from the ethanol rectifying column and the stillage from the mash column. The preheated mash is then fed to the mash column.

The alcohol vapor (about 48 vol. %) separated at the top of the mash column is fed to the ethanol rectifying column where the alcohol is concentrated to the binary azeotropic point of alcohol/water and then it is fed to the dehydration column. In this column, benzene is added as the third component to the binary state of alcohol/water, for ternary azeotropic distillation of benzene/alcohol/water.

The anhydrous alcohol (95.5 vol. %) drawn out from the bottom of the dehydration column is cooled down to about 40°C and sent to the product storage tanks.

The ternary azeotropic mixture is drawn out from the top of the column and fed to the benzene recovery column where benzene is recovered at the top for the re-use as the dehydration agent. The bottoms containing a small amount of alcohol are returned to the ethanol rectifyig column.

The stillage drawn out from the bottom of the mash column is cooled and sent to the waste water pit where it is mixed with other waste water, for spraying in the sugarcane fields as the irrigation water.

The stillage from the ethanol rectifying column is recycled to the milling process for the use as the imbibition water.

(6) Finished-product storage and loading

The product alcohol is stored in the storage tanks having the capacity of thirty-day production.

Loading arm facility is provided assuming that the product is delivered by tank trucks.

Drawing VII-15 shows the process flow of this facility. Drawing VII-16 shows the material balance and Table VII-18 lists the utilities and chemicals consumption.

5-3 Off-site Facilities

The off-site facilities are as follows:

5-3-1 Utility facilities

As the utilities facilities, the water treatment facility, the boiler facility and the power generation facility are provided.

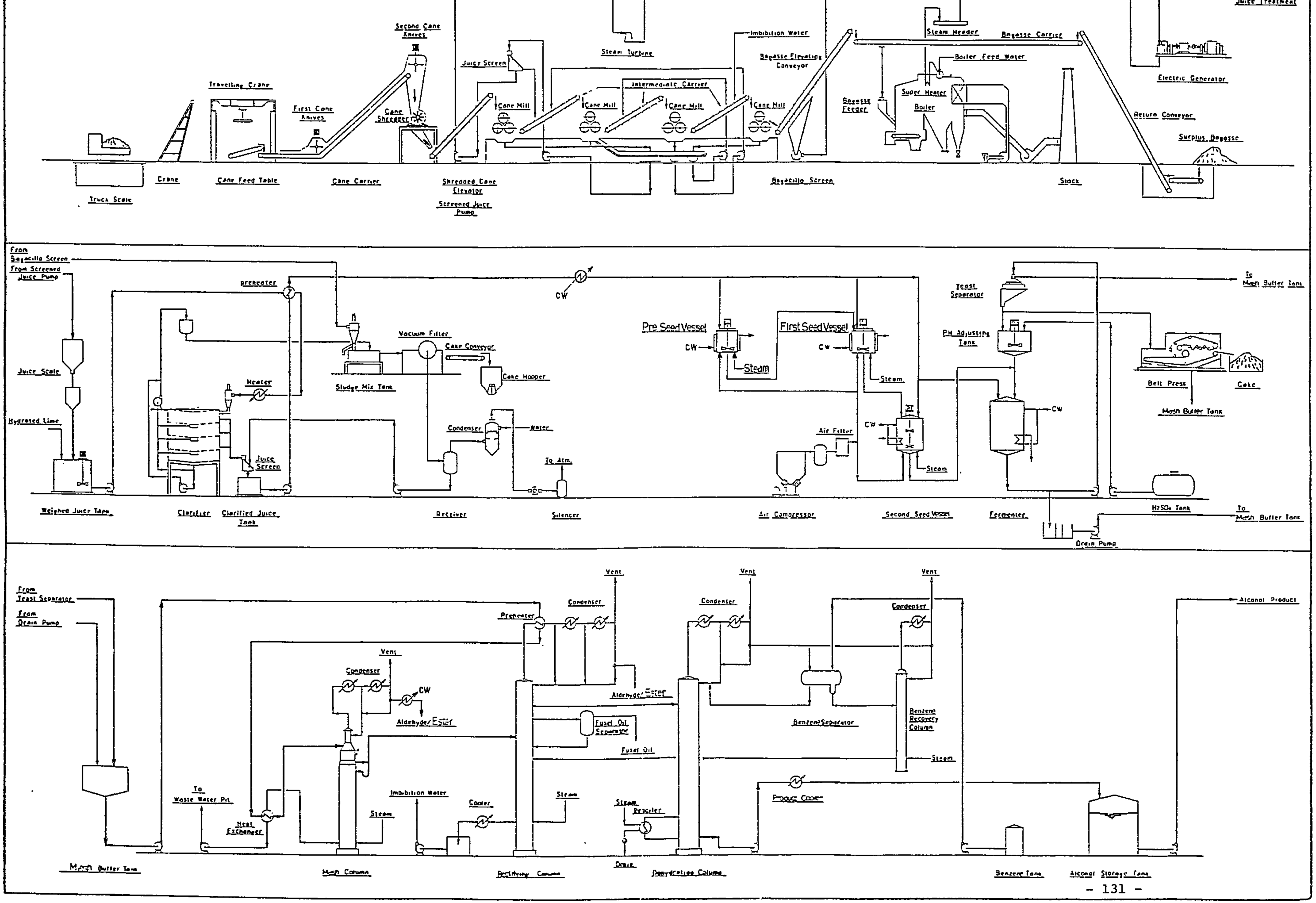
Consumptions of water, steam and electric power are shown in Drawing VII-17, Drawing VII-18 and Drawing VII-19, respectively.

An outline of the utilities facilities is given below.

(1) Water treatment facility

Underground water from two deep wells located within the battery limits is used in each of the following water treatment facilities.

Drawing VII-15 Process Flow



Drawing VII-16 Material Balance

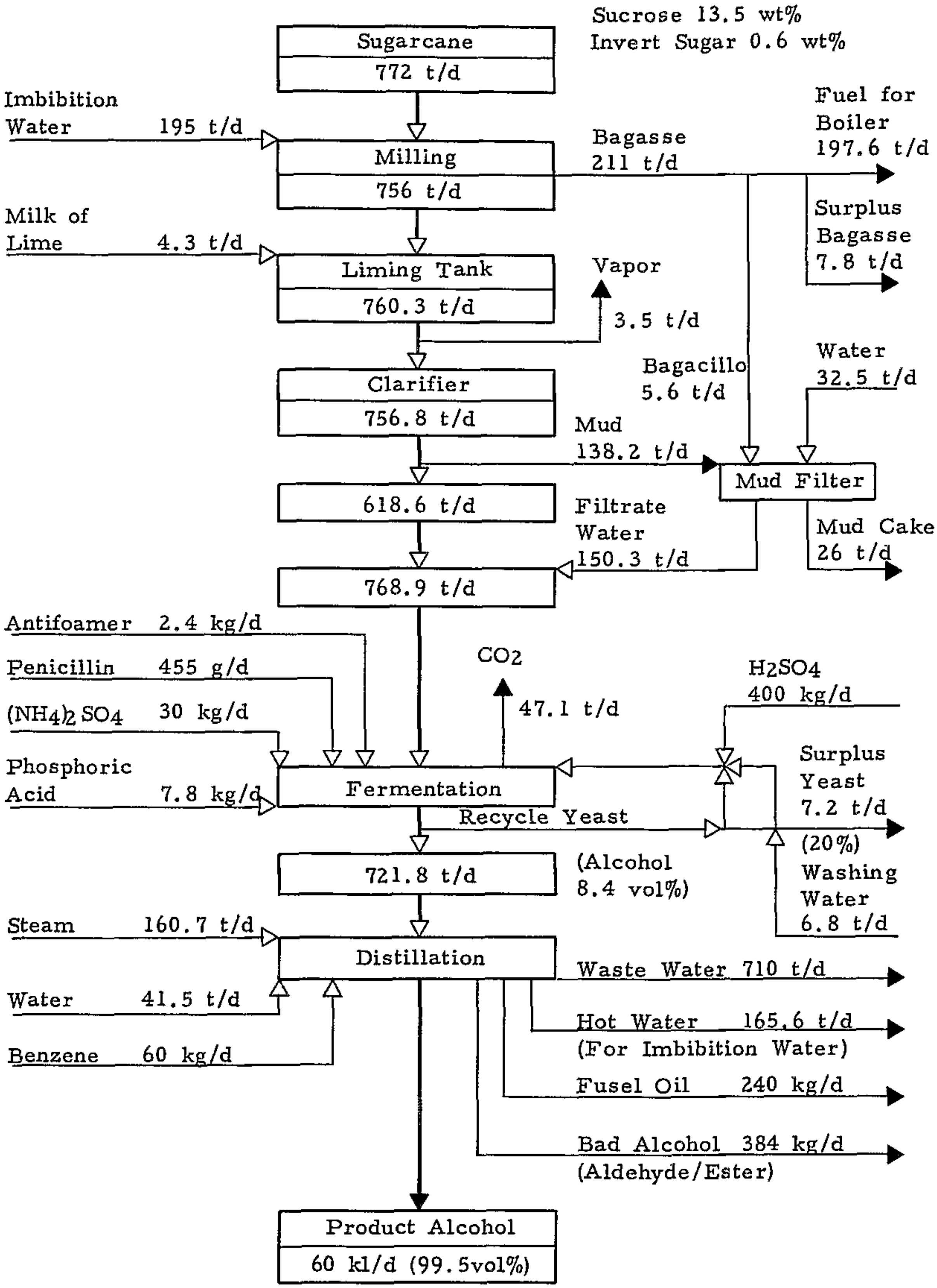


Table VII-18 Consumption of Raw Material, Chemicals and Utilities

	Raw Material, Chemicals and Utilities	Consumption/d	Consumption/ kl - Alcohol
1	Sugarcane	772 t	12.87 t
2	Well Water	2,832 t	47.2 t
3	Electric Power	19,200 KWH	320 KWH
4	Benzene (For Distillation) Initial Running	 3.08 t 60 kg	 1 kg
5	H_2SO_4 (98%) (For Fermentation)	400 kg	6.7 kg
6	Antifoamer (For Fermentation)	2.4 kg	40 g
7	Lime (100%) (For Clarification)	600 kg	10 kg
8	Penicillin (For Fermentation)	455 g	7.6 g
9	$(NH_4)_2SO_4$ (For Fermentation)	30 kg	0.5 kg
10	Phosphoric Acid (For Fermentation)	7.8 kg	0.13 kg
11	NaOH (100%)(For Demineralizer etc)	150 kg	2.5 kg
12	HCl (100%) (For Demineralizer etc)	100 kg	1.7 kg
13	Corrosion Inhibitor (For Cooling Water)	27 kg	0.45 kg
14	Slime Inhibitor (For Cooling Water)	1.2 kg	20 g
15	Phosphoric Acid Soda (For Boiler)	4.9 kg	82 g
16	Hydrazine (For Boiler)	7.3 kg	122 g
17	Bagasse (For Fuel)	197.6 t	3.3 t

1) Water supply facility

a) Deep well pumps

Pump capacity	:	60 m^3/h
Differential head	:	150 mH
Quantity	:	2

b) Water storage tank

Capacity	:	150 m^3
Type	:	Cone-roof tank
Quantity	:	1

c) Water feed tank

Capacity	:	150 m^3
Type	:	Cone-roof tank
Quantity	:	1

2) Boiler feed water facility

The followings are provided as the water treatment facility for boiler feed water.

Processing capacity : 20 t/h

a) Cation exchange vessel (2.5 m^3)	:	1
b) Anion exchange vessel (3 m^3)	:	1
c) Carbonatation vessel (2 m^3)	:	1
d) Hydrochloric acid tank (5 m^3)	:	1
e) Caustic soda tank (5 m^3)	:	1

3) Cooling tower facility

The following equipment are provided to allow recycling of cooling water.

a) Cooling tower

Flow rate	:	440 m^3/h
Quantity	:	1

b) Cooling water pit

Capacity	:	70 m^3
Construction	:	Reinforced concrete
Quantity	:	1

c) Recycle pumps

Pump capacity	:	480 m^3/h
Differential head	:	50 mH
Quantity	:	2

(2) Boiler facility

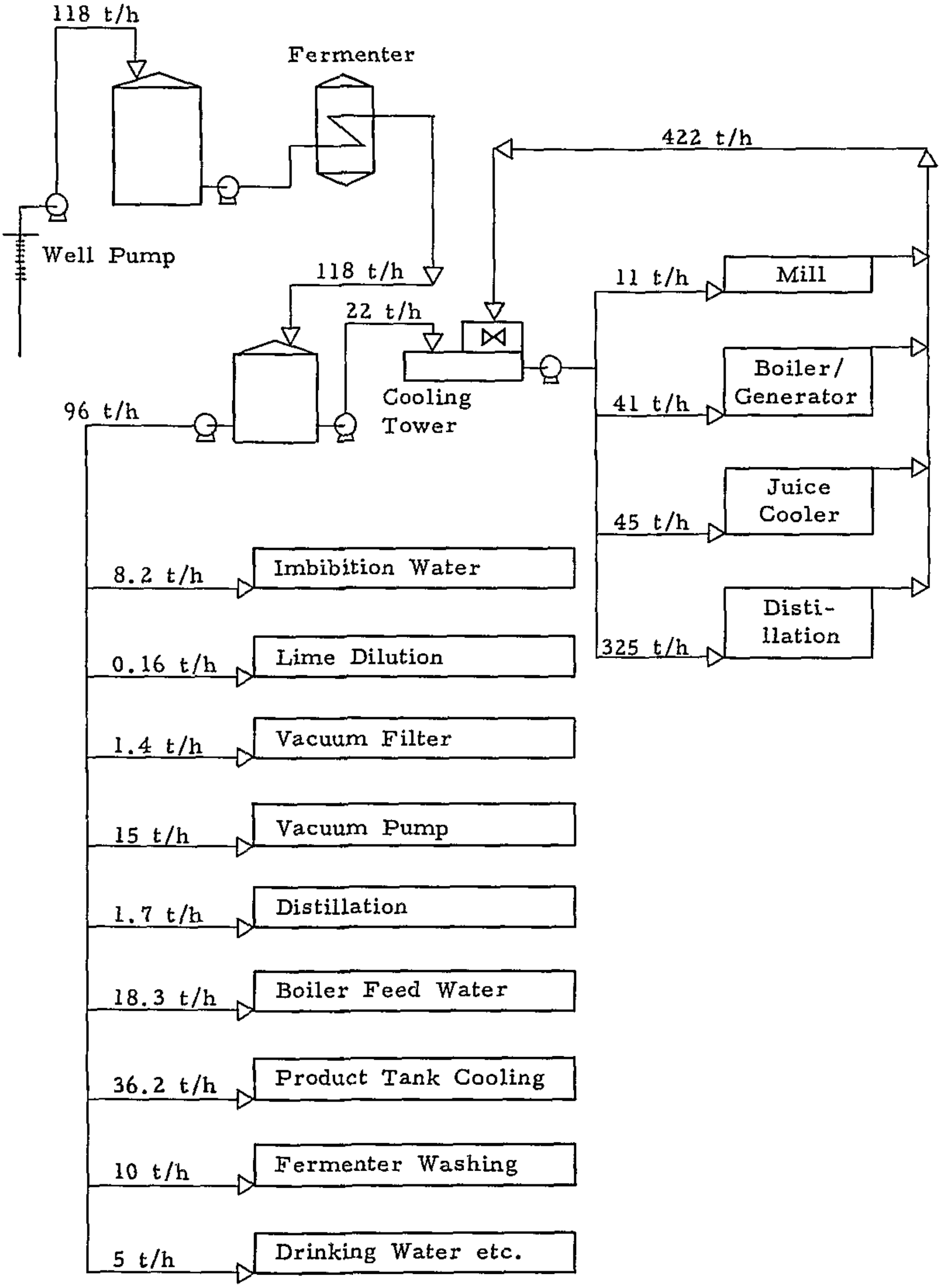
The steam generated by the boiler is used for the following purposes.

1) Drive of milling machine
2) Electric power generation
3) Process use

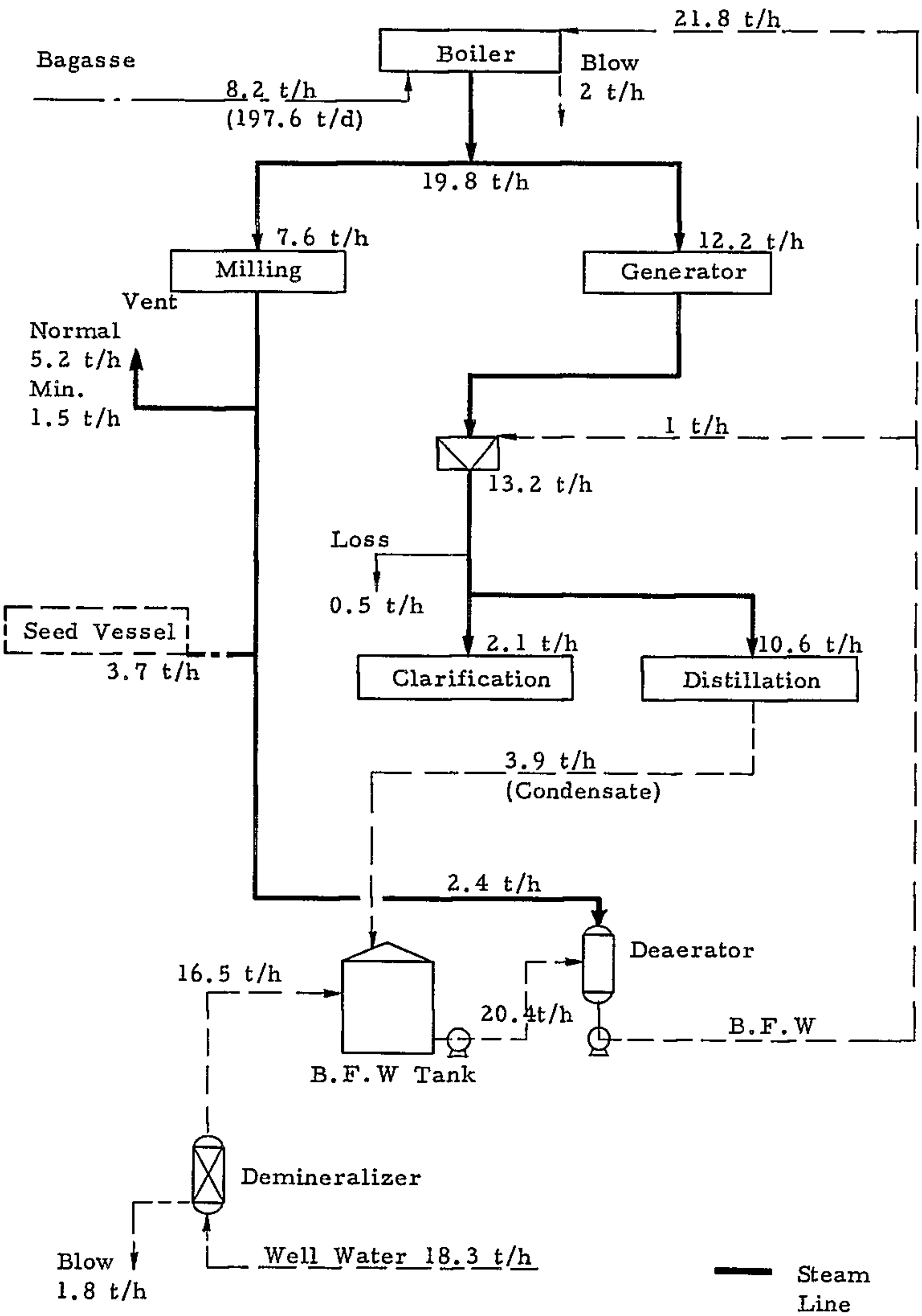
The major specifications of the boiler are as follows:

1) Boiler capacity	:	25 t/h
2) Steam pressure	:	21 kg/cm^2G
3) Steam temperature	:	360°C

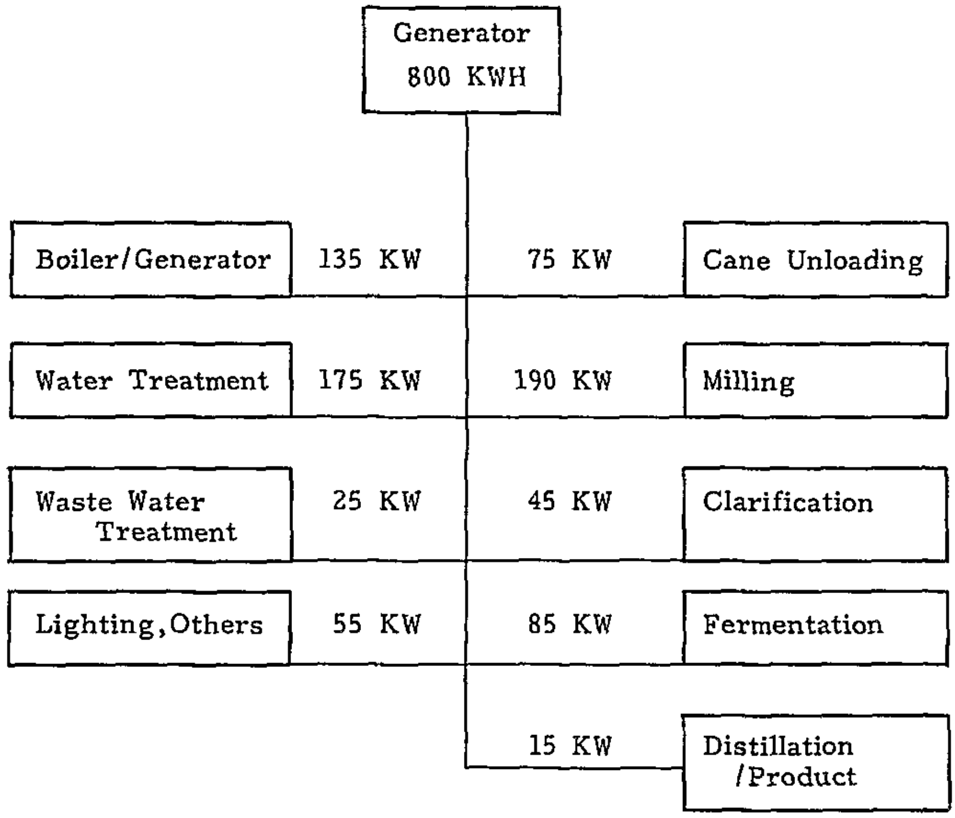
Drawing VII-17 Water Balance



Drawing VII-18 Steam Balance



Drawing VII-19 Power Balance



4) Fuel : Bagasse
5) Quantity : 1

(3) Power generation facility

The following steam turbine generator is provided to meet the electric power requirement of the distillery.

1) Generator capacity : 800 KW
2) Voltage : 440 V
3) Frequency : 60 Hz
4) Quantity : 1

The following diesel engine generator is provided for use in initial start-up of the boiler and in an emergency.

1) Generator capacity : 280 KW
2) Fuel : Diesel oil
3) Quantity : 1

5-3-2 Maintenance facilities

In-house maintenance is limited to simple routine maintenance, with major maintenance relying on contractors. Major maintenance equipment are listed below.

(1) Machining facility

1) Lather : 1
2) Bench type drilling machine : 1
3) Milling machine : 1

(2) Can machining facility

1) Welding machines : 2
2) Gas cutting torches : 2

3) Bending machine : 1

(3) Tools and measuring instruments : 1 set

(4) Compressor : 1

(5) Work table : 1

(6) Spare equipment and parts : 1

1) Installed spare equipment for Major rotating equipment : one each

2) Spare parts : Only parts not locally available are stored for two-year operation.
Major spare parts are listed in Table VII-19.

(7) Vehicles

The following vehicles are provided to transport equipment and materials:

1) Land cruisers : 2
2) Fork lifts : 2
3) Shovel loader : 1
4) Dump truck (4 t) : 1

Table VII-19 Spare Parts List for Main Equipment (1/9)

Equip. No.	Equip. Name	Spare Parts Name	Q' ty
M-103	Cane Feed Table	Conveyor Chain	20%
		Apron with Bolt	20%
		Drive Chain	20%
		Bearing	100%
M-104	First Cane Knives	Knife	150%
M-105	Second Cane Knives	Bearing	100%
		V Bent	100%
M-106	Cane Shredder	Hammer	200%
		Hammer Pin	100%
		Bearing	100%
M-107	Tramp Iron Separator	Fuse Element	100%
		Pilot Lamp	100%
M-108	Cane Mill	Roll and Shaft	3
		Bearing Metal for Top Roll	1
		Bearing Metal for Side Roll	2
		Turn Plate	4
		Scraper Knife	100%
		Oil Seal	200%
		Chain for Lubricating Oil	25%
M-110	Steam Turbine	End Gland Seal (Carbon Ring)	100%
		Inter Stage Seal (Labyrinth)	33%
		Thrust Pad	100%

Table VII-19 Spare Parts List for Main Equipment (2/9)

Equip. No.	Equip. Name	Spare Parts Name	Q' ty
M-110	Steam Turbine (Cont.)	Journal Pad	100%
		Steam for Governor Valve	100%
		Packing for Governor Valve	100%
		Bushing for Governor Valve	100%
		Worm Wheel for Governor	100%
		Each Kind of Spring	100%
		Packing for Hand Valves	100%
		Paste Type Gasket	100%
		Liquid Packing	100%
		Anti-Seize Lubricant	100%
M-111	Primary Gear Reduction	Bearing	50%
		Oil Seal	100%
M-112	Secondary Gear Reduction		
M-113	Final Gear Reduction		
C-101	Cane Carrier	Conveyor Chain	10%
	Intermediate Carrier	Apron with Bolt	10%
		Drive Chain	20%
		Bearing	100%
C-102	Shredded Cane Elevator	Conveyor Chain	20%
C-104	Bagasse Elevating Conveyor	Slat with Bolt	20%
		Drive Chain	20%
		Bearing	100%

Table VII-19 Spare Parts List for Main Equipment (3/9)

Equip. No.	Equip. Name	Spare Parts Name	Q'ty
P-101	Maceration Juice Pump	Gland Packing	200%
P-102	Maceration Juice Pump	Oil Seal	100%
P-103	Screened Juice Pump	Shaft Sleeve	100%
		Bearing	100%
Bo-201	Boiler	Water Level Gauge Glass with Packing	200%
		Manhole Packing	200%
		Handhole Packing	200%
		Boiler Tube	2%
		Fire Grate Link	2%
		Fire-proof Bricks	2%
		Shear Pin for Screw Feeder	300%
		Burner Gun with Tip	100%
		Peephool Glass	300%
		Fuse and Lamp for Switch Board Control Panel	100%
		Recording Chart	200%
B-201	No.1 FDF	Impeller	100%
B-202	No.2 FDF	Bearing	100%
B-203	IDF		
P-201	D-201 Feed Pump	Gland Packing	200%
		Shaft Sleeve	100%
		Bearing	100%
		Oil Seal	100%

Table VII-19 Spare Parts List for Main Equipment (4/9)

Equip. No.	Equip. Name	Spare Parts Name	Q' ty
P-202	B.F.W Pump	Mechanical Seal	100%
		Shaft Sleeve	100%
		Bearing	100%
C-201	Bagasse Carrier	Slat with Bolt	20%
C-203	Return Conveyor	Drive Chain	20%
C-202	Bagasse Feeder	Bearing	100%
C-204	Ash Conveyor	Flight	20%
C-205	Dust Conveyor	Drive Chain	20%
C-206	Ash Transfer Conveyor	Bearing	100%
G-201	Electric Generator	Carbon Ring with Spring	100%
		Gasket	100%
		Spring	100%
		Bearing Liner	100%
		Liquid Packing	100%
		Flow Sight for Lubrication	100%
		Element for Oil Cooler	100%
M-301	Juice Scale	Load Cell	100%
		Counter	100%
		Fuse	100%
		Pen & Ink	200%
		Chart	200%

Table VII-19 Spare Parts List for Main Equipment (5/9)

Equip. No.	Equip. Name	Spare Parts Name	Q' ty
	Mixer for	Bearing	100%
TK-301	Weighed Juice Tank	Oil Seal	100%
TK-303	Sludge Tank		
TK-304	Sludge Mix Tank		
TK-305	Lime Milk Tank		
E-301	Juice Preheater	Gasket	100%
E-303	Juice Cooler	Plate	5%
E-302	Juice Heater	Gasket	100%
		Tube	5%
S-301	Clarifier	Seal Rubber	100%
		Scraper	10%
		Bearing	100%
		Oil Seal	100%
S-302	Juice Screen	Screen	100%
S-303	Bagacillo Screen		
S-301	Exhauster	Impeller	100%
		Bearing	100%
		V Belt	100%
F-301	Vacuum Filter	Gasket	100%
		Wear Plate	100%
		Connector	100%
		Valve Bushing	100%
		Take up Spring	100%

Table VII-19 Spare Parts List for Main Equipment (6/9)

Equip. No.	Equip. Name	Spare Parts Name	Q'ty
F-301	Vaucum Filter (Cont.)	Vacuum Gauge	100%
		8A Rubber Hose	100%
		Bushing	100%
		Thrust Bearing	100%
		Oil Seal	100%
		Screens	100%
		Caulking	100%
		Pipe Plate	100%
		Gird	100%
		Agitator Bushing	100%
		Scraper Blade	100%
		Cake Wash Spray Nozzle	100%
P-301	Pumps	Gland Packing	200%
P-306		Shaft Sleeve	100%
P-308		Bearing	100%
P-311		Oil Seal	100%
P-307	Vacuum Pump	Liquid Packing	200%
		Gland Packing	200%
		Shaft Sleeve	100%
		Bearing	100%
		V Belt	100%

Table VII-19 Spare Parts List for Main Equipment (7/9)

Equip. No.	Equip. Name	Spare Parts Name	Q' ty
C-301	Cake Conveyor	Carrier Roller	20%
		Return Roller	20%
		Bearing	100%
	Mixer for		
R-402	First Seed Vessel	Bearing	100%
R-403	Second Seed Vessel	Oil Seal	100%
TK-402	PH Adjusting Tank		
S-401	Yeast Separator	Ball Bearing Protection Ring	2
		Neck Bearing Protection Cap	1
		Neck Bearing Bridge	1
		Counter Ring	1
		Rubber Metal Cushion	1
		Journal	1
		Pendulum Ball Bearing	2
		Angular Contact Ball Bearing	2
		Grooved Ball Bearing	1
		Angular Contact Ball Bearing	2
		Sight Glass	2
		Gasket	100%
		Brake Lining	2
		Rivet	8
		Nozzle	12
		Disk	2

Table VII-19 Spare Parts List for Main Equipment (8/9)

Equip. No.	Equip. Name	Spare Parts Name	Q'ty
BP-401	Belt Press.	Scraper	300%
		Belt	200%
		Bearing	100%
P-401	R-404 BTM Pump	Gland Packing	200%
P-402	Mash Pump	Oil Seal	100%
P-403	Drain Pump	Shaft Sleeve	100%
		Bearing	
C-501	Mash Column	Manhole Packing	100%
C-502	Rectifying Column	Sight Glass	100%
C-503	Dehydration Column	Gasket	
C-504	Benzene Recovery Column		
E-501	Heat Exchangers	Gasket	100%
E-512		Tube	5%
D-501	Vessels	Gasket	100%
D-504			
TK-501	Tanks	Gasket	100%
TK-507			
P-501	Product Pump	Mechanical Seal	100%
P-505	Benzene Feed Pump	Shaft Sleeve	100%
P-506	Fusel Oil Pump	Bearing	100%
P-507	Bad Alcohol Pump		

Table VII-19 Spare Parts List for Main Equipment (9/9)

Equip. No.	Equip. Name	Spare Parts Name	Q' ty
P-502	C-501 BTM Pump	Gland Packing	100%
P-503	C-502 BTM Pump	Shaft Sleeve	100%
P-504	E-503 Condensate Pump	Bearing	100%
		Oil Seal	100%
TK-601	Alcohol Storage Tank	Gasket	100%
P-601	Product Pump	Mechanical Seal	100%
		Shaft Sleeve	100%
		Bearing	100%
TK-701	Tanks	Gasket	100%
TK-705			
CT-701	Cooling Tower	Bearing	100%
		Packing & Oil Seal	100%
		V-Belt	100%
P-701	Pumps	Gland Packing	100%
		Shaft Sleeve	100%
P-708		Bearing	100%
P-801		Oil Seal	100%

5-3-3 Environmental protection facilities

(1) Waste water treatment facility

Stillage from mash column	:	709 t/d
Washing water return from fermenters	:	60 t/d
Blow-down from a boiler	:	100 t/d
Blow-down from cooling towers	:	431 t/d
Cooling water return from product storage tanks	:	860 t/d
Total		2160 t/d

The above waste water is collected in the waste water pit from where it is pumped by the waste water pump to the irrigation water pond located about 2 km away. Then, the waste water is sprayed in the sugarcane fields as the fertilizer. The waste water from the administration building, rest house and laboratory is processed by the septic tank before it flows to the waste water pit.

An outline of the waste water pit, etc. is given below.

1) Waste water pit

Capacity	:	1000 m^3
Construction	:	Excavated pond
Quantity	:	1

2) Waste water pumps

Pump capacity	:	100 m^3/h
Differential head	:	50 mH
Quantity	:	2

(2) Noise protection facility

The following measures are taken to meet the noise control requirements set forth by NPCC as shown below.

Control level for daytime : 70 dB
Control level for morning and evening : 65 dB
Control level for night time : 60 dB

1) Sound insulating walls are provided around the mill turbines.

2) Soundproof chambers are provided for IDF and FDF in boiler facility.

5-3-4 Safety facilities

The following safety facilities are provided.

(1) Fire-fighting facilities

1) Overall distillery

Fire extinguishers are installed in each area as listed below.

Table VII-20 Number of Fire Extinguishers Installed

Area	Small Size Fire Exting.	Large Size Fire Exting.
Electric Gen. House	2	0
Boiler Section	2	1
Distillation Section	16	1
Alcohol Storage Area	2	1
Laboratory	2	0
Maintenance Shop	2	0
Warehouse	11	0
Admin. Building	4	0
Rest House	2	0
Total	43	3

2) Area handling flammable and combustible materials

In the product alcohol storage facility, the following foam extinguishing system is provided:

Foam concentrate tank (3 m^3) : 1
Fire pump (2 m^3/min. x 80 mH, engine/motor) : 1
Air foam chambers : 2
Foam solution hydrants : 2

(2) Dikes

Dikes as specified by the National Fire Codes are installed around the product alcohol storage tanks.

(3) Others

In addition to the above, the following safety measures are taken.

1) Installation of lightning rods

2) The electric equipment used for the distillation facility and the product alcohol storage and loading facility are explosion proof type.

5-3-5 Laboratory

The laboratory is equipped with the following equipment and materials.

Table VII-21 Analytical Equipment and Materials

	Equipment/Materials	Q'ty
1	Microscope	1
2	Jar-Fermenter	1
3	Constant Temperature Bath	1
4	Autoclave	1
5	Refrigerator	1
6	Germ-free Box	1
7	Saccharose Meter	2
8	Drying Oven	1
9	pH Meter	1
10	Spectrophoto-meter	1
11	Chemical Balance	1
12	Event Balance	1
13	Steel/Yard Scale	1
14	Gas Burner	2
15	Centrifugal Separator	1
16	Glass Tools	1 set
17	Baumé Hydrometer	2

5-3-6 Receiving and loading facilities

The following facilities are installed.

(1) Raw-material receiving facility

Road vehicle weighbridge (Weighing range 0 - 30 t)	:	2
Unloading crane (15 t)	:	2

(2) Product-alcohol loading facility

Tank truck loading facility	:	1

5-3-7 Major buildings

In designing the buildings, the following points have been taken into consideration:

1) Climate, natural features and way of living in the plant site
2) Ease of maintenance
3) Civil engineering level and construction skill in the Philippines
4) Use of domestic equipment and materials as much as possible

An outline of each building is given below.

(1) Raw-materilal storage/Milling/Boiler building

1) Structure	:	Steel structure, slate roof
2) Building area	:	2420 m^2
3) Floor space	:	2420 m^2

For details, see Drawing VII-20.

(2) Clarification Structure

1) Structure	:	Steel structure, slate roof, two stories above ground

2) Building area : 192 m^2
3) Floor space : 384 m^2

For details, see Drawing VII-21.

(3) Fermentation building

1) Structure : Steel structure, slate roof, 2 stories above ground
2) Building area : 510 m^2
3) Floor space : 750 m^2

For details, see Drawing VII-24.

(4) Yeast recovery structure

1) Structure : Steel structure, slate roof, 3 stories above ground
2) Building area : 80 m^2
3) Floor space : 200 m^2

For details, see Drawing VII-21.

(5) Distillation structure

1) Structure : Steel structure, slate roof, 8 stories above ground
2) Building area : 128 m^2
3) Floor space : 800 m^2

For details, see Drawing VII-21.

(6) Generator house

This house accommodates the steam turbine generator and the diesel engine generator, the latter to be used at the start-up.

1) Structure : Reinforced concrete and steel structure, single story above ground
2) Building area : 220 m^2
3) Floor space : 200 m^2

For details, see Drawing VII-22.

(7) Excess bagasse storage house

1) Structure : Steel structure, slate roof, slate wall, single story
2) Building area : 2050 m^2
3) Floor space : 2000 m^2

For details, see Drawing VII-23.

(8) Administration building

This building consists of the general manager's room, the department heads' rooms, the secretaries' room, offices and conference room, etc.

1) Structure : Reinforced concrete and steel structure, single story
2) Building area : 325 m^2
3) Floor space : 250 m^2

For details, see Drawing VII-24.

(9) Rest house

1) Structure : Reinforced concrete and steel structure, single story
2) Building area : 325 m^2
3) Floor space : 250 m^2

For details, see Drawing VII-25.

(10) Laboratory

This building accommodate facilities to perform analysis and experimental tests necessary for quality control.

1) Structure : Reinforced concrete and steel structure, single story
2) Building area : 168 m^2
3) Floor space : 120 m^2

For details, see Drawing VII-26.

(11) Maintenance shop

This building accommodates the machines and tools necessary for distillery equipment maintenance. Also, spare equipment and spare parts are stored in this building.

1) Structure : Steel structure, slate roof, slate wall, single story
2) Building area : 330 m^2
3) Floor space : 300 m^2

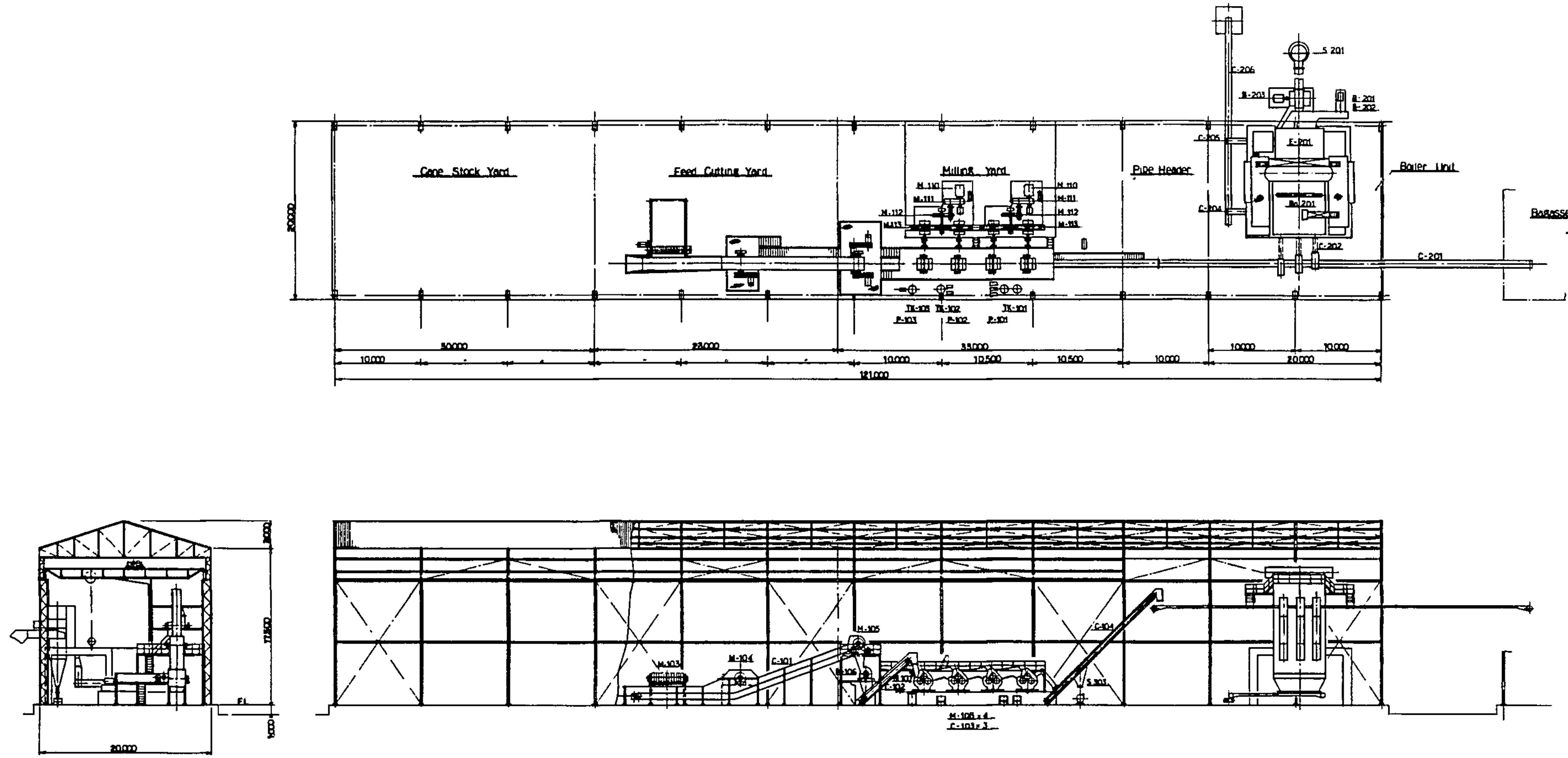
For details, see Drawing VII-27.

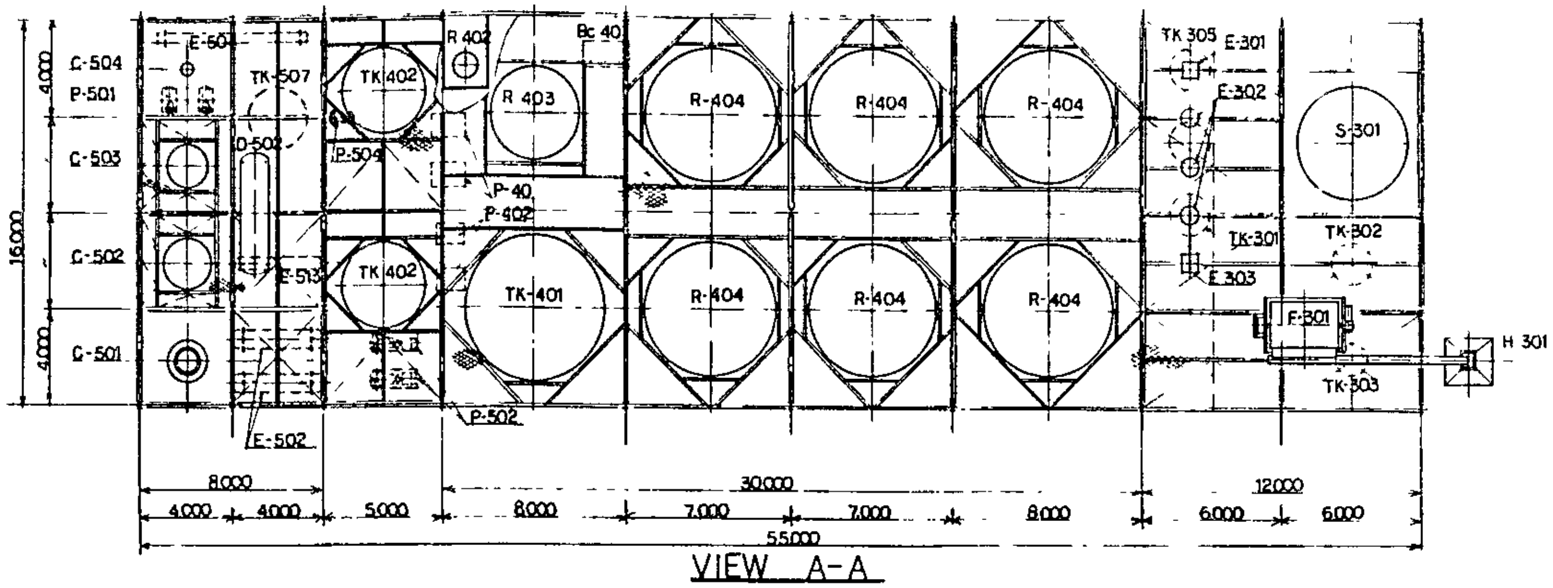
(12) Warehouse

This building stores chemicals and other materials.

1) Structure : Steel structure, slate roof, slate wall, single story
2) Building area : 220 m^2
3) Floor space : 200 m^2

Drawing VII-20 Cane Stock Yard, Milling, Boiler, Structure

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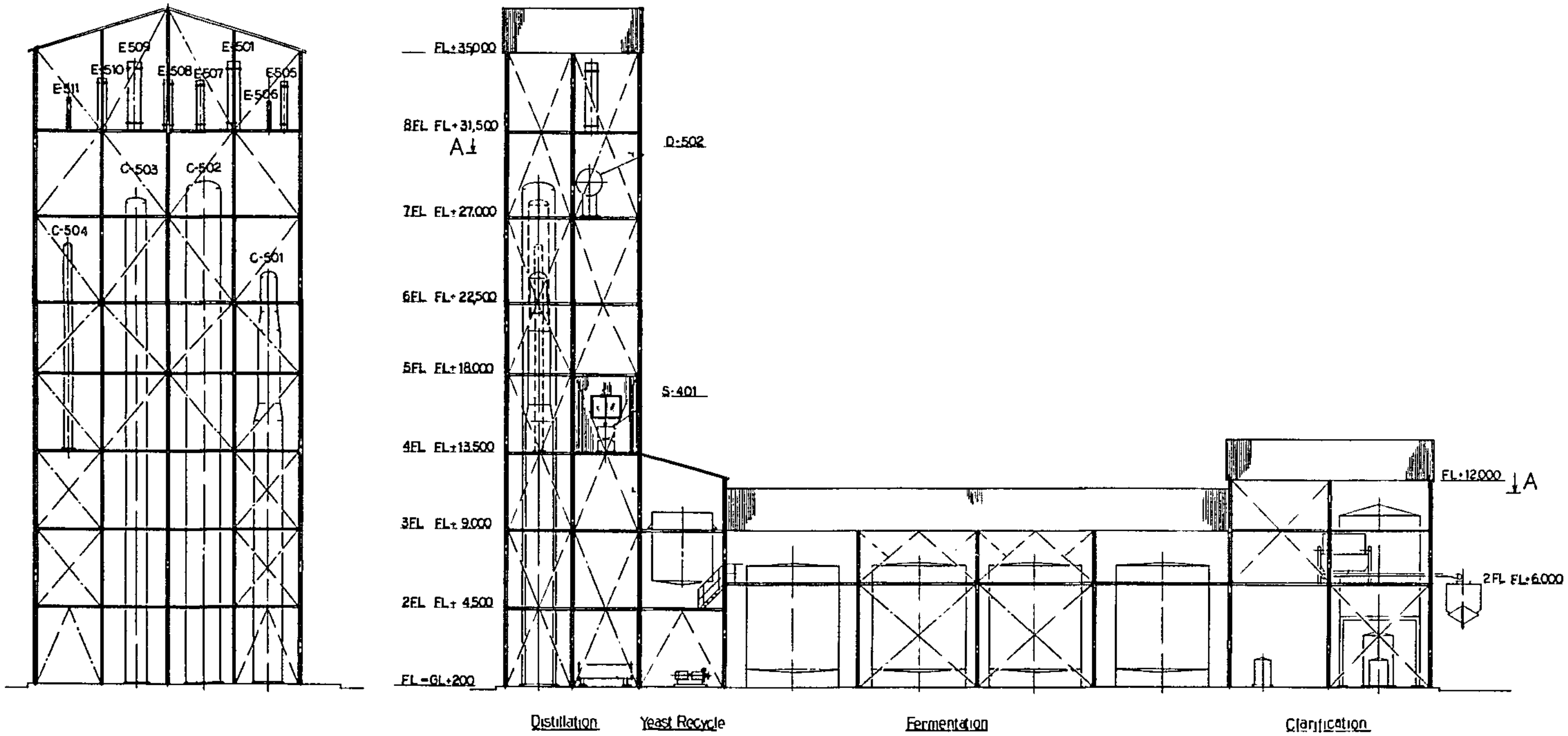
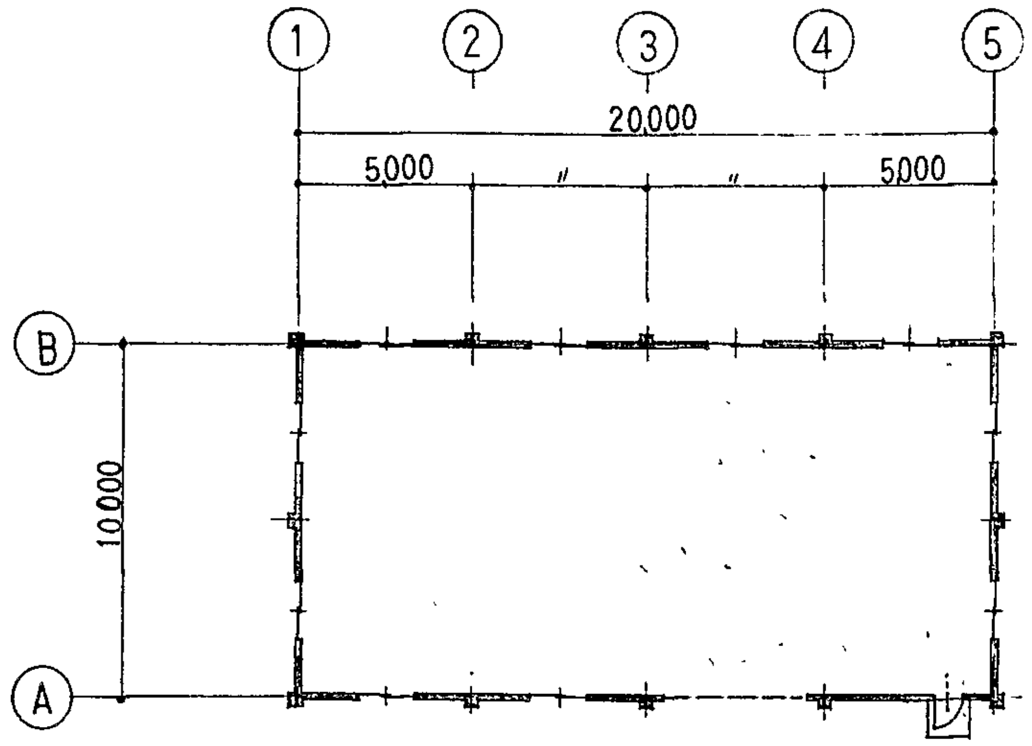
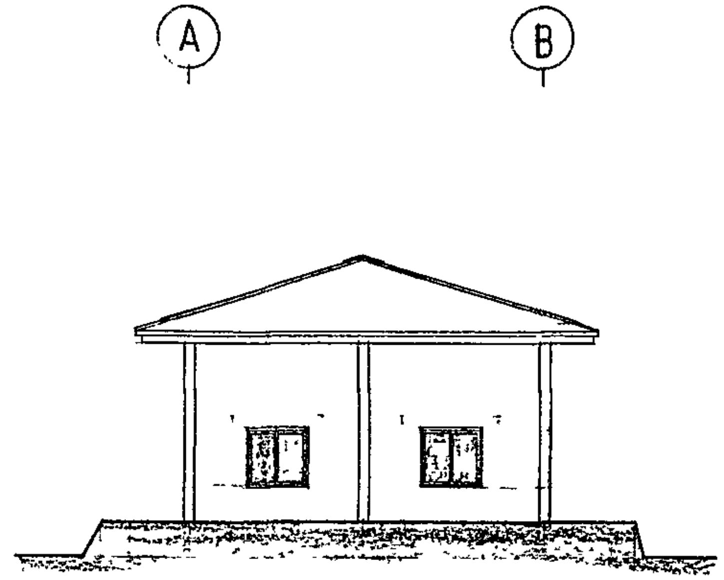
C-504
P-501
C-503
C-502
C-501
E-502
TK-507
D-502
TK 402
R 403
R-404
TK-401
S-301
TK-302
TK-301
TK-303
F-301
H 301
P-502
8000
4000
5000
30000
7000
12000
6000
55000
16000

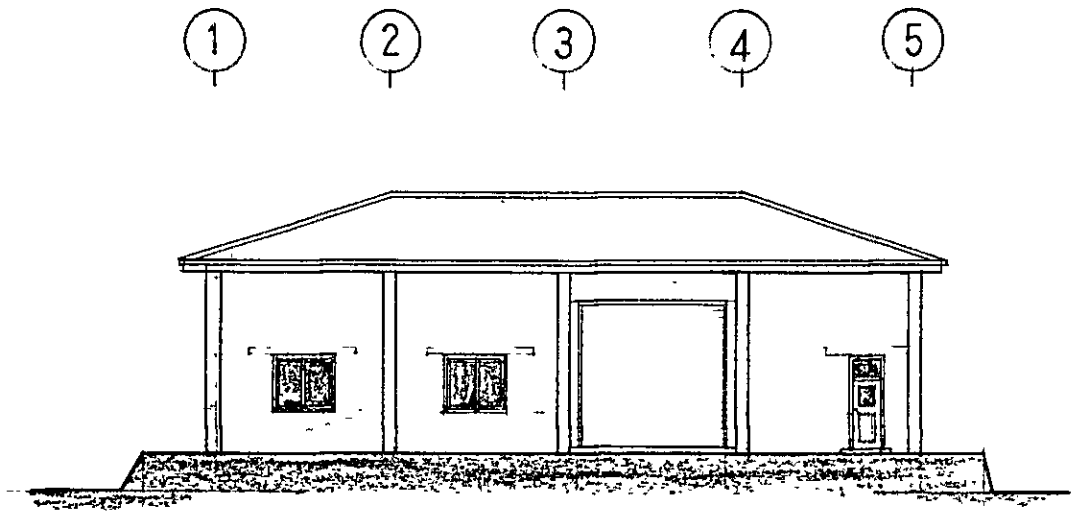

E509
E501
E510
E508
E507
E505
E511
E506
C-503
C-502
C-504
C-501
FL+35000
8FL FL+31,500
7FL FL+27000
6FL FL+22,500
5FL FL+18000
4FL FL+13,500
3FL FL+9000
2FL FL+4500
FL=GL+200
D-502
S-401
FL+12000
2FL FL+6000
Distillation
Yeast Recycle
Fermentation
Clarification



Plan



⑤ Elevation



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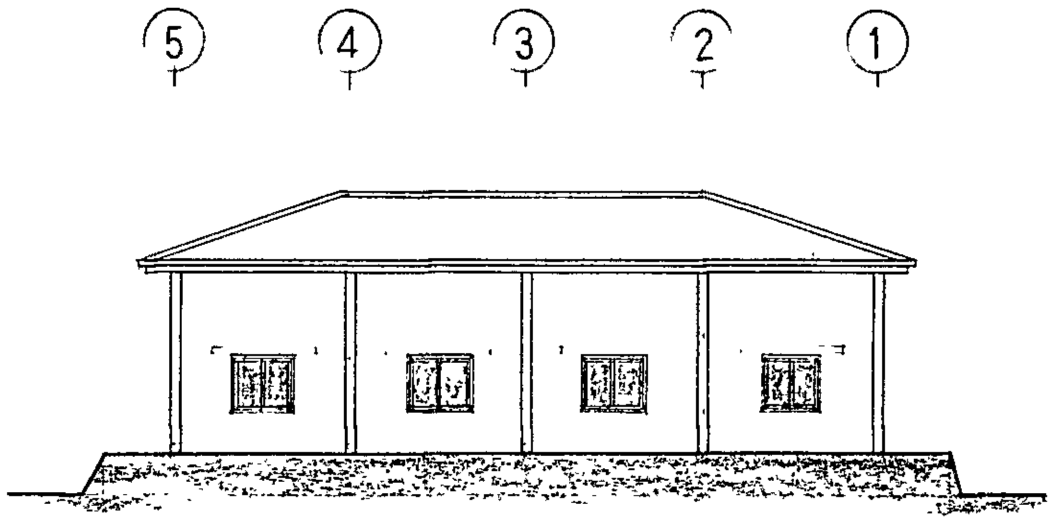
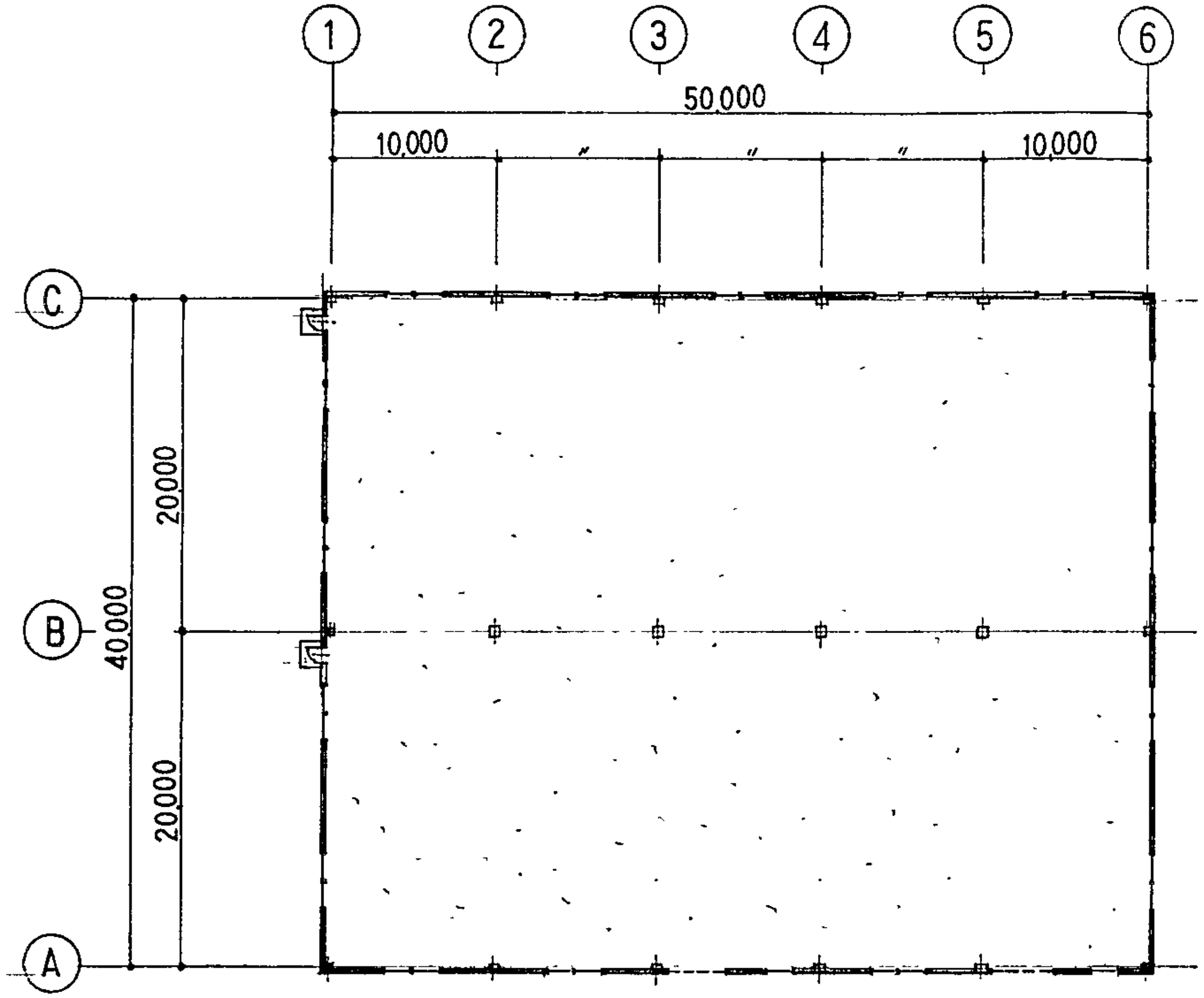


Ⓑ Elevation

Electric Generator House S= 1/200



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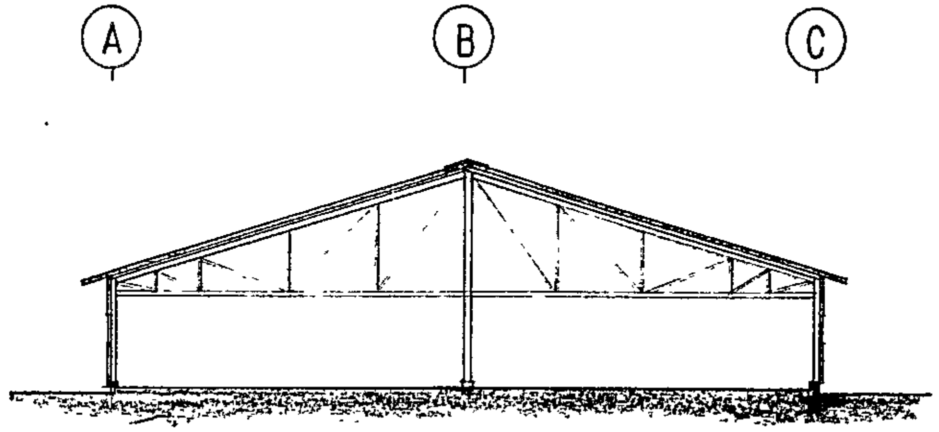
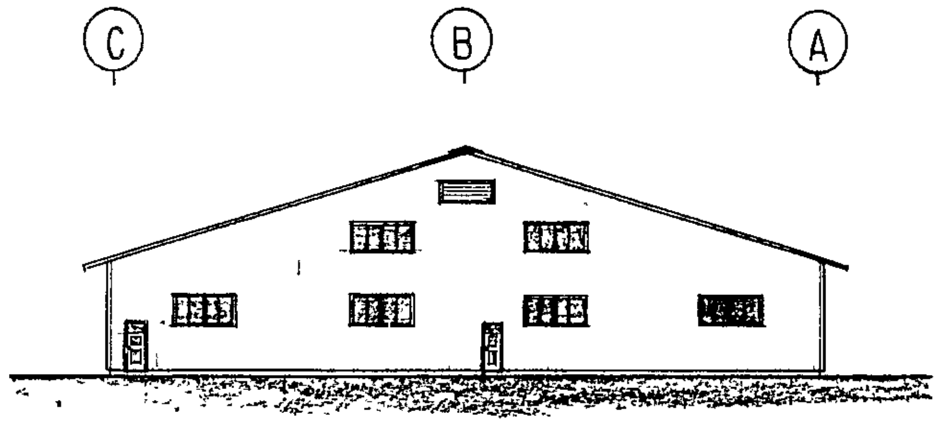


Section



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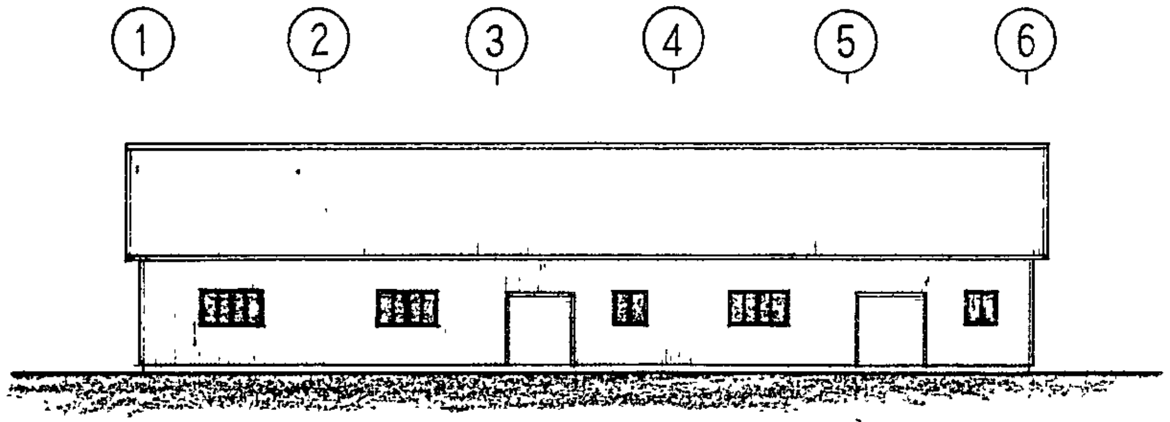

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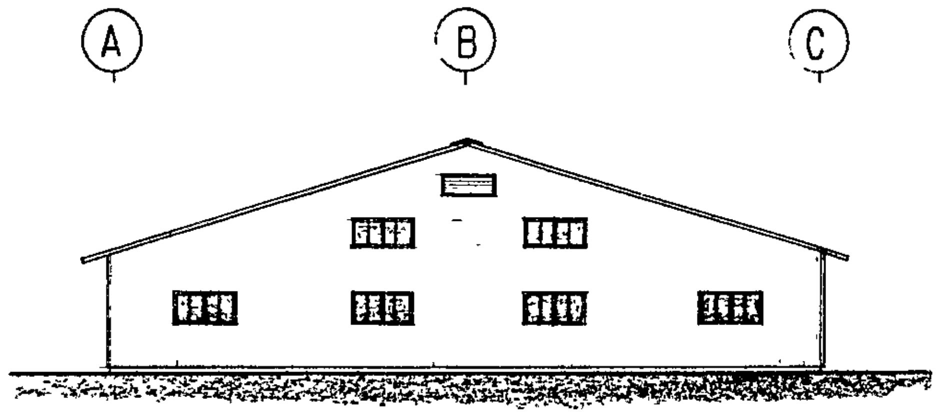
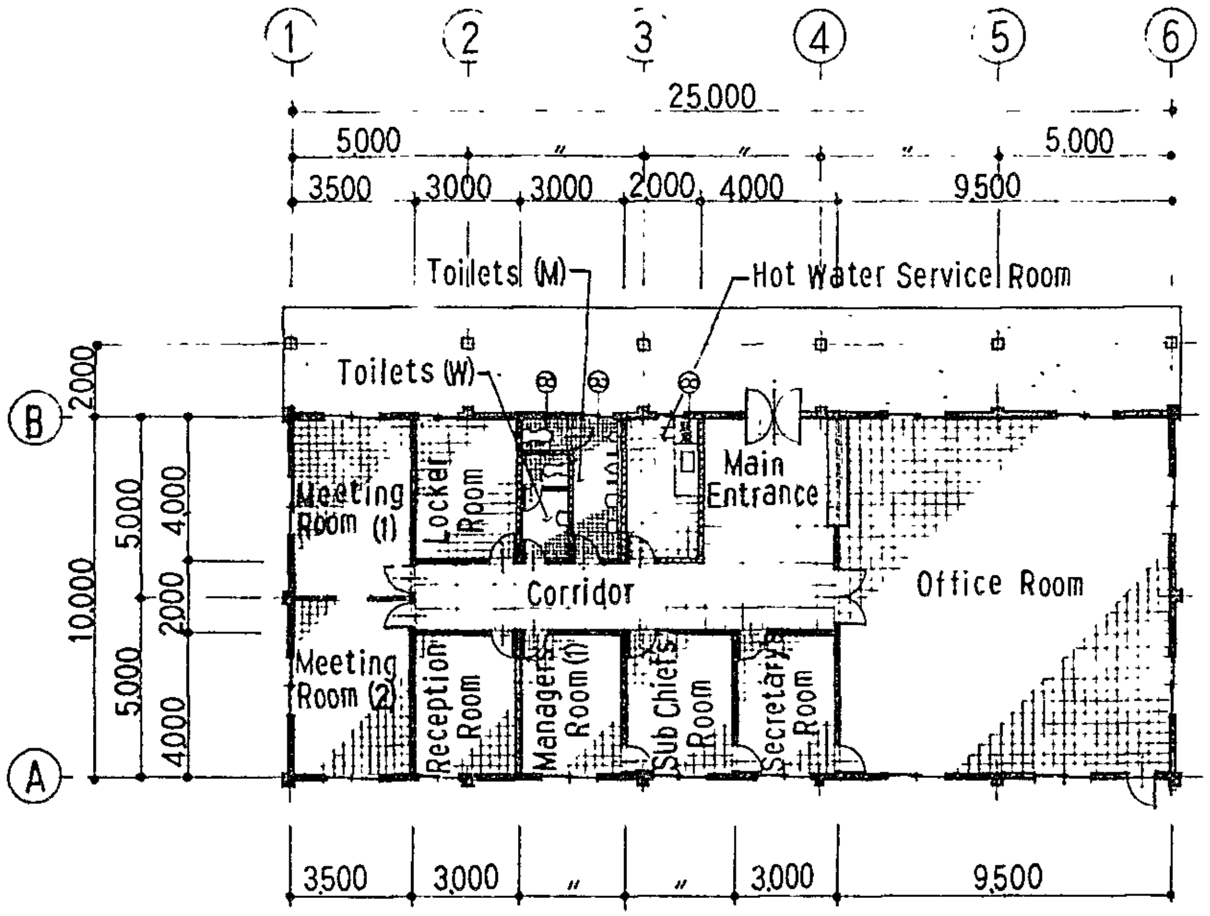


⑥ Elevation

Bagasse Ware House S-1/400



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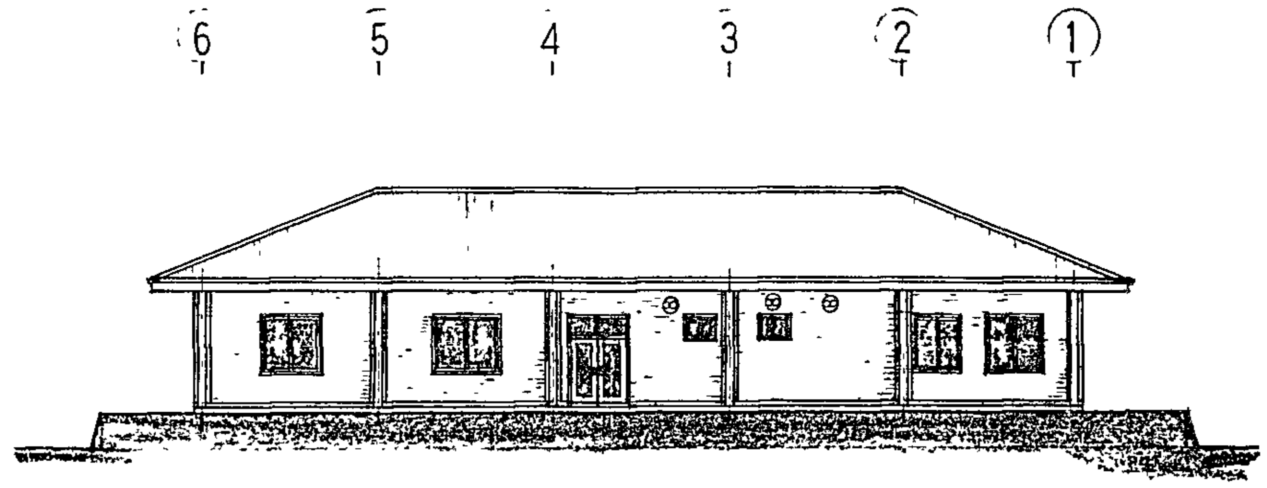
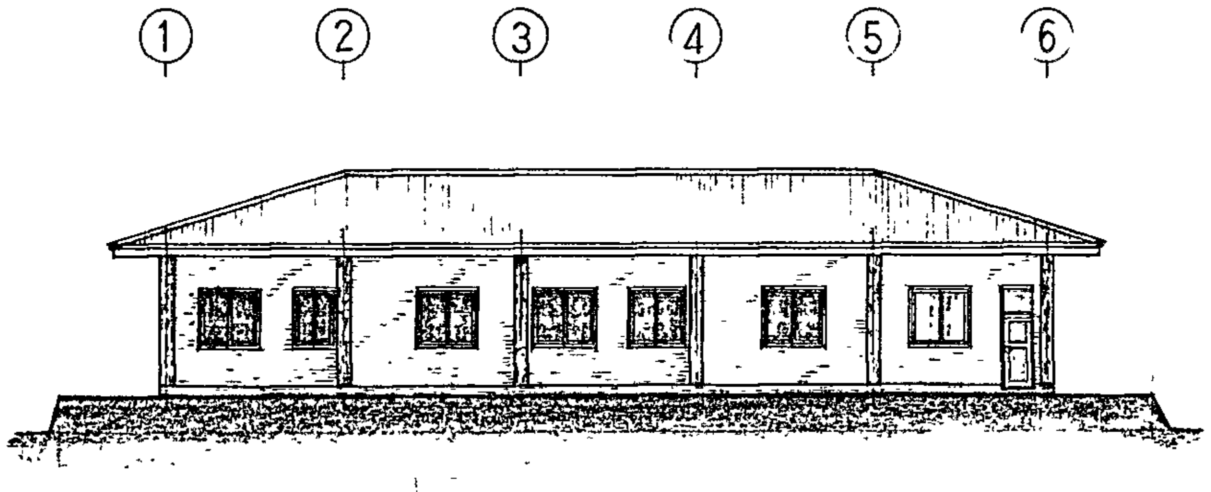
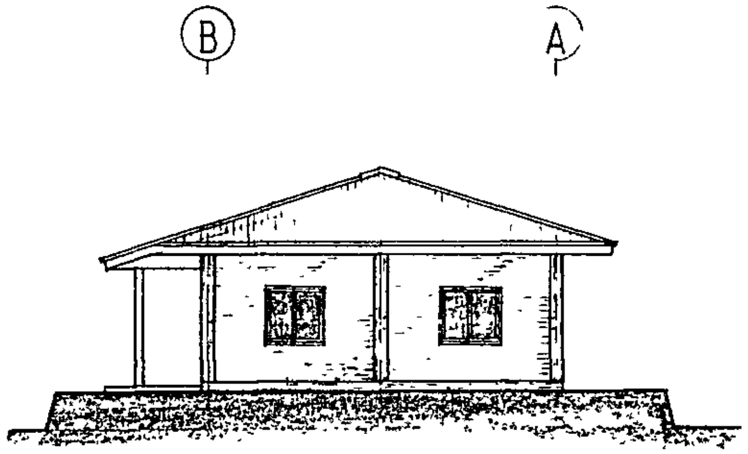


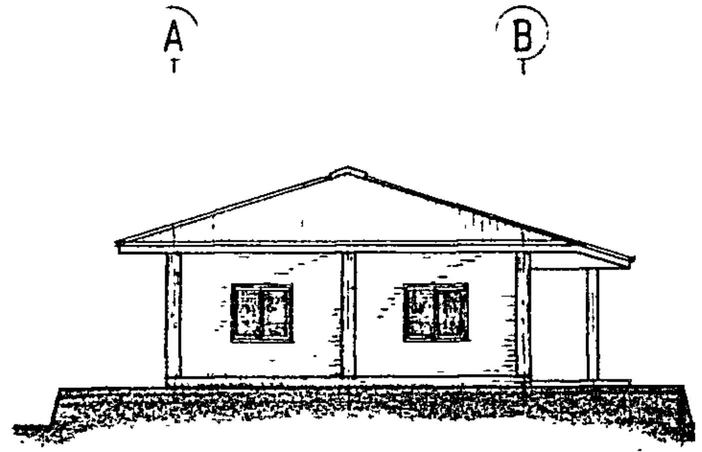
B Elevation



A Elevation

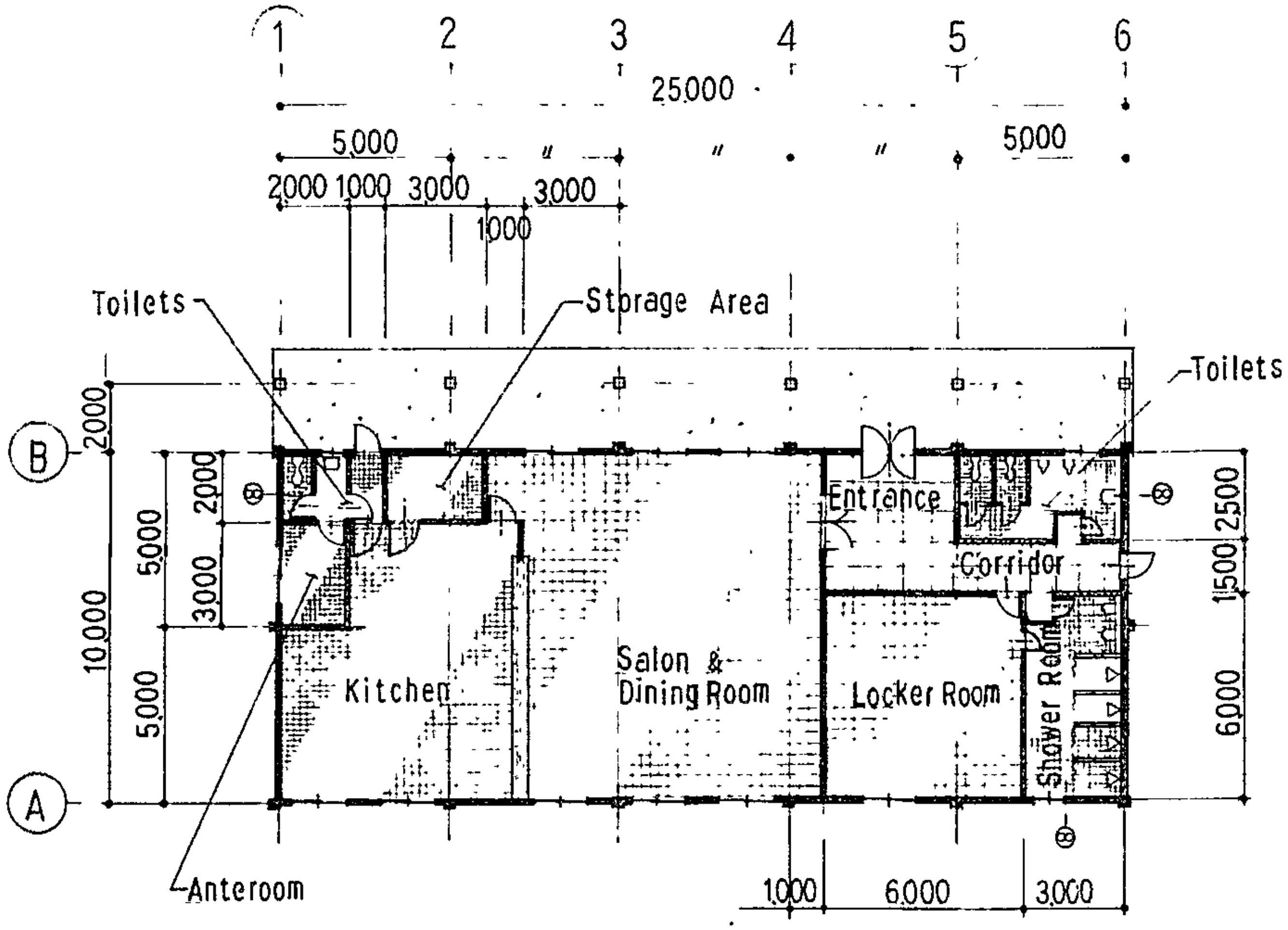


1 Elevation

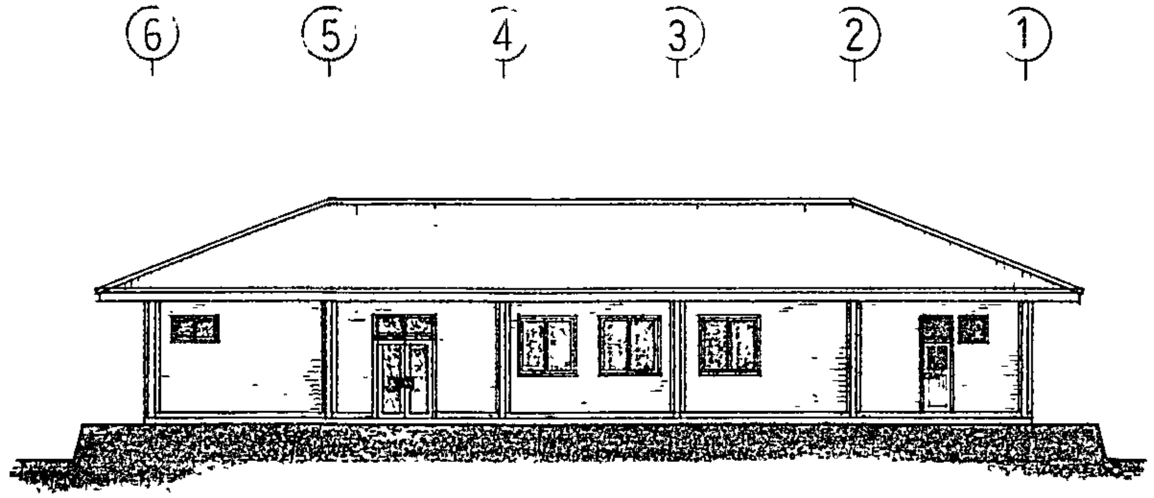


6 Elevation

Administration Office S=1/200



Plan



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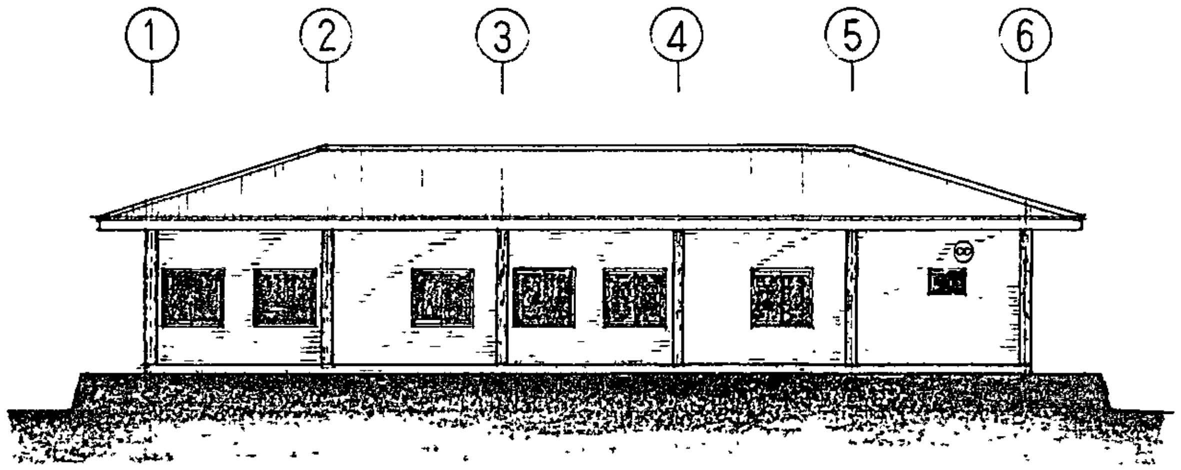

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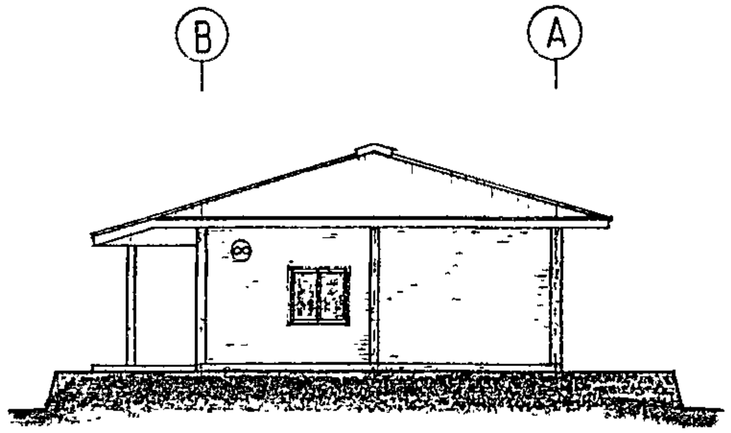

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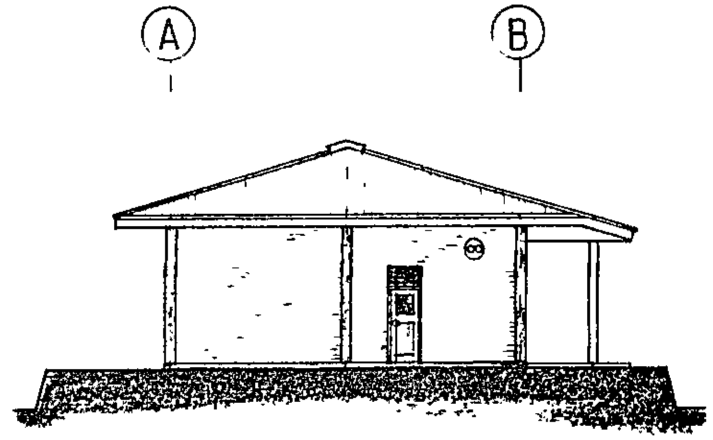
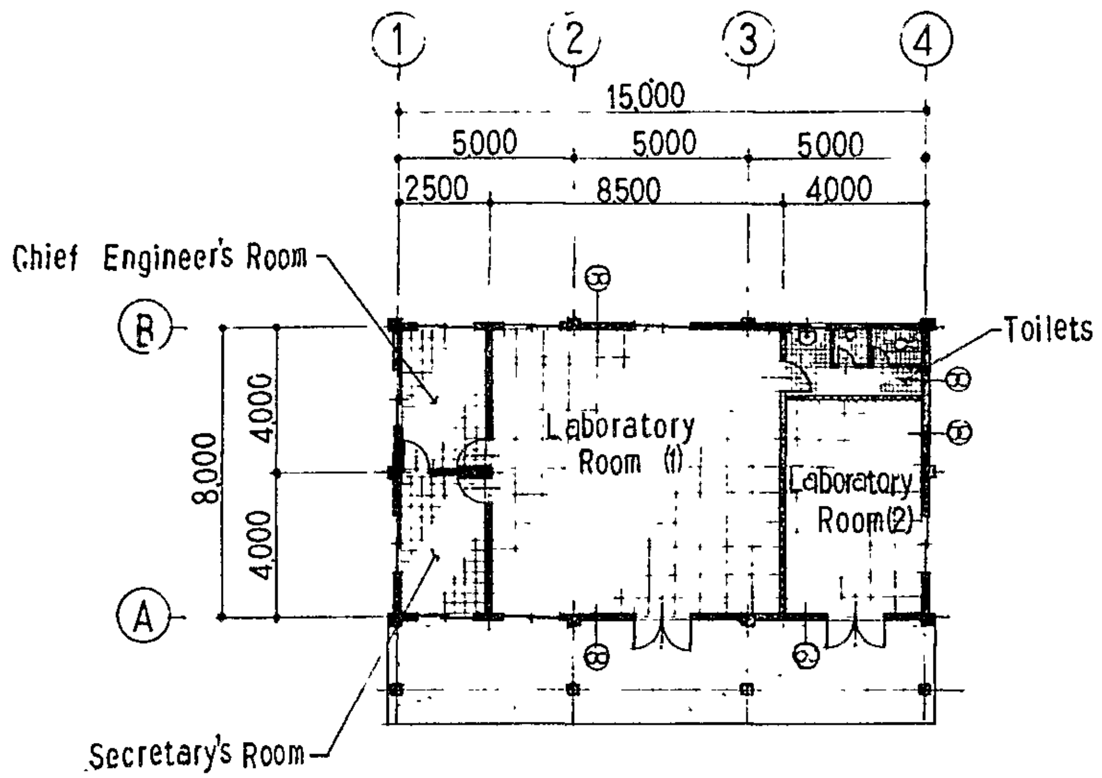


⑥ Elevation

Rest House S=1/200



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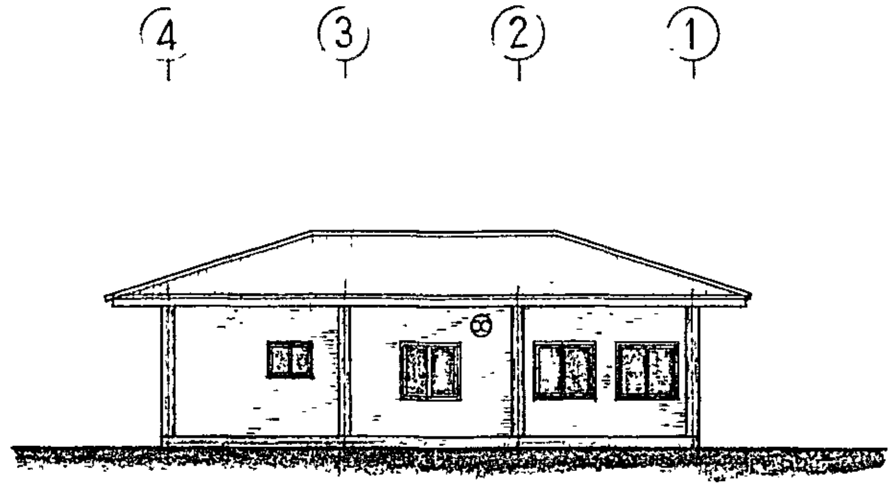
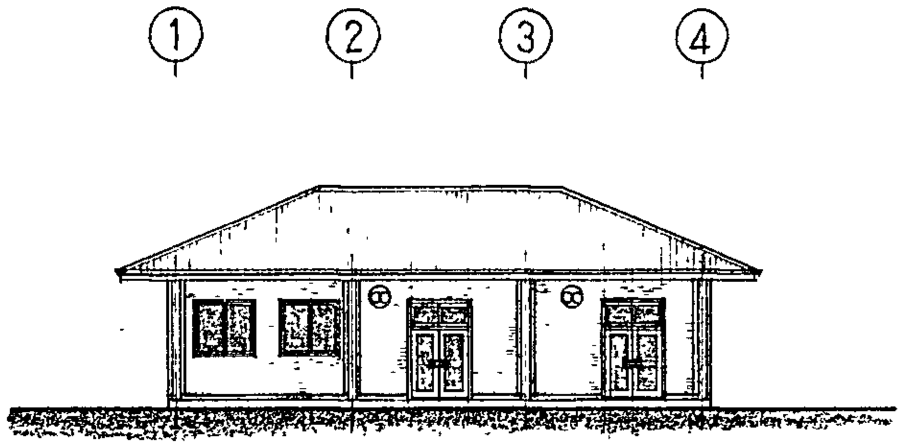
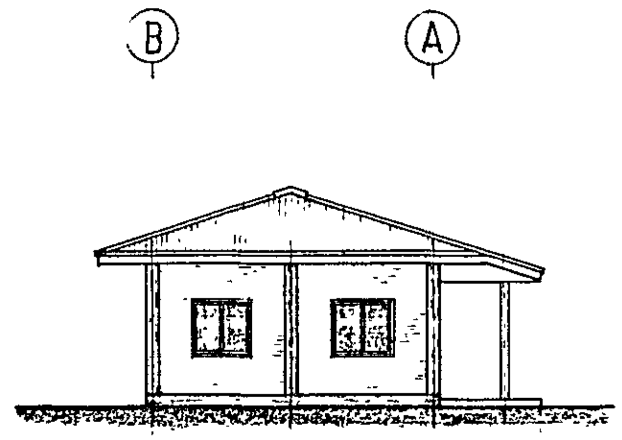


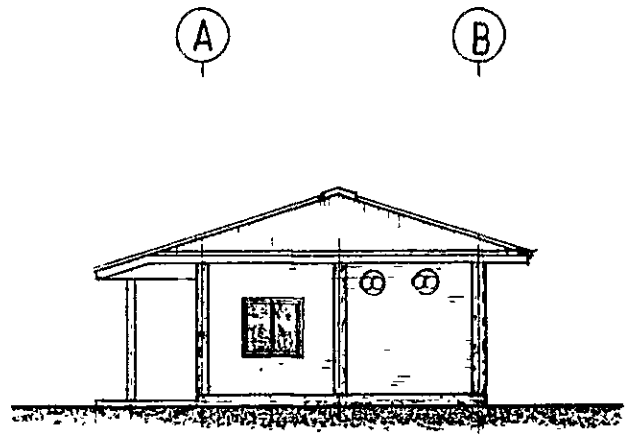
B Elevation



A Elevation

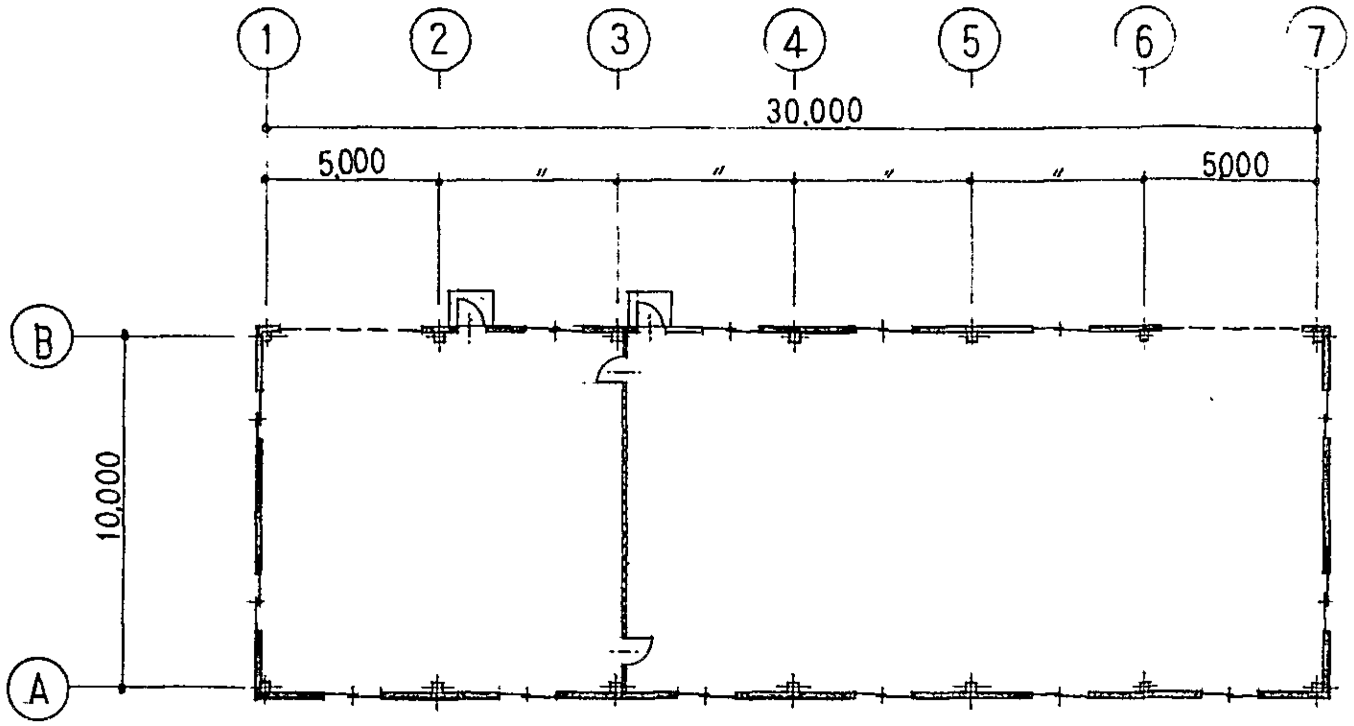


1 Elevation



4 Elevation

Laboratory S=1/200



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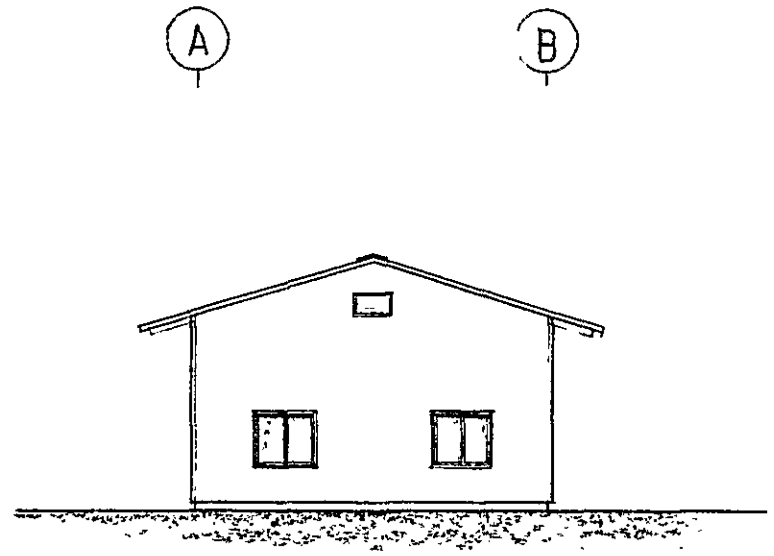
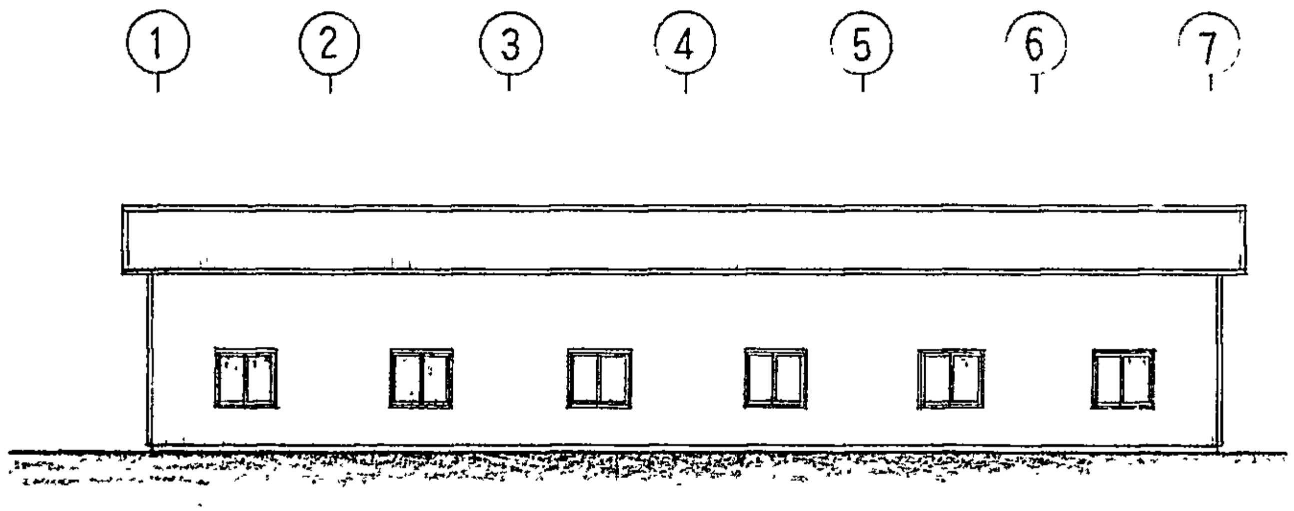


⑦ Elevation



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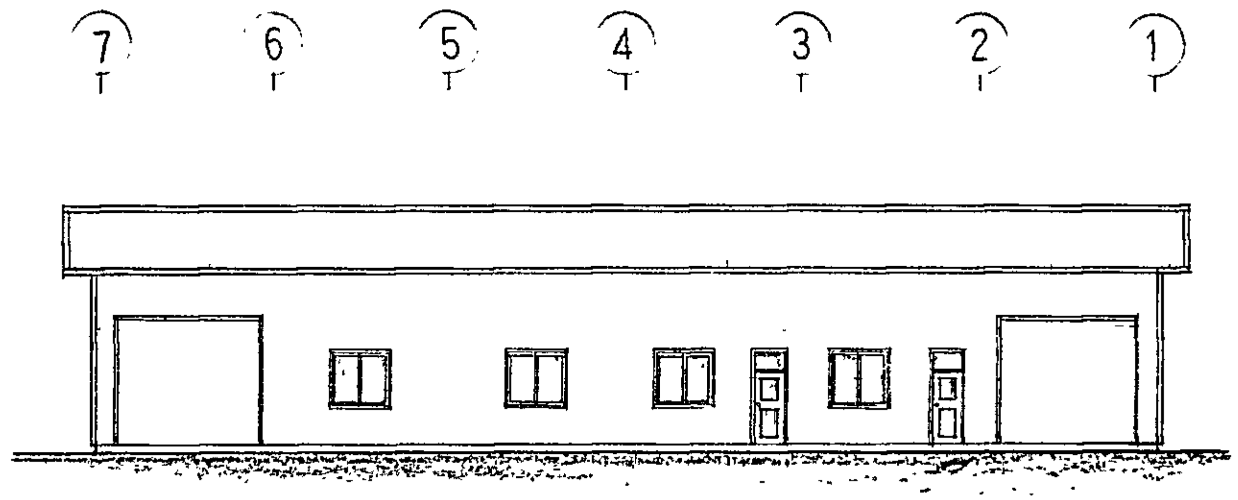
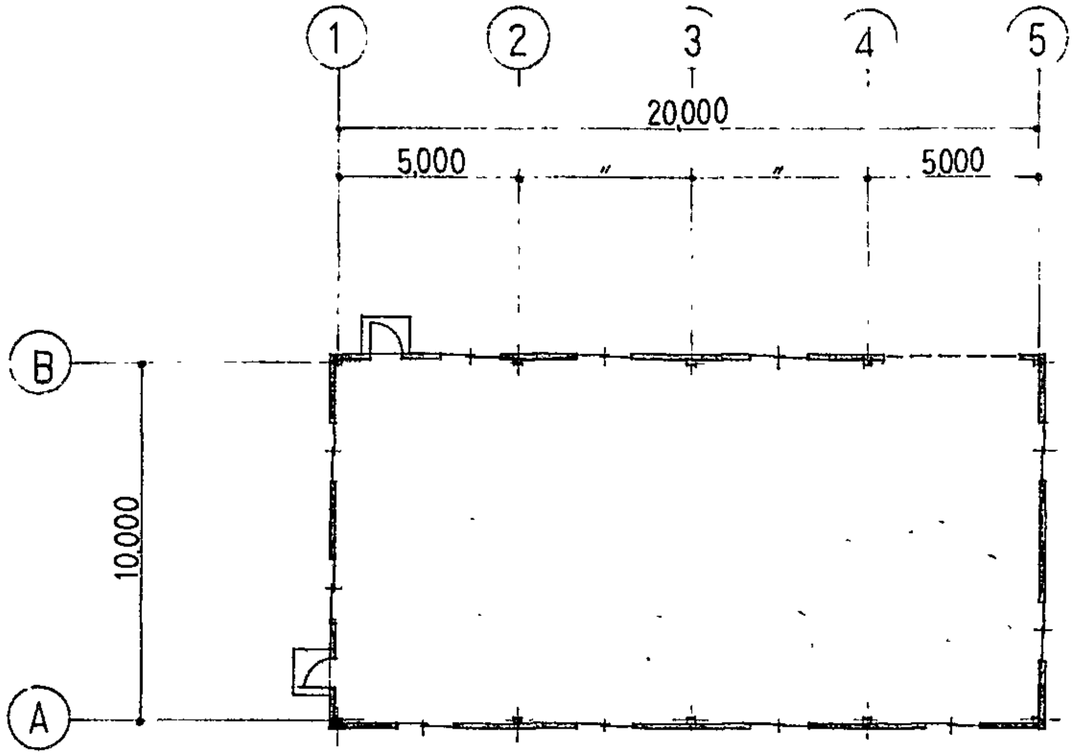
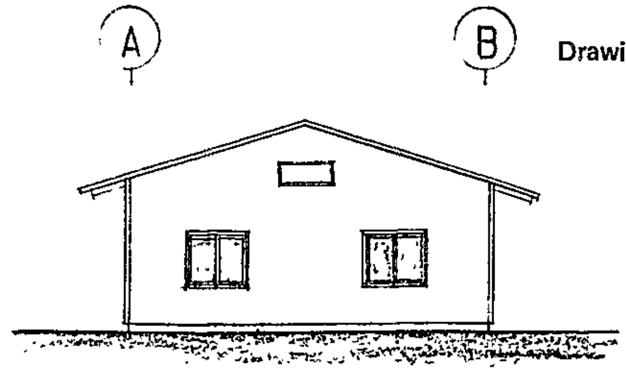


Ⓑ Elevation

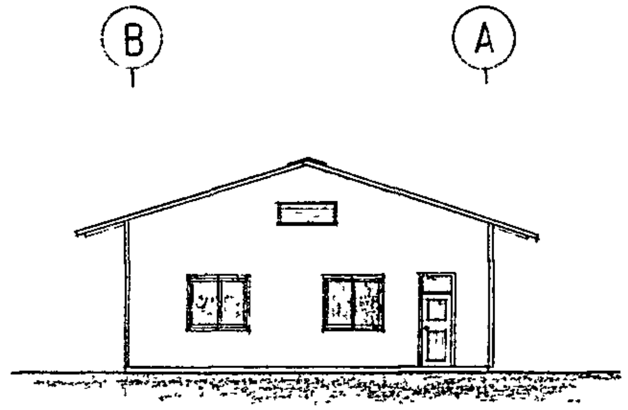
Maintenance House $S = 1/200$



Plan



(5) Elevation



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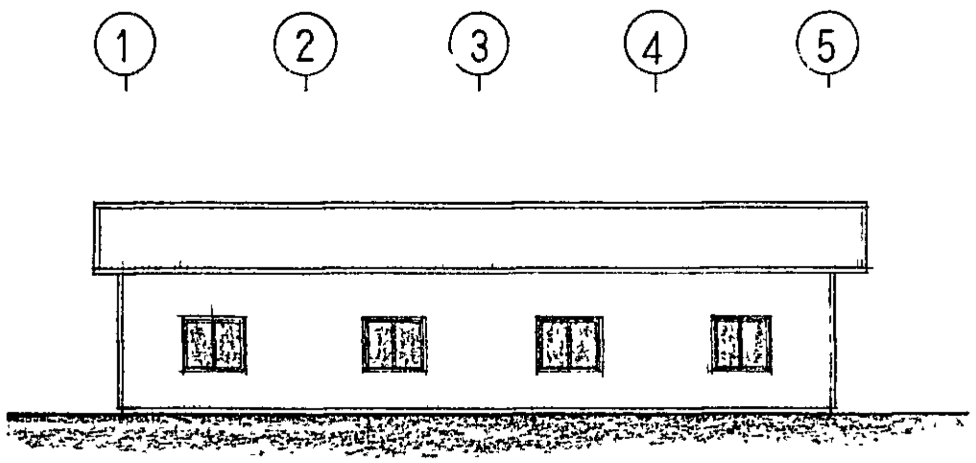
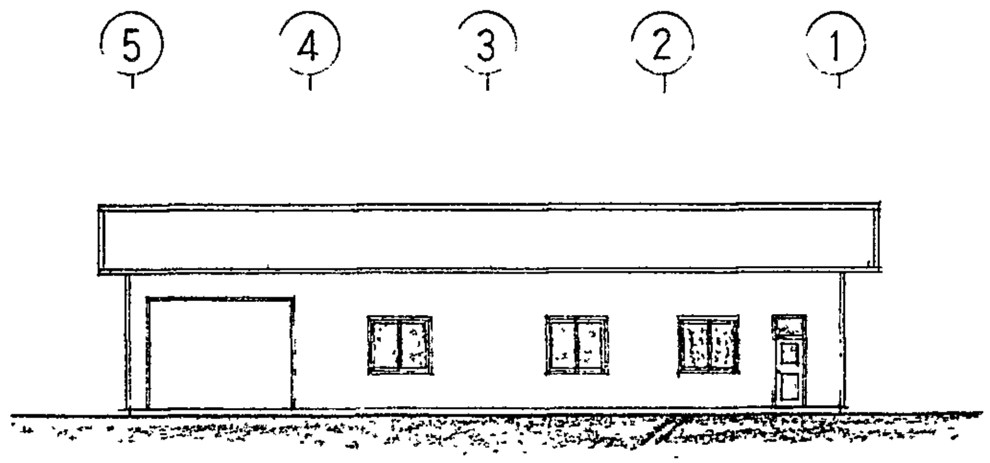
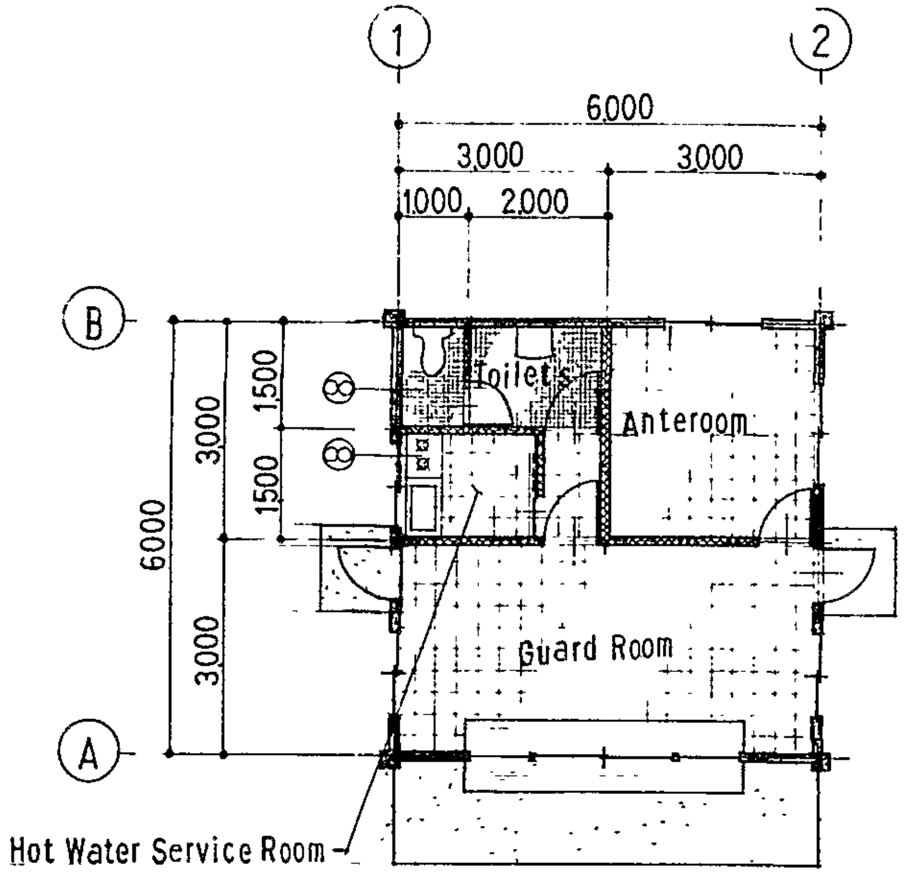


(A) Elevation



(B) Elevation

Store House S=1/200



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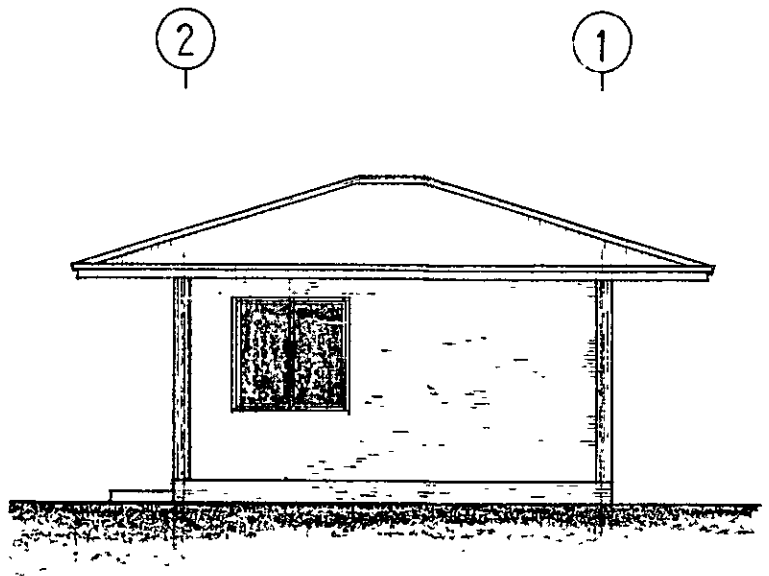

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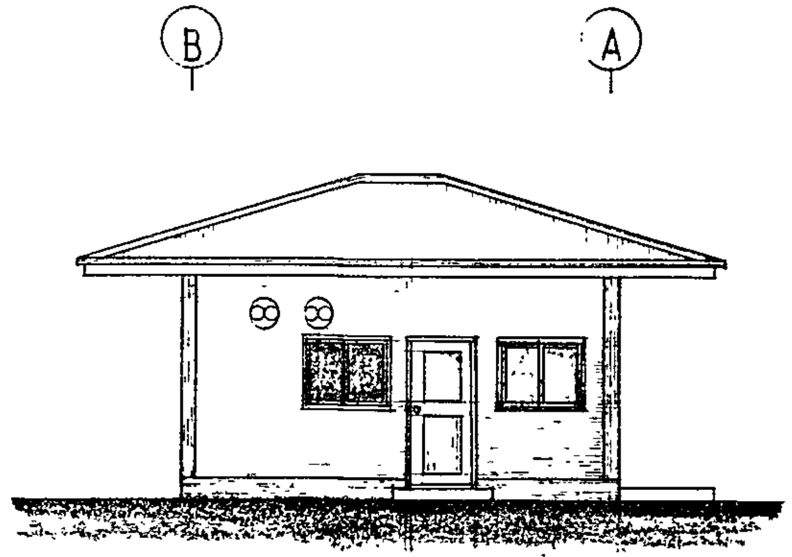
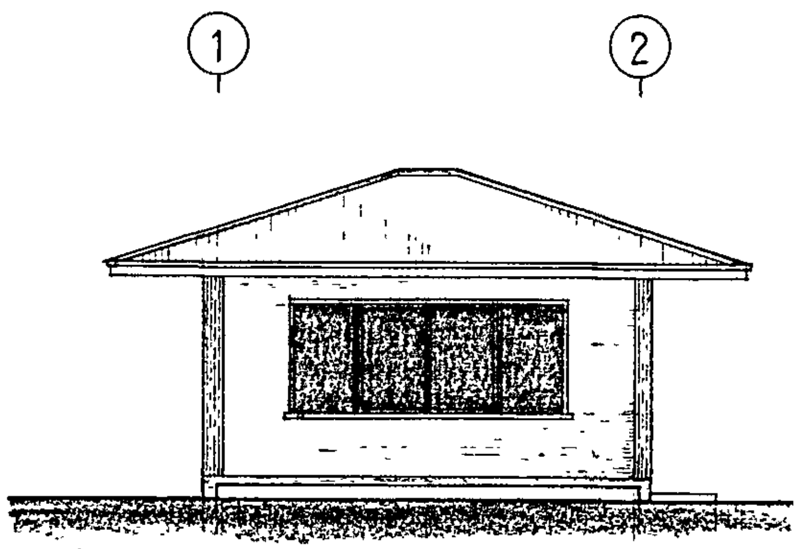
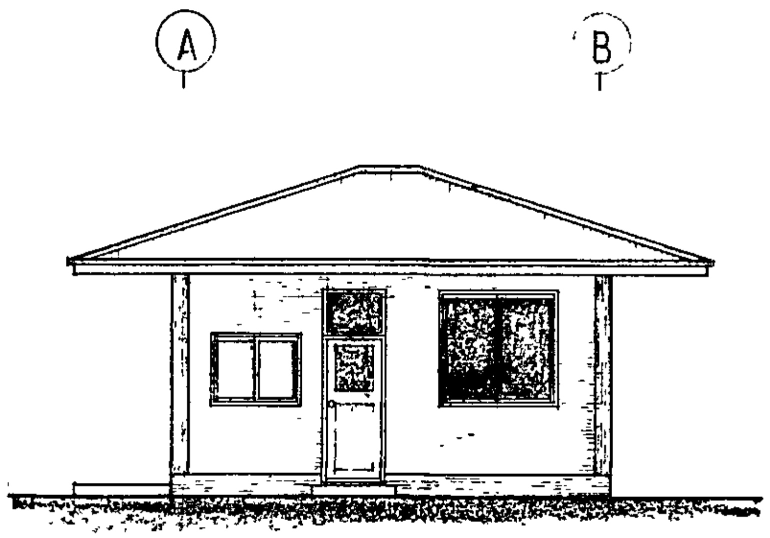


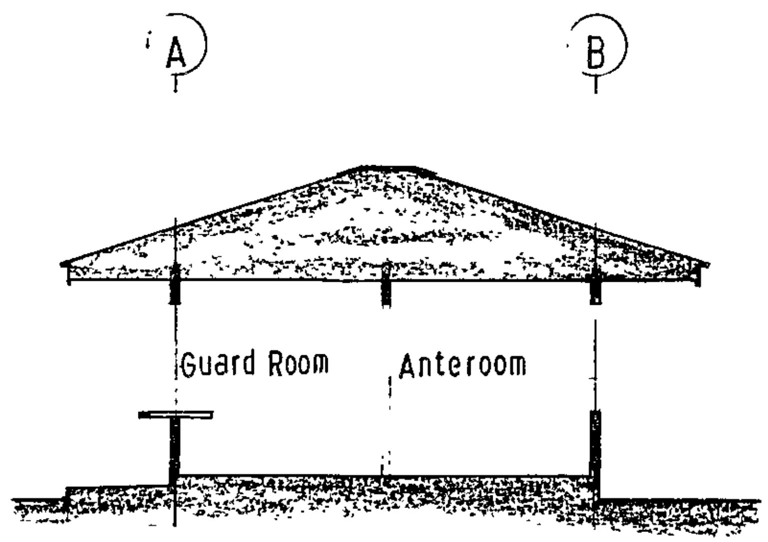
(1) Elevation



(A) Elevation



(2) Elevation



Section

Guard House S=1/100

For details, see Drawing VII-28.

(13) Guard house

This building controls entry and exit to and from the distillery and also controls delivery and dispatch of raw material and product.

1) Structure	:	Reinforced concrete and steel structure, single story
2) Building area	:	49 m^2
3) Floor space	:	36 m^2

For details, see Drawing VII-29.

5-4 Major Equipment

Major equipment are listed in Table VII-22.

5-5 Plot Plan

The plot plan is shown on Drawing VII-30. In making the distillery layout arrangement, the following points have been taken into consideration.

(1) To provide convenient maintenance of process equipment, equipment for each process unit are grouped into one block wherever possible and they are arranged according to the process flow sequence.

(2) Entrance and exit of the distillery are limited to the front where the entrance gate and the exit gate are separately installed and the guard house is located.

(3) To ensure safety, the product tanks are installed in non-hazardous area with adequate spacing in accordance with the National Fire Codes (U.S.A.).

(4) Utility facilities such as boiler and water treatment facility are located as close as possible to the facilities using such utilities.

5-6 Construction Schedule

The construction schedule is shown on Drawing VII-31. Main schedule is as shown below, taking 24 months from the start of design to the completion of the distillery.

Design start-up	:	November 1984
Civil work start-up	:	May 1985
Installation start-up	:	December 1985
Completion of mechanical tests	:	October 1986
Completion of test run	:	December 1986
Start-up of commercial operation	:	January 1987

5-7 Organization and Personnel

(1) Distillery organization

The organization chart of distillery is shown in Fig. VII-4. The distillery organization consists of 3 departments - Administration Dept., Production Dept. and Maintenance Dept.. The President (General Manager) manages these three departments.

(2) Function of each department and its manning plan

In manning, number of shift personnel is estimated on the basis of 3 shift system by 3 shift teams. The principal functions of the general manager and each department are stated below:

a) President (General Manager)

Manage 3 departments mentioned before, make decisions and take necessary measures for important external affairs, and make decisions on the organization and personnel of the distillery. In addition, make final judgement on overall problems of the distillery. A secretary is attached exclusively to the general manager.

b) Administration department

The department is in charge of personnel affairs finance, purchasing, inventory control, security control and other general services throughout the distillery. The security personnel are on the 3 shift system by 3 shift teams and fight fires in the event of a fire. Other administration Dept. personnel are on the daytime duty. A secretary is attached exclusively to Administration Dept. Head.

c) Maintenance department

Mainly in charge of daily and periodic check-up and repair of production and off-site facilities.

Two daytime staff make plans for a daily check-up and repair and a periodic turnaround. The staff give work instructions to each shift supervisor according to the plan and job list. In addition, they perform inventory control of spare equipment, spare parts and construction materials.

The shift supervisor directs and controls shift foreman and shift workers accoding to the instructions given by the staff to proceed with the work. In the case of unexpected problems at night, the supervisor passes proper judgement and deals with it. The shift supervisor and his subordinates are on the duty of 3 shift system by 3 shift teams, each shift having 3 maintenance men, one for rotating equipment, one for electric equipment and instruments, and one for the overall maintenance of other equipment. A secretary is attached exclusively to Maintenance Dept. Head.

d) Production department

Production Dept. engages in the operation and control of the distillery according to the plant's production program under the control of Dept. Head.

Five daytime staffs take charge of plant's production planning and control, quality control and solution of technical problems on operation. Daytime operators engage in raw-material receiving; product loading; and analysis of raw material, semi-products, product and waste water, including yeast culture and preservation control of yeast.

The shift team headed by shift supervisor engages in the operation of the distillery under the 3 shift system by 3 shift teams according to the production program.

(3) Personnel Employment plan

For employment of the 132 personnel required for the normal operation of the distillery, the following sequence is recommended to hire required personnel.

a) Personnel to be hired two years prior to the initiation of normal production:

President (General Manager)	1
Department heads	3
Engineers	10
Analysts	3
Secretary	1
Total	18

b) Personnel to be hired one year prior to the initiation of normal production:

Foremen	3
Operators	20
Total	23

c) The remaining personnel will be hired when the production is commenced.

(4) Education and training of personnel

As a rule, the education and training of personnel will be carried out by means of on-the-job training during the plant construction and trial operation. As for especially important matters in operation and management of the distillery, 5 staff engineers will be given three months technical training in Japan.

The technical training in Japan will be commenced seven months prior to the normal operation for three months in a Japanese distillery to obtain the operation and management technique focussing on the subjects, such as yeast culture and preservation control of yeast, operational technique in fermentation and distillation. After return to their country, they will take part in the mechanical test of the plant and trial operation and will be responsible for operator's education and training to be performed at plant site.

5-8 Distillery Construction Cost

The results of estimation of the construction cost are listed in Table VII-23. It amounts to 120,460 (10^3 pesos) in total.

The supply source of equipment and materials is determined as shown below based on the results of field surveys conducted in the Phase-I and Phase-II.

(1) Cutters, shredder, milling machine, pumps, blowers, mixers, compressors, electric generators, yeast separators and other rotating equipment are procured from foreign sources.

(2) Boiler proper and associated rotating equipment are procured from foreign sources.

(3) As for distillation columns, vessels and heat exchangers, only stainless steel materials and trays of distillation columns are procured from foreign sources and others including carbon steel materials are procured domestically.

(4) As for piping materials and parts,

   1) Pipe: Stainless steel pipes are procured overseas and carbon steel pipes are procured locally.

   2) Couplings and values: Procured locally.

(5) Instruments are procured overseas but the instrumentation works are conducted by local contractors.

(6) Lighting appliances are procured locally and the electrical construction works are executed by local contractors.

(7) Civil and construction materials are procured locally and works are executed by local contractors.

The above gives the local procurement ratio of 51.1%. Therefore, in estimating the construction cost, the equipment and materials to be imported are assumed to be exempted from customs. This estimate is based on price and cost prevailing in 1982.

Table VII-22 Main Equipment List (1/16)

Equip. No.	Name	Q'ty		Description	Material	Remarks
		Normal	Spare			
	Raw Material Receiving, Storage and Milling Section					
W-101	Truck Scale	2		30t Scale		
M-101	Crane	2		20t Cane Unloading		25 kW
M-102	Travelling Crane	1		20t Cane Unloading, Mill-Repair		56.3 kW
M-103	Cane Feed Table	1		4000W x 6000L 6 m/min	Mild Steel	13 kW
M-104	First Cane Knives	1		1200ϕ x 1220W 600 rpm	Face Hardened Tool Steel	55 kW
M-105	Second Cane Knives	1		1200ϕ x 1220W 600 rpm	Face Hardened Tool Steel	55 kW
M-106	Cane Shredder	1		1065ϕ x 1220W 1200 rpm	Mild Steel Coated Tangsten Carbide	150 kW
M-107	Tramp Iron Separator	1		1200W DC 200V Rated Power 5.5 kW		

Table VII-22 Main Equipment List (2/16)

Equip. No.	Name	Q'ty		Description	Material	Remarks
		Normal	Spare			
M-108	Cane Mill	1		Capacity 880 t/d 3 Roller type mill 680φ x 1220ℓ Roller Speed 5 rpm Hydraulic pressure 260t Drive: Steam Turbine	Special Cast-Iron	
M-109	Hydraulic Equipment	1		Accumulation, Control System		3.7 kW
M-110	Steam Turbine	2		Single Stage/Back Press. Type Rated Output, Speed: 400 HP, 4500 rpm	Cast Steel	
M-111	Primary Gear Reduction	2		Enclosed Double Reduction Gear Type Transmission Power 400 HP Input/Output Speed 4500/120 rpm		
M-112	Secondary Gear Reduction	2		Open Gear Type Transmission Power 400HP Input/Output Speed 125/25 rpm	Cr-Mo Alloy Steel	

Table VII-22 Main Equipment List (3/16)

Equip. No.	Name	Q'ty		Description	Material	Remarks
		Normal	Spare			
M-113	Final Gear Reduction	2		Open Gear, Compound Type Transmission Power 400 HP Input/Output Speed 25/5 rpm	Cr-Mo Alloy Steel	
C-101	Cane Carrier	1		1220W x 24m 8 m/min	Mild Steel	15 kW
C-102	Shredded Cane Elevator	1		1220W x 7.5m 20 m/min	Mild Steel	3.7 kW
C-103	Intermediate Carrier	3		Mill Shaft Driven 1220W x 4m		
C-104	Bagasse Elevating Conveyor	1		Paddle Type 1000W x 16m	Mild Steel	5.5 kW
TK-101	Maceration Jiuce Tank	2		0.3 m^3 1000ϕ x 450H	A167 G304	
TK-102	Mixed Juice Tank	1		0.3 m^3 1000ϕ x 450H	A167 G304	
TK-103	Screened Juice Tank	1		1.2 m^3 1200ϕ x 1200H	A167 G304	
S-101	Juice Screen	1		1000W x 1500L x 0.7ϕ mesh	A167 G304	
P-101	Maceration Juice Pump	2	1	22 m^3/h x 7 mH	Stainless Steel	2.2 kW

Table VII-22 Main Equipment List (4/16)

Equip. No.	Name	Q'ty Normal	Q'ty Spare	Description	Material	Remarks
P-102	Macertain Juice Pump	1	1	45 m^3/h x 12 mH	Stainless Steel	5.5 kW
P-103	Screened Juice Pump	1	1	45 m^3/h x 15 mH	Stainless Steel	5.5 kW
	Boiler and Electric Generator Section					
Bo-201	Boiler	1 set		Capacity: 25 t/h x 21.5 kg/m^2G Superheater Outlet Temp. 360°C		
E-201	Air Preheater	1		750 m^2		
E-202	Steam Superheater	1		95 m^2		
E-203	Desuperheater	1		Water Spray Type		
E-204	Oil Heater	1				
D-201	Deaerator	1		Capacity: 25 t/h		
B-201	No.1 FDF	1		600 m^3/min x 230 mmH_2O		45 kW
B-202	No.2 FDF	1		170 m^3/min x 220 mmH_2O		15 kW
B-203	IDF	1		1700 m^3/min x 220 mmH_2O		120 kW
P-201	D-201 Feed Pump	1	1	25 m^3/h x 30 mH		5.5 kW

Table VII-22 Main Equipment List (5/16)

Equip. No.	Name	Q'ty		Description	Material	Remarks
		Normal	Spare			
P-202	B.F.W Pump	1	1	25 m^3/h x 260 mH		45 kW
P-203	Oil Feed Pump	1	1			1.5 kW
P-204	Chemical Feeder (H.P)			130 cc/min x 30 kg/m^2G		0.2 kW
P-205	Chemical Feeder (L.P)	1				0.1 kW
P-206	Oil Pump (For G201)	1				5.5 kW
C-201	Bagasse Carrier	1		Double Deck type		7.5 kW
C-202	Bagasse Feeder	3		Screw Feeder		2.2 kW
C-203	Return Conveyor	1		Single Deck type		7.5 kW
C-204	Ash Conveyor	1		Flight type		1.5 kW
C-205	Dust Conveyor	1		Flight type		1.5 kW
C-206	Ash Transfer Conveyor	1		Flight type		2.2 kW
C-207	Dust Collector	1		Multi-Cyclone type		
H-201	Ash Banker	1		10 m^3		
M-201	Seal Damper	2				0.2 kW

Table VII-22 Main Equipment List (6/16)

Equip. No.	Name	Q'ty		Description	Material	Remarks
		Normal	Spare			
TK-201	Fuel Oil Tank (Start up)	1				
G-201	Electric Generator	1		<u>Generator</u> Type : Revolving field Cylindrical Pole, Brashless Type Synchronous Generator Capacity: 800 kWH, 440V, 60 Hz, 3 phase. <u>Turbine</u> Type : Back-pressure turbine with Reduction Gear Steam : 12.2 t/h x 20 kg/m^2G x 350°C		
Gs-201	Diesel Generator	1		Capacity: 280 kWH, 440V, 60 Hz, 3 phase.		
Bc-201	Air Compressor	1	1	Oil-free Baby Compressor		5.5 kW

Table VII-22 Main Equipment List (7/16)

Equip. No.	Name	Q'ty		Description	Material	Remarks
		Normal	Spare			
S-201	Stack	1				
	<u>Clarification Section</u>					
M-301	Juice Scale	1		40 t/h Load Cell Type	A167 G304/ Mild Steel	
TK-301	Weighed Juice Tank	1		7 m^3, 1800W x 2400L x 1800H	Mild Steel	Mixer 2.2 kW
TK-302	Clarified Juice Tank	1		8 m^3, 1800W x 3000L x 1800H	Mild Steel	
TK-303	Sludge Tank	1		3 m^3, 1600ϕ x 1600H	Mild Steel	Mixer 0.75 kW
TK-304	Sludge Mix Tank	1		1 m^3, 600W x 2400L x 750H	Mild Steel	Mixer 1.5 kW
TK-305	Lime Milk Tank	2		5 m^3, 1800ϕ x 2400H	Mild Steel	Mixer 1.5 kW
TK-306	Lime Dosing Apparatus	1		3ℓ, Head Tank	Mild Steel	
TK-307	F-301 Mud Washing Tank	1		0.7 m^3, 950ϕ x 1200H	Mild Steel	

Table VII-22 Main Equipment List (8/16)

Equip. No.	Name	Q'ty		Description	Material	Remarks
		Normal	Spare			
TK-308	E-302 Washing Tank	1		10 m^3, 1500W x 4500L x 1500H	Mild Steel	
E-301	Juice Preheater	1		Plate Type	Stainless Steel	
E-302	Juice Heater	3		85 m^2, Shell/Tube Type	Mild Steel/ Stainless Steel	
E-303	Juice Cooler	1		Plate Type	Stainless Steel	
S-301	Clarifier	1		103 m^3, 4600ϕ x 6100H	Mild Steel	0.75 kW
S-302	Juice Screen	1		1000W x 1500L	Stainless Steel	
S-303	Bagacillo Screen	1		2 m^2, 950W x 2100L	Stainless Steel	
F-301	Vacuum Filter	1		21 m^2, 2440ϕ x 2750 L	Stainless Steel (Drum)	3 kW
D-301	Flash Tank	1		1000ϕ x 1400H	Mild Steel	
D-302	Cyclone Bagacillo Separator	1		780ϕ	Mild Steel	
D-303	Pickup Filtrate Receiver	1		750ϕ x 1500H	Mild Steel	
D-304	Wash Filtrate Receiver	1		750ϕ x 1500H	Mild Steel	

Table VII-22 Main Equipment List (9/16)

Equip. No.	Name	Q'ty		Description	Material	Remarks
		Normal	Spare			
D-305	Condenser	1		750ϕ x 2100H	Mild Steel	
D-306	Condensate Receiver	1		$1.5m^3$, 1250ϕ x 1500H	Mild Steel	
P-301	Weighed Juice Pump	1	1	40 m^3/h x 50 mH	Cast Iron/ Bronze	11 kW
P-302	Clarified Juice Pump	1	1	45 m^3/h x 40 mH	Cast Iron/ Bronze	11 kW
P-303	Lime Milk Pump	1	1	2 m^3/h x 20 mH	Cast Steel	0.75 kW
P-304	Mud Pump	1	1	8 m^3/h	Cast Steel	2.2 kW
P-305	Liquidation Pump	1		40 m^3/h x 15 mH	Cast Iron/ Bronze	3.7 kW
P-306	Filtrate Pump	2	1	9 m^3/h x 15 mH	Cast Iron/ Bronze	2.2 kW
P-307	Vacuum Pump	1	1	7.5 m^3/min x -500 mmHg	Cast Iron	18.5 kW
P-308	Mud Recirculation Pump	1	1	9 m^3/h x 15 mH	Cast Iron/ Bronze	2.2 kW
P-309	Mud Washing Pump	1		6 m^3/h x 30 mH	Mild Steel	1.5 kW
P-310	Condensate Pump	1		3 m^3/h x 20 mH	Cast Iron/ Bronze	1.5 kW

Table VII-22 Main Equipment List (10/16)

Equip. No.	Name	Q'ty		Description	Material	Remarks
		Normal	Spare			
P-311	Caustic Soda Pump	1		15 m^3/h x 20 mH	Cast Iron	3.7 kW
B-301	Exhauster	1		42 m^3/min x 250 mmH_2O	Mild Steel	5.5 kW
C-301	Cake Conveyor	1		1.8 t/h 250W x 7000L		0.75 kW
H-301	Cake Hopper	1		6 m^3, 2000W x 2000L x 1600H	Mild Steel	
	Fermentation Section					
R-401	Pre Seed Vessel	1		200ℓ	Stainless Steel	
R-402	First Seed Vessel	1		1 m^3, 1000ϕ x 1650H	Stainless Steel	Mixer 3.7 kW
R-403	Second Seed Vessel	1		16 m^3, 2500ϕ x 4000H	Stainless Steel	Mixer 15 kW
R-404	Fermenter	6		160 m^3, 5550ϕ x 7000H	Mild Steel	
TK-401	Mash Buffer Tank	1		160 m^3, 5550ϕ x 7000H	Mild Steel	
TK-402	PH Adjusting Tank	2		55 m^3, 4000ϕ x 4500H	Mild Steel	Mixer 3.7 kW
TK-403	H_2SO_4 Tank	1		10 m^3, 2500ϕ x 2500H	Stainless Steel	
TK-404	H_2SO_4 Head Tank	1		0.2 m^3	Stainless Steel	

Table VII-22 Main Equipment List (11/16)

Equip. No.	Name	Q'ty		Description	Material	Remarks
		Normal	Spare			
TK-405	Drain Tank	1		5 m^3	Mild Steel	
S-401	Yeast Separator	2	1	40 m^3/h	Stainless Steel	30 kW
P-401	R-404 B'TM Pump	1	1	70 m^3/h x 30 mH	Stainless Steel	11 kW
P-402	Mash Pump	1	1	35 m^3/h x 60 mH	Stainless Steel	11 kW
P-403	Drain Pump	1		10 m^3/h x 15 mH	Stainless Steel	1.5 kW
P-404	H_2SO_4 Pump	1		2 m^3/h x 20 mH	Stainless Steel	0.4 kW
Bc-401	Air Compressor	1		2 m^3/min x 7 kg/cm^2G		15 kW
AF-401	Air Filter	1		2 m^3/min	Mild Steel	
F-401	Mash Filter	2		70 m^3/h Backet Type 40 mesh	Stainless Steel	
Bp-401	Belt Press	1		1 m^3/h	Mild Steel	3.9 kW
	Distillation Section					
C-501	Mash Column	1		1150ϕ/1450ϕ/1700ϕ x 24000H	Stainless Steel	Bubble Cap Tray

Table VII-22 Main Equipment List (12/16)

Equip. No.	Name	Q'ty		Description	Material	Remarks
		Normal	Spare			
C-502	Rectifying Column	1		2000ϕ x 29000H	Stainless Steel	Bubble Cap Tray
C-503	Dehydration Column	1		1770ϕ x 28000H	Stainless Steel	Sieve Tray
C-504	Benzene Recovery Column	1		600ϕ x 12000H	Stainless Steel	Sieve Tray
D-501	Fusel Oil Separator	1		570ϕ x 3000H	Stainless Steel	
D-502	Benzene Separator	1		1500ϕ x 5000L	Stainless Steel	
D-503	Benzene Measuring Drum	1		300ϕ x 400H	Stainless Steel	
D-504	Drain Separator	1		3 m^3	Mild Steel	
E-501	C-502 OVHD Condenser	1		200 m^2 Shell/Tube Type	S.S/S.S	S.S: Stainless Steel
E-502	Waste Effluent H/E	2		70 m^2 Shell/Tube Type	S.S/S.S	
E-503	C-503 Reboiler	1		80 m^2 Shell/Tube Type	C.S/S.S	C.S: Carbon Steel
E-504	Product Cooler	1		19 m^2 Shell/Tube Type	C.S/S.S	

Table VII-22 Main Equipment List (13/16)

Equip. No.	Name	Q'ty		Description	Material	Remarks
		Normal	Spare			
E-505	C-501 OVHD Condenser	1		11 m^2 Shell/Tube Type	C.S/S.S	
E-506	C-501 OVHD Condenser	1		45 m^2 Shell/Tube Type	C.S/S.S	
E-507	C-502 OVHD Condenser	1		70 m^2 Shell/Tube Type	C.S/S.S	C.S: Carbon Steel
E-508	C-502 OVHD Condenser	1		66 m^2 Shell/Tube Type	C.S/S.S	
E-509	C-503 OVHD Condenser	1		170 m^2 Shell/Tube Type	C.S/S.S	
E-510	C-503 OVHD Condenser	1		70 m^2 Shell/Tube Type	C.S/S.S	
E-511	C-504 OVHD Condenser	1		20 m^2 Shell/Tube Type	C.S/S.S	
E-512	By Product Cooler	1		0.7 m^2 Shell/Tube Type	C.S/S.S	
E-513	C-502 Waste Water Cooler	1		12 m^2 Shell/Tube Type	C.S/S.S	
TK-501	Benzene Tank	1		2000ϕ x 2000H	Stainless Steel	

Table VII-22 Main Equipment List (14/16)

Equip. No.	Name	Q'ty		Description	Material	Remarks
		Normal	Spare			
TK-502	Bad Alcohol Middle Tank	1		2.7 m^3 1400ϕ x 1800H	Stainless Steel	
TK-503	Fusel Oil Tank	1		20 m^3 2800ϕ x 3250H	Mild Steel	
TK-504	Bad Alcohol Tank	1		30 m^3 3200ϕ x 3800H	Mild Steel	
TK-505	Waste Water Tank	1		8 m^3	Mild Steel	
TK-506	Waste Water Tank	1		5 m^3	Mild Steel	
TK-507	E-503 Condensate Tank	1		5 m^3	Mild Steel	
P-501	Product Pump	1	1	3 m^3/h x 40 mH	Stainless Steel	3.7 kW
P-502	C-501 BTM Pump	1	1	35 m^3/h x 15 mH	Stainless Steel	3.7 kW
P-503	C-502 BTM Pump	1	1	8 m^3/h x 20 mH	Cast Iron	2.2 kW
P-504	E-503 Condensate Pump	1	1	5 m^3/h x 20 mH	Cast Iron	1.5 kW
P-505	Benzene Feed Pump	1		50 ℓ/h x 40 mH	Stainless Steel	0.4 kW
P-506	Fusel Oil Pump	1		5 m^3/h x 10 mH	Cast Iron	0.75 kW
P-507	Bad Alcohol Pump	1		5 m^3/h x 10 mH	Cast Iron	0.75 kW

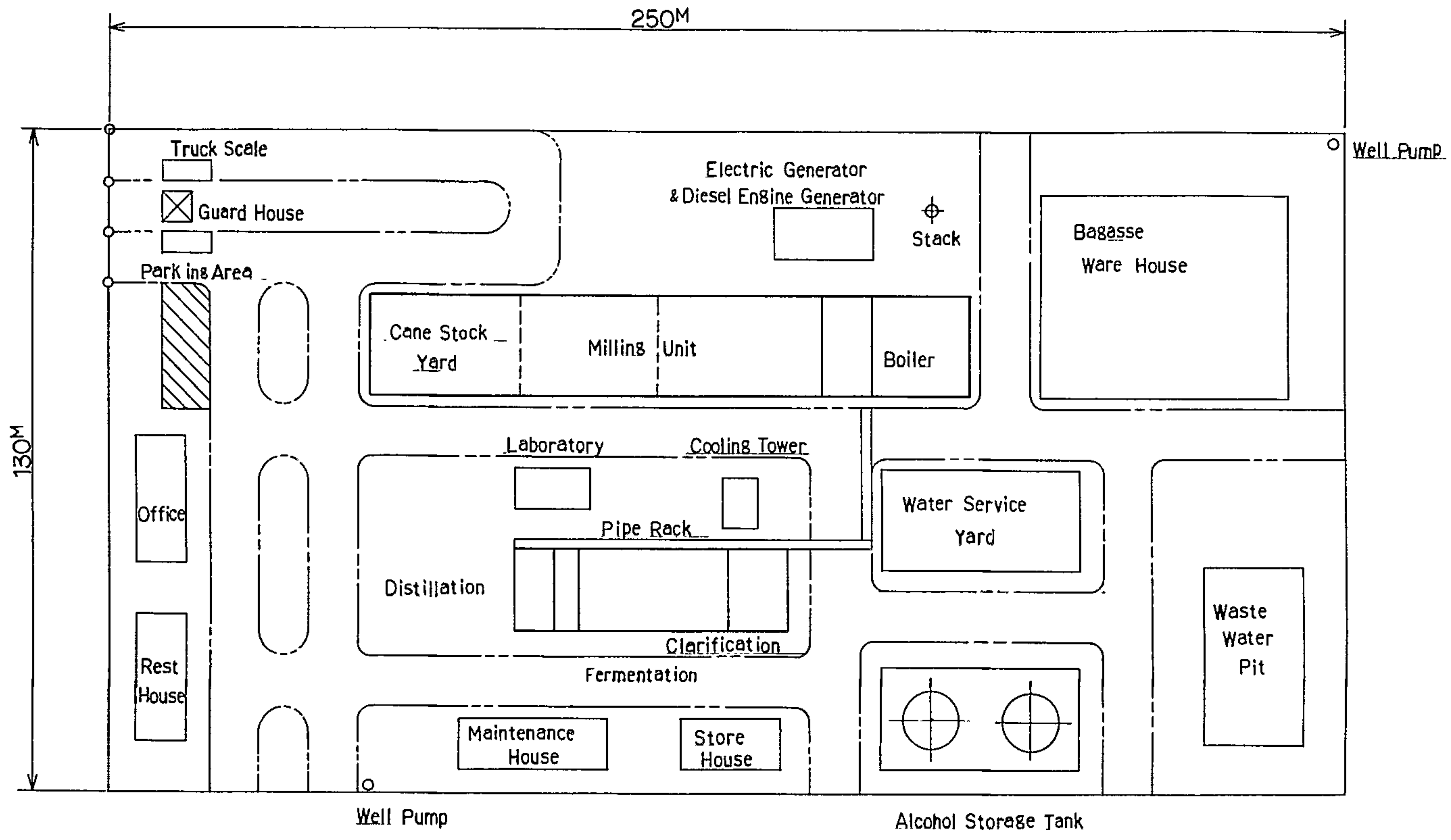
Table VII-22 Main Equipment List (15/16)

Equip. No.	Name	Q'ty		Description	Material	Remarks
		Normal	Spare			
	Product Storage and Loading Section					
TK-601	Alcohol Storage Tank	2		1000 m^3 11620ϕ x 10660H	Mild Steel	
P-601	Product Pump	1	1	10 m^3/h x 10 mH	Stainless Steel	0.75 kW
	Water Treatment Section					
TK-701	Well Water Tank	1		150 m^3	Mild Steel	
TK-702	Water Supply Tank	1		150 m^3	Mild Steel	
TI-703	Pure Water Tank	1		60 m^3	Mild Steel	
TK-704	B.F.W Tank	1		100 m^3	Mild Steel	
TK-705	Imbibition Water Tank	1		50 m^3	Mild Steel	
CT-701	Cooling Tower	1		Capacity: 480 m^3/h		30 kW
PT-701	CT-701 Pit	1		100 m^3	R.C.	
Bc-701	Air Compressor	1				7.5 kW
D-701	Demineralizer	1 set		Capacity: 25 t/h		10 kW
P-701	Well Water Pump	2		60 m^3/h x 150 mH	Cast Iron	37 kW

Table VII-22 Main Equipment List (16/16)

Equip. No.	Name	Q'ty Normal	Q'ty Spare	Description	Material	Remarks
P-702	Fermenter Cooling Pump	1	1	120 m^3/h x 20 mH	Cast Iron	11 kW
P-703	PT-701, TK-703 Feed Pump	1	1	50 m^3/h x 15 mH	Cast Iron	3.7 kW
P-705	I/W Pump	1	1	60 m^3/h x 20 mH	Cast Iron	5.5 kW
P-706	Pure Water Pump	1	1	25 m^3/h x 20 mH	Cast Iron	3.7 kW
P-707	Imbibition Water Pump	1	1	10 m^3/h x 15 mH	Cast Iron	1.5 kW
P-708	Cooling Water Pump	1	1	480 m^3/h x 50 mH	Cast Iron	90 kW
	Waste Water Treatment Section					
PT-801	Waste Water Pit	1		1000 m^3	Earthen Pit	
P-801	Waste Water Pump	1	1	100 m^3/h x 50 mH	Cast Iron	37 kW

Drawing VII-30 Plot Plan



SHEET NO. OF

APPROVED	
CHECKED	
MADE	
DATE	

ORDER NO.

JOB NO.

Drawing VII-31 Project Schedule

CLIENT Philippine National Alcohol Commission | PLANT Alcohol Distillery | LOCATION Cavite, Philippines | REV.

NO.	ITEM	1984: 11, 12 · 1985: 1–12 · 1986: 1–12 · 1987: 1
1.	Basic Design	
2	Detail Design	
3	Manufacturing & Supply of Equipment & Materials	
3-1	Milling Unit	
3-2	Boiler & Electric Generator	
3-3	Other Equipment	
3-4	Supply of Materials	
3-5	Shipping	
4	Civil Work	
5	Election	
6	Piping	
7	Electrical & Instrumentation Work	
8	Mechanical Test	
9	Test Run	Commercial Run

COPY

LEGEND: PLANT ENG'G & MECHANICAL DESIGN; PROCUREMENT; FABRICATION; INSPECTION; TRANSPORTATION; CONSTRUCTION

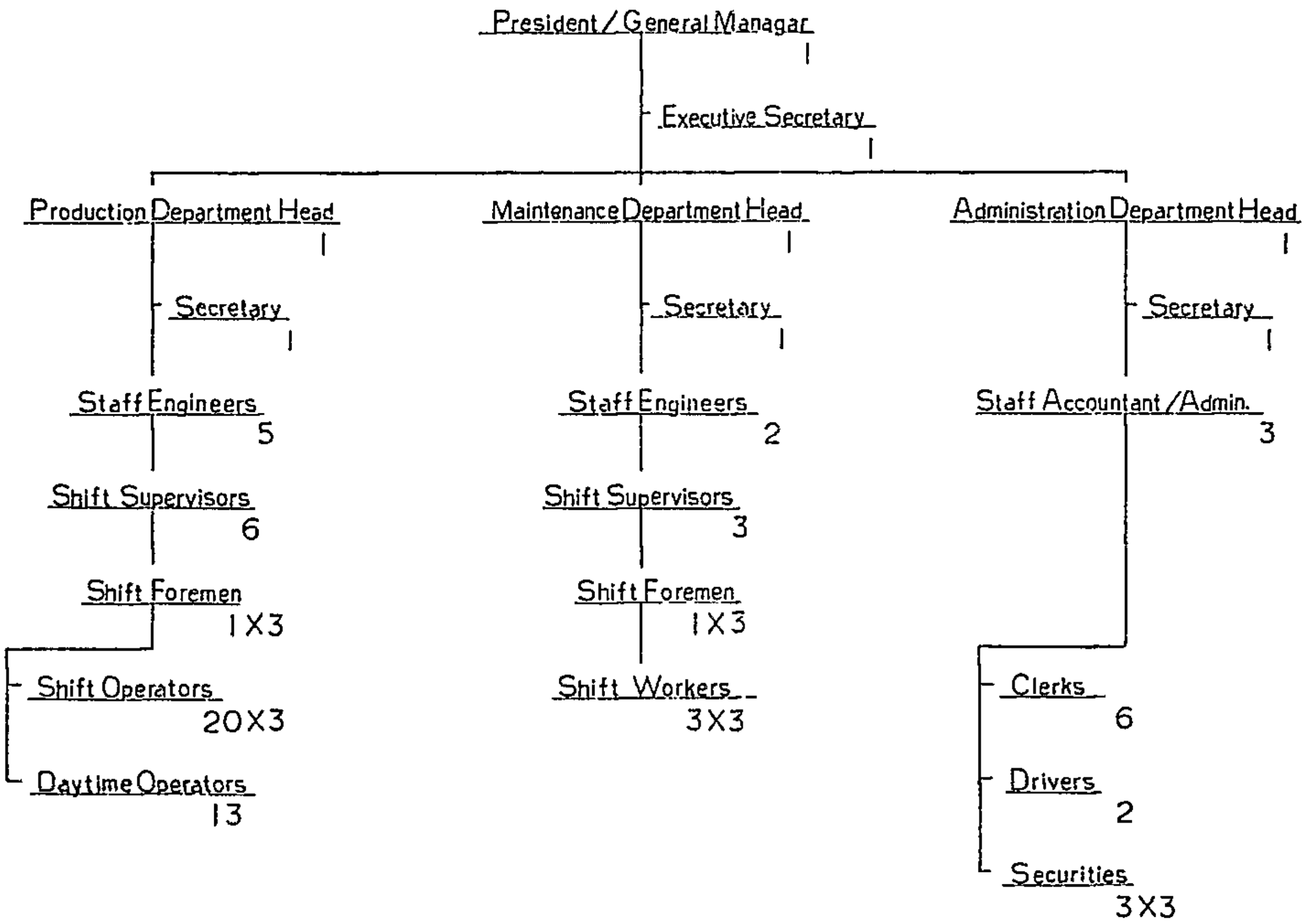
NO. 008. TP.

Table VII-23 Plant Construction Cost

(Unit: 10^3 pesos)

Items		Foreign Portion	Philippine Portion	Total
Equipment	Milling Unit	13,400	5,210	18,610
	Boiler & Electric Generator	9,670	3,530	13,200
	Clarification Unit	3,040	1,170	4,210
	Columns	2,280	760	3,040
	Heat Exchangers	920	800	1,720
	Tanks & Vessels	1,190	4,530	5,720
	Machineries	7,360	1,050	8,410
	Fire Fighting System	-	420	420
	Maintenance	1,050	700	1,750
	Laboratory	700	-	700
	Spare Parts	2,020	70	2,090
Construction	Erection	-	2,710	2,710
	Piping	3,010	4,510	7,520
	Insulation	-	1,400	1,400
	Painting	-	540	540
	Field Expense	-	1,220	1,220
Instrument		1,150	60	1,210
Electrical		2,510	1,310	3,820
Civil & Architect	Site Preparation	-	2,730	2,730
	Civil: Onsite Foundation	-	2,960	2,960
	Civil: Offsite Foundation	-	2,300	2,300
	Civil: Access Road, Fence etc.	-	4,500	4,500
	Building: Auxiliary	-	6,360	6,360
	Building: Production	-	8,320	8,320
Transportation		700	3,480	4,180
Supervising		3,690	870	4,560
Engineering		6,260	-	6,260
Total		58,950	61,510	120,460
		48.9%	51.1%	

Fig. VII-4 Organization Chart for 60 kl/d Alcohol Distillery



Kinds of Personnels	No. of Personnels
President/Gen. Manager	1
Executive Secretary	1
Depart. Heads	3
Secretaries	3
Staffs	10
Shift Supervisors	9
Shift Foremen	6
Shift Operators	60
Shift Workers	9
Daytime Operators	13
Clerks	6
Drivers	2
Securities	9
Total	132

5-9 Energy Balance

The entire energy balance for the production of alcohol from cultivation of sugarcane is shown in Table VII-24.

In this study only the energy which is directly consumed in order to produce alcohol was taken in to account as input energy. Namely, energies such as solar energy and energies required for irrigation and construction of the plant are excluded.

Premises in calculating the energy balance are as follows:

Plantation area of sugarcane	:	2,380 ha
Crop yield of sugarcane per year	:	123,670 t/y
Average crop yield per hectare	:	52.0 t/ha
Alcohol yield	:	12.87 t/kl-alcohol

Input and output which were taken into account in calculating the energy balance are as follows:

Input Energy:
- i) Farms
  - Fuel, fertilizer, labor and carabao
- ii) Fuel for transporting sugarcane to the distillery
- iii) Distillery
  - Nutrients, dehydration agent, labor

Output Energy: Alcohol

As the result of the aforementioned study, the energy balance as expressed by the ratio of Output/Input has turned out to be 13.5.

Table VII-24 Examination of Energy Balance

Basic Data	Possible Plantation Area (ha)		2,380
	Anticipated Raw Material Production (t/y)		123,670
	Harvesting Period (Annual Plant Operating days) (days)		200
	Daily Processing Capacity (t/d)		618
	Production Capacity of Alcohol (kl/d)		48
	Raw Material Required per kl of Alcohol (t)		12.87
	Energy Required per Ton of Raw Material (kcal/t)		27,870
		Consumption (kg or Man-day/kl)	Energy Required (kcal/kl)
Energy Inputs per kl of Alcohol	i) Farms		
	Diesel Oil		233,516
	Fertilizers		
	Labor		
	Carabao		
	ii) Transportation		
	Diesel Oil		126,843
	iii) Distillery		
	Benzene	1.01	9,797
	Ammonium Sulfate	0.50	102
	Phosphoric Acid	0.13	23
	Labor	2.76	8,280
	Total Energy Inputs (kcal/kl)		387,561
Energy Outputs per kl of Alcohol (kcal/kl)			5,113,000
Generated/Utilized Energy Ratio			13,5

CHAPTER VIII

FINANCIAL ANALYSIS AND ECONOMIC ANALYSIS

Scope of financial and economic analysis is as follows:

(1) Financial analysis

Financial analysis is conducted for the following two cases:

1) Alcohol distillery

2) Alcohol distillery and estate

Individual farmers are excluded from the study.

(2) Economic analysis

Economic analysis is conducted including alcohol distillery, estates and individual farmers.

1. Financial Analysis

An analysis is made on the operating cost of alcohol produced in this project, and evaluation of the project is made from financial aspect.

The followings are the major premises of financial analysis.

(1) As a result of studies by Agricultural Sector Team, the capacity of the alcohol distillery is set as 48 kl/d, and the annual operating days as 200 d/y.

(2) Operation will be started in January 1987, and the construction period is included in the financial analysis period of 24 years.

(3) Based on the Minutes of Meetings dated December 1, 1981, studies are conducted on the following cases:

1) The case in which incentives are taken into consideration using the fixed price of the start-up year, and its sensitivity analysis.

2) The case in which incentives and escalation after the start-up are taken into consideration, and its sensitivity analysis.

3) The case in which incentives are not considered and the fixed price of the start-up year prevails throughout the project period.

4) The case in which incentives are not considered but escalation is taken into consideration after start-up of operation.

1-1 Set-up of Study Cases

1-1-1 Base case

In order to make financial analysis, a base case is set up as below.

(1) Escalation

In order to decide whether the fixed price of the start-up year is to be adopted throughout the project period or escalation should be taken into consideration after the start-up of operation, the FIRR on Investment (hereinafter referred to as FIRR on I) and FIRR on Equity (hereinafter referred to as FIRR on E) are shown in the following Table for both cases.

(Unit: %)

	Without Escalation	With Escalation
FIRR on I	9.2	16.3
FIRR on E	16.8	32.9

As shown in the above Table, the result of financial analysis indicates that taking escalation into consideration for the period after operation start-up will result in better result. However, as feasibility studies of other projects in the Philippines adopt the fixed price of the start-up year throughout the project period according to information obtained from MOF, the basis to use the fixed price of the start-up year is adopted. The case in which escalation is taken into consideration after the start-up of operation is studied as a reference case, and a sensitivity analysis is conducted for this case.

(2) Deflation of interest

When the fixed price of the start-up year is used, studies are made as to whether long-term interest and short-term interest are to be deflated or not, and the results of the study are shown in the following Table.

(Unit: %)

	Without Deflation	With Deflation
FIRR on E	16.8	27.5

In the case of deflating interest using 7%/yr equivalent to the escalation of operating costs after start-up, the value of FIRR on E is enhanced considerably, but since most of other projects in the Philippines do not consider deflation, the method to deflate interest is not adopted.

(3) Investment on agricultural roads, bridges, etc. for individual farmers

Studies are made as to whether investment should be made on infrastructures such as agricultural roads, bridges, etc. for farmers, and as such investment should be included in the investment cost of the project or not. The results are shown in the following Table.

(Unit: %)

	Without Infrastructure	With Infrastructure
FIRR on I	9.2	7.9
FIRR on E	16.8	12.9

As shown in the above Table, when the agricultural roads and bridges are included in the investment cost of this project, the FIRR values are lowered. Therefore, our recommendation is as follows: when this project is materialized, tax revenue to the Government are expected after the start-up of operation, hence the agricultural roads and bridges outside the estate should be treated as Government investment, thus not including in the project cost.

(4) Establishment of estate

The results of studies made as to whether there should be establishment of estate or not are shown in the following Table. In these studies, when as estate is established, calculations are made on the basis of plant capacity being 48 kl/d and operating days being 200 d/y, while when estates are not established, on a basis of plant capacity being 56 kl/d and operating days being 163 d/y.

(Unit: %)

	With Estate	Without Estate
FIRR on I	9.2	7.9
FIRR on E	16.8	12.7

As seen from the above Table, the results of financial analysis indicate higher values when the estate are established. As establishment of estate also contributes to the stabilized operation of the alcohol plant, it is determined that it should be incorporated in the project.

The above statements are summed up as follows, concerning the financial analysis for a base case:

1) A basis to use the fixed price of operation start-up year shall be adopted.

2) No deflation shall be considered on interest.

3) Investment on agricultural roads, bridges, etc. for individual farmers is deemed as Government investment.

4) Estate shall be established.

As to the case for which escalation is taken into consideration continuously even after the start-up of operation, a sensitivity analysis will be conducted as a reference case.

1-1-2 Set-up of cases for sensitivity analysis

For sensitivity analysis purposes, the following 5 cases are selected, and the change in the profitability in each case is analized.

(1) Changes in the product price
(2) Changes in the raw material cost
(3) Changes in the construction cost
(4) Changes in the interest
(5) Changes in the operating rate (Molasses are used as supplementary raw material)

1-1-3 Set-up of reference cases

As a result of discussion with PNAC, the followings are adopted as reference cases, and financial analysis are conducted.

(1) The case in which escalation is considered even after the start-up of operation, and incentives are offered. Sensitivity analysis will be included.

(2) The case in which the fixed price of the start-up year is used, and for which no incentives are given.

(3) The case in which escalation is taken into consideration even after the start-up of operation, but no incentives are given.

(4) The case in which the distillery capacity is assumed 60 kl/d with annual operation days of 200 d/y and the fixed price of the start-up year and the incentives are assumed.

1-2 Total Capital Requirement and Operating Expenses

The total capital and operating expenses which constitute a base for financial analysis are obtained as follows:

1-2-1 Total capital requirement

The total capital requirement is the total of capitals invested up to the start-up of commercial operation, and these capitals are divided into fixed capital and working capital. In Table VIII-1, fixed capitals and working capitals are shown. For integration of all the capitals required, the following conditions are incorporated.

1) Standard of price

The construction cost is calculated based on the price of 1981, and necessary escalations are incorporated in the actual costs which are spread up to 1987.

2) Escalation rate

The escalation rate for the construction cost of foreign portion is assumed 6.5% per annum, whereas the rate for the cost of domestic portion is 10% per annum.

Table VIII-1 Summary of Total Capital Requirement

(Unit: x 10^3 Pesos)

		Total	1983	1984	1985	1986	1987
1	Land Acquisition	12,460	12,460				
2	Cane Farm Construction	4,243	1,100	3,143			
3	Farm Machinery & Equipment	6,286		1,907	1,236	3,143	
4	Construction for Building	18,777		1,567		17,210	
5	Plant Construction	120,108			39,000	57,136	23,972
6	Pre-operating Expenses	9,494		822	2,521	6,151	
7	Initial Chemicals	61				61	
8	Sub-Total	171,429	13,560	3,143 4,296	39,000 3,757	74,346 9,355	23,972
9	Interest During Construction	14,743		814	1,179	3,833	8,917
10	Total Fixed Capital	186,172	13,560	8,253	43,936	87,534	32,889
11	Working Capital	-					-
12	Total Capital	186,172	13,560	8,253	43,936	87,534	32,889

3) Currency and exchange rate

For the Philippine currency calculation is done using Peso, and for foreign currencies, both US$ and ¥ (Japanese Yen) are used with the exchange rate as below:

US$ 1 = 8 Pesos = ¥230

(1) Fixed capital

1) Land acquisition and construction cost

Land acquisition and construction cost are shown in Table VII-2.

a) Land acquisition

Sites required for the estate and plant will be purchased in 1983, the area covering the estate being 4,000,000 m^2, and that covering the plant 32,500 m^2. The expenses necessary for the purchases of lands is 12,460 x 10^3 pesos.

b) Construction cost

As to construction cost of the estate and plant, calculations are made based on the price in 1981 as well as by taking future escalation in consideration. For the alcohol plant, a contract will be made in the very beginning 1985, and escalations up to 1985 are considered. The total amount of construction cost including land acquisition cost is 161,874 x 10^3 pesos which covers both estate and alcohol plant.

Table VIII-2 Disbursement Schedule of Construction Cost for Estate and Plant

(Jan. 1983 - Jan. 1987)

(Unit: x 10^3 Pesos)

	F.C.	L.C.	TOTAL	1983	1984	1985	1986	1987*
1 Land Acquisition for Estate		10,135	10,135	10,135				
2 Cane Farm Construction	1,485	1,521	3,006	842	2,164			
3 Farm Machinery & Equipment	4,204		4,204		1,373	836	1,995	
4 Farm Buildings		1,031	1,031		1,031			
5 Physical Contingency for Estate	815	364	1,179	98	657	125	299	
6 Land Acquisition for Plant		163	163	163				
7 Machinery & Equipment & Election	53,340	41,830	95,170			31,471	45,352	18,374
8 Buildings for Plant		12,930	12,930				12,930	
9 Price Contingency	12,855	21,201	34,056	2,322	1,392	7,804	16,940	5,598
TOTAL	72,699	89,175	161,874	13,560	6,617	40,236	77,489	23,972

Note : F.C. Foreign Currency

L.C. Local Currency

1987* Jan. 1987

c) Incentives for import custom duties and taxes

In the case of materials and machinery imported from abroad, the incentives from BOI for registered projects are given, exempting them from import custom duties and taxes.

2) Pre-operating expenses

Pre-operating expenses are the expenses required during the construction period, which are shown in Table VII-3. The total of such expenses amounts to 9,494 x 10^3 pesos.

a) Administration and maintenance expenses for estate

The expenses necessary for the estate such as the maintenance of machinery and equipments, labor costs and expenses for fertilizers, agricultural chemicals, etc. required by the time of start-up of commercial operation of the plant in 1987 are named administration maintenance expenses for the estate.

b) Training expenses

Included in the personnel training expenses are the salaries paid to 3 foremen and 20 operators during the period of training in the Philippines, and the living expenses paid to 5 engineers during the period of their training abroad, and the expenses paid to these engineers covering their travels abroad.

c) Plant administration cost

Assuming that the below-mentioned personnel are employed 2 years before the start of commercial operation, salaries paid to these personnel during the 2 years period, and indirect expenses incidental to such payment are also calculated as administration costs.

i)	President (Concurrently Plant Manager) and Secretary	1 respectively
ii)	Department Heads	3
iii)	Staff Engineers	10
iv)	Shift Supervisors and Analyst	3

d) Start-up expenses (including test run)

Assuming that 3 supplementary personnel are dispatched by licensers and contractors for a period of 60 days during the period of test run of the plant, expenses required for such personnel and chemicals are named start-up expenses.

3) Initial chemicals

The expenses required for the initial filling up of chemicals at the time of the start-up of operation at the plant.

Table VIII-3 Summary of Pre-operating Expenses & Initial Chemicals

(Unit: 1,000 pesos)

	Total	1984	1985	1986
Pre-Operating Expenses	9,494	822	2,521	6,151
a) Costs for Estate	(5,762)	(822)	(1,645)	(3,295)
b) Training Fee	(658)			(658)
c) Administration Costs	(1,813)		(876)	(937)
d) Start-up Expenses	(1,261)			(1,261)
Initial Chemicals	61			61

4) Interest during construction period

The amount of fixed capital mentioned in Items 1) to 3) shall be paid during construction period under the following conditions.

a) Constructiom cost

The timer of defrayment of construction cost is estimated based on the construction schedule.

b) Pre-operating expenses

Pre-operating expenses shall be defrayed in 1984, 1985 and in 1986.

c) Initial chemicals

This expenses shall be defrayed at the time of start-up of test run.

It is assumed that 25% of the yearly defrayment of capital mentioned in the above a), b) and c) would be replenished by own capital (paid-up capital), and 75% of the yearly capital defrayment by means of long-term loan.

It is also set upon that the interest during the construction period is added to the fixed capital. As to financial conditions, the premises for financial analysis mentioned later on are also used.

(2) Working capital

The initial working capital means the funds required for an enterprise to continue its production activity without trouble. In this study, the working capital is defined as the total of operating cash, raw material and product inventories and accounts receivable, minus accounts payable.

It is assumed that the sugarcane raised in the estate and not consumed for test run during 1985 and 1986 and the alcohol produced during the test run are sold. As the cash generated by the said sales of sugarcane and alcohol exceeds the total amount of initial working capital, namely 8,350 x 10^3 pesos, which is shown in Table VII-4, no amount is counted as initial working capital.

Inspite of the above, the premises of calculating the initial working capital are summed up, for reference sake as below.

1) Operating cash

The amount equivalent to 1/12 of personnel expenses for a year and utilities costs is always held on hand as operating cash.

2) Raw material inventory

It is calculated on the assumption that the average inventory of material is for 1 day.

3) Product inventory

It is calculated on the assumption that the average product inventory would be for 15 days.

4) Account receivable

14 days' gross margin is reckoned as account receivable, assuming the trade account receivable days of 14 days.

5) Account payalbe

It is estimated on the assumption that the payment grace days are 14 days for the costs, mainly raw material cost.

Table VIII-4 Initial Working Capital

(Unit: 10^3 pesos)

1) Operating Cash	631
2) Inventory of Raw Material	148
3) Inventory of Product	4,990
4) Account Receivable	4,657
5) Account Payable	2,076
Initial Working Capital (1+2+3+4-5)	8,350

The working capital during operation was calculated using the formula; 2) + 3) + 4) - 5).

1-2-2 Operating costs

Operating costs are composed of variable costs and fixed costs. However, in this study, the raw material cost has been separated from the variable costs, because the proportion of raw material cost is large. As to escalation of operating costs up to 1987, a year of starting commercial operation, an annual rate of 7% is adopted using the growth rate of GNP Implicit Price Index reported by NEDA.

(1) Raw material cost

The quantity of consumption of raw materials (sugarcane), the price thereof and the annual raw material cost are summarized in Table VII-5. Concerning the price of raw material, as a result of studies made by the Agricultural Sector Team, the price is 160 pesos/t for

1981, and the price is assumed to escalate at an annual rate of 7% like other operating costs. Accordingly, the price of 240 pesos/t is used for the year of 1987 and thereafter.

Table VIII-5 Raw Material Quantity & Cost

(Unit: t/y & 10^3 pesos)

	1987	1988	1989	1990	1991-2006
Raw Material from Estate	22,925	22,925	22,925	22,925	22,925
Raw Material from Individual Farm	61,027	89,787	95,354	99,197	100,744
Total (t/y)	83,950	112,710	118,280	122,120	123,670
Raw Material Cost Paid to Individual Farmer (10^3 pesos)	14,646	21,549	22,885	23,807	24,179

(2) Variable costs

Variable costs are composed of utilities and chemicals costs.

1) Utilities costs

The utilities costs are none because of the self-supply system of steam, water and electricity. The fuel cost is also not counted because bagasse is used as fuel.

2) Chemicals

The expenses of chemicals necessary for the operation of the plant are shown in Table VIII-6. A total of 1,559 x 10^3 pesos is estimated for the annual consumption.

Table VIII-6 Summary of Utility and Chemicals Costs

	Consumption/d	1000 Pesos/d
1. Well Water	2,352 t	Self Supply
2. Electric Power	1,6220 kwh	Self Supply
3. Benzene	49 kg	162
4. H_2SO_4 (98%)	324 kg	117
5. Antifoamer	2 kg	10
6. Lime (100%)	490 kg	118
7. Penicillin	369 g	77
8. $(NH_4)_2SO_4$	25 kg	48
9. Phoshoric Acid	6,300 g	26
10. NaOH (100%)	120 kg	162
11. HCl (100%)	80 kg	32
12. Corrosion Inhibitor	22 kg	202
13. Slime Inhibitor	1 kg	6
14. Phosphoric Acid Soda	4 kg	22
15. Hydrazine	5,900 g	57
Sub-Total		1,039
Price Contingency		520
Total		1,559

(3) Fixed cost

In this study, fixed costs are broken down as below.

1) Operation and maintenance costs of estate
2) Labor costs for alcohol distillery
3) Property taxes
4) Insurance expenses
5) Maintenance costs of alcohol distillery
6) General expenses and plant overhead
7) Depreciation

Explanations of respective expense are given hereunder.

1) Operation and maintenance costs of estate

Included in this cost are costs necessary for the operation and maintenance of agricultural machinery, equipments farmers' salaries, costs of fertilizers and agricultural agents, costs required for the maintenance of buildings, costs required for the operation and maintenance of farm land, etc. Summary of these costs is given in Table VIII-7.

Table VIII-7 Operations & Maintenance cost of Estate

(Unit: 10^3 pesos)

Items	1987	1988	1989	1900-2006
1. Machinery Operation Cost				
(1) Repair & Maintenance	539	740	767	767
(2) Fuel & Oil	247	298	316	316
2. Personnel Cost				
(1) Staff	208	208	208	208
(2) Operator	54	54	54	54
(3) Driver	246	364	385	407
(4) Permanent Labor	28	28	28	28
(5) Hired Labor	654	709	709	709
(6) Hired Animal	7	7	7	7
3. Fertilizer & Chemicals	553	553	553	553
4. Maintenance Cost for Building	29	29	29	29
5. O&M Costs of Farm Land	159	159	159	159
6. Miscellaneous	173	206	211	212
Sub-Total	2,897	3,355	3,436	3,449
Price Contingency	1,451	1,680	1,716	1,727
Total	4,348	5,035	5,142	5,176

2) Labor cost for alcohol plant

Based on the plant organization and salary system obtained from PNAC, estimation is made on the labor force for the plant, and the total amount of labor costs is sought.

Summary is given in Table VIII-8. As to part-time operators, it is assumed to employ one-half of the total number of the employees during the plant idle period.

Table VIII-8 Job Classification, Personnel Requirements & Payrolls

Job Classification	Personnel Requirement	Payrolls (10^3 Pesos)
1. General Manager	1	74
2. Department Heads	3	170
3. Staff Engineers & Accountants, Admin.	10	327
4. Shift Foremen	6	109
5. Shift Operators & Shift Workers (full time)	34	436
6. Shift Operators & Shift Workers (part time)	35	246
7. Daytime Operators (full time)	6	67
8. Daytime Operators (part time)	7	43
9. Executive Secretary	1	27
10. Secretaries	3	52
11. Clerks, Drivers & Securities	17	259
12. Shift Supervisors	9	241
Sub-Total	132	2,051
Price Contingency		1,027
Total	132	3,078

3) Property taxes

0.1% of the residual value of the plant, buildings and lands will be used to cover the taxes.

4) Insurance

An amount of insurance will be equivalent to 1.6% of the residual value of the plant, buildings, machinery and equipments.

5) Maintenance costs for alcohol distillery

The annual maintenance costs are equivalent to 3% of the construction cost. The costs required for the temporary employment of personnel and machines and tools required during the repair period are included in the maintenance costs.

6) General expenses and plant overhead

An amount equivalent to 100% of the labor cost is estimated as general expenses and plant overhead. Included in the general expenses are expenses for office supplies, travelling expenses, etc., and included in the plant overhead are expenses necessary for the efficient operation of the plant, namely expenses for dining rooms, medical care, fire fighting, etc., although such expenses have no direct relationships to the production.

7) Depreciation

The straight line method is adopted for depreciation, and an amount of 10% will be considered as salvage values. The regular depreciation period is as shown in the left column of the below Table. However, in the financial analysis conducted in this study, the period indicated in the right column is adopted due to the incentives for the project.

	Regular (year)	With incentives (year)
Pre-operation expenses	-	10
Plant construction cost	15	8
Buildings	20	10
Interest during construction period	15	8
Agricultural machinery & equipment	7	4
Road construction cost	40	20

1-3 Sales

Concerning the sale of products, it is assumed from the nature of this project that all the alcohol products produced could be sold.

As to operation load, the following rates are adopted based on the information on the sugarcane yield estimated by the Agricultural Sector Team.

1987	67%
1988	91%
1989	95%
1990	98%
1991 and thereafter	100%

With the exception of the quantity to be consumed for trial run, the sugarcane produced by individual farmers in 1985 and 1986 will all be sold to sugar plants at the price of purchasing price from farmers plus expenses. The sugarcane from estate in that period will be also sold to sugar mills at market price. Also, the alcohol to be produced in the test run will all be sold.

As to the selling price of the alcohol produced, the price of 4.37 pesos/l for 1981 is used as a basis, to which an escalation rate of 8% per annum (1% higher than the percentage being applied to other costs) will be applied from 1981 to 1987. Accordingly, the price for 1987 will be 6.93 pesos/l.

The revenue of sales is shown by production quantity x product price taking 15 days' inventory into consideration.

1-4 Premises for Financial Analysis

In conducting the financial analysis, the premises used are as mentioned below.

(1) Project period

The project period for the analysis covers 24 years up to 2006, in which a construction period of 4 years from 1983 to 1986 and an operation period of 20 years after the start of commercial operation in January 1987 are included.

(2) Operating load

The operating load for the 1st year of commercial operation and thereafter is set at 67%, 91%, 95%, 98%, and 100% of the design capacity respectively.

(3) Consideration for future price escalation

The constant price of 1987 is made as the basis and the escalation until the time of start-up of operation is taken into consideration.

(4) Exchange rate

The exchange rate (1 US$ = 8 pesos = ¥230) is used.

(5) Capital arrangement plan

1) Capital

25% of the fixed capital is paid-up own capital fund.

2) Conditions for long-term load

75% of fixed capital is borrowed as long-term loan.

The repayment terms of interest and principal are as follows:

Interest Rate	:	8.0% per annum
Repayment of Principal	:	Equal payment for 12 years after 3 years' grace period.

3) Condition for short-term loan

The cash requirement after start-up will be made up with short-term loan under the following terms:

Interest Rate	:	18% per annum
Repayment of Principal	:	When fund surplus is generated, repayment is made within the limits of the loan balance.

(6) Incoming tax

35% and 3% of ordinary income before tax are appropriated for income tax and local tax, respectively.

(7) Incentives

In making financial evaluation, the following points are considered.

1) Acceleration of depreciation
2) Operating loss carryover
3) Exemption of custom duties and taxes for imported machinery and equipments
4) Treatment of pre-operation expenses as subject of depreciation

1-5 Results of Financial Analysis and Discussion

Based on the study result and premises so far described, the following statements are prepared to make a financial analysis. The financial statements for the base case is attached as Appendix-6.

i) Cost Accounting
ii) Profit and Loss Statement
iii) Cash Flow Analysis Table
iv) Break-even Point

In the study, as an indication of profitability, financial internal rate of return (FIRR) is used.

(1) FIRR on I (financial internal rate of return on investment)

FIRR on I means IRR against the total capital requirement, including load, which indicates the profitability of the project subjected. An indicator to show essentially the profitability of a project, excluding effects concerning financing conditions, debt and equity ratio, etc.

(2) FIRR on E (financial internal rate of return on equity)

FIRR on E represents IRR against the own fund invested, an indicator to show the profitability of own capital alone, excluding the funds financed.

The formulae used for the calculation of FIRR in the study are shown in the following Table.

	Out flow	In flow
FIRR on I	Investment	Profit after tax + Depreciation + Interest + Salvage value + Working capital
FIRR on E	Investment + Interest during construction - Long term loan - Short term loan	Inflow of FIRR on I + Requirement of long term loan and short term loan - Interests of long term loan and short term loan

1-5-1 Results of financial analysis of base case

(1) Operating Cost

Operating costs are summarized in Table VIII-9. The time changes in the variable cost including raw material cost versus fixed cost are as shown in the following Table.

(Unit: %)

	1987	1990	1995	2000
Variable cost (Including raw material cost)	29.7	34.1	47.7	56.7
Fixed cost	70.3	65.9	52.3	43.3

The reason why the ratio of variable costs for this project is relatively small owes to the fact that part of the raw materials are produced by the estate.

Table VIII-9 Operating Cost

(Unit: 10^3 pesos)

	1987	1990	1995	2000
Operating rate (%)	67	98	100	100
Alcohol Production (t/y)	6,523	9,489	9,609	9,609
Raw Material Cost	14,646	23,807	24,179	24,179
Variable Cost	1,058	1,539	1,559	1,559
Fixed Cost (including depreciation)	37,243	38,396	22,011	18,053
Sub-total	52,947	63,742	47,749	43,791
Interest	-	10,685	6,218	1,632
Total	52,947	74,427	53,967	45,423
Unit Cost (pesos/l)	8.12	7.84	5.62	4.73

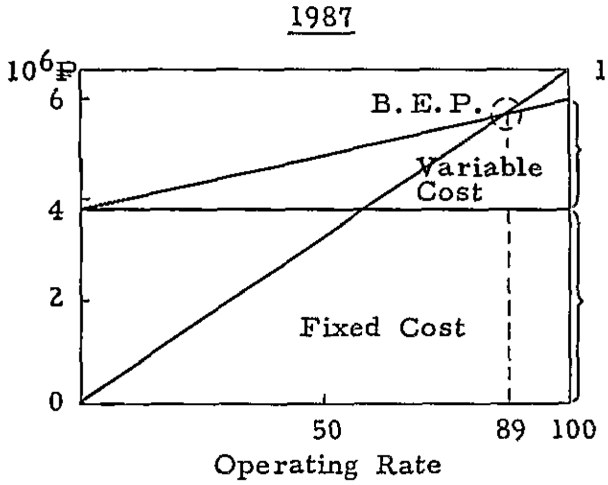
(2) Break-even Point

The break-even point for the operating rate and that for the sales price are shown in Figure VIII-1 and in Figure VIII-2 respectively.

The break-even point for operating rate is 89% in the initial year, which exceeds the actual operating rate, however, in the years thereafter, the percentages show a swift lowering.

As for the break-even point for sales prices, the value shows 8.12 pesos/l, and it indicates a tendency of lowering in the years thereafter.

Fig. VIII-1 Break Even Point by Operating Rate



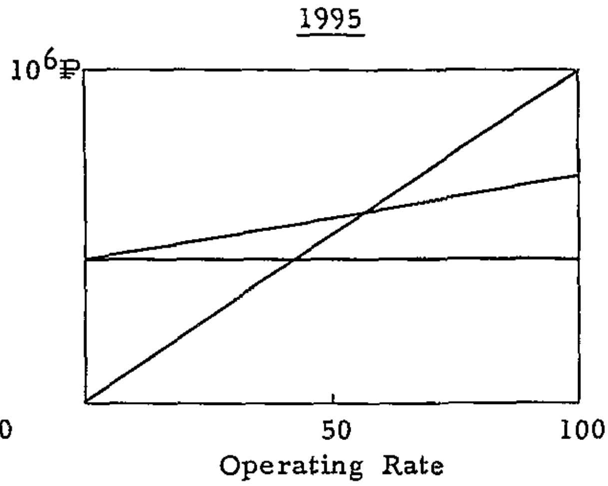
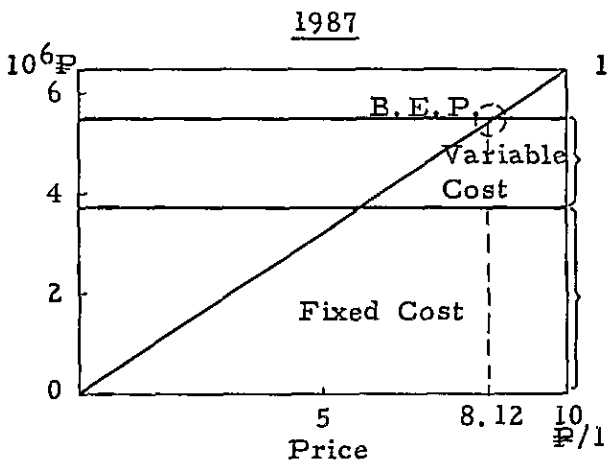
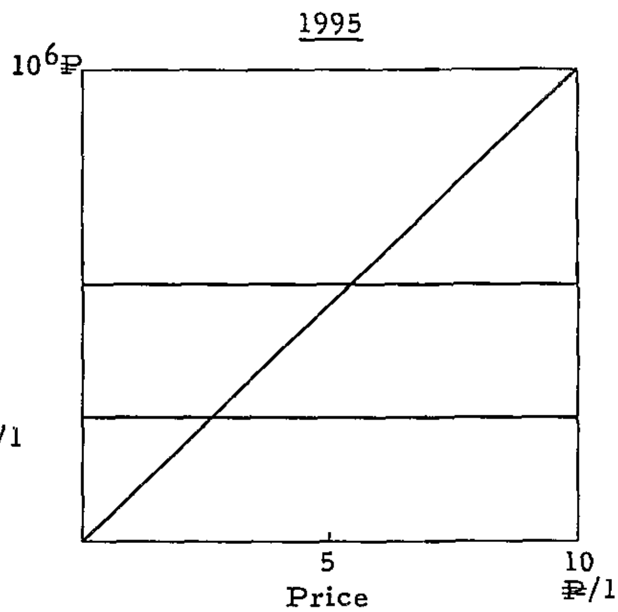


Fig. VIII-2 Break Even Point by Price





(3) Debt service coverage ratio

The capability to repay loan is indicated by DSR (Debt Service Coverage Ratio), and this DSR is obtained by the following formula.

$$DSR = \frac{(\text{Depreciation} + \text{Profit after tax} + \text{Interest})}{(\text{Repayment of principle borrowed} + \text{Interest})}$$

The DSR always exceeds 1 during the project life. In view of such repaying capability, although some difficulty is involved in this project concerning the repayment of debt at the beginning, it shows the financial conditions promising independent existence.

(4) Profitability

The profitability of Base Case is summarized in the following Table.

FIRR of Basic Case

(Unit: %)

FIRR on I	9.2
FIRR on E	16.8

As seen from the above Table, FIRR on I indicates 9.2%, and judging from this value, it can be said that this project is profitable to some extent if not very profitable.

While, FIRR on E, which is an own capital versus profitability indicator, represents 16.8%. This figure, in view of the interest rate exceeding the actual interest rate, can certainly be attractive to the investors.

In Table VIII-10 and Table VIII-11, the financial evaluation and operation costs are summarized.

Table VIII-10 Summary of Financial Evaluation

(Unit: $\times 10^3$ Pesos)

		1990	1995	2000
1. Capital Requirement				
Land	12,460			
Construction of Estate	12,096			
Construction of Plant	137,318			
Pre-operating Expenses	9,494			
Initial Chemicals	61			
Interest During Construction	14,743			
Fixed Capital Requirement	186,172			
Working Capital	-			
Total Capital Requirement	186,172			
2. Sales Revenue		65,775	66,590	66,590
3. Operation Cost				
Raw material Cost		23,807	24,179	24,179
Variable Cost		1,539	1,559	1,559
Fixed Cost		38,396	22,011	18,053
Sub-Total		63,742	47,749	43,791
Interest		10,685	6,218	1,632
Total		74,427	53,967	45,423
4. FIRR on Investment (%)	9.2			
FIRR on Equity (%)	16.8			

Table VIII-11 Summary of Unit Operating Cost

(Unit: Pesos/l)

	1990	1995	2000
1. Raw Material Cost	2.51	2.52	2.52
2. Variable Cost	0.16	0.16	0.16
3. Fixed Cost			
Operation & Maintenance Cost of Estate	0.55	0.54	0.54
Labor	0.32	0.32	0.32
Maintenance	0.43	0.43	0.43
General Expenses & Plant Overhead	0.32	0.32	0.32
Insurance & Tax	0.22	0.15	0.08
Depreciation & Amortization	2.20	0.53	0.19
Sub-Total	4.04	2.29	1.88
Interest	1.13	0.65	0.17
Total	5.17	2.94	2.05
4. Unit Operation cost	7.84	5.62	4.73

1-5-2 Sensitivity analysis of base case

Sensitivity analysis are carried out as to the following factors by varying numerical values.

(1) Changes in product price
(2) Changes in raw material price
(3) Changes in construction cost
(4) Changes in interest rate
(5) Changes in operating rate (using molasses as sub-raw material)

(1) Changes in product price

By varying the alcohol sales price in 1987 by ±10%, studies are made to see the effects given on the profitability.

Basic price 6.93 pesos/l → +10% 7.62 pesos/l
→ -10% 6.22 pesos/l

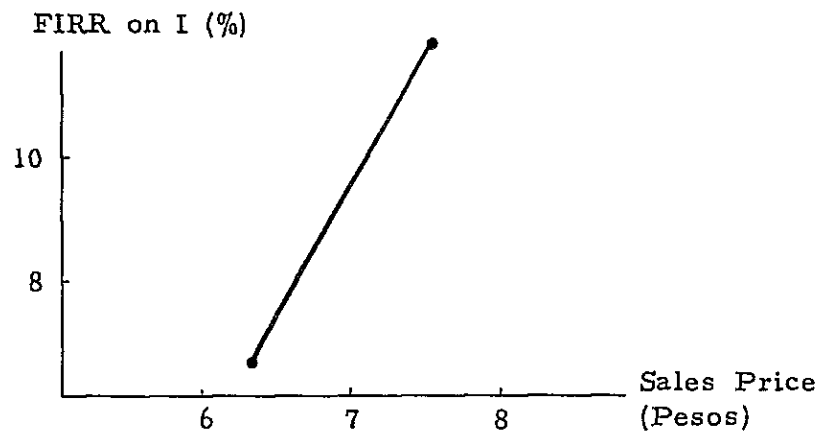
As indicated in Table VIII-12, when the sales price rises by 10%, FIRR on I is raised from 9.2% to 12.1%.

Table VIII-12 FIRR vs Sales Price

(Unit: %)

	Basic Price	+10%	-10%
FIRR on I	9.2	12.1	6.4
FIRR on E	16.8	27.3	>-10.0

Fig. VIII-3 FIRR vs Sales Price



(2) Changes in raw material price

As a result of discussion made with the Agricultural Sector Team, the price of sugarcane to be purchased from individual farmers is set at 160 pesos/t for 1981, and the price for 1987 is set at 240 pesos/t by taking a 7% per annum escalation rate into consideration.

Studies are conducted to see the effects on the profitability in the case of lowering the 1987 price, 240 pesos/t, to 210 pesos/t and 180 pesos/t.

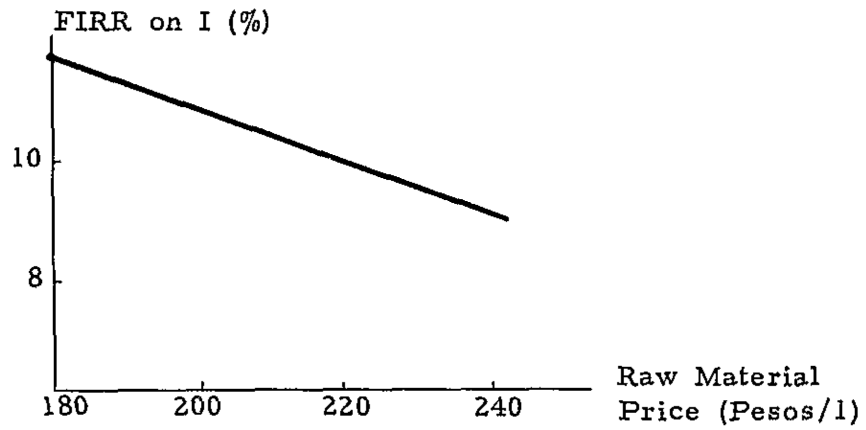
As indicated in Table VIII-13, the profitability is raised considerably as raw material prices are lowered.

Table VIII-13 FIRR vs Raw Material Price

(Unit: %)

	Basic Price (240)	210 Pesos/t	180 Pesos/t
FIRR on I	9.2	10.5	11.8
FIRR on E	16.8	21.4	26.1

Fig. VIII-4 FIRR vs Raw Material Price



(3) Changes in construction cost

Changes in the construction cost generate changes in the depreciation, insurance and taxes, exerting effects upon operating costs.

Studies are made to see the effects on the profitability by varying the total capital requirement within the limits of ±10%.

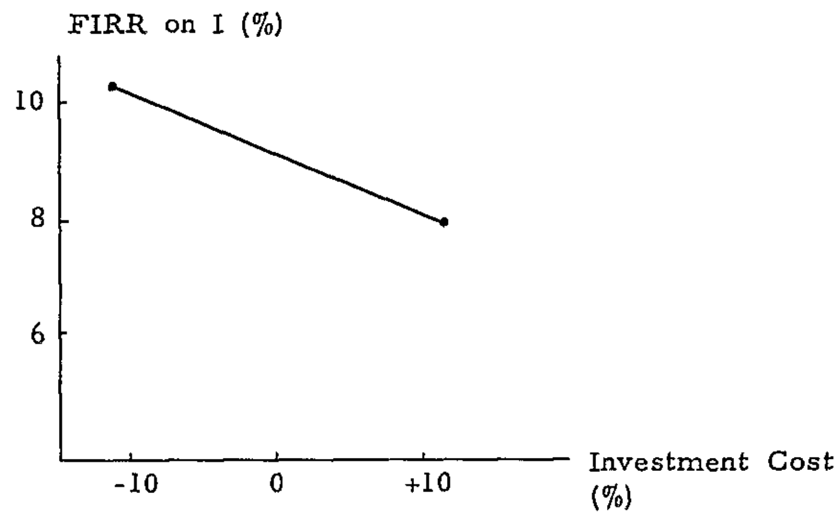
As indicated in Table VIII-14, the effects exerted by 10% changes of the total capital requirement upon FIRR on I are not so remarkable.

Table VIII-14 FIRR vs Investment Cost

(Unit: %)

	Basic Cost	+10%	-10%
FIRR on I	9.2	8.2	10.3
FIRR on E	16.8	13.8	20.9

Fig. VIII-5 FIRR vs Investment Cost



(4) Changes in interest

Summarized in Table VIII-15 are the effects of changes in interest on FIRR on E. As to changes in interest, the interest rate of long-term loan, 8%, is varied to 6% and 10%.

As shown in Table VIII-15, the interest affects FIRR on E considerably. Therefore, in order to make this project attractive to investors, it is essential to borrow funds with low interest rate.

Table VIII-15 FIRR vs Interest

(Unit: %)

	Base Case (8%)	6%	10%
FIRR on E	16.8	21.0	13.6

(5) Changes in operating rate (using molasses as sub-raw material)

When molasses are used as sub-raw material, an increase in the operating days from 200 d/y to 300 d/y can be expected. To enable this, the total capital requirement is also increased by 3.7%, however, FIRR on I can be raised remarkably. As a premise for the study, the price of molasses was assumed 810 pesos/t or 1,010 pesos/t. The results are summarized in Table VIII-16.

Table VIII-16 FIRR vs Using Molasses

(Unit: %)

	Base Case	Molasses (1,010)	Moalsses (810)
FIRR on I	9.2	14.9	15.9
FIRR on E	16.2	39.2	43.5

1-5-3 Results of financial analysis for reference case

(1) Case for which escalation and incentives are taken into consideration and sensitivity analysis thereof

When a financial analysis is conducted, how to treat escalation becomes a significant factor. In this study, the escalation is treated as mentioned below. When evaluation of input and output of the project is made as part of a financial analysis, there are 2 methods of handling escalation/inflation in principle:

a) A method to raise the prices of all items by estimated inflation rate. When this method is used, the IRR tends to get bigger. Since an average escalation/inflation rate is included in the discount rate when future costs, expenses and profit are discounted to the present value for the calculation of IRR.

b) A method to fix the prices of all items at the price in the standard year, disregarding escation/inflation. This is the same as the method to deflate the prices of all items with certain price index.

The results of financial analysis using the method a) above for the occurrence of escalation throughout the project period are mentioned under.

1) Premises

a) Total capital requirement

All escalations estimated to occur up to 1987 are included for the calculation of capital requirement, and as disbursement of all expenses will be effected by 1987, the total capital needed is equivalent to that for the base case.

b) Escalation rate

Escalation rates are set throughout 24 years subjected to the study as follows.

a)	Operating costs	:	7%, based on the GNP implicit price index of Philippine Development Plan
b)	Alcohol price	:	8% (1% higher than that of operating costs)

2) Results of financial analysis

a) Results of financial analysis of the case for which escalation and incentives are taken into consideration

FIRR on this case is shown in Table VIII-17.

Table VIII-17 FIRR vs Escalation Case

(Unit: %)

	Base Case	Escalation Case
FIRR on I	9.2	16.3
FIRR on E	16.8	32.9

As seen from the above Table, when escalation is considered, the profitability is improved remarkably. However, this escalation is estimated throughout the project period and, therefore, some questions arise concerning its certainty because estimating escalation rate applicable for such a long period involves quite an uncertainty.

b) Sensitivity analysis of the case for which escalation and incentives are considered

As a reference, the results of this analysis are as follows.

i) Changes in product price

The 8% escalation rate for product alcohol price is varied to 7% and 9%.

Table VIII-18 FIRR vs Product Escalation Rate

(Unit: %)

	Escalation Case	7%	9%
FIRR on I	16.3	12.5	19.6
FIRR on E	32.9	23.8	41.3

ii) Changes in raw material price

The 7% escalation rate for raw material price is varied to 6% and 8%.

Table VIII-19 FIRR vs Raw-material Escalation Rate

(Unit: %)

	Escalation Case	6%	8%
FIRR on I	16.3	17.2	14.6
FIRR on E	32.9	35.4	19.2

iii) The construction cost is varied by +10% and -10%.

Table VIII-20 FIRR vs Investment Cost

(Unit: %)

	Escalation Case	+10%	-10%
FIRR on I	16.3	15.1	17.6
FIRR on E	32.9	29.3	37.6

(2) Case for which constant price basis is used and no incentives are considered

The results of a financial analysis conducted for the case in which the constant price basis is used and no incentives are considered, are shown in Table VIII-21.

Table VIII-21 FIRR of without Incentives

(Unit: %)

	Base Case	Without Incentives
FIRR on I	9.2	7.1
FIRR on E	16.8	10.7

As indicated in the above Table, when no incentives are considered, the profitability of the project lowers considerably. Therefore, in order to make this project profitable, exercise of incentives such as exemption of imported machinery from taxes, carryover of operating loss, shortening of depreciation period, etc., is essential.

(3) Case for which escalation is considered but no incentives are considered

The results of a financial analysis conducted for the case in which escalation is considered but no incentives are considered are shown in Table VIII-22.

Table VIII-22 FIRR of without Incentives

(Unit: %)

	Escalation Case	Without Incentives
FIRR on I	16.3	14.0
FIRR on E	32.9	26.2

Even when escalation is considered for the case, but the incentives are not considered, the profitability of the case lowers.