No.

TECHNICAL INFORMATION
FOR
8KL/DAY
ETHANOL PRODUCTION FROM CASSAVA
AT THE BERDC
IN INDONESIA

JAPAN INTERNATIONAL COOPERATION AGENCY

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Content

Abbreviation

BERDC	Biomas Energy Research and Development Center
BTM	Bottom
Conc.	Concentration or Concentrated
CW1	Ist water
CW2	2nd water
Distri.	Distribution
DW	Distilled water
Equip.	Equipment
EtOH	Ethyl Alcohol
Fig.	Figure
hr, hrs	hour, hours
L, l	Liter
LS	Low pressure steam
Max.	Maximum
min.	minute or minutes
N	Normal
OVHD	Over head
PA	Plant air
Pres.	Pressure
Quan.	Quantity
rpm	rotation per minute
Sol.	Solution
STD	Standard
t	ton
Tab.	Table
Temp.	Temperature
TK	Tank
T. T.	Test Tube
vs	versus

1. Material Balance

1-1 Raw Materials and Product

1-1 Raw Materials and Product

1-1-1 Standard Consumption of Raw Materials for Ethyl Alcohol Fermentation

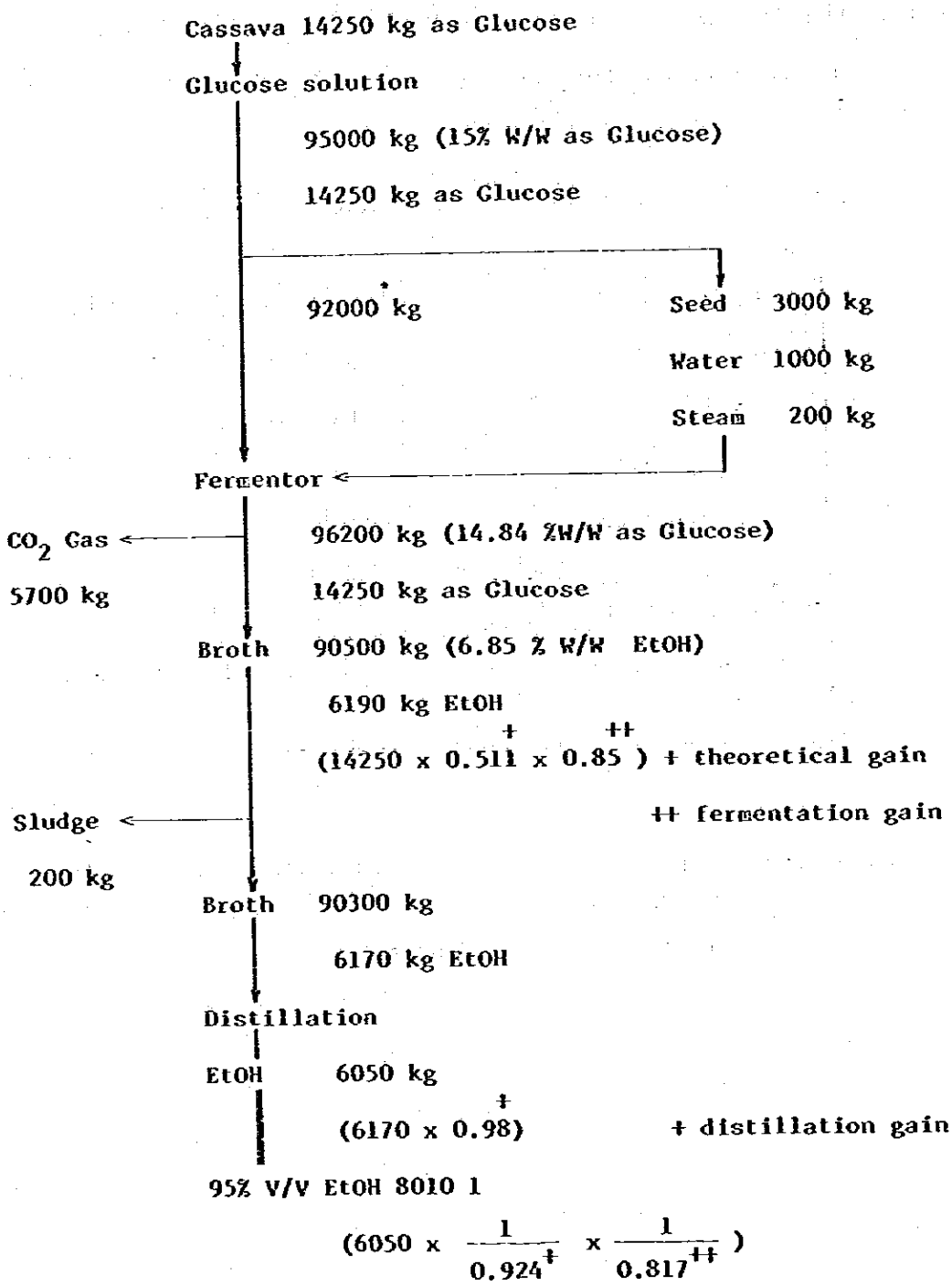
Ordinarily, one fermentor (120 kl) is made to start its run every day.

Tab. 1-1-1 Raw Materials Consumption in a day (in a batch)

Raw Material	Consumption Rate kg/day
Cassava	* 50000 kg/day (14250 kg as Glucose)
α-Amylase	15.5 kg/day
Gluco Amylase	9.3 kg/day
Urea $(NH_2)_2CO$	74 kg/day
Ammonium Phosphate Mono Basic $(NH_4)H_2PO_4$	15 kg/day
Sulfuric Acid H_2SO_4	Reagent of pH adjustment for Saccharifying

* Cassava is weighed after peeled and washed. And the figure of 14250 kg as Glucose is calculated from the supposition that cassava contains 28.5 %W/W starch as glucose.

1-1-2 Standard Material Balance of 95 %V/V Ethyl Alcohol Production



+, ++ 95 %V/V EtOH has 92.4 %W/W and 0.817 Specific gravity at 15°C.

1-2 Water

1-2 Water

1-2-1 List of Main Equipment using 1st Water

Specifications of the supply of 1st water are below

Quan.: 80 tons / hr. 1920 tons / day

Temp.: 28 °C (Max.)

Tab. 1-2-1

Equipment	Name of Equipment	Max. Consumption Rate tons/hr.	Total Consumption tons/day
Crusher	K-107,108(A,B)	2	30 (2x15)
Medium Cooler-2	E-102	60	540 (60x9)
Seed TK	D-201 (A,B)	20 (10x2)	360 (20x18)
Fermentor	D-202(A,B,C,D)	40 (10x4)	840 (40x21)
Screen Filter	K-202	5	15 (5x3)
Boiler	K-401	3	39

1-2-2 List of Main Equipment using 2nd Water

Specifications of the supply of 2nd water are below

Quan.: 120 tons/hr. Recovery of 1st water is 89.6%.

Temp.: 32°C (Max.)

Tab. 1-2-2

Equipment	Name of Equipment	Max. Consumption Rate tons/hr.	Total Consumption tons/day
Washer	K-104	2	30 (2x15)
Saccharifying TK	D-103	65	585 (65x9)
Medium Cooler-1	E-101	65	390 (65x6)
OVHD Condenser-1	E-302	16	384 (16x24)
VENT Condenser-2	E-303	1	24 (1x24)
Product Cooler	E-304	2	48 (2x24)
Fusel Cooler	E-305	1	24 (1x24)
Generator	-	20	480 (20x24)

1-3 Steam

1-3 Steam

Specifications of the supply of steam are below

Quan.: Max. 3 tons/hr.

Total 39 tons/day

Pres.: 4 kg/cm^2

Temp.: 150°C

List of Main Equipment using steam

Tab. 1-3-1

Equipment	Name of Equipment	Max. Consumption Rate tons/hr.	Total Consumption tons/day
Cooking TK	D-102	2	18 (2x9)
Seed TK	D-201 (A,B)	0.2	0.2 (0.2x1)
Mash Column	C-301	0.825	19.8 (0.825x24)

In some cases, the fermentors, the saccharifying tank and the related lines are washed and sterilized with steam. And the air filters are usually sterilized with steam once a week, concomitantly with seed tank medium sterilization.

1-4 Electricity

1-4 Electricity

Specifications of the supply of electricity are below

Load : Connection Load 312 KW
Operation Load Max. 275 KW
Min. 165 KW

Distri.: 380 V, 3φ, 4 W

List of Main Equipment using electricity

Tab. 1-4-1

	Equipment	Name of Equipment	Power Consumption KW
Pretreatment Process	Cassava Milk Pit	D-101	3.7
	Cooking TK	D-102	15.0
	Saccharifying TK	D-103	11.0
	Belt-Conveyer-1	k-101	2.2
	Belt-Conveyer-2	k-102	3.7
	Peeler	k-103	5.5
	Washer	k-104	5.5
	Belt-Conveyer-3	k-105	5.5
	Conveyer Scale	k-106	2.2
	Crusher-1	k-107	22.0
	Crusher-2 A	k-108 A	15.0
	Crusher-2 B	k-108 B	15.0
	Pump	p-101	5.5
	Pump	p-102	5.5
Fermentation Process	Seed TK-A	D-201 A	5.5
	Seed TK-B	D-201 B	5.5
	Fermentor A	D-202 A	5.5
	Fermentor B	D-202 B	5.5
	Fermentor C	D-202 C	5.5
	Fermentor D	D-202 D	5.5
	Screen Filter	k-202	5.9
	Belt-Conveyer-4	k-203	1.5
	Pump	p-201	2.2
	Pump	p-202	5.5
	Pump	p-203	5.5
	Pump	p-204	2.2

	Equipment	Name of Equipment	Power Consumption KW
Distillation Process	Pump	P-301	2.2
	Pump	p-302	1.5
	Pump	p-303	1.5
	Pump	p-304	2.2
	Pump	p-305	2.2
Utility Supply	Air Compressor	k-402	30.0
	Dehumidifier	k-403	1.2
	Cooling Tower	k-404	3.7
	Pump	p-401 A	22.0
	Pump	p-401 B	22.0
	Pump	p-402 A	22.0
	Pump	p-402 B	22.0
	Pump	p-403	2.2
	Pump	p-404 A	0.3
	Pump	p-404 B	0.3

1-5 Plant Air

1-5 Plant Air

Specifications of the supply of Plant air are below

Quan.: 4000 Nl/min.

Pres.: 4 kg/cm^2

Temp.: 35 °C

List of Main Equipment using Plant Air

Tab. 1-5-1

Equipment	Name of Equipment	Consumption Rate Nl/min.
Seed TK	D-201 A	400
Seed TK	D-201 B	400
Fermentor	D-202 A	1000
Fermentor	D-202 B	1000
Fermentor	D-202 C	1000
Fermentor	D-202 D	1000
Control system of plant	-	-

2. Working Schedule of Main Equipment

2-1 List of Main Equipment

2-1 List of Main Equipment

2-1-1 Pretreatment Process

Tab. 2-1-1

Equipment	Name of Equipment	Number of installed	Capacity
Cassava Pit	D-101	1	20 m^3
Cooking Tank	D-102	1	35 m^3
Saccharifying Tank	D-103	1	35 m^3
Medium Cooler-1	E-101	1	120 m^3
Medium Cooler-2	E-102	1	90 m^3
Belt-Conveyer-1	K-101	1	10 t/hr
Belt-Conveyer-2	K-102	1	10 t/hr
Peeler	K-103	1	10 t/hr
Washer	K-104	1	10 t/hr
Belt-Conveyer-3	K-105	1	10 t/hr
Automatic Conveyer Scale	K-106	1	10 t/hr
Crusher-1	K-107	1	10 t/hr
Crusher-2	K-108 A	1	5 t/hr
Crusher-2	K-108 B	1	5 t/hr
Forklift Truck	K-109	1	1.5 t
Balance	K-110	1	Spring type 200kg
Cassava Pump	P-101	1	15 m^3/hr
Medium Pump	P-102	1	15 m^3/hr

2-1-2 Fermentation Process

Tab. 2-1-2

Equipment	Name of Equipment	Number of installed	Capacity
Seed Tank	D-201 A	1	6.5 m^3
Seed Tank	D-201 B	1	6.5 m^3
Main Fermentor	D-202 A	1	120 m^3
Main Fermentor	D-202 B	1	120 m^3
Main Fermentor	D-202 C	1	120 m^3
Main Fermentor	D-202 D	1	120 m^3
Broth Pit	D-203	1	13 m^3
Broth Tank	D-204	1	120 m^3
Air Filter	K-201 A	1	0.4 m^3
Air Filter	K-201 B	1	0.4 m^3
Screen Filter	K-202	1	30 m^3/hr
Belt-Conveyer-4	k-203	1	500 kg/hr
Seed Pump	P-201	1	10 m^3/hr
Main Fermentor Pump	P-202	1	30 m^3/hr
Broth Pump	P-203	1	30 m^3/hr
Feed Pump	P-204	1	5 m^3/hr

2-1-3 Distillation Process

Tab. 2-1-3

Equipment	Name of Equipment	Number of installed	Capacity
Mash Column	C-301	1	
Concentration Column	C-302	1	
Fusel Decanter	D-301	1	0.05 m^3
Fusel Oil Tank	D-302	1	1 m^3
Waste Water Tank	D-303	1	120 m^3
Foam Breaker	D-304	1	0.13 m^3
Alcohol Checking Tank	D-305	1	4 m^3
Denaturant Tank	D-306	1	0.15 m^3
Fusel Cooler	E-305	1	0.5 m^3
Conc. Column OVHD Condenser	E-302	1	25 m^3
Conc. Column Vent Condenser	E-303	1	0.5 m^3
Product Cooler	E-304	1	4 m^3
Fusel Cooler	E-305	1	0.5 m^3
Mash Column BTM Pump	P-301	1	5 m^3/hr
Conc. Column BTM Pump	P-302	1	2 m^3/hr
Transfer Pump	P-303	1	5 m^3/hr
Product Pump	P-304	1	10 m^3/hr
Waste Water Pump	P-305	1	5 m^3/hr
Alcohol Storage Tank	T-301	1	100 m^3

2-1-4 Utility Supply

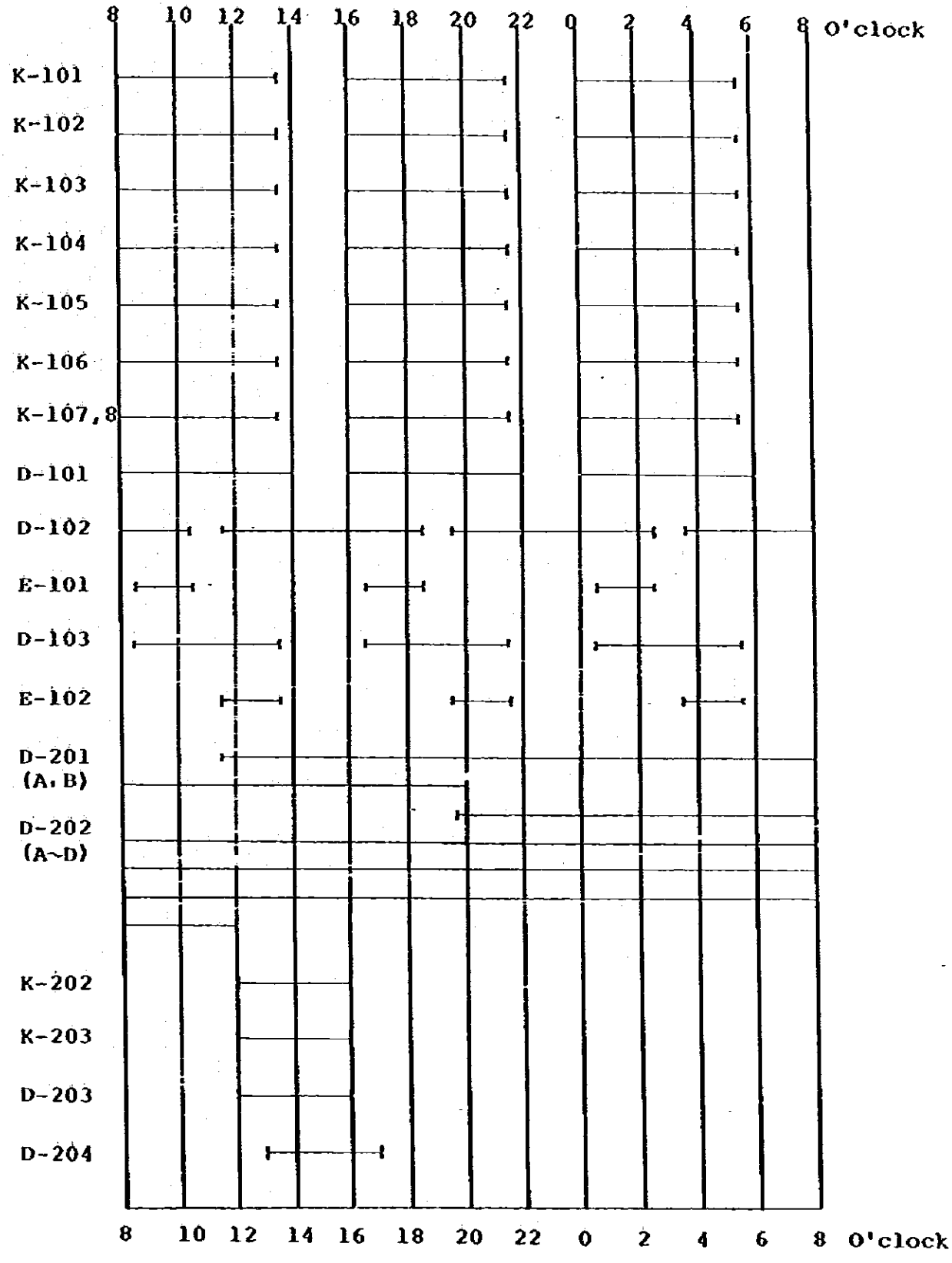
Tab. 2-1-4

Equipment	Name of Equipment	Number of installed	Capacity
Sedimentation Pit	D-401	1	
1st Water Pit	D-402	1	
2nd Water Pit	D-403	1	
Boiler	K-401	1	3.0 t/hr
Air Compressor	K-402	1	250 Nm^3/hr
Dehumidifier	K-403	1	50 Nm^3/hr
Cooling Tower	K-404	1	100 m^3/hr
Fire Extinguisher	K-405	32	ABC-10 Type.25 ABC-50 Type.7
1st Water Pump	P-401 A	1	120 m^3/hr
1st Water Pump	P-401 B	1	120 m^3/hr
2nd Water Pump	P-402 A	1	100 m^3/hr
2nd Water Pump	P-402 B	1	100 m^3/hr
Fuel Oil Pump	P-403	1	4 m^3/hr
Fuel Oil Service Pump	P-404 A	1	0.25 m^3/hr
Fuel Oil Service Pump	P-404 B	1	0.25 m^3/hr

2-2 Working Schedule of Main Equipment

2-2 Working Schedule of Main Equipment in 24 hrs.

Fig 2-2-1



3. Guide to Microbe Handling

3-1 General Concepts in Strain Preservation

3-1 General Concepts in Strain Preservation

3-1-1 Preservation of Strains

When a strain is preserved in any way we have to take care of the following two items.

Contamination with other organisms must be prevented. The strain is kept of its productivity and properties as similar as those of before.

For the purpose of the above mentioned, whichever we preserve the strain with slant culture or other methods, we ordinarily take the clean and cold (0~5°C) place for stocking the strain.

3-1-2 Sterilization and Exclusion of Contaminants

For a pure culture of a strain, contamination with other organisms must not be allowed. Sterilization of medium is indispensable. Microbes in the air and other spaces out of a culture vessel must be kept from contamination.

1) Cotton Plug

A cotton plug is still the best utensil for culturing microbes in glass vessel as test tubes and flasks, to prevent contamination and to provide the proper gas exchange between outside and inside of the culture vessel. Following, the method of making a cotton plug is mentioned.

① Cut a cotton wool sheet having from one to two cm thickness to the proper size of square.

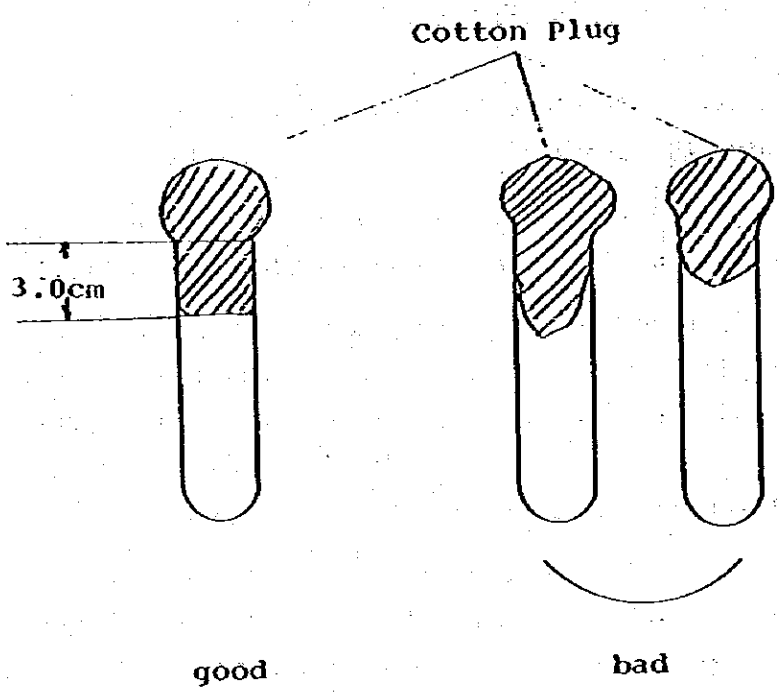
② At the center of the square cotton wool sheet, place a packed cotton wool ball as a core.

③ The two corners facing each other of the square are joined, then the shape becomes right-angled triangle.

④ The other two corners now shaped into half right-angle are folded in, then the four corners will become like gathered at one point and will look as a cone.

⑤ The top of the cone shaped cotton wool is bended and the cone is inserted into the mouth of a vessel.

⑥ Good and bad examples are illustrated below.



2) Methods of Sterilization

① Dry Oven

Mainly a dry oven is used for sterilizing glass and metal utensils, in some cases for cotton wool, woody needle, paper and so on.

Usually, the condition of sterilization is at 160°C for two hours.

② Flame

Flame is prepared with a gas burner or an alcohol lamp. The top of a inoculating needle, a forceps, a pipet and so on are burnt and sterilized. Also, the mouth of a vessel is burnt. Especially, an inoculating needle is burnt on the most of its body except the grasp. Burning the cotton plug of a vessel, it is enough to burn the surface of the cotton plug, whichever head or bottom is sterilized.

③ Autoclave

Mediums and aqueous solutions are ordinarily sterilized by a autoclave.

Close the lid of an autoclave and fasten its handle tightly not to leak. Set the thermostat of the autoclave to control at 120°C (Pressure 1 kg/cm^{2}G). Set the timer of the autoclave to maintain the temperature set (120°C), for necessary time, so the heater is put on. When the temperature of the autoclave reaches the set point, the thermostat begins control and the timer starts.

The time set is over, then the heater is put off. Checking the pressure inside is 0 kg/cm^{2}G, open the lid and take out the articles sterilized.

④ Ultra Violet Light

The inside of a clean bench is sterilized with ultra violet lamp.

Don't expose eyes directly to the lamp.

⑤ 70% (V/V) Ethyl Alcohol

Fingers, hands and arms are sterilized by soaking and washing with 70% EtOH.

Also, the surface of glass wares and hard wares can be treated as same way.

3-1-3 Inoculation and Reagents

1) Utensils and Reagents

Usually these are used everywhere

Clean bench, burner, inoculating needle, pipet, forceps, spatula, alcohol lamp.

70% EtOH

2) Clean Bench

A clean bench is used for inoculation and other handling of microbes under aseptic condition.

Ordinary operation procedure is given below.

① Put on the air curtain switch of a clean bench.

② Put on the light.

③ Put off the ultra violet lamp.

④ Pull up the slide window slightly.

⑤ Place utensiles and materials in the clean bench.
Usually, they must be sterilized according to the methods mentioned before.

⑥ Perform inoculation after washing fingers hands and arms with soap and 70 % EtOH.

⑦ After the inoculation, wipe the floor of the clean bench with 70 % EtOH so as to keep it clean and aseptic.

⑧ Pull down the window thoroughly.

⑨ Put on the ultra violet lamp, then don't put off until the next practice.

⑩. Put off the light.

⑪. Put off the air curtain switch.

3) Procedure of Inoculation

All operations must be conducted to avoid contamination as possible as we can.

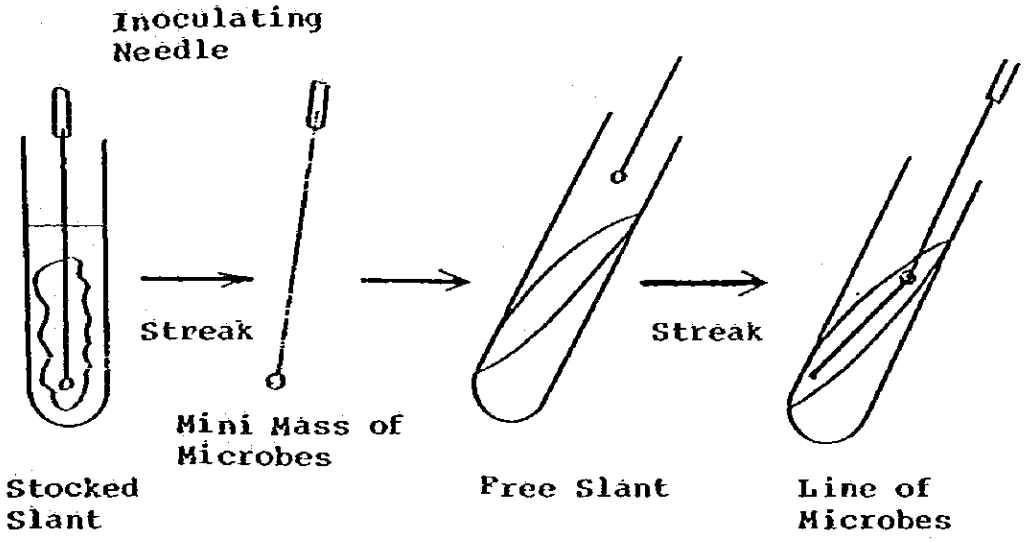
In inoculating, the top of an inoculating needle, a pipet and a cotton plug with others.

They are held with a hand or placed on an apparatus for preventing the touches.

The mouth of a vessel, also, cannot be touched with fingers and others.

Various mediums and methods of inoculation for strain preservation have been developed corresponding to progress of technology and findings of new strains. Inspire of the above mentioned, it should be remembered that slant to slant inoculation is a most fundamental and important technique and slant culture is a basic method for growing of microbes.

In the case of the yeast, usually the inoculation of a slant is conducted as below.



3-1-4 Culture of Slants

Usually, slant cultures are incubated at 37°C.

But yeast cultures are ordinarily incubated at 30°C or below.

In some cases cultures may form spores and the spores are used for keeping the strains.

3-1-5 Stock of Cultures

Many methods have been developed for keeping strains. For long term stock of cultures, lyophilization and freezing (below-50°C) are useful, but they demand special apparatus, materials and techniques.

To this day the slant culture stock method is still useful everywhere in the world as its simplicity and reliability although it has some weak points.

3-2 Preservation of Strains with Slant Cultures

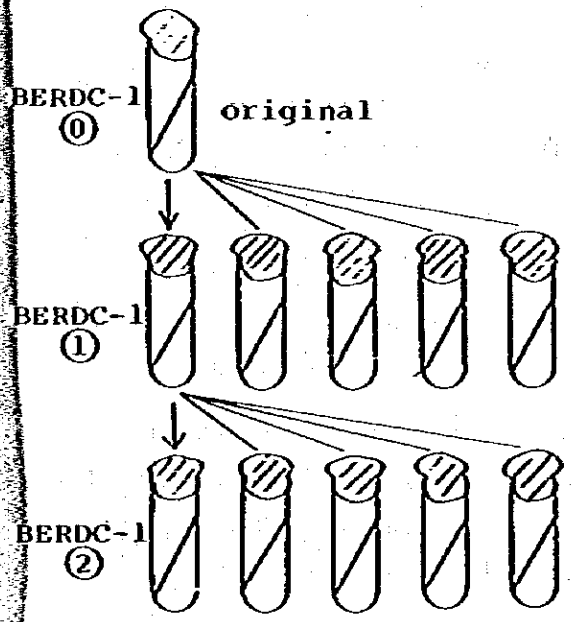
3-2 Preservation of Strains with Slant Cultures

We preserve the yeast strains which can produce ethyl alcohol sufficiently, with slant cultures. The slant cultures are kept in a refrigerator at 5°C.

3-2-1 Strains applied

Strains preserved and tested are managed by making the strain cards as below.

Fig 3-2-1



Example: Record of Strain Transfer

Date of Transfer	Strain	Times of Transfer	Batch and Test Used
1983 1/1	BERDC-1	BERDC-1 ⓪	original
2/1	BERDC-1	BERDC-1 ①	B-1,2,3 T-1
3/1	BERDC-1	BERDC-1 ②	B-4,5,6 T-2

3-2-2 Medium

Yeast extract and Malt extract agar (YM agar) medium are used as preserving medium for yeasts.

1) Composition

The medium has many variations. Then, we choose the composition below as slant medium.

Yeast Extract	3 g/l
Malt Extract	3 g/l
Peptone	5 g/l
Glucose	10 g/l
Agar	20 g/l
pH 5.5	1 L

2) Preparation

Pre-mixed medium constituents or the components above mentioned are dissolved with distilled water of the half final volume.

If necessary, the pH of the medium can be adjusted to the indicated value with diluted alkali or acid solution. Then the volume of the medium is filled up to the final volume with DW. And the agar in the medium must be melted thoroughly in a water bath.

10 ml portions of the medium are dispended to test tubes. And cotton plugs are inserted to the mouthes of the test tubes.

Before used, the test tubes with their cotton plugs must be heated over 100°C with a dry oven. Then the plugs can maintain the shape formed.

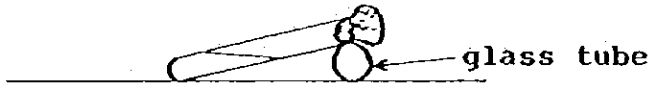
3) Sterilization

Cover the tops of the test tubes with alminum foils or others in order to avoid the cotton plugs being drenched with drain.

Sterile them for the indicated time at 120°C with an autoclave. As the temperature descends to 100°C and the pressure inside becomes 0 kg/cm^2G, the test tubes can be taken out.

4) Making Slant Form

Before hardening of the medium sterilized, the test tubes are laid on a horizontal place with their heads on a glass tube (diameter 10 mm) in order to make slope.



After hardening, the test tubes are set in a test tube rack and checked at room temperature for a few days whether the sterilization is complete or not.

Then, they are stocked in a clean place.

3-2-3 Preservation

1) Interval between transfer inoculations.

Usually, stocked slant cultures are transferred to free slants once a month.

2) Inoculation

Conduct as mentioned in the clause 3-1-3.

The head of a slant is wraped with a paraffin paper.

3) Culture of Slants

The inoculated slants are placed in an incubator at the indicated temperature for necessary time.

4) Stock of Slant Cultures

After properly grown, the slant cultures can be stocked as strain preserving slant cultures in a refrigerator at 5°C, if any unusual symptoms can not be find out in the culture.

4. Directions for Safety

4-1 Basic Directions

4-1 Basic Directions

1) Tools for work and safety must be arranged in the ordered ways.

2) Don't work in condition of poor carefulness and/or a little consideration.

3) In working, concentrate your attention only to your objects, but not to others.

4) You must put on simply designed wears in the ordered ways for fast action and safety.

5) Don't use flames and other fire sources in other place than the specified places.

6) Clean your working places and their circumferences, and arrange tools and materials in order.

7) Maintain spaces for passage in working places without leaving obstacls unnecessary.

8) Comunicate carefully each other, when you are going to cooperate works.

9) You must put on something to protect and must use tools for safety when you do dangerous operations.

10) Safety devices set on equipment should not be removed without reasons. Removing them for repairing, the facts must be told clearly to the members related and must be indicated on the equipment.

11) Never mend equipment when they are running.

12) In repairs of equipment and lines including disassemblies, before you take actions, whether any leaking contents are there or not must be checked. If some are there, they must be washed away or removed.

13) Don't place articles catching fire and/or explosive near electric machines.

14) Avoid leaks of electricity, taking much care about insulation and not to drench electric wires.

15) Before transmitting utilities (electricity, steam, water and plant air), tell the supplies of them to the members related and check the lines and the equipment are ready or not.

16) Drains in steam suppling lines are removed out before steam is transferred.

4-2 Working in Vessels

4-2 Working in Vessels

1) When you do inspecting and repairing works in a vessel, essentially you must put off the main switch of the vessel in the power distribution room and must hang the board, which tells somebodies are working in the vessel, on the switch.

2) Also, to prevent for steam and other dangerous materials accidentaly to stream into the vessel, the nearest and the next valves to the vessel, of each line must be closed and the board above mentioned must be hung on each valve.

3) Works in a vessel must be done by a team of members more than two. One of them always must be out of the vessel and must take care of his team member's safety in the vessel.

4) When use fires in a vessel, the vessel is washed thoroughly and filled fully with water and the water is discharged out. So the exchange of the air can be complete.

5) In long time works in a vessel, supply fresh air, and keep the safety in the vessel.

6) Main points of inspection in vessels.

   ① Degree of cleanness.

   ② Somethings wrong with valves inside.

   ③ Stirring propellers.

   ④ State of the bolts which tighten stirring propellers buffles and others.

   ⑤ Bubbling hole of air sparger.

7) You must not close the manhole until you make sure that nobody is in the vessel.

4-3 Operation of High Pressure Vessels

4-3 Operation of High Pressure Vessels

1) You can open the lid of a hole, after you open an exhaust valve fully and make sure of no pressure inside.

2) When you are going to disassemble the parts in which some pressure inside may be left, release the pressure gradually and remove the contents.

3) High pressure vessels can endure inside pressure, but not outside. So, cooling them fast after heating should not be made. And the decrease of inside pressure caused by the descending of temperature inside has to be avoided by taking care about the operations of valves.

4-4 Operation of Rotary Machines

4-4 Operation of Rotary Machines

1) After you put off the power switch of a rotary machine and indicate it being under maintenance operations, you can do inspection, repair, injection of machine oils and so on. You should not touch the rotating parts, whether they go slow or rapid.

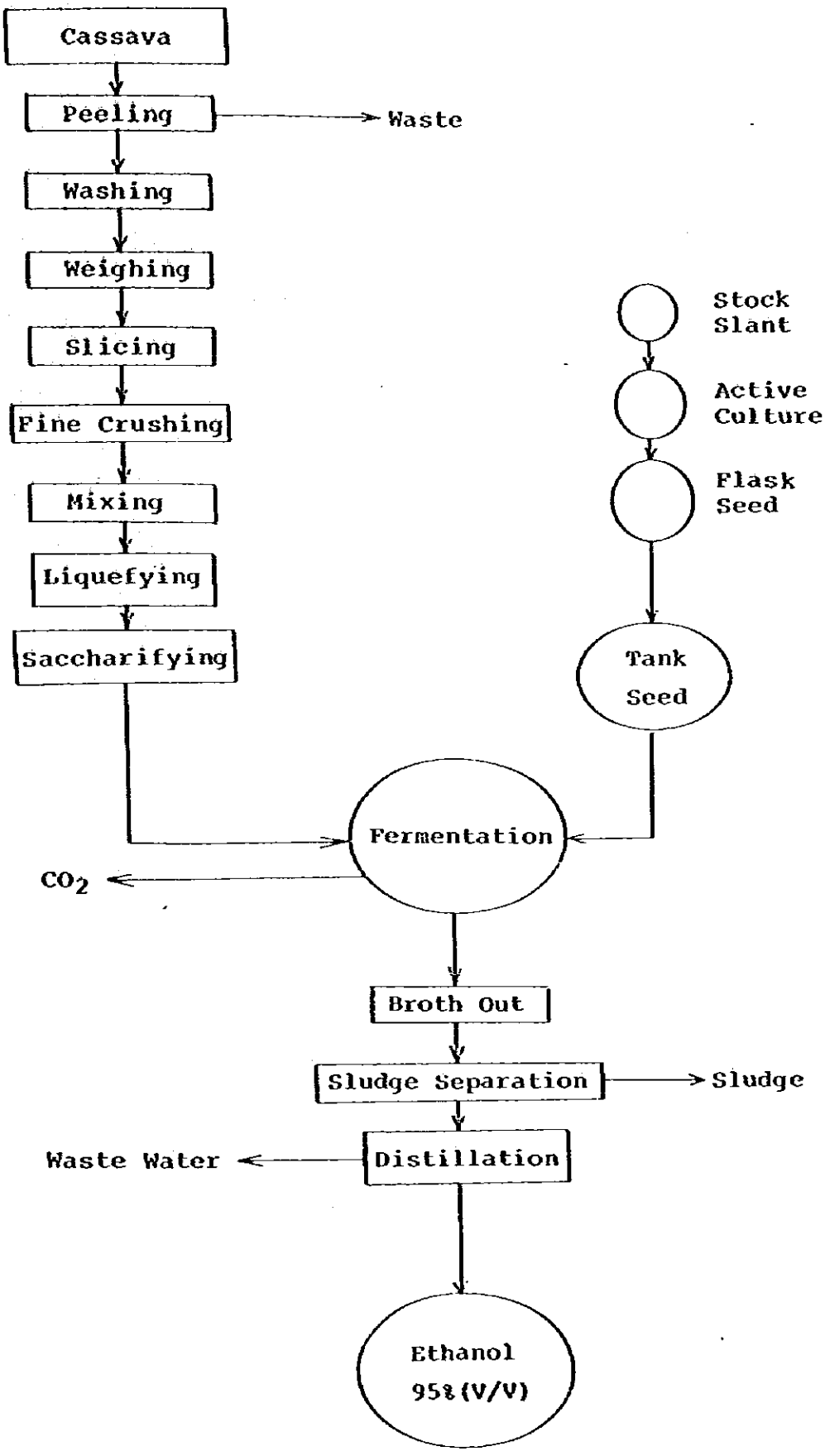
2) Starting a motor must be done after making sure of safety. Especially the motor which has been ceased to work for a long time or has been left in unfavorable conditions had better be measured of its insulation resistance for safety.

3) Pumps and stirrers should not be operated without load.

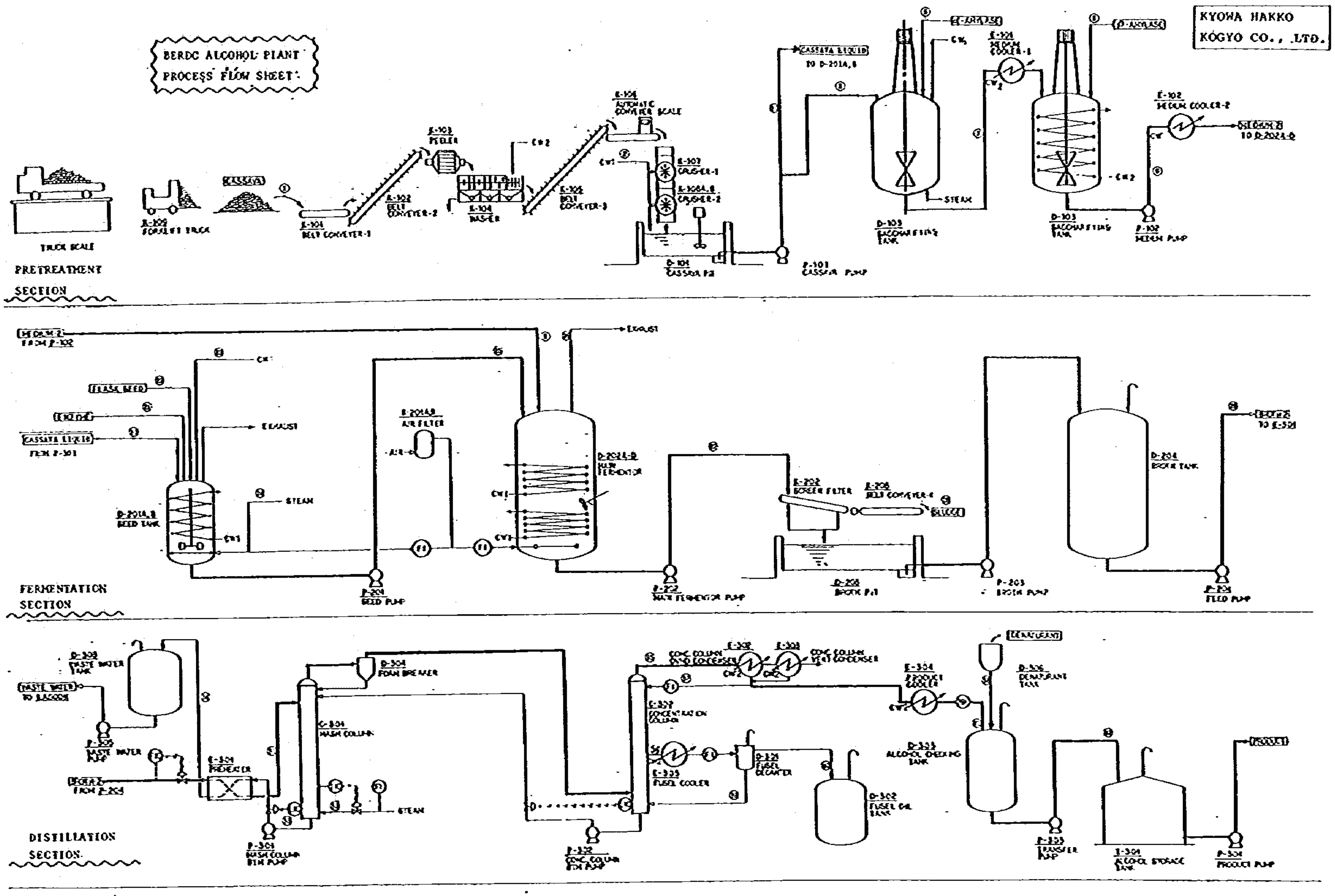
5. Outline of Ethyl Alcohol Production from Cassava

5-1 Process Block Diagram

5-1 Process Block Diagram



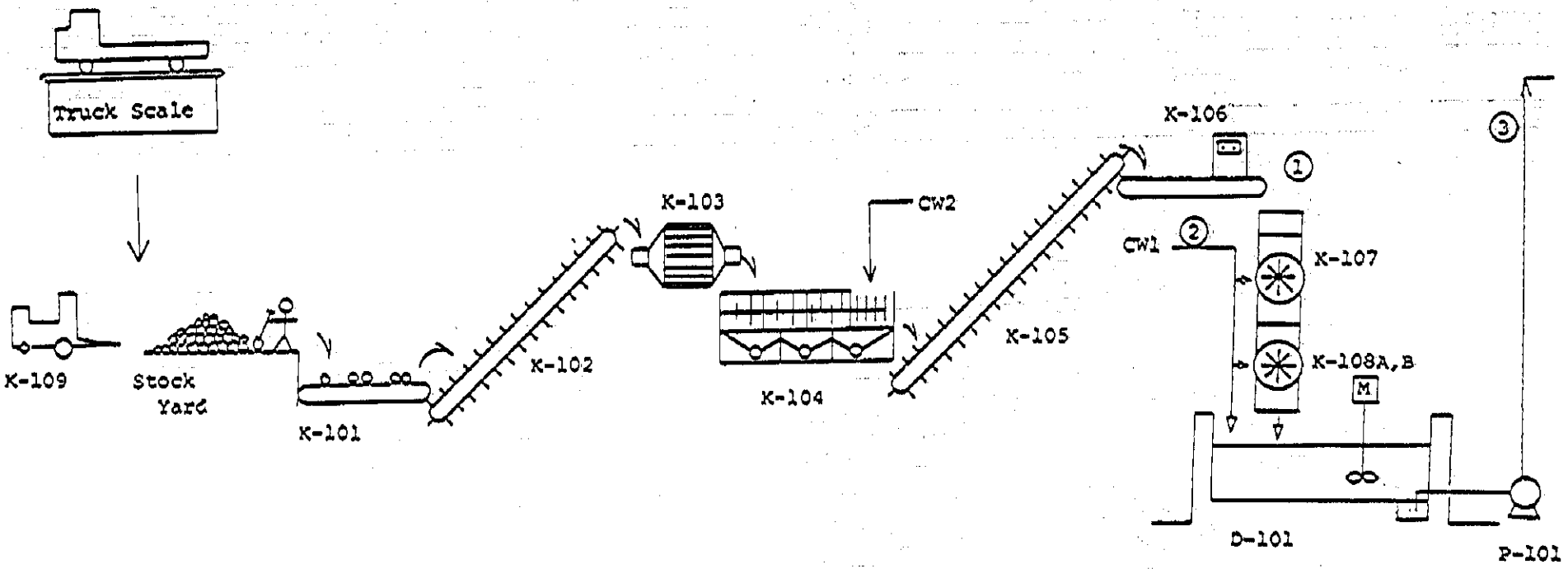
5-2 Process Flow Sheet



BERDC ALCOHOL PLANT
PROCESS FLOW SHEET
KYOWA HAKKO KOGYO CO., LTD.
PRETREATMENT SECTION
TRUCK SCALE
CASSAVA
FORKLIFT TRUCK
BELT CONVEYER-1
BELT CONVEYER-2
PEELER
WASHER
BELT CONVEYER-3
AUTOMATIC CONVEYER SCALE
CRUSHER-1
CRUSHER-2
CASSAVA PIT
CASSAVA PUMP
CASSAVA LIQUID TO D-201A,B
SACCHARIFYING TANK
STEAM
MEDIUM COOLER-1
MEDIUM COOLER-2
MEDIUM PUMP
FERMENTATION SECTION
EXHAUST
CASSAVA LIQUID FROM P-101
SEED TANK
STEAM
SEED PUMP
AIR FILTER
AIR
MAIN FERMENTOR
MAIN FERMENTOR PUMP
SCREEN FILTER
BELT CONVEYER-4
BROTH PIT
BROTH PUMP
BROTH TANK
FEED PUMP
DISTILLATION SECTION
WASTE WATER TANK
WASTE WATER PUMP
PREHEATER
FOAM BREAKER
MASH COLUMN
STEAM
MASH COLUMN BTM PUMP
CONC COLUMN CND CONDENSER
CONC COLUMN VENT CONDENSER
CONCENTRATION COLUMN
FUSEL COOLER
FUSEL DECANTER
FUSEL OIL TANK
CONC COLUMN BTM PUMP
PRODUCT COOLER
DENATURANT
DENATURANT TANK
ALCOHOL CHECKING TANK
TRANSFER PUMP
ALCOHOL STORAGE TANK
PRODUCT
PRODUCT PUMP

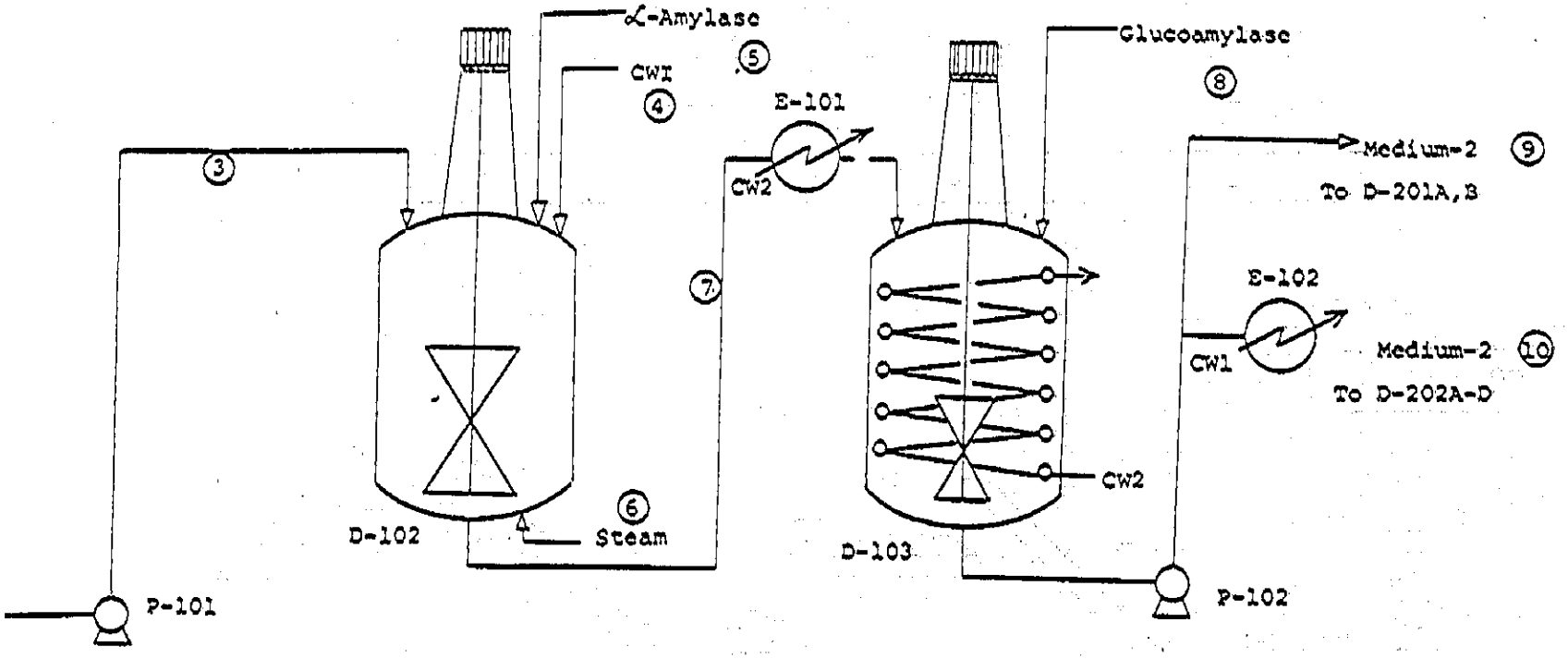
5-2 Process Flow Sheat

5-2-1 Crushing



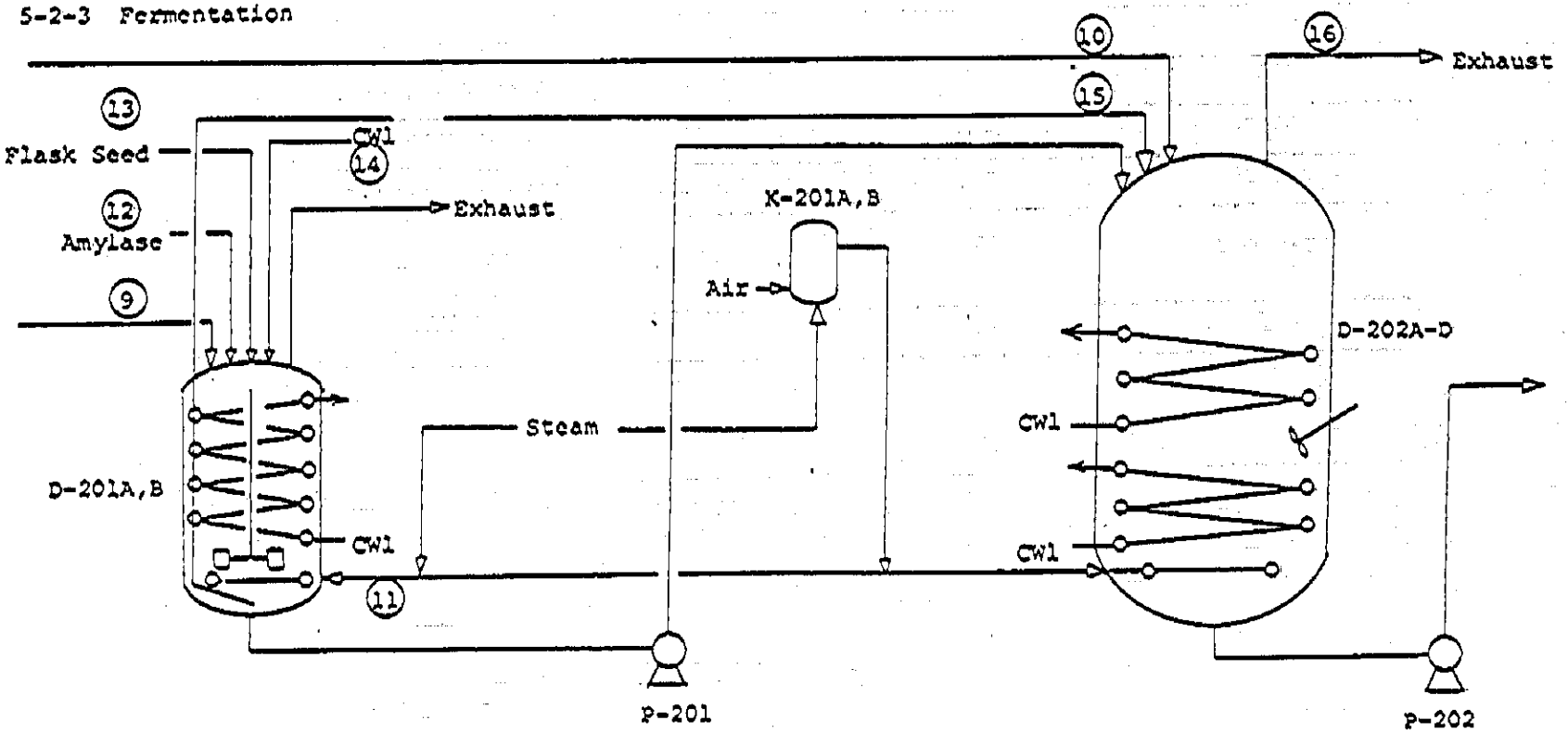
Stream Number	①	②	③
Stream Name	Cassava	Water	Cassava Milk
Flow Rate kg/Batch	16,700	8,300	25,000
Flow Rate kg/Day	50,000	25,000	75,000
Specific Gravity		0.995	1.09
Concentration W/W%	28.5	-	19.0

5-2-2 Liquefying and Saccharifying



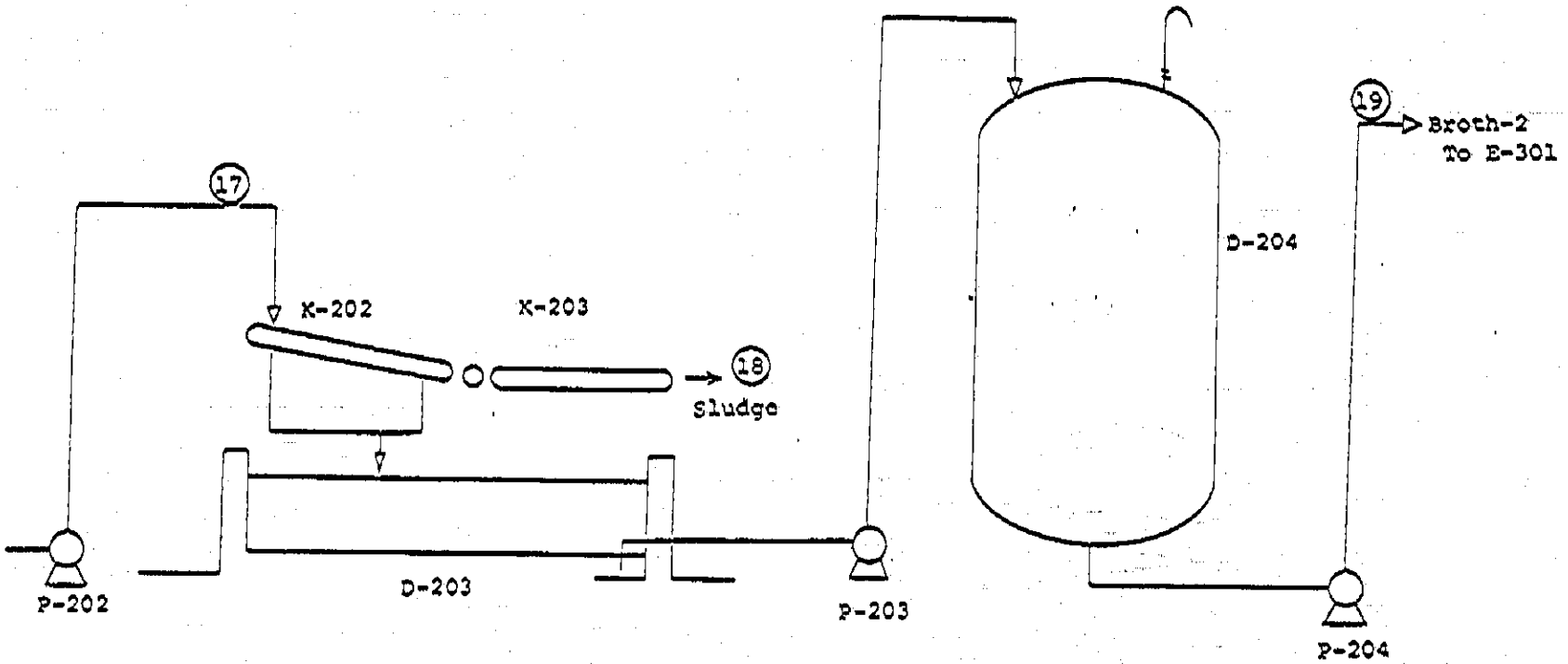
Stream Number	④	⑤	⑥	⑦	⑧	⑨	⑩
Stream Name	Water	α-Amylase	Steam	Medium-1	Glucoamylase	Medium-2	Medium-2
Flow Rate kg/Batch	1,400	5.0	5,300	31,700	3.0	3,000	28,700(1)31,700(2)(3)
Flow Rate kg/Day	4,000	15.0	16,000	95,000	9.0	3,000	92,000
Specific Gravity	0.995			106		1.06	1.06
Concentration W/W%				15.0		15.0	15.0

5-2-3 Fermentation



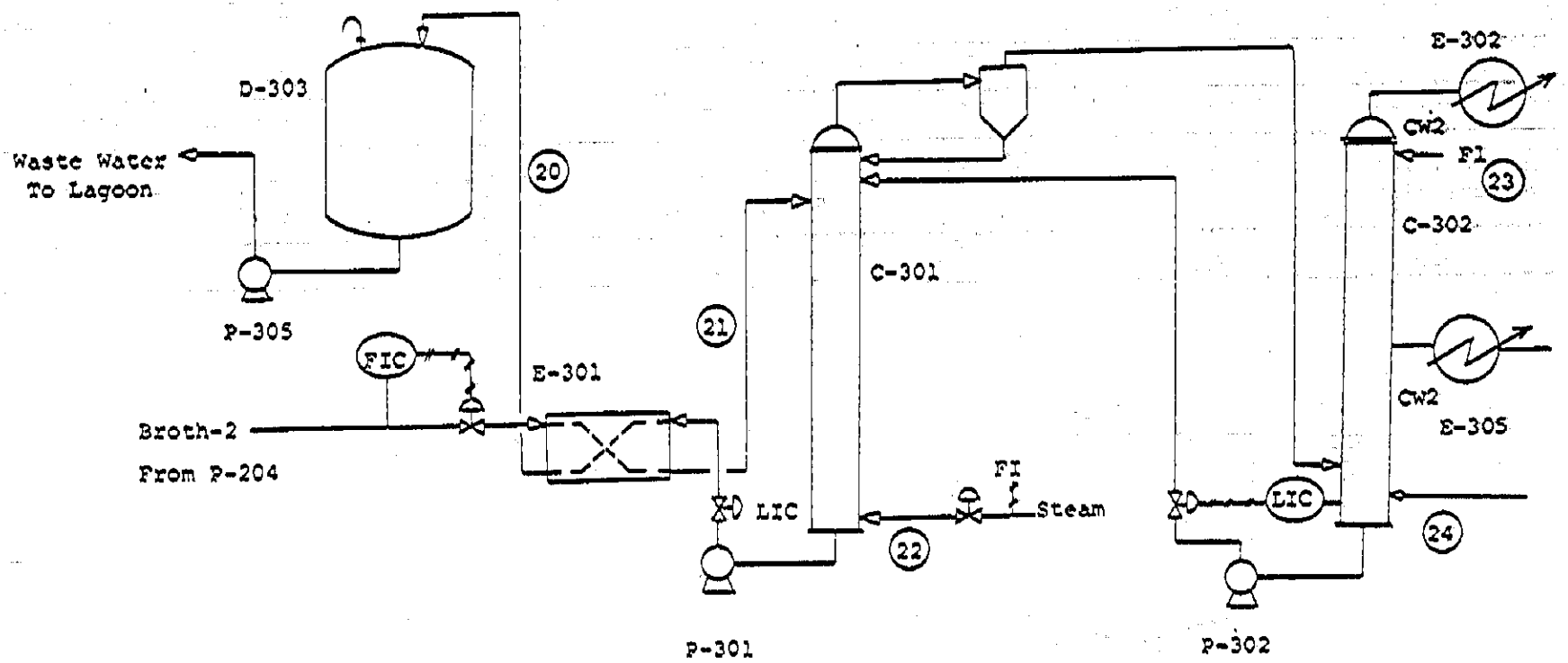
Stream Number	11	12		13	14	15	16
Stream Name	Steam	Amylase		Flask Seed	Water	Tank Seed	CO_2 Gas
		∝	Gluco				
Flow Rate kg/Batch	200	0.5	0.3	0.6	1,000	4,200	5,700
Flow Rate kg/Day	200	0.5	0.3	0.6	1,000	4,200	5,700
Specific Gravity					0.995	1.0	
Concentration W/W%						11.5	

5-2-4 Broth Out

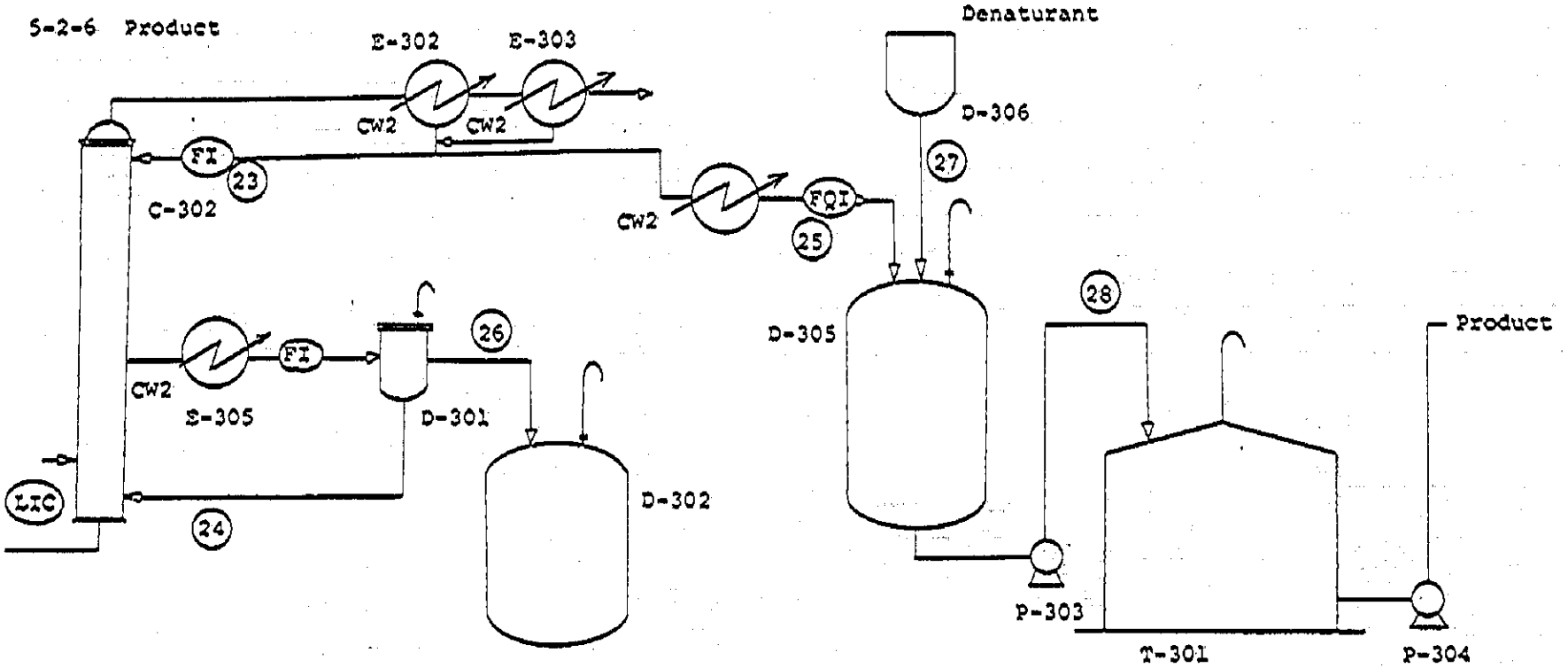


Stream Number	17	18	19
Stream Name	Broth-1	Sludge	Broth-2
Flow Rate kg/Batch	90,500	200	90,300
Flow Rate kg/Day	90,500	200	90,300
Specific Gravity	1.00		1.00
Concentration W/W%	6.85		6.85

5-2-5 Distillation



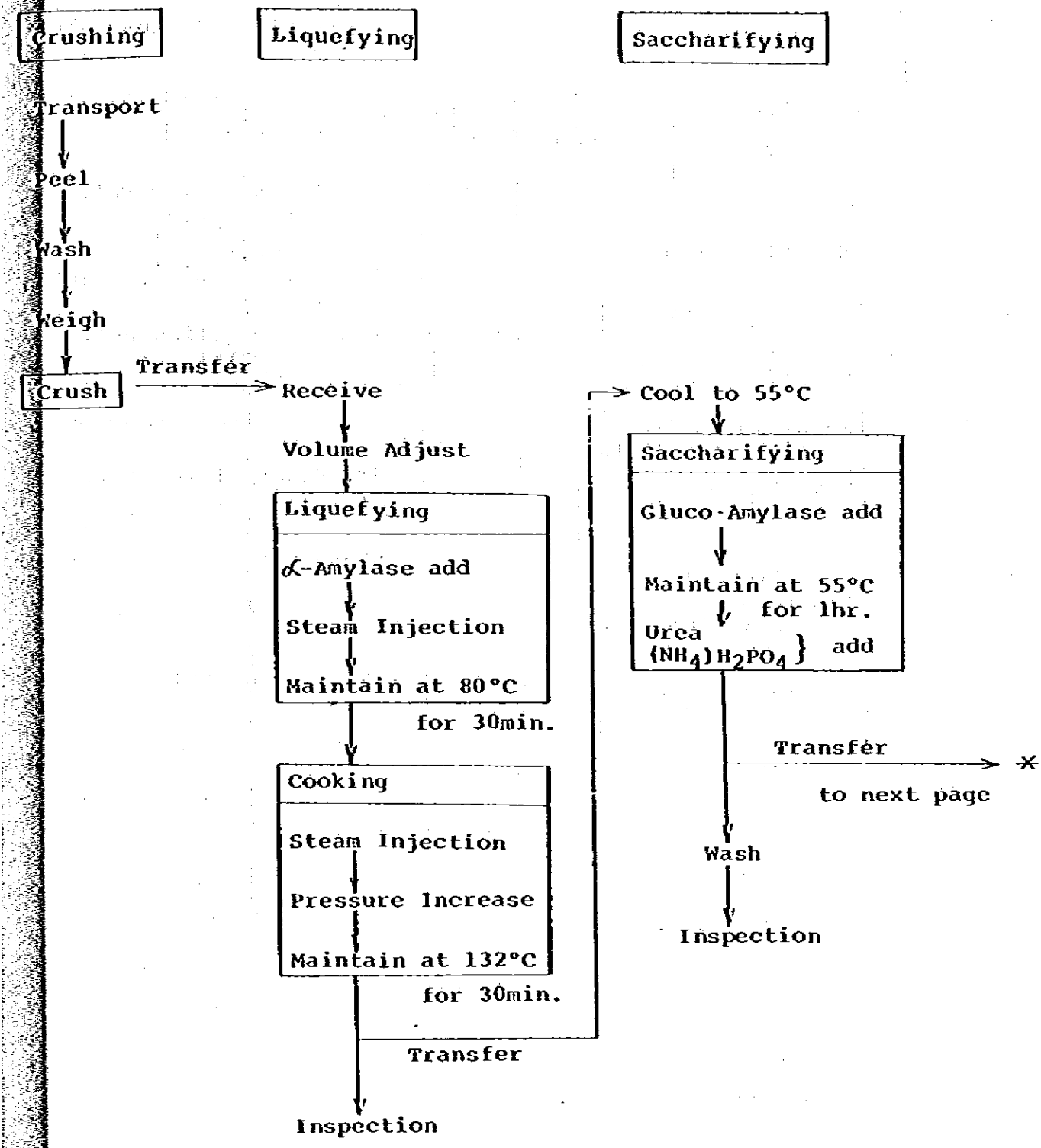
Stream Number	20	21	22	23	24
Stream Name	Waste Water	Broth-2	Steam	Ethyl Alcohol Reflux	Fusel Oil Lower Layer
Flow Rate kg/Day	103,050	90,300	19,700	24,200	1,700
Flow Rate kg/hr	4,300	3,760	820	1,010	71
Temperature °C	68	80	150	70	35
Concentration W/W%		6.85		92.44	

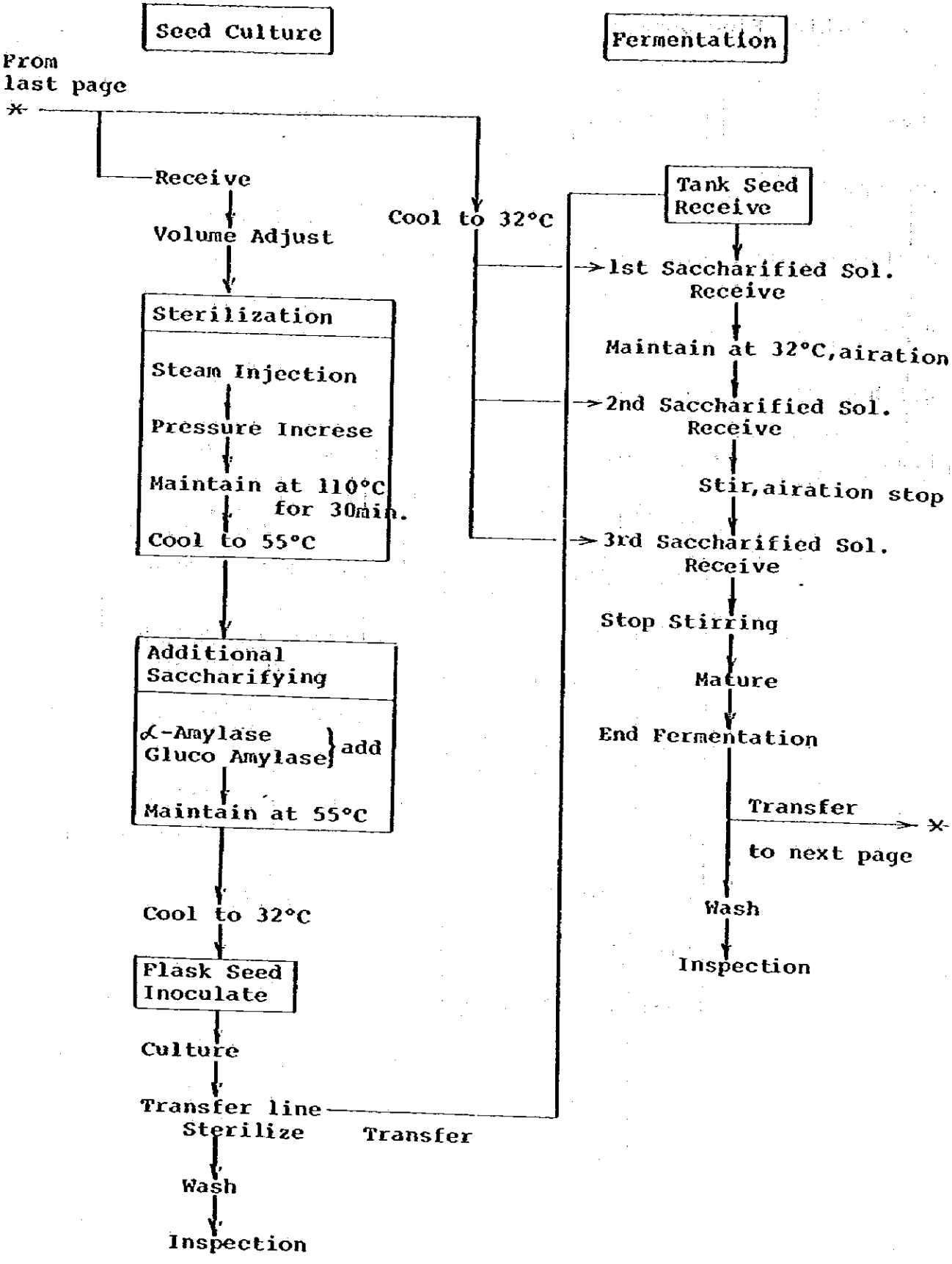


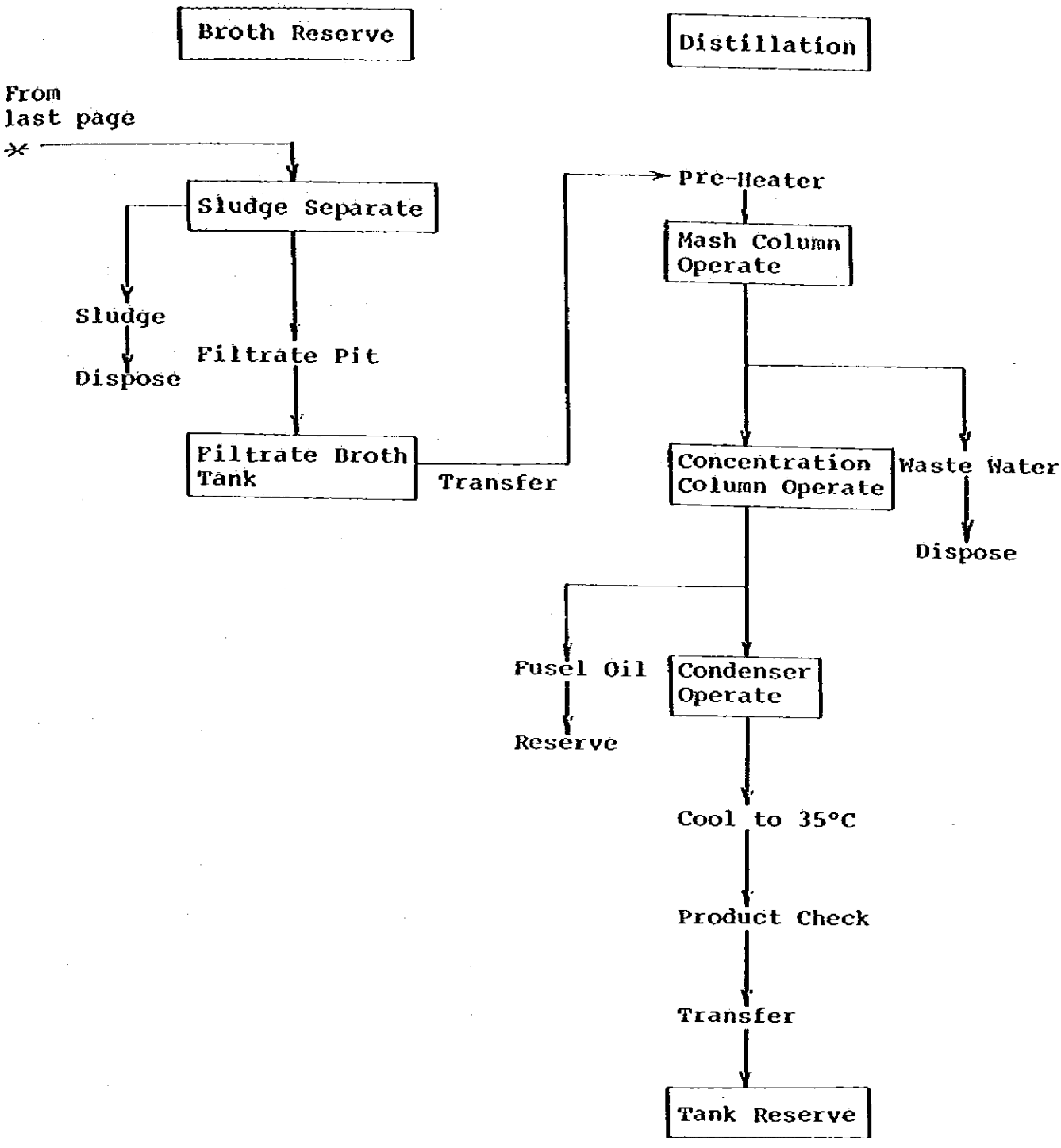
Stream Number	23	24	25	26	27	28
Stream Name	Ethyl Alcohol Reflux	Fusel Oil Lower Layer	Ethyl Alcohol Product	Fusel Oil	Denaturant	Ethyl Alcohol Denatured
Flow Rate kg/Day	24,200	1,700	6,050	400	180	6,230
Flow Rate kg/hr	1,010	71	252	17		
Temperature °C	70	35	35	35	30	35
Concentration w/w%	92.44		92.44			

5-3 Working Flow Sheet

5-3 Working Flow Sheet




Seed Culture
Fermentation
From last page
Receive
Volume Adjust
Cool to 32°C
Sterilization
Steam Injection
Pressure Increse
Maintain at 110°C for 30min.
Cool to 55°C
Additional Saccharifying
α-Amylase
Gluco Amylase
add
Maintain at 55°C
Cool to 32°C
Flask Seed Inoculate
Culture
Transfer line Sterilize
Transfer
Wash
Inspection
Tank Seed Receive
1st Saccharified Sol. Receive
Maintain at 32°C,airation
2nd Saccharified Sol. Receive
Stir,airation stop
3rd Saccharified Sol. Receive
Stop Stirring
Mature
End Fermentation
Transfer
to next page
Wash
Inspection


Broth Reserve
Distillation
From
last page
Sludge Separate
Sludge
Dispose
Filtrate Pit
Filtrate Broth
Tank
Transfer
Pre-Heater
Mash Column
Operate
Concentration
Column Operate
Waste Water
Dispose
Fusel Oil
Reserve
Condenser
Operate
Cool to 35°C
Product Check
Transfer
Tank Reserve

5-4 Standard Operation Conditions

5-4 Standard Operation Conditions

5-4-1 Standard Consumption of Raw Materials

These figures express the consumption of raw materials for one fermentor run.

We start one fermentor run every day.

Tab. 5-4-1

Raw Material	Consumption Rate (kg/day or batch)	
	Seed	Fermentor
Cassava (Starch Value: 28.5% as Glucose)	1600 (456 kg as Glucose)	48400 (13794 kg as Glucose)
α-Amylase+	0.5 0.1% vs Sugar	15.0 0.1% vs Sugar
Gluco Amylase++	0.3 0.06% vs Sugar	9.0 0.06% vs Sugar
Urea $CO(NH_2)_2$	5.0 1.0% vs Sugar	69.0 0.5% vs Sugar
Ammonium Phosphate Monobasic $(NH_4)H_2PO_4$	1.0 0.2% vs Sugar	14.0 0.1% vs Sugar
Sulfuric Acid H_2SO_4	pH adjustment for Saccharifying Reaction	

+	α-Amylase	Novo	Termamyl 60L
++	Gluco-Amylase	Amano	Glucozyme AF6

5-4-2 Standard Operation Conditions

5-4-2-1 Cassava Consumption

16.7 t/Batch

3 Batch/day

50 t/day

5-4-2-2 Crusher

Cassava Feed Rate	3 t/hr.
Time for One Batch	5.6 hr./Batch
Water Feed Rate	1.5 t/hr.
Cassava Milk Producing Rate	4.5 t/hr.
Total Cassava Milk Produced	25.0 t/Batch

5-4-2-3 Cassava Milk Pit

Capacity 20 m^3

When the volume of cassava milk in the pit reaches to 15 m^3, work the stirrer and transfer the cassava milk to the cooking tank (D-102).

Transfer rate is 12.5 t/hr.

So, the transfer is finished in two hours.

Wash the transfer line with 1.4 t of water.

5-4-2-4 Liquefying Process

Cooking Tank

Capacity 42.8 m^3

Stirrer 20 rpm

Tab. 5-4-2 Composition of Solution

Constituent	Quantity (kg)
Cassava	16700 (4760 kg as Glucose)
Water	9700
α-Amylase	5
Total	26405

The final quantity after cooking is 31705 kg.

Tab. 5-4-3 Temperature Control

Unit Process or Parameter	Condition
Speed of heating	Below 1°C/min.
Heating time for 30°C to 80°C	50 min.
Liquefying at 80°C	30 min.
Heating time for 80°C to 132°C	50 min.
Cooking at 132°C (Pressure: 2kg/cm^{2}G)	30 min.

Transfer of the Cassava Liquid is made with the steam pressure inside the tank.

5-4-2-5 Saccharifying Process

Saccharifying Tank

Capacity 47.8 m^3

Stirrer 20 rpm

Tab. 5-4-4 Composition of Solution

Constituent	Quantity (jg).
Cassava Liquid	31705
Gluco Amylase	3
Urea $CO(NH_2)_2$	24
Ammonium Phosphate Monobasic $(NH_4)H_2PO_3$	4.8
Total	31736.8

pH 5.0 with H_2SO_4

Temperature Control at 55°C maintained for 60 minutes.
With one of the three batches, the saccharified solution is separated into two portions such as seed medium (3000 kg) and fermentor medium (28700 kg).

5-4-2-6 Tank Seed Culture

Seed Tank — Capacity 6 m^3

Stirrer 100 rpm

Tab. 5-4-5 Composition of Medium

Constituent	Quantity (kg)
Saccharified liquid	3000
Urea $CO(NH_2)_2$	0.5
Ammonium Phosphate Monobasic $(NH_4)H_2PO_3$	0.3
Water	1000
Total	4000.8

Final quantity after sterilization becomes 4200 kg

Conditions of Sterilization

At 110°C, maintained for 10 minutes, then cooled to 55°C for saccharifing.

Reinforcement of Saccharifing

Additional Enzymes

α-Amylase	500 g
Glucoamylase	300 g

At 55°C, maintained for 3 hours, then cooled to 32°C for inoculation.

Flask Seed

600 ml of 1 day standing culture in 1 L flask.

Culture Conditions

Temperature	32°C
Stirring	100 rpm
Airation	400 Nl/min.
Culture time	26 hrs.

5-4-2-7 Fermentation

Fermenter

Capacity 120 m^3

Stirrer 100 rpm
(side mounted)

Tab. 5-4-6 Composition of Medium

Component	Quantity (kg)
Tank Seed	4200
1st Saccharified Sol.	28700
2nd Saccharified Sol.	31700
3rd Saccharified Sol.	31700
Total	96300

Culture Conditions

Temperature 32 °C

Stirring 100 rpm, from the 2nd feed to 3rd feed

Aeration 1000 Nl/min, for 8 hrs from 1st feed

Culture Time 86 hrs. after 1st feed.

5-4-2-8 Distillation

① Mash Column

Dimension 1100 ϕ x 13700 x 3 t

Tray Bubble Cap Type
Number of tray 26
Tray distance 400 mm

Operation Conditions

Broth Feed Rate 3.8 kl/hr.

Column Top 95 °C

Column Middle 102 °C

Column Bottom 108 °C

② Concentration Column

Dimension	800 ϕ x 10500 x 3 t	
Tray	Sieve tray	
	Number of tray	25
	Tray distance	300 mm
Operation Conditions		
Temperature		
Column Top		79 °C
Column Middle		84 °C
Colum Broth		95 °C
Reflux and Product		70 °C
Flow rate		
Reflux		1340 l/hr.
Product		335 l/hr.
Reflux ratio		4.0

5-4-3 Schematic Description of Operations

5-4-3-1 Time Course of Cassava Consumption in Crushing Process Equipment including K-101, 102, 103, 104, 105, 106, 107, 108

Fig. 5-4-1 Total Amount consumed and Produced Cassava Milk

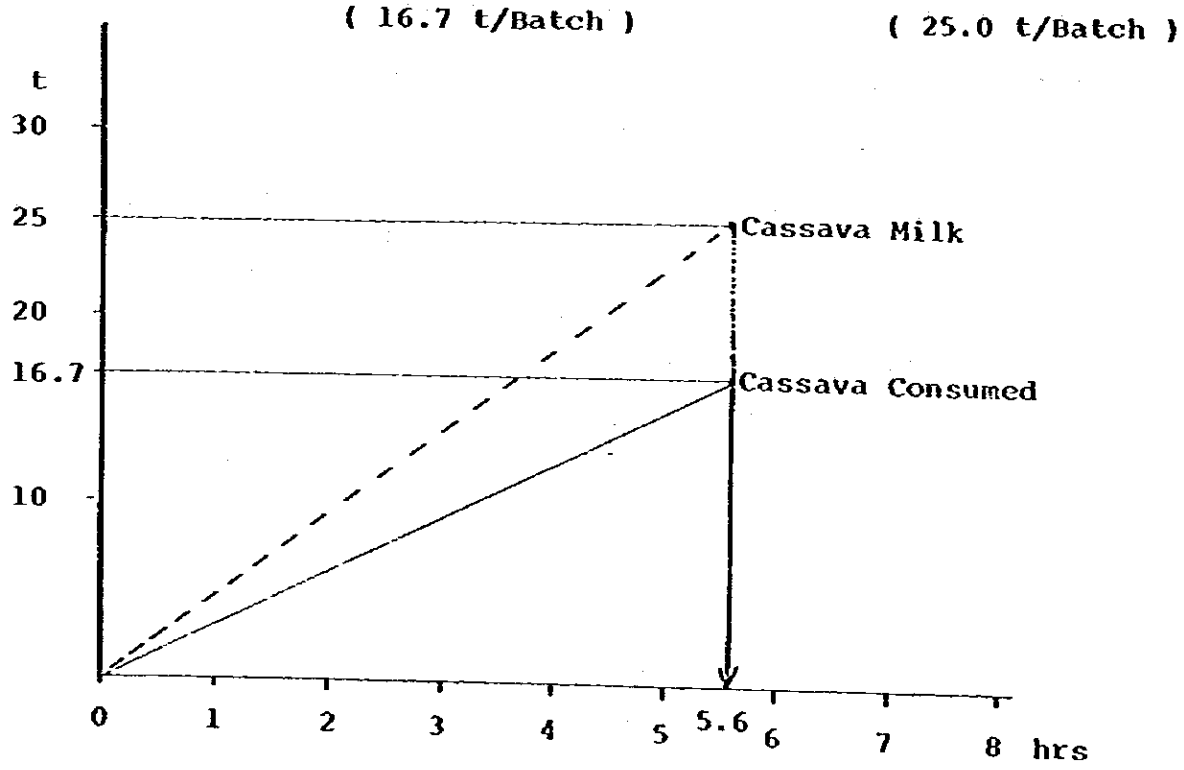
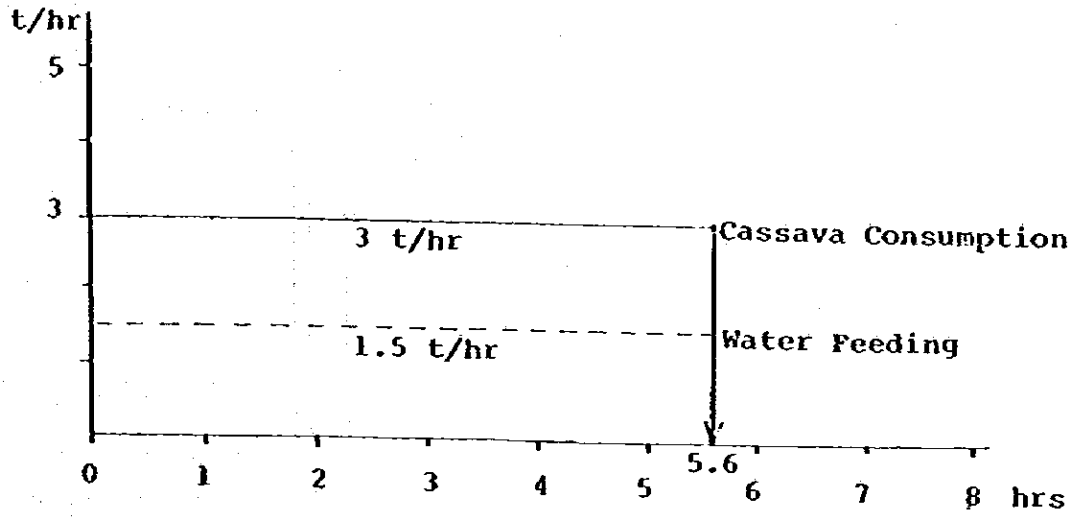


Fig. 5-4-2 Rate of Cassava Consumption and Water Feeding



5-4-3-2 Time Course of Cassava Milk held in Cassava Milk Pit Equipment D-101

Fig. 5-4-3 Total Cassava Milk fed and held Amount in Pit

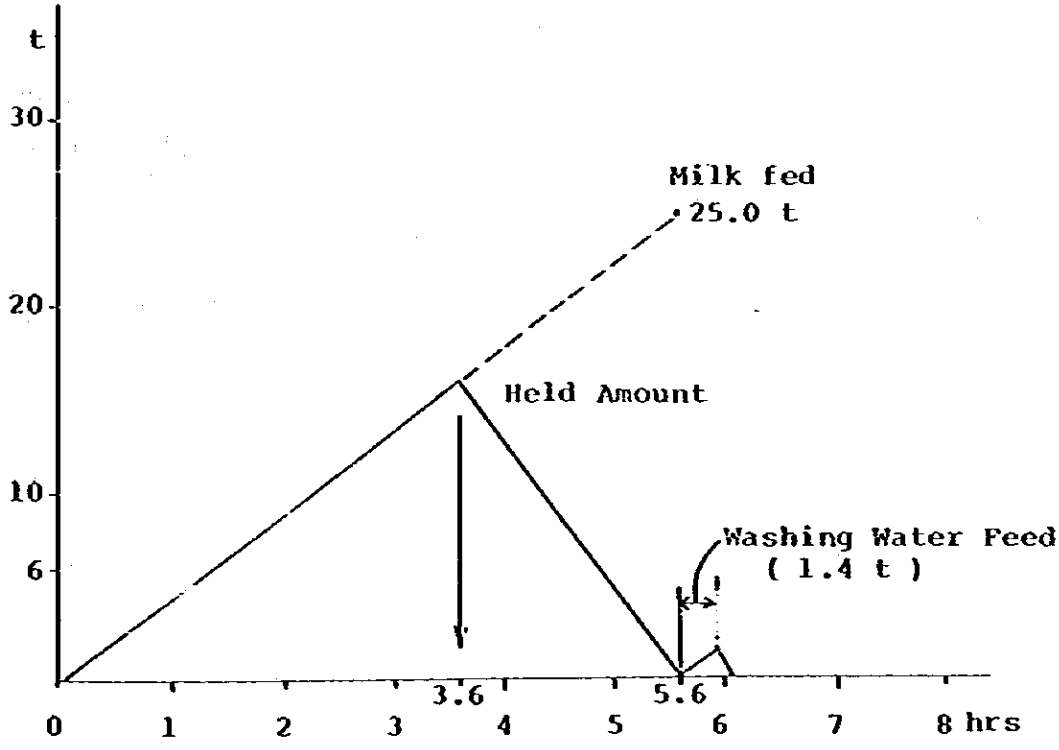
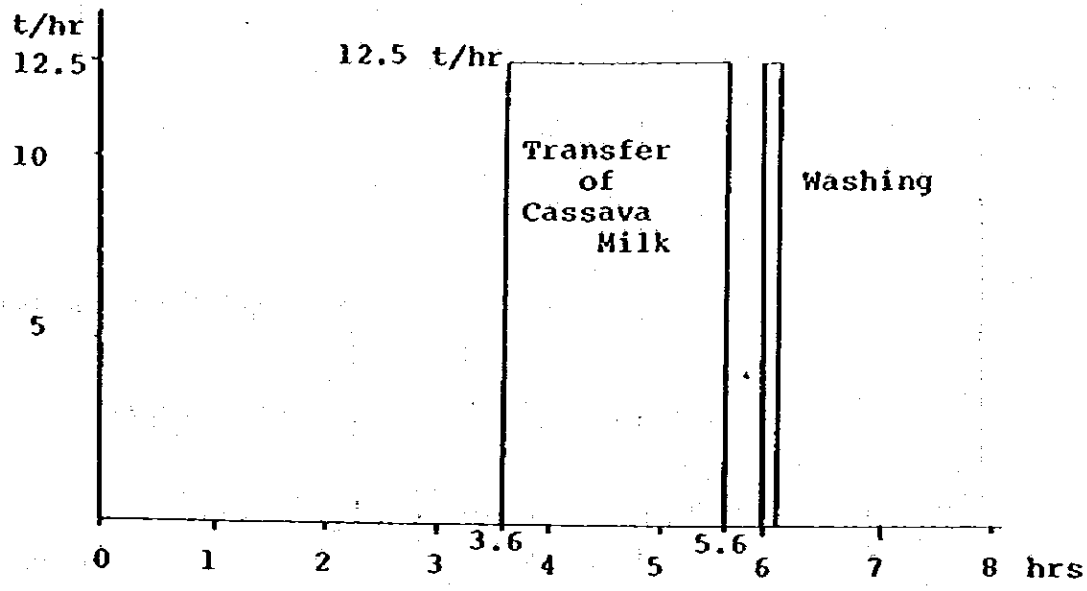


Fig. 5-4-4 Transfer Rate (D-101→D-102)



5-4-3-3 Time Course of Operation Parameters in Liquefying Process (Equip. No. D-102, E-102)

Fig. 5-4-5 Temperature

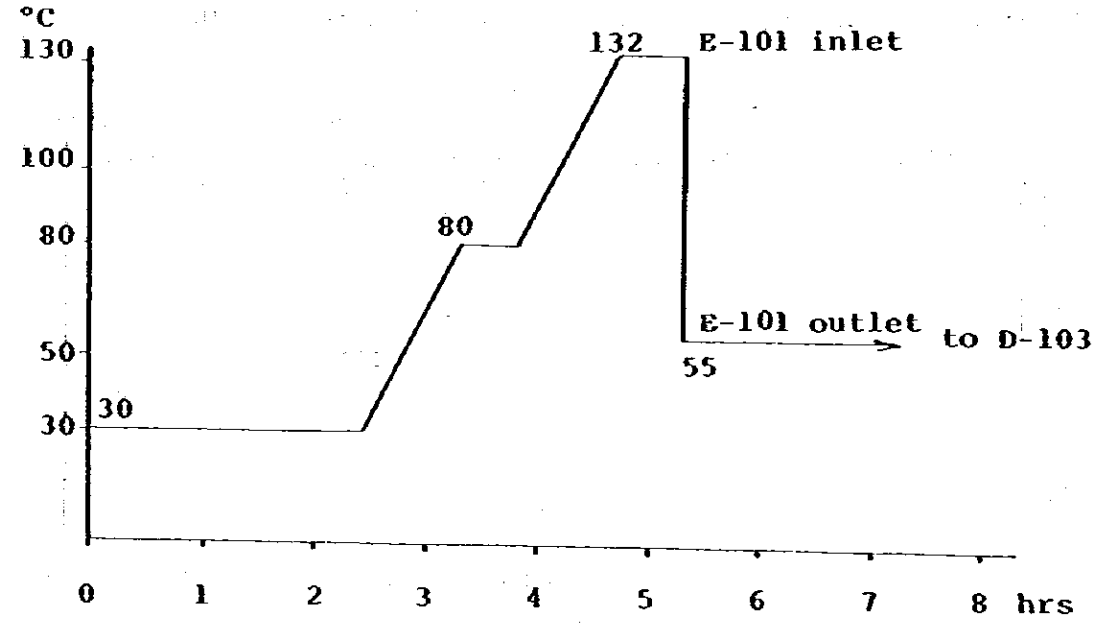
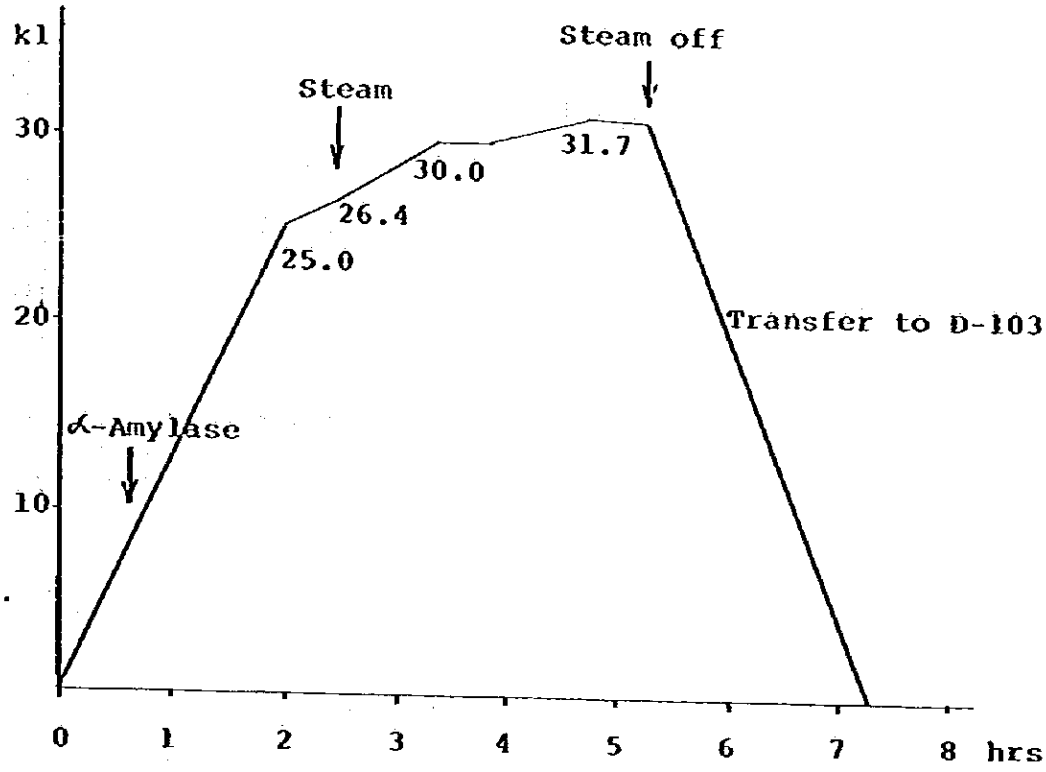


Fig. 5-4-6 Volume



5-4-3-4 Time Course of Operation Parameters in Saccharifying Process (Equip. D-103, E-103)

Fig. 5-4-7 Temperature

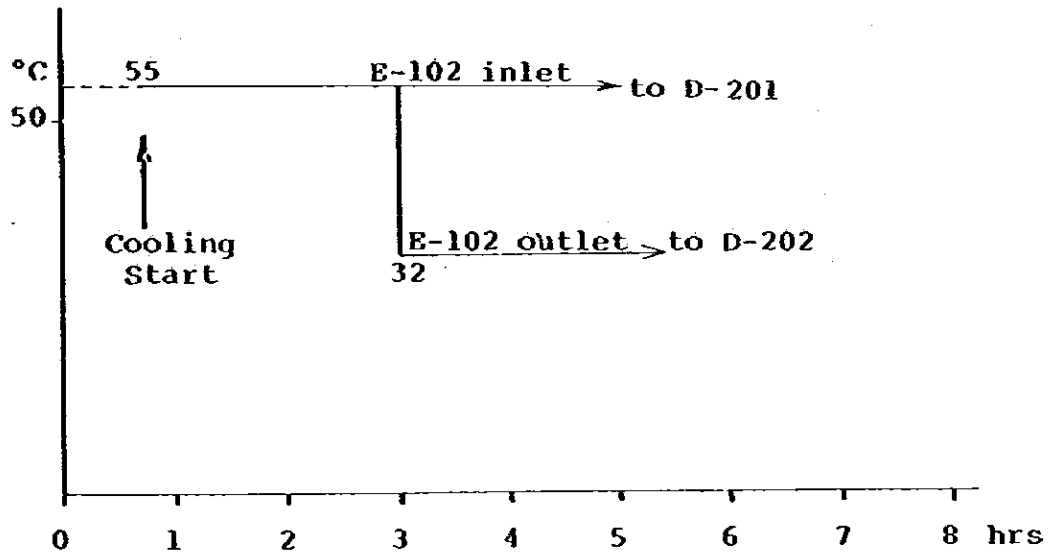
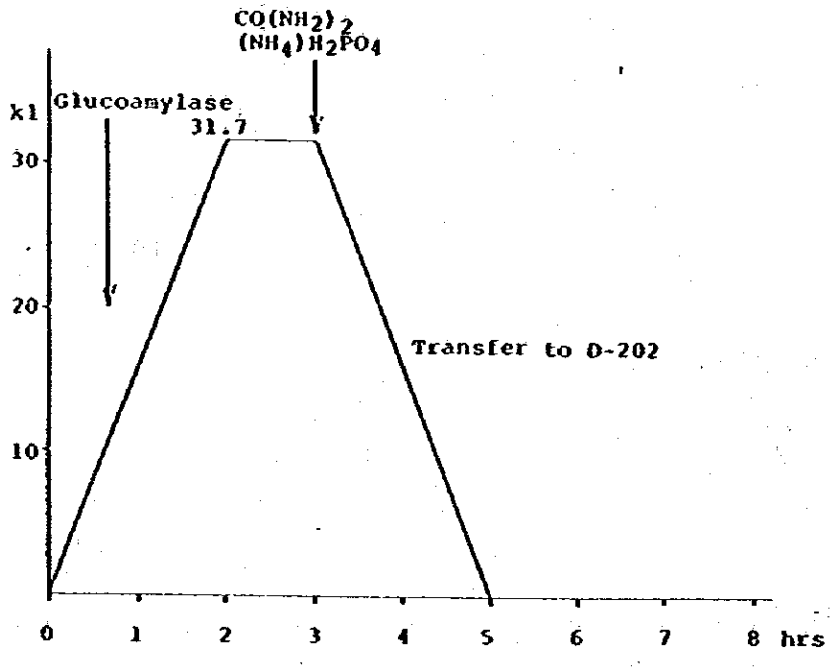


Fig. 5-4-8 Volume



5-4-3-5 Time Course of Operation Parameters of Seed Culture (Equip. D-201, K-201)

Fig. 5-4-9 Temperature

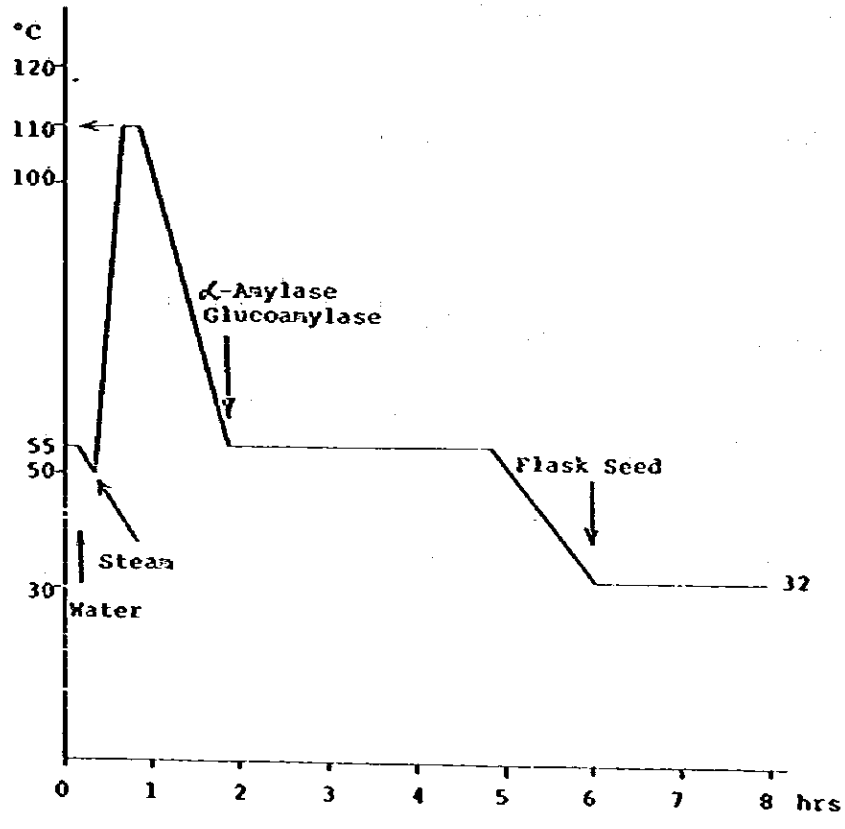
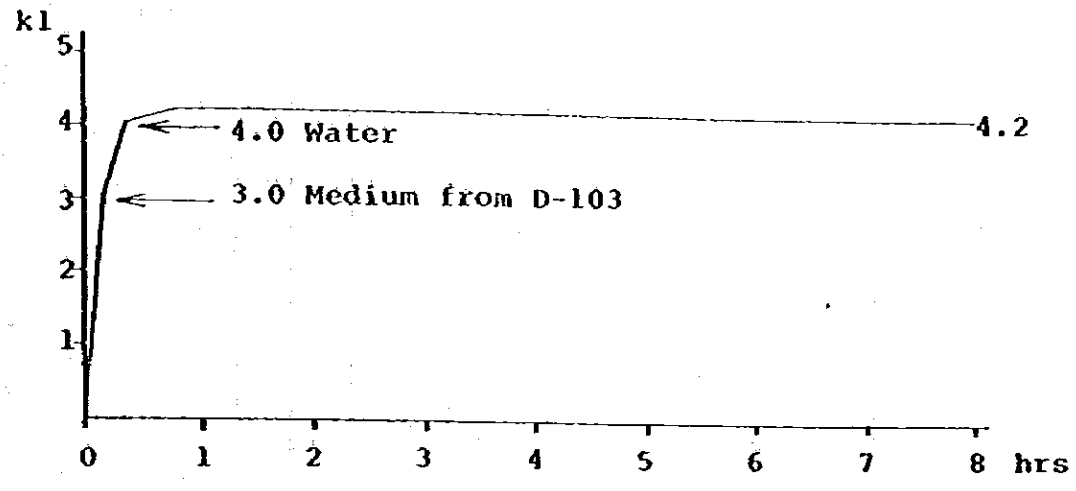
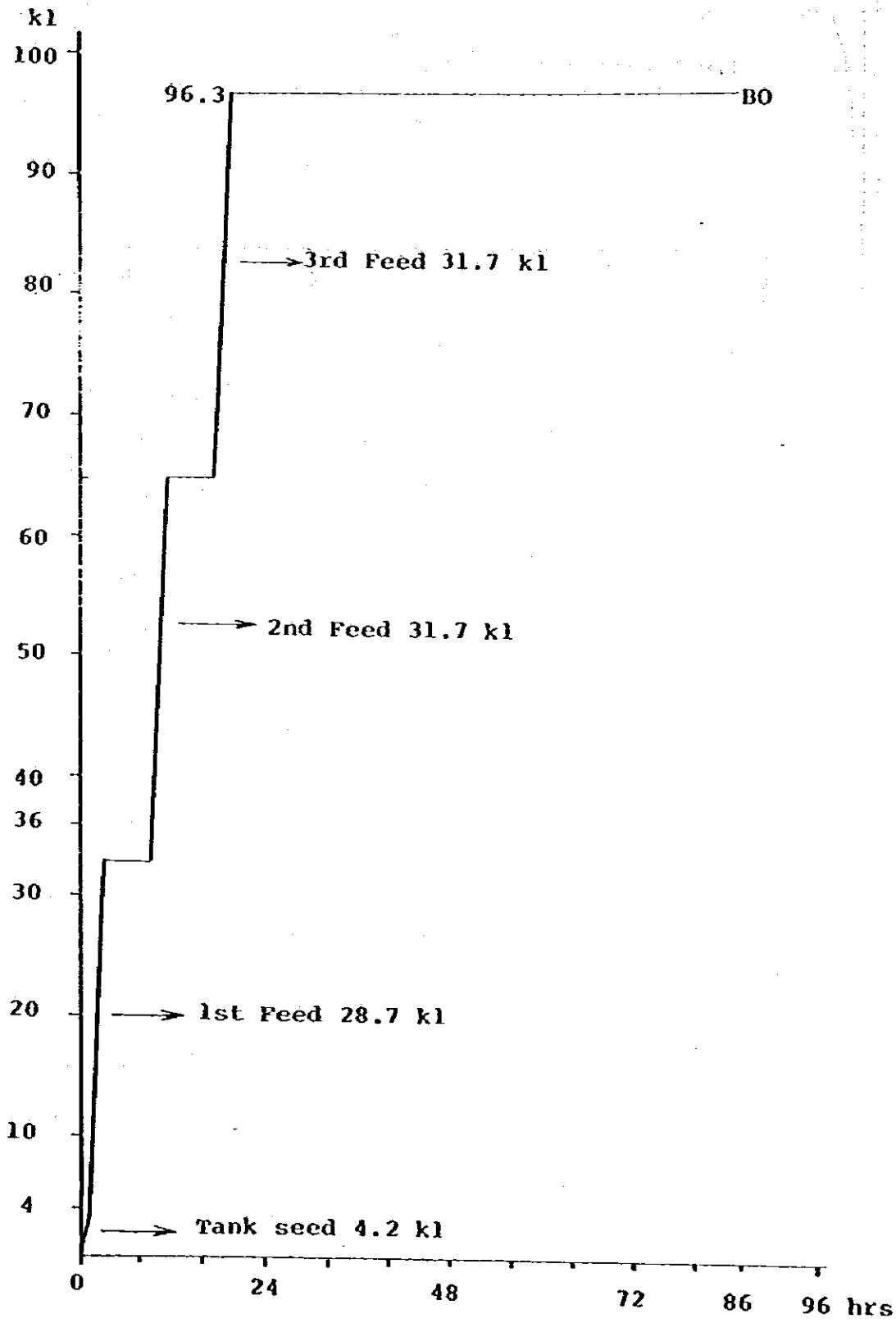


Fig. 5-4-10 Volume



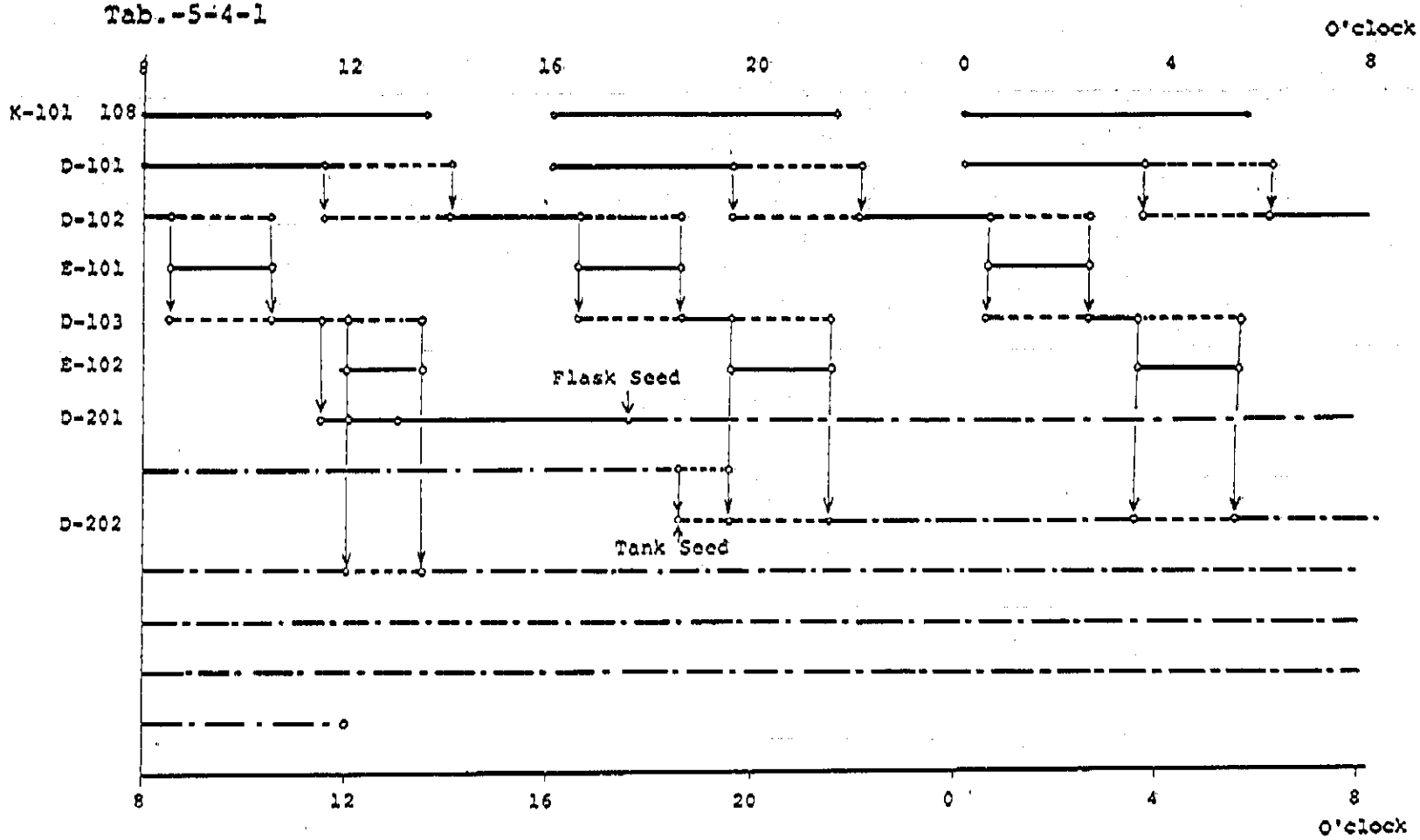
5-4-3-6 Time Course of Operation Parameters of Fermentation (Equip. D-202, K-201)

Fig. 5-4-11 Volume



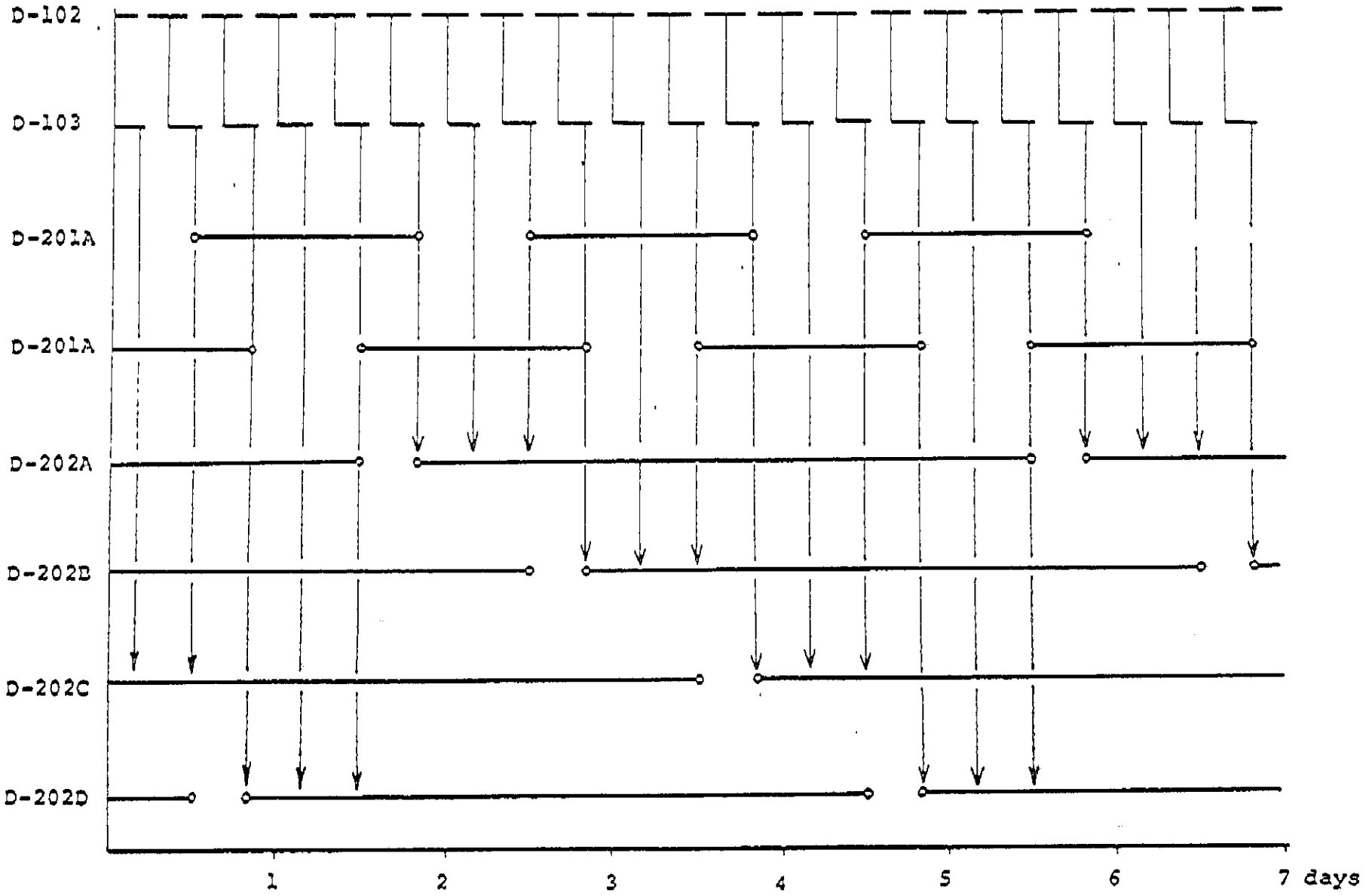
5-4-3-7 Working Schedule of Main Process in EtOH Fermentation from Cassava in 24 hours

Tab.-5-4-1



5-4-3-8 Working Schedule of Main Tank in EtOH Fermentation in a Week

Tab.-5-4-2



6. Operation Manual

6-1 Culture of Flask Seed

6-1 Culture of Flask Seed

6-1-1 Slant medium for stock culture

1) Composition

Yeast extract and Malt extract Agar medium (YM Agar medium) are used for the stock cultures of yeasts.

Its composition is below.

Yeast Extract	3 g/l
Malt Extract	3 g/l
Peptone	5 g/l
Glucose	10 g/l
Agar	20 g/l

pH 5.5 , Volume 1 L

2) Preparation

Weigh each component and dissolve them except the agar with half of the final volume of DW.

The pH value of the solution is adjusted to 5.5 with diluted alkali sol. or acid sol.. Then the agar is added to the solution. It is filled up to the indicated volume with DW and the agar must be melted thoroughly in a water bath. After well mixed, the medium is dispensed to test tubes (18 mmϕ x 165 mm) by the 10 ml. Take care not to spoil the cotton plugs and/or the mouths of the test tubes with the medium. The test tubes inserted with cotton plugs have been heated at the temperature over 100°C for hours before use.

3) Sterilization

The tops of the test tubes are covered with alminum foil or others, for the cotton plugs should not be wetted with drain. The conditions of sterilization with a autoclave are below.

Temperature	120 °C (1 kg/cm^{2}G)
Time	15 minutes

4) Hardening and Stock

After sterilization, the test tubes have been laid on a table with their heads on a glass tube in order to make slope, before hardening of the medium in them begins. After hardening, they are kept at room temperature for a few days to check whether the sterilization is complete or not.

Then, they are stocked in a clean and cool place.

6-1-2 Active Medium

Active medium is used for making microbes, which have ceased almost their physiological activities, grow actively again.

1) Composition

YM medium is used.

Its composition is below.

Yeast Extract	3 g/l
Malt Extract	3 g/l
Peptone	5 g/l
Glucose	70 g/l

pH 5.5 , volume 1 L

2) Preparation

Apply the method mentioned in clause 6-1-1 excluding the step of adding agar.

3) Sterilization

Apply the method mentioned in clause 6-1-1.

4) Stock

Apply the method mentioned in clause 6-1-1, excluding the step of hardening.

6-1-3 Flask Seed Medium

Flask seed medium is used to greatly increase the cells proliferating in the active medium.

1) Composition

a. YM medium

The composition is same as the active medium.

b. Molasses medium

Molasses	70 g/l as glucose
$(NH_4)_2SO_4$	1 g/l

pH not adjusted

2) Preparation

Apply the method mentioned in clause 6-1-2.

Exceptions are following. The vessel used is a 1000 ml Erlenmyer flask having a nozzle to transfer its content and the amount of the medium is 600 ml in the 1000 ml flask.

3) Sterilization

Apply the method mentioned in clause 6-1-2.

4) Stock

The flasks are stocked in a clean and cool place.
And the medium had better be consumed within a week.

6-1-4 Conditions of Culture

1) Slant Culture

Volume of medium	10 ml in a test tube (18 mmϕ x 165 mm)
Inoculum size	A bit of cell mass extended with an inoculating needle
Temperature	30°C
State of Culture	Standing
Culture time	48 hrs.
Conditions of stock	5°C in dark and dry place

2) Active Culture

Volume of medium	10 ml in a test tube (18 mmϕ x 165 mm)
Inoculum size	A bit of cell mass
Temperature	30 °C
State of Culture	Standing
Culture time	24 hrs.

3) Flask Seed Culture

Volume of medium	600 ml in a 1000 ml Flask
Inoculum size	10 ml of active culture
Temperature	30 °C
State of Culture	Standing
Culture time	24 hrs.

6-2 Crushing of Raw Materials

6-2 Crushing of Raw Materials

6-2-1 Cassava

The cassavas transported from their farm by trucks are, at first, weighed with the truck scal, and piled up in the stock yard.

6-2-2 Crushing Process

1) The cassavas piled up are carried by forklift trucks (K-109) near the entrance of the belt-conveyer-1 (K-101) and are thrown on it at the constant rate (3 t/hr) by the feeder men. They are transferred to the belt-conveyer-2 (K-102) and reach to the peeler (K-103).

2) It rubs off their soil, sands and dirt and peels their barks with the rotation of its blades.

3) The cassavas rubbed and peeled go into the washer (K-104), which washes them in the water tank having a screw like stirrer. Forwarding by the stirrer in the water tank, the cassava are again transferred by the conveyer-3 (K-105) to the automatic conveyer scale (K-106).

   There, they are automatically measured of their total amount which has passed through the scale.

4) The cassava continuously weighed, then, go to the Crusher-1 (K-107) which slices them to small bit with its blades. The cassava sliced are further crushed to fine particles with the crusher-2 (K-108A, B). Concomitantly with the fine crushing, water is injected to the fine crusher, then the fine crushed cassava forming heavy slurry is washed down to the cassava milk pit (D-101). The injection rate of the water (1.5 kl/hr) is controlled by the valves Ⓐ and Ⓑ in fig. 6-2-2.

5) The cassava milk in the pit always separates into precipitation part and supernatant part unless stirring. So, when its level in the pit reaches to the propeller of the stirrer, begin stirring for making it homogeneous and breaking the precipitation.

6) Estimate the time when the automatic conveyer scale showes the indicated value (16.7 ton) and stop the belt-conveyer (K-101, 102, 105), the peeler (K-104) and the washer (K-105) at the proper time according to the estimation.

7) The automatic conveyer scale reaches to the indicated point, and stop its operation.

8) Make sure that the content in the crushers has been all out and put off the switches of the crusher-1, 2A and 2B.

6-2-3 Transfer of Cassava Milk

1) The cassava milk in the pit is transferred to the cooking tank (D-102) with the cassava milk pump (P-101).

2) The level in the pit goes down and reaches to the propeller of the stirrer, then stop the stirring.

3) After the cassava milk has been transferred, the transfer line must be washed to prevent stopping, with 1.4 kl of water which is fed into the pit from the valve Ⓒ in fig. 6-2-2. This washing water is joined with the cassava milk already transferred into the cooking tank.

4) Stop the cassava pump (P-101).

Fig-6-2-1 Peeler, Washer

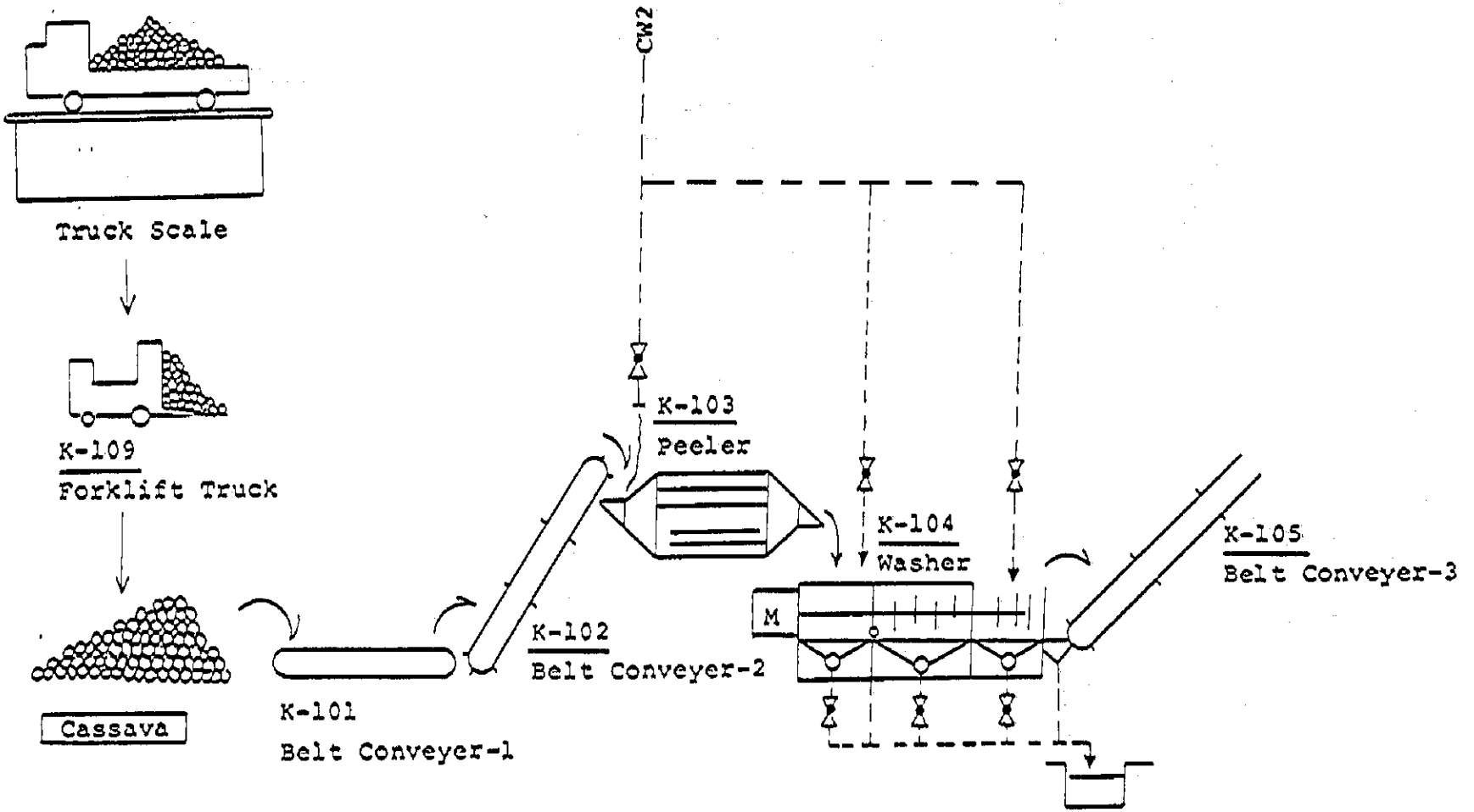
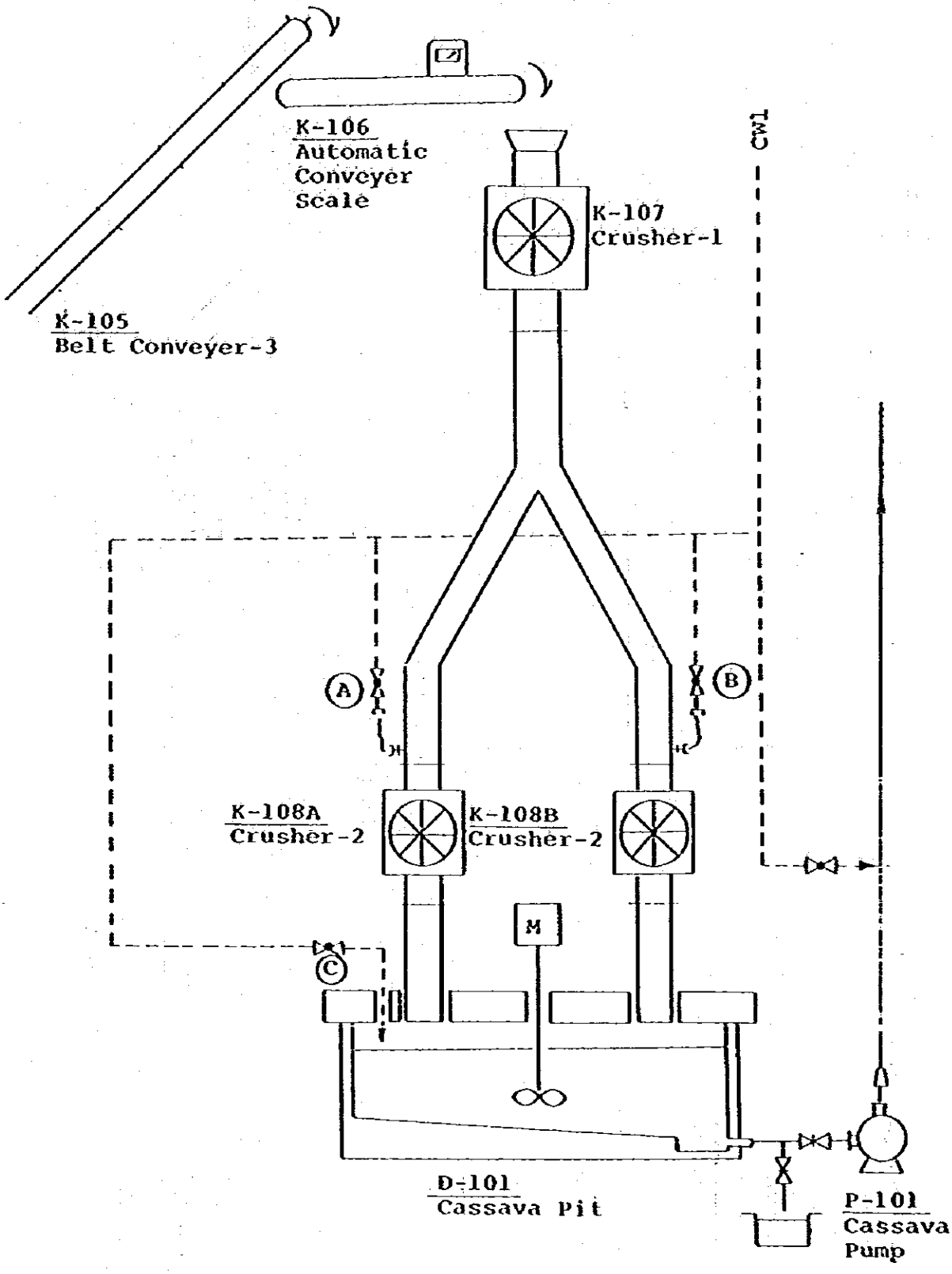


Fig-6-2-2 .Automatic Conveyer Scale.Crusher



6-3 Liquefying Process

6-3 Liquefying Process

6-3-1 Arrangements

1) Open the manhole of the cooking tank (D-102).

2) Close the valve Ⓐ in fig. 6-3-1, at the bottom of the cooking tank and open the valve Ⓒ in fig. 6-3-1, the exhaust valve. The flexible hose for injection of the cassava milk is inserted into the tank from the manhole.

3) Start the cassava milk pump (P-101) then the milk streams into the tank from the manhole.

4) The level of the milk in the tank reaches to propeller of the stirrer, then start stirring.

5) After the whole volume (25 kl) of the milk has been accepted, the washing water for the transfer line (1.4 kl) can be accepted.

6) After accepting the washing water, stop the cassava pump (P-101) and pull up the hose from the manhole.

7) Stop the stirring for a minutes and adjusted the volume of the milk including the washing water to the indicated volume (26.4 kl) with water.

8) Add the indicated amount (5kg) of the α-Amylase to the milk from the manhole.

9) Start the stirring again.

10) Check the packing of the manhole and make sure of no troubles. Then fasten the lid of the manhole firmly.

6-3-2 Liquefying

1) Before starting the injection of steam, you should tell it to the related members especially to those in charge of the boiler.

2) The drain in the steam lines for the cooking tank must be removed thoroughly. Then the eight valves for steam injection are opened gradually and in order. So, the steam can be injected.

3) The degree of the opening in the valves should be controlled to maintain the rate of heating near 1 °C/minute and not to exceed over the rate.

4) The rate of temperature rising can be estimated from the chart of its time course in the recorder.

5) When the temperature rises to 80 °C, the eight valves are closed.

6) Maintain the temperature at 80 °C ± 2 °C for half an hour, so the liquefying reaction can proceed.

7) Control the temperature, observing the chart in the recorder. If the temperature descends, some of the eight valves can be opened to keep the temperature.

6-3-3 Cooking

1) The cooking process is performed, continuing after the liquefing process.

2) Remove the drain in the steam pipes and open the eight valves as mentioned formerly in clause 6-3-2.

3) The temperature control is conducted similarly as mentioned formerly in clause 6-3-2.

4) The temperature rises gradually. When the temperature reaches near 90 °C, the steam begins to blow out from the exhaust line. So, make the opening of the exhaust valve Ⓒ in fig. 6-3-1 a little.

5) Continue rising of the temperature. Make sure of the blow of steam and let the opening of the exhaust valve still less.

After a while, the temperature reaches to 100 °C, so close the exhaust valve firmly.

6) Still the rise of temperature continues and the pressure inside the cooking tank rises gradually.

7) The pressure inside the cooking tank can be known from the pressure gauge set on the tank.

8) When the temperature reaches to the indicated point (132 °C, 2.0 kg/cm^{2}G), close the eight valves.

The relations between temperature and steam pressure of water are described below.

Tab. 6-3-1

Temperature	Steam Pressure of Water
108.7 °C	0.4 kg/cm^{2}G
112.7	0.6
116.3	0.8
119.6	1.0
122.6	1.2
126.7	1.5
132.8	2.0
138.2	2.5

As the extraordinary pressure inside the tank arises, the pressure rises even to the critical point (3.0 kg/cm^{2}G). So, the safety valve set to work at 3.0 kg/cm^{2}G begins to expire the steam in the tank.

9) Keep the temperature at 132 ± 2 °C for thirty minutes, so the cooking process can proceed.

10) After the cassava milk has been liquefied and cooked, tell it to the members in charge of the boiler.

6-3-4 Transfer of Liquefied Milk

1) Before the cooking ends, make the medium cooler-1 (E-101) and the saccharifing tank (D-103) ready to work. The details of the preparations will be mentioned in the clause of saccharifying process.

2) The transfer of the liquefied milk can be performed by the pressure (2.0 kg/cm^2G) of the steam derived from the liquefied milk it self.

3) On the transfer line (Cooking tank to Saccharifying tank), the valves Ⓖ and Ⓗ in Fig. 6-3-1 are opened and the valves Ⓓ, Ⓔ and Ⓕ in Fig. 6-3-1 are closed. Open the valve Ⓐ in Fig. 6-3-1, at the bottom of the cooking tank, gradually.

4) The liquefied milk streams into the medium cooler-1 and can be cooled from 132 °C to 50 ∿ 60 °C there. After cooled, the milk is transferred into the saccharifying tank.

5) You can notice the end of the transfer from the rapid decrease of the pressure in the cooking tank.

6) At the end of transfer of the liquefied milk, the eight valves are opened for a minutes and are blowed with steam in order to wash away the remnants in them.

7) After the liquefied milk has been transferred, close the valve Ⓐ in Fig. 6-3-1, at the bottom of the cooking tank.

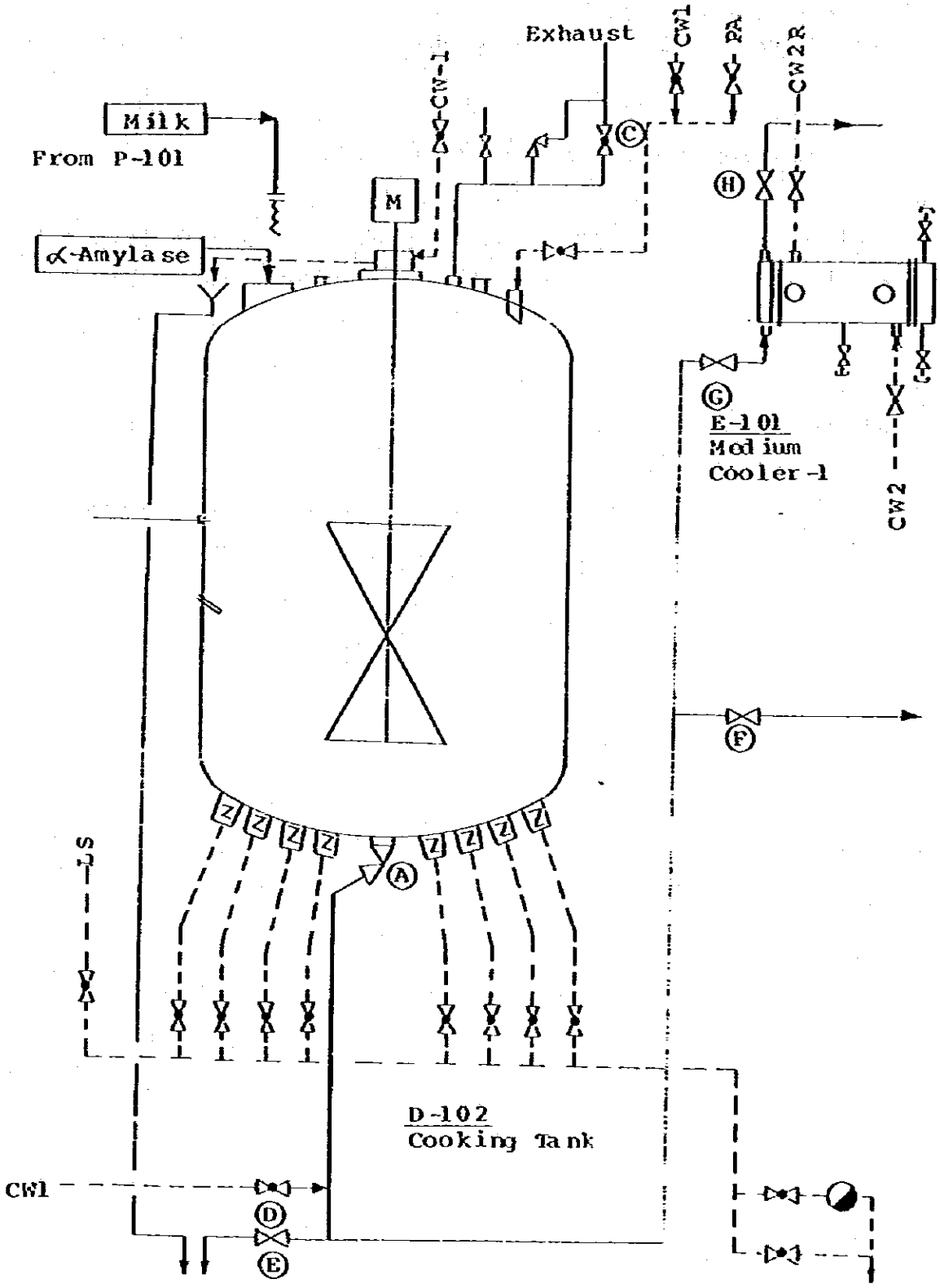
8) Stop the stirrer of the cooking tank.

9) Gradually, open the exhaust valve Ⓒ in Fig. 6-3-1, of the cooking tank, in order to release the remaining steam in it to the external.

10) After making sure of no pressure in the cooking tank, open the manhole.

11) Inspect the inside of the cooking tank.

Fig-6-3-1 Cooking Tank



6-4 Saccharifying Process

6-4 Saccharifying Process

6-4-1 Reception of Liquefied Milk

1) Open the liquefied milk receiving valve (B) in Fig. 6-4-1, and close the valve (A) in Fig. 6-4-1, at the bottom of the saccharifying tank and the sampling valve (S) in Fig. 6-4-1. Then shut the manhole.

2) Flow the 2nd water to the cooling jacket of the medium cooler-1.

3) Begin the transfer of the liquefied milk from the cooking tank to the saccharifying tank.

4) The milk streams into the medium cooler-1 along the transfer line. There, the milk can be cooled from 132 °C to 55 ∿ 60 °C and the regulation of the cooling is controlled with the flow rate of the 2nd water. When it is impossible, the milk, still hot over 60 °C, can be cooled by the cooling coil in the saccharifying tank.

5) After about half an hour since the transfer has begun start the stirring of the saccharifying tank.

6) The temperature of the milk can be noticed from its chart in the recorder.

7) After the milk has received, close the valve (A) in Fig. 6-3-1, at the bottom of the cooking tank, and the receiving liquefied milk valve (B) in Fig. 6-4-1.

8) Washing of the medium cooler-1 and the transfer line are practiced as follows.

   Open the valve (D) in Fig. 6-3-1 and flow the 1st water to the transfer line. The washing water from the line can be discharged from the blow near the valve (B) in Fig. 6-4-1.

9) After washing, stop the flow of the 1st water and discharge the remaining water in the line by opening the valve (E) in Fig. 6-3-1.

6-4-2 Saccharifying

1) Adjust the temperature of the milk to 55 °C.

2) Take the sample of the milk from the valve Ⓢ in Fig. 6-4-1 and measure its pH. If the pH value is over 5.5, the pH of the milk in the tank must be adjusted from 5.0 to 5.5 by adding sulfuric acid (H_2SO_4) from the manhole.

3) Stop the stirrer and open the manhole.

4) Add the indicated amount (3kg) of the Gluco-Amylase into the milk from the manhole.

5) Start the stirrer and close the manhole.

6) Maintain the temperature at 55 °C for an hour. So, the saccharifying of the liquefied milk can proceed.

7) The temperature control is performed according to the observation on the chart of the recorder.

8) When the reaction has been proceeding for an hour, 69 kg of urea ($CO(NH_2)_2$) and 14 kg of ammonium phosphate mono basic ($NH_4H_2PO_4$) are added into the milk from the manhole.

   Of course, the stirrer stops its work while adding the chemicals.

   Start the stirrer, again.

6-4-3 Transfer of Saccharified Liquid

1) Before the saccharifying reaction is ended, make the medium cooler-2 and one of the four fermentors ready to work. The details of the preparation will be described in the clause of fermentation.

2) The transfer of the saccharified liquid is practiced as follows. On the transfer line (saccharifying to fermentor), the valves Ⓒ and Ⓗ in Fig. 6-4-1 are opened and the valves Ⓓ , Ⓔ and Ⓕ in Fig. 6-4-1 are closed. The valve Ⓐ in Fig. 6-4-1 at the bottom of the saccharifying tank is gradually opened.

3) Start the medium pump (P-102) and begin the transfer of the liquid.

4) The liquid streams into the medium cooler-2 along the transfer line. There, the liquid can be cooled from 55 °C to 32 °C. Then, the liquid flows into one of the four fermentors appointed.

5) After the liquid has transferred, stop the medium pump (P-102).

6) Stop the stirrer of the saccharifying tank.

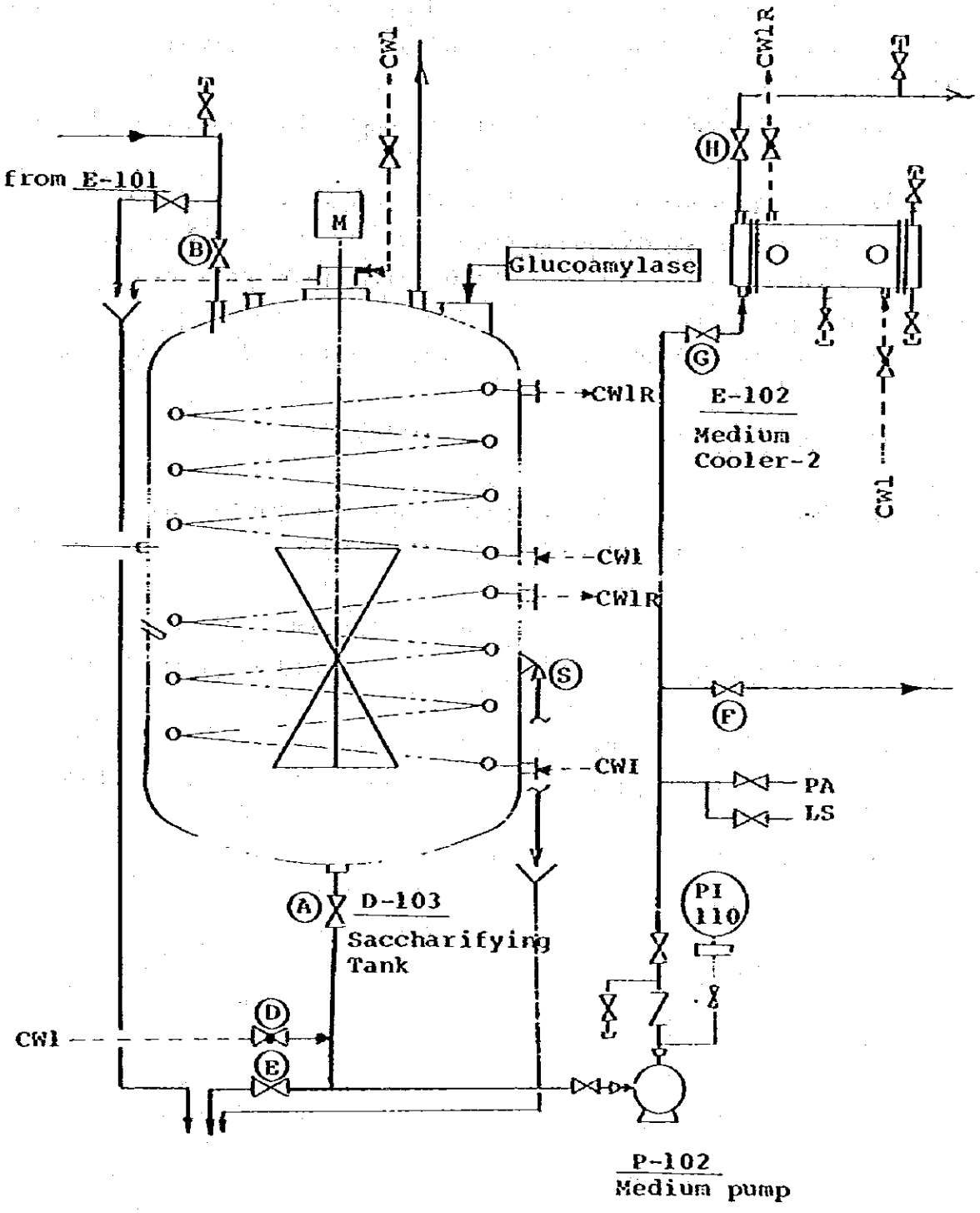
7) The remaining liquid in the transfer line can be purged into the fermentor with plant air.

8) The washing of the medium cooler-2 and the transfer line can be performed with the similar procedure as mentioned in clause 6-4-1.

9) Open the manhole of the saccharifying tank and wash the inside of the tank with the 1st water which is rushing out from a hose.

10) Inspect the inside of the tank.

Fig.6-4-1 Saccharifying Tank



6-5 Tank Seed Culture

6-5 Tank Seed Culture

6-5-1 Sterilization of Air Filter

1) Two air filters are installed. They are sterilized every week, in turn.

2) The inlet of air valve Ⓐ and the outlet of air valve Ⓓ in Fig. 6-5-1 are closed and the blow of drain valve Ⓒ and the blow of steam valve Ⓔ in Fig. 6-5-1. are opened.

3) Open the inlet of the steam valve Ⓑ in Fig. 6-5-1 gradually, then the steam is injected into the air filter. The air filter has been filled with the steam after a while and the steam begins to blow out from the valve Ⓔ in Fig. 6-5-1. The drain in the air filter is discharged from the valve Ⓒ in Fig. 6-5-1. So as to raise the pressure in the air filter, the valves Ⓒ and Ⓔ in Fig. 6-5-1 are narrowed with their opening.

4) Then, the pressure inside begins to rise and in a while reaches to 1 kg/cm^{2}G. So, maintain the pressure at 1 kg/cm^{2}G for an hour with controlling the opening of the valve Ⓑ in Fig. 6-5-1.

5) After maintaining the pressure at 1 kg/cm^{2}G for an hour, close the valve Ⓑ in Fig. 6-5-1 and open the valve Ⓐ in Fig. 6-5-1 gradually in order to dry the air filter.

6) After two hours since beginning to dry the filter, the valve Ⓔ in Fig. 6-5-1 is closed and the valve Ⓓ in Fig. 6-5-1 is opened. So the air filtered and sterilized can be flowed into the air lines.

7) The sterilization for the air lines are performed using the steam for the air filter sterilization, regarding their working schedules.

6-5-2 Arrangements for Sterilizing Seed Medium

1) The saccharified liquid made from the cassava by the processes mentioned before can be used as a carbon source.

   Before receiving the liquid in the seed tank (D-201), the valve Ⓐ at the bottom of the seed tank and sampling valve Ⓢ in Fig. 6-5-2 are closed. The manhole of the seed tank is opened.

2) The liquid receiving valve Ⓑ in Fig. 6-5-2 is opened. Then the valves Ⓓ and Ⓔ in Fig. 6-4-1 are closed and the valve Ⓐ in Fig. 6-4-1 is opened.

   So, start the pump (P-102) and transfer the liquid from the saccharifying tank to the seed tank.

3) In this case, the liquid is not necessary to be cooled by the medium cooler-2, so the medium by-passes it and flows into one scheduled of the two seed tanks. The end of the transfer line is made of a flexible hose, so receiving the liquid into the seed tank must be performed by inserting the hose to the manhole.

4) After the indicated volume (3.0 kl) of the liquid has been received, the remaining in the transfer line is washed away into the seed tank with the 1st water.

5) 5.0 kg of urea ($CO(NH_2)_2$) and 1.0 kg of ammonium-phosphate mono basic ($(NH_4)H_2PO_4$) are added into the liquid from the manhole.

6) Make the volume of the liquid to 4.0 kl adding the 1st water.

7) Start the stirrer of the seed tank.

8) Close the manhole of the seed tank.

6-5-3 Sterilization of Seed Medium

1) Open the exhaust valve Ⓒ in Fig. 6-5-2.

2) Remove the drains in the steam line to the seed tank and in the seed transfer line from the seed tank to the fermentor scheduled.

3) Steam is injected from the air-sparger in to the seed tank along the air line from steam line (LS) in Fig. 6-5-2.

4) Also, steam can be injected from the seed transfer line by opening the seed transferring valve Ⓣ in Fig. 6-5-2.

5) The temperature of the medium rises gradually. When the temperature rises over 90 °C, the steam begins to blow from the exhaust line of the seed tank. Then, reduce the opening of the valve Ⓒ in Fig. 6-5-2.

6) Still, the rise of the temperature continues. Making sure of the blowing of the steam from the exhaust line, reduce further the opening of the valve Ⓒ in Fig. 6-5-2.

7) When the temperature reaches to 110 °C, maintain the temperature at 110 °C for 10 minutes by controlling the openings of the valves which are the steam injection valve on the steam line (LS) and the valve Ⓒ in Fig. 6-5-2, regarding the chart on the recorder.

8) After maintaining the temperature at 110 °C for 10 minutes, close the valve Ⓣ in Fig. 6-5-2.

9) Increasing the opening of the valve Ⓒ in Fig. 6-5-2, the pressure inside begins to descend. So, open the valve on the air line (PA) in Fig. 6-5-2 gradually and close the valve on the steam line (LS).

10) Flow the 1st water into the cooling coil in order to cool the medium fast.

11) Regulate the pressure inside from 0.2 kg/cm^2G to 0.5 kg/cm^2G by controlling the opening of the valve on the air line (PA) in Fig. 6-5-2.

12) Paying much attention on the pressure gauge of the seed tank, never make the pressure inside below 0 kg/cm^{2}G.

13) When the temperature has descended to 57 °C, stop the flow of the 1st water to the cooling coil.

The temperature can descend further with the remaining water in the coil.

14) 500 g of α-Amylase and 300 g of glucoamylase which are dissolved into 3 l of sterilized water, are added to the medium, sterilized just now and cooled near 55 °C, from the nozzle for inoculation.

While the enzyme solution is adding, the aeration and the stirring has to be ceased.

15) The liquefing and saccharifying reactions are made for three hours at 55 °C.

6-5-4 Cooling of Medium for Inoculation

1) Begin to flow the 1st water to the cooling coil of the seed tank.

2) When the temperature of the medium has descended to 32 °C, stop the flow of the 1st water to the coil.

3) Adjust the rate of aeration at the indicated level (400 Nl/min.) regarding the indication of the metal tube rotameter on the air line. And regurate the pressure inside at 0.2 kg/cm^{2}G by controlling the opening of the valve Ⓒ in Fig. 6-5-2.

6-5-5 Inoculation and Culture

1) Make sure that the temperature is 32 °C, that the aeration rate is 400 Nl/min., and that the pressure inside is 0.2 kg/cm^{2}G.

2) Decrease the pressure inside by opening the valve Ⓒ in Fig. 6-5-2.

3) Stop the stirring.

4) Add the 600 ml of the Flask seed in 1000 ml Erlenmeyer flask to the 4.2 kl of the medium from the nozzle for inoculation.

5) Reduce the opening of the valve Ⓒ in Fig. 6-5-2 as similar as before and adjust the pressure inside at 0.2 kg/cm^{2}G.

6) Start the stirring.

7) The seed culture grow for 26 hours under these conditions mentioned below.

Temperature	32 °C ± 1
Aeration	400 Nl/min.
Pressure inside of tank	0.2 kg/cm^{2}G
Stirring	100 rpm.

8) The regulation of the temperature can be conducted by controlling the flow rate of the 1st water into the cooling coil.

9) After 26 hours culture, the tank seed culture can be transferred to the one fermentor scheduled.

6-5-6 Transfer of Tank Seed

1) Before the transfer of the tank seed, the one fermentor scheduled must be arranged for the fermentation. The details of the arrangements will be described in the clause of fermentation.

2) The transfer line is flowed with steam in order to sterile it, for an hour before use.

3) Close the exhaust valve Ⓒ in Fig. 6-5-2 and the air line from the air filter to the seed tank is changed to by-pass its rotameter. Then, the pressure inside the seed tank can be raised to 1.0 kg/cm^{2}G.

4) Making sure of the rise of the pressure inside, the seed transferring valve (T) in Fig. 6-5-2 is opened so the tank seed can be transferred to the one fermentor scheduled.

5) Stop the stirring of the seed tank.

6) When the tank seed has been transferred, close the seed transferring valve (T) in Fig. 6-5-2.

7) Close the valve on the air line (PA) in Fig. 6-5-2 and open the exhaust valve (C) in Fig. 6-5-2 in order to deplete the pressure inside.

8) Making sure of no pressure inside, open the manhole of the seed tank.

9) The transfer line can be washed with the 1st water. Of course, the end of the transfer line has to be stopped and the washing water can be discharged from blows.

10) After washing the line, the seed tank is filled about half of its volume with the 1st water.

11) Air is bubbled up to clean the air-sparger by opening the valve on the air line (PA) in Fig. 6-5-2.

12) Start the stirring to wash the inside of the seed tank.

13) After washing, the water in the tank is discharged from the valve (A) in Fig. 6-5-2 at the bottom of the seed tank, and close the valve on the air line (PA) in Fig. 6-5-2.

14) Wash the upper part of the inside of the seed tank using a hose.

15) The water remaining in the cooling coil of the seed tank can be discharged from its blow.

16) Inspect the inside of the seed tank.

6-5-7 Record of Temperature

The time courses of the temperature of the cooking tank (D-102), medium cooler-1 (E-101), saccharifying tank (D-103), medium cooler-2 (E-102), seed tank (D-201-A) and the seed tank (D-201-B) are recorded on the chart of the recorder TJR-101.

Fig. 6-5-1

Air Filter

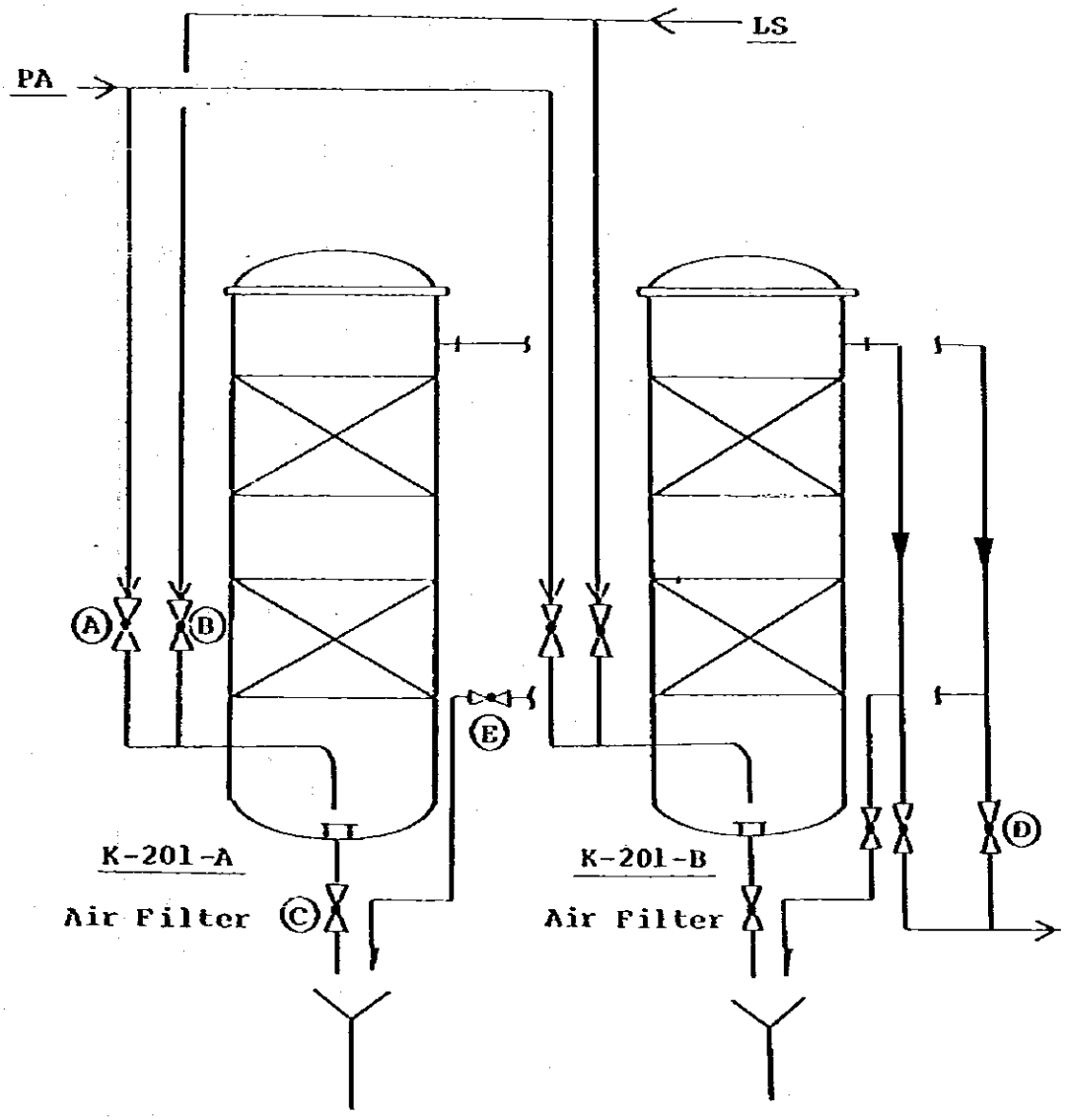
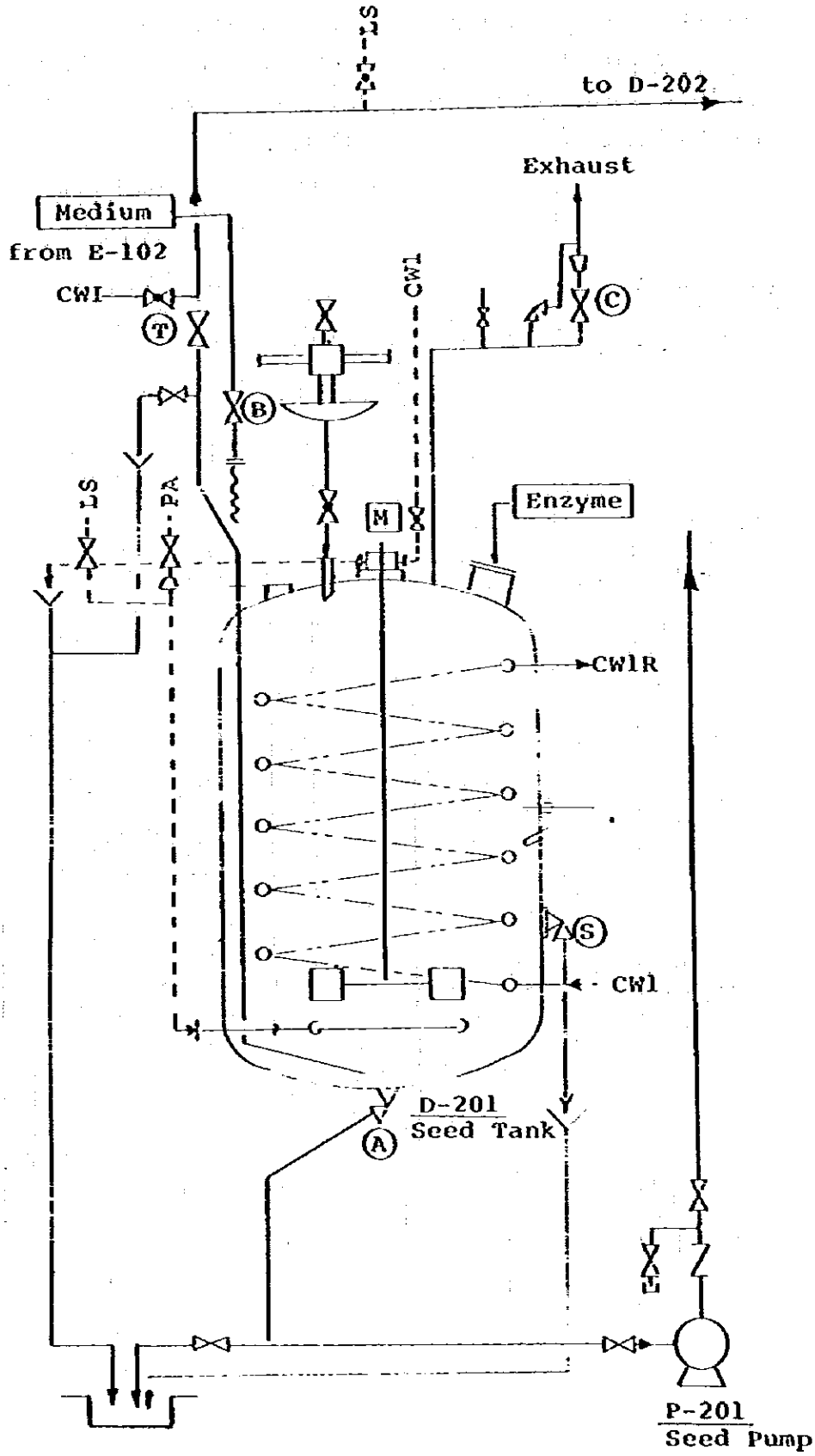


Fig.6-5-2 Seed Tank



NOTE: A

Procedure of adding Enzymes to Tank Seed Medium

1. 3 l of distilled water is put into the flask same as the inoculating flask and is sterilized with an autoclave for 30 minutes.

2. 300 g of glucoamylase is weighed with a balance, using sterilized beaker and spatula. 500 ml of α-amylase is taken with a sterilized graduated cylinder. The beaker and the cylinder are placed in a cleanbench and the flask, too.

3. The glucoamylase is put into the flask, the water in which has been cooled near 50 °C and is dissolved thoroughly. Then, the α-amylase is added to the solution. Of course, the cotton plug which has been taken off during the above operations, must be put on again.

4. So, the arrangements are set. The enzymes solution can be injected to a seed tank through the inoculation nozzle by the same way as the seed inoculation.

NOTE: B

Inoculating Method of Flask Seed to Seed Tank

1. The flask seed is cultured in the inoculating flask same as illustrated in Figure.

   The rubber tube part of the flask is tighten firmly with a screwcock for preventing the escape of medium.

2. Spray 70% ethanol on the stainless pipe of the flask. The cap of the inoculation nozzle is loosened.

3. Take off the caps of the stainless pipe and inoculation nozzle. Spray 70% ethanol on both mouthes.

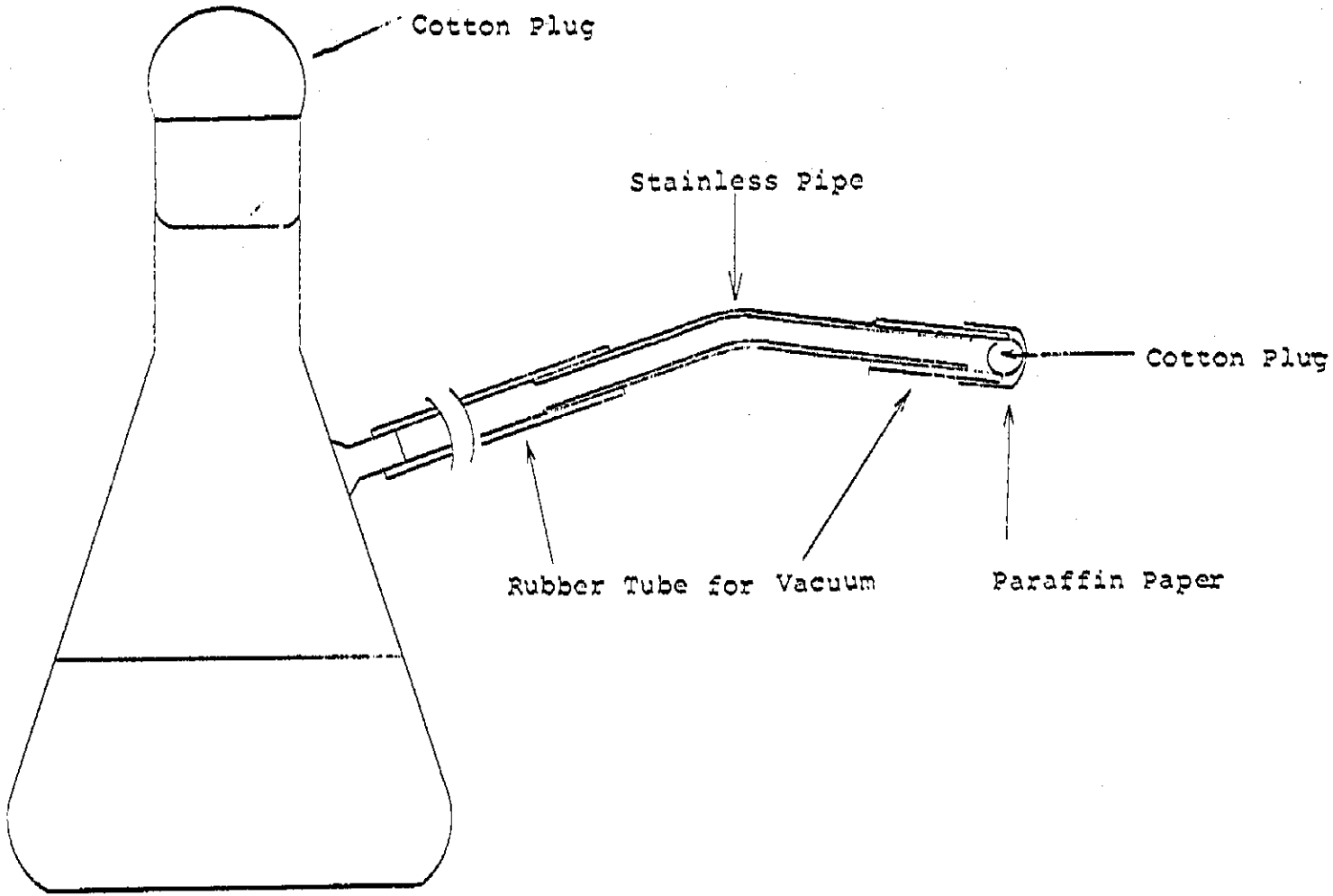
4. Insert the pipe of inoculating flask into the inoculation nozzle and inject the seed. When the seed has been injected, the valve of the nozzle must be closed. After removing the pipe, the mouth of the nozzle is spraied with 70% ethanol and also, the inside of the cap of the nozzle is spraied with 70% ethanol.

5. Then, the cap of inoculation nozzle is screwed to the mouth, again.

6. The sterilization of the inoculation nozzle accompanying the sterilization of the seed medium is described below. Before injecting steam into a seed tank, the valve of the nozzle and the valve of the nozzle cap are opened fully. With inspiring steam, the steam begins to blow out from the valve of the nozzle cap. When the temperature of the tank reaches too 100 °C, reduce the opening of the valve of the cap. Then, the temperature becomes 110 °C, reduce the opening further. After 10 minutes of maintaining at 110 °C, close the valve of the cap first.

Figure: Inoculating Flask

Flask for adding seed and others through a inoculation nozzle



6-6 Fermentation

6-6 Fermentation

6-6-1 Reception of Tank Seed

1) The manhole, the sampling valve Ⓢ , the bottom valve Ⓐ , the valve Ⓓ and the valve Ⓔ in Fig. 6-6-1, of the fermentor used are closed.

2) Opening the seed receiving valve Ⓘ in Fig. 6-6-1, receive the tank seed in the fermentor.

3) When the tank seed has been received, close the seed receiving valve Ⓘ in Fig. 6-6-1.

6-6-2 Reception of Saccharified Liquid and Fermentation

1) The saccharified liquid is received in the fermentor where the tank seed already has been.

2) Opening the saccharified liquid receiving valve Ⓑ in Fig. 6-6-1, start the medium pump (P-102) for feeding the saccharified liquid. So, the first reception of the saccharified liquid (28.7 kl) begins.

3) After receiving the liquid, close the valve Ⓑ in Fig. 6-6-1.

4) Open the valve on the air line (PA) in Fig. 6-6-1 and supply the air from the sparger at the rate of 1000 Nl/min. into the fermentor, regarding the indication of the metaltube rotameter, for 8 hours.

5) The regulation of the temperature of the fermentor can be performed by flowing the 1st water to the lower cooling coil.

   Maintain the temperature at 32 °C.

6) 6 hours later after the first reception of the liquid has ended, receive the second liquid feed (31.7 kl).

7) When the second reception is finished, the stirrer which is set on the side wall of the fermentor is started.

8) 6 hours later after the second reception of the liquid has ended, receive the third liquid feed (31.7 kl).

9) After all, the volume operated in the fermentor will become 96.3 kl. After the reception of the 3rd liquid feed, stop the stirrer set on the side wall of the fermentor.

10) Cool further the fermentor by flowing the 1st water to the upper cooling coil.

11) Regarding the thermometer inserted to the wall of the fermentor, regulate the fermentation temperature by controlling the flow of the 1st water into the coils.

12) Regulate the temperature between 32 °C and 34 °C as possible as you can.

13) Usually, the fermentation can be finished within 80 hours, so, the end time of the fermentation in the working schedule is decided to be 86 hours later after the end of the first reception of the saccharified liquid.

14) Open the manhole of the fermentor.

15) Start the stirrer set on the side wall of the fermentor in order to mix the broth.

16) Open the bottom valve (A) and the valve (D) in Fig. 6-6-1 and start the main fermentor pump (P-202) for transferring the broth to the screen filter (K-202).

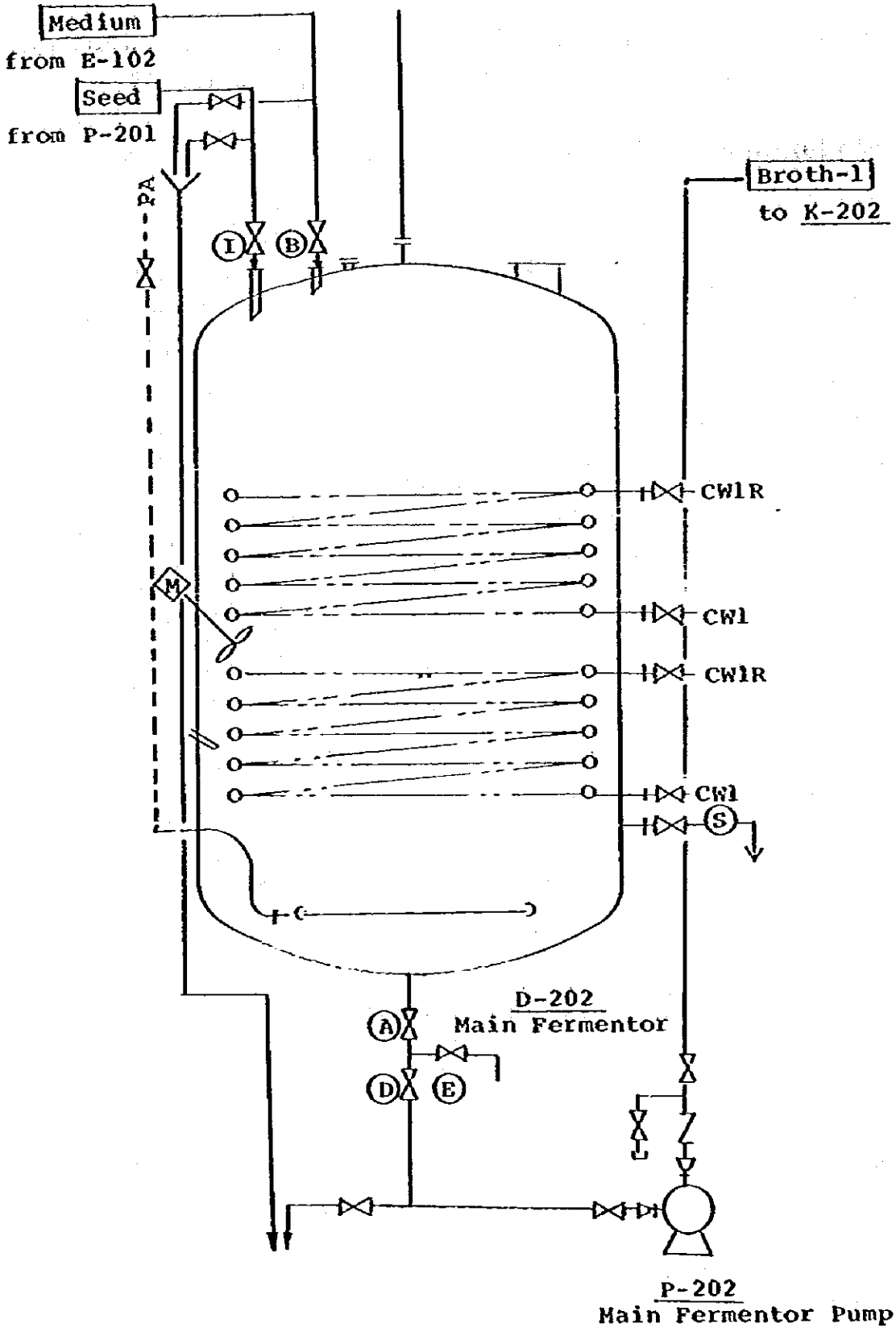
17) When the level of the broth in the fermentor descends to below the propeller of the stirrer, stop it.

18) After the broth has been transferred, close the valve Ⓓ in Fig. 6-6-1 and open the valve Ⓔ in Fig. 6-6-1.

19) Wash the inside of the fermentor by a hose with the 1st water, from the manhole.

20) Inspect the inside of the fermentor.

Fig.6-6-1 Main Fermentor



6-7 Broth Out

6-7 Broth Out

6-7-1 Screen Filter

1) Before transferring the broth to the screen filter (K-202) start the stirrer of the fermentor.

2) The switches of the components in the screen filter (K-202) are put on in order, as following mentioned.

   1. Belt-Conveyer (K-203)
   2. Screw-Conveyer (K-202)
   3. Screw-Press (K-202)
   4. Brush-Scraper (K-202)

3) Open the bottom valve of the fermentor (A) in Fig. 6-6-1 gradually and start the main fermentor pump (P-202) to send the broth (Broth-1) from the fermentor to the screen filter.

4) The broth is flowed on to the sieve of the screen filter.

   The sludge remains on the sieve and the filtrate drops down into the broth pit (D-203). The sludge can be scrapped into the screw-conveyer by the brush-scraper moving on the sieve.

   In the following, the filtrate is mentioned as Broth-2.

5) The sludge is transferred to the screw-press by the screw-conveyer and is separated to extract and remnant by the hard pressure of the screw-press. The extract drops into the broth pit and the remnant is sent out on the belt-conveyer (K-203) by the screw-press. Then, the sludge is transferred to the sludge yard by the belt-conveyer.

6) If the flow rate of the broth-1 overcomes the capacity of the screen-filter, the recovery of the broth-2 becomes worse. So, the supply of the broth-1 has to be controlled by the valve (J) in Fig. 6-7-1.

7) When the broth-1 has been filtered, stop the main fermentor pump (p-202).

8) Stop the operation of the screen filter by putting off the switches in order, as mentioned below.

①	Brush-Scraper	(K-202)
②	Screw-Press	(K-202)
③	Screw-Conveyer	(K-202)
④	Belt-Conveyer	(K-203)

6-7-2 Broth Tank

1) Open the broth-2 receiving valve Ⓑ in Fig. 6-7-2, of the broth tank (D-203) and close the bottom valve Ⓐ in Fig. 6-7-2, of the broth tank.

2) The broth-2 in the broth pit (D-203) is transferred to the broth tank (D-203) by the broth pump (P-203).

3) The transfer rate of the broth-2 has to be balanced with the rate of the filtration.

So, the transfer rate of the broth-2 is controlled by the valve Ⓚ of the broth pump in Fig. 6-7-1.

4) When the broth-2 has been transferred, stop the broth pump and close the broth-2 receiving valve Ⓑ in Fig. 6-7-2, of the broth tank.

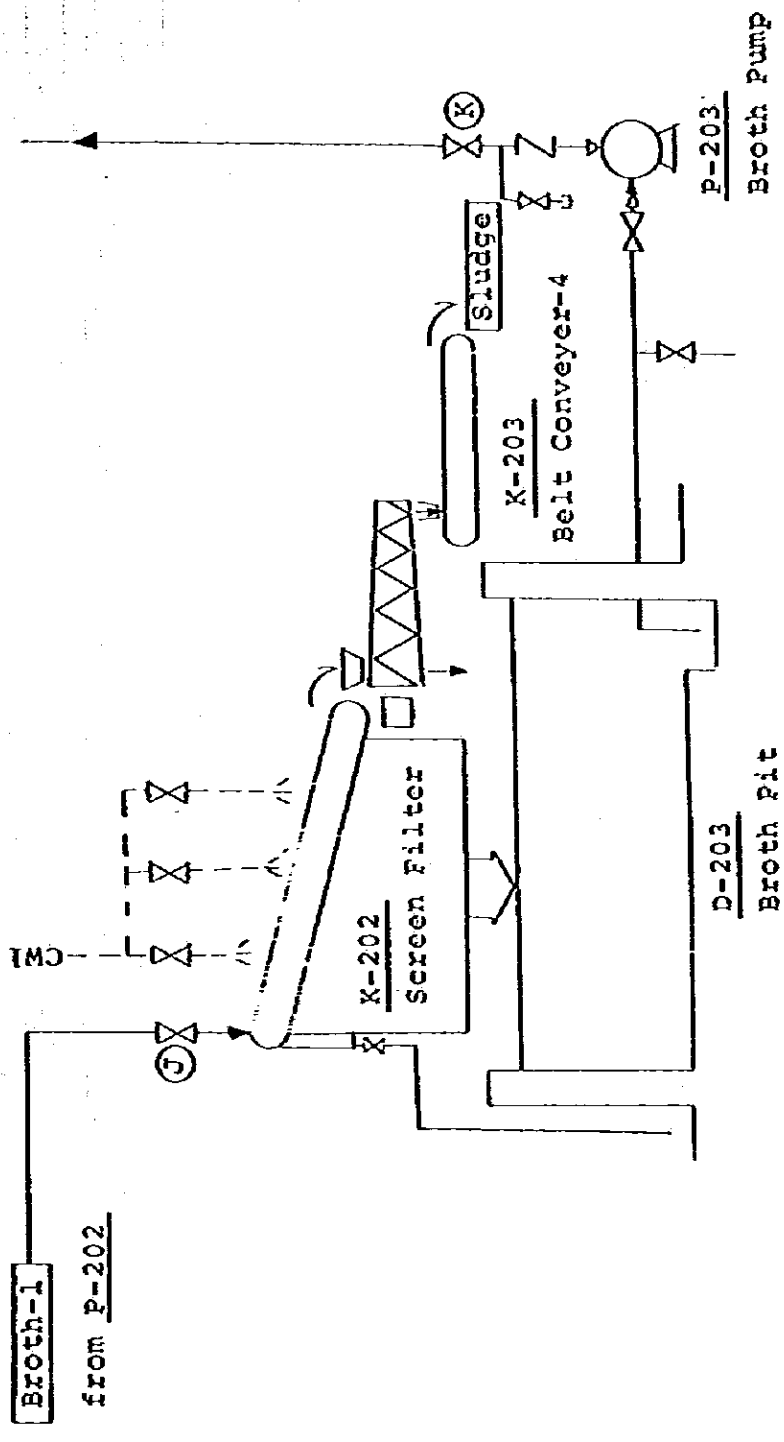
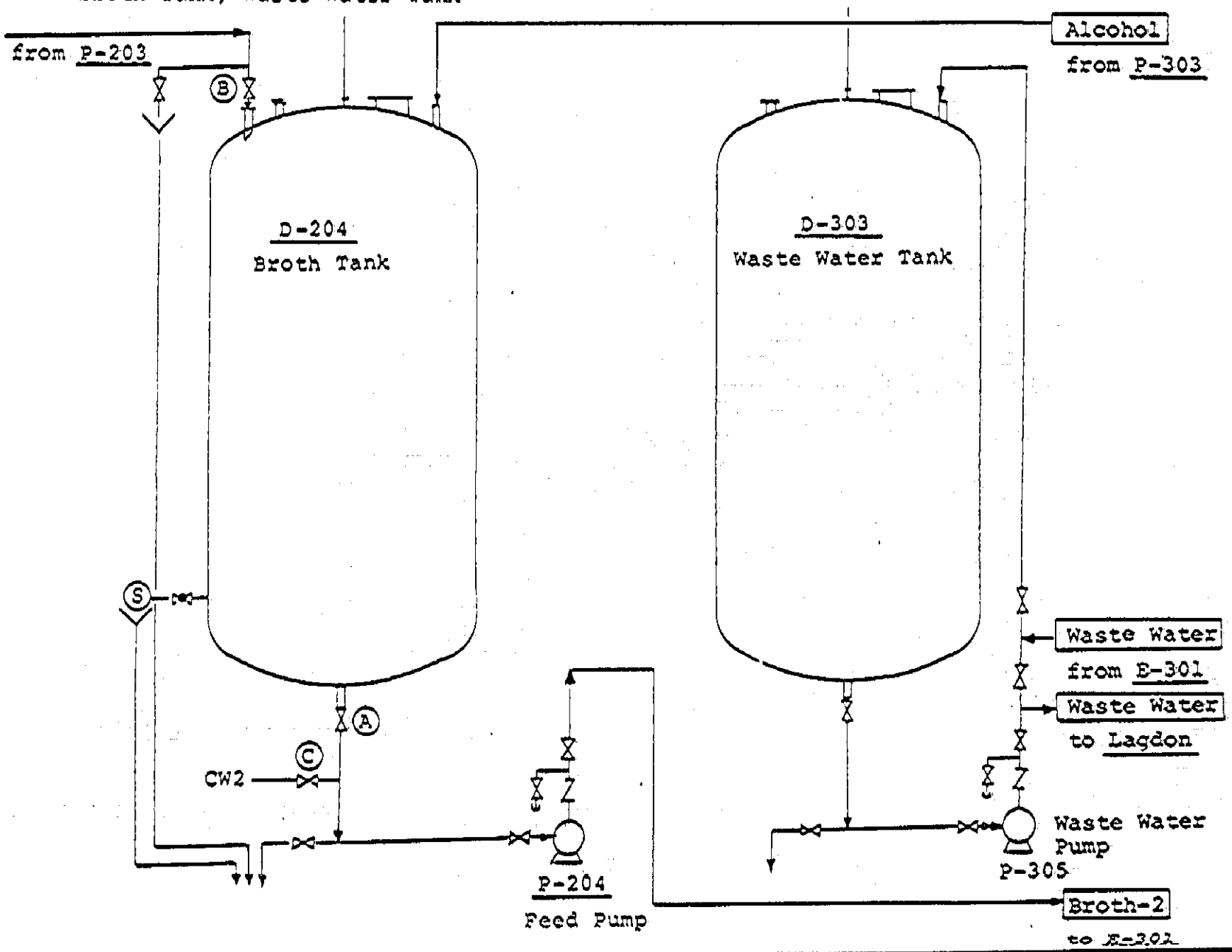


Fig.6-7-1 Screen Filter

Fig.6-7-2 Broth Tank, Waste Water Tank



6-8 Distillation

6-8 Distillation

6-8-1 Operation with Water

1) Arrangements for operation with water

① Supply the 1st water for sealing to the mash column bottom pump (P-301) and the concentration column bottom pump (P-302).

② The controller of broth feed (FIC-301) is put on. Start the broth feed pump (P-204) and send the 2nd water to the mash column (C-301) from the valve Ⓒ in Fig. 6-7-2.

③ The 2nd water which has entered into the top of the mash column drops down through each tray, staying there for a certain time, to the bottom of the column. Then, the 2nd water can be discharged through the valve Ⓑ and the valve Ⓒ in Fig. 6-8-1.

④ Making sure of the discharge from the valve Ⓒ in Fig. 6-8-1, stop the broth feed pump (P-204) and close the valve Ⓒ in Fig. 6-7-2.

⑤ Flow the 2nd water to the overhead condenser (E-302), the vent condenser (E-303) and the product cooler (E-304).

⑥ The instruments other than the FIC-301, for controlling the distillation system are switched on. They are LIC-302, FIC-303, TJR-304, LIC-305 and TIC-307.

⑦ The valve Ⓓ of the rotameter FI-308 in Fig. 6-8-1 is closed and the valve Ⓔ of the rotameter FI-309 in Fig. 6-8-1 is opened. These operations are performed to recycle alcohol vapor containing water vapor for concentrating the alcohol vapor. The recycling process is called as "reflux".

⑧ The hand-operation valves are made to be opened or closed according to indications.

2) Operation with Water

① Set the TIC-307 to control the temperature of the bottom in the mash column at 100 °C. The injection of steam into the mash column bottom has to be performed gradually.

② The steam raises the temperature of the inside of the column gradually.

③ Still, the rising of the temperature continues. And the water in each tray of the mash column begins to boil.

④ Moreover, the steam can extend to the foam breaker (D-304), overflowing from the top of the mash column. Next, the steam comes out from the top of the foam breaker and goes down into the bottom of the concentration column (C-302).

⑤ In the foam breaker, some of the steam can be condensed to form water and it goes out from the bottom of the foam breaker and enters into the top of the mash column.

⑥ The steam which has entered into the concentration column rises along the column and makes the whole column hot.

⑦ Set the FIC-301 to control the feed rate of the 2nd water at 1 kl/hr and make the broth feed pump (P-204) start for supplying the 2nd water to the mash column.

⑧ At the bottom of the concentration column, the valve Ⓕ in Fig. 6-8-1 is opened and the valve Ⓖ in Fig. 6-8-1 is closed.

⑨ Start the mash column bottom pump (P-301).

⑩ Make the pre-heater (E-301) ready to use, by operating the valves.

⑪ Raise the set point of the TIC-307 gradually and the temperature of the mash column can rise slowly.

⑫ TIC-307 is controlled so that the temperature of the top of the mash column is stabilized at 95 °C.

6-8-2 Mash Column

1) Continuing the operation with water, the temperature of the top of the mash column, which can be measured by the sensor TE-304-③, reaches to 95°C.

   If the fluctuation of the temperature is a little, the 2nd water fed to the mash column can be exchanged with the broth-2 from the broth tank for beginning the distillation.

2) The broth-2 is warmed to about 80°C in the preheater with the waste water from the mash column and is sent to the top of the mash column.

3) The broth-2 sent to the top of the mash column goes down through each tray of the column.

   The alcohol vapor generated from the broth-2 acts similar way as that of the steam mentioned in clause of 6-8-1 "operation with water".

4) The waste water at the bottom of the mash column passes through the valve Ⓑ in Fig. 6-8-1. Then, the waste water is sent to the pre-heater by the mash column bottom pump (P-301) and warms the broth-2 there. Finally the waste water is discharged into the waste water tank (D-303).

5) The waste water level at the bottom of the mash column is controlled with the LIC-302.

6) Gradually, increase the feed rate of the broth-2 and fix the control point of the FIC-301 at the directed value (3.8 kl/hr).

7) The fluid accumulating at the bottom of the concentration column is recycled to the top of the mash column by the concentration column botton pump (P-302).

   So, start the pump (P-302).

8) The mash column is operated under these conditions.

broth feed rate	3.8	kl/hr
temperature of feed broth	80	°C
temperature of column		
top (TE-304-③)	95	°C
middle (TE-304-②)	102	°C
bottom (TE-304-①)	108	°C

9) The temperatures of the column are recorded on the chart of the recorder (TJR-304).

6-8-3 Concentration Column

1) The alcohol vapor from the mash column enters to the bottom of the concentration column and rises through each tray along the column. Then, the vapor goes out from the top of the column and flows into the overhead condenser (E-302), in which the vapor is cooled to be condensed with the 2nd water.

2) The mixture of vapor and liquid of the ethanol cooled in the overhead condenser, is further cooled in the vent condenser (E-303) with the 2nd water.

3) The regulation of temperatures in the two condensers can be conducted by controlling the flow rate of the 2nd water regarding the indications of the two thermometers, TI-343 and TI-347. So, regulate the TI-343 at 74°C and the TI-347 at 70°C.

4) The ethanol cooled in the vent condenser returns to the top of the concentration column through the metal tube rotameter FI-309.

5) The three valves which are set at the 21st, the 23rd and the 25th tray of the concentration column, respectively, are opened to extract the components having high boiling points, continuously.

The extracts are cooled in the fusel cooler (E-305) and transferred to the fusel decanter (D-301) by the fusel discharge pump (P-306).

6) In the decanter, the fusel oil in the liquid separates to the upper part, so the fusel oil can overflows from the decanter into the fusel oil tank (D-302). The lower part of the liquid returns into the bottom of the concentration column.

7) Make the flow rate of the reflux, which is indicated in the rotameter FI-309, become to 1340 l/hr., by controlling the TIC-307 which regulates the FIC-303 which regulates the injection of steam into the mash column.

8) When the indication of the rotameter FI-309 becomes 1340 l/hr., open the valve Ⓓ in Fig. 6-8-1.

So, a portion of the reflux can be removed as product and it goes into the product cooler (E-304). The rate of removal from the reflux must be regulated at 335 l/hr., regarding the indication of the rotameter FI-308.

9) The ethanol cooled to 35°C in the product cooler is measured of its volume continuously with the volumetric flow integrater FQI-310. So, the ethanol which has been measured of its volume can be taken as product of 95%V/V ethanol.

10) The product ethanol is transferred into the alcohol checking tank (D-305).

11) The concentration column is operated under these conditions mentioned below.

temperature of column		
	top (TE-304-⑥)	79 °C
	middle (TE-304-⑤)	84 °C
	bottom (TE-304-④)	95 °C
temperature of reflux		70 °C
temperature of fusel cut		88 ∿ 90 °C
flow rate of reflux (FI-309)		1340 l/hr.
flow rate of product (FI-308)		335 l/hr.
ratio of reflux to product		4.0

12) After making sure that the concentration of the product ethanol in the checking tank is over 95 %V/V, it is transferred to the alcohol storage tank (T-301) by the transfer pump (P-303).

13) If the concentration is below 95 %V/V, the ethanol must be transferred to the broth tank (D-204) by the transfer pump (P-303). It is mixed there with ethanol fermentation broth and will be distilled again.

14) The temperature of the column are recorded on the chart of the recorder (TJR-304).

6-8-4 Stop of Operation

1) The product ethanol in the checking tank is transferred to the storage tank to avoid entrance of the diluted alcohol by water distillation.

2) Exchange the feed of broth-2 with the feed of the 2nd water.

3) Waiting for a while, the temperature of the top of the mash column begins to rise.

4) Also, the concentration column takes similar changes. Then, the water portion of the vapor in the concentration column increases.

The vapor of low concentration of ethanol in the column is cooled to liquid with the condensers and the cooler. The liquid goes into the alcohol checking tank (D-305) through the by-pass of the FQI-310.

If the concentration is below 95 %V/V, the ethanol must be transferred to the broth tank (D-204) by the transfer pump (P-303). It is mixed there with ethanol fermentation broth and will be distilled again.

5) When the temperature of the top of the mash column reaches to 100°C, that of the concentration column may have become near 90°C.

6) When the starts of the two columns become similar as now mentioned, decrease the supply of steam gradually and finally stop it by controlling the TIC-307.

7) Stop the mash column bottom pump (P-301) and the concentration column bottom pump (P-302).

8) Cease to supply of the 2nd water by stopping the feed pump (P-204).

9) To prevent vacuum from forming in the columns, open the exhaust valves of the columns and the lines.

10) Stop the supplies of the 2nd water to the condensers and coolers.

Fig 6-8-1 Distillation-1

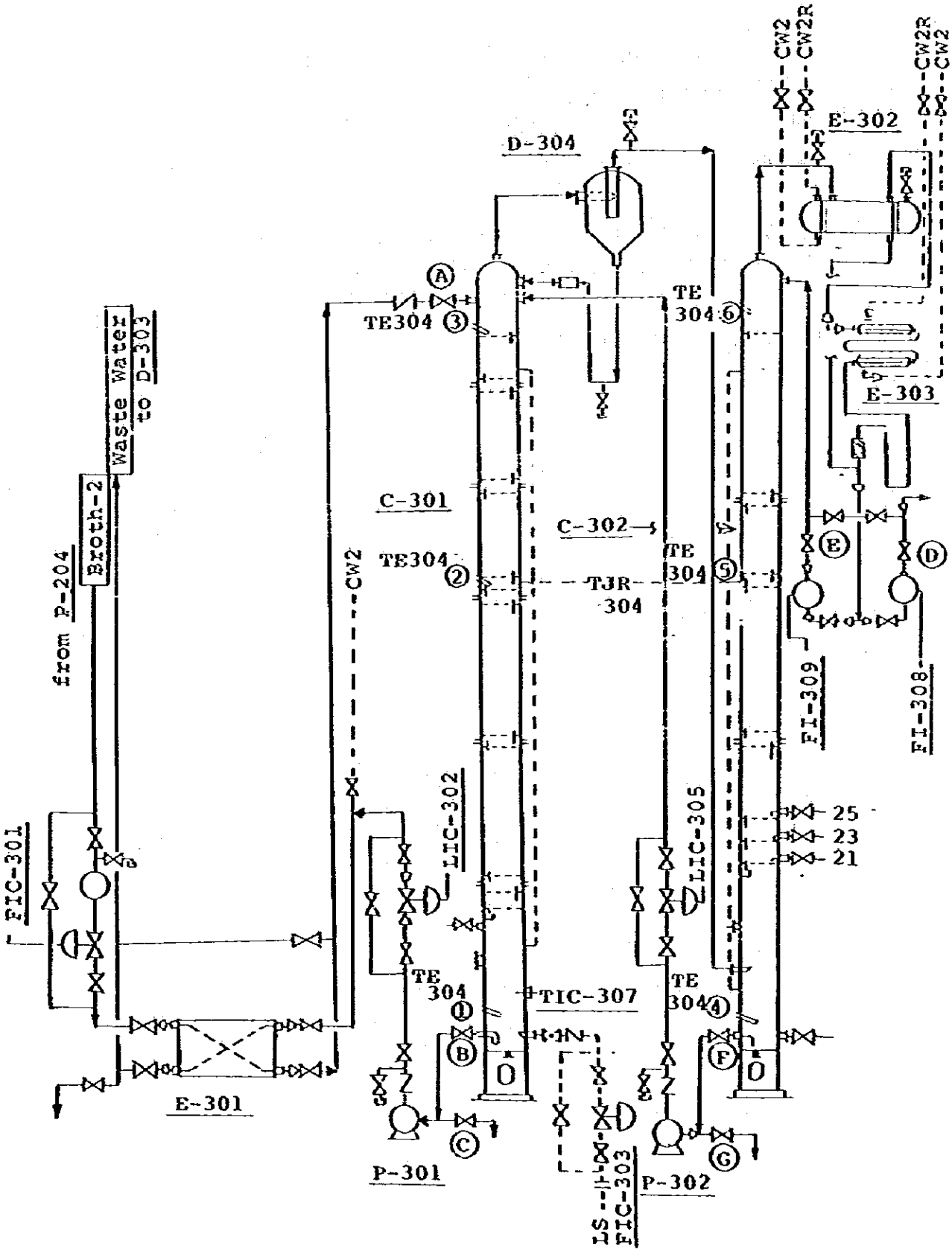
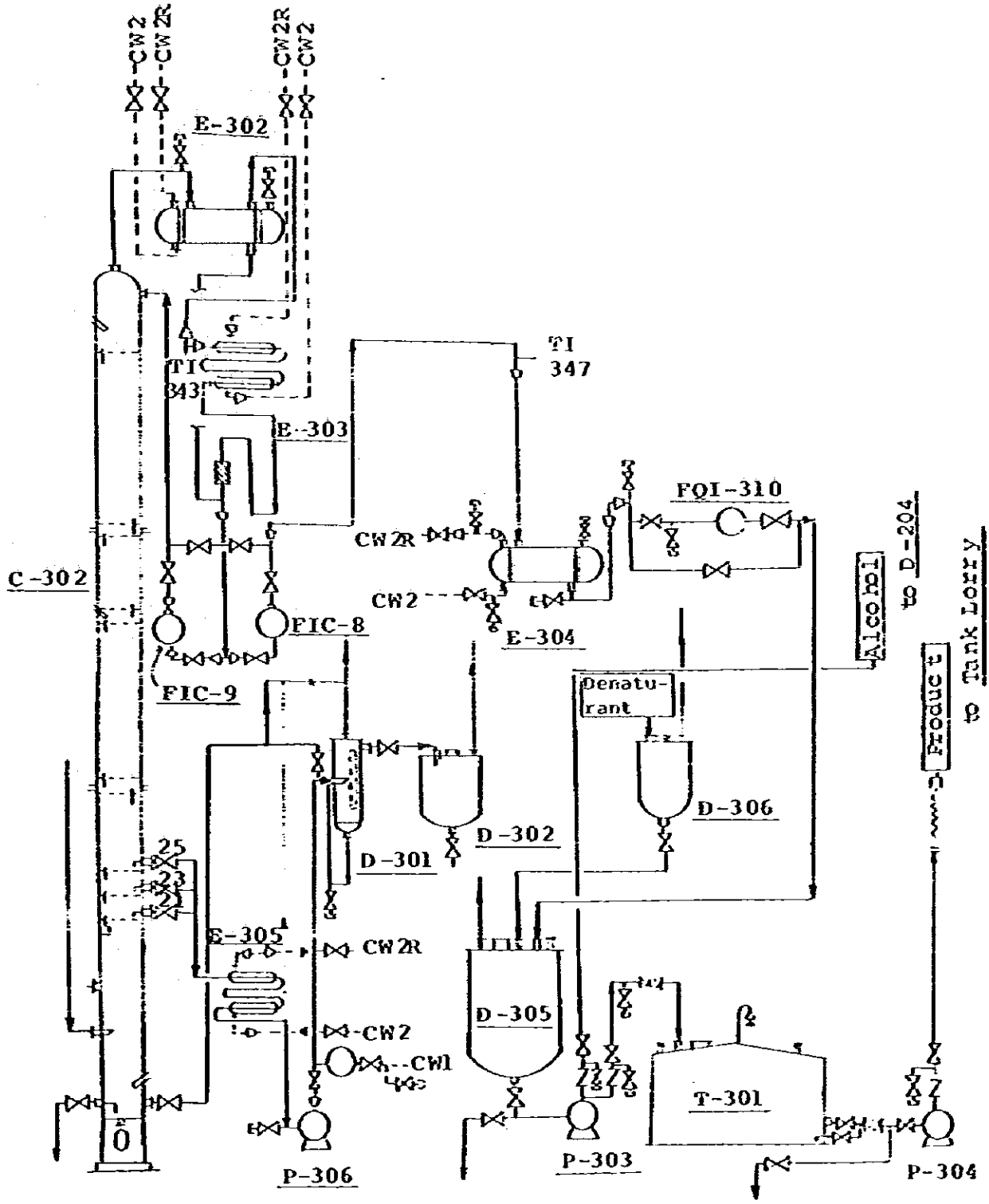


Fig 6-8-2 Distillation



6-9 Shipping of Product

6-9 Shipping of Product

The product ethanol in the alcohol storage tank (T-301) can be loaded to tank lorries along the product shipping line by the product pump (P-304) in Fig. 6-8-2.

7. Action for Emergency

7-1 General

7-1 General

The effects of the troubles urgent such as stops of supplies of electricity, steam, air, water and so on in the plants on working, the actions for those emergencies and the starts of operations after restoration from those troubles will be discussed in the view of protecting equipment and maintaining processes normal.

The emergencies happen not only at single equipment and/or process, but also in more than two equipment and/or processes concomitantly. So, the states of emergencies vary according to cases.

If emergencies should happen, first, the protection of the equipment must be performed, then the actions for saving the processes from losing much should be taken. So, operators should be learned in the effects of emergencies and the actions to be done for them. And the operators must take the proper decisions and actions to prevent other emergencies from being induced, in the scenes of emergencies.

7-2 Action for Emergency and Start after Restoration

7-2 Action for Emergency and Start after Restoration

Urgent stop of operations for interruptions of electricity, water, air and steam

and

Starting of operations after restoration of utility supplies

Process	Actions at the happening of emergency	Actions before starting operations again
Crushing of Raw Materials	1) Stop feeding of raw materials. 2) Check the state of crusher which has been put off. 3) Check the state of cassava pit.	1) In cassava pit, the cassava crushed has precipitated at the bottom. Starting the stirrer, the precipitate puts heavy load on it, then some treatments are necessary to lower the load. 2) In crusher, if great amount of cassava remains, the cassava has to be taken out because of its heavy load at starting the crusher.

Process	Actions at the happening of emergency	Actions before starting operations again
Liquefing Process	1) At the time, temperature of cooking TK is below 80°C. ① Open the exhaust valve. ② Make sure that the temperature is below 80°C. 2) Temperature is above 80°C. If steam is not interrupted, steam is injected till the cooking temperature (132°C) taking care of the pressure gauge. 3) If cooking has been over, normal operations have to be performed till the end of transferring liquefied cassava milk.	1) Inject steam into cooking TK gradually. 2) Add α-Amylase to promote liquefing reaction easily. 3) When the stirrer is started, repeat switching of " on and off " several times for prevention of empty rotation.
Saccharifying Process	1) If the saccharified sol. is on transferring to fermentor, close the receiving valve of fermentor and stop the reception of saccharified solution.	1) Open the receiving valve and receive the saccharified sol. again. 2) Saccharified sol. on reaction has to be treated for the time longer than usual because emzyme reaction cannot be performed due to the temperature decrease less than 55 °C and also insufficient agitation of the liquid.

Process	Actions at the happening of emergency	Actions before starting operations again
Tank Seed Culture	1) If on sterilizing, open the exhaust valve and close the steam valves 2) On culture ① close the air line valve. ② Reduce the opening of exhaust valve and maintain the pressure inside at a certain level.	1) Inject steam gradually then start the stirrer, to begin sterilization again from the point stopped. 2) Open the air line valve and begin the culture again.
Fermentation	1) If on aeration, close the air line valve. 2) If on feeding of the saccharified sol.,take care of the temperature of fermentor. In the case of unusual rise of temperature, stop the feed.	1) Open the air line valve and begin fermentation again. 2) Making sure of supply of cooling water, feed the saccharified sol. again.
Screen Filter	1) Close the broth-1 receiving valve.	1) Open the broth-1 receiving valve and begin filtration again. Check the volume of broth in broth TK.

Process	Actions at the happening of emergency	Actions before starting operations again
Distillation	1) TIC-307 and hand-operation valves on the steam line must be closed, in order to prevent injection of steam into the mash column. 2) Close the valve for removing the reflux as product situating with rotameter FI-308. 3) Stop the broth-2 feed pump (P-204). 4) Stop the mash column bottom pump (P-301) and close the valve in front of it. 5) Stop the concentration column bottom pump (P-302) and close the valve in front of it. 6) Open the exhaust valves of mash column and concentration column for leaking gases. 7) Discharge the remainings in the two columns from their blow valves, respectively.	1) Close the blow valves of the two columns. 2) Inject steam into the mash column, operating the TIC-307, gradually. 3) Making sure of blowings of steam from the gas leak valves in the two columns, close them. 4) Begin to feed the broth-2. When the waiting time is rather long, there are scarcely to be distilled with water instead of the broth-2. 5) Following operations are same as mentioned in chapter-6, " operation manual ".

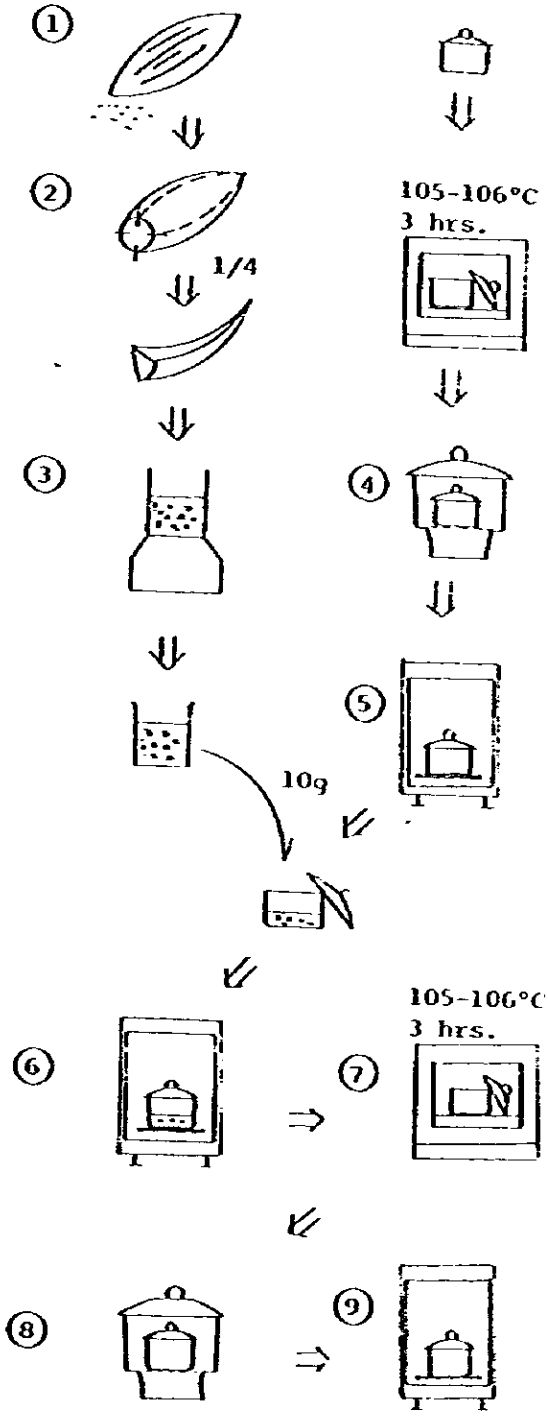
8. Analytical Methods

8-1 Raw Materials

8-1-1 Section: Raw Materials

Item : Moisture

Flow Diagram



Equipment and Reagents

Chemical balance

Electric mixer

Drying oven

Desiccator

Weighing bottle

Knife

Beaker

Procedure

* Preparation of sample

1. Remove the sand and soil on the surface of raw material.
2. Quarter the sample with a knife
3. Crush a piece of quatered sample using a electric mixer.

* Determination

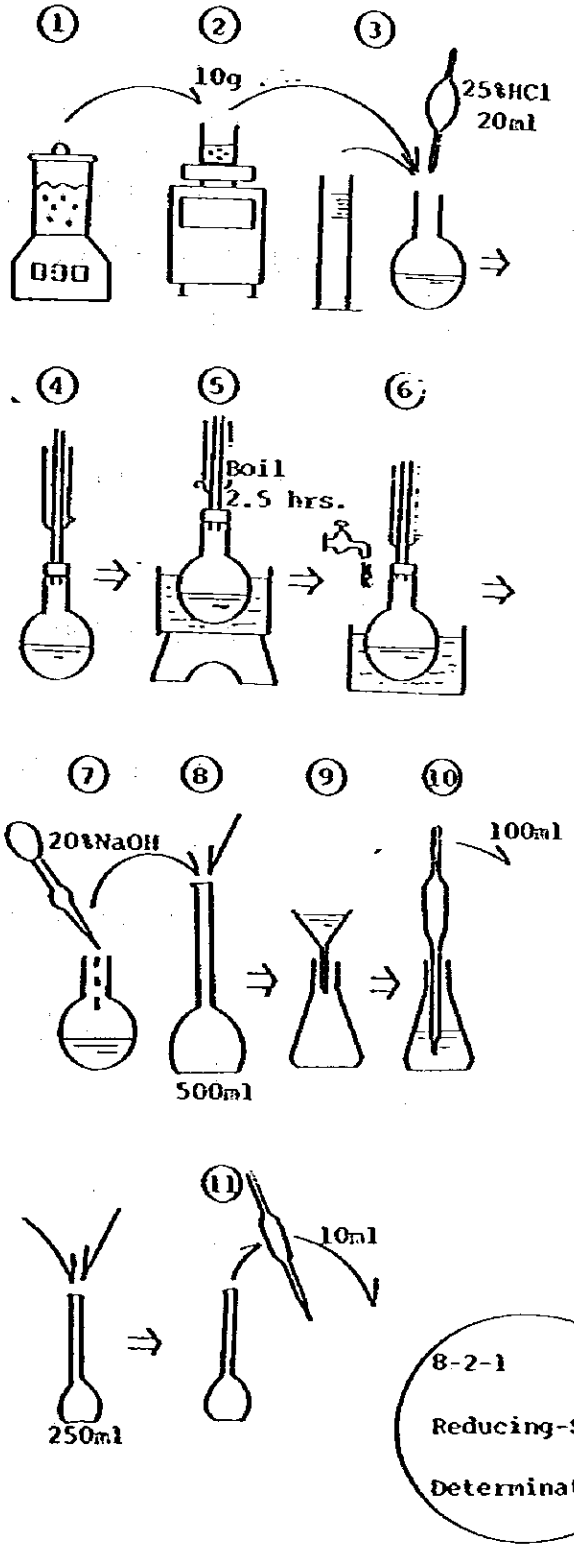
4. Dry a weighing bottle with cover in a electric drying oven (105 - 106°C 3 hrs.) and desiccator (30 min.).
5. Weigh the cooled weighing bottle with cover on a chemical balance. ..... A gr.
6. After mixing the crushed sample sufficiently, take about 10g of the sample into the weighing bottle and weigh with cover. ..... B gr.
7. Dry the sample to constant weight at 105 - 106°C for 3-5 hrs. in a drying oven.
8. Remove the bottle from the oven, and place into a desicator with over replaced on the bottle.
9. Cool for 30 min. in the desiccator and weigh. ..... C gr.
10. Calculate the moisture and dried matter content of sample as follow.

$$\text{Moisture}(\%) = \frac{B - C}{B - A} \times 100$$

8-1-2 Section: Raw Materials

Item : Total Sugar

Flow Diagram



Equipment and Reagents

Electric mixer

Balance

Water bath

200ml graduated cylinder

250,500ml volumetric flask

10, 20, 100ml volumetric pipet

Glass tube condenser

Funnel

500 ml rounded bottom flask

100 ml beaker

Filter paper or cotton cloth

25% HCl sol.

20% NaOH sol.

pH test-paper

Procedure

* Preparation of sample

1. Same as in the method of "Raw material; Moisture"

* Determination (Hydrolysis process)

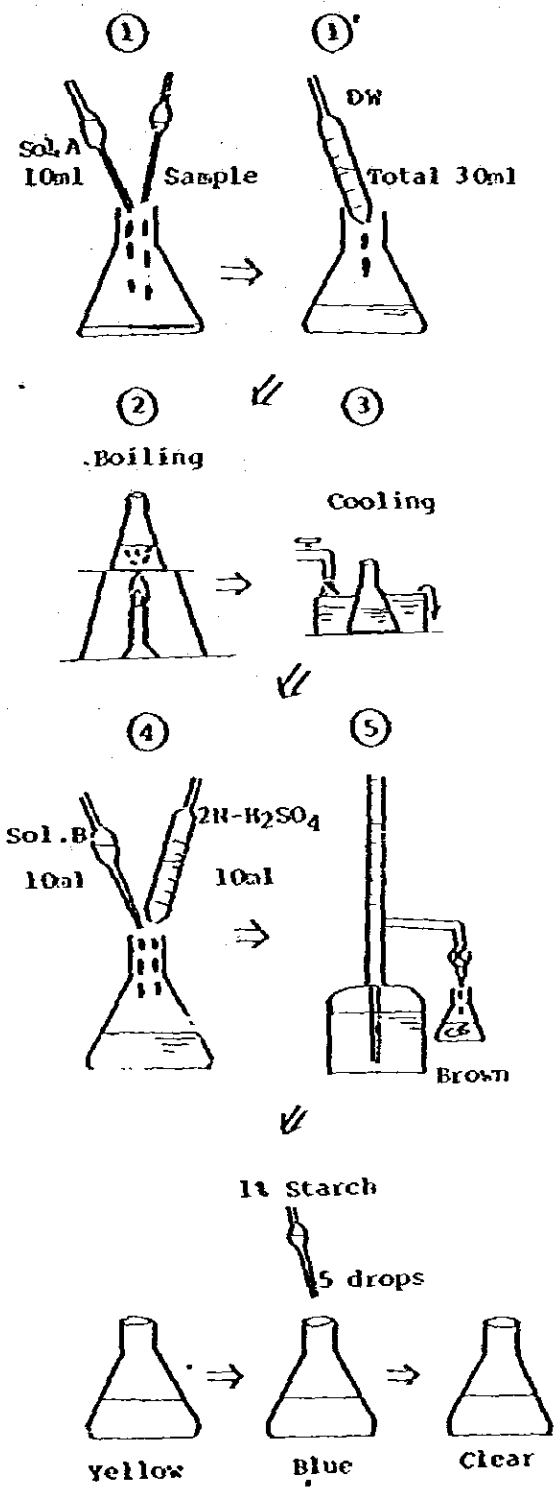
2. Weigh 10g of sample in a 100ml beaker using a balance.
3. Put the sample into a round bottom flask and 200ml of distilled water and 20ml of 25% HCl sol., (Wash the used beaker with a portion of distilled water and together into the 500 ml flask).
4. Set a glass tube condenser on the flask.
5. Hydrolyze the sample for 2.5 hrs. in a boiling water bath.
6. After hydrolysis, cool the sample in running water.
7. Neutralize the sample with 20% NaOH sol. in the range of pH: 6 - 7 using pH test paper.
8. Fill up to 500ml with distilled water using a 500ml volumetric flask.
9. Filtrate the diluted sample using a funnel with filter paper or cotton cloth.
10. Take 100ml of the filtrate by a 100ml volumetric pipet and dilute again to 250ml using a 250ml volumetric flask with distilled water.
11. Determine the sugar content using 10ml of the diluted sample by the "8-2-1, Reducing-sugar Determination".

8-2 Process Analysis

8-2-1-1 Section: Process Analysis

Item : Reducing Sugar (Modified Somogy's Method)

Flow Diagram



END

Equipment and Reagents

Erlenmeyer flask	100 ml
Volumetric pipet	1, 5, 10 ml
Graduated pipet	20 ml
Burner or Hot plate	
Wire net with asbestos	
Buret	25 ml
Solution A.	
Solution B.	
2N-H_2SO_4 sol.	
0.05N-Sodium-Thiosulfate sol.	
1% soluble starch sol.	

Procedure

Modified Somogy's Method

1. 10 ml of sol. A and the proper quantity of a sample (5 ∿ 25 mg as glucose) are put into a 100 ml Erlenmeyer flask. And distilled water is added to the mixture to make the total volume of the mixture to 30 ml by a graduated pipet.

2. Heat the mixture by a burner or a hot plate to boil within 2 minutes. And maintain the boiling exactly for 3 minutes.

3. Soon after, cool the mixture with a running water. In this operation, don't disturbe the mixture, not to expose the copper precipitate to oxygen in air.

4. 10 ml of sol. B and 10 ml of 2N-H_2SO_4 sol. are added to the mixture and are well mixed by shaking.

5. Immediately, the mixture has to be titrated with 0.05N-sodium-thiosulfate sol., 1% soluble starch sol. is used as indicator. When the colour of the mixture begins to be faded with the proceeding of the titration, add 5 drops of the indicator to the mixture.

6. At the time when the blue colour of the mixture disappears, the titration is ended. The amount of the titrant required is V ml. The blank test is conducted samely then the amount required for the blank test is V'ml. The quantity of reducing sugar in the sample is calculated as below.

$$1.449\ (V'-V)\ \text{mg as glucose}$$

Preparation of Reagents

a. Sol. A

Rochelle salt (Na,K-tartrate: $NaKC_4H_4O_6 \cdot 4H_2O$) 90 g
Sodiumphosphate tri-basic ($Na_3PO_4 \cdot 12H_2O$) 225 g
Dissolve above two chemicals into about 600 ml of distilled water.

Cupric sulfate ($CuSO_4 \cdot 5H_2O$) 30 g, dissolved in about 100 ml of distilled water.

Potassium iodate (KIO_3) 3.5 g, dissolved in 100 ml distilled water.

Add the above two solutions to the first mixture and fill up the solution to 1 L finally with distilled water.

b. Sol. B

Potassium oxalate ($K_2C_2O_4 \cdot H_2O$) 90 g
Potassium iodine (KI) 40 g
Dissolve above two chemicals with distilled water and make the volume to 1 L.

c. 0.05N-sodium-thiosulfate ($Na_2S_2O_3 \cdot 5H_2O$) sol.
Sodium-thiosulfate ($Na_2S_2O_3 \cdot 5H_2O$) 24.82 g
Sodium carbonate anhydrous 0.2 g
Dissolve the two chemicals to 1 L of distilled water.

Stock it in an amber reagent bottle at cold and dark place.

d. 1 % Soluble starch sol.

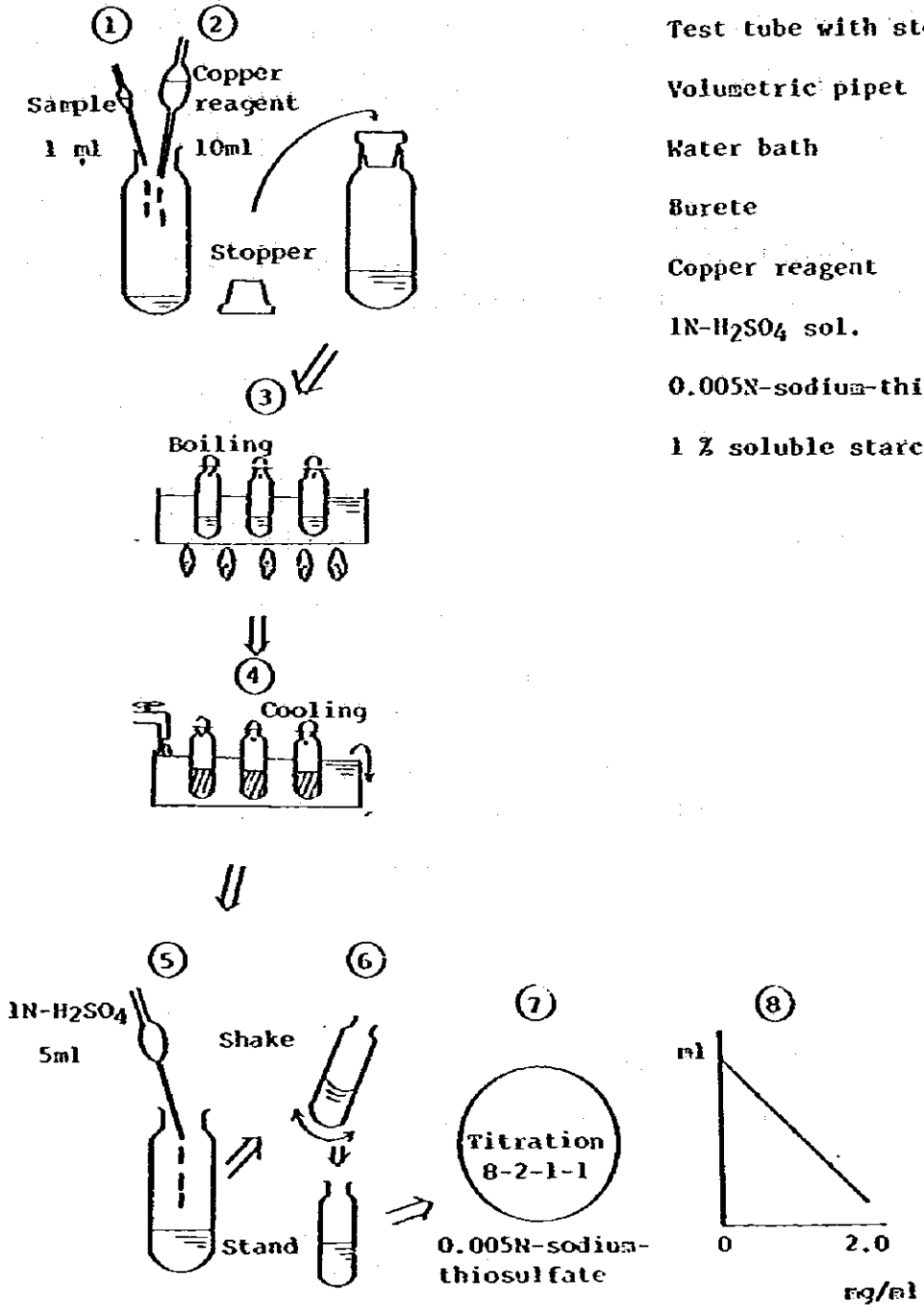
1 gram of soluble starch is kneaded with some water and is added into 100 ml of boiling distilled water.

Dissolve completely and boil for 1 minute. If necessary, the solution can be filterated with gauze.

8-2-1-2 Section: Process Analysis

Item : Reducing Sugar (Somogy Method)

Flow Diagram



Equipment and Reagents

Test tube with stopper	50 ml
Volumetric pipet	1, 5, 10 ml
Water bath	
Burete	25 ml
Copper reagent	
1N-H_2SO_4 sol.	
0.005N-sodium-thiosulfate sol.	
1 % soluble starch	

Procedure

Somogy Method

1. 1 ml of a sample (0.5 ∿ 2 mg/ml) is put into the test tube (50 ml, having a stopper)

2. 10 ml of copper reagent is added to the sample in the test tube. And the test tube is plugged with its stopper.

3. The mixture is boiled for 20 minutes in a water bath.

4. Then, the mixture is cooled with a running water.

5. The mixture is added with 5 ml of 1N-H_2SO_4 sol, and is mixed by shaking.

6. Stand it for 5 minutes.

7. Titrate it with 0.005N-sodium-thiosulfate sol. The procedure of the titration is similar as modified Somogy's method (the clause 8-2-1-1).

8. The standard samples of glucose are treated same as the sample. Their concentrations are 0, 0.5, 1.0, 1.5 and 2.0 mg/ml. Plot the amount of titrant to the concentration, so the standard curve can be obtained. Then, the concentration of the test sample can be read out from the standard curve.

Preparation of Reagents

a. Copper reagent

Sol. A 7 g of potassium iodine (KI) is dissolved in 1200 ml of distilled water. And 200 g of anhydrous sodium sulfate (Na_2SO_4) is dissolved to the solution gradually.

Sol. B 25 g of Rochelle salt is dissolved in 200 ml of distilled water. And 25 g anhydrous sodium carbonate (Na_2CO_3) is dissolved to the solution gradually.

Sol. C 1.6 g of NaOH is dissolved in 100 ml of distilled water.

Sol. D 13.15 g of cuppric sulfate ($CuSO_4 \cdot 5H_2O$) is dissolved in 100 ml of distilled water.

Sol. E 0.75 g of potassium iodate (KIO_3) is dissolved in 100 ml of distilled water.

Join the 5 solutions in this order, stirring them. And fill up to 1800 ml then stir for 5 minutes. Heat the solution at 95 ∿ 100 °C for 30 minutes in a water bath. After standing at room temperature over night, the solution is filtered with paper filters and is stocked in an amber reagent bottle at a dark and cool place.

b. 0.005N-sodium-thiosulfate sol.

Dilute the 0.05N-sodium-thiosulfate sol., prepared in modified Somogy's method, 10 times.

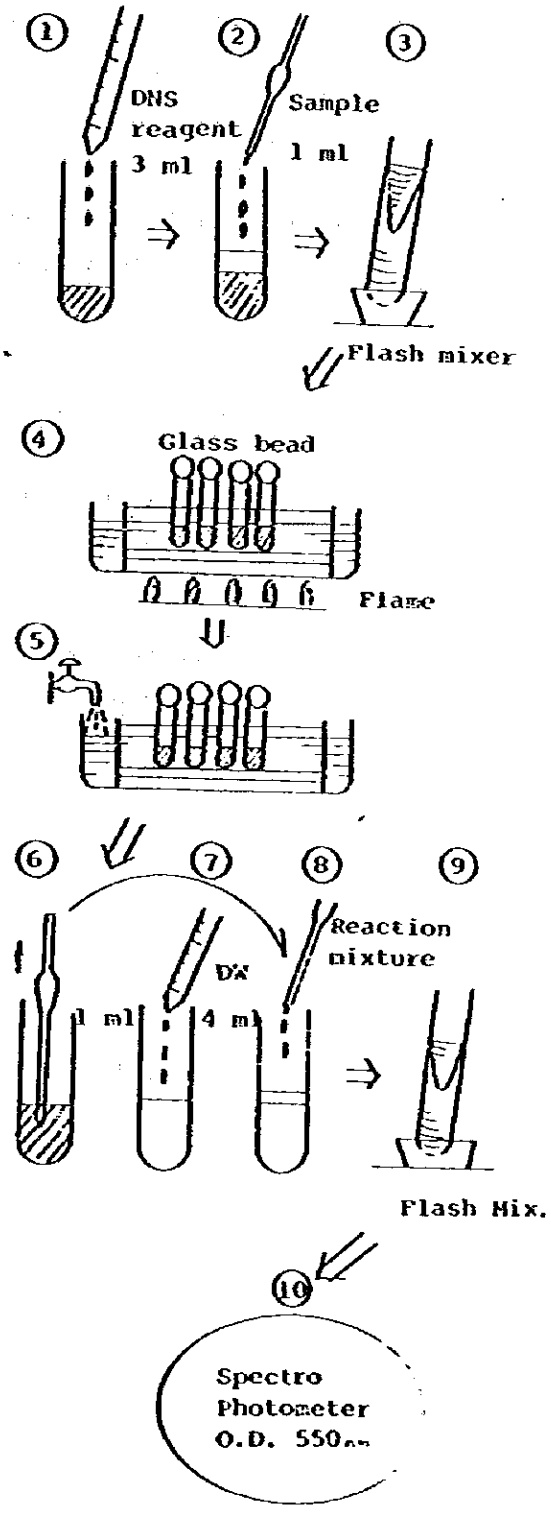
c. 1% Soluble starch sol.

Same as the preparation of modified Somogy's method.

8-2-1-3 Section: Process Analysis

Item : Reducing Sugar (DNS Reagent Method)

Flow Diagram



Equipment and Reagents

Test tube	Small
Volumetric pipet	1 ml
Graduated pipet	25 ml

Glass bead cover the lip of the T.Tube

Spectro-photometer

Glucose standard solution

DNS Reagent

Flash mixer

Water bath

Procedure

1. Dispense the DNS reagent into the small test tubes by the 3 ml.

2. 1 ml of a properly diluted sample (containing 0.5 mg/ml as glucose) is added to the reagent dispensed.

3. Mix well with a flash mixer.

4. The mixture is boiled in a water bath for 5 minutes, being covered on the mouth of the test tube with a glass bead. Brown colour appears.

5. Cool the mixture in running water.

6. 7, 8, 9
   Dilute the coloured reaction mixture 5 times with distilled water.

10. Measure the absorbance at 550 nm.

    The concentration is read out from the standard curve (0 ∿ 1 mg/ml as glucose). Usually, standard samples are measured every one set of test samples.

DNS Reagent

Distilled Water	1416 ml
3.5-Dinitro-Salicylic acid	10.6 g
NaOH	19.8 g

Mix the above three chemicals and dissolve them thoroughly.

Rochelle Salt (Na-K-tartrate)	306 g
Phenol (melt at 50 °C)	7.6 ml

Add the above two chemicals and dissolve.

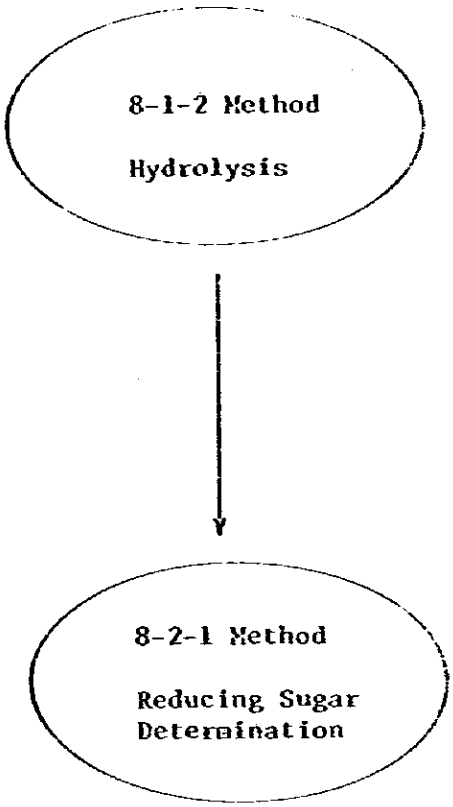
Then the solution can be stocked at room temperature.

Before using the solution, add Na-meta-bisulfite ($Na_2O_5S_2$) at 0.5 % W/V concentration to the solution.

8-2-2 Section: Process Analysis

Item : Total Sugar

Flow Diagram



Equipment and Reagents

Refer the 8-1-2 method and the 8-2-1 method

Procedure

Apply the 8-1-2 and the 8-2-1 methods.

1. Hydrolysis step

   50 ml of a sample is taken with a graduated cylinder and is put into a 500 ml round bottom flask. Then, the sample is treated according to the 8-1-2 method.

2. Reducing sugar determination

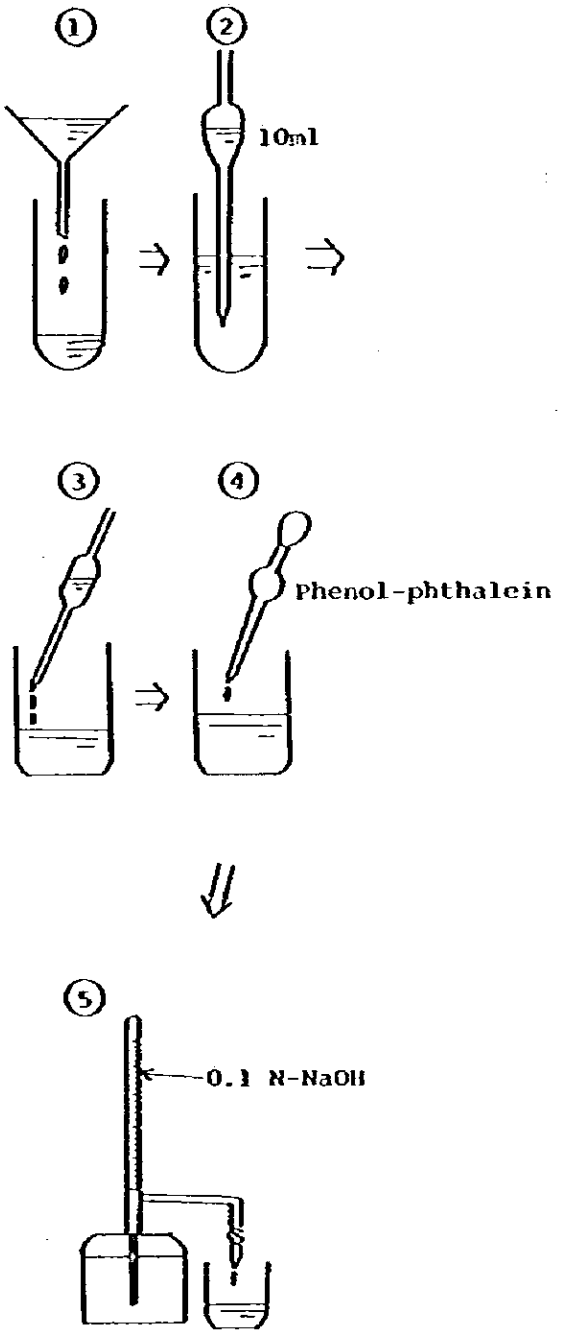
   The hydrolyzed and neutralized sample is diluted to the proper concentration.

   Then, the sample is determined of its sugar content according to the 8-2-1 method.

8-2-3 Section: Process Analysis

Item : Acid Value

Flow Diagram



Equipment and Reagents

Volumetric pipet	10 ml
Beaker	100 ml
Burette	50 ml with 0.1 ml Scale
Phenol phthalein sol.	1 %
o.1N-NaOH sol.	

Procedure

* Pretreatment of broth

1. Filter a sample with a paper filter.

* Determination

2. Take 10 ml of the filtrate with a volumetric pipet.

3. Put the filtrate into a 100 ml beaker.

4. Add a few drops of Phenolphthalein sol. to the filtrate as indicator.

5. Titrate the filtrate with 0.1N-NaOH sol. till the point of colour appearance as end of titration.

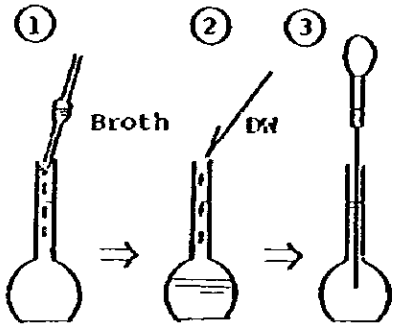
6. Acid value is expressed as ml of 0.1N-NaOH sol. required to neutralize 10 ml of broth.

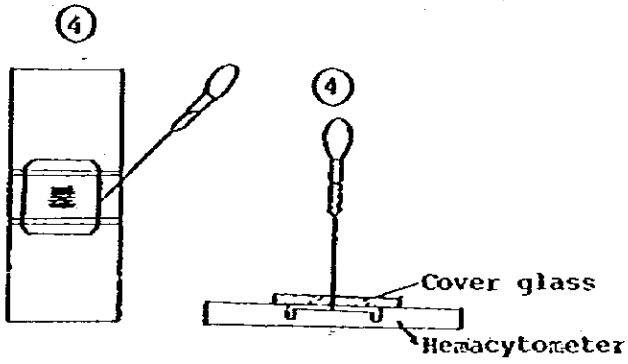
Acid value = 0.1N NaOH (ml)

8-2-4 Section: Process Analysis

Item : Cell Number

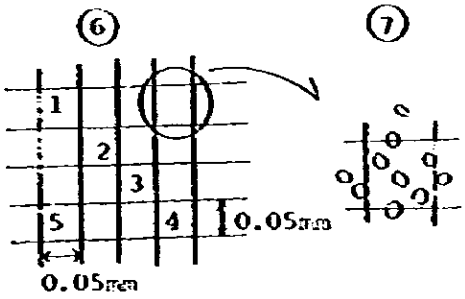
Flow Diagram





⑤

Microscopic Observation



Equipment and Reagents

Volumetric flask	100 ml
Volumetric pipet	1, 10 ml
Pasteur pipet	
Hemacytometer (Thoma's)	
Cover glass for Hemacytometer	
Microscope	
Counter	

Procedure

1, 2 Dilute a broth with distilled water, so as the cell number becomes near 10^7 cells per ml.

3. A portion of the diluted broth is taken off with a Pasteur-pipet.

4. A hemacytometer and a cover glass (specialized for hemacytometer) are pressed each other with fingers so as for them to adhere firmly. The diluted broth is supplied to the space between the hemacytometer and the cover glass with the Pasteur-pipet.

   The depth of the space is 0.1 mm.

5. The hemacytometer is put on the stage of a microscope.

6. Microscopic view of a hemacytometer.

   The lines are cut on at 0.05 mm spaces to one another. The cell numbers in the five squares are counted.

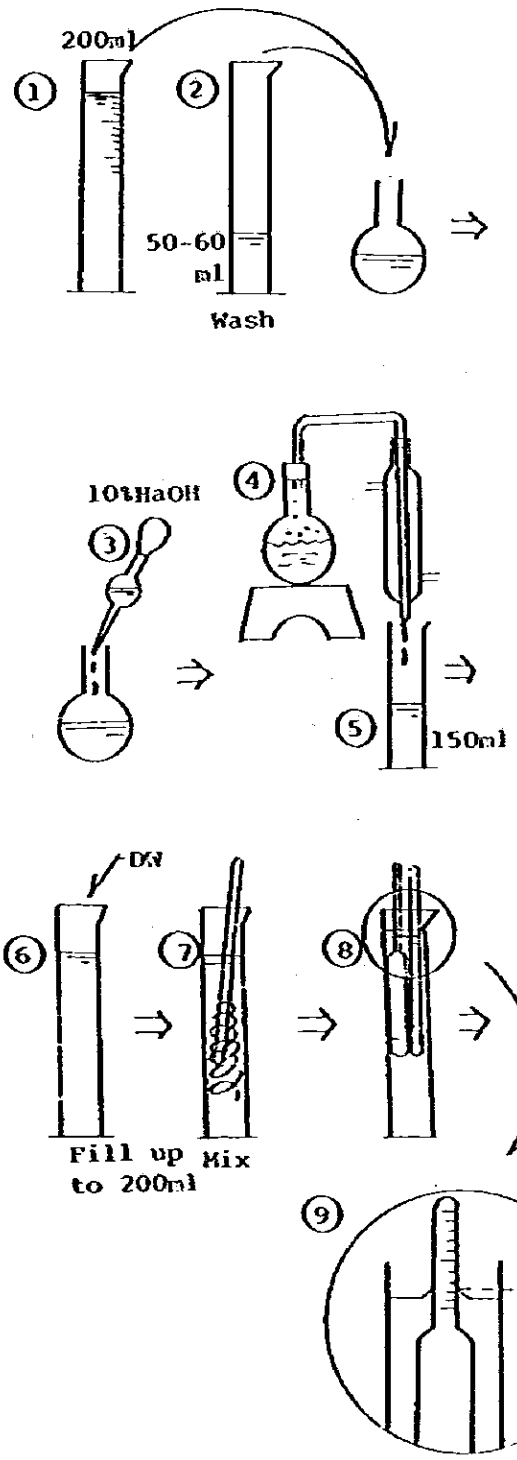
7. The cells on the upper and the right lines of a square can be counted and those on the down and the left lines must not be counted. In the case of Fig. (7) , the cell number in the square is six. The space which has 0.05 mm length, 0.05 mm width and 0.01 mm depth, has 0.00025 mm^3 of volume. If the average cell number of the five squares is 5.2 cells per ml, the cell suspension contains

$$5.2 \times \frac{10^3 mm^3}{0.00025\ mm^3}$$ cells per ml, namely 20.8×10^6 cells/ml.

8-2-5 Section: Process Analysis

Item : Ethanol

Flow Diagram



Equipment and Reagents

Alcohol distillation apparatus

200 ml graduated cylinder

500 ml round bottom flask

Alcohol meter

Thermometer

10% NaOH sol.

Distilled water

Procedure

1. Take 200 ml of sample into a 500 ml round bottom flask using a 200 ml graduated cylinder.

2. Wash the used cylinder with 50 ml of water, and put the washing water into the flask together.

3. Neutralize the sample with 10% NaOH sol.

4. Connect the flask to a Liebig-condenser with connecting tube.

5. Distill and take at least 150 ml of distillate into a 200 ml graduated cylinder.

6. Fill up to original volume of 200 ml with distilled water.

7. Shake well for mixing, and measure the alcohol volume percent using an alcohol-meter.

8. Read the temperature of liquid in the cylinder at the same time.

9. The alcohol volume percent at 15 °C is derived from the Gay-Lussac conversion table.

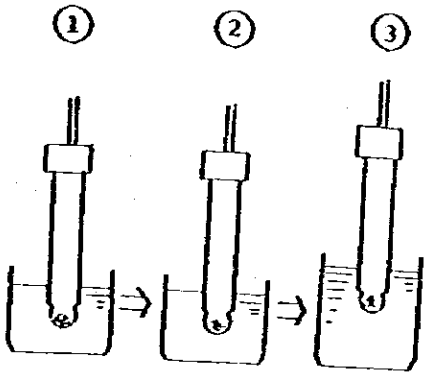
Tab.-8-2-1 Gay Lussac's table

Alcohol Meter (°C) \ (o)	1	2	3	4	5	6	7	8	9	10	11	12	13
15	1.0	2.0	3.0	4.0	5.0	6.0	7.0	8.0	9.0	10.0	11.0	12.0	13.0
16	0.9	1.9	2.9	3.9	4.9	5.9	6.9	7.9	8.9	9.9	10.9	11.9	12.9
17	0.8	1.8	2.8	3.8	4.8	5.8	6.8	7.8	8.8	9.8	10.8	11.7	12.7
18	0.7	1.7	2.7	3.7	4.7	5.7	6.7	7.7	8.7	9.7	10.7	11.6	12.5
19	0.6	1.6	2.6	3.6	4.6	5.5	6.5	7.5	8.5	9.5	10.5	11.4	12.4
20	0.5	1.5	2.5	3.4	4.4	5.4	6.4	7.3	8.3	9.3	10.3	11.2	12.2
21	0.4	1.4	2.3	3.3	4.3	5.2	6.2	7.1	8.1	9.1	10.1	11.0	11.9
22	0.3	1.3	2.2	3.2	4.1	5.1	6.1	7.0	7.9	8.9	9.9	10.8	11.6
23	0.1	1.1	2.1	3.1	4.0	4.9	5.9	6.8	7.8	8.7	9.7	10.6	11.5
24		1.0	1.9	2.9	3.8	4.8	5.8	6.7	7.6	8.5	9.5	10.4	11.3
25		0.8	1.7	2.7	3.6	4.6	5.5	6.5	7.4	8.3	9.3	10.2	11.1
26		0.7	1.6	2.6	3.5	4.4	5.4	6.3	7.2	8.1	9.0	9.9	10.8
27		0.5	1.5	2.4	3.3	4.3	5.2	6.1	7.0	7.9	8.8	9.7	10.6
28		0.3	1.3	2.2	3.1	4.1	5.0	5.9	6.8	7.7	8.7	9.5	10.3
29		0.1	1.1	2.0	2.9	3.9	4.8	5.7	6.6	7.5	8.4	9.2	10.1
30		0.0	0.9	1.9	2.8	3.7	4.6	5.5	6.4	7.3	8.1	9.0	9.8
31			0.8	1.8	2.7	3.5	4.4	5.2	6.1	7.0	7.8	8.7	9.5
32			0.7	1.7	2.5	3.3	4.2	5.0	5.9	6.7	7.5	8.4	9.2
33			0.6	1.5	2.3	3.1	4.0	4.7	5.6	6.4	7.2	8.1	8.9
34			0.5	1.3	2.1	2.9	3.8	4.5	5.4	6.2	7.0	7.9	8.7
35			0.3	1.1	1.9	2.7	3.5	4.3	5.2	6.0	6.8	7.6	8.4

8-2-6 Section: Process Analysis

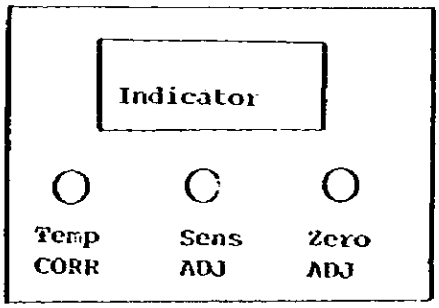
Item : pH

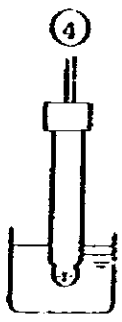
Flow Diagram



pH 6.86 pH 4.01 Test sample

Front View of pH meter





KCl saturated

Equipment and Reagents

Standard solution

pH 4.01

pH 6.86

Distilled water

Tissue paper

pH meter

Procedure

* Two points correction

Wash a electrode with distilled water and wipe drain with tissue paper.

1. pH 6.86 adjustment

   Standard sol. of pH 6.86 is put into a beaker.
   The top of the electrode is submerged in the solution.
   The indication of the pH meter has to be adjusted to 6.86 with the ZERO ADJ knob.

2. pH 4.01 adjustment

   It may be performed similar as above, except adjust the indication to 4.01 with the SENS ADJ knob.

* Measurement of sample

3. After two points correction, a sample can be measured as above and read out the indication.

* Preservation of electrode

4. Submerge the top of a electrode in KCl saturated sol.

8-3 Product

8-3-1 Section: Product

Item : Ethanol

8-2-5
Method

Equipment and Reagent

200ml graduated cylinder

Alcohol-meter

Thermometer

Procedure

Apply the 8-2-5 method.

See Gay Lussac's convertion table on next page.

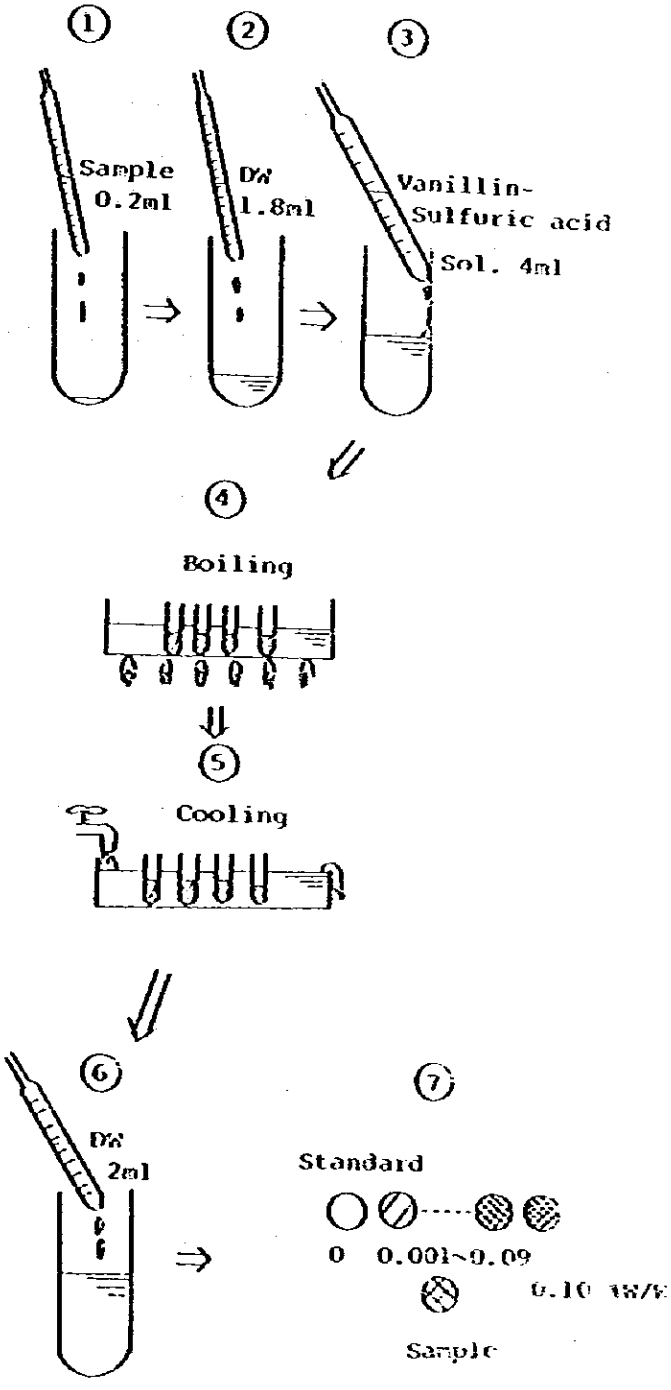
Tab,-8-3-1 Gay Lussac's table

Alcohol Meter / °C	(o) 90	91	92	93	94	95	96	97
15	90.0	91.0	92.0	93.0	94.0	95.0	96.0	97.0
16	89.7	90.8	91.8	92.8	93.8	94.8	95.8	96.8
17	89.5	90.5	91.5	92.6	93.6	94.6	95.6	96.6
18	89.2	90.2	91.3	92.3	93.3	94.3	95.4	96.4
19	88.9	90.0	91.1	92.1	93.1	94.1	95.2	96.2
20	88.7	89.7	90.8	91.8	92.9	93.9	95.0	96.0
21	88.4	89.5	90.5	91.6	92.6	93.7	94.7	95.8
22	88.1	89.2	90.2	91.3	92.4	93.4	94.5	95.6
23	87.9	89.0	90.0	91.1	92.1	93.2	94.3	95.4
24	87.6	88.7	89.7	90.8	91.9	93.0	94.1	95.2
25	87.4	88.4	89.5	90.6	91.6	92.7	93.8	94.9
26	87.1	88.2	89.2	90.4	91.4	92.5	93.6	94.7
27	86.8	87.9	89.0	90.3	91.1	92.2	93.4	94.5
28	86.5	87.7	88.7	89.8	90.9	92.0	93.1	94.3
29	86.2	87.3	88.4	89.5	90.6	91.7	92.9	94.1
30	86.0	87.1	88.2	89.3	90.4	91.5	92.7	93.8
31	85.7	86.8	87.9	89.0	90.2	91.3	92.4	93.5
32	85.5	86.6	87.8	88.9	90.0	91.1	92.3	93.4
33	85.2	86.3	87.4	88.6	89.7	90.8	91.9	93.1
34	84.8	85.9	87.1	88.2	89.4	90.5	91.6	92.8
35	84.6	85.7	86.9	88.0	89.2	90.3	91.5	92.6

8-3-2 Section: Product

Item : Fusel Oil

Flow Diagram



Equipment and Reagents

Test tube

Graduated pipet 1, 2, 5 ml

Water bath

Vanillin-Sulfuric acid sol.

Isoamylalcohol STD. sol.

0.001 ∿ 0.01 % W/W

Procedure

1. 0.2 ml of a sample is put into a test tube.

2. 1.8 ml of distilled water is added to the sample.

3. 4 ml of Vanillin-Sulfuric acid sol. is added to the mixture gently along the wall of the test tube.

4. Mix well by shaking and heat the mixture exactly for 3 minutes in a boiling water bath.

5. Cool the mixture with a running water.

6. 2 ml of distilled water is added to the mixture and the mixture is shaken to develope the colour appearance.

7. 15 minutes later, compare the colour with those of the standards which have been concomitantly treated same as the sample and determine the concentration.

Preparation of Reagents

a. Vanillin-Sulfuric Acid sol.

Vanillin ($CH_3O \cdot C_6H_3(OH) \cdot CHO$)	0.5 g
Conc. sulfuric acid	100 ml

0.5 g of Vanillin is dissolved with 100 ml of conc. sulfuric acid then the solution is stocked in an amber reagent bottle. Never use the reagent old over 10 days.

b. Isoamylalcohol Standard sol.

Isoamylalcohol ($(CH_3)_2CH_2CH_2CH_2OH$)	81 mg
95 %V/V Ethylalcchol	1000 ml

(Vanillin-Sulfuric acid reaction is not detected with the ethylalcohol)

81 mg of isoamylalcohol is dissolved with 1000 ml of 95 %V/V ethylalcohol. So, the concentration becomes 0.01 %W/W.

The series of standard concentrations from 0.001 to 0.01 %W/W has to be made.

The method is described, in followings.

A parts of 0.01 %W/W isoamylalcohol sol. and B parts of 95 %W/W ethylalcohol are joined. When the sum of A and B is fixed at 10, the newly established concentration becomes as below.

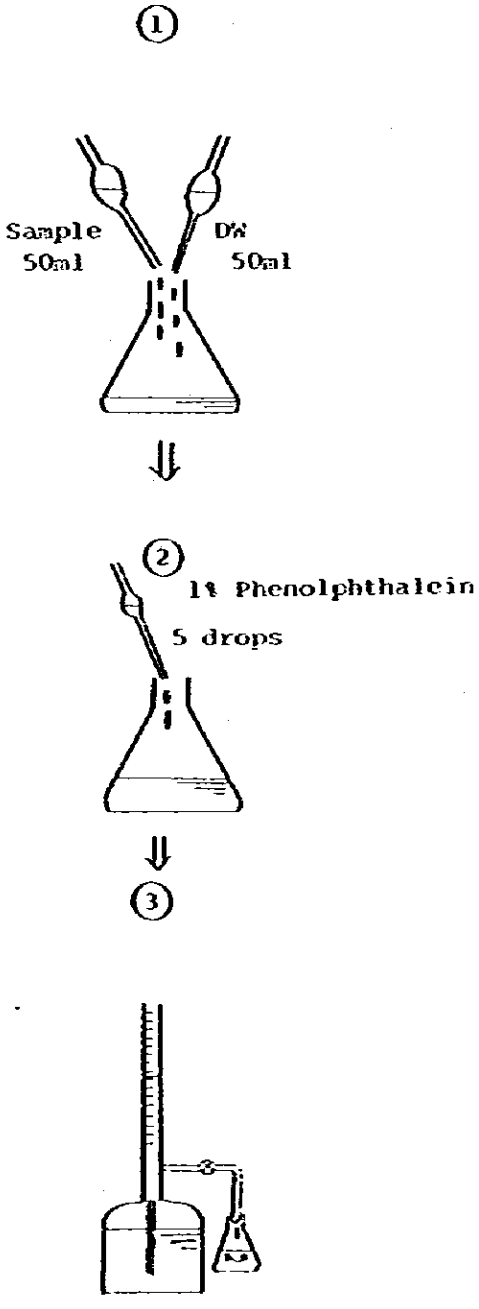
$$0.01 \times \frac{A}{A+B} \text{ \%W/W}$$

So, the series of concentrations of 10 steps can be easily obtained.

8-3-3 Section: Product

Item : Free Acids

Flow Diagram



Equipment and Reagents

Erlenmeyer flask	250 ml
Volumetric pipet	50 ml
Buret	10 ml

Phenolphthalein 1 % sol.

1/50N-NaOH sol.

Degased cold distilled water by reboiling and cooling.

Procedure

1. 50 ml of a sample and 50 ml of the degased cold distilled water are put into a 250 ml Erlenmeyer flask.

2. 5 drops of the phenolphthlin sol. are added to the mixture.

3. The mixture is titrated with 1/50N-NaOH sol. till the point when the mixture is coloured red slightly. The amount required for the neutralization is V ml.

4. The concentration of free acids is calculated as below.

$$\frac{V \times 0.0012}{40.5} \times 100 \quad (\%W/W \text{ as Acetic acid})$$

8-3-4 Section: Product

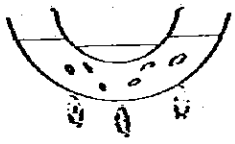
Item : Non Volatile Residue

Flow Diagram

①

120mmφ dish

Sample 100ml→20ml



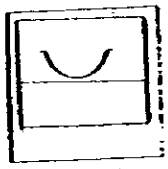
②④

30mmφ dish

20ml→Dry residue

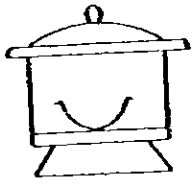
⑤

105～110°C

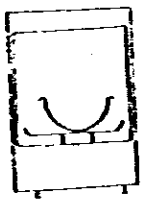


Dry Oven

⑥ ⑦



Desiccator



Chemical Balance

Equipment and Reagents

Evaporating dish	30,120 mmφ
Graduated cylinder	100 ml

Water bath

Surport for the dishes

Washing bottle with distilled water

Dry oven

Chemical balance

Desiccator

Procedure

1. Take 100 ml of a sample with a graduated cylinder of 100 ml and put into a evaporation dish with 120 mmφ.

2. Evaporate the sample near 20 ml on a water bath and transfer the content to the smaller evaporating dish with 30 mmφ, throughly by washing with some distilled water.

3. The smaller evaporating dish has been weighed of its dried weight by a chemical balance before use.

   Its weight is A mg.

4. The sample is dried up on the water bath.

5. The sample dried up is further dehydrated to the constant weight in a day oven at 105 ∿ 110 °C.

6. The dish is cooled in a desiccator.

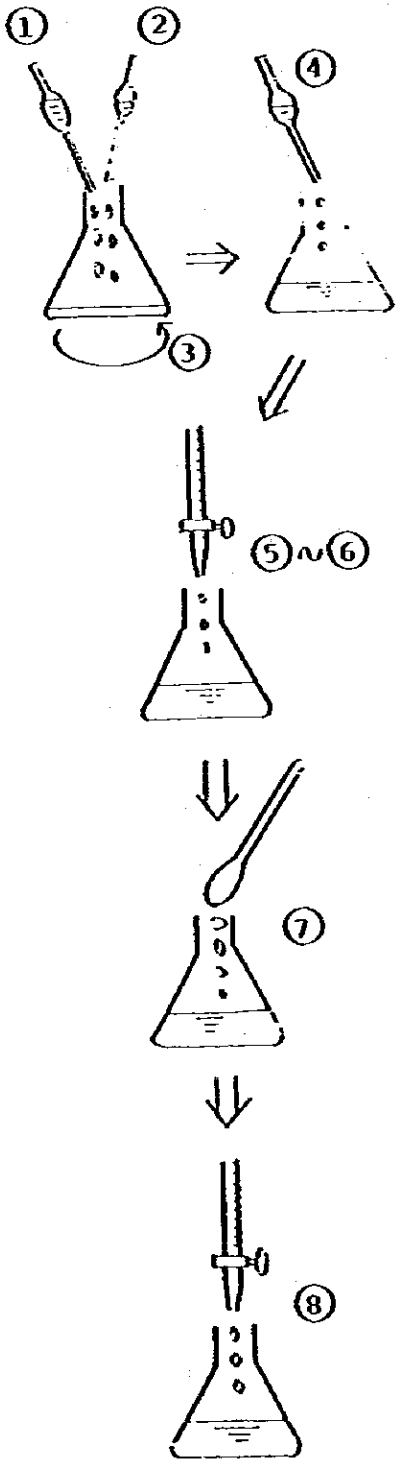
7. The weight of the dish including the dried sample is weighed by the chemical balance and is B mg.

   So, the concentration of non volatile residue is calculated as (B-A) mg in 100 ml.

8-3-5 Section: Product

Item : Aldehyde

Flow Diagram



Equipment and Reagents

Erlenmeyer flask with stopper (200 ml)

Volumetric flask (1000 ml)

Bulet (brown color, 5 ml, 0.02 ml graduated)

Sodium bisulfite

Potassium iodine

Iodine

Starch (soluble)

Hydrochloric acid

Procedure

1. Take 10 ml of sample in a Erlenmeyer flask with stopper.

2. Add 40 ml of DIW and 2 ml of 0.1 sodium bisulfite sol. on it.

3. Shake it and allow to stand for 30 min. at room temperature.

4. Add 2 ml of starch sol. (1 %) before titration.

5. Titrate with 0.1 N iodine sol. until its color turns nearly to blue color.

6. Titrate with 0.01 N iodine sol. until its color turns to blue color.

7. Add the power of sodium bicarbonate and let the excess solid leave in the solution. (pH 8.0 in the solution)

   In this case, blue color of iodine-starch is disappeared.

8. Once more, titrate with 0.01 N iodine sol. until the blue color maintains for a while.

9. Calculate aldehyde by the following equation.

$$\text{Aldehyde (mg/100 ml)} = (\text{ml of 0.01 N iodine sol. used at the second time}) \times 2.2$$

Preparation of Reagents

a. 0.1 N sodium bisulfite sol.

   Dissolve 5.204 g of sodium bisulfite ($NaHSO_3$) to 1000 ml with DIW.

   Store in a brown colored bottle.

   This sol. should not be used over 2 weeks.

b. 0.1 N iodine sol.

Dissolve 40 g of potassium iodine (KI) to 25 ml of DIW.

Add 12.6 g of iodine (I_2), and mix well to dissolve it. Dilute to 1000 ml with DIW.

Add 3 drops of hydrochloric acid.

Store in a brown colored bottle.

c. 0.01 N iodine sol.

Dilute 0.1 N iodine sol. with DIW to make exactly 10 times by volume.

Potency of this sol. is determined with 0.01 N sodium thiosulfate.

d. 1 % soluble starch sol.

Triturate 1 g of starch with 10 ml of DIW, and pour slowly it into 90 ml of boiling water with stirring.

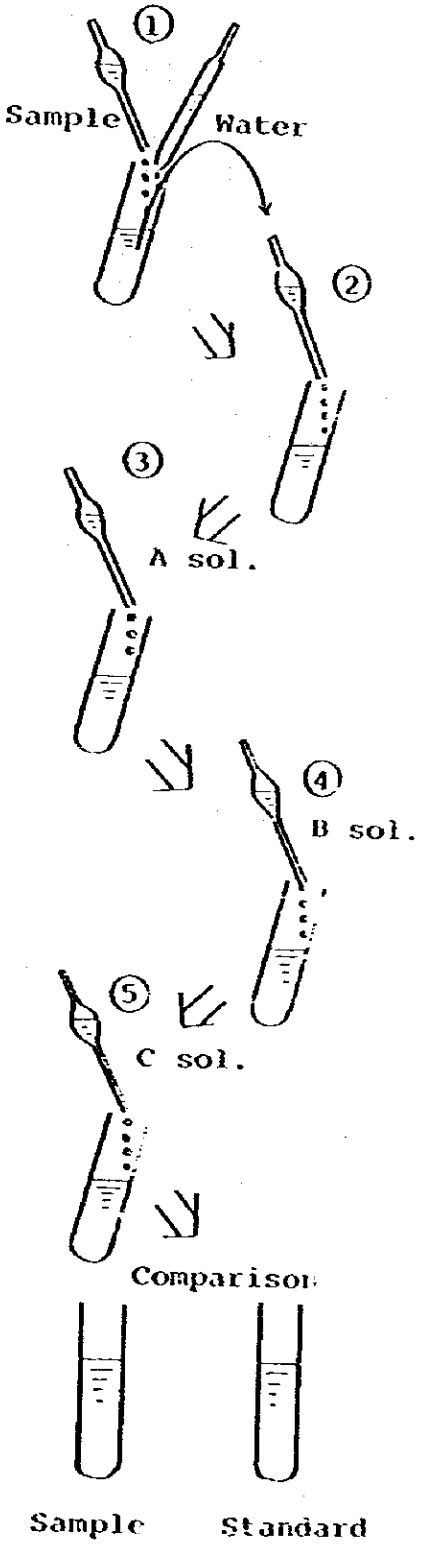
Heat for one min., cool, and filt with the gauze.

Prepare this sol. just before use.

8-3-6 Section: Product

Item : Methanol

Flow Diagram



Equipment and Reagents

Test tube

Graduated pipet
(10 ml, 0.1 ml graduated)

Graduated pipet
(1 ml, 0.01 ml graduated)

Volumetric flask (50 ml, 500 ml)

Phosphoric acid

Potassium permanganate

Sulfuric acid
(specific gravity 1.84)

Oxalic acid

Fuchsin (basic)

Sodium sulfite (anhydrous)

Conc. Hydrochloric acid
(specific gravity 1.18)

Methanol (standard grade)

Ethanol (standard grade)

Procedure

1. Add 0.5 ml of sample to 9.5 ml of DIW.

2. Mix well and take 5 ml of its sol. into T.T..

3. Add 2 ml of A sol., mix well, and allow to stand for 15 min.

4. Add 2 ml of B sol., and mix well.

5. When this sol. is decolored, add 5 ml of C sol. and mix well.

6. After it allow to stand at 25 °C for 1 hr., measure amount of methanol by comparing its color with color of sol. treated in the same manner as sample about methanol standard A or B.

Preparation of Reagents

a. A sol.

   1) Dilute 75 ml of phosphoric acid (H_3PO_4; 85 %) to 500 ml with DIW.

   2) Add 15 g of potassium permanganate ($KMnO_4$).

   3) Heat to dissolve, and cool.

   4) This sol. should not be used over 4 weeks.

b. B sol.

   1) Add 250 ml of DIW to 250 ml of sulfuric acid (specific gravity 1.84) by cooling.

   2) Dissolve 25 g of oxalic acid ($(COOH)_2 \cdot 2H_2O$) in this sol.

c. C sol.

1) Dissolve 0.5 g fuchsin basic in 300 ml of the hot DIW.

2) Separately, dissolve 5 g of anyhdrous sodium sulfite (Na_2SO_4) in 30 ml of DIW.

3) Mix both sol. by shaking.

4) Add 5 ml of hydrochloric acid (HCl, specific gravity 1.18) by shaking well.

5) Dilute to 500 ml with DIW.

d. Standard sol.

Standard sol. should be prepared at every determination.

Methanol standard sol. A

Add 5 ml of 0.1 % methanol sol. to 2.5 ml of 95 % ethanol and 42.5 ml of DIW to make 50 ml of volume.

Methanol standard sol. B

Add 2.5 ml of 0.1 % methanol sol. to 2.5 ml of 95 % ethanol and 45 ml of DIW to make 50 ml of volume.

Note: Preparation of 0.1 % methanol sol.
Dilute 1 g of methanol (1.263 ml) to 1000 ml with DIW.

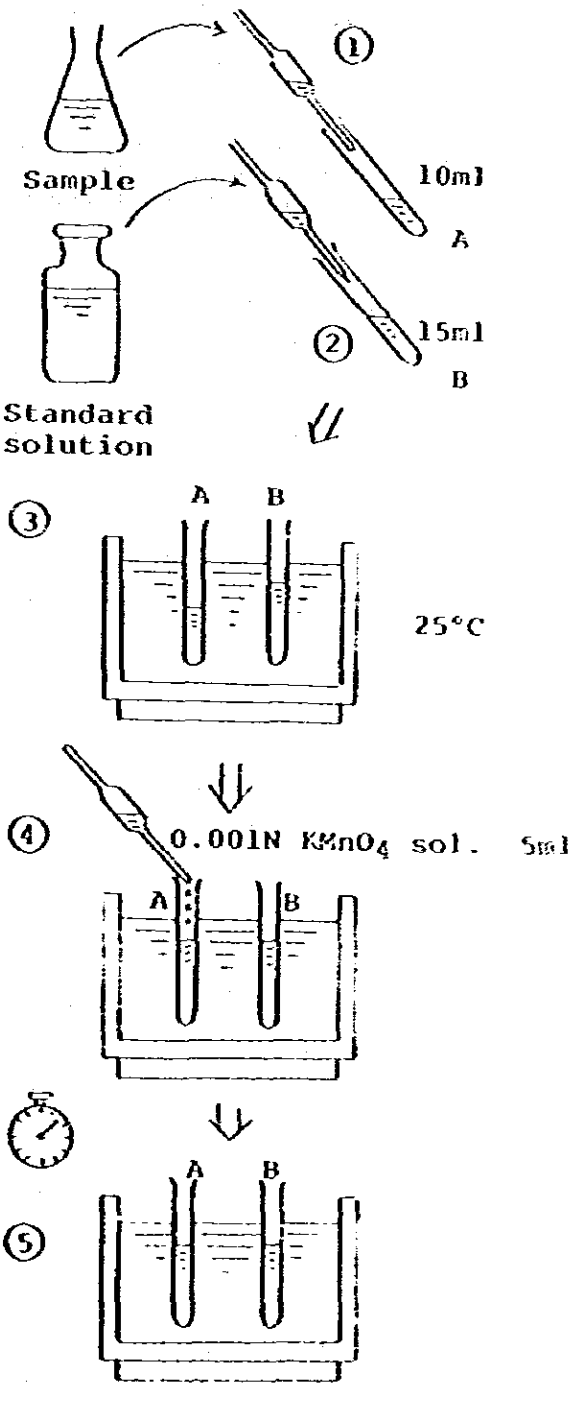
Reference

Ratio of Mixture / No. of Test Tube	0.1 % Methanol (ml)	95 % Ethanol (ml)	DIW (ml)	Methanol Content in Sample (mg/ml)
1	0.05	0.25	4.70	0.2
2	0.10	0.25	4.65	0.4
3	0.15	0.25	4.60	0.6
4	0.20	0.25	4.55	0.8
5	0.30	0.25	4.50	1.2
6	0.40	0.25	4.35	1.6
7	0.50	0.25	4.25	2.0
8	0.60	0.25	4.15	2.4
9	0.75	0.25	4.00	3.0
10	1.00	0.25	3.75	4.0

8-3-7 Section: Product

Item : Permanganate Test ($KMnO_4$ value)

Flow Diagram



Equipment and Reagents

Water-bath

Watch

Volumetric pipet (5ml, 10 ml, 15 ml)

Test tube

Standard sol.

0.001N $KMnO_4$ sol.

Procedure

1. Pipet 10 ml of sample into a clean test tube (18 mmϕ x 165 mm).

2. Besides, take 15 ml of the standard sol. in another test tube.

3. Hold the test tubes in a water-bath controlled at the temperature of 25 °C ± 0.5 °C.

4. Add 5 ml of 0.001N $KMnO_4$ sol. into the test tubes and shake for mixing. From this moment, the time must be counted until the sample shows same grade color to standard solution.

5. The time in minutes indicate the "$KMnO_4$" value.

Note: Water in the water-bath must be colorless, transparent and clean.

Preparation Reagents

a. Standard sol.

1) A sol.: 1.5 % Cobalt chloride sol.

Take 1.5 g of Cobalt chloride ($CoCl_2 \cdot 6H_2O$) into 100 ml of valumetric flask and make it to 100 ml with DIW.

2) B sol.: 1.5 % of Uranyl nitrate.

Take 1.5 g of Uranyl nitrate ($UO_2(NO_3)_2 \cdot 6H_2O$) into 100 ml of volumetric flask and make it to 100 ml with DIW.

3) Add at the rate of 10 ml of A sol. and 8 ml of B sol., mix well, and take 15 ml of its sol. to make the standard sol.

b. 0.001N Potassium permanganate sol.

1) Dilute 3.160 g of potassium permanganate ($KMnO_4$) to 1000 ml with DIW.

2) Titrate with 0.1 N sodium oxalate.

3) Dilute 5 ml of this sol. to 500 ml with DIW.

Note: 0.001 N potassium permanganate sol. should not be used over 5 hours.

Determination of 0.1 N potassium permanganate sol.

1) Take 25 ml of 0.1 N sodium oxalate sol. into 100 ml of flask.

2) Add 10 ml of Conc. sulfuric acid.

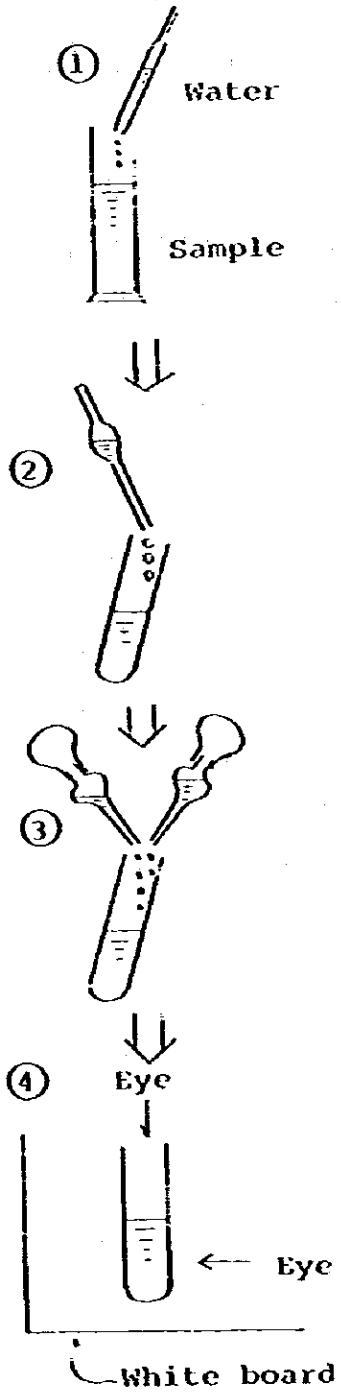
3) Titrate with 0.1 N potassium permanganate sol. keeping at 60 ∿ 70 °C. (until pink color is remained for 30 min.)

1 ml of 0.1 N sodium oxalate = 0.00316 g $KMnO_4$

8-3-8 Section: Product

Item : Heavy Metal

Flow Diagram



Equipment and Reagents

Graduated cylinder (50 ml)

Graduated pipet (10 ml)

Volumetric Pipet (5 ml)

Dropping bottle

Test tube

Sodium sulfide

Glycerin

Ammonium water
(specific gravity 0.90)

Procedure

1. Dilute sample to make 90 %V/V ethanol with DIW.

2. Take 5 ml of its sol. into test tube.

3. Add 3 drops of sodium sulfide sol. and 2 drops of ammonium water, and mix well.

4. When the presented color is occurred within 1 min. after mixing, there is a heavy metal in sample.

Preparation of Reagents

a. Sodium sulfide sol.

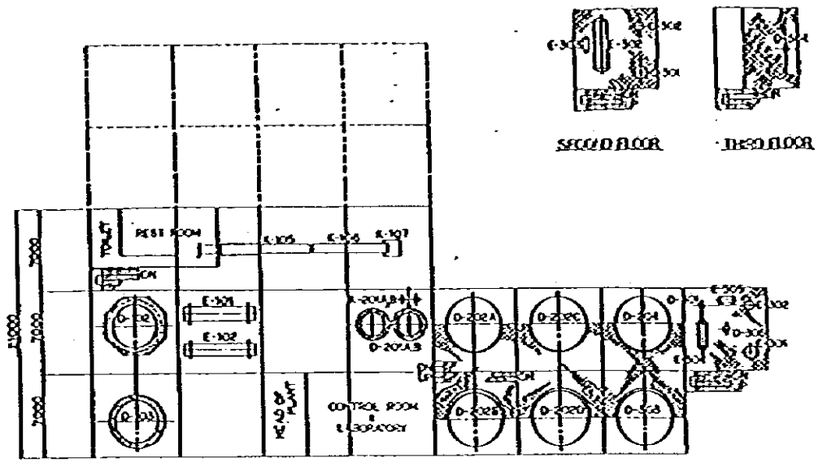
Dissolve 5 g of sodium sulfide ($Na_2S \cdot 9H_2O$) into mixture of 10 ml DIW and 30 ml of glycerin.

Store in a brown tightly stoppered bottle, filled nearly to the top of bottle.

This solution should not be used over 3 months.

9. Lay-out

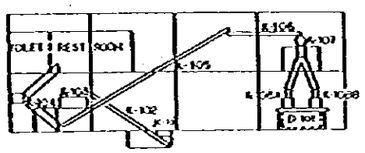
KYOWA HAKKO
KOGYO CO., LTD.



1ST FLOOR

SECOND FLOOR THIRD FLOOR

DD'VIEW



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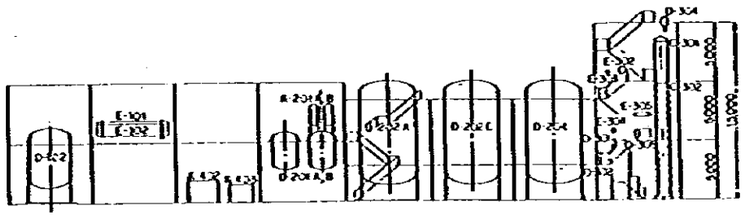
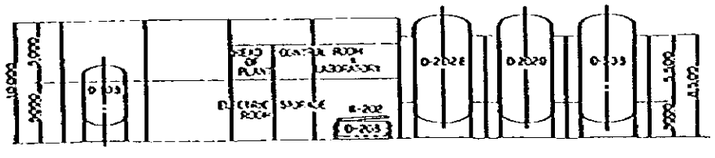
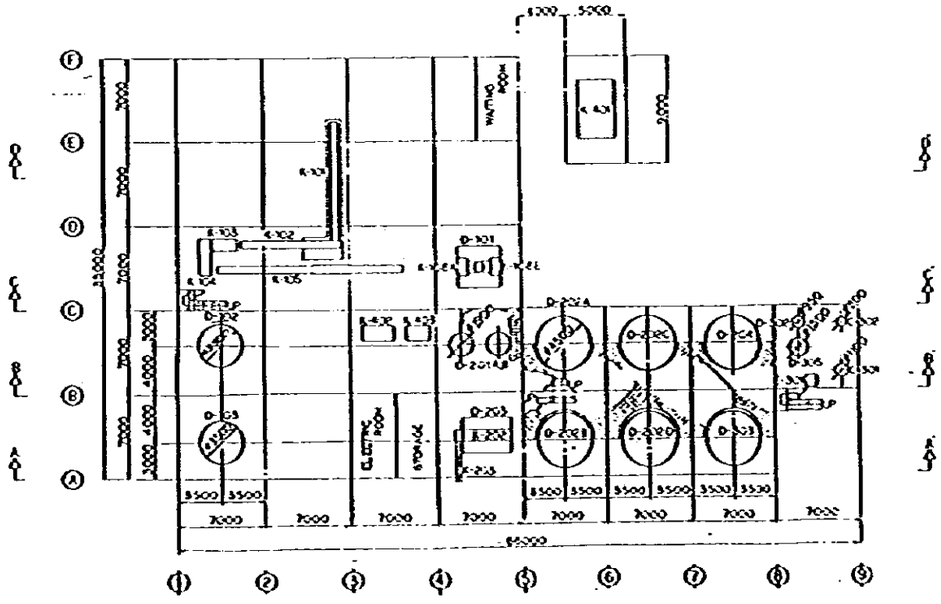


BB'VIEW



AA'VIEW



GROUND FLOOR

SERDC ALCOHOL PLANT
EQUIPMENT LAYOUT

10. Equipment List

EQUIPMENT LIST

(DRUMS, TANKS AND PITS)

JOB NO.	BERDC	DATE	KYOWA HAKKO KOGYO CO., LTD.
PLANT	ALCOHOL PLANT	REVISIONS	

EQUIP. NO.	NAME	SPECIFICATION	PRINCIPAL MATERIALS	PROCESS FLUID	DESIGN TEMP. (°C)	DESIGN PRESS. (m/cm²)	CODE & STANDARDS	AGITATOR	ACCESSORIES	REMARKS
D-101	CASSAVA PIT	20 m^3 3 m × 6 m × 1.3 m HIGH	CONCRETE	CASSAVA FLUID	30	ATM	JIS	PROPELLER 450 ϕ 350RPM, 3.7KW	—	REFER TO CIVIL DRAWING
D-102	COOKING TANK	VERTICAL CYLINDER, 10 % DISH 35 m^3 3500 ϕ × 3574(TL-TL) × 16 t	SS42	CASSAVA FLUID	180	4	JIS P.V.	RIBBON 2000 ϕ 17RPM, 15KW	—	P.V. PRESSURE VESSEL
D-103	SACCHARIFYING TANK	VERTICAL CYLINDER, 10 % DISH 35 m^3 3500 ϕ × 3574(TL-TL) × 9 t	SS41	CASSAVA LIQUID	100	ATM	JIS	RIBBON 2000 ϕ 17RPM, 11KW	COOLING COIL STPG-38-M-Sch 40 3B, 48 m^2	
D-201 A	SEED TANK	VERTICAL CYLINDER, 10 % DISH 6.5 m^3 1900 ϕ × 2310(TL-TL) × 6 t	SS41	SEED MEDIUM	133	2	JIS P.V.	DISK TURBINE 640 ϕ 88RPM, 5.5KW	COOLING COIL:10 m^2 AIR SPARGER:2 B	P.V. PRESSURE VESSEL
D-201 B	SEED TANK	DITTO	DITTO	DITTO	DITTO	DITTO	DITTO	DITTO	DITTO	DITTO
D-202 A	MAIN FERMENTOR	VERTICAL CYLINDER, 10 % DISH 120 m^3 4500 ϕ × 6810(TL-TL) × 12 t	SS41	FERMENTION MEDIUM	32	ATM	JIS	—	COOLING COIL:53 m^2 AIR SPARGER:1 1/2 B	
D-202 B	MAIN FERMENTOR	DITTO	DITTO	DITTO	DITTO	DITTO	DITTO	—	DITTO	
D-202 C	MAIN FERMENTOR	DITTO	DITTO	DITTO	DITTO	DITTO	DITTO	—	DITTO	
D-202 D	MAIN FERMENTOR	DITTO	DITTO	DITTO	DITTO	DITTO	DITTO	—	DITTO	
D-203	BROTH PIT	15 m^3 4 m × 3 m × 1.3 m HIGH	CONCRETE	BROTH	—	—	JIS	—	—	REFER TO CIVIL DRAWING
D-204	BROTH TANK	VERTICAL CYLINDER, 10 % DISH 120 m^3 4500 ϕ × 6810(TL-TL) × 12 t	SS41	BROTH	32	ATM	JIS	—	—	
K-201 A	AIR FILTER	VERTICAL CYLINDER, 10 % DISH 0.427 m^3 550 ϕ × 1658(TL-TL) × 4.5 t	SS41	AIR & STEAM	180	4	JIS P.V.	—	ND FILTER 590 ϕ × 50 t × 12 SHEETS	
K-201 B	AIR FILTER	DITTO	DITTO	DITTO	DITTO	DITTO	DITTO	—	DITTO	

EQUIPMENT LIST

(DRUMS, TANKS AND PITS.)

JOB NO.	BERDC'
PLANT	ALCOHOL PLANT

DATE
REVISIONS

KYOWA HAKKO KOGYO CO., LTD.

EQUIP. NO.	NAME	SPECIFICATION	PRINCIPAL MATERIALS	PROCESS FLUID	DESIGN TEMP. (°C)	DESIGN PRESS. (kg/cm²G)	CODE & STANDARDS	AGITATOR	ACCESSORIES	REMARKS
D-301	FUSEL DECANTER	VERTICAL CYLINDER FLAT/10 % DISH 0.05 m³ 318.5 ϕ OD x 1015 x 6.9 t	SPG	FUSEL OIL/ ALCOHOL	100	ATM	JIS	—	GAUGE GLASS WINDOW	
D-302	FUSEL OIL TANK	VERTICAL CYLINDER FLAT/10 % DISH 1 m³ 950 ϕ x 1300 x 4.5 t	SS41	FUSEL OIL	50	ATM	JIS	—	GAUGE GLASS TUBE	
D-303	WASTE WATER TANK	VERTICAL CYLINDER, 10 % DISH 120 m³ 4500 ϕ x6810(TL-TL) x12 t	SS41	WASTE WATER	60	ATM	JIS	—	FLOAT GAUGE	
D-304	FOAM BREAKER	VERTICAL CYLINDER 10 % DISH/90° CONICAL 0.13 m³ 500 ϕ x 550(TL-TL) x 3 t	SUS304	ALCOHOL	120	1	JIS	—	—	
D-305	ALCOHOL CHECKING TANK	VERTICAL CYLINDER FLAT/10 % DISH 4 m³ 1500 ϕ x 2420(TL-TL) x 4.5 t	SS41	ALCOHOL	40	ATM	JIS	—	GAUGE GLASS TUBE	
D-306	DENATURANT TANK	VERTICAL CYLINDER FLAT/10 % DISH 0.15 m³ 550 ϕ x 750(TL-TL) x 4.5 t	SS41	DENATURANT	30	ATM	JIS	—	GAUGE GLASS TUBE	
D-401	SEDIMENTATION PIT	75 m³ 3.7 m x 13.7 m x 2 m	CONCRETE	WATER	—	—	JIS	—	—	REFER TO CIVIL DRAWING
D-402	1 ST WATER PIT	120 m³ 5.7 m x 13.7 m x 2 m	CONCRETE	WATER	—	—	JIS	—	—	REFER TO CIVIL DRAWING
D-403	2 ND WATER PIT	75 m³ 3.7 m x 13.7 m x 2 m	CONCRETE	WATER	—	—	JIS	—	—	REFER TO CIVIL DRAWING
T-301	ALCOHOL STORAGE TANK	VERTICAL CYLINDER CONE ROOF/FLAT BOTTOM 100 m³ 5800 ϕ x 4500(TL-TL) x 4.5 t	SS41	ALCOHOL	35	ATM	JIS	—	FLOAT GAUGE WATER SHOWER	
T-401	FUEL OIL STORAGE TANK	VERTICAL CYLINDER CONE ROOF/FLAT BOTTOM 50 m³ 3800 ϕ x 4500 (TL-TL) x 4.5 t	SS41	FUEL OIL	30	ATM	JIS	—	FLOAT GAUGE	

EQUIPMENT LIST

(COLUMN)

JOB NO.	BEKDC	DATE		KYOWA HAKKO KOGYO CO., LTD.
PLANT	ALCOHOL PLANT	REVISIONS		

EQUIP. NO.	NAME	SPECIFICATION	PRINCIPAL MATERIALS	PROCESS FLUID	DESIGN TEMP. (°C)	DESIGN PRESS. (kg/cm²G)	CODE & STANDARDS	AGITATOR	ACCESSORIES	REMARKS
C-301	MASH COLUMN	1100φ x 13700 x 3 t CAP TRAY NUMBER OF TRAY : 26 TRAY DISTANCE : 400 mm	SUS304	ALCOHOL BROTH	120	1	JIS	—	—	
C-302	CONCENTRATION COLUMN	800 φ x 10500 x 3 t SIEVE TRAY NUMBER OF TRAY : 25 TRAY DISTANCE : 300	SUS 304	ALCOHOL	120	1	JIS	—	—	

1/1

JOB NO.	BEROC	EQUIPMENT LIST (HEAT EXCHANGER)	DATE / REVISIONS	KYOWA HAKKO KOGYO CO., LTD.
PLANT	ALCOHOL PLANT			

EQUIP. NO.	NAME	DESIGN CONDETION SPECIFICATION		MATERIAL	PASS	FLUID NAME	FLUID VOLUM	FLUID TEMP.	FLUID PRESS.	CORD & STANDARDS	REMARKS
E-101	MEDIUM COOLER-1	SHELL AND TUBE TYPE SURFACE 120 m^2 SHELL I.D. 750 mm TUBE 27.2 O.D.x 5000L x 2t x 288 x Δ34 mm BAFFLE SEGMENTAL HORISONTAL TYPE PITCH 700 mm CUT 25 %	SHELL SIDE	SS41	1	WATER	65m^3/H	32/55 °C	4kg/cm^2G	JISB 8249 CLASS-1 (PVC-1)	
			TUBE SIDE	STB-35E	12	MEDIUM	20m^3/H	130/55 °C	3kg/cm^2G		
E-102	MEDIUM COOLER-2	SHELL AND TUBE TYPE SURFACE 90 m^2 SHELL I.D. 700 mm TUBE 27.2 O.D. x 5000L x 2t x 216 x Δ34 mm BAFFLE SEGMENTAL HORISONTAL TYPE PITCH 700 mm CUT 25 %	SHELL SIDE	SS41	1	WATER	60m^3/H	28/32 °C	4kg/cm^2G	JISB 8243	
			TUBE SIDE	STB-35E	18	MEDIUM	10m^3/H	33/32 °C	3kg/cm^2G		
E-301	PREHEATER	PLATE TYPE (UX-216-J-24) SURFACE 8.25 m^2	A SIDE	SUS304	11	BROTH	3.9m^3/H	80/32 °C	4kg/cm^2G	—	SPANER (SPECIAL TOOL FOR MAINTENANCE)
			B SIDE	SUS304	12	WASTEL WATER	4.5m^3/H	130/68 °C	4kg/cm^2G		
E-302	CONC. COLUMN OVHD CONDENSER	SHELL AND TUBE TYPE SURFACE 25 m^2 SHELL I.D. 500 mm TUBE 27.2 O.D. x 4000L x 2.1t x 78 x Δ 34mm BAFFLE SEGMENTAL HORISONTAL TYPE PITCH 361 mm	SHELL SIDE	SUS304	1	ALCOHOL VAPOR		79/70 °C	1kg/cm^2G	—	
			TUBE SIDE	aSUS304TP-SCH SCH10S	6	WATER		50/32 °C	4kg/cm^2G		
E-303	CONC. COLUMN VENT CONDENSER	DOUBLE TUBE TYPE SURFACE 0.5 m^2 OUTER TUBE SGP 1 1/2B INNER TUBE SUS304 TP 3/4B SCH 10S	INNER TUBE	SUS304 TP	1	INER GAS		70/50 °C	1kg/cm^2G	—	
			OUTER TUBE	SGP	1	WATER		35/32 °C	4kg/cm^2G		
E-304	PRODUCT COOLER	SHELL AND TUBE TYPE SURFACE 4.0 m^2 SHELL I.D. 309.5 mm TUBE 27.2 O.D. x 2000L x 2.1t x 40 x Δ34mm BAFFLE SEGMENTAL HORISONTAL TYPE PITCH 270 mm	SHELL SIDE	SUS304TP-E	1	ETHYL ALCOHOL		35/70 °C	2kg/cm^2G	—	
			TUBE SIDE	SUS304TP-SCH SCH10S	4	WATER		32/34 °C	4kg/cm^2G		
E-305	FUSEL COOLER	DOUBLE TUBE TYPE SURFACE 0.5 m^2 OUTER TUBE SGP 1 1/2B INNER TUBE SUS304 TP 3/4B SCH 10S	INNER TUBE	SUS304 TP	1	FUSEL OIL		90/50 °C	1kg/cm^2G	—	
			OUTER TUBE	SGP	1	WATER		32/35 °C	4kg/cm^2G		

EQUIPMENT LIST

(CONVEYERS)

JOB NO.	BERDC	DATE	KYOWA HAKKO KOGYO CO., LTD.
PLANT	ALCHOHOL PLANT	REVISIONS	

EQUIP. NO.	NAME	SPECIFICATION	PRINCIPAL MATERIALS BELT/STRUCTURE	PROCESS MATERIAL	DESIGN TEMP (°C)	CODE & STANDARDS	ACCESSORIES	REMARKS
K-101	BELT CONVEYER-1	HORIZONTAL TYPE CAPACITY 10T/H x 1.5KW LENGTH 7000 BELT SPEED 30m/min 500W x 3PLY PLAIN BELT	RUBBER/C.S.	RAW CASSAVA	30	—	SKIRT RUBBER	
K-102	BELT CONVEYER-2	INCLINED TYPE CAPACITY 10T/H x 1.5KW LENGTH 9500 BELT SPEED 40m/min 600W x 3PLY CLIMBER BELT (1000P)	RUBBER/C.S.	RAW CASSAVA	30	—		
K-105	BELT CONVEYER-3	INCLINED TYPE CAPACITY 10T/H x 2.2KW LENGTH 17000 BELT SPEED 40m/min 600W x 3PLY CLIMBER BELT (1000P)	RUBBER/C.S.	RAW CASSAVA	30	—	HOPPER RUBBER	
K-106	AUTOMATIC CONVEYER SCALE	LOAD-CELL TYPE WEIGHTING CAPACITY 0.1-15T/H(0.75KW) LENGTH 5000 BELT SPEED 15m/min 700W x 3PLY FLEXOWELL BELT (100h) BOTH SIDE	RUBBER/C.S.	RAW CASSAVA	30	—	CONTROL PANEL BELT SPEED INDICATOR MOMENTARY LOAD INDICATOR TOTALIZING COUNTER PRESETTING COUNTER	
K-203	BELT CONVEYER-4	HORIZONTAL TYPE CAPACITY 0.5T/H x 0.75KW LENGTH 3200 BELT SPEED 30m/min 350W x 2PLY PLAIN BELT	RUBBER/C.S.	SLUDGE	32	—	HOPPER RUBBER	

JOB NO.	BERDC	EQUIPMENT LIST	DATE	KYOWA KAKKO KOGYO CO., LTD.
PLANT	ALCHOHOL PLANT	(OTHER EQUIPMENT)-1	REVISIONS	

EQUIP. NO.	NAME	SPECIFICATION	PRINCIPAL MATERIALS	PROCESS MATERIAL	DESIGN TEMP (°C)	MOTOR	ACCESSORIES	REMARKS
K-103	PEELER	TYPE : CYLINDLICAL ROTARY SCREEN REVOLUTION SPEED : 33 RPM SCREEN SIZE : 1210 ϕ x 3000 L	SS41	RAW CASSAVA	30	5.5 KW GEARED MOTOR 1/30	HOPPER CHUTE FOOD LADDER OPERATION STAGE	
K-104	WASHER	TYPE : ROTOR PADDLE REVOLUTION SPEED : 33 RPM TANK SIZE : 1014 W x 3850 L	SS41	RAW CASSAVA	30	5.5 KW GEARED MOTOR 1/30	OVER FLOW PIPE SEPARATOR PLATE CHUTE	
K-107	CRUSHER-1	TYPE : ROTOR CUTTER REVOLUTION SPEED : 500 RPM KNIFEBLADE 410 L x 12 PICES STELLITE HARDENING	SS41	RAW CASSAVA	30	7.5 KW 6 P		
K-108 A	CRUSHER-2	TYPE : SENO MP-5 CAPACITY 5 TON/H ROTOR SPEED : 1450 RPM ROTOR SIZE : 560 ϕ x 369 W NUMBER OF BLADES : 152	SS41/SUS304	RAW CASSAVA	30	22 KW 4 P		
K-108 B	CRUSHER-2	DITTO	DITTO	DITTO	DITTO	DITTO		
K-202	SCREEN FILTER	TYPE : ROTATING BRUSH AND SIEVE TYPE BRUSH SPEED : 20 RPM BRUSH MATERIAL : NYLON	SUS304/SS41	BROTH	32	2.2 KW GEARED MOTOR	SCREW CONVEYER SCREW PRESS (3.7 KW)	

JOB NO.	DKRDC	EQUIPMENT LIST (OTHER EQUIPMENT)-2					DATE / REVISIONS	KYOWA HAKKO KOGYO CO., LTD
PLANT	ALCOHOL PLANT							
EQUIP. NO.	NAME	SPECIFICATION	PRINCIPAL MATERIALS	PROCESS MATERIAL	DESIGN TEMP (°C)	MOTOR	ACCESSORIES	REMARKS
K-402	AIR COMPRESSOR	TYPE : KAJI VS-30-OL VERTICAL, OIL FREE RECIPROCATING, 1 STAGE, DOUBL ACTING, WATER COOLED CAPACITY 250 Nm^3/H x 4 kg/cm^2G x 30 KW SPEED 800 RPM	FC20/S45C	AIR	ATS.	30 KW 4 P	SUCTION FILTER PRESSURE REGULATOR FLOW SWITCH (COOLING WATER) FLOW INDICATOR (COOLING WATER) MAINTENANCE TOOLS AFTER COOLER (K-402-2) DRAIN SEPARATOR (K-402-3) AIR RECEIVER (K-402-4)	
K-403	DEHUMIDIFIER	TYPE : DOMAL DA-15 V CAPACITY 50 Nm^3/H DESIGN PRESSURE : 8 kg/cm^2G DEWPOINT OF DRIED AIR : -40 °C OPERATING METHOD CONTINUOUS BY ALTERNATE SWITCHING OF ABSORPTION TOWER		AIR	INLET 35 °C	HEATER 1.5 KW/TOWER	CONTROL PANEL AND AUTOMATIC CONTROL DIVICES	RECOVERY METHOD INTERNAL HEAT OF ELECTRICITY ALTERNATING TIME : 8 Hr ABSORBENT USED : SILICA GEL
K-404	COOLING TOWER	MODEL : HITACHI R.C. MT-15014 L WATER FLOW RATE : 100 m^3/H D/A DIMENSION 2760 ϕ x 3590 H FAN 930 m^3/min x 438 RPM	MAIN BODY F.R.P. FILLING PCV	WATER	INLET WATER 37 °C OUTLET WATER 32 °C W.B. 28 °C	3.7 KW 4 P	LADDER	

JOB NO.	BERDC	EQUIPMENT LIST (OTHER EQUIPMENT)-3		DATE / REVISIONS	KYOWA KAKKO KOGYO CO., LTD.
PLANT	ALCOHOL PLANT				
EQUIP. NO.	NAME	SPECIFICATION	CODE & STANDARDS	ACCESSORIES	REMARKS
K-109	FORKLIFT TRUCK	MODEL : NISSAN FOIA/M15 1.5 TON	—	OVER HEAD GUARD TOOL KIT-STANDARD PALLET-10 SETS (900 x 1200)	
K-110	BALANCE	TYPE : KAMACHO D-250 SPRING TYPE AUTOMATIC INDICATING SCALE WEIGHTING CAPACITY : 250 kg MINIMUM GRADUATION : 500 g LOADING PLATFORM : 570 x 390 mm	—		
K-405	FIRE EXTINGUISHER	ABC-10 HANDY TYPE 25 SETS CHEMICAL WEIGHT 3.5 kg TIME OF DISCHARGE 20 SEC ABC-50 WHEEL TYPE 7 SETS CHEMICAL WEIGHT 20 kg TIME OF DISCHARGE 38 SEC	—		

JOB NO.	BKRDC	PUMP LIST	DATE	BY	KYOWA HAKKO KOGYO CO., LTD.
PLANT	ALCOHOL PLANT		REVISIONS		

EQUIPMENT NO.	P-101	P-102			P-201	P-202	P-203	P-204		
NAME	CASSAVA PUMP	MEDIUM PUMP			SEED PUMP	MAIN FERMENTOR PUMP	BROTH PUMP	FEED PUMP		
TYPE	SCREW (NOHNO PUMP)	CENTRIFUGAL			CENTRIFUGAL	CENTRIFUGAL	CENTRIFUGAL	CENTRIFUGAL		
CAPACITY (m3/h)	10	15			10	30	30	5		
HEAD (m)	20	30.5			20.5	21	21	30		
PRINCIPAL MATERIALS	ROTOR : SUS304 + H.Cr STATOR : NBR	IMPELLER : SC46 CASING : SC46			IMPELLER : SC46 CASING : SC46	IMPELLER : SC46 CASING : SC46	IMPELLER : SC46 CASING : SC46	IMPELLER : SC46 CASING : SC46		
PROCESS FLUID	CASSAVA LIQUID	FERMENTATION MEDIUM			FERMENTATION SEED	BROTH	BROTH	BROTH		
TEMP (°C)	30	55			32	32	32	32		
PUMP ROTATION SPEED (RPM)	390	2930			2920	2930	2930	2930		
MOTOR (KW)	3.7	3.7			2.2	5.5	5.5	3.7		
SHAFT SEAL	GLAND SEAL	GLAND SEAL			GLAND SEAL	GLAND SEAL	GLAND SEAL	GLAND SEAL		
REMARKS										

JOB NO.	DKRDC
PLANT	ALCOHOL PLANT

PUMP LIST

DATE	BY
REVISIONS	

KYOWA HAKKO KOGYO CO., LTD.

EQUIPMENT NO.	P-301	P-302	P-303	P-304	P-305	P-306				
NAME	MASH COLUMN BTM PUMP	CONC. COLUMN BTM PUMP	TRANSFER PUMP	PRODUCT PUMP	WASTE WATER PUMP	FUSEL PUMP				
TYPE	CENTRIFUGAL	CENTRIFUGAL	CENTRIFUGAL	CENTRIFUGAL	CENTRIFUGAL	CENTRIFUGAL				
CAPACITY (m3/h)	5	2	5	10	5	10 — 70 l/H				
HEAD (m)	30	30	20	20	20					
PRINCIPAL MATERIALS	IMPELLER : SCS13 CASING : SCS13	IMPELLER : SCS13 CASING : SCS13	IMPELLER : SCS13 CASING : SCS13	IMPELLER : FC25 CASING : FC25	IMPELLER : FC25 CASING : FC25	PLUNGER : SUS304 CYLINDER : SUS304				
PROCESS FLUID	WASTE WATER	ALCOHOL	ALCOHOL	ALCOHOL	WASTE WATER	FUSEL OIL				
TEMP (°C)	110	95	40	35	60	30				
PUMP ROTATION SPEED (RPM)	2000 (SYN. SPEED)	3000 (SYN. SPEED)	3000 (SYN. SPEED)	3000 (SYN. SPEED)	3000 (SYN. SPEED)	ROTATING SPEED 72 (STROKE/min)				
MOTOR (KW)	2.2	1.5	1.5	1.5	1.5	0.4				
SHAFT SEAL	GLAND SEAL	MECHANICAL SEAL	MECHANICAL SEAL	MECHANICAL SEAL	GLAND SEAL	GLAND SEAL				
REMARKS										

JOB NO.	BERDC	PUMP LIST	DATE	BY	KYOWA HAKKO KOGYO CO., LTD.
PLANT	ALCOHOL PLANT		REVISION		

EQUIPMENT NO.	P-401 A	P-401 B	P-402 A	P-402 B	P-403	P-404 A	P-404 B
NAME	1 ST WATER PUMP	1 ST WATER PUMP	2 ND WATER PUMP	2 ND WATER PUMP	FUSEL OIL PUMP	FUSEL OIL SERVICE PUMP	FUSEL OIL SERVICE PUMP
TYPE	VERTICAL SUBMERGED CENTRIFUGAL	VERTICAL SUBMERGED CENTRIFUGAL	VERTICAL SUBMERGED CENTRIFUGAL	VERTICAL SUBMERGED CENTRIFUGAL	GEAR	GEAR	GEAR
CAPACITY (m3/h)	120	120	100	100	4	0.5	0.5
HEAD (m)	40	40	40	40	20	50	50
PRINCIPAL MATERIALS	IMPELLER : FC20 CASING : FC20	IMPELLER : FC20 CASING : FC20	IMPELLER : FC20 CASING : FC20	IMPELLER : FC20 CASING : FC20	DRIVING GEAR : S45C CASING : FC25	DRIVING GEAR : S45C CASING : FC25	DRIVING GEAR : S45C CASING : FC25
PROCESS FLUID	WATER	WATER	WATER	WATER	FUSEL OIL	FUSEL OIL	FUSEL OIL
TEMP (°C)	28	28	28	28	30	30	30
PUMP ROTATION SPEED (RPM)	2920	2920	2910	2910	1500	1450	1450
MOTOR (KW)	22	22	18.5	18.5	2.2	0.4	0.4
SHAFT SEAL	GLAND SEAL	GLAND SEAL	GLAND SEAL	GLAND SEAL	MECHANICAL SEAL	MECHANICAL SEAL	MECHANICAL SEAL
REMARKS						POWER SUPPLIED AND CONTROLLED BY BOILER PANEL	POWER SUPPLIED AND CONTROLLED BY BOILER PANEL