IV. CONCEPTUAL DESIGN OF MODEL PLANT AND ITS APPLICATION

In order to more concretely show the contents of measures for energy saving and for environment pollution control to each model plant mentioned in Chapters II and III, the outlines are designed as follows. In addition, the possibility of application of those designs to other plants than the model plants is studied. Since the scheme of renovating the present two reheating furnaces costs higher than the expenses for building a new furnace for the effects, the outline is designed only for constructing the new furnace.

1. NO.5 COKE OVEN (INCL. NO.2 CDQ) AND NO.1 COKE CHEMICAL PLANT

Fig. IV.1-1.shows the whole outline of measures for energy saving and for environmental pollution control regarding No.5 Coke Oven (incl. No.2 CDQ), and Fig.IV. 1-2. shows the whole outline of environmental measures for No.1 Coke Chemical plant. The conceptual designs for the coke oven and coke chemical plant consist of the followings.

(1) Facilities of energy saving and technology

Item No.	Name of facilities
111.	Installation of a gas chromatography
121.	Installation of new BFG piping and a mixer of BFG/COG
131.	Installation of semi-automatic combustion control system
141	Complete renewal of No.2 CDQ

(2) Facilities with environmental measures and technology

Item No.	Name of facilities
151. & 152.	Installation of facilities to reduce dust emission during charging
161.	Installation of a dust collector for pushing and for CDQ
171.	Improvement of the activated sludge facilities
181.	Automatic pH control of ammonia liquor flow to ammonia distillation facility
193.	Installation of condensation precipitator

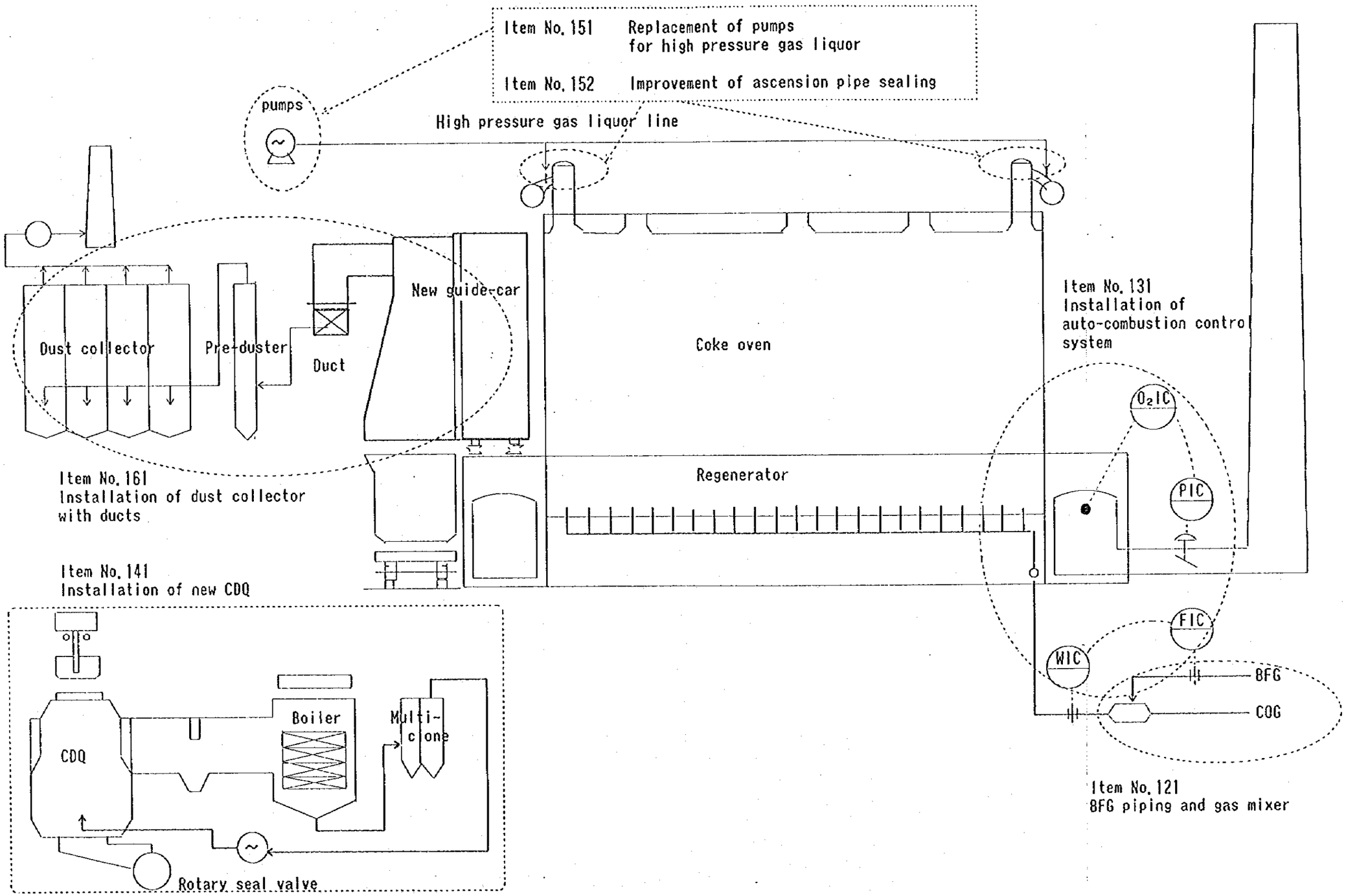


Fig. IV. 1-1. OVERALL VIEW OF ENERGY-SAVING & ENVIRONMENTAL PROTECTION IN No. 5 COKE OVEN BATTERIES

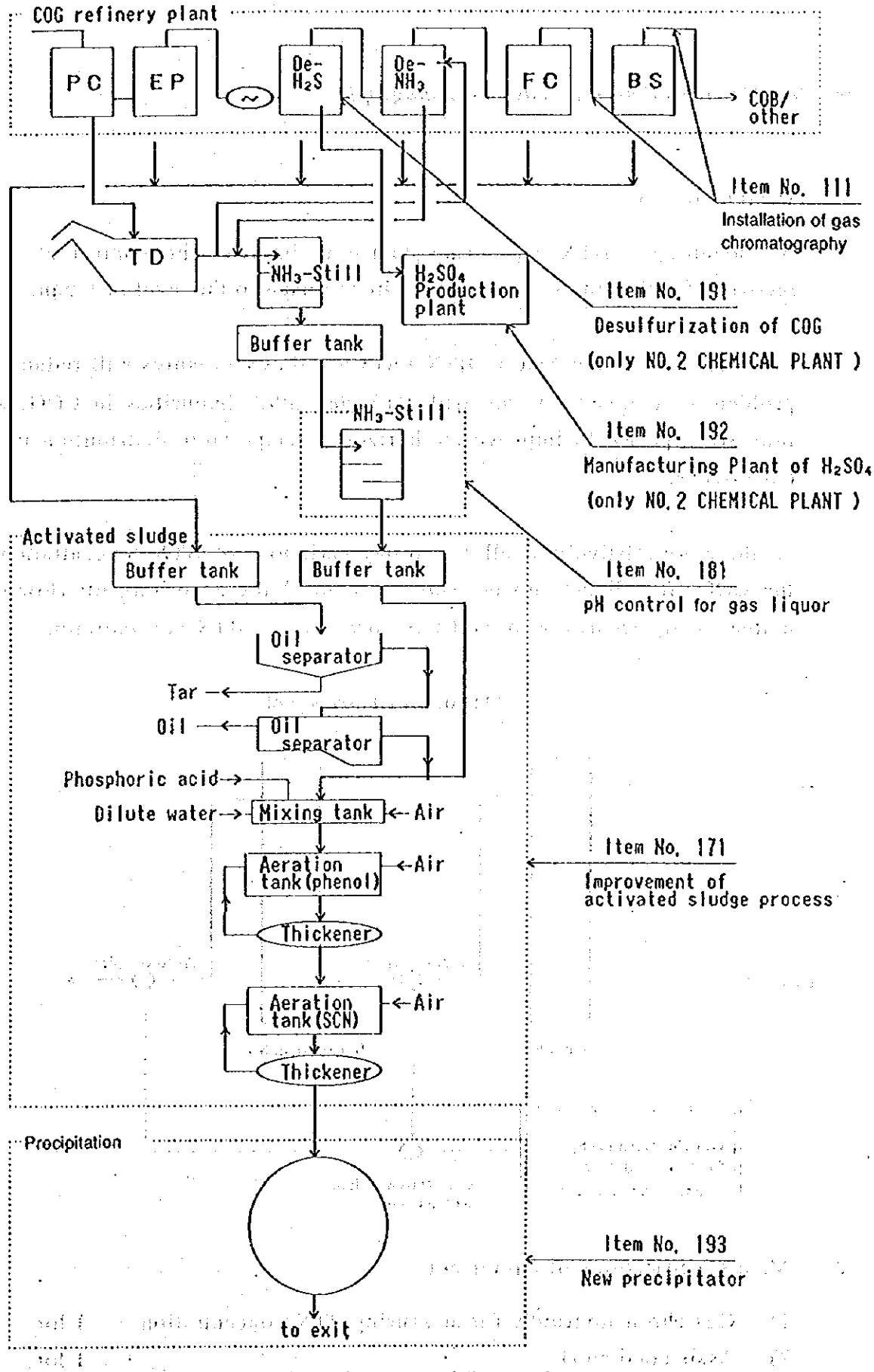


Fig. IV. 1-2. Overall view of Environmental Protection No. 1 Coke Chemical Plant

Item No.111 Installation of gas-chromatography

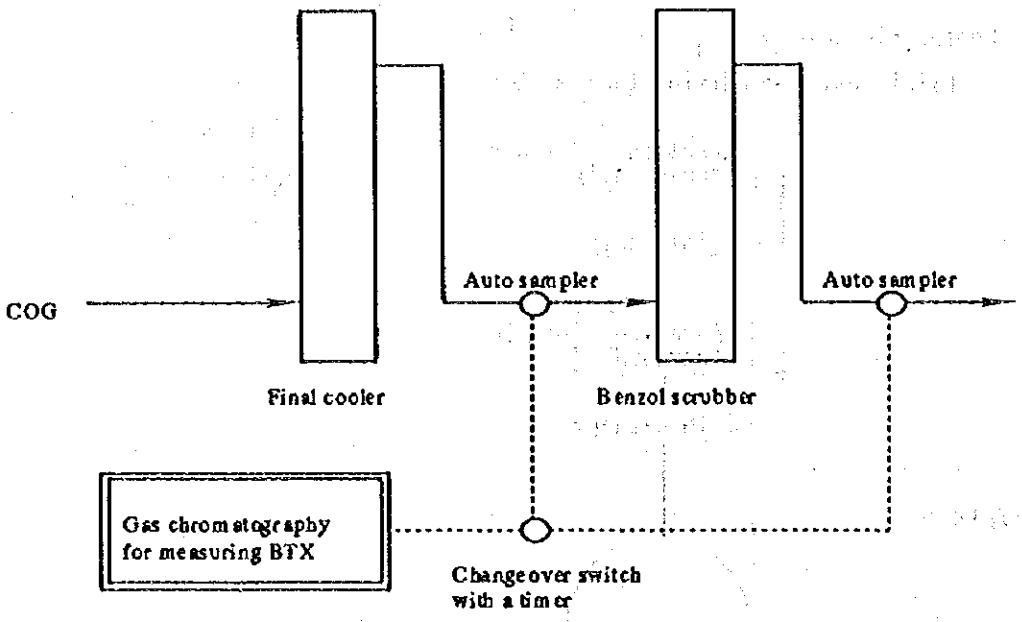
1. Design concept

By installing a BTX measuring device to improve the control of BTX recovery facility, the recovery rate will be raised to the level in Japan.

In addition to an increase in BTX recovery, these measures will reduce the problem of clogged nozzles with BTX and other impurities in COG, and thus are expected to improve the horizontal temperature distribution in the coke ovens.

As there are relatively small day-to-day variations of BTX concentration in the COG, it will take no measures to control the absorbing oil flow-rate automatically according to the COG flow-rate and BTX concentration.

Outlook of flow-sheet



2. Main specifications of equipment

1) Gas chromatography for measuring BTX concentration : 1 lot
2) Associated work : 1 lot

Item No.121 Installation of new BFG piping and a mixer of BFG/COG

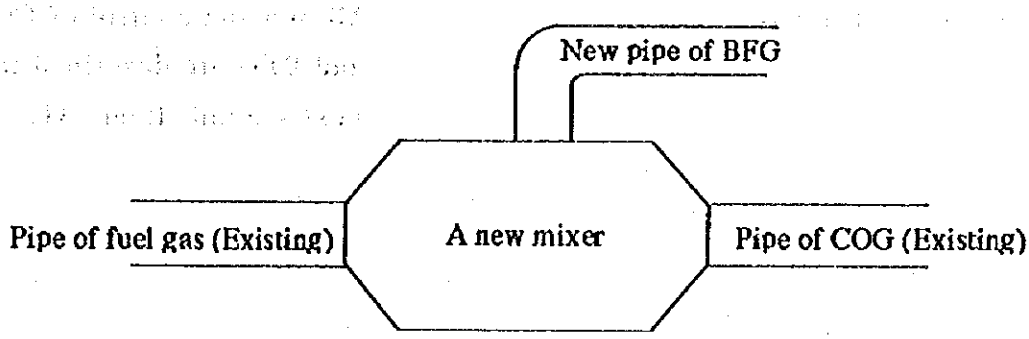
1. Design concept

By changing the fuel gas from COG alone to a mixture of COG and BFG (3,800-4,000 kcal/Nm^3), reduction of NOx emission and energy-saving would be expected.

A main BFG pipe is run from the blast furnace area to the No.3 COB.
A BFG pipe would have to be run from the main BFG pipe and the BFG would be mixed with COG in front of No.5-6 COB and the mixture's calorific value would be adjusted before being fed to the ovens.

The diameter of the BFG pipe was approximated by assuming the No.5 and No.6 COBs to be running at full capacity.

Outlook of flow-sheet



2. Design conditions

1) Calorific values of gases, and mixing rate

BFG	: Max 740 kcal/Nm^3
COG	: Max 4,300 kcal/Nm^3
Mixed gas	: 3,800 kcal/Nm^3
Ratio of BFG	: 15%

2) Flow-rate

Coal consumed by No.5 and No.6 COBs	: 4,700 t-coal/D
Number of discharge	: 210 times/D for maximum operation
Heat consumption	: Max 800 Mcal/t-coal (coal moisture content (Max.) 10%)
Flow-rate of the mixed gas	: 990,000 Nm^3/D
Flow-rate of the BFG	: 8,000 Nm^3/H (≒ 990,000 x 0.15/24 x 1.25)

3. Main specifications of equipment

1) BFG pipe (for No.5 and No.6 COBs) (450 mm ϕ x 100 m)	: 1 lot
2) Gas mixer	: 1 set (for No.5 COB)
3) Miscellaneous	: Mixing and control of COG and BFG are described in the next section, Item 131.

Item No.131 Installation of semi-automatic combustion control system

1. Design concept

Consideration has been given to reducing investment cost and operability, the system configuration will be as simple as possible.
Therefore, unlike large-scale systems in Japan, equipped with a process control computer, thermocouples for continuous temperature measurement, and other auxiliary devices.

By following a standard procedure, the system will be set to the target flue temperature and fuel gas input thermal value (Flow-rate of fuel gas x calorific value) according to the coke oven's operating rate and raw coal specifications (moisture content, grain size, volatile matter content, etc.).
So that the target gross coking time, which is determined from the coke production schedule (target quantity and coke specification), will be attained.

The system will automatically control the fuel gas quantity so as to maintain constant input thermal value. It will also control flue draft so as to maintain O2 concentration that assures complete combustion.

Flue temperature will be measured twice a shift by the operator with a new radiation pyrometer. The data obtained will be processed by a personal computer and indicated:

- Amount by which to adjust the set-point of the fuel gas input thermal value and O2 concentration in the waste gas, if necessary.
- Amount by which to adjust gas flow-rate for each oven if "Termination of coking period" computed by the measured flue temperature is outside the target range, and
- Ovens in which a poor horizontal temperature distribution is developing.

The operator will use these information to guide his adjustment works.

2. Main specifications of equipment

1) Control system : 1 lot

2) Sensors

- Calorimeter & fuel gas specific gravity analyzer : 1 set
- O2 meter : 1 set
- NOx & SOx meter : 1 set
- Radiation pyrometer : 5 sets

3) Personal computer : 1 set

3. Attached information

Fig. IV.1-3 System flow for semi-automatic combustion control

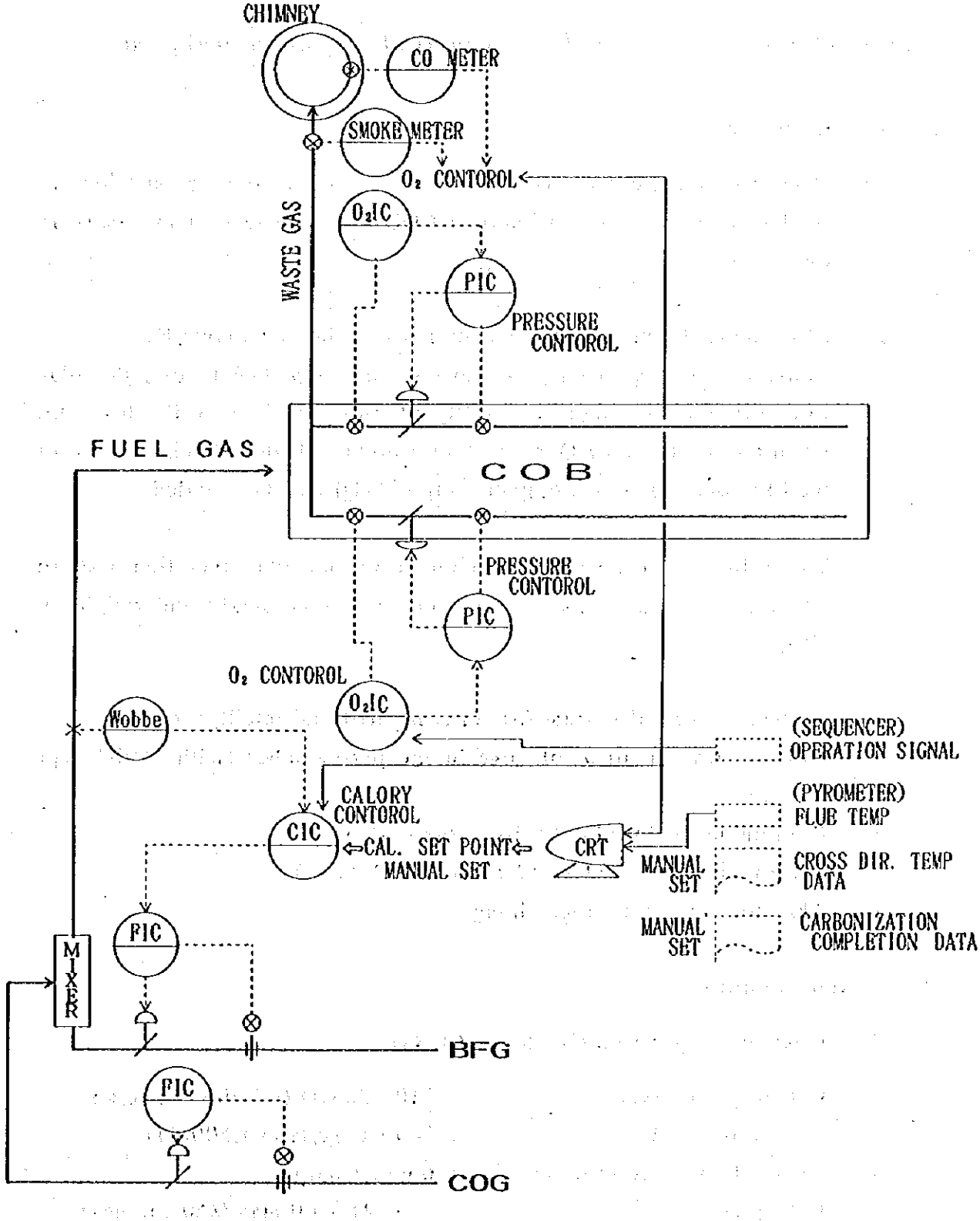


Fig. IV.1-3. System flow of semi-automatic combustion control

Item No.141 Complete renewal of No.2 CDQ (Coke dry quenching) plant

1. Design concept

1) Overall replacement of No.2 CDQ with new one is recommended, as fundamental measures to improve CDQ operation and steam recovery rate.

2) After the replacement, the capacity needs to be 145 t-coke/H. Consideration has been given to reducing investment cost, the plan calls for one unit with a capacity of 145 t/H, and as the back-up, when the boiler of CDQ must be shut down for annual maintenance or the like, one (1) coke wet quenching (CWQ) unit is installed.

3) The following measures are adopted to improve operation rate of CDQ, to increase steam recovery and to reduce height and weight of CDQ.

- Automatic control system for boiler by artificial intelligence
- Uniform level control of coke in the pre-chamber (with "Bell" type device)
- Continuous enclosed coke discharge system (with a vibrating feeder and a rotary seal valve)
- Abrasion-resistant boiler piping

2. Design conditions

1) Coke oven operation (No.5 & 6 COBs)

- Discharges (Max.) : 210 times/D (=3,500 t-coke/D)
- Coke processed : 145 t-coke/H (=3,500/24)
- Cycle of charging into the CDQ plant : 6 min./charge (=21 x 60 min./210 charges)

3. Main specifications of equipment

1)	CDQ (coke dry quenching) plant	: 1 unit
•	Coke processing capacity	: 145 t-coke/H (Max.)
•	Pre-chamber capacity	: 350 m^3(approx. 160 t-coke)
•	Cooling chamber capacity	: 610 m^3(approx. 300 t-coke)
•	Coke discharge temperature	: Below 200℃ at 145 t-coke/H
•	CDQ cycle time	: 6 min./charge
2)	Boiler	: 1 unit
•	Evaporation	: 80 t-steam/H (Max.)
•	Steam pressure	: 35 kg/cm^2 (Max. 135 kg/cm^2)
•	Steam temperature	: Max.440 ℃
•	Circulating gas volume	: 195,000 Nm^3/H
•	Inlet gas temperature	: 935℃ (Max. 950℃)
•	Outlet gas temperature	: 180℃
•	Inlet dust content	: 10 g/Nm^3
3)	CWQ (Coke Wet Quenching)	: 1 unit

4. Attached information

Fig. IV.1-4 Overall view of new No.2 CDQ
Fig. IV.1-5 Plot plan of new No.2 CDQ

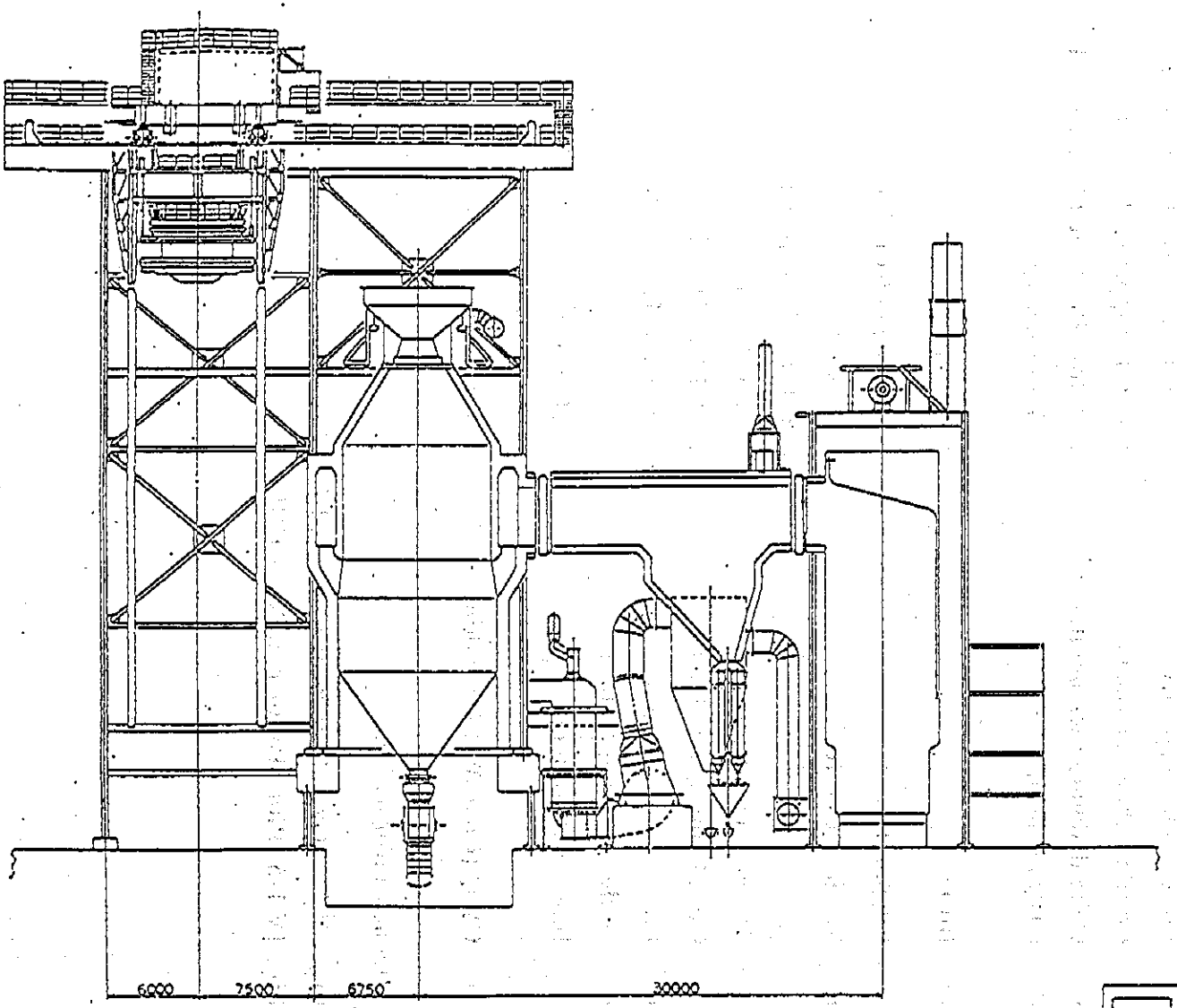


Fig.IV.1-4. Overall view of new No.2 CDQ

KOBE STEEL, LTD.
ENGINEERING & MACHINERY DIVISION

TITLE

DWG. NO. D841-

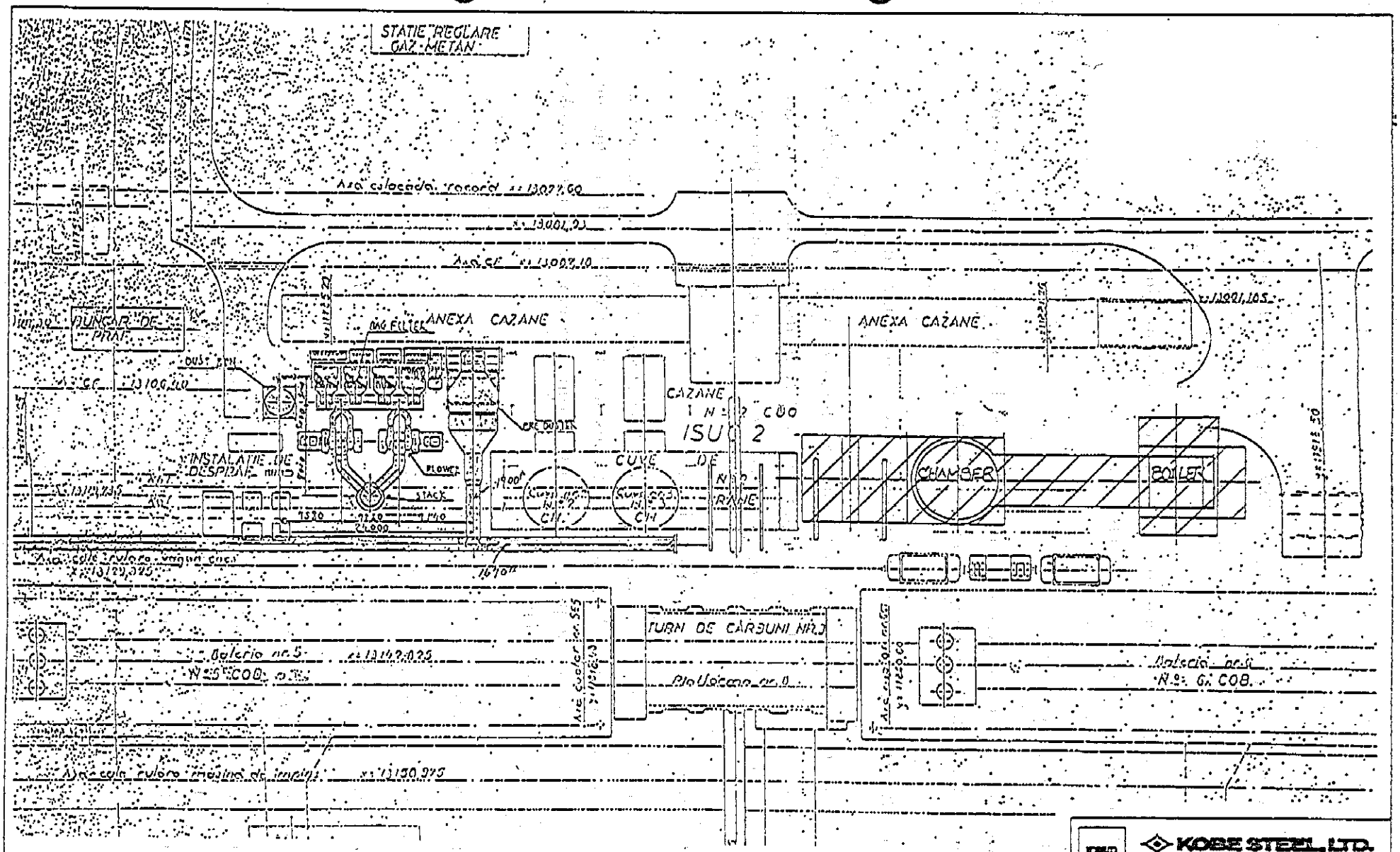


Fig.IV.1-5. Plot plan of new No.2 CDQ

Item No.151 & 152 Installation of facilities to reduce dust emission during charging

No.151 Replacement of pumps for high pressure ammonia liquor
No.152 Improvement of ascension pipe seal

1. Design concept

To reduce dust emission and raw COG leak during charging coal into coke oven, the following improvement will be done.

1) Replacement of pumps with high pressure ammonia liquor

The outlet pressure of the pumps should be increased till 40 kg/cm^2, and as the result the reduction of dust emission and COG leak from charging hole during charging coal into a coke oven can be expected.

2) Improvement of ascension pipe seal

The existing mechanical seal should be changed to water seal, and as the result, the reduction of dust emission and COG leak from the top of the ascension pipe, especially during charging coal into a coke oven can be expected.

2. Design conditions

1) Coke oven operation (No.5 COBs)

- Discharges (Max.) : 105 times/D

2) Existing pump specification

- Pressure at pump inlet : 3.5 kg/cm^2
- Temperature at pump inlet : 68-73℃
- Flow-rate of ammonia liquor : 30 t/H

3. Main specification of equipments

1) Pump for high pressure ammonia liquor : 2 sets

- Flow-rate of ammonia liquor : 30 t/H
- Pressure at pump inlet : 3.5 kg/cm^2
- Pressure at pump outlet : 40 kg/cm^2
- Temperature at pump inlet : 68-73℃

2) Ascension pipe with cleaning nozzle : 130 units (=65 ovens x 2)

- Type of the seal : Water seal
- Water pipe for seal : 1 set

4. Attached information

Fig. IV.1-6 Overall view of smokeless charge

Fig. IV.1-7 Cleaning device for bent portion and water circulation system for top cover water sealing

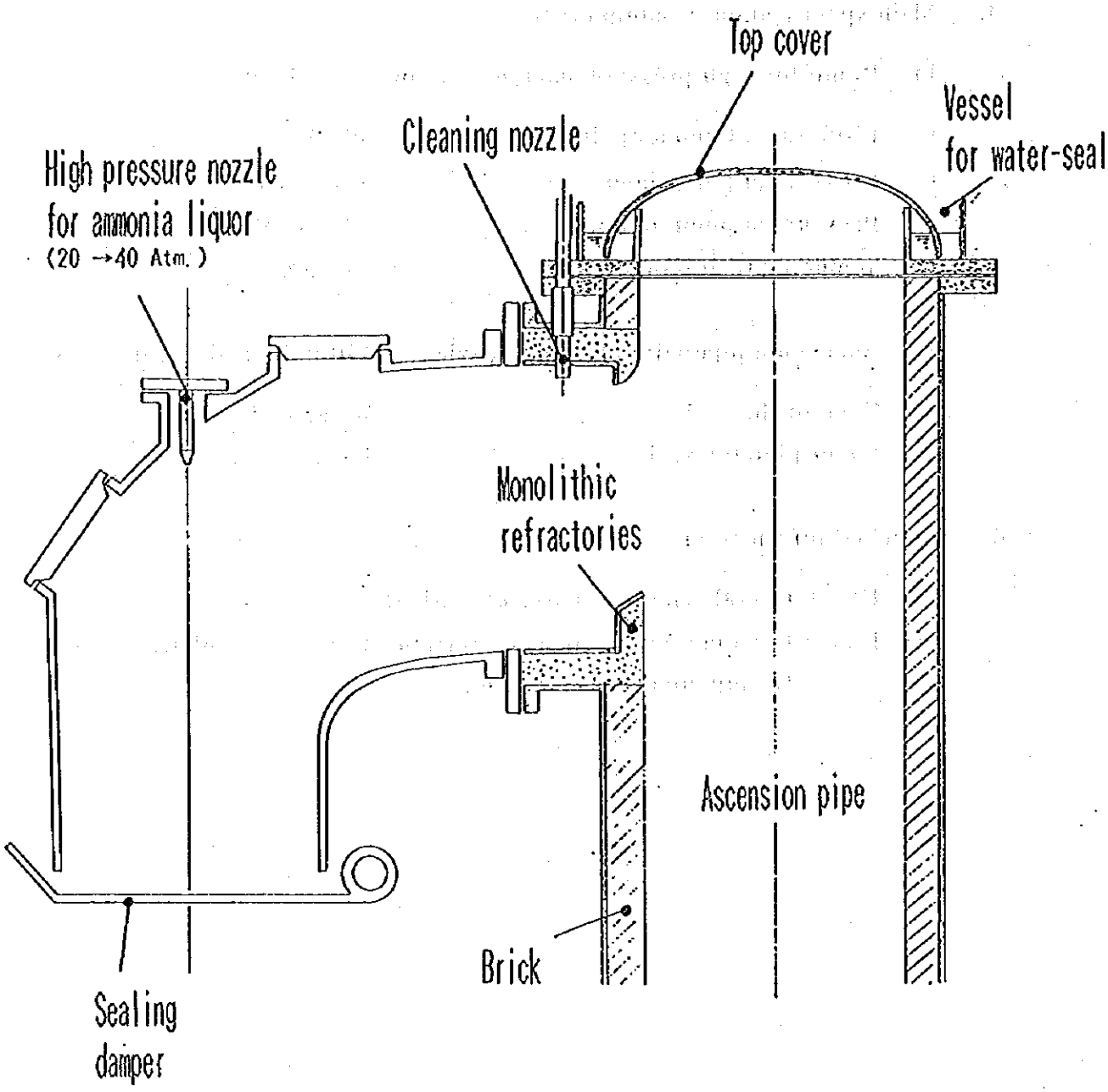


Fig. IV.1-6. Overall view of smokeless charge

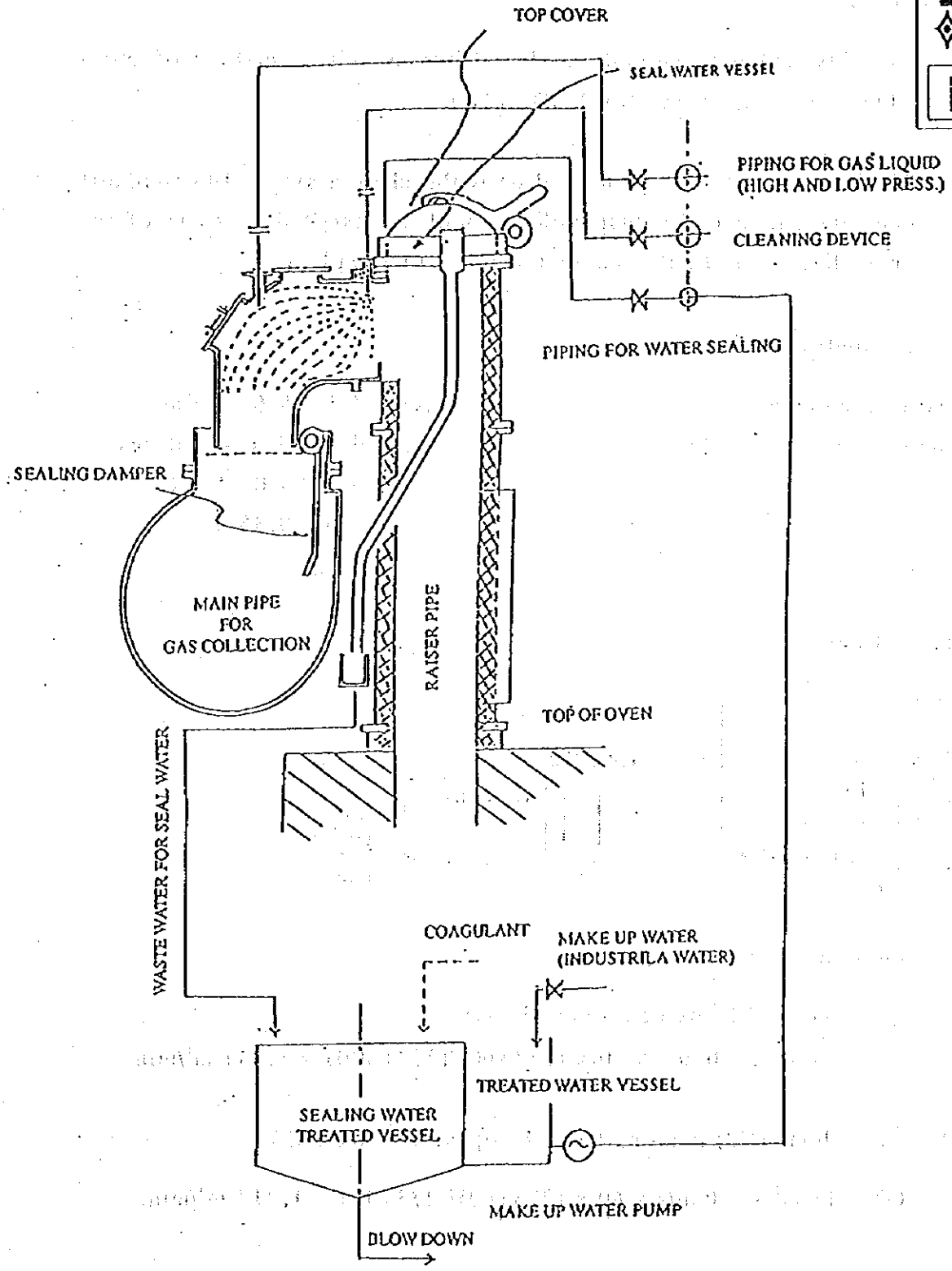


Fig.IV.1-7. Cleaning device for bent portion and water circulation system for top cover water sealing

Item No.161 Installation of a dust collector for pushing and for CDQ

1. Design concept

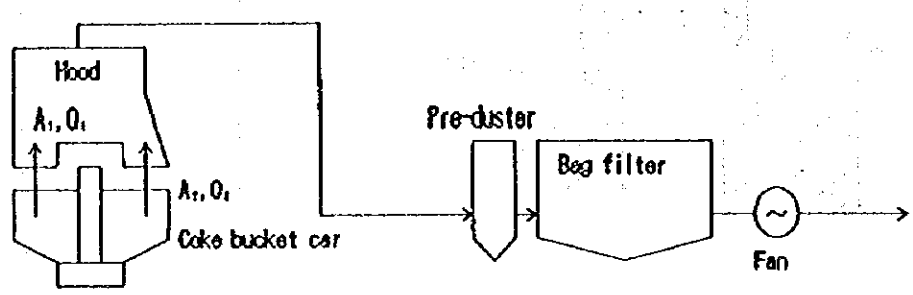
   1) One dust collector should be shared by smokeless pushing of No.5 COB and charging into No.2 CDQ plant.

   2) The entire No.2 CDQ plant will be replaced by a single 145 t-coke/H capacity unit and the dust collector will be installed in some of the space left vacant by the removal of the old CDQ plant.

2. Design conditions

- Dust emitted area : A1 = 4.5 x 5.6 = 25 m^2
- Opening area : A2 = 4 m x 1 m x 2 places
  + 1.2 x 0.35 x 2
  + 6 x 0.35 x 2
  = 13 m^2

Design conditions



1) Emitted gas volume (Q1)

Q1 = A1 x (Velocity of generated gas)
= 25 m^2 x 2.0 m/s x 60 x (273+60)/(273+600) = 1,041 m^3/min.

2) Air volume (Q2) inhaling from the opening space (A2)

Q2 = 13 m^2 x 2.0 m/s x 60 x (273+60)/(273+30) = 1,714 m^3/min.

3) Total volume:

Q = Q1 + Q2 + leak rate (10%) = 3,030 ≒ 3,000 m^3/min. (60℃)

3. Main specifications of equipment

1) Guide car with hood : 1 set

Connector : Lifting magnet type

2) Dust collector : 1 set

Bag-filter type; 3,000 m^3/min. (60℃) x 600 mm Aq.
the dust dislodging method : By pulse jet
Dust concentration : Inlet 15 g/Nm^3
Outlet <50 mg/Nm^3

3) Ducts : 1,670W x 1,670L mm (angular type), 100 m long

4. Attached information

Fig. IV.1-8 Overall view of the bag filter equipment

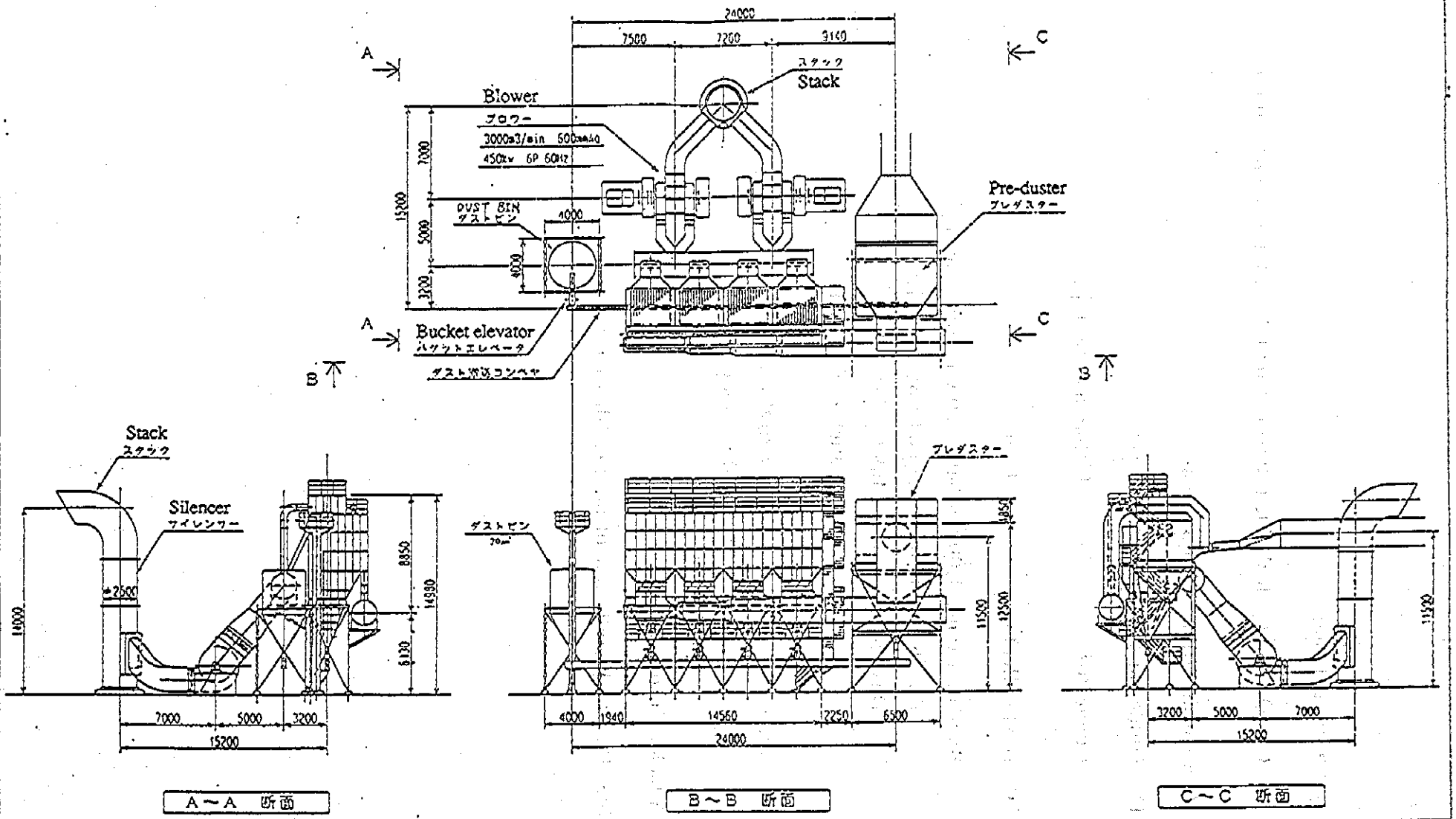


Fig.IV.1-8. Overall view of the bag filter equipment

Item No.171 Improvement of the activated sludge facilities

1. Design concept

   1) In order to reduce phenol and CN^-, the activated sludge facility will be modified and pH adjustment, aeration, and excess sludge concentration adjustment will be improved.

   2) Control instruments needed for the above purposes will be installed.

2. Design conditions

   1) Specifications of waste water

	Ammonia liquor	Process waste water
Flow-rate (t/H)	60 - 80	50 - 55
Temperature (°C)	65 - 75	60 - 70
pH (-)	10 - 11	7 - 9
SS	300 - 800	300 - 800
(mg/lit)	1,000 - 2,000	1,000 - 2,000
BOD_5	3,000 - 4,000	3,000 - 4,000
(mg/lit)	2 - 15	2 - 15
COD_{CR}	1,000 - 2,000	1,000 - 2,000
(mg/lit)	150 - 200	150 - 200
T-CN^-		
(mg/lit)		
Phenol		
(mg/lit)		
T-N		
(mg/lit)		

3. Main specifications of equipment

   1) Thickener 20 m ϕ x 3.8 m high : 2 units

   2) Modified mixing tank (adding partitions) : 2 units

3) Modified aeration tank : 2 units
Raising height/removing partitions

4) Sludge dehydration equipment : 2 units

5) Instrumentation : 1 lot

- Level gauge
- Flow meter and controller
- pH meter and controller
- COD meter, MLSS meter, ORP meter, etc.

4. Attached information

Fig. IV.1-9 System flow of the activated sludge process
Fig. IV.1-10 Plot plan of the activated sludge process

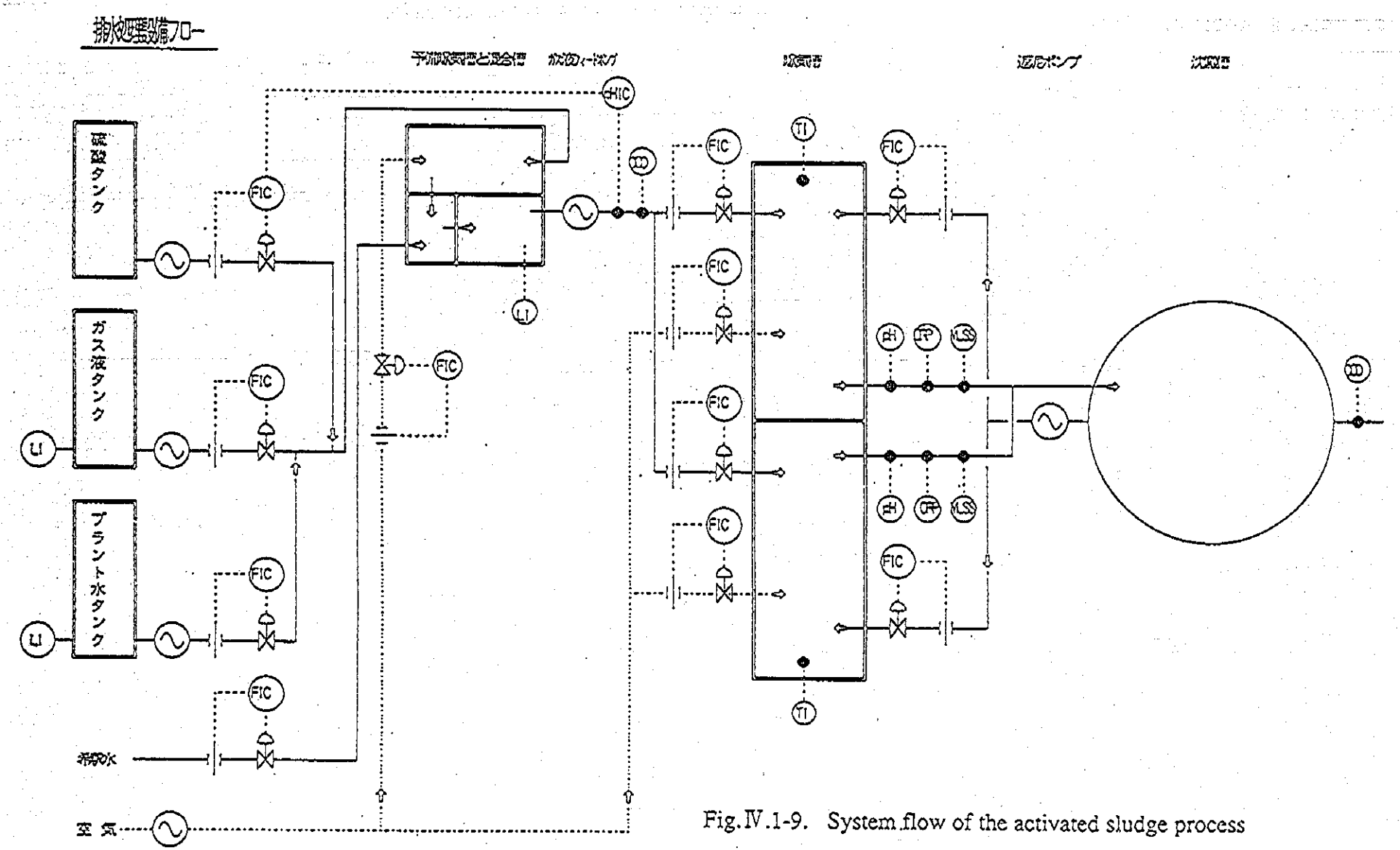


Fig.Ⅳ.1-9. System flow of the activated sludge process

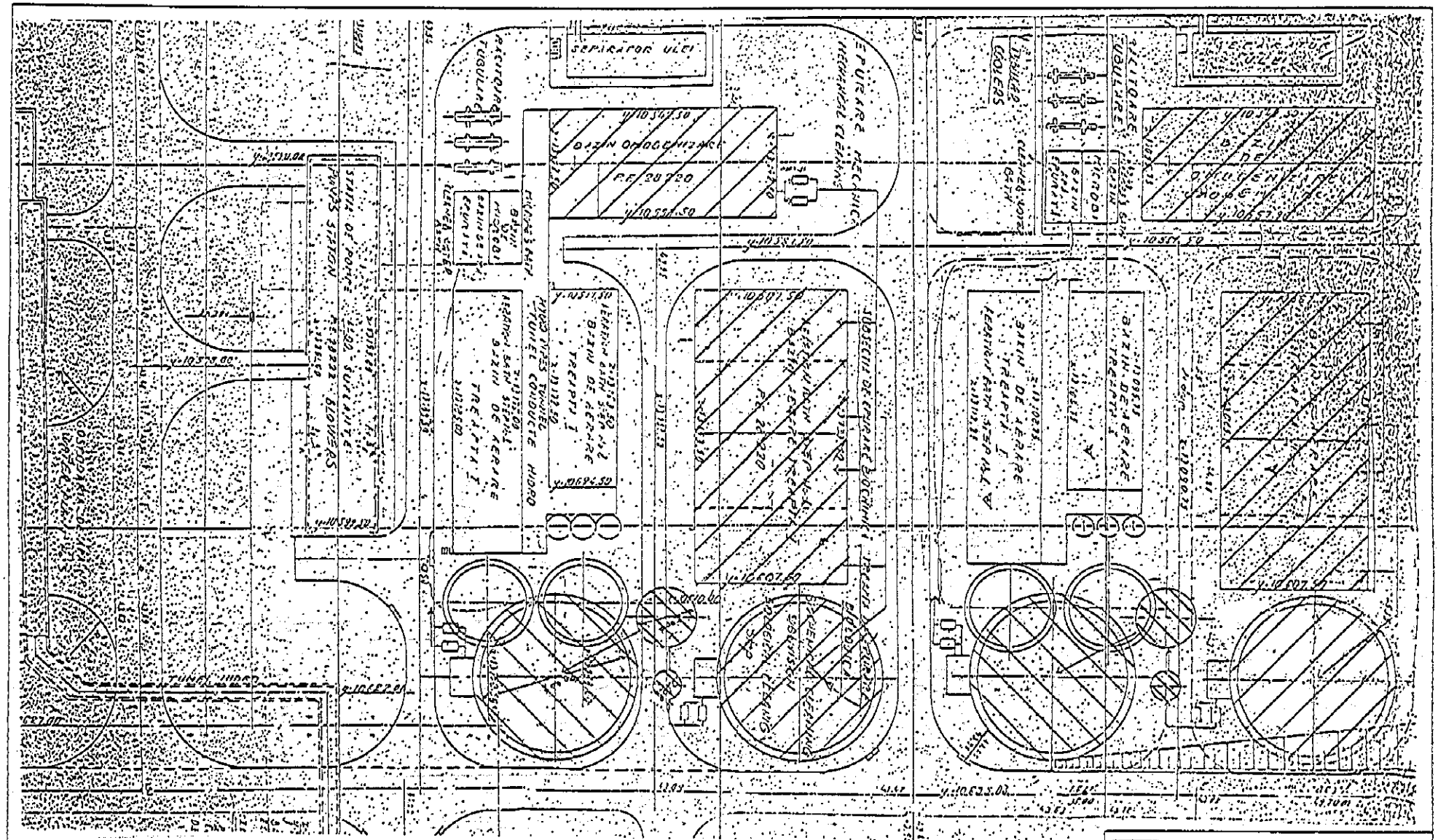


Fig.IV.1-10. Plot plan of the activated sludge process

: Activated sludge process

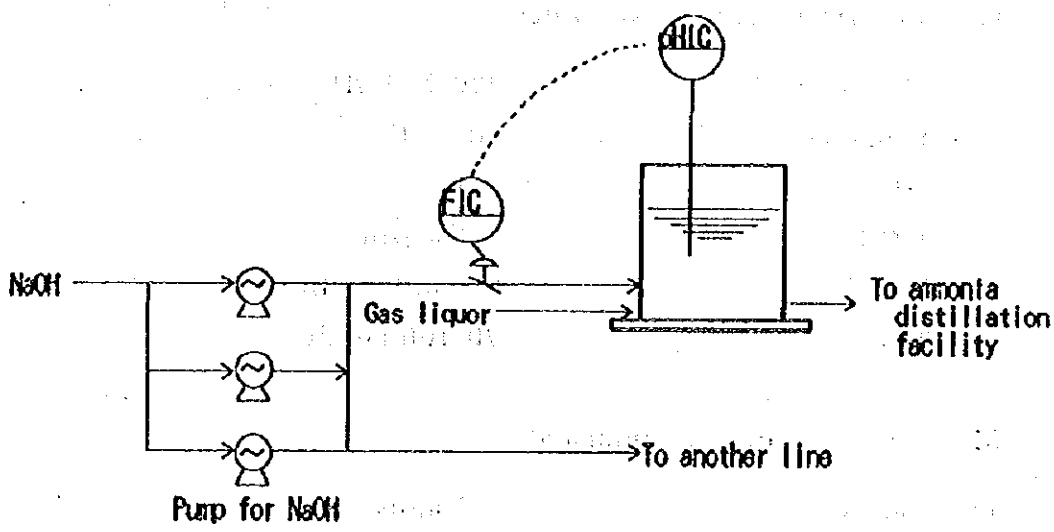
: New precipitator

Item No.181 Automatic pH control of ammonia liquor flow to ammonia distillation facility

1. Design concept

In order to reduce ammonia concentration in the waste water, automatic control system of pH should be installed in the up-stream of ammonia still.

Outlook of control flow



2. Main specifications of equipment

1) Chemicals pump (NaOH) 1 m^3/H : 3 units

2) Instrumentation : 1 lot

Item No.193 Installation of condensation precipitator

1. Design concept

In order to reduce CN^- concentration in the waste water, a new precipitator should be installed in downstream of the improved activated sludge process.

2. Design conditions

1) Specifications of waste water

- Flow-rate : 220-270 t/H
- Temperature : 30-35℃
- pH : 7-8
- T-CN^- : 1-4 mg/lit
- Phenol : 0.1-0.3 mg/lit
- T-N : 70-100 mg/lit

3. Main specifications of equipment

1) Thickener : 2 units
20 mϕ x 3.8 mH (Made of concrete)

2) Tanks

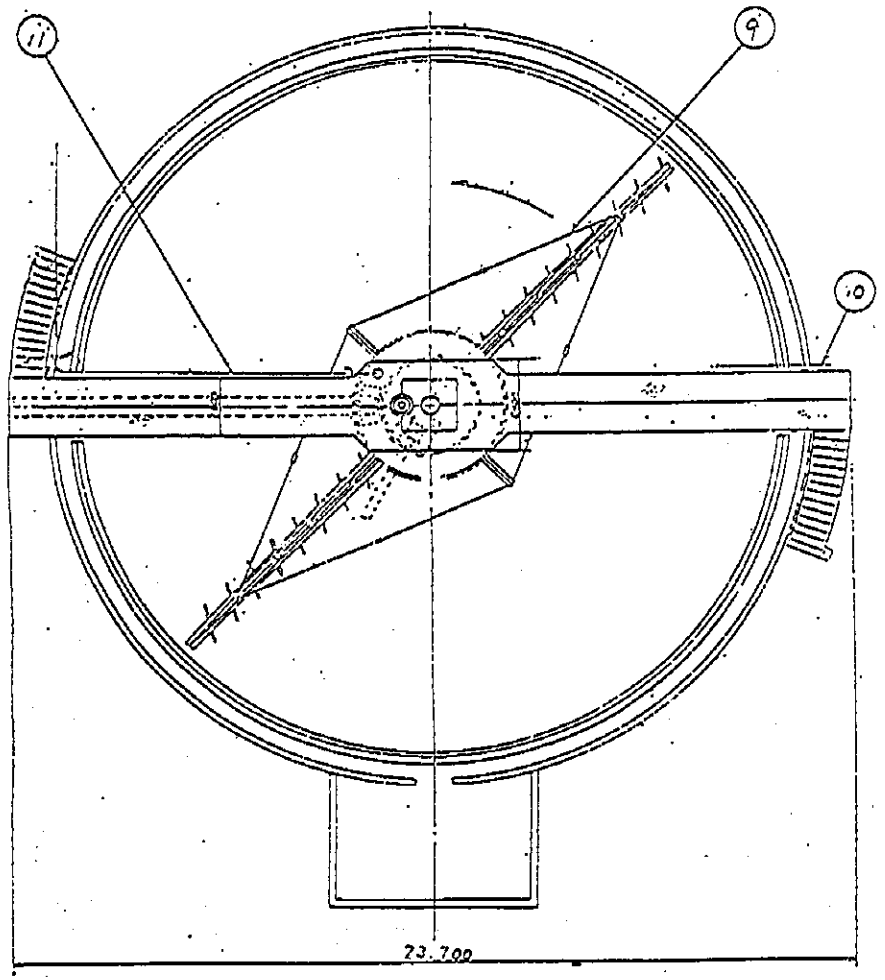
- Tank with high-speed agitator: 2 units
3.6 mϕ x 4 mH (40 m^3)
(Made of Steel)
Coated with tar epoxy resin
- Tank with low-speed agitator : 2 units
8.0 mϕ x 4 mH (200 m^3)
(Made of Steel)
Coated with tar epoxy resin
- Tank for a flocculent : 10 m^3 1 unit

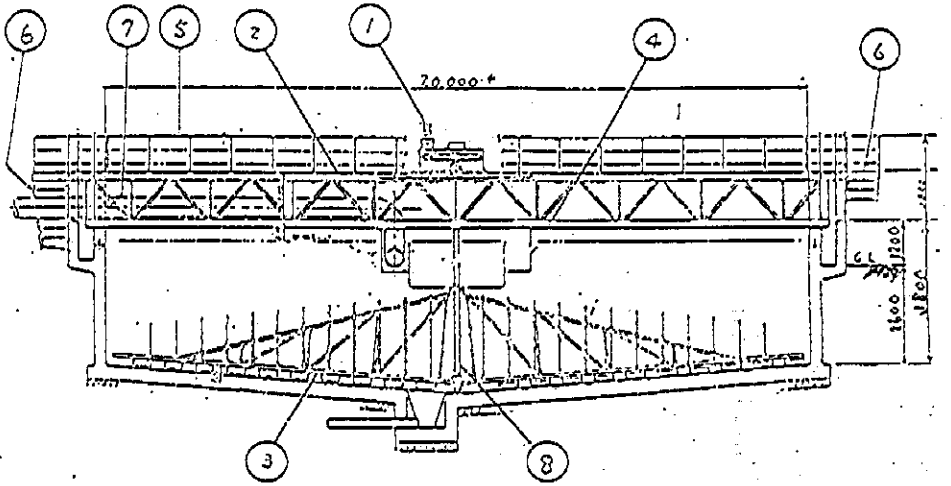
3) Pumps : 1 lot

4) Instrumentation : 1 lot

4. Attached information

Fig. IV.1-11 Overall view of the new precipitator





No	PART	MAT.	Q'TY	DWG. No.	REMARK
1	MOTOR		1		
2	MAN WAY		1		
3	RAKE		1		
4	CENTER WELL		1		
5	HANDRAIL		1		
6	STAIRS		1		
7	INLET DUCT		1		
8	MAIN SHAFT		1		
9	TURN BACKLE		1		
10	HANGLING PIPE		1		
11	SLUDGE OVERFLOW		1		

KOBE STEEL, LTD.
ENGINEERING & MACHINERY DIVISION

TITLE

DWG. NO. D841-

Fig.IV.1-11. Overall view of the new precipitator

2. NO.7 SINTERING PLANT

2.1 Outline of conceptual design

Conceptual design of 9 measures for energy saving and 3 measures for pollution control has been studied.

Equipment items to have been studied conceptual design are shown at Table IV.2-1. and schematic diagram about outline of total conceptual design is shown in Figure IV.2-1.

As the basic condition for designing, the production capacity of No.7 sintering plant is settled 15,000 t/d (30 t/d/m^2).

Table IV.2-1.Equipment items to study conceptual design

Class		Equipment Item
Enhancement of the operational control system	211	Measurement of the cold strength of sinter product (Shutter Tester)
	213	Constant feeding weigher of raw materials and coke breeze
Improvement of burning coke breeze	221	Intensified Sifting Feeder
	224	Coke breeze recrushing system
Ignition furnace	231	Compact furnace
Recovery of cooler waste heat	241	Reusing system of cooler waste gas
	242	Waste heat recovery boiler
Pollutants control of main waste gas	251	De-dusting (Moving electrode E.P.)
	252	De-sulfurization
De-dusting of plant	261	On strand suction system

Increasing productivity	271	Yard stock system for sinter product
	272	Quick lime adding system

2.2 Contents of conceptual design

2.2.1 Enhancement of the operational control system

Quality control of sinter product and constant feed of raw materials are necessary to attain good operational control and to promote energy saving for sintering plant.

For quality control, cold strength and FeO concentration of sinter product are important. Because cold strength affects the permeability in the blast furnace and FeO concentration indicates reducibility. And both indexes are useful to control sintering process as the level of sintering strength and heat.

Constant feed of raw materials is important to decrease the variation of sintering process and also to promote energy saving.

2.2.2 Improvement of burning coke breeze

It is necessary for high energy efficiency in sintering reaction to obtain good heat pattern.

At upper layer in the sintering bed, air temperature for burning is lower than at lower layer. Therefore the upper layer must be supplied more amount of coke breeze than the lower layer. For this purpose, charging material must be segregated such as smaller particles put on the upper layer and coke breeze must be crushed into smaller particles.

2.2.3 Ignition furnace

In order to improve the energy efficiency, combined ignition with flame ignition and atmosphere ignition is applied for the ignition furnace. And preheating furnace is installed before the ignition furnace.

2.2.4 Recovery of cooler waste heat

The pattern of waste gas temperature is different by the type of cooler.
In the case of circular bin type cooler at No.7 sintering plant, waste gas temperature is averaged and highest temperature is low about 200℃.
Therefore waste heat recovery by steam is not suitable and so the waste heat should be used as preheating air for raw materials and combustion air of the ignition furnace.
In the case of linear trough type cooler at No.6 sintering plant, the waste heat recovery by steam from the high temperature gas in the upstream part of the cooler is possible to be applied.

2.2.5 Pollutants control of main waste gas

It is predicted that soot and SOx in main waste gas will exceed the limit value in year 2002 if no measure is taken. (Soot already exceeds the limit value) As a measure, the existing EP will be modified for moving electrode type which cope with high alkali contained dust. Further, dry type desulfurization system which utilizes activated coke is installed to decrease SOx.

2.2.6 De-dusting of plant

De-dusting from the charging part and discharging part is done to eliminate dust generation around the sintering plant. A strand suction type is adopted to avoid addition of dust collector.

2.2.7 Increasing productivity

Considering the production balance in year 2002, production will be integrated in Nos. 6, 7, and 8 sintering plants. In order to actualize this plan, increasing of the productivity is essential. Yard stock system for sinter product to adjust the supply/demand for blast furnace and quick lime adding system to improve the permeability are installed.

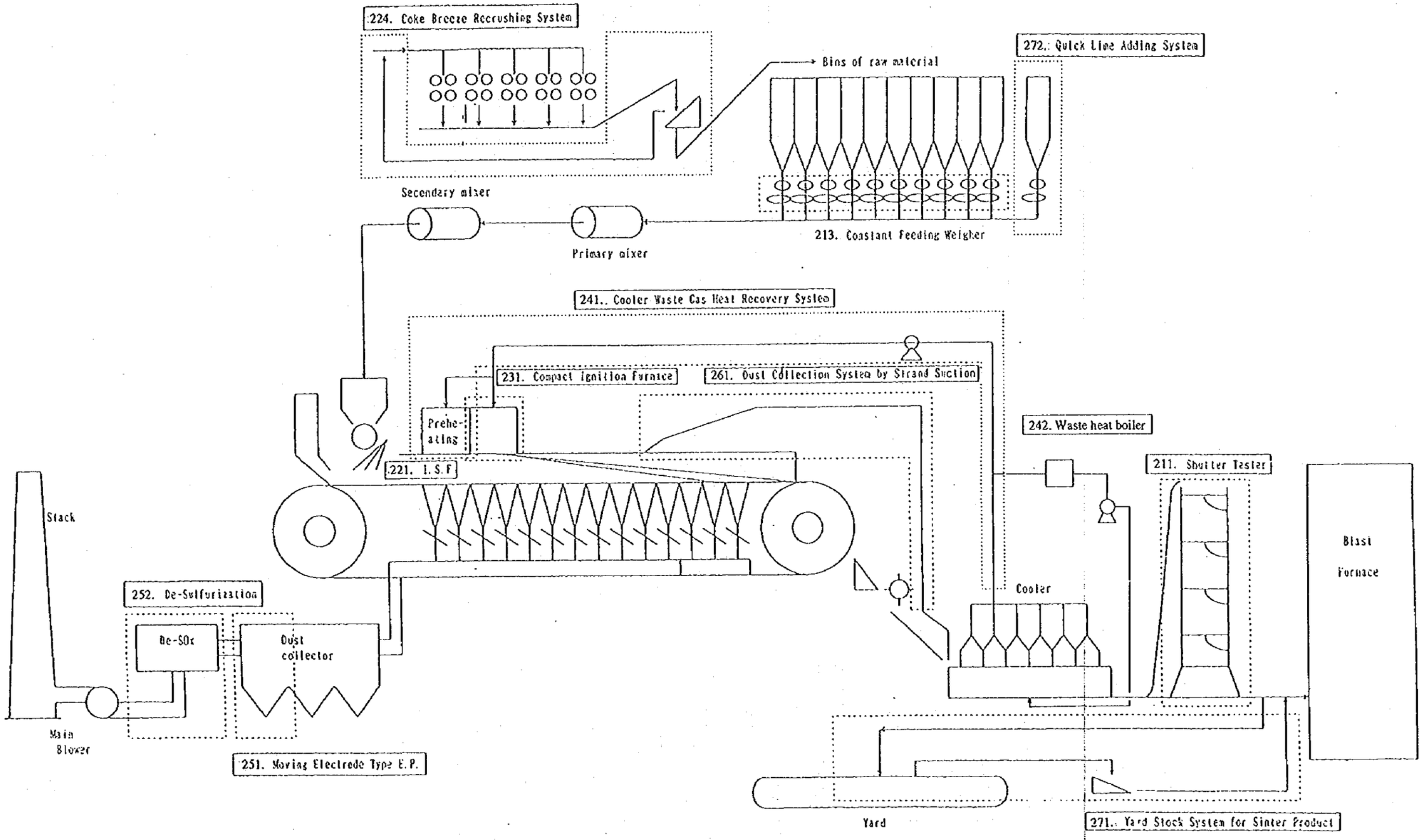


Fig.IV.2-1. Schematic diagram of Energy Saving and Pollution Control Measures for No.7 Sintering Plant

Item No. 211 Measurement of the cold strength of sinter product(Shutter tester)

1. Design concept

1) The cold strength of sinter product is measured by shutter tester.

2) Sinter product is sampled automatically twice a shift from existing sinter product line after cold screen.

3) Test sample of over 10mm size particles is selected by 20kg from sampled material.

4) Test sample material is fallen down four times by 2 meters height.

5) After test, over 10mm size particles are weighed.

6) Used material is returned to existing sinter product line.

2. Main specifications

1)	Total weight of sample	: 50 kg
2)	Sample weight for testing	: 20 kg
3)	Grain size of sample for testing	: over 10 mm

3. Equipment List

1) Mechanical equipment

· Belt sampler	: 1 unit
· Belt conveyor	: 4 units
· Screen	: 1 unit
· Shutter tester	: 1 set

2) Electrical equipment and instrumentation

· Hopper scale	: 100 g - 100 kg × 1 set
· Sequencer	: 1 lot

3) Civil and Construction

· House	: 100 $m^2 \times 12$ mH
· Basement	: 1 lot

4. Attached information

Fig IV.2-2 Flow sheet of measurement of the cold strength of sinter product

Fig IV.2-3 Typical drawing of shutter tester and skip elevator

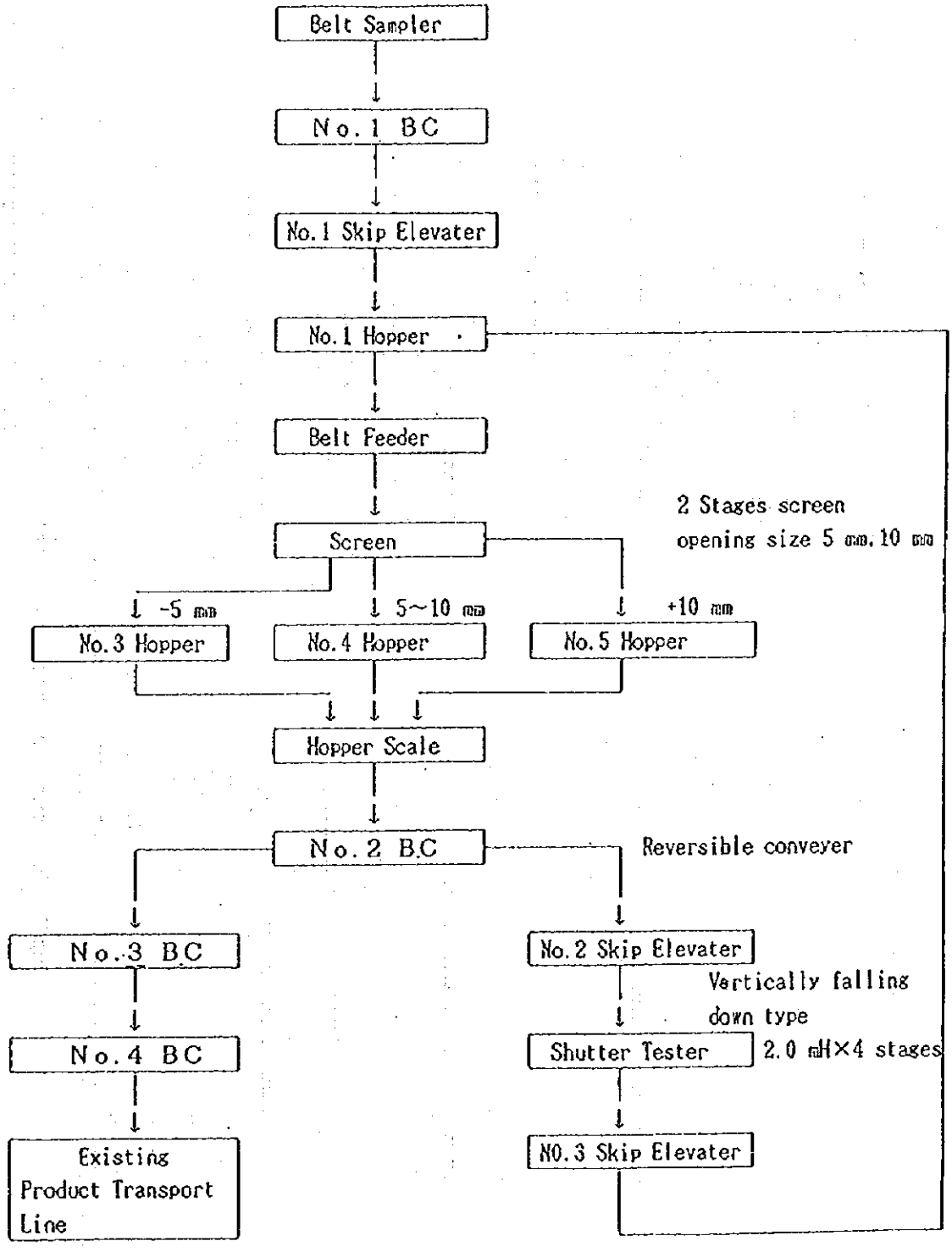


Fig.IV.2-2. Flow sheet of measurement of the cold strength of sinter product

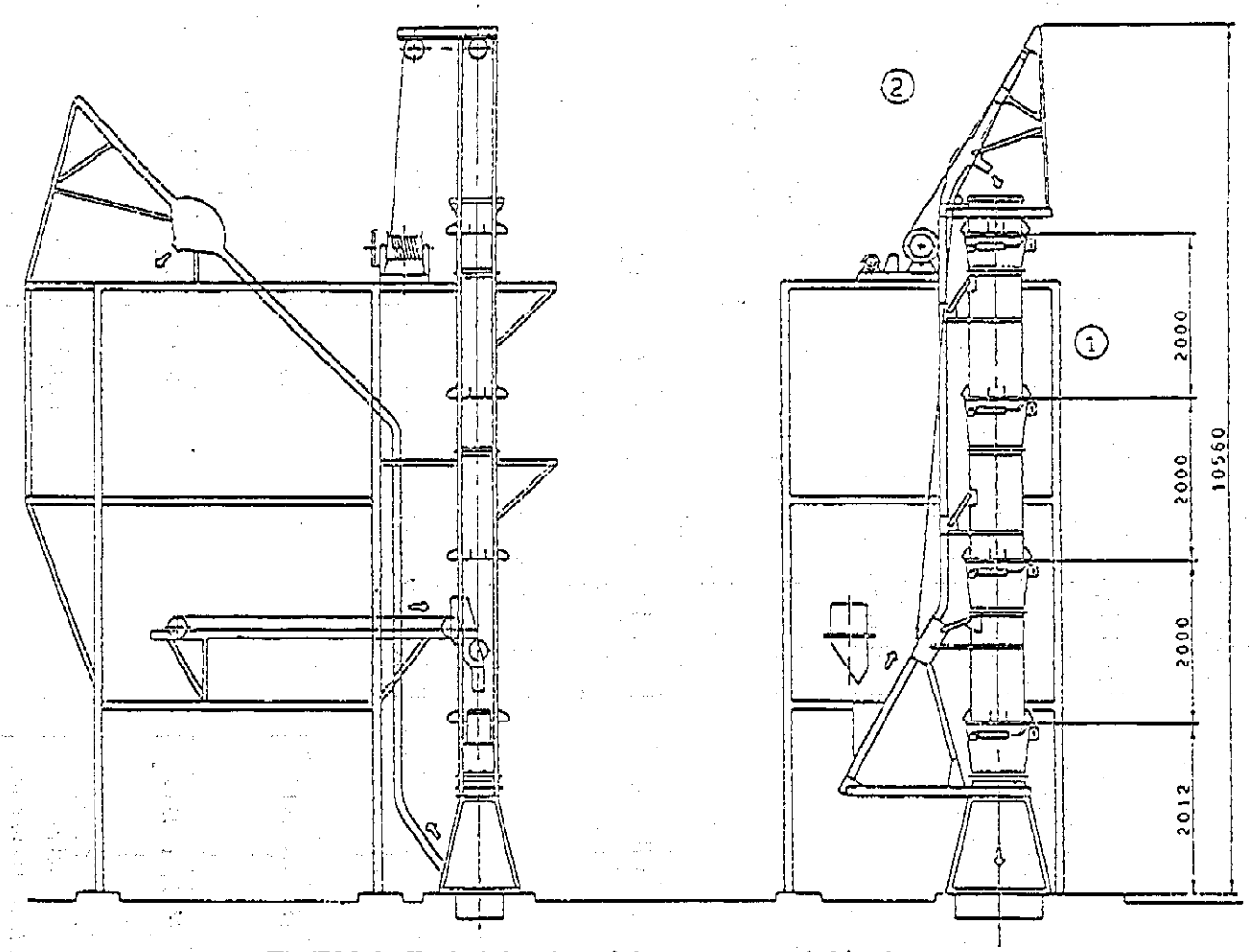


Fig.IV.2-3. Typical drawing of shutter tester and skip elevator

GALA-C4SV001

NO.	DESCRIPTION	BY	CHKD	APPRD	DATE
1					
2					
3					
...					

① SHUTTER TESTER
② SKIP ELEVATOR

GALA-C4SV001-WAZ.-PET

OWNER: SIDEX-GALATI WORKS-RUMANIA

TITLE: NO 7 SINTERING PLANT
MEASUREMENT OF THE COLD STRENGTH OF SINTER PRODUCT/SHUTTER TESTER

	BY	DATE
DESIGNED		
DRAWN	T. Hamano	29. JUN. 2001
CHECKED		
APPROVED		

NIPPON STEEL CORPORATION-NSC
PLANT ENG'G & TECHNOLOGY CENTER

SCALE: 1/40 | DWG. NO.: GALA-C4SV001 | REV.: 0

Item No.213 Constant feeding weigher of raw materials and coke breeze

1. Design concept

Weighing devices of raw materials and coke breeze are renewed from existing single belt type to double belts type to improve weighing accuracy.

2. Main specifications

1)	Feeding weight of coke breeze	: 45 t/h × 2 sets
2)	Feeding weight of iron ore	: 200 t/h × 6 sets
3)	Feeding weight of miscellaneous material	: 150 t/h × 2 sets

3. Equipment list

Constant feeding weigher : 10 units

4. Attached information

Fig IV.2-4 Flow sheet of improvement of the weighing-out accuracy of raw material and fuels

Fig IV.2-5 Typical drawing of constant feed weigher

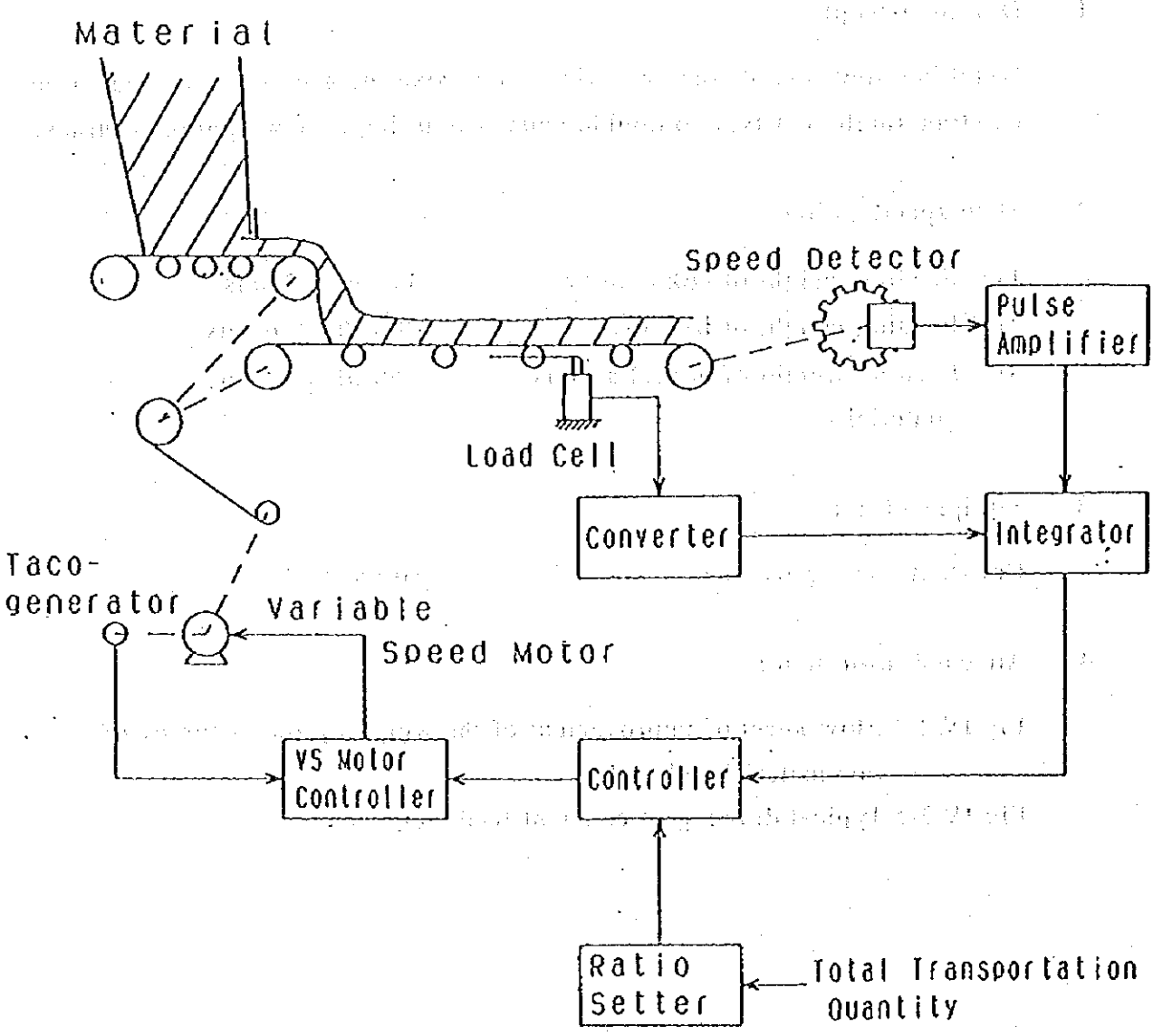


Fig.IV.2-4. Flow sheet of improvement of the weighing-out accuracy of raw material and fuels

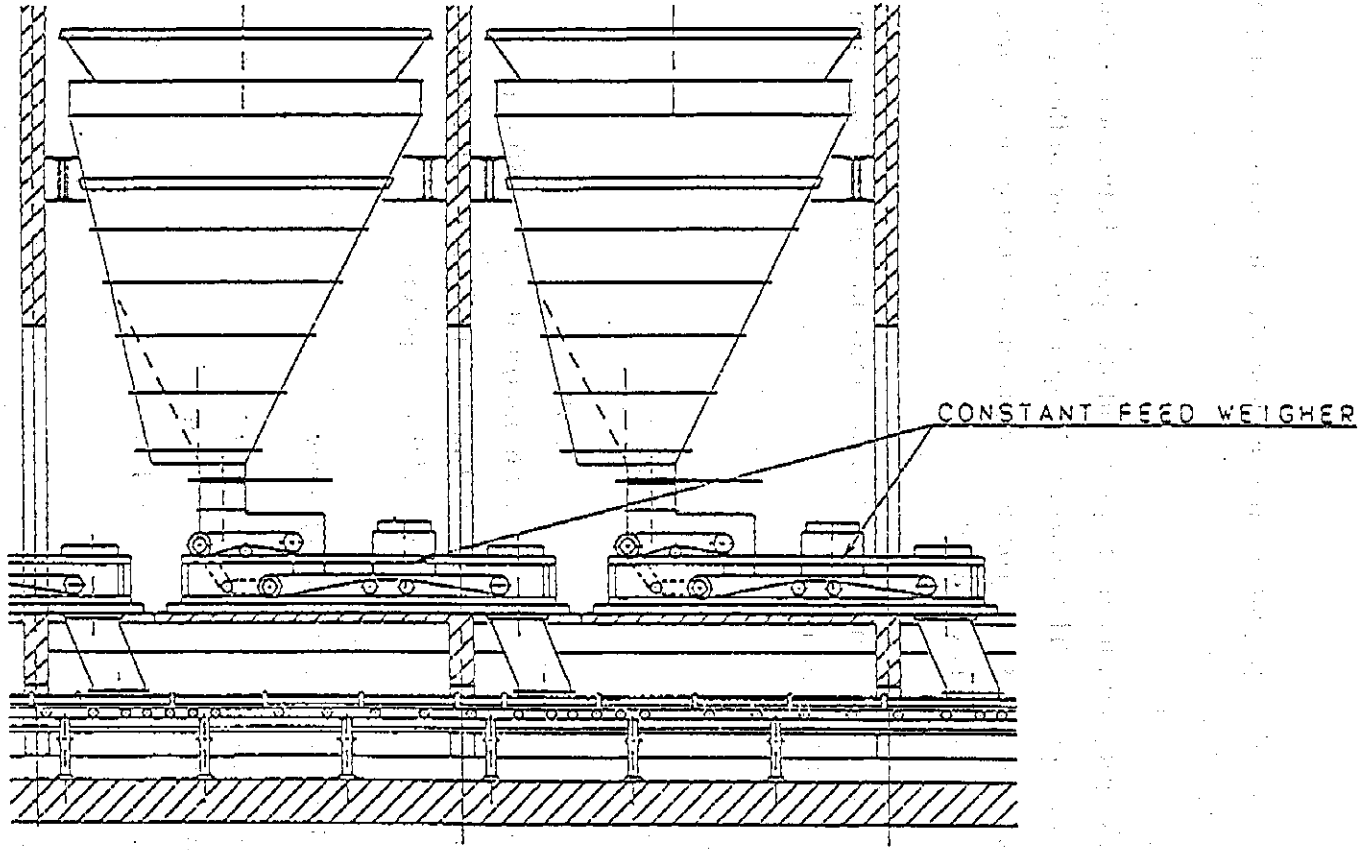


Fig.IV.2-5. Typical drawing of constant feed weigher

Item No. 221 Intensified Sifting Feeder(ISF)

1. Design concept

   1) New type charging equipment sifts efficiently charging material by three dimensional screen.

   2) New type charging equipment is placed at the space between the drum feeder and the pallet. The charging hopper has to be pulled up by 550mm, because the space for new equipment should be enlarged. Existing sloping plate is removed.

   3) This equipment is exchanged for spare units to renew worn sifting bars every about four months.

2. Main specifications

   1) Sifting feeder

   · Number of units : 5 units
   · Number of bars : 56 bars/unit × 5 = 280 bars
   · Driving motors : 2 motors/unit × 5 = 10 motors (60 w, 4 poles)

   2) Equipment for exchanging sifting feeder

   · Pulling up equipment : 1 set
   · Pulling out equipment : 1 set
   · Spare parts holder : 1 set

3. Equipment list

   1) Sifting feeder : 5 units (& 5 spare units)
   2) Sifting feeder stand : 1 set
   3) Equipment for exchanging sifting feeder : 1 set
   4) Connectors for power supply : 1 set

4. Attached information

Fig IV.2-6 Outline of the equipment

Fig IV.2-7 Typical drawing of new type charging device

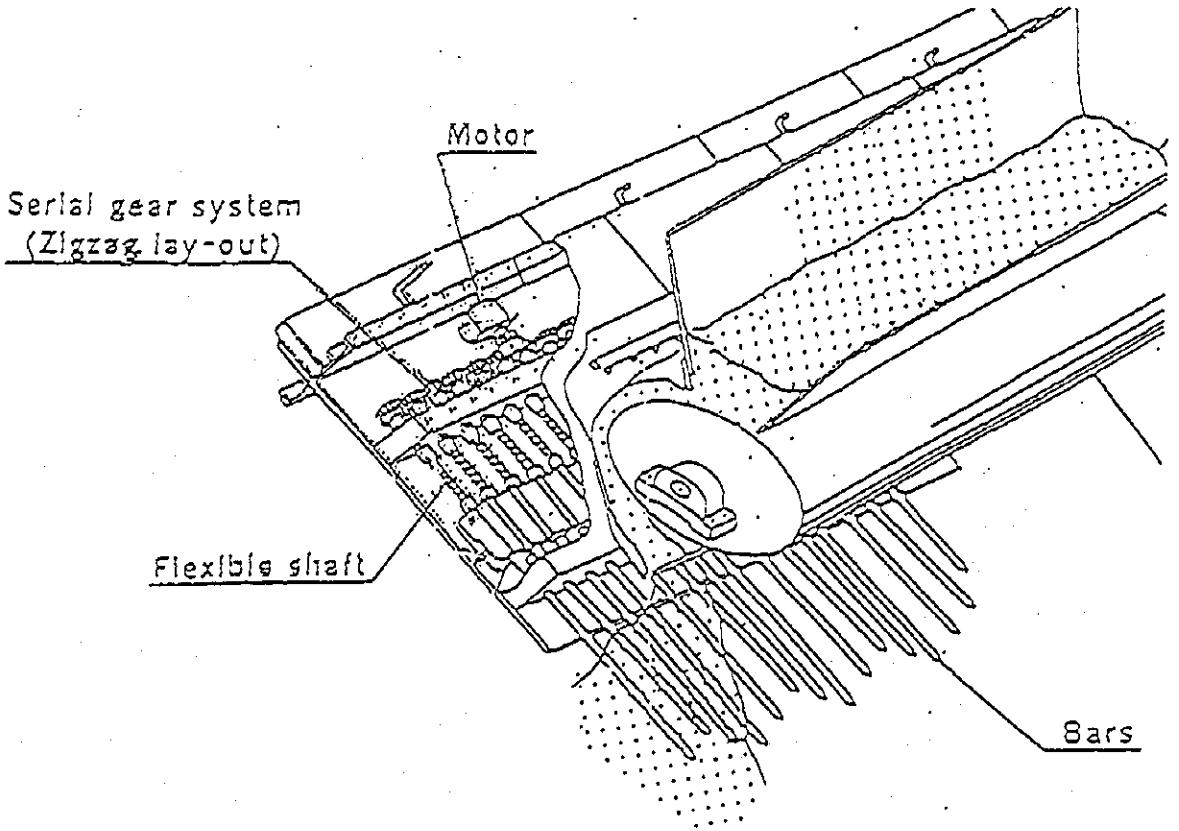


Fig.IV.2-6. Outline of the equipment

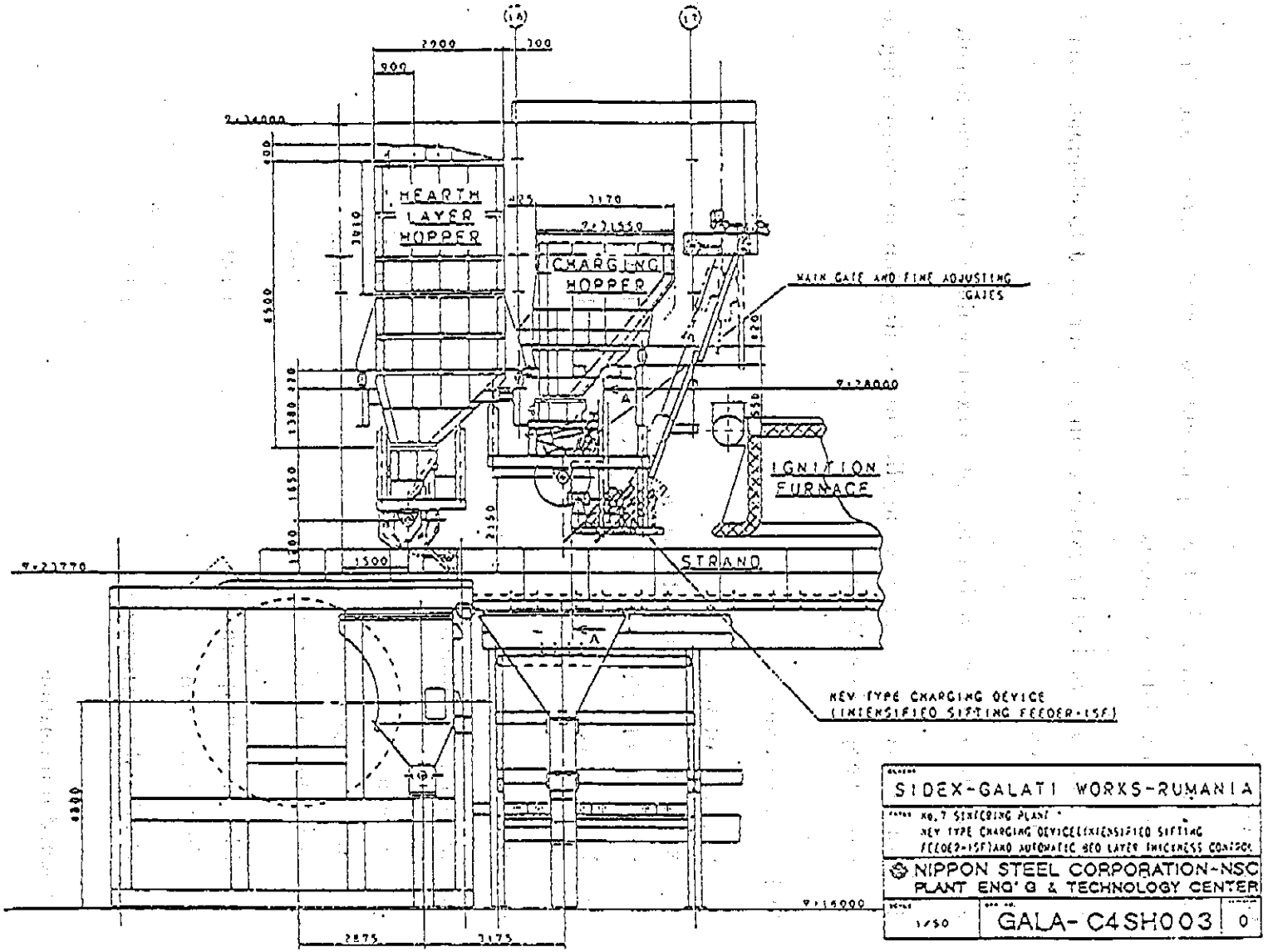


Fig.IV.2-7. Typical drawing of new type charging device

Item No.224 Coke breeze recrushing system

1. Design concept

1) Recrushing screen is the equipment to avoid coarse coke breeze charged on sintering pallets.

2) Coke breeze crushed by existing mills is screened to eliminate over 5 mm particles.

3) Over size coke breeze is returned to existing line of supplying to mill.

4) Under size coke breeze is supplied to existing line of transporting to stock hopper of coke breeze.

2. Main specifications

1)	Capacity of screen	: 100 t/h
2)	Separating grain size of screen	: 5 mm
3)	Capacity of belt conveyor after screen	: 100 t/h
4)	Dust collection	: 1 unit

3. Equipment list

1) Mechanical equipment

· Screen	: 1 unit
· Belt conveyor	: 4 units
· Switching damper	: 1 unit

2)	Electrical equipment and instrumentation	: 1 set
3)	Civil and Construction	: 1 lot

4. Attached information

Fig IV.2-8 Outline of recrushing screen for coke breeze

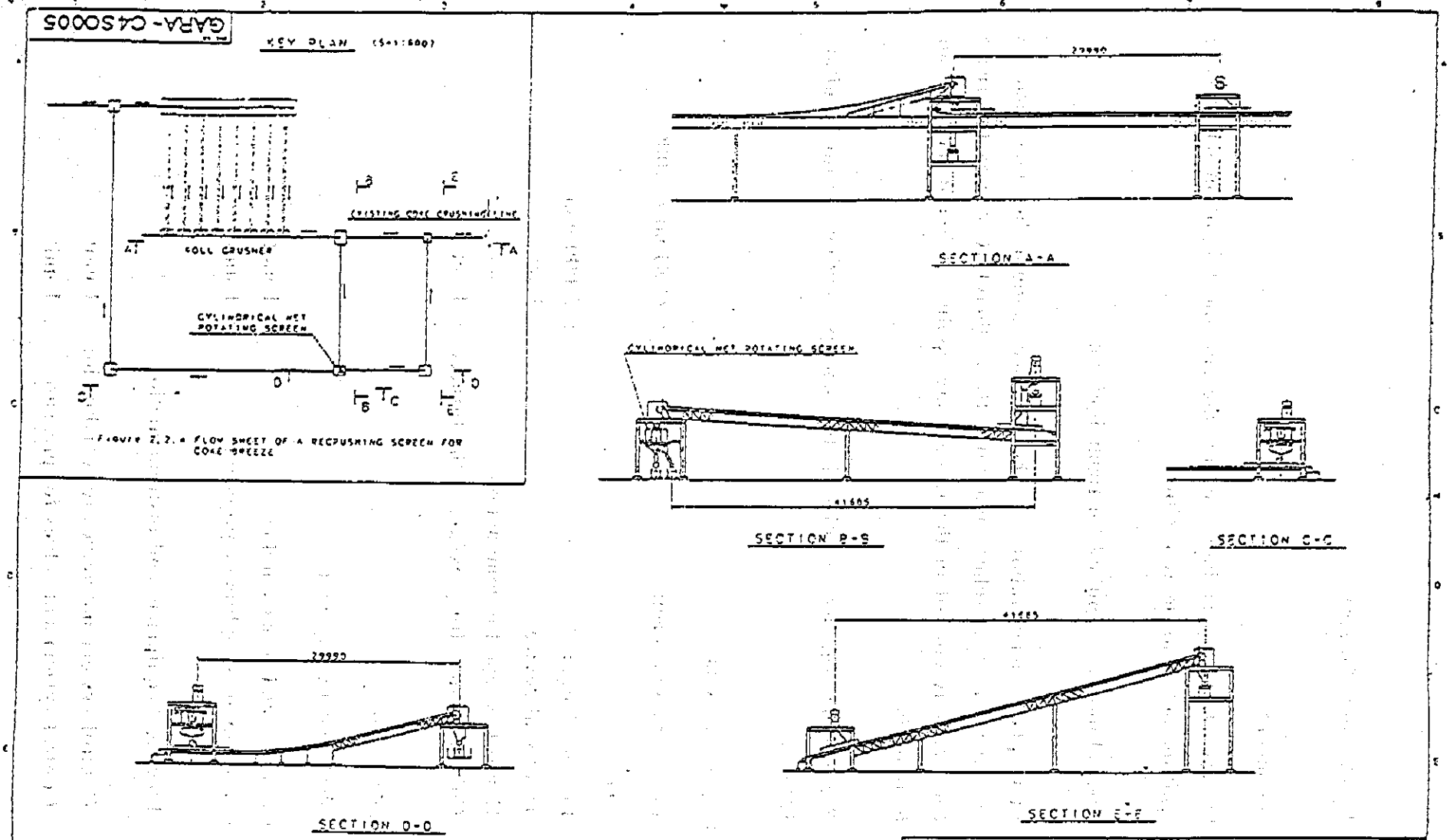


Fig.IV.2-8. Outline of recrushing screen for coke breeze

Item No. 231 Compact furnace

1. Design concept

1) Energy efficiency is improved by the combined ignition with flame ignition and atmosphere ignition.

2) Vertical burner is applied for flame ignition.

3) Atmosphere temperature in the furnace should be increased to intensify the atmosphere ignition effect. therefore compact furnace and pressure control in the furnace are applied to avoid the cool air penetration.

4) Pre-heating furnace is placed for energy saving before ignition furnace.

2. Main specifications

1)	Fuel burning capacity Nm^3/h	: COG max 2,000
2)	Furnace length	: 2,000 mm
3)	Tight seal device	: 1 set
4)	Control system for combustion	: 1 set
5)	Control system for pressure in the furnace	: 1 set

3. Equipment list

1) Mechanical equipment

· Furnace and furnace holder	: 1 unit
· Gas and air supplying equipment	: 1 unit

2) Electrical equipment and instrumentation

· Control system and valves for combustion	: 1 unit
· Control system and valves for pressure	: 1 unit

in furnace

4. Attached information

Fig IV.2-9 Flow sheet of a compact furnace

Fig IV.2-10 Typical drawing of compact furnace

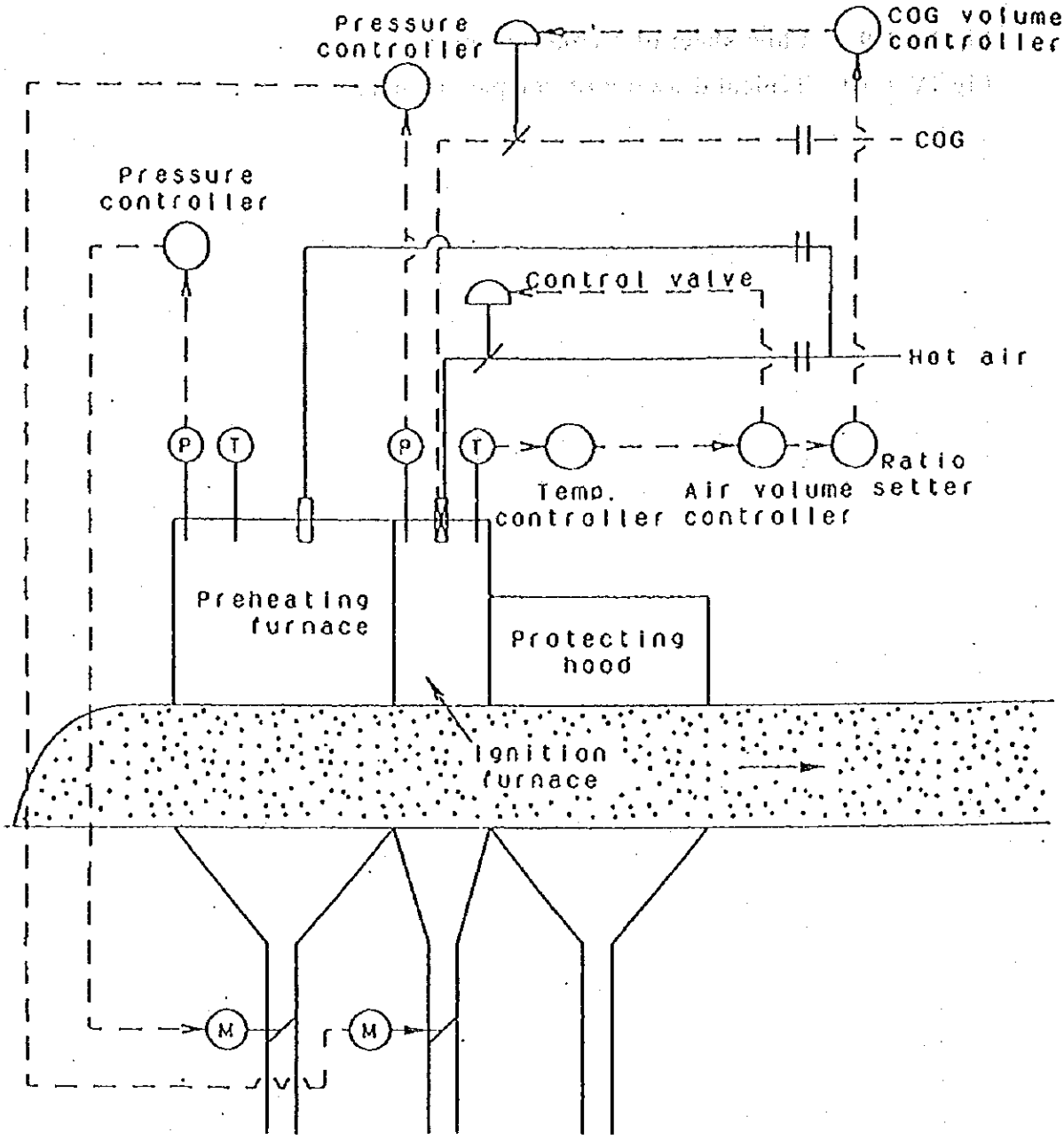


Fig.IV.2-9. Flow sheet of a compact furnace

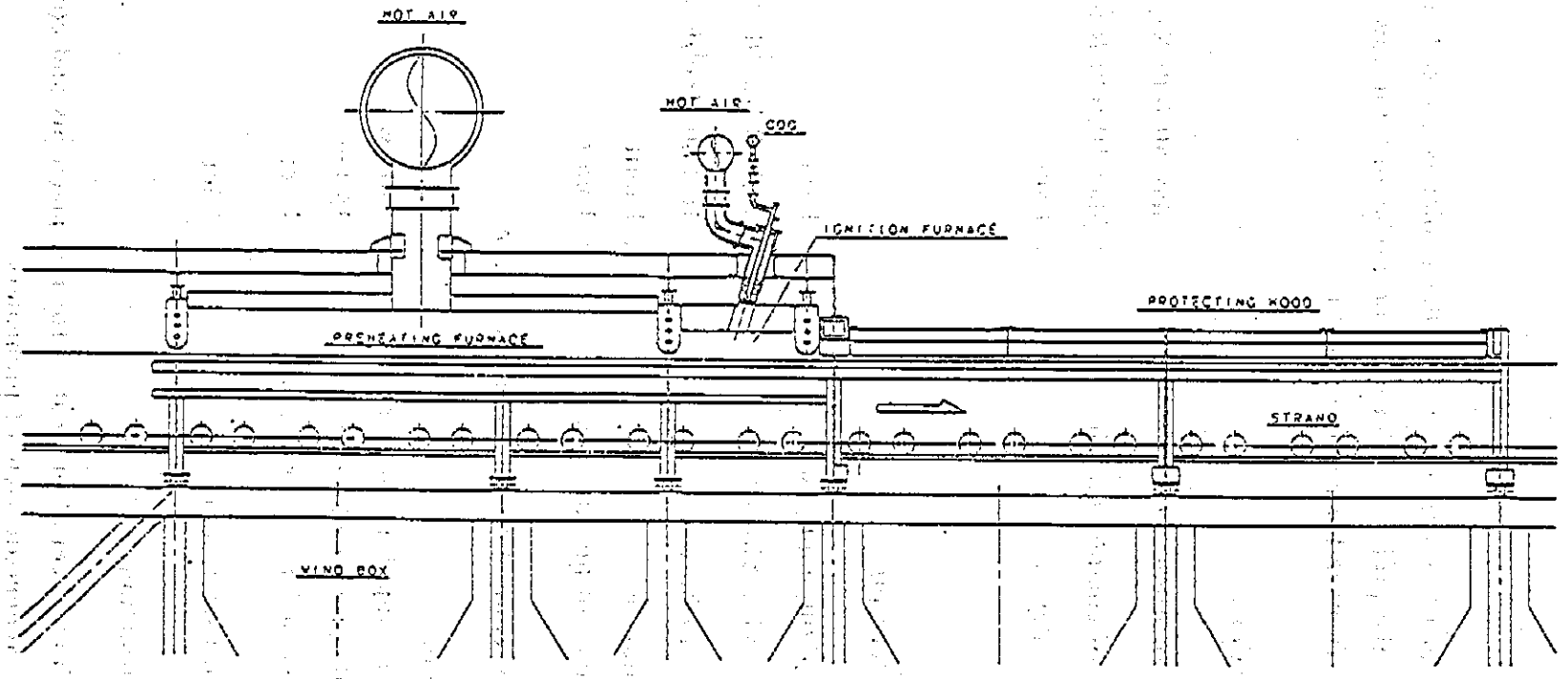


Fig.IV.2-10. Typical drawing of compact furnace

SIDEX-GALATI WORKS-RUMANIA
NO. 7 SINTERING PLANT
REPLACEMENT WITH A SMALL-SIZE IGNITION FURNACE(HIGHER PERFORMANCE FURNACE)
NIPPON STEEL CORPORATION-NSC
PLANT ENG'G & TECHNOLOGY CENTER
GALA-C4Si 006 0

Item No. 241 Reusing system of cooler waste gas

1. Design Concept

Waste hot air at the upstream part of the cooler is sucked, dedusted, and transported to the preheating furnace for preheating the raw materials and to the ignition furnace for combustion air

2. Main specifications

1)	Capacity of preheating	: Max 50,000 Nm^3/h
2)	Capacity of combustion air	: Max 10,000 Nm^3/h
3)	Dedusting device	: 1 set

3. Equipment list

1) Mechanical equipment

· Hot air supplying equipment	: 1 set
· Hot air supplying blower	: 60,000 $Nm^3/h \times 400$ mmAq
· Combustion air blower	: 10,000 $Nm^3/h \times 200$ mmAq
· Dedusting device	: 1 unit
· Control valves of hot air volume	: 1 unit

2) Electrical equipment and instrumentation

· Blower motor	
Hot air supplying blower	: 300 kw
Combustion air blower	: 35 kw
· Control system for hot air volume	: 1 set

3) Civil and Construction : 1 lot

4. Attached information

Fig IV.2-11 Flow sheet of preheaters for raw materials and combustion air
Fig IV.2-13 Schematic view of preheaters

Item No. 242 Waste heat recovery boiler

1. Design concept

   1) Waste hot air at the upstream part of the cooler is sucked and transported to the boiler after dedusting.

   2) Waste air after the boiler is recycled as cooling air of the cooler.

   3) Pure water is supplied to the boiler and low pressure steam is recovered and transported to existing steam line.

2. Main specifications

1)	Capacity of circulating air	: max 200,000 Nm^3/h × 300 mmAq
2)	Capacity of boiler	: 20 t/h × 10 kg/cm^2
3)	Dedusting device	: 1 set

3. Equipment list

   1) Mechanical equipment

· Hot air circulation equipment	: 1 set
· Boiler	: 1 unit
· Treated water supplying equipment	: 1 set
· Steam recovery equipment	: 1 set

   2) Electrical equipment and instrumentation

· Circulation fan motor	: 700 kw
· Control system of hot air circulation	: 1 set
· Control system for boiler	: 1 set

   3) Civil and Construction

· Basement for boiler, hood and duct	: 1 lot

4. Attached information

Fig IV.2-12 Flow sheet of waste heat boiler for cooler

Fig IV.2-14 Schematic view of waste heat boiler

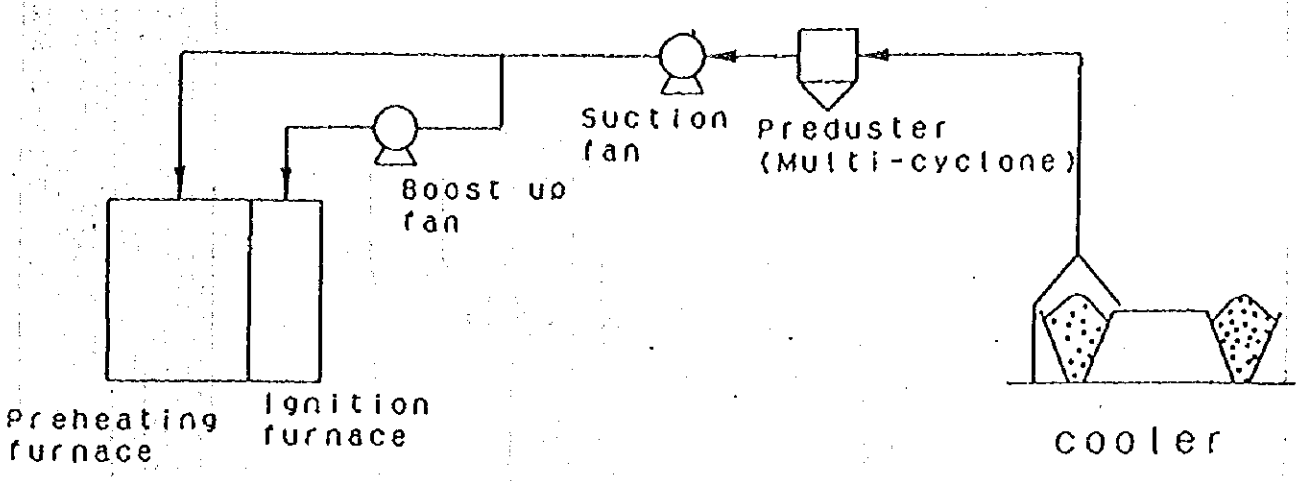


Fig.IV.2-11. Flow sheet of preheaters for raw materials and combustion air

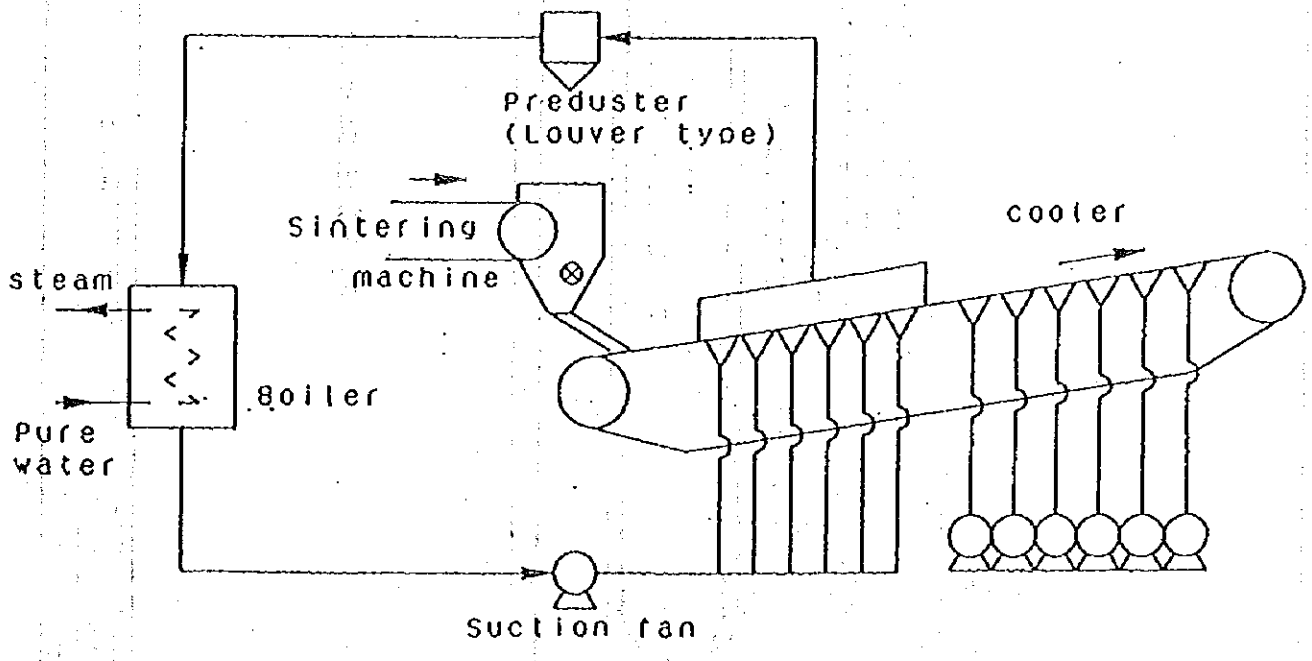


Fig.IV.2-12. Flow sheet of waste heat boiler for cooler

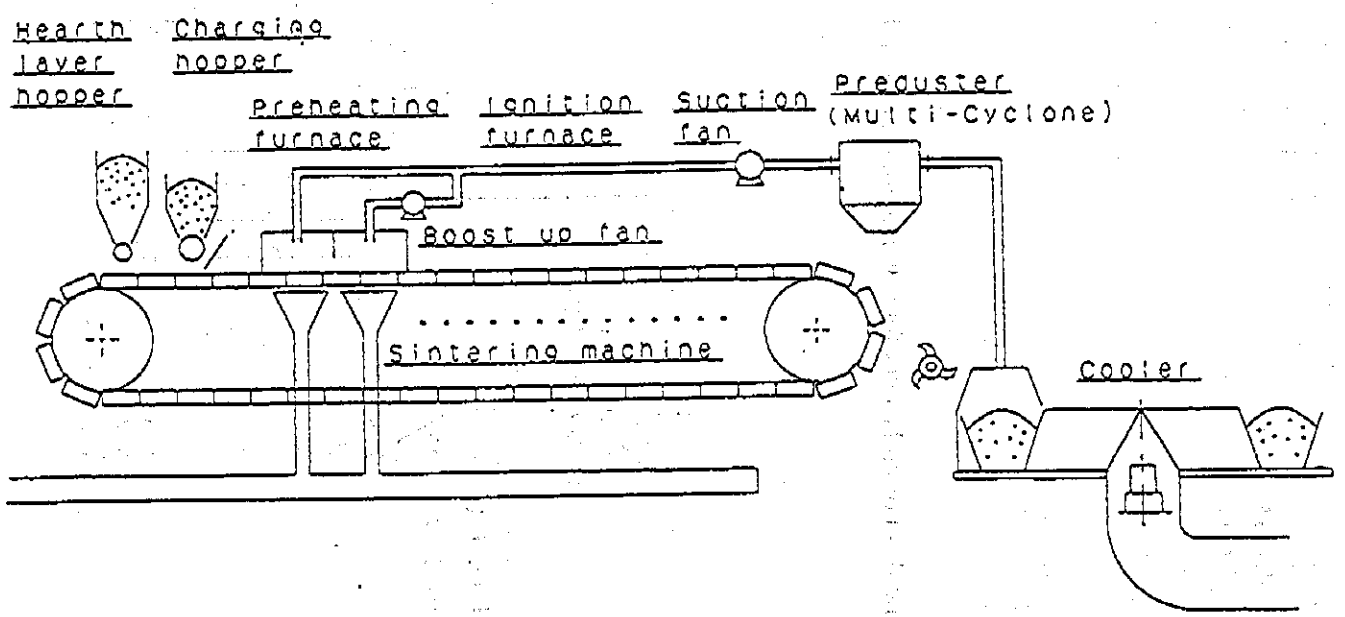


Fig.IV.2-13. Schematic view of preheaters

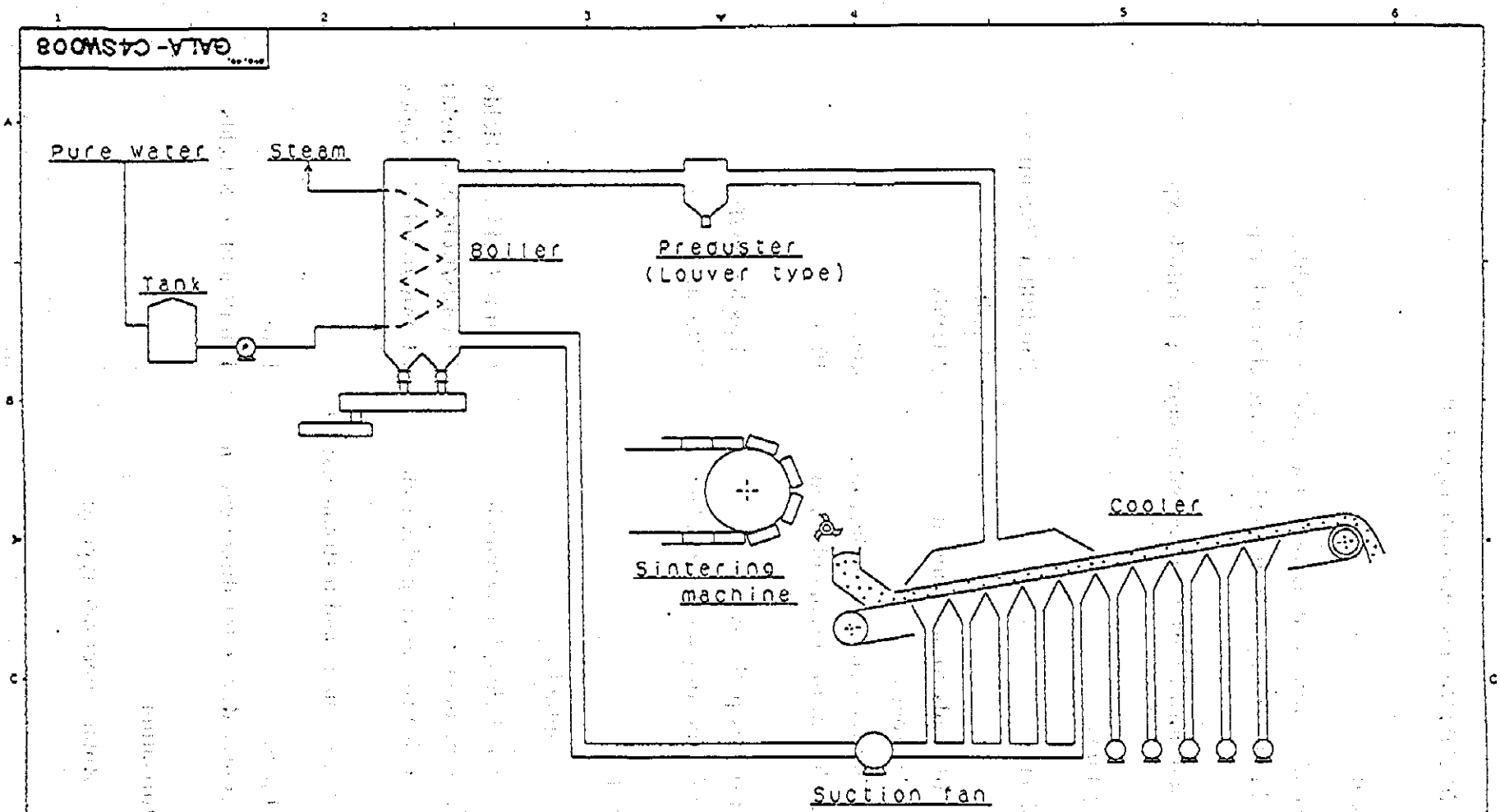


Fig.IV.2-14. Schematic view of waste heat boiler

Item No. 251 De-dusting(Moving electrode type E.P.)

1. Design concept

1) The part of existing E.P. is reused as much as possible.
First field of existing E.P. is used as fixed electrode type.

2) Second and third fields are renewed to moving electrode type.

2. Main specifications

1)	Gas volume	: 750,000 m^3/h/unit × 4 units
2)	Number of fields to be mounted moving electrodes	: 2 fields
3)	Distance between collecting electrodes	: 460 mm
4)	Effective height of moving electrode strand	: 10 m
5)	Number of gas pathways	: 25 pathways/field
6)	Length of collecting electrode plate	: 3500 mm

3. Equipment list

1) Mechanical equipment

· Collecting and charging electrode	: 13 units/field × 8 fields
· Dust scraping device	: 13 units/field × 8 fields
· Driving device for moving electrode	: 13 units/field × 8 fields

2) Electrical equipment and instrumentation

· Control panel	: 1 lot
· Power source device for direct current	: 1 unit/field × 8 fields

4. Attached information

Fig IV.2-15 Rotary electrode type EP

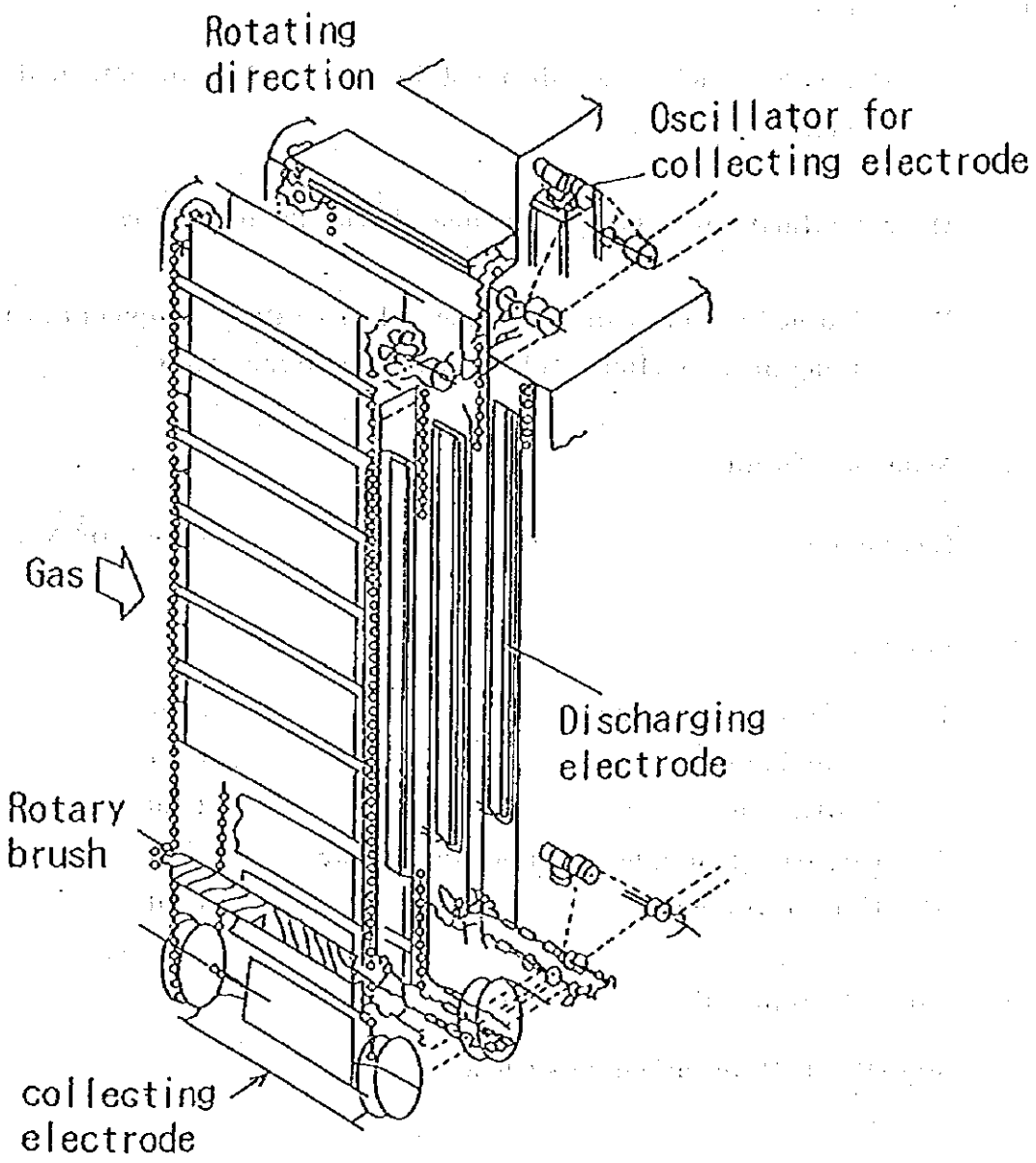


Fig.IV.2-15. Rotary electrode type EP

Item No. 252 Desulfurization

1. Design concept

   1) Dry type which is desulfurized by moving bed of activated coke is selected.

   2) Desulfurization equipment is placed after the main blower.

   3) Adsorbed sulfur is treated at the sulfur treating equipment in the coke making process after resolved at the resolving tower.

2. Main specification

Gas volume	: 500×10^3 Nm^3/h

3. Equipment list

1)	Sulfur adsorbing tower	: 1 lot
2)	Resolving tower	: 1 lot
3)	Booster fan	: 1 lot
4)	Circulating equipment for activated coke	: 1 lot
5)	Control equipment	: 1 lot

4. Attached information

   Fig IV.2-16 Desulfurization system

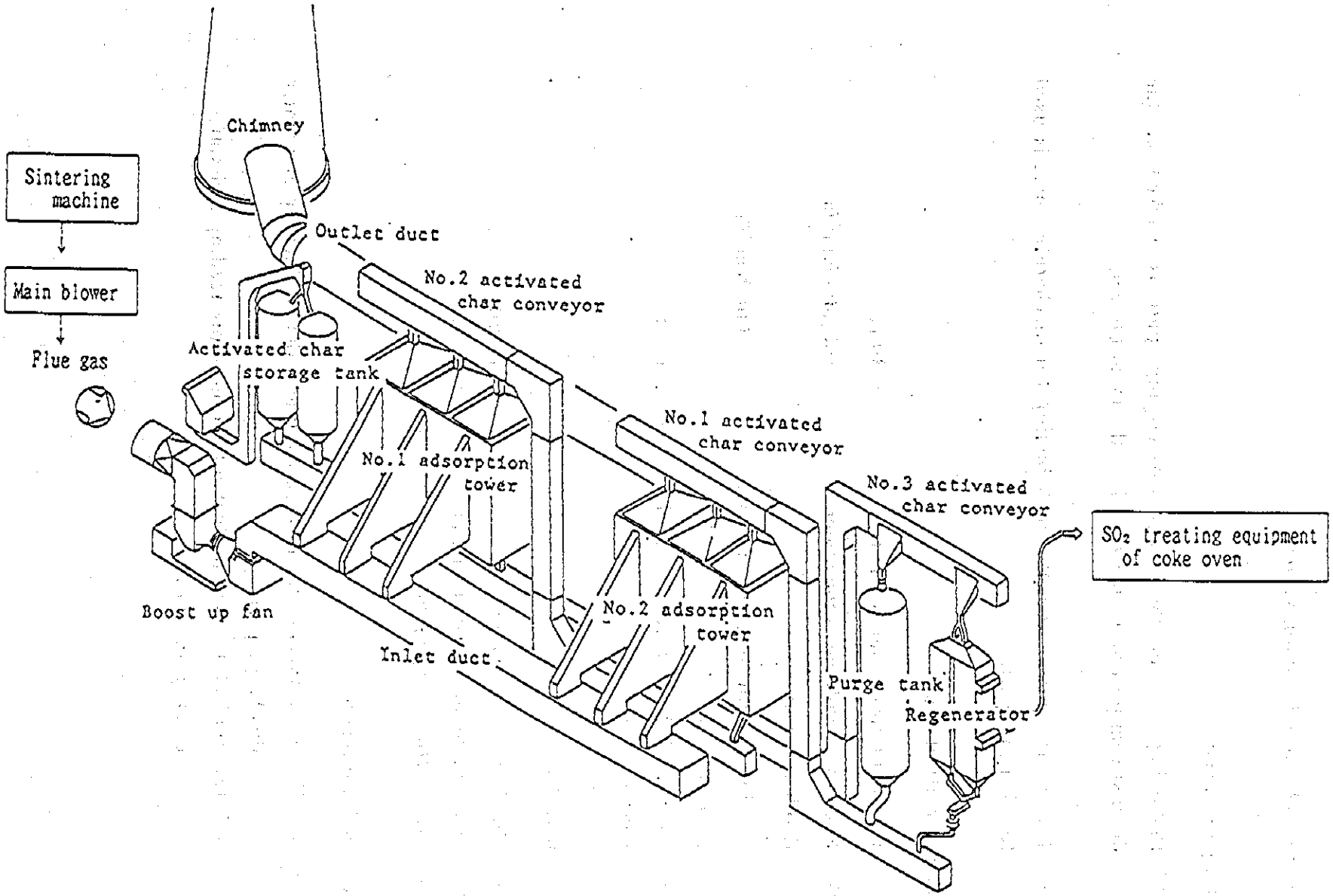


Fig.IV.2-16. Desulfurization system

Item No. 261 On strand suction system

1. Design concept

   1) Dedusting gas in the sinter discharging part is sucked at the downstream portion of the strand by the main blower.

   2) The reserve power of E.P. for dedusting for discharging part is used for charging part.

2. Main specifications

1)	Length of strand suction hood	: 30 m
2)	Suction air volume at the sinter discharging part	: 160,000 Nm^3/h
3)	Suction air volume at the material charging part	: 40,000 Nm^3/h
4)	Duct for dedusting at the material charging part	: 1 set

3. Equipment list

1)	Hood of strand suction	: 1 unit
2)	Duct and hood for dedusting at the material charging part	: 1 set

4. Attached information

Fig IV.2-17 Flow sheet of the dust collection in the ore feeding and sinter discharge part

Fig IV.2-18 Typical drawing of dust collection in ore feeding and sinter discharging part

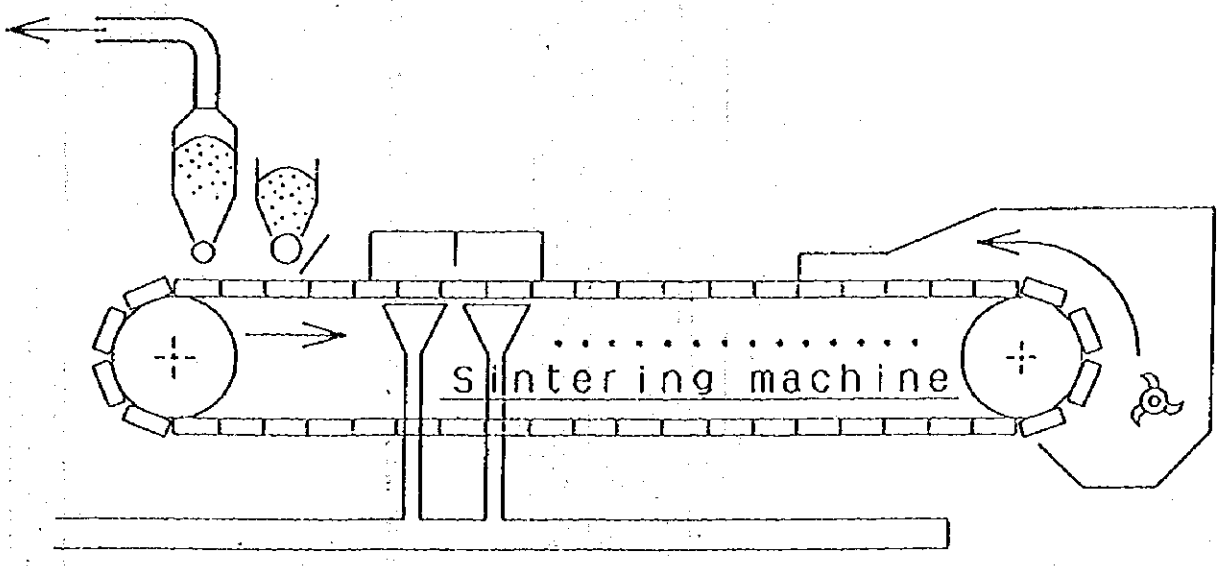


Fig.IV.2-17. Flow sheet of the dust collection in the ore feeding and sinter discharge part

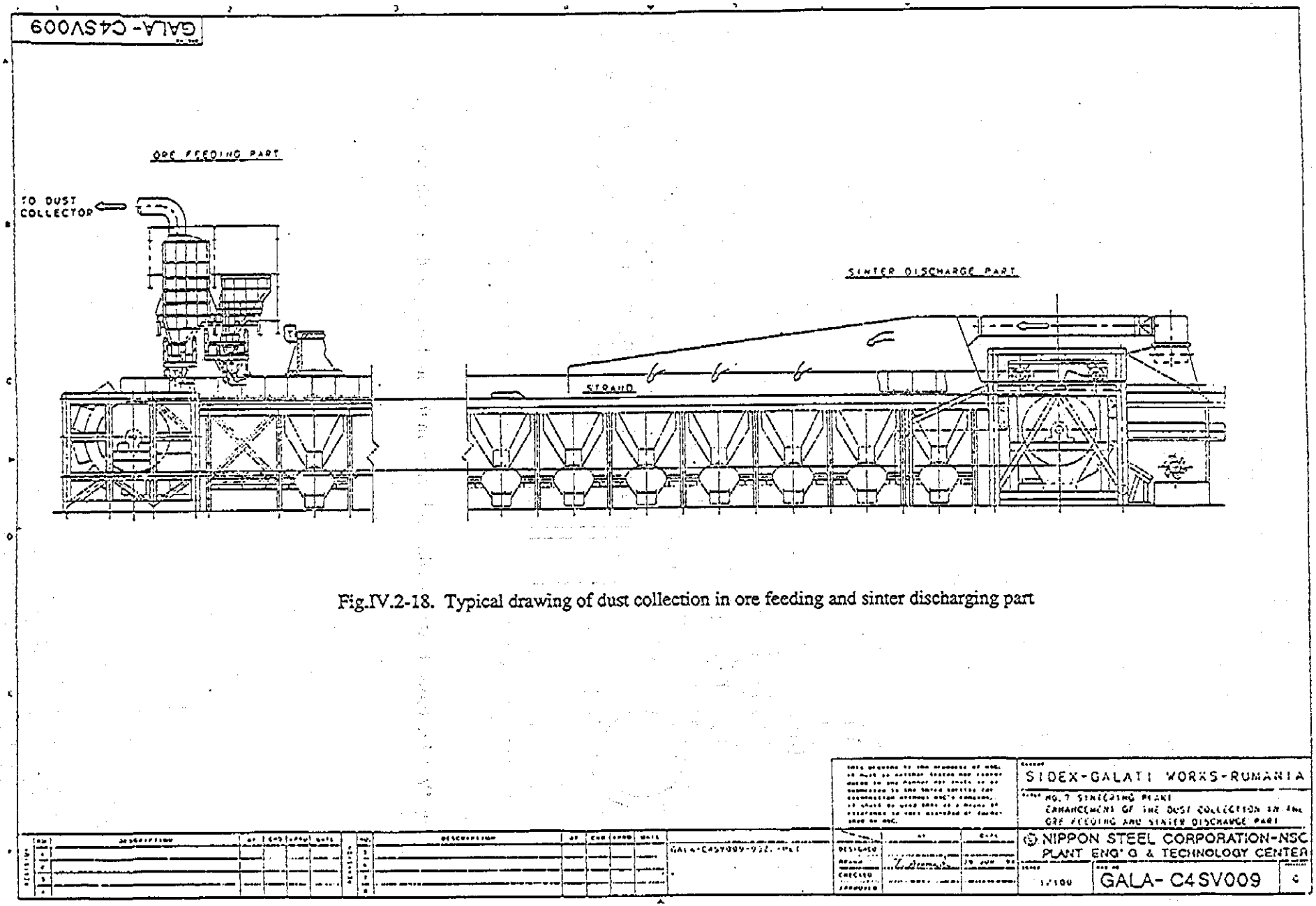


Fig.IV.2-18. Typical drawing of dust collection in ore feeding and sinter discharging part

Item No. 271 Yard stock system for sinter product

1. Design concept

1) Line which transports sinter product to yard is newly installed after the product screen and used by switching from existing transport line to blast furnace to this line.

2) Existing pellet yard is used as sinter product yard and new line is connected to the existing pellet receiving line.

3) Sinter product which is stocked at yard is reclaimed by existing line and is supplied to blast furnace stock house after sifting by existing pellet screen.

2. Main specification

Capacity of new belt conveyor to yard	: 650 t/h

3. Equipment list

1)	Belt conveyor	: 3 sets
2)	Control system	: 1 set

4. Attached information

Fig IV.2-19 Flow sheet of Yard stock System for sinter Product

Item No. 272 Quick lime adding system

1. Design concept

   1) Quick lime powder transported by a tank lorry from the lime treating plant is transported to a new sealed type hopper.

   2) Quick lime powder is fed by the constant feeding weigher from the hopper to the existing material compounding line and is mixed with the other material.

2. Main specifications

1)	Feeding capacity of quick lime	: 15 t/h
2)	Capacity of quick lime hopper	: 150 m^3

3. Equipment list

1)	Quick lime hopper	: 1 unit
2)	Constant feeding weigher	: 1 unit
3)	Tank lorry	: 1 unit
4)	Control system	: 1 lot

4. Attached Information

Fig IV.2-20Flow sheet of burnt lime supplying equipment

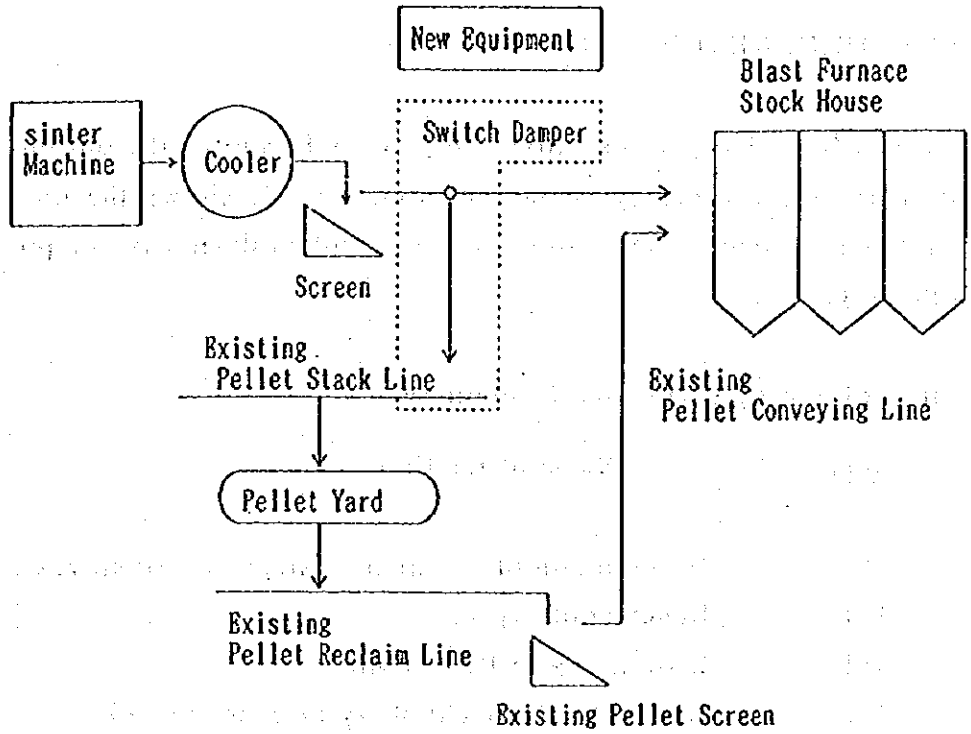


Fig.IV.2-19. Flow sheet of Yard Stock System for Sinter Product

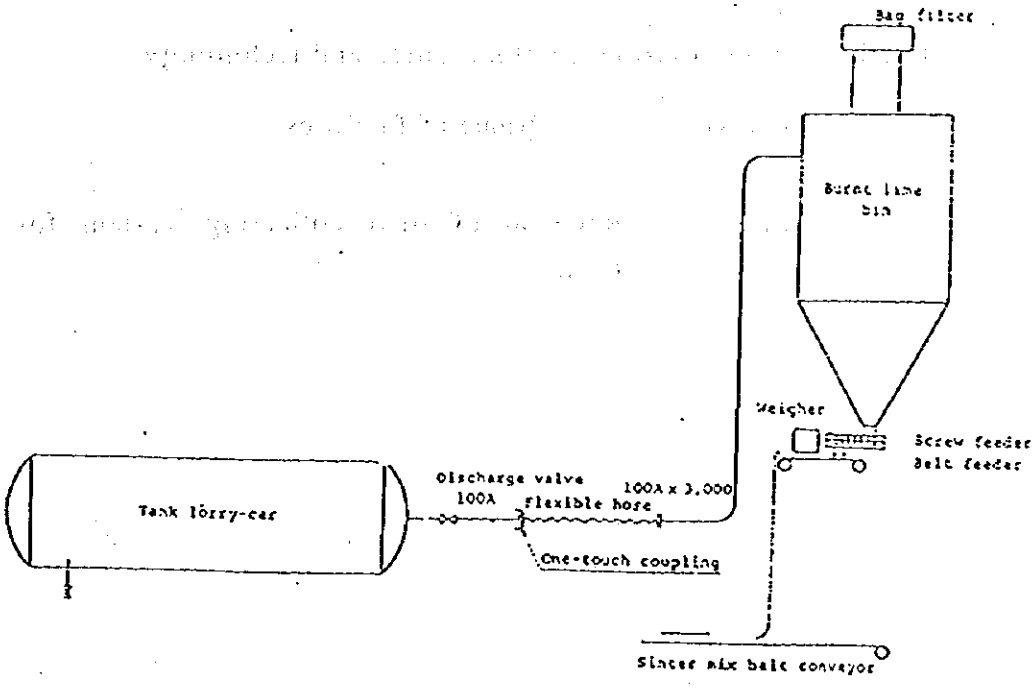


Fig.IV.2-20. Flow sheet of burnt lime suppling equipment

3. NO.6 BLAST FURNACE (INCL. HOT STOVES)

With regard to No.6 BF and hot stoves, Fig. IV.3-1. shows the outline of the whole measures for energy saving and Fig. IV.3-2. shows the outline of the whole environmental measures. The conceptual design is composed of the followings.

(1) Facilities of energy saving and technology

Item No.	Name of facilities
311.	Introduction of a control system for hot stoves
321.	Renewal of tuyere
331.	Installation of PCI facilities
332.	Application of technology of charging coke
341.	Installation of TRT facilities for power generation
361.	Installation of preheating equipment for fuel
362.	Installation of preheating equipment for combustion air

(2) Facilities with environmental measures and technology

Item No.	Name of facilities
371.	Renewal of dust collecting system for casting floor

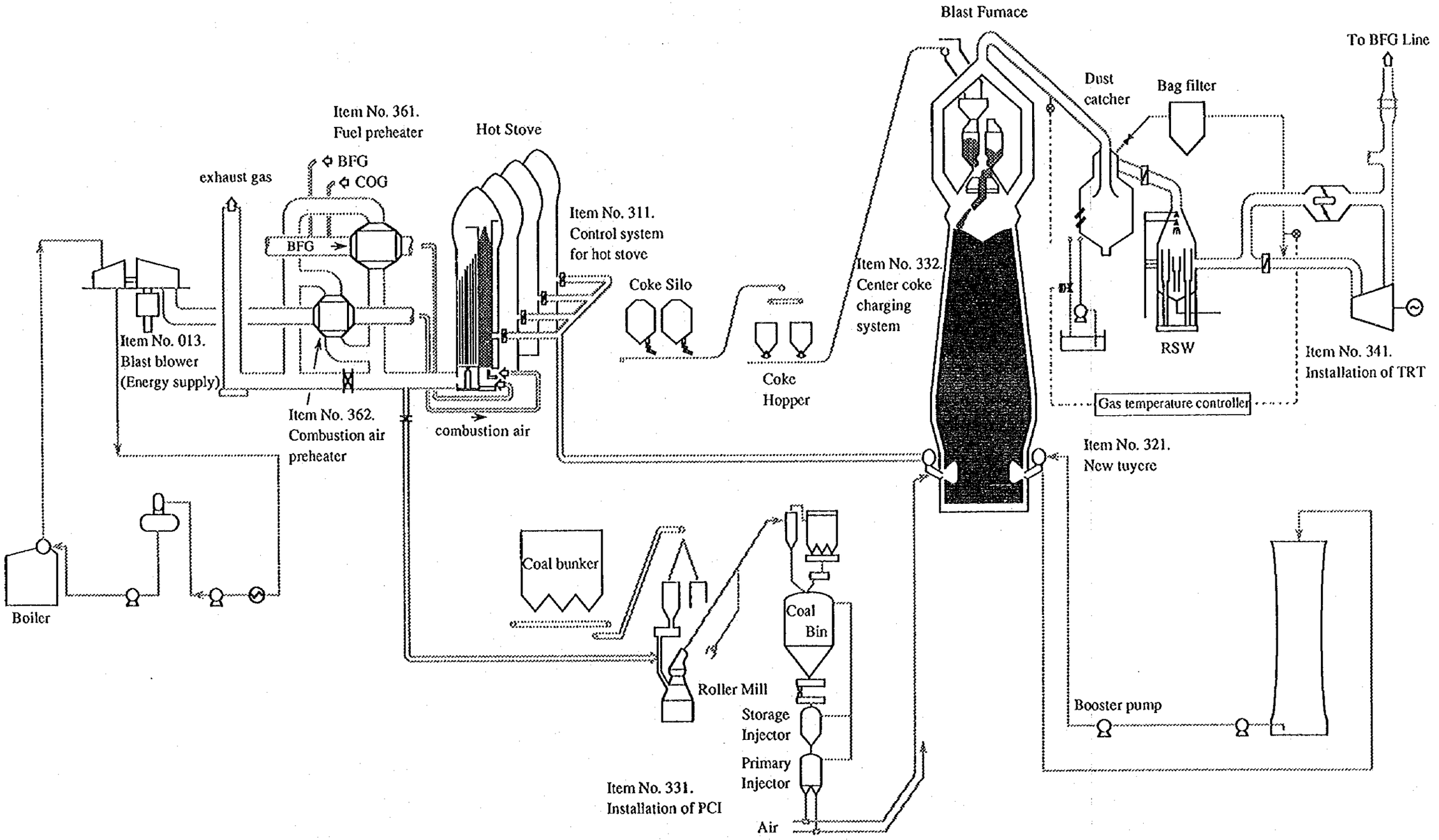


Fig. IV.3-1. Overall view of energy saving in blast furnace

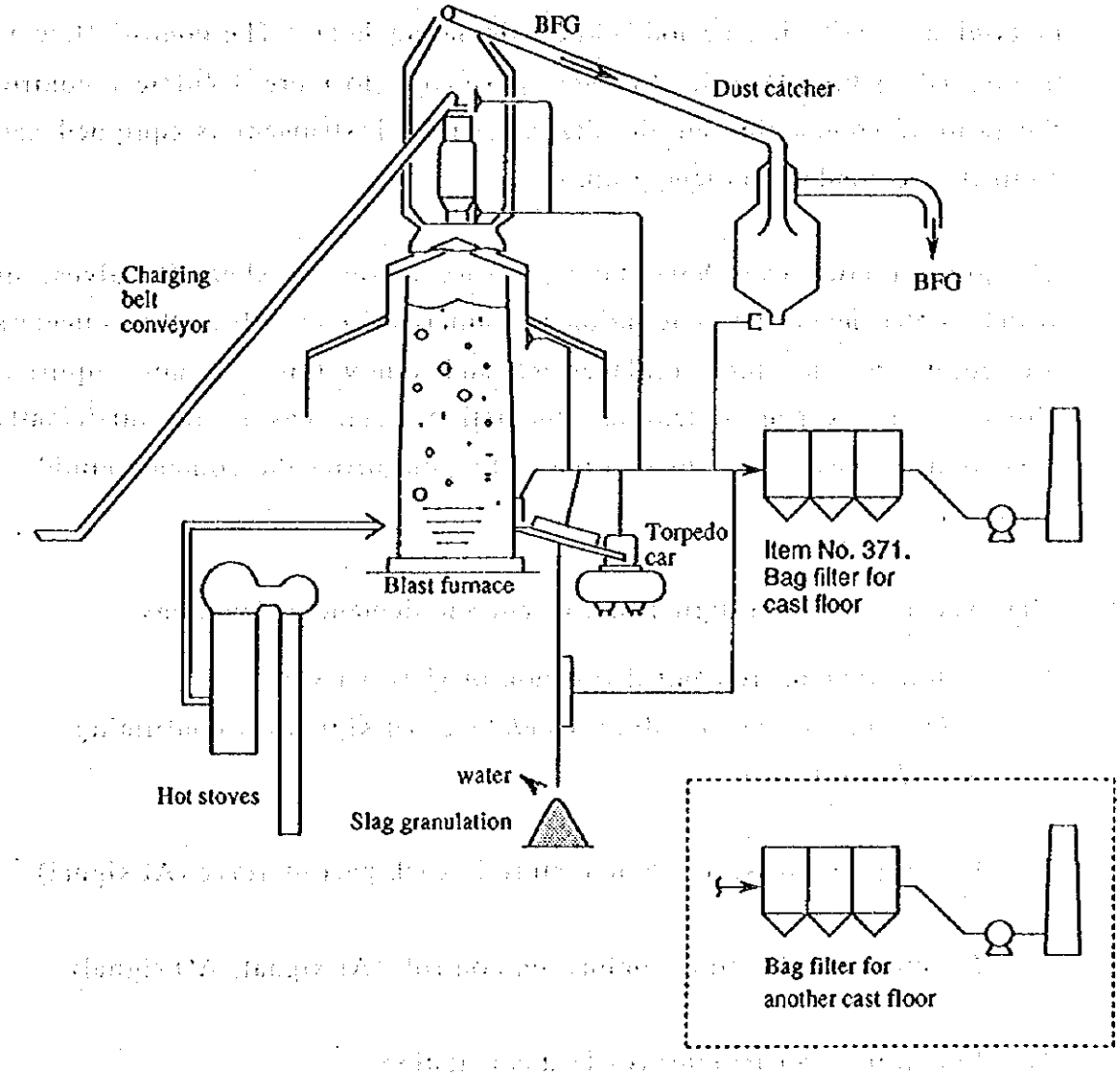


Fig.IV.3-2. Overall view of environmental pollution control in blast furnace

Item No. 311 Introduction of a control system for hot stoves

1. Design concept

A system, introducing the digital electric instrument in order to switch the blow in hot stoves with the staggered parallel method, is designed to determine a switching period while calculating heat. The control flow is mentioned in Fig. IV.3-3. Further, purposing to more accurately control the ratio of combustion air the digital electric instrument is equipped and controls the combustion temperature.

The present hot stoves have the necessary automatic shut-off valves, of which replacement and renovation are not required. Also, thermometers are equipped, and their replacement and renovation are not required. However, as oxygen content in combustion waste gas is not sufficiently measured for now, a sensor continuously monitoring the content should be installed.

2. Main specifications of digital instrument and demanded functions

1) Automatic closing control function of shut-off valve
(DO signal for commanding open/close, DI signal for confirming open/close)

2) Function of measuring temperature in each part of stove (AI signal)

3) Function of adjusting combustion control (AI signal, AO signal)

4) Function as a computer for heat calculation

5) Function of accurate sequence control (a calculation timer, etc.)

3. Attached information

Fig. IV.3-3 Hot stove control diagram
Fig. IV.3-4 Time table of Hot stove operation

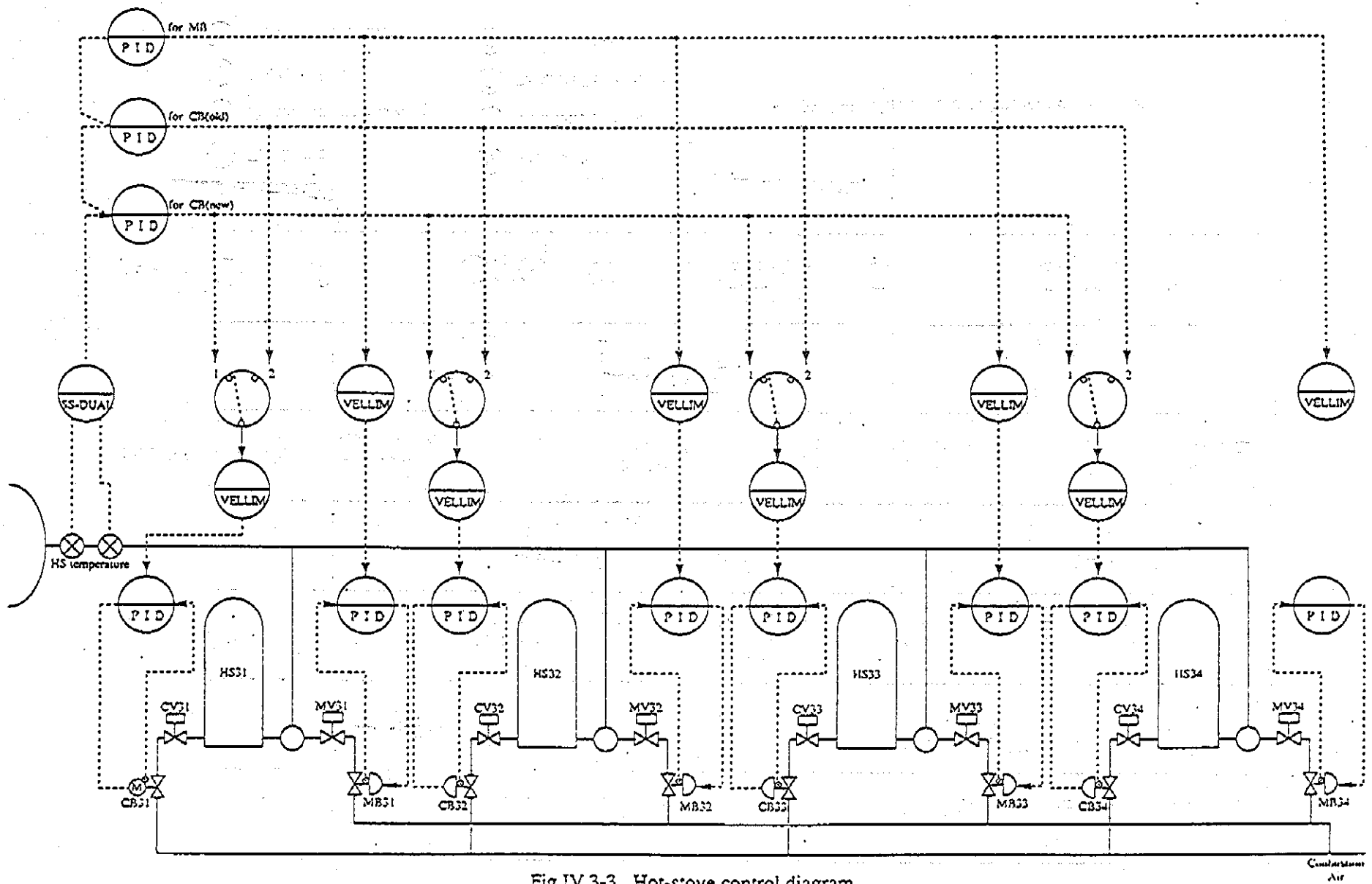


Fig.IV.3-3. Hot-stove control diagram

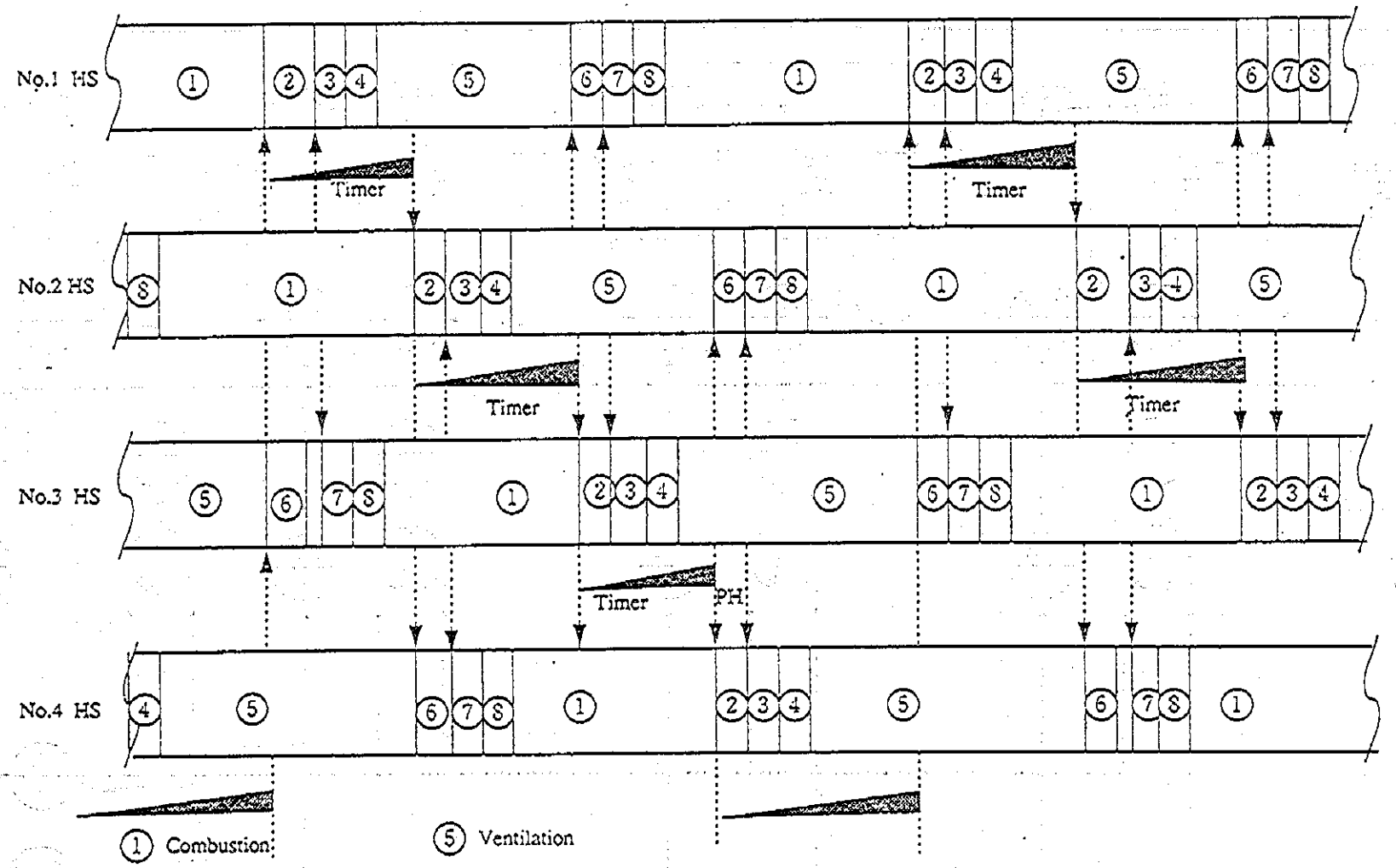
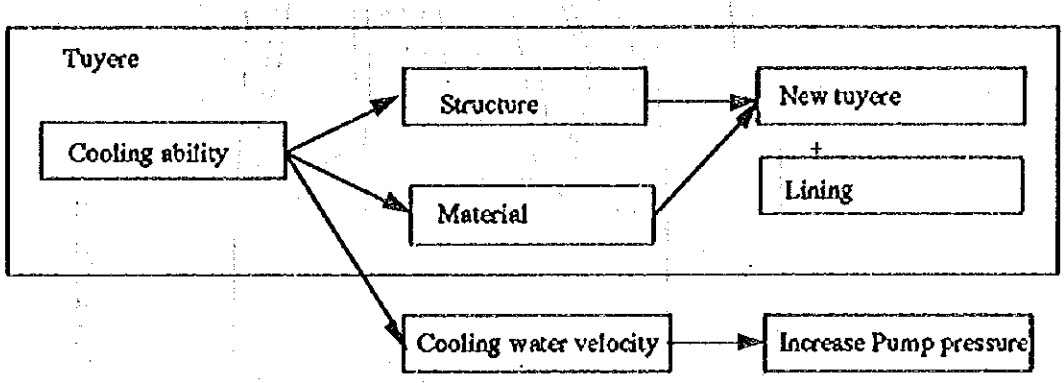


Fig.IV.3-4. Time table of hot-stove operation

Item No. 321 Renewal of tuyere

1. Design concept

The tuyere of No.6 BF lives 60 ~ 80 days, and its life is extremely short comparing to the Japanese one that lives for more than a year. The cause is analyzed as follows, which the know-hows developed in the advanced countries should be used in improving the materials and the shapes. In order to avoid over heat loss caused by enhanced cooling of the tuyere, it should be so designed in structure that a refractory sleeve can be fitted to the tuyere inside.



2. Cooling water necessary for tuyere

1) Necessary cooling water : 500 lit./min. (for a tuyere)
(Total : 36 x 500 lit./min. = 18,000 lit./min. = 1,080 m^3/h)

2) Pressure of cooling water: 20 kg/cm^2 at tip of tuyere
(For the pressure, a booster pump should be added.)

3. Main specifications of equipment

1)	Tuyere	: 36 sets (material: CuCl)
2)	Water pump	: 1 + 1 sets (1,080 m^3/h x 230 mH)
3)	Water piping	: 1 set

4. Attached information

Fig. IV3-5 Typical view of tuyere

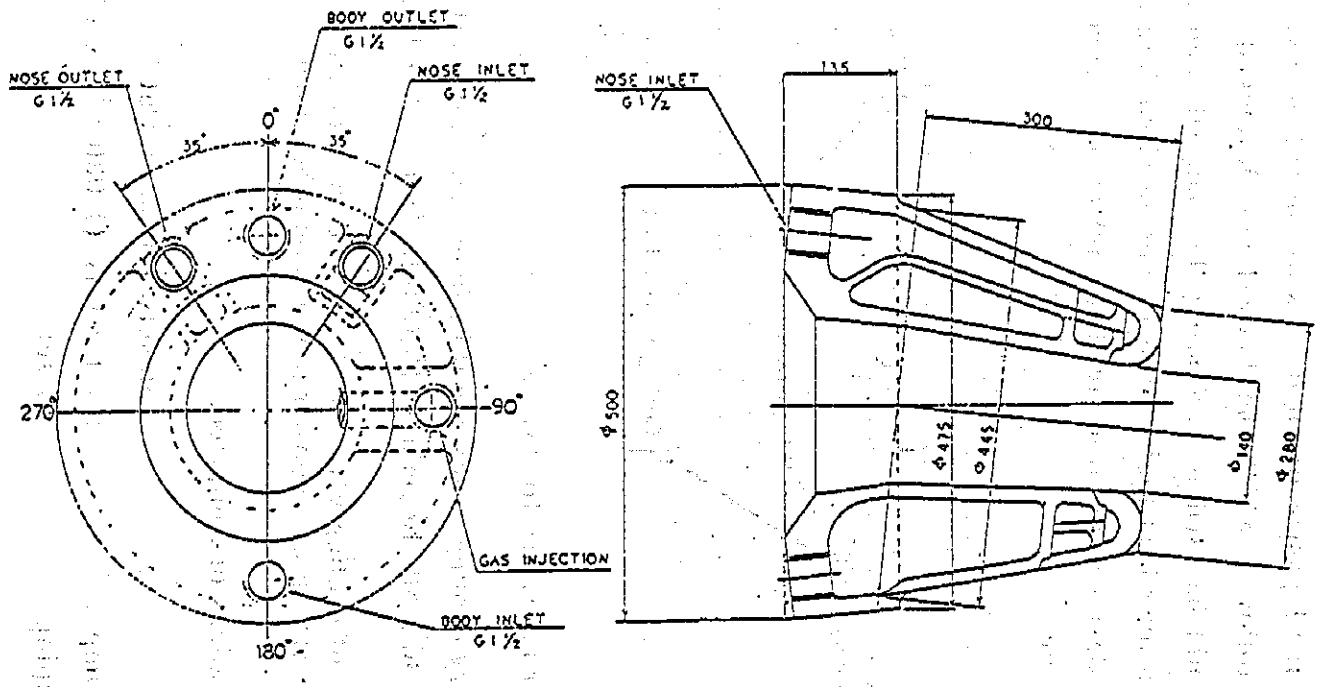


Fig.IV.3-5. Typical view of tuyer

KOBE STEEL, LTD.
ENGINEERING & MACHINERY DIVISION

TITLE: SIDEX
TUYER DRAWING

DWG. NO. D841-

Item No. 331 Installation of PCI facilities

1. Design concept

When the maximum amount of pulverized coal(PC rate) to be injected into No.6 BF is 200 kg/t-p, the capacity of 65 t/h is necessary for PCI facilities. The minimum amount is one thirds of the maximum, and then 67 kg/t-p will have to be injected from the beginning of operation when PCI is installed. However, as the experience in No.5 BF, under construction at the present, will be reflected, the said value seems all right.
Accordingly, 65t/h x 1 unit is to be installed for PCI facilities.

Blowing PCI more than 150 kg/t-p is never easy. Besides installation of PCI facilities, application of technology for charging coke and exact grasp of the inside condition of furnace by a profile meter and a descending probe are required. The pulverized coal should be dried by waste gas of hot stoves.

2. Design conditions

1) Production of pulverized coal and drying facilities

Maximum production rate : 65 t/h/l set (dry base)

2) Transfer of pulverized coal and injecting facilities

Maximum injection rate : 65 t/h/l set (dry base)

Turn down ratio : 1 : 3

3) Quality of available coal

	lean + low coking coal	fiery coal
• Coal mix	70 %	30 %
• Ash	11 - 13 %	7 - 9 %
• Volatiles	15 - 17 %	39 - 41 %
• Melting point of ash	More than 1375 ℃	
• Hard Grove Index (HGI)	45	51
• Moisture	7 - 13 %	8 - 13 %
• Angle of repose	45°	
• Bulk density	0.93 t/m^3 (wet base)	0.88 t/m^3 (wet base)

4) Properties of pulverized coal to be injected

(1) Hygroscopic moisture

- Normal : 1.0 %
- Maximum : 2.0 %

(2) Distribution of granule
(Under the condition of HGI = 45)

- + 10 mesh : 0 %
- + 10 - 200 mesh : 25 %
- - 200 mesh : 75 %

5) Condition of operation

Facilities should be operated for 24 hours a day and 7 days a week, including 20 hours shutdown for maintenance every two months.

3. Main specifications of equipment

1) Coal pulverizing and drying system : 65 t/h 1 lot

- Raw coal bunker
- Pulverizer
- Bag filter

- Scalping screw
- Pneumatic conveyor
- System fan
- Gas heater
- Combustion air fan

2) Distribution and injection system : 65 t/h 1 lot

- Pulverized coal bin
- Storage injector
- Primary injector
- Injection piping

3) Utilities system : 1 lot

- Nitrogen and air compressor
- Nitrogen receiver tank
- Dryer of compressed air

4. Attached information

Fig. IV.3-6 SIDEX No.6 BF PCI Plant flow sheet
Fig. IV.3-7 SIDEX No.6 BF PCI Plant sectional drawing
Fig. IV.3-8 SIDEX No.6 BF PCI Plant plot plan

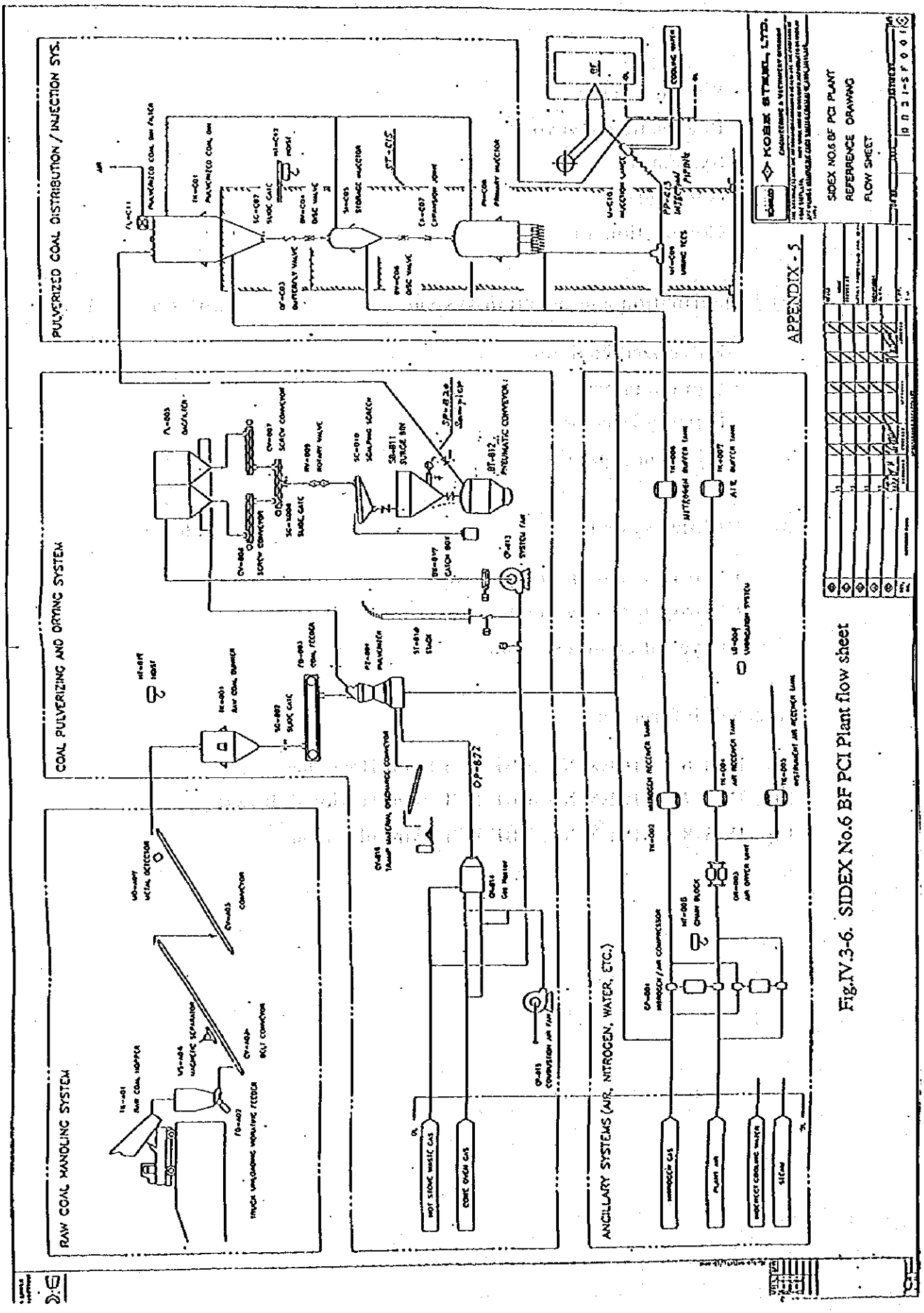


Fig.IV.3-6. SIDEX No.6 BF PCI Plant flow sheet

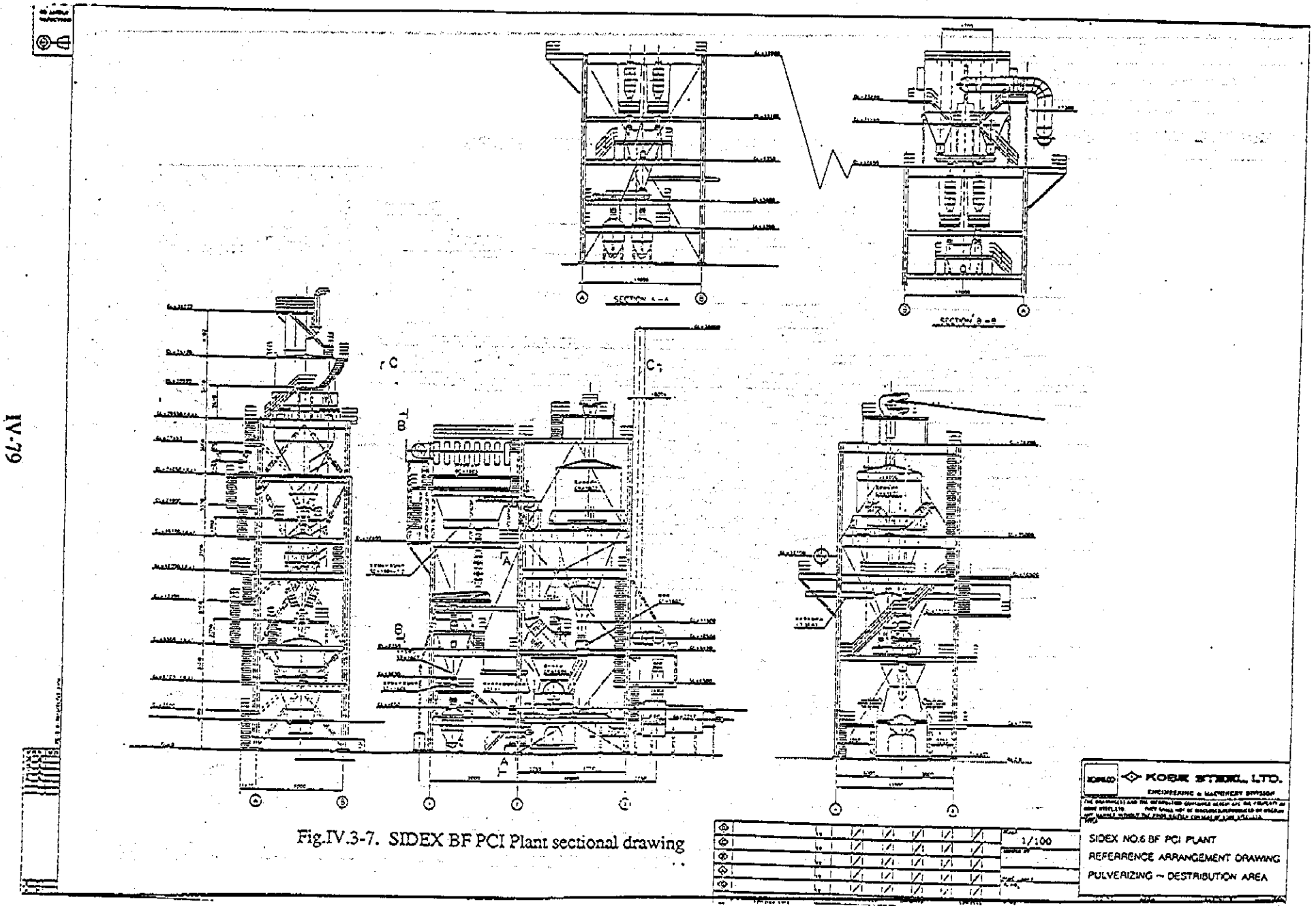


Fig.IV.3-7. SIDEX BF PCI Plant sectional drawing

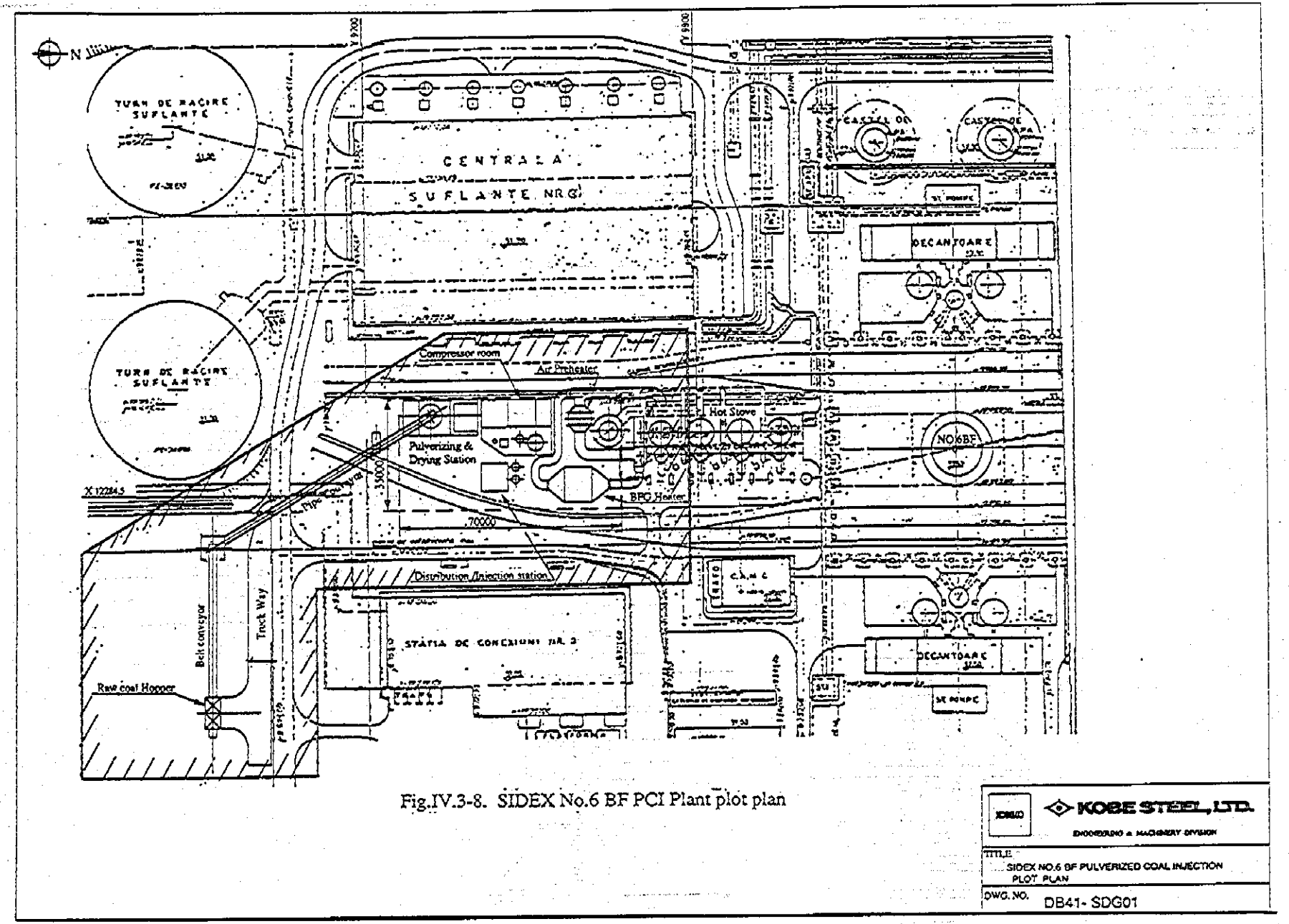


Fig.IV.3-8. SIDEX No.6 BF PCI Plant plot plan

Item No. 341. Installation of TRT facilities for power generation

1. Design concept

1) Turbine output

Considering the starting period of operation with high pressure, such facilities, as work with the present pressure and even after the blower for BF is renewed, should be selected.

Operation mode 1 : Turbine inlet pressure = 1.3 bar, output 6.7 MW

Operation mode 2 : Turbine inlet pressure = 2.0 bar, output 10.8 MW

2) Turbine type

TRT, that had been developed in Russia and France at first, was introduced into Japan, and then is still improving. TRT changes from the radial type to the axial type, of which efficiency is increased. Even with gas containing dust like BFG or moisture it efficiently works in stable performance. Therefore, the axial type of TRT is adopted, and in order to assure more efficient operation the variable blade type is applied to. Further, even if the dry type dust collector is equipped in the future, the facilities can function with little modification.

2. Design conditions

1) BFG condition

- Branching point (Gas inlet) : Dust between RSW and Septum valve
- Branching point (Gas outlet) : Duct between Septum valve and BFG supply line
- BFG analysis : H2 = 4 %, N2 = 52 %, CO = 22 %, CO2 = 22 %
- Dust concentration : Less than50 mg/Nm^3

- Humidity (relative) : 100 %
- Associated mist : Less than 10 g/Nm^3

2) Condition of BF operation

	Case-1	Case-2
• Production : t-p/d	4,000 t-p/d	8,000
• Top gas pressure : atg	1.7 atg	2 . 0
• Pressure at branching point (Gas inlet) :	1.3 atg	1.7 atg
• Temperature at branching point (Gas inlet):	55 ℃	55 ℃
• Flow quantity :	330,000 Nm^3/h	458,000 Nm^3/h

3) Control system

Furnace top gas pressure in normal conditions is ordinarily adjusted by the angle of turbine blade efficiently, and by the governor if the BFG flow drops lower than the adjusting range. On the contrary, when the pressure exceeds the adjusting range by blade angle, it should be adjusted by the by-pass septum valve.

3. Main specifications of equipment

1) Turbine and Generator : 1 set

Axial, wet reaction turbine:
- horizontal split casing
- 3,000 rpm
- 11,160 kW

Synchronous generator:
- 12,800 kVA, 2p, 11 kV

2) Sealing and dust protection equipment : 1 set

Water spray system

3) Safe guard and protection equipment : 1 set

Gas line, Rotation line, Generating line, Auxiliary

4) Lube. oil unit and governor oil unit : 1 set

5) Electrical equipment/Instruments : 1 set

6) Main gas piping system : 1 set

Joints, Valves, Control Valves, Flow Meters

4. Attached information

Fig. IV.3-9 Transition of TRT in Japan
Fig. IV.3-10 Progress of TRT system in Kobe Steel Kakogawa
Fig. IV.3-11 Flow sheet for recovery turbine generator system of blast furnace gas
Fig. IV.3-12 TRT drawing
Fig. IV.3-13 SIDEX TRT plot plan

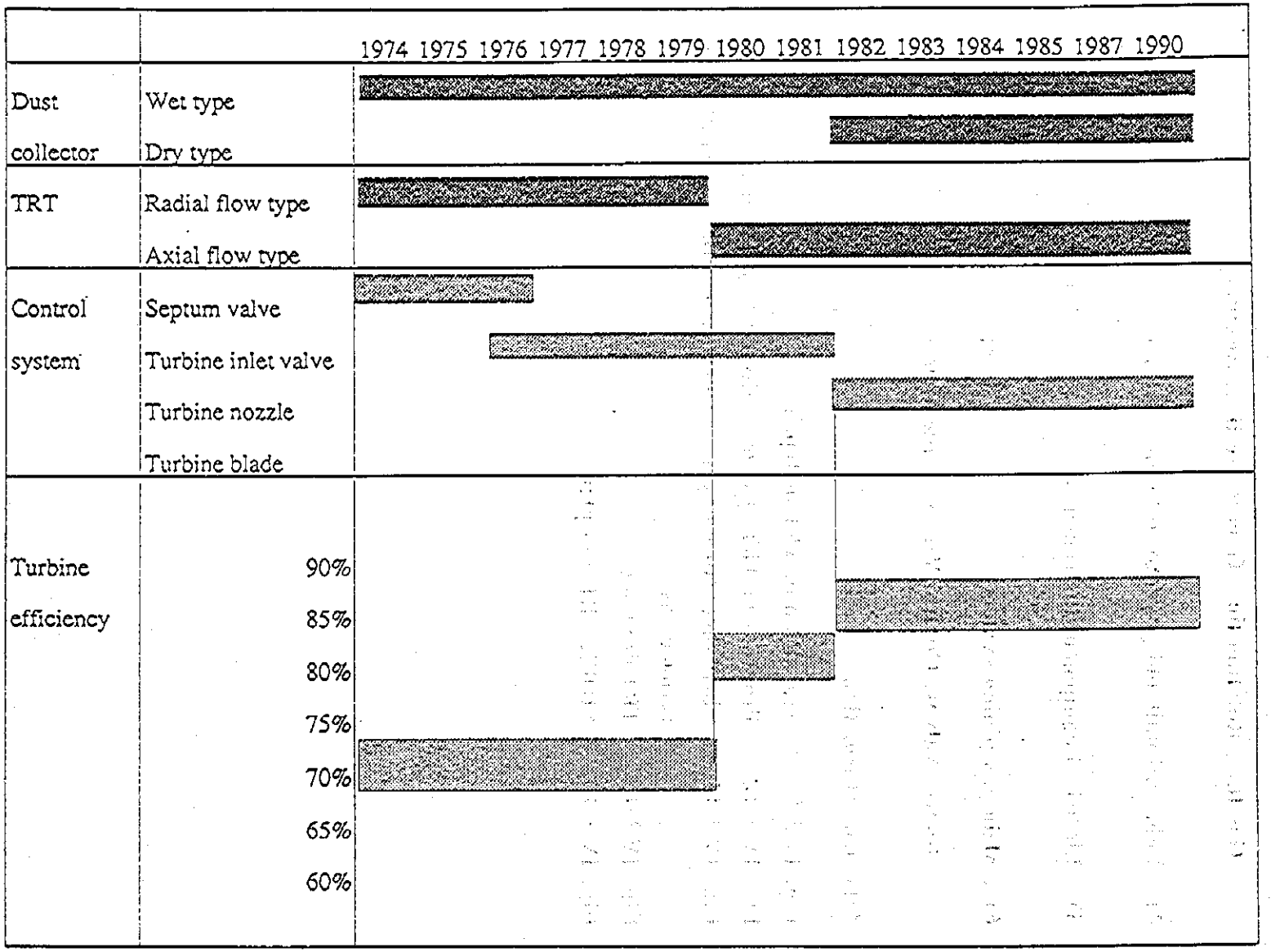
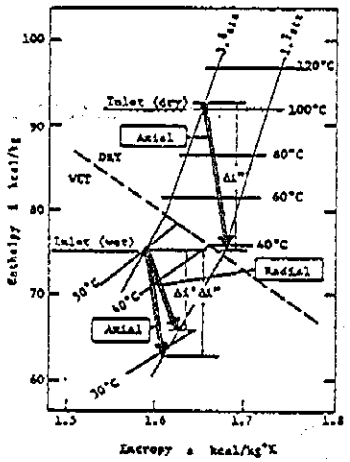
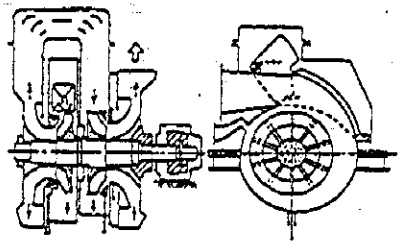


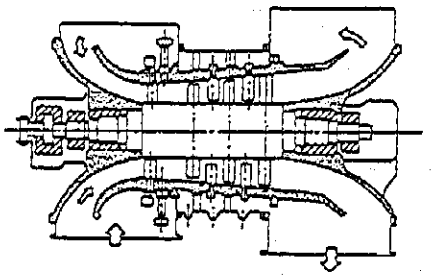
Fig.IV.3-9. Transition of TRT in Japan





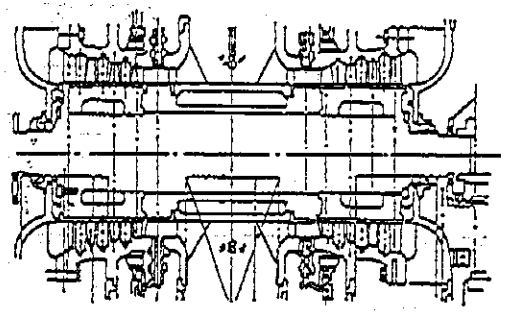
Turbine type		Wet-Radial
Gas flow (dry)	×10³Nm³/h	600
Turbine inlet gas temperature	°C	55
Turbine inlet gas pressure	atg	NOR 2.61 MAX 3.0
Turbine out-put	kW	MAX 14,300
Number of stage		2
Turbine speed	r.p.m	1,600

(Inner volume of blast furnace 4,500 m³)



Turbine type		Wet-Axial
Gas flow (dry)	×10³Nm³/h	530
Turbine inlet gas temperature	°C	60
Turbine inlet gas pressure	atg	NOR 2.4 MAX 2.5
Turbine out-put	kW	MAX 14,000
Number of stage		3
Turbine speed	r.p.m	3,600

(Inner volume of blast furnace 3,830 m³)



Turbine type		Dry-Axial
Gas flow (dry)	×10³Nm³/h	450
Turbine inlet gas temperature	°C	130
Turbine inlet gas pressure	atg	NOR 2.5 MAX 3.0
Turbine out-put	kW	NOR 22,000 MAX 33,000
Number of stage		4 (double-flow)
Turbine speed	r.p.m	1,800

(Inner volume of blast furnace 4,550 m³)

Fig.IV.3-10. Progress of TRT system in Kobe Steel Kakogawa

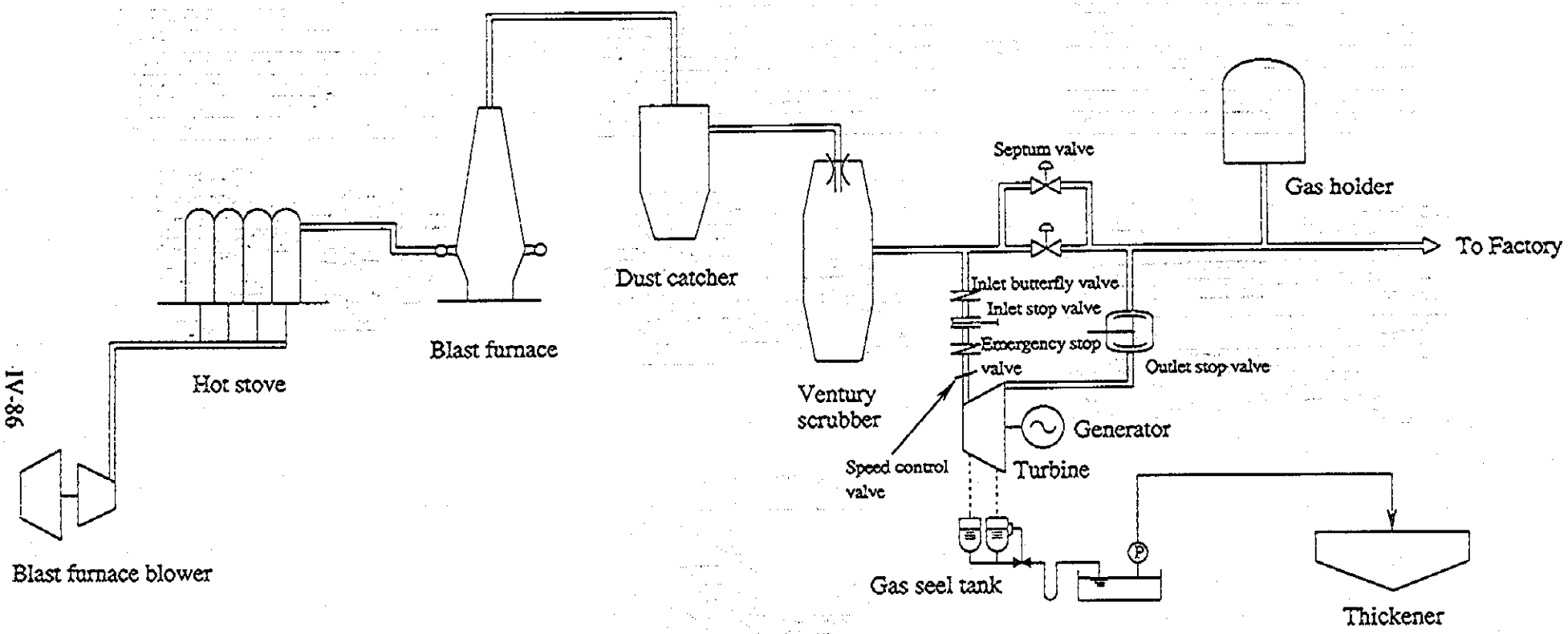


Fig.IV.3-11. Flow sheet for recovery turbine generator system of blast furnace gas

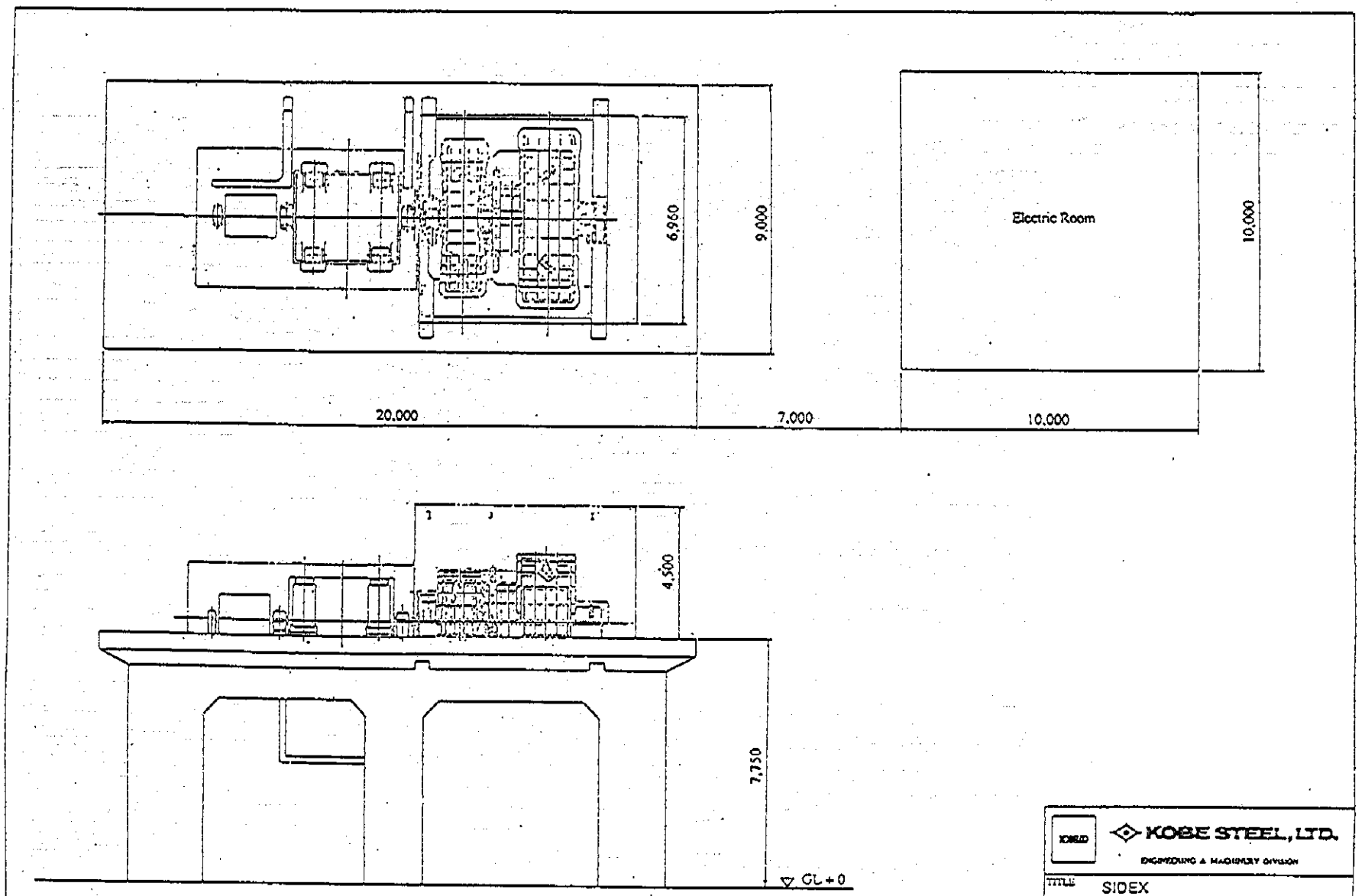


Fig.IV.3-12. TRT drawing

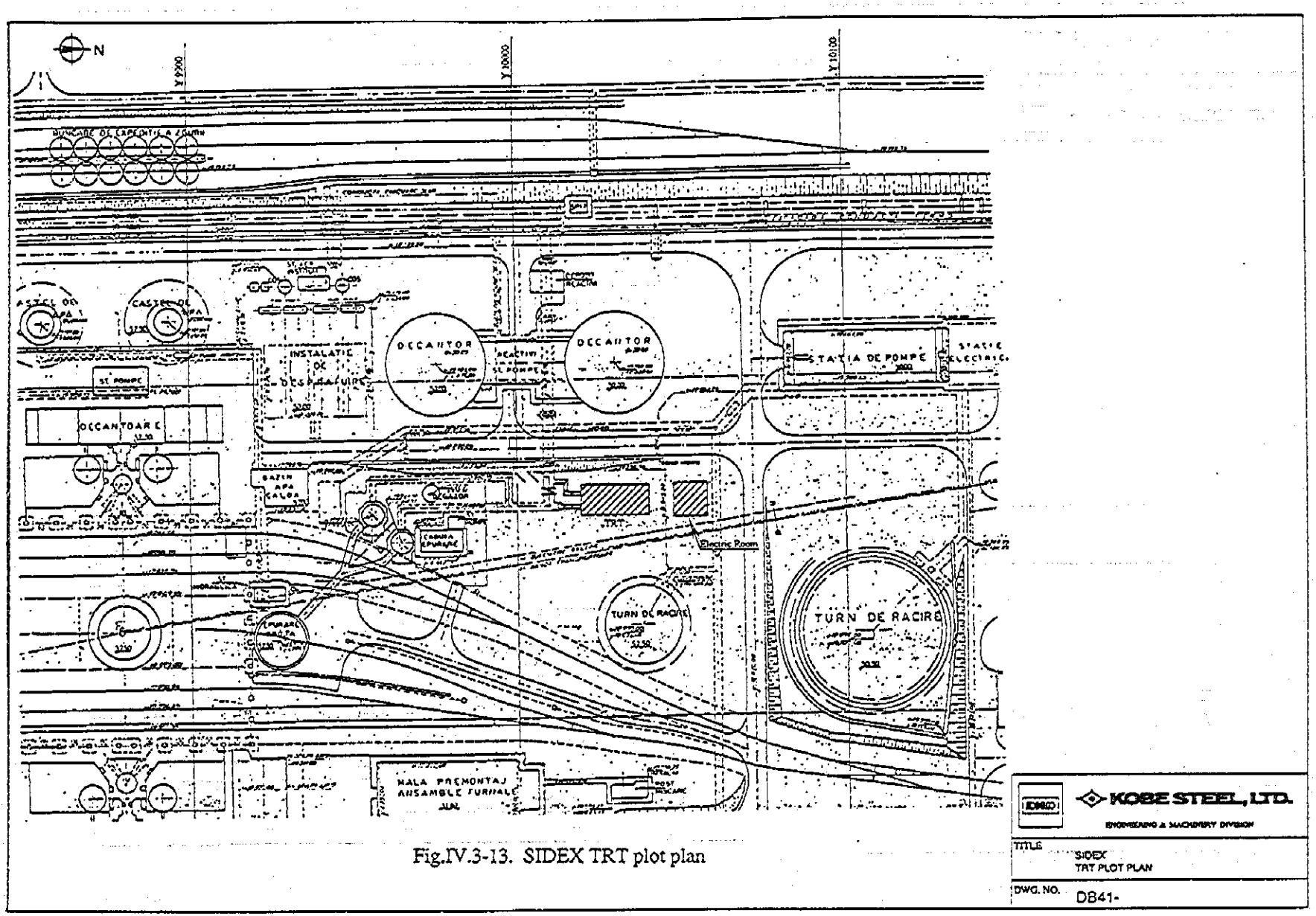


Fig.IV.3-13. SIDEX TRT plot plan

Item No. 361/362 Installation of preheating equipment for fuel and for air

1. Design concept

1) Temperature of waste gas of hot stoves seems about 210 ℃ even the staggered parallel blowing method or the dome temperature control is done, and waste heat should be collected because there is much waste gas. First the waste gas shall pass through the fuel preheater and the air preheater, and then it is used for drying pulverized coal in PCI mill. Since temperature of waste gas at the outlet of fuel preheater will be around 100 ℃, another waste gas from hot stoves is mixed with to increase it to 120 ℃ for utilizing in PCI mill.

2) Judging from water content and SOx in the waste gas, sensible heat to be collected in the preheater should be higher than the sulfuric acid dew point where the material of preheater does not corrode, that is to say higher than 90 ℃ .

3) Because the system of air preheater is not so easily influenced by gas leak, Yungstrorm type heater should be in use. As Yungstrorm is a rotating type heater and its elements are exposed to not only the cold but also the heat, they hardly corrode. As to the materials, mild steel and corrosion resistance steel will be good enough.

2. Design conditions

Respective design conditions for fuel preheater, air preheater, and a heater for drying pulverized coal are mentioned as follows.

	Unit	Fuel preheater		Air preheater		PCI mill
Fluid		Mix gas	Waste gas	Air	Waste gas	Waste gas
Inlet temp.	℃	50	210	30	210	-
Outlet temp.	℃	150	95	150	91	120
Flow quantity	Nm^3/h	187,500	155,800	154,000	129,780	60,000
Pressure at inlet	mmH_2O	1,000	50	950	50	50
Pressure loss	mmH_2O	50	50	50	50	50
Pressure at outlet	mmH_2O	950	0	900	0	0
Heat transfer area	m^2	4,000		3,600		-
Gas analysis						
CO	Vol (%)	18.7				
CO_2	Vol (%)	19.6	24.7		24.7	24.7
H_2	Vol (%)	3				
N_2	Vol (%)	57.7	71	79	71	71
CH_4	Vol (%)	1				
O_2	Vol (%)		1.1	21	1.1	1.1
H_2O	Vol (%)		3.2		3.2	3.2
		100	100	100	100	100

3. Main specifications of equipment

1) Fuel preheater : 1 set

- Type : Tube (mild steel)
- Heat transfer area : 4,000 m^2

2) Air preheater : 1 set

- Type : Yungstrorm
- Heat transfer area : 3,600 m^2
- Material : Mild steel and corrosion resistance low alloy steel

3) Valves for flow control : 1 set

4) Connection ducts : 1 set

4. Attached information

Fig. IV.3-14 Hot stove heat recovery system
Fig. IV.3-15 SIDEX BFG Heater drawing
Fig. IV.3-16 SIDEX Air preheater drawing

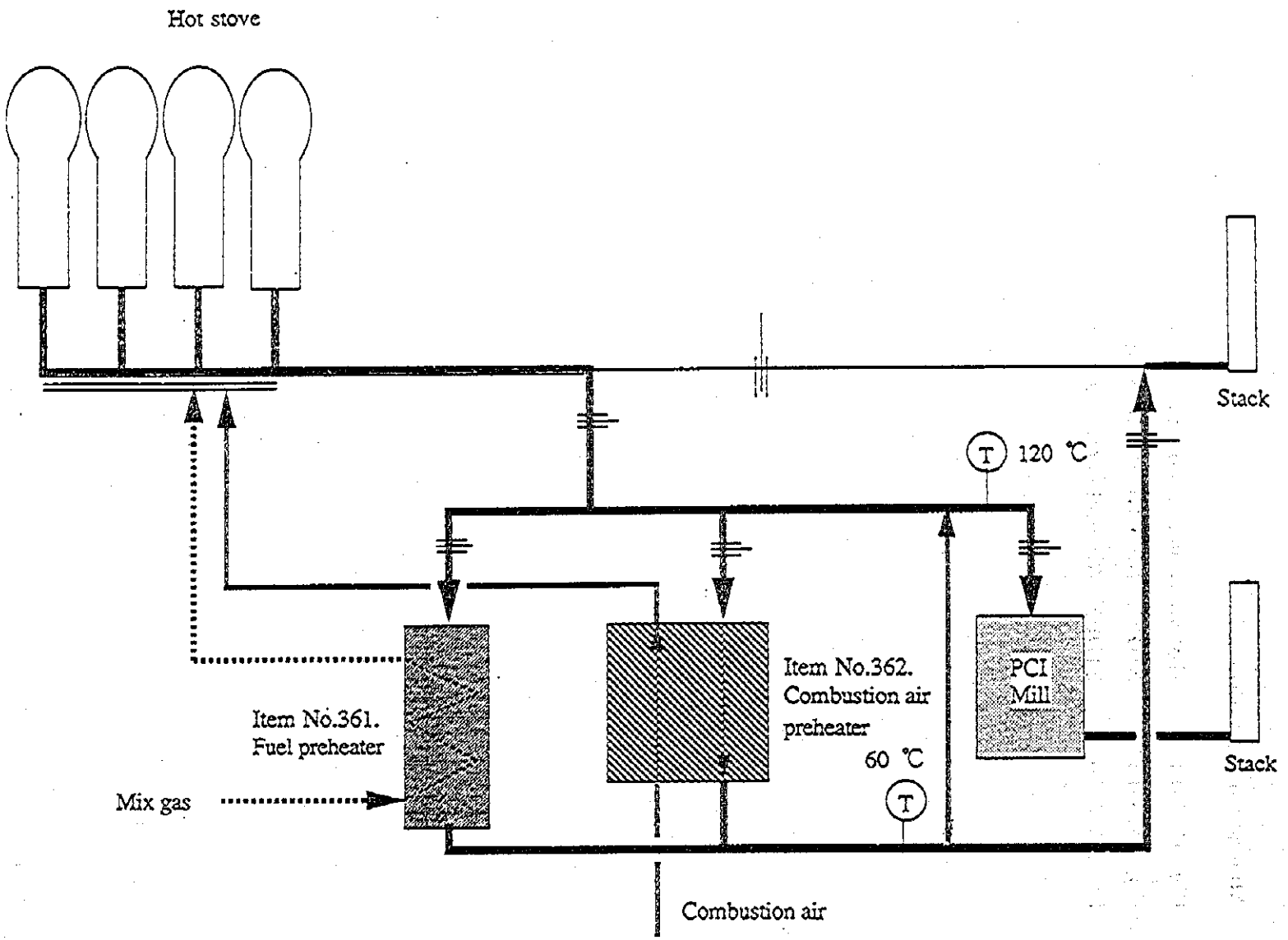


Fig.IV.3-14. Hot stove heat recovery system

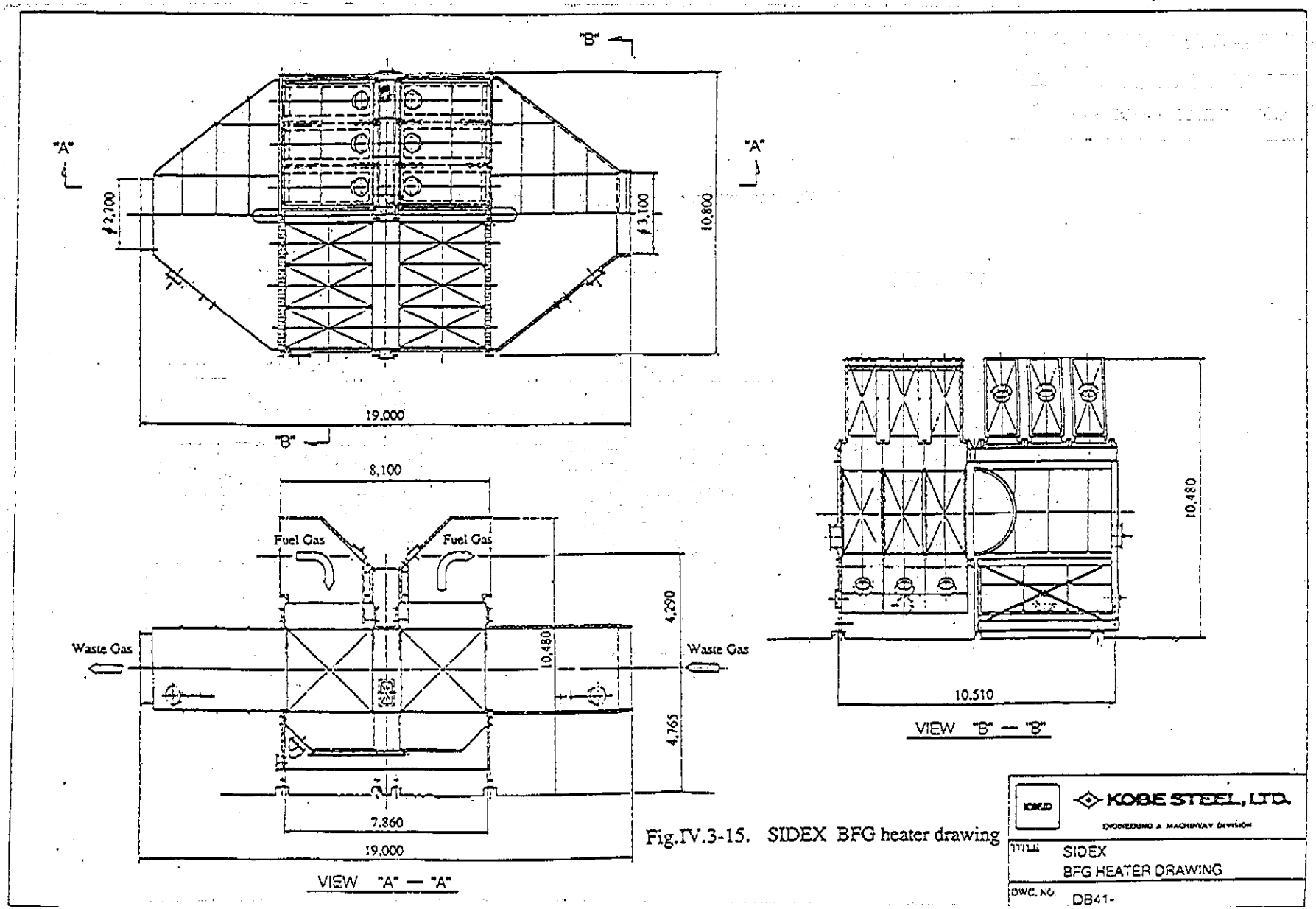


Fig.IV.3-15. SIDEX BFG heater drawing

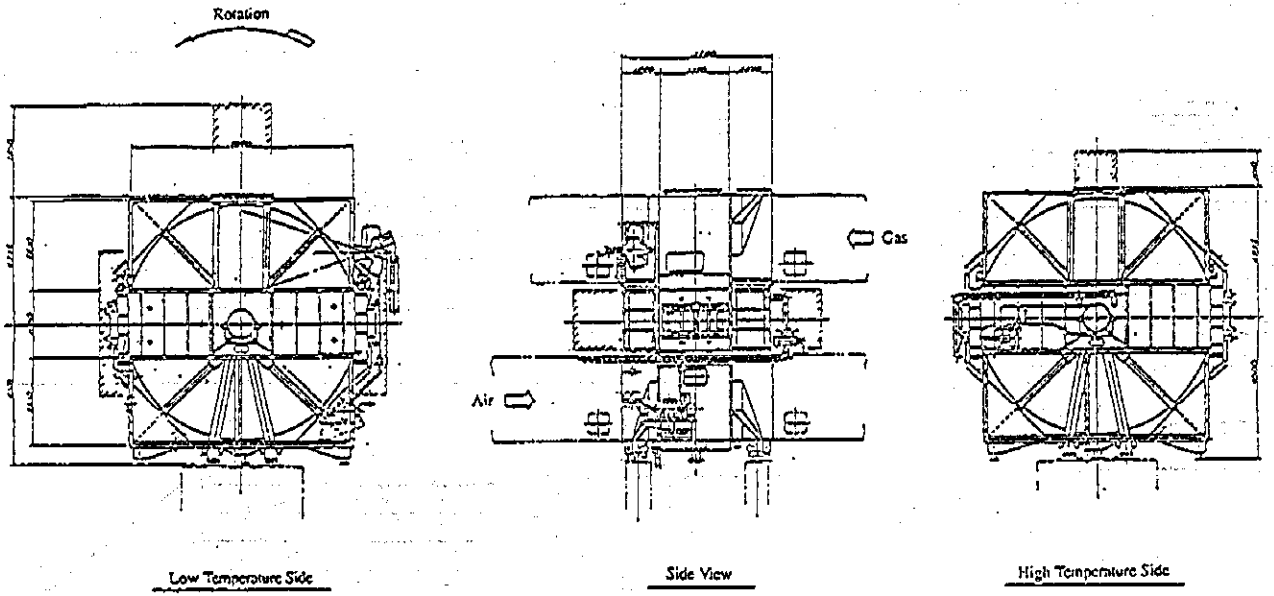


Fig.IV.3-16. SIDEX Air preheater drawing

KOBE STEEL, LTD.
TITLE: SIDEX
AIR PREHEATER DRAWING
DWG. NO. DB41-

Item No. 371 Renewal of dust collection system for casting floor

1. Design concept

1) Capacity of dust collection facilities

Compared with the Japanese actual results, the present dust collection facilities (3,000 m^3/min. x 4 sets) is small in scale, and in order to improve the working environment, 15,000 m^3/min.per floor (30,000 m^3/min. in total for two floors) will be necessary.

2) Type of dust collection facilities

In selecting the type of bag filter, material of bag and such structure as can remove collected dusts from the bag are most important. The material of bag should meet the properties of treated gas, and have a long life with less pressure loss; a Tetron bag is recommended as the following table shows.

As to the dust removal system, the back wash system which is efficient in stable performances should be adopted.

Material	Heat resisting temperature	Special property
Tevilon	Normal 60 ℃	Excellentin chemicalresistivityand in strength,butsoftened at low temperature
Pylen	Normal 80 ℃	Excellentin moisture absorbing property and chemicalresistivityand extensivelyutilizedfor dust collectorlikeTetron
Nylon	Normal 100 ℃	Having favorablewear-resisting, impact resting, and electricinsulating property
Tetron	Normal 130 ℃	Having relativelyhigh heat-resisting temperatureand excellentchemicalresistivity, and most popularly adopted as filtercloth for dust collector
NPMEX(Aromatic polyamidefiber)	Normal 200 ℃	For high temperaturegas Having favorablestrength
Fiber glass	Normal 270 ℃	For high temperaturegas :usable up to 300 ℃ max.

2. Design conditions

1) Dedusting space : 2-cast floors and inside roofs

2) Dust concentration and gas temperature

Dust concentration : 5 g/Nm^3

Gas temperature : Less than 130 ℃

3. Main specifications of equipment

1) Bag filter : 2 sets

- Capacity : 15,000 m^3/min.
- Type : Bag filter
- Dust concentration : 50 mg/Nm^3 at outlet
- Pressure loss : 150 mmH2O
- Filter cloth : Tetron
- Cleaning method : Back wash type by the exhaust fan
- Accessories : Rotary valves
  : Local control panels
  : Mist separator with auto drain and sluice valve for compressed air

2) Exhaust fan with motor : 2 sets

- Capacity : 15,000 m^3/min.
- Static pressure : 500 mmH2O
- Temperature : Ambient

3) Safe Guard and Protection Equipment and Gas line : 1 set

4) Conveyor and ducts : 1 set

4. Attached information

Fig. IV.3-17 Schematic flow of dust collection system at casting floor of No.6 Blast furnace

Fig. IV.3-18 SIDEX bag filter image

Fig. IV.3-19 SIDEX bag filter plot plan

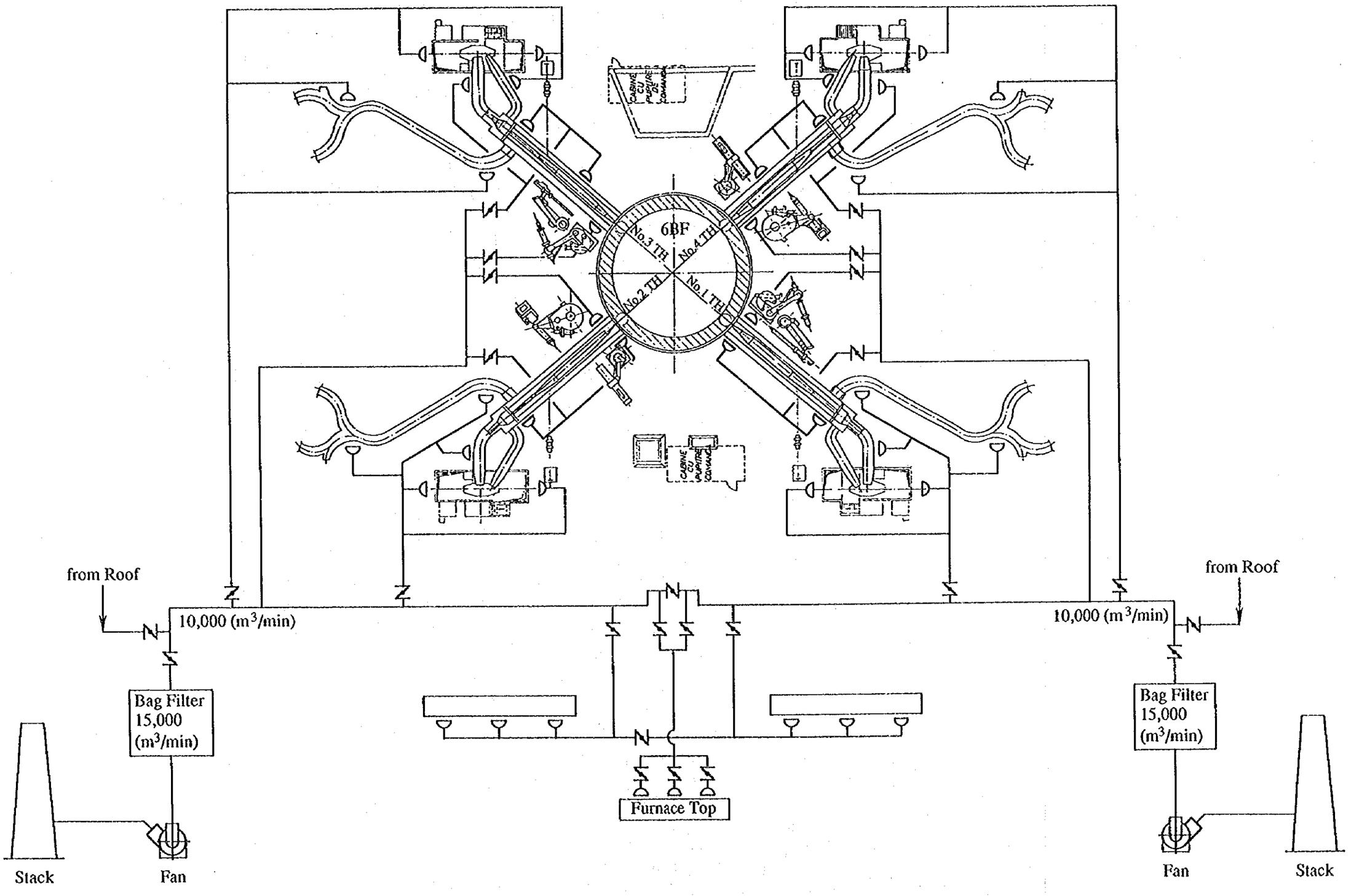


Fig.IV.3-17 Schematic flow of dust collection system at casting floor of No.6 blast furnace

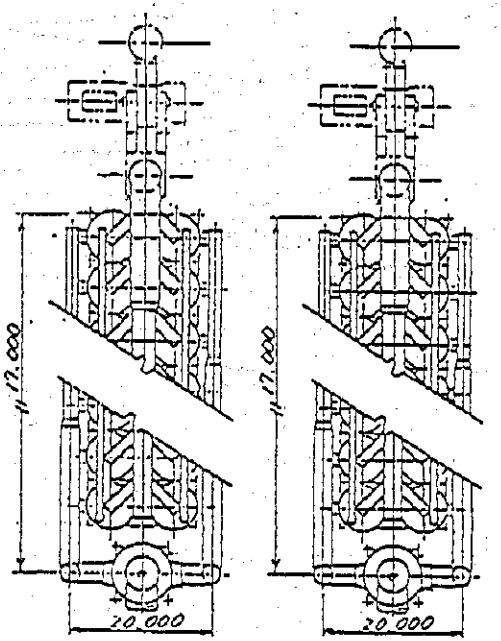


Fig.IV.3-18. SIDEX bag filter image

KOBE STEEL, LTD.

TITLE: SIDEX
BAG FILTER LAYOUT

DWG. NO. DB41-

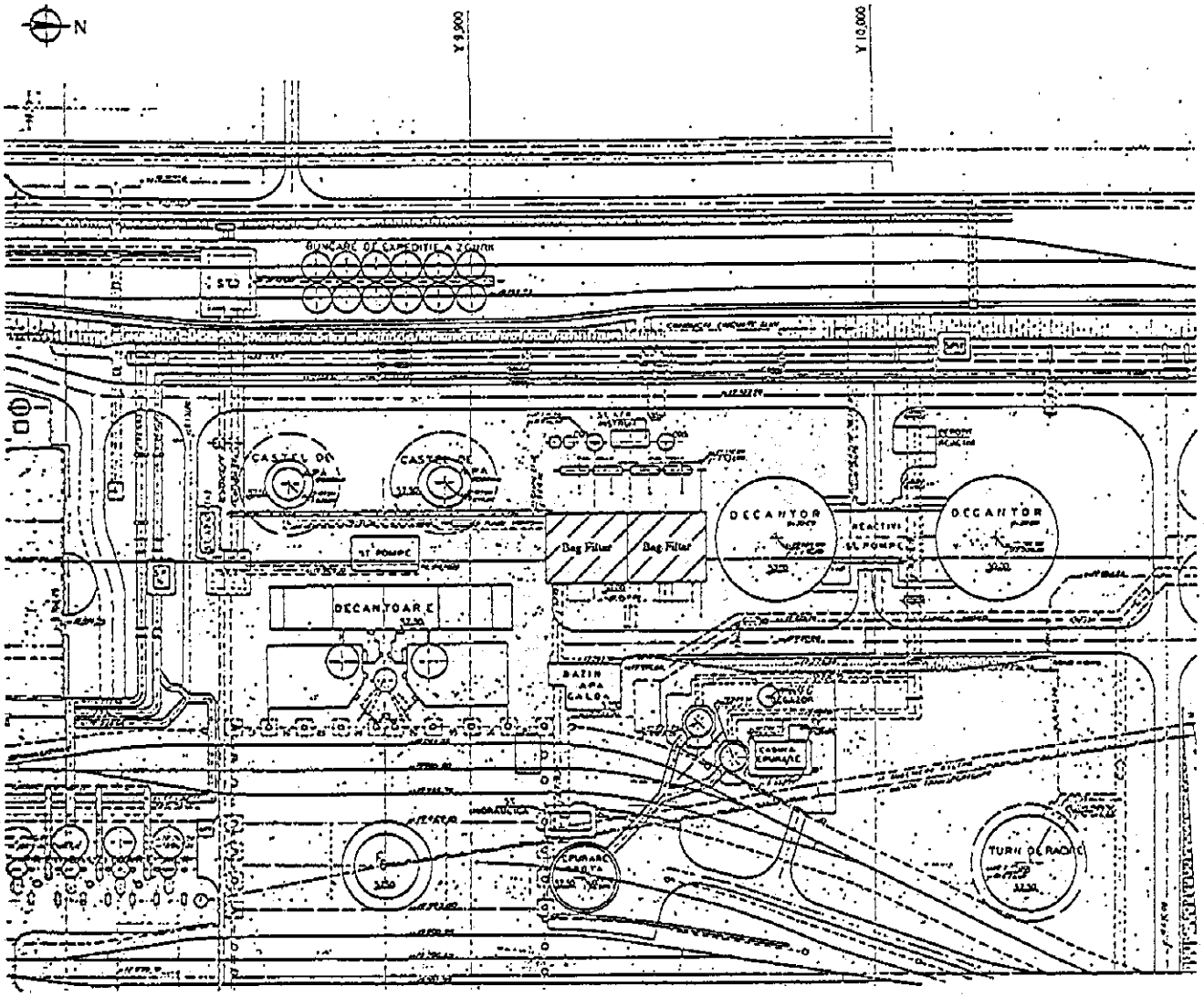


Fig.IV.3-19. SIDEX bag filter plot plan

KOBE STEEL, LTD.
ENGINEERING & MACHINERY DIVISION

TITLE SIDEX
BAG FILTER PLOT PLAN

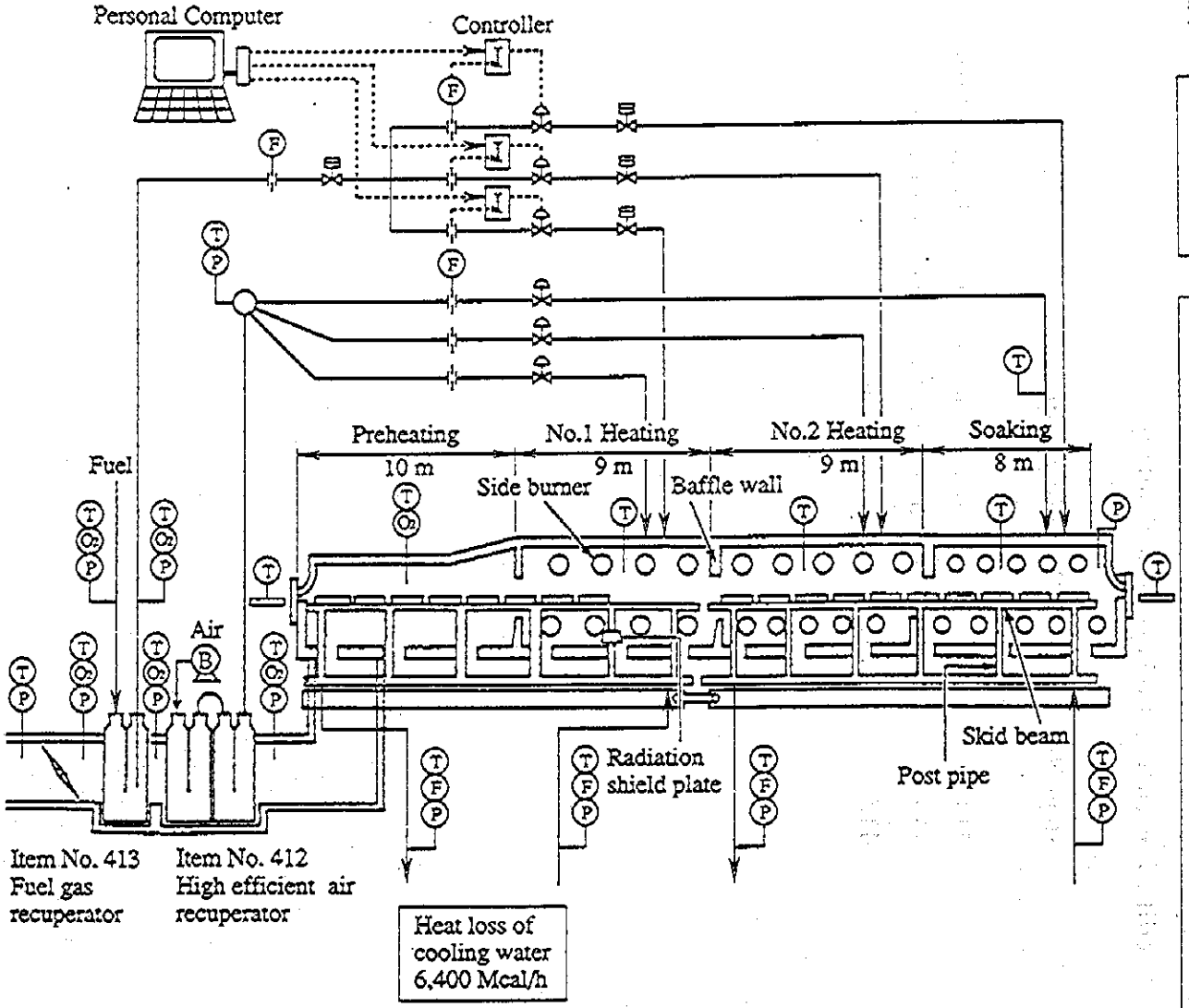
DWG. NO. D841-

4. ROLLING MILL NO.3 REHEATING FURNACE

Based on the measures described in Chapter II, a conceptual design for No.3 reheating furnace is done and Fig. IV.4-1. shows the whole outline. The concept is to replace the present two operating furnaces with a new furnace, and purposes to meet the production (1,880,000 t/y) in year 2002. Hence, a great deal of effects on energy saving is expected. The measures for facilities consists of the followings.

• Facilities of energy saving and technology

Item No.	Name of facilities
411.	Installation of high performance reheating furnace
412.	Installation of high efficient air recuperator
413.	Installation of fuel gas recuperator



Item No. 411.
New Reheating Furnace

1. Promotion of Heat Transfer

- Box type furnace without the nose
- Skid shift at the soaking zone
- Optimizing the height of baffle wall
- Making higher the skid rider

2. Energy Saving

Heat Loss of Furnace Wall

- Ceramic fiber lining

Heat Loss of Cooling Water

- Ceramic fiber lining of skid bean and post
- Natural convection cooling of skid post

Sensible Heat of Exhaust Gas

- Low excess air ratio by O2 % control and cross-limit control
- Thinned-out burner control
- Firing ratio increases toward discharge side

Radiation Loss

- Radiation shield plate at the hearth
- Closed type charging door

Heat Recovery

- Furnace pressure control
- Closed type charging door

Fig.IV.4-1. Outline of New Reheating Furnace

Item No. 411 Installation of high performance reheating furnace

1. Design concept

A high performance reheating furnace is planned based on the following intentions.

1) Promotion of thermal performance (heat transfer)

(1) Change the present pusher type with the walking beam type, and improve the performance of heat transfer and the quality of products.

(2) Change the shape of furnace from the existing nose type to the box type, and select the most suitable furnace profile for heated materials, in order to improve the performance of heat transfer.

(3) Shift the arranged skid pipes in the soaking zone, and apply the heat resistance and abrasion resistance steel to the skid button so as to make it high. By taking such a step, improve the quality of product with uniform heating and reduce the loss of cooling water.

2) Measures for energy saving

(1) Cover the furnace wall with ceramic fiber in order to reduce heat loss.

(2) Fit the ceramic lining to the skids and the post in order to reduce heat loss ascribed to cooling water.

(3) Reduce the excessive combustion air by controlling O2 in order to prevent the sensible heat from diffusing with waste gas.

(4) Purposing to reduce the radiating heat loss which occurs in the opening of door for charging and discharging products, adopt a close-tight type door by lengthening the stroke of charger and extractor.

(5) Place shield plates to openings on the hearth.

3) Measures for future HCR (hot charge rolling) and the like

(1) Adopt the individual driving system to the walking beam, so that the traveling speed can be partly changed in the furnace according to temperature of charged material.

(2) Change numbers of burner according to temperature of charged material, referring to the properties of each burner.

4) Adopt the new low NOx burner, that can control occurrence of NOx.

5) As to the beam driving, adopt the electric type that does not have a huge oil hydraulic device and that easily maintained with less adjustment.

2. Main specifications of new furnace

• Type	: Walking beam
• Reheating capacity	: Max. 250 t/h (Slab Size 200 x 1,250 x 9,500) : Standard 200 t/h (Slab Size 200 x 1,250 x 7,500)
• Material properties	: Low carbon steel, Low alloy, Alloy, Stainless steel
• Reheating temperature	: 950 - 1,270 ℃
• Combustion control	: 6 - zone
• Fuel	: Mixed gas
• Charging method	: End charge by charger
• Discharging method	: End discharge by extractor
• Material transfer system	: By walking beam

3. Equipment list

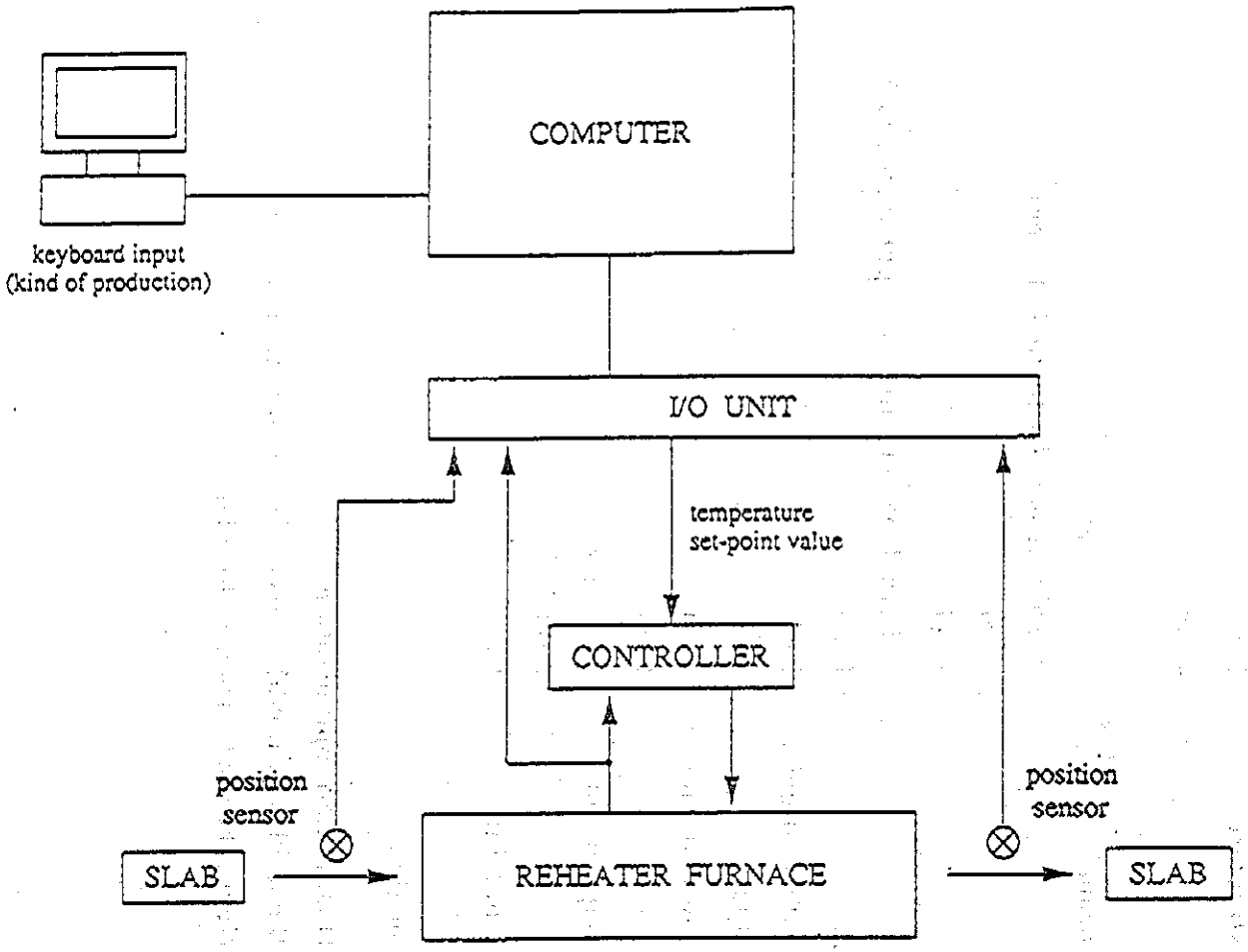
1)	Furnace structure	: 1 set
2)	Doors	: 1 set
3)	Walking beam	: 1 set (skids, trough, actuators, frame)
4)	Platform	: 1 set
5)	Piping	: 1 set (air, fuel, water, nitrogen, pneumatic air)
6)	Refractory	: 1 set
7)	Burner system, Blower	: 1 set
8)	Fuel gas duct	: 1 set
9)	Charger and extractor	: 1 set
10)	Instruments	: 1 set
11)	Electrical equipment	: 1 set
12)	Others	: 1 set
13)	Basic Engineering	: 1 set

4. Attached information

Fig. IV.4-2 Heat pattern optimization

Fig. IV.4-3 Basic idea of double-cross-limit combustion control

Fig. IV.4-4 New reheating furnace plot plan



The kind data of waiting slab is put into the computer by the keyboard.
The computer automatically recognize the timing of slab going into and out the furnace by the Position sensor.
The computer instructs to the furnace controller of the furnace temperature set-point value.
The furnace controller acts for the necessary control.

Fig.IV.4-2. Heat pattern optimization

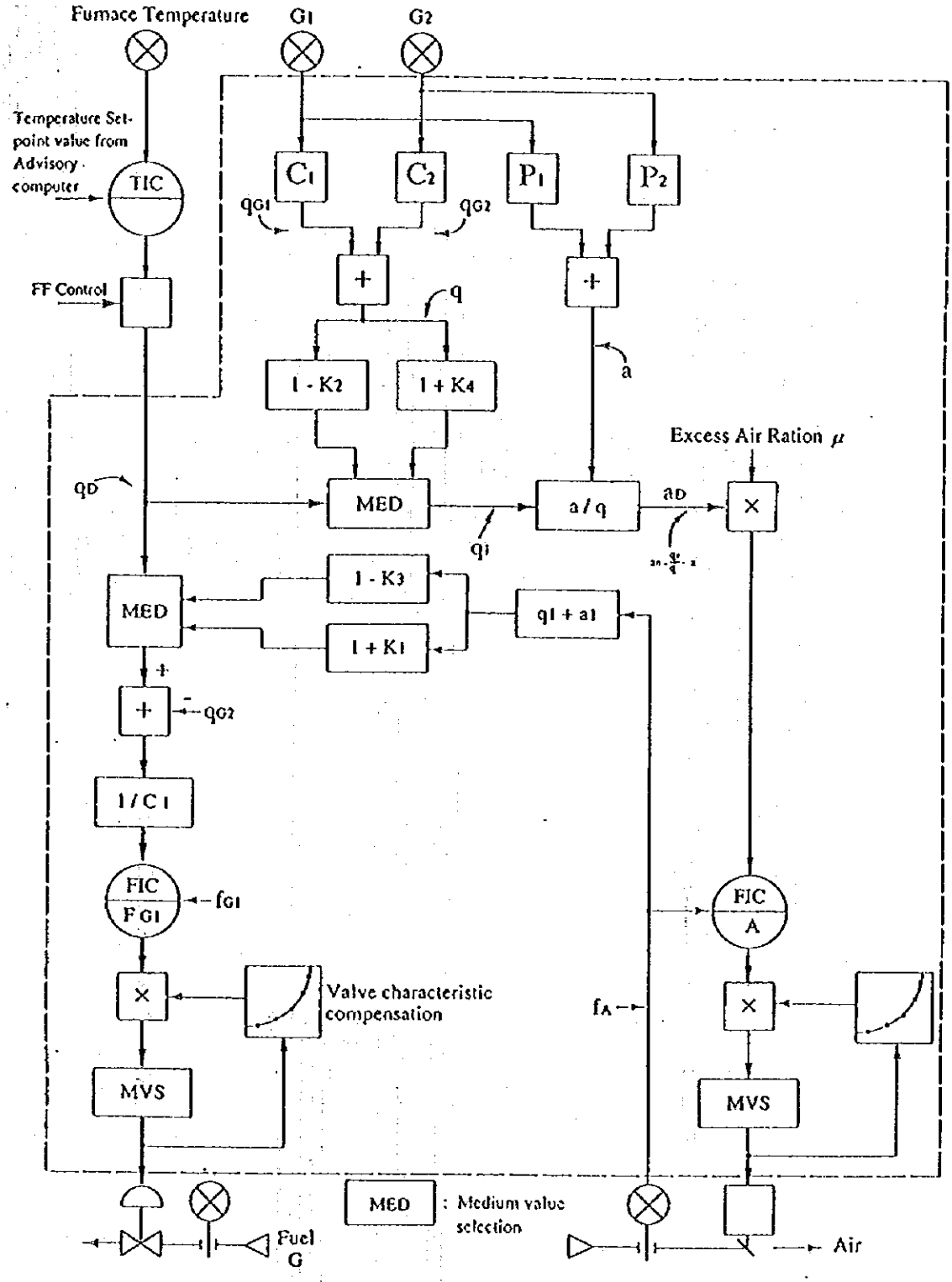


Fig.IV.4-3. Basic idea of double-cross-limit combustion control

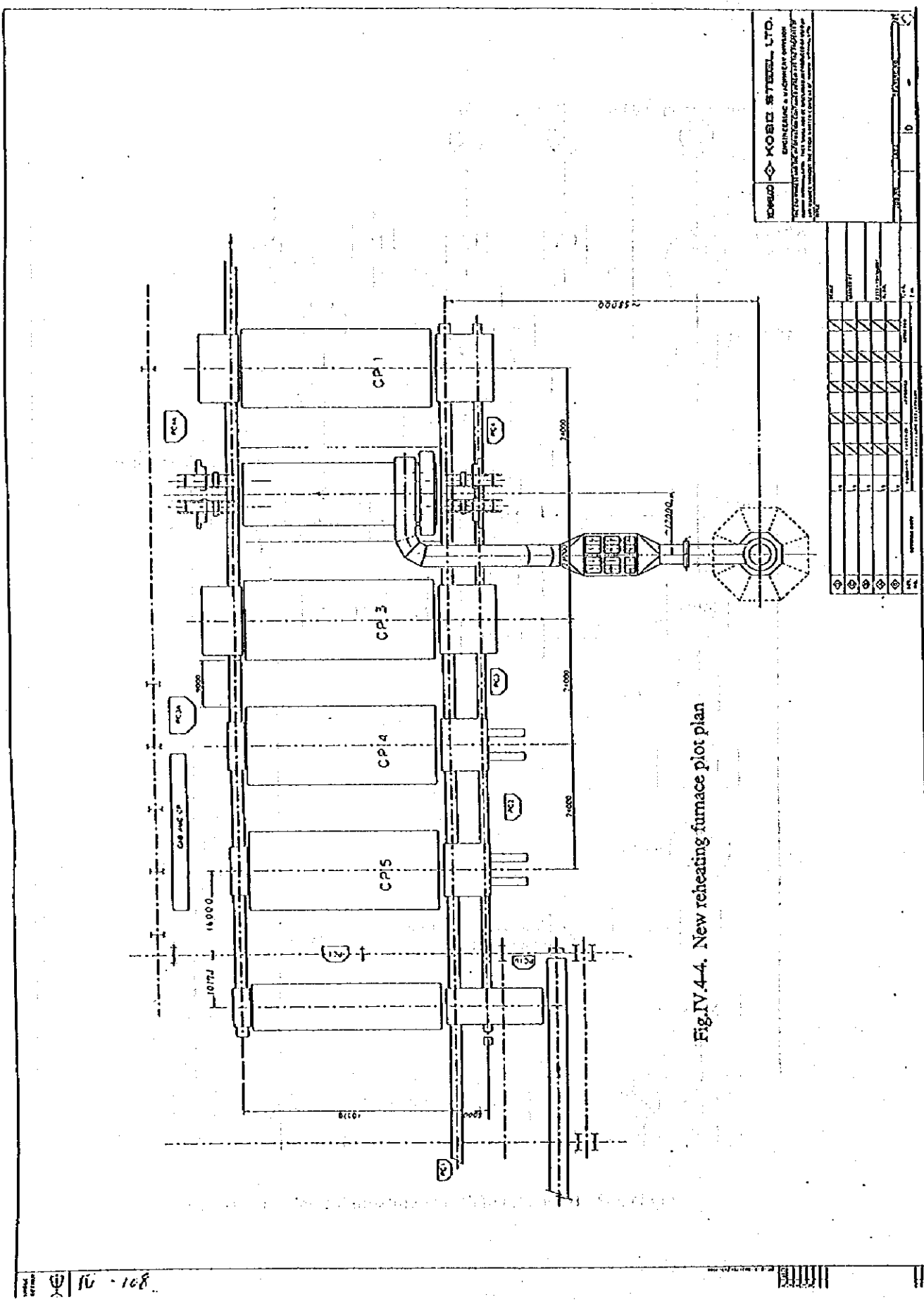


Fig.IV.4-4. New reheating furnace plot plan

Item No. 412 Installation of high efficient air recuperator

Item No. 413 Installation of fuel gas recuperator

1. Design concept

1) Selection of recuperator type

The present radiation type recuperator should be changed with the tube type, that can easily collect heat even if it in the range of low temperature.

2) Arrangement of recuperator

The recuperator should be placed in series with air/fuel.

2. Main specifications of equipment

1) Air Recuperator : 1 set

• Exhaust gas

Inlet temp. (℃)	: 750
Outlet temp. (℃)	: 296
Flow rate (Nm^3/h)	: 46,100
Pressure loss (mmH2O)	: 25

• Combustion Air

Inlet temp. (℃)	: 20
Outlet temp. (℃)	: 614
Flow rate (Nm^3/h)	: 65,600
Pressure loss (mmH2O)	: 300
Heat transfer are (m^2)	: 3,370

2) Fuel Recuperator : 1 set

• Exhaust gas

Inlet temp. (℃)	: 296
Outlet temp. (℃)	: 273
Flow rate (Nm^3/h)	: 72,800

Pressure loss (mmH2O) : 25

• Combustion fuel

Inlet temp. (℃)	: 20
Outlet temp. (℃)	: 252
Flow rate (Nm^3/h)	: 8,060
Pressure loss (mmH2O)	: 30
Heat transfer area (m^2)	: 600

3. Attached information

Fig. IV.4-5 Waste heat recovery system in new reheating furnace

Fig. IV.4-6 SIDEX recuperator drawing

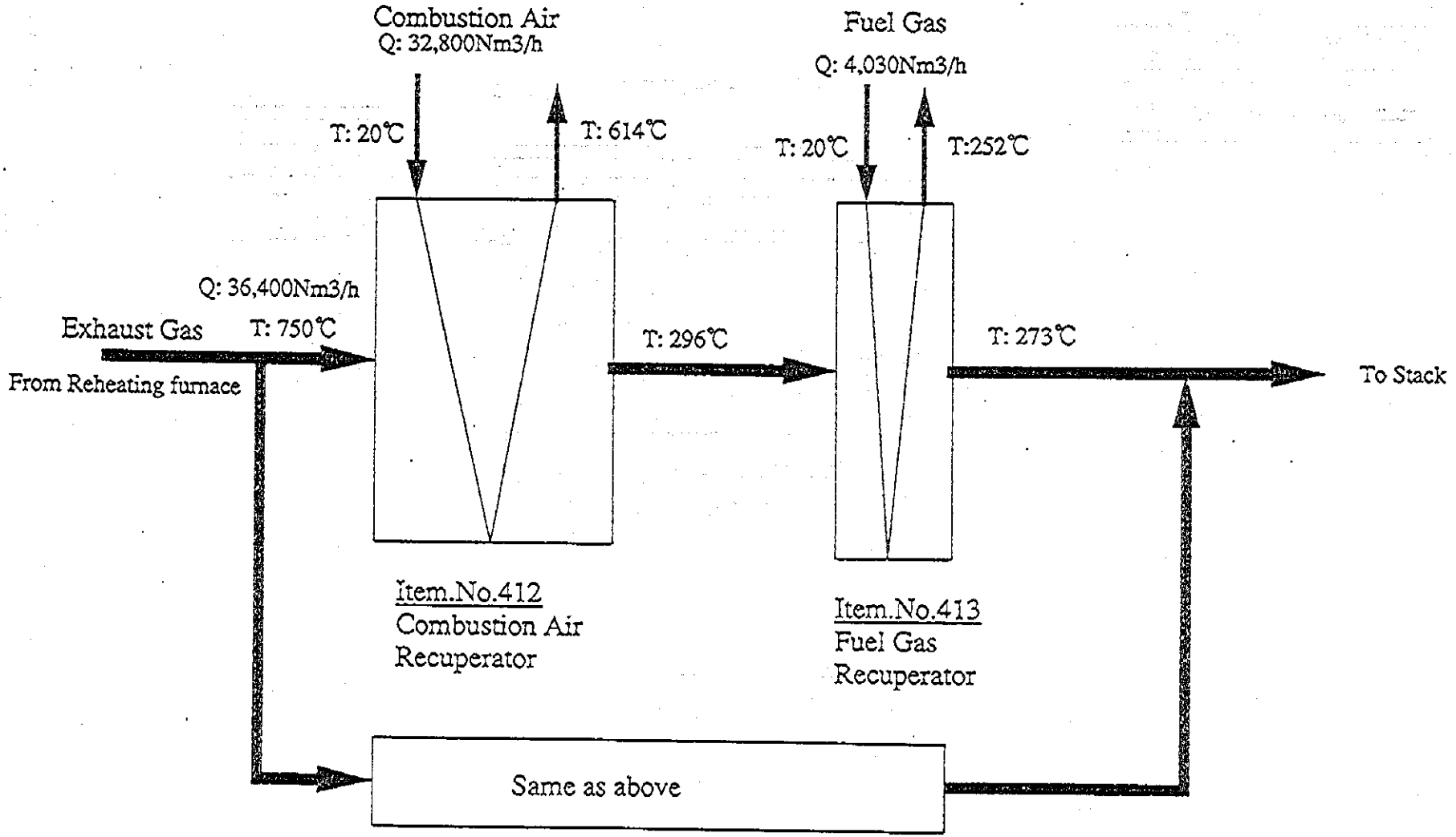


Fig.IV.4-5. Waste Heat Recovery System in New Reheating Furnace

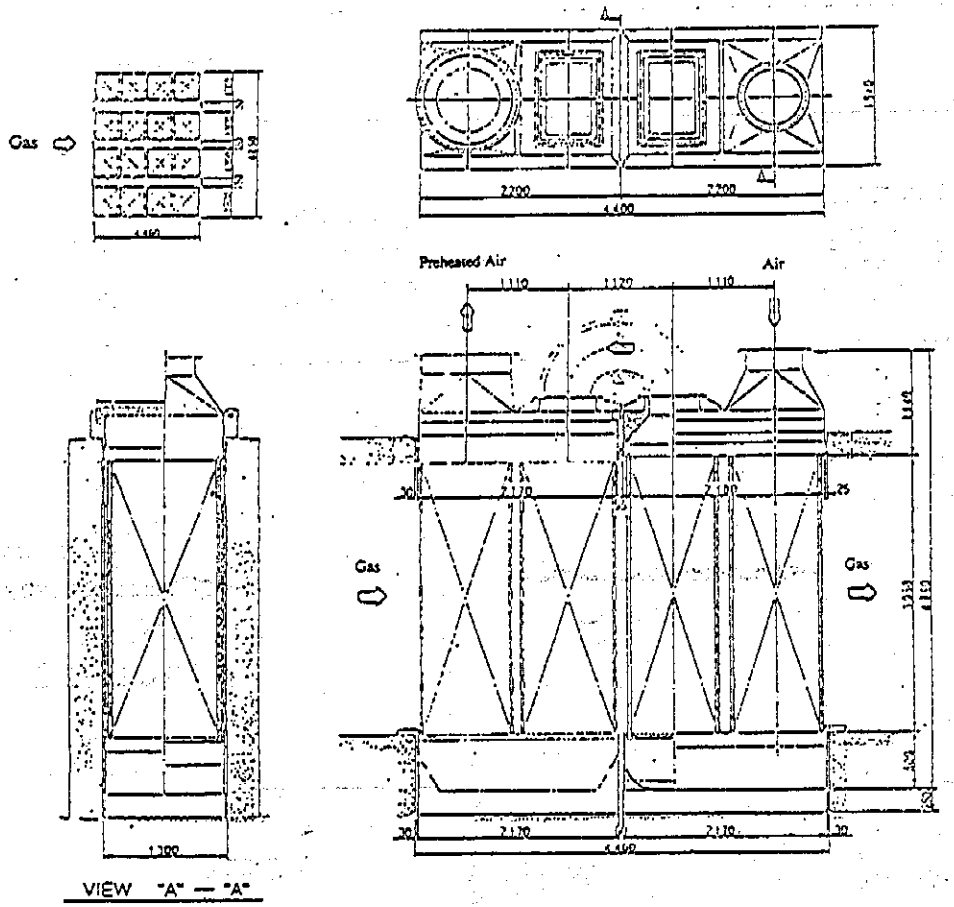


Fig.IV.4-6. SIDEX recuperator drawing

5. ENERGY SUPPLYING FACILITIES

Measures for saving energy in energy supplying facilities is essential for actually saving energy in steelworks. Energy saving in each plant is studied on the premise that stable qualitative energy is supplied. Therefore, insufficient function of the energy supplying facilities will make inaccurate measures for energy saving in every plant.

- Facilities of energy saving

Item No.	Name of facilities
011.	Installation of gas holders
012.	Installation of gas mixing device
013.	Renewal of blower, turbine and boiler

Item No. 011 Installation of gas holders

1. Design concept

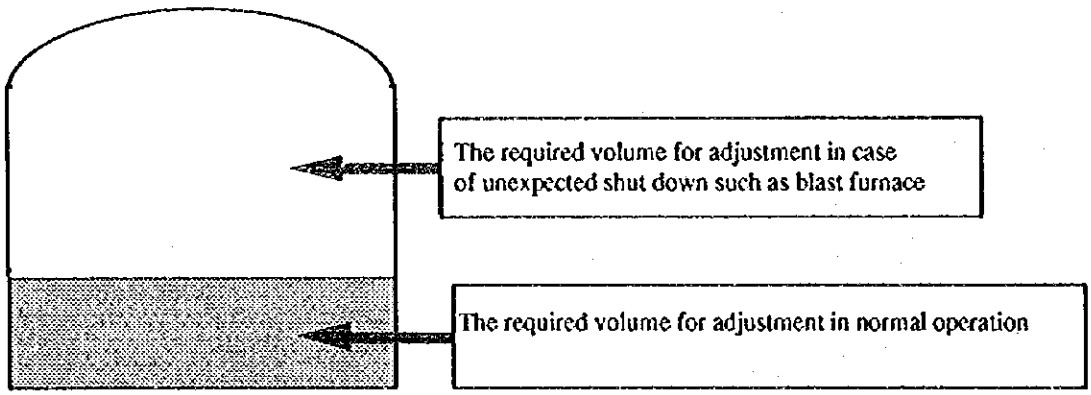
1) Purpose of installation of gas holder

- By controlling pressure of gas supply and keep it constant (lower than 20 mmH2O in variation of gas pressure of gas holder), each plant can save the excess of combustion air.

- Diffusion of gas is minimized by adjusting the supply and demand of byproduct gas.

2) Capacity of gas holder

The following two adjustment ranges in total will make up the capacity of gas holder.



3) Type of gas holder

The following type with excellent performance in long-term operation is recommended.

- Type : Cylindrical type, spherical roof
- Sealing method : Static oil seal system, endurable for 1000 mmH2O
- Sliding material : Reinforced rubber

2. Design conditions

1) Condition of byproduct gas

	Blast furnace	Coke oven
Products (1,000 t/y)	4,770	2,850
Gas production quantity (x 10^6 Nm^3/y)	6,850	870
Calorific value (kcal/Nm^3)	700	4,250

2) Capacity of gas holder

The gas holding capacity, in the case of SIDEX, is determined according to the following table, prepared based on the Japanese experience.

	Holder capacity SIDEX (m^3)	Holder capacity Japan (m^3)	Remarks
For BFG	100,000	80,000 - 110,000	
For COG	50,000	30,000 - 200,000	Such a gas holder is included that gas is saved during night and consumed for generating power if the purchase electric power for daytime costs high.

3. Main specifications of equipment

1) BFG gas holder : 1 set

- Type : Dry-seal (Static oil seal system), Cylindrical shell, Spherical roof type
- Gas holding capacity : 100,000 m^3
- BFG pressure : 635 mmH2O
- Height : 77 m
- Diameter of holder : 45 m
- Piston stroke : 65 m
- Capacity of gas bleeder : 60,000 Nm^3/h (Max.)

2) COG gas holder : 1 set

- Type : Dry-seal (Static oil seal system), Cylindrical shell, Spherical roof type
- Gas holding capacity : 50,000 m^3
- COG pressure : 635 mmH2O
- Height : 63 m
- Diameter of holder : 35 m
- Piston stroke : 52 m
- Capacity of gas bleeder : 30,000 Nm^3/h (max.)

4. Attached information

Fig. IV.5-1 Flow sheet of BFG line with gas holder
Fig. IV.5-2 Flow sheet of COG line with gas holder
Fig. IV.5-3 Overall view of BFG gas holder

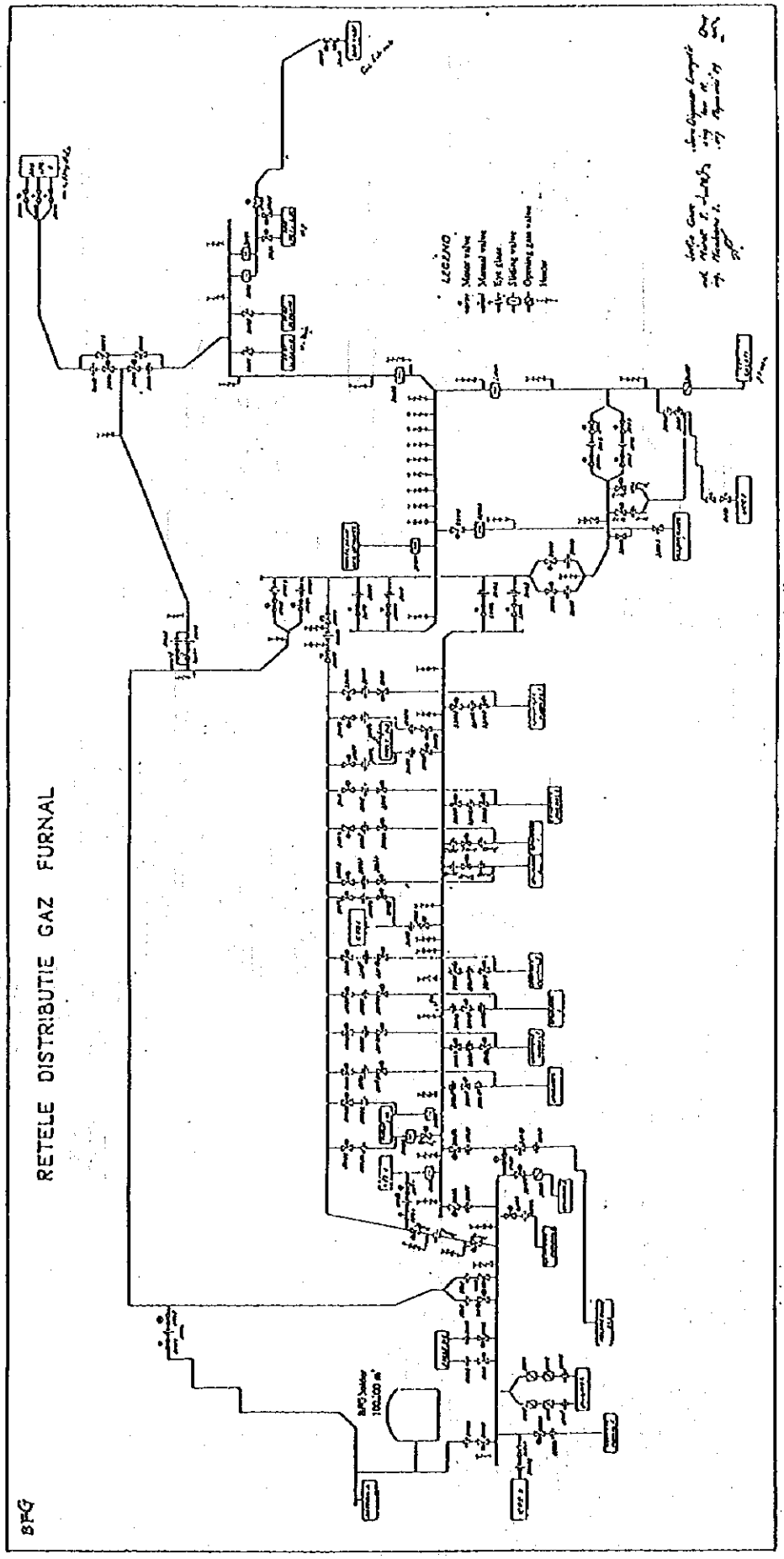


Fig.IV.5-1. Flow sheet of BFG Line with gas holder

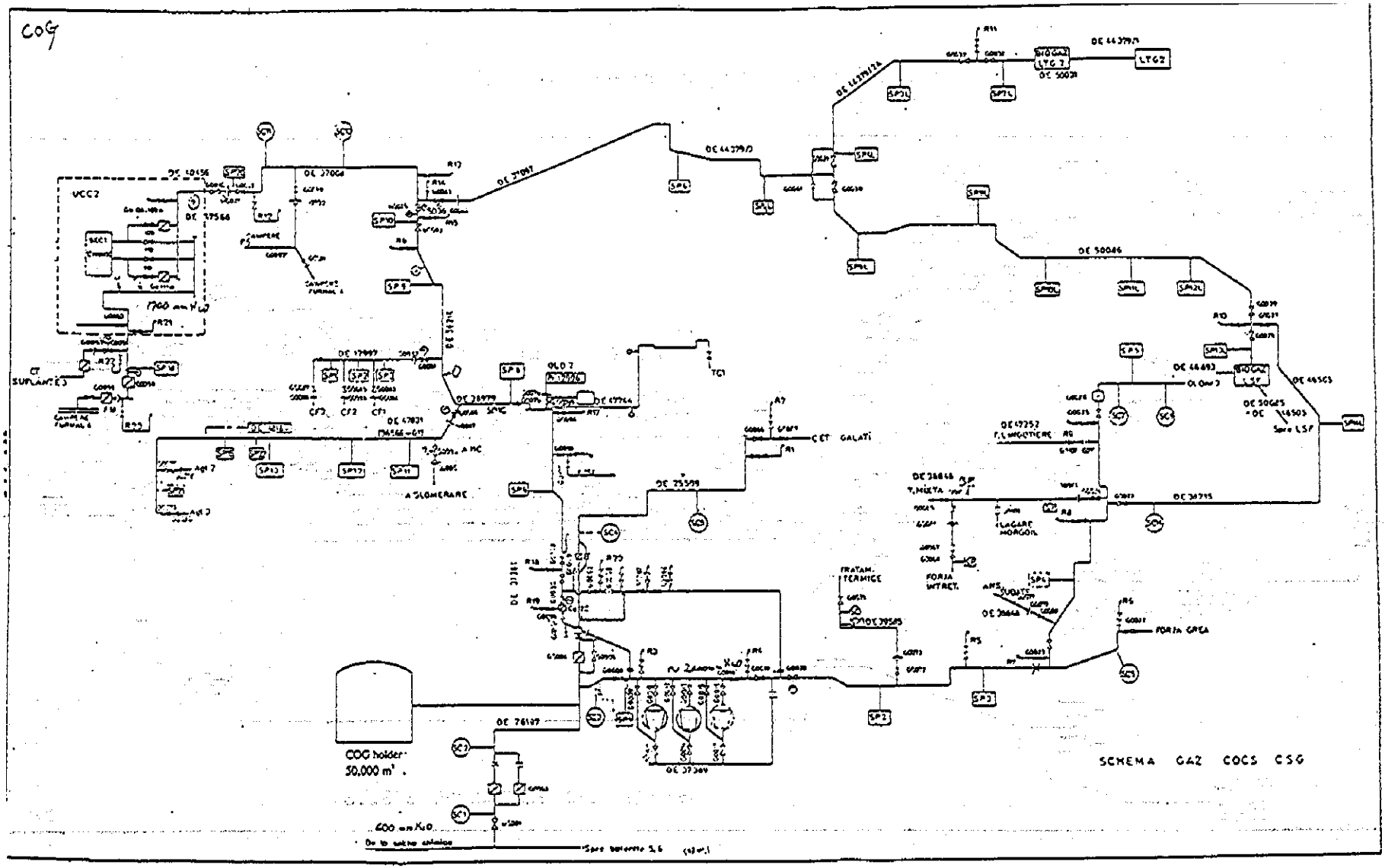


Fig.IV.5-2. Flow sheet of COG Line with gas holder

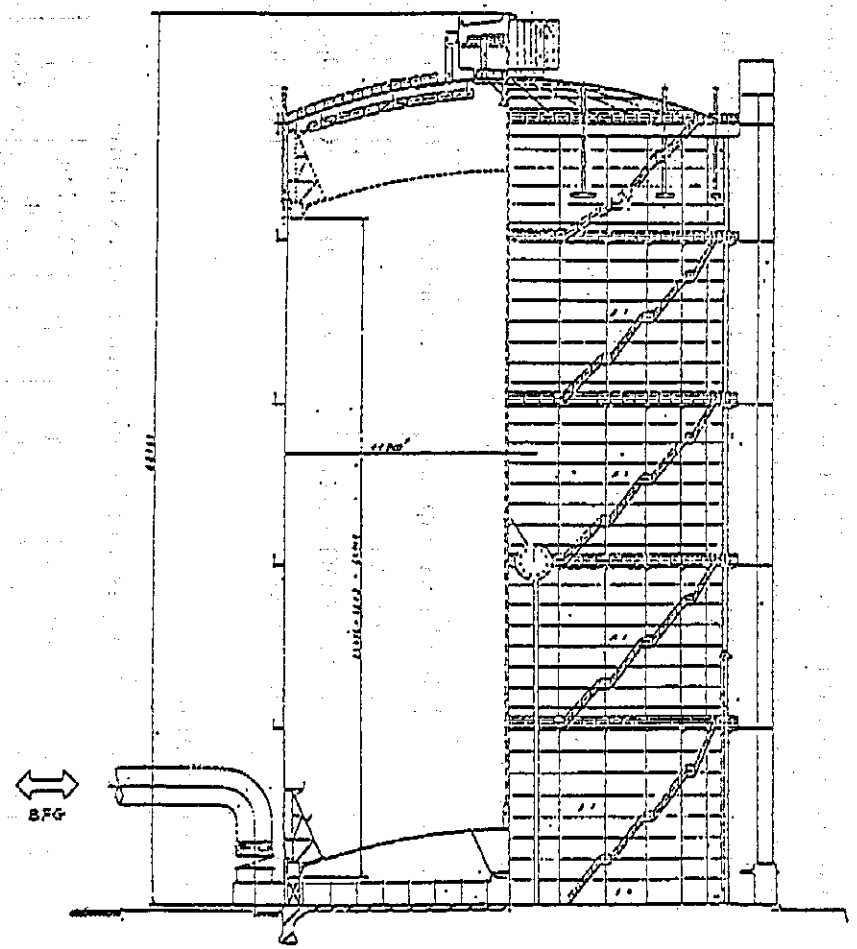


Fig.IV.5-3. Overall view of BFG gas holder

KOBE STEEL, LTD.
ENGINEERING & MACHINERY DIVISION

TITLE SIDEX
BFG Gas Holder

DWG. NO. DB41-

Item No. 012 Installation of gas mixing device

1. Design concept

1) Sources of mixing gas

- Use the byproduct gas, BFG and COG, with the highest priority.
- Use natural gas if COG shorts.

2) Controlling method of gas mixing

- In comparison with the constant control of gas calorie (Wobbe Index), the other method of controlling Ao Index (Ao $/\sqrt{\gamma}$) (Ao : Theoretical amount of air, γ : gas density) is generally used in Japan, for it does not need to adjust the air ratio if the component of gas changes.
- Pressure of mixed gas is adjusted by BFG amount.
- Unexpected variation of gas amount should be absorbed in the power generation plant, or should be returned to BFG line.

2. Design conditions

1) Operation mode

Mode	Mixed gas component	Ao index	Operation condition
I	BFG + COG	2.7 - 3.0	Normal operation
II	BFG + COG + NG		COG shortage
III	BFG + NG		COG shut down

2) Component of gas

The component of gas and its properties are as below.

	Co (%)	H_2 (%)	CH_4 (%)	CH_m (%)	CO_2 (%)	N_2 (%)	Carolific value (kcal/Nm3)	Ao (Nm3/Nm3)	γ (kg/Nm3)
BFG	22.0	3.0	-	-	21.0	54.0	742	0.59	1.37
COG	6.5	57.0	28.0	3.6	2.2	2.7	4,598	4.78	0.46
NG	-	-	94.0	-	-	6.0	8,050	8.95	0.75

3) Plant using the mixed gas

The following plant use the mixed gas.

Plant consuming mixed gas	Necessary calorie
Reheating furnace of Hot rolling mill Reheating furnace of Plate mill Reheating furnace of Slabbing mill Others	Total : 2,350 x 10^9 kcal/y Average consumption : 357 x 10^6 kcal/h Maximum consumption : 430 x 10^6 kcal/h

4) Gas balance in each mode

Mode	Ao-Index	Carolific value of mixed gas (kcal/Nm^3)	Component of mixed gas (%)			Supply quantity of mixed gas (x 10^3 Nm^3/h)
			BFG	COG	NG	
I	2.7	2,590	52.0	48.0	-	166
II	2.7	2,600-2,790	53.4 - 71.0	44.6 - 2.0	2.0 - 27.0	165 - 154
III	2.7	2,800	71.9	-	28.1	154

5) Max. supply quantity of each gas

	Maximum supply quantity (10^3 Nm^3/h)	Mode
BFG	109	I
COG	80	II
NG	43	III

6) Supply pressure of mixed gas : 1,250 mm H2O

3. Main specifications of equipment

1) Booster blower : 1 + 1 set

- Capacity : 170,000 Nm^3/h
- Pressure : 1,000 mmH2O
- Motor : 700 kW
- Temperature : Ambient

2) Gas mixing piping station : 1 set

• Piping, control valves, sealing and purging piping.

3) Instruments : 1 set

• Including Ao Index meter and controllers

4) Process computer for calculation : 1 set
of mixing ratio

4. Attached information

Fig. IV.5-4 Schematic flow of gas mixing system

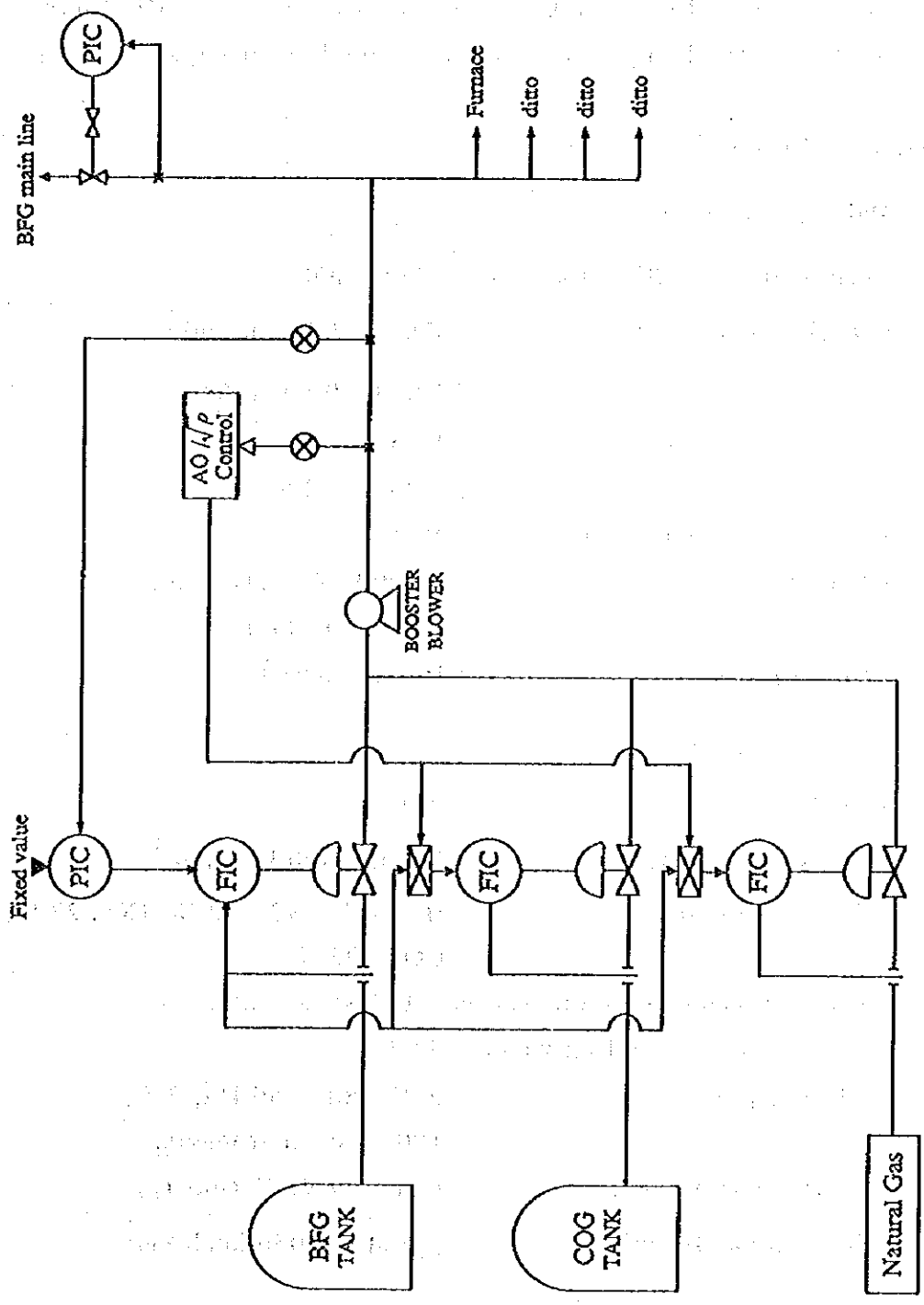


Fig.IV.5-4. Schematic flow of gas mixing system

Item No. 013 Renewal of blower, turbine and boiler

1. Design concept

One blower works for No.6 BF, and a blower for No.5 BF (previously used for No.6 BF) shall partly supply air if the blower trips.

2. Design conditions

1) Main specifications

- Productivity of Blast Furnace : 8,000 t-p/d
- Discharge quantity : Max. 7,250 Nm^3/min.
  Ave 6,200 Nm^3/min.
- Discharge pressure : 4.25 ata
- Suction pressure : -300 mm H2O
- Suction air temperature : 20 ℃
- Driver : 30,000 kW, 5,180 rpm, (Steam turbine)
- Steam pressure : 100 ata, 540 ℃

2) Utilities supply

- Fuel : BFG
- Pressure of BFG : 0.1 ata, 800 kcal/Nm^3
- Analysis of BFG : H2 : 4 %, N2 : 52 %, CO : 22 %, CO2 : 22 %
- Cooling water for condenser etc.: Industrial water
- Temperature of cooling water : 30 ℃
- Electric power : 6kV, 380 v, 50 Hz, 3 ϕ, 100 V for instruments
- Inert gas (nitrogen) : 6 ata, 99.97 % (purity)
- Natural gas for pilot : 3.5 ata, 8,050 kcal/Nm^3

3. Main specifications of equipment

1) Blower, turbine and boiler : 1 set

- Blower : Variable stators blade control, Shaft power 29,500 kW, 11 stages
- Turbine : Impulse type, 30,000 kW, 5,180 rpm, 98,000 kg/h
- Boiler : Water tube boiler, two drums, Natural circulation type, 150 t/h, 104 kg/cm^{2}G, 543 ℃

2) Accessory : 1 set

- Feed water line : From demineralizer, deaerator, feed water pump
- Condensate line : From condenser, condensate pump, feed water heater, etc.
- Fuel line : From shut down valve to burner equipment
- Waste gas line : Up to stack
- Combustion air line : Blower, air heater, etc.
- Electric power line : Power distribution boar, MCC, Local Panel, etc.

3) Safe guard and protection equipment : 1 set

4) Electrical equipment/instruments: 1 set (Standard control : ACC)

5) Piping system : 1 set (Joints, valves, control valve, flow meter, etc.)

4. Attached information

Fig. IV.5-5 SIDEX Blower heat balance diagram
Fig. IV.5-6 SIDEX Blower drawing for No.6 Blast furnace
Fig. IV.5-7 SIDEX Steam turbine drawing

Fig. IV.5-8 SIDEX Boiler drawing

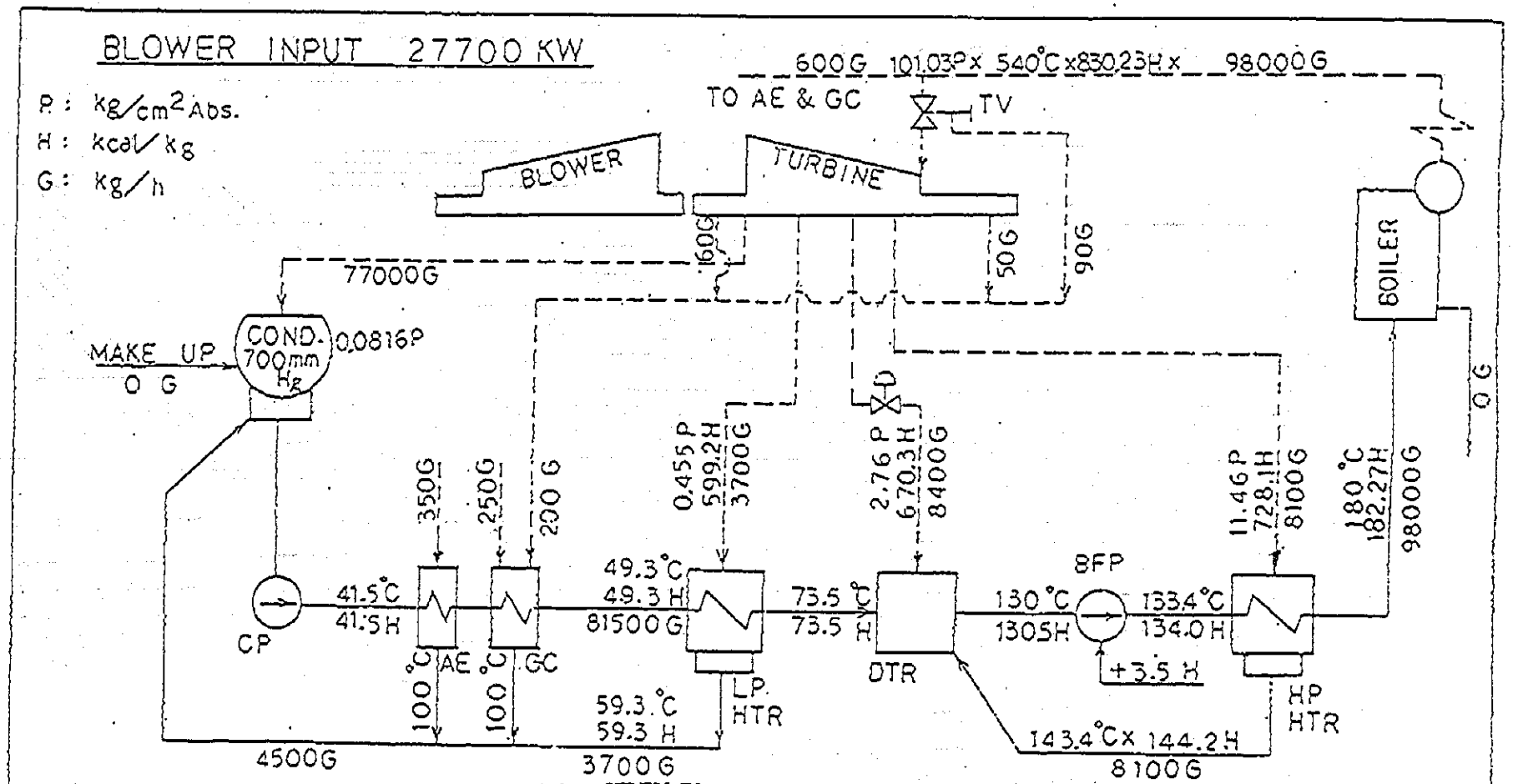
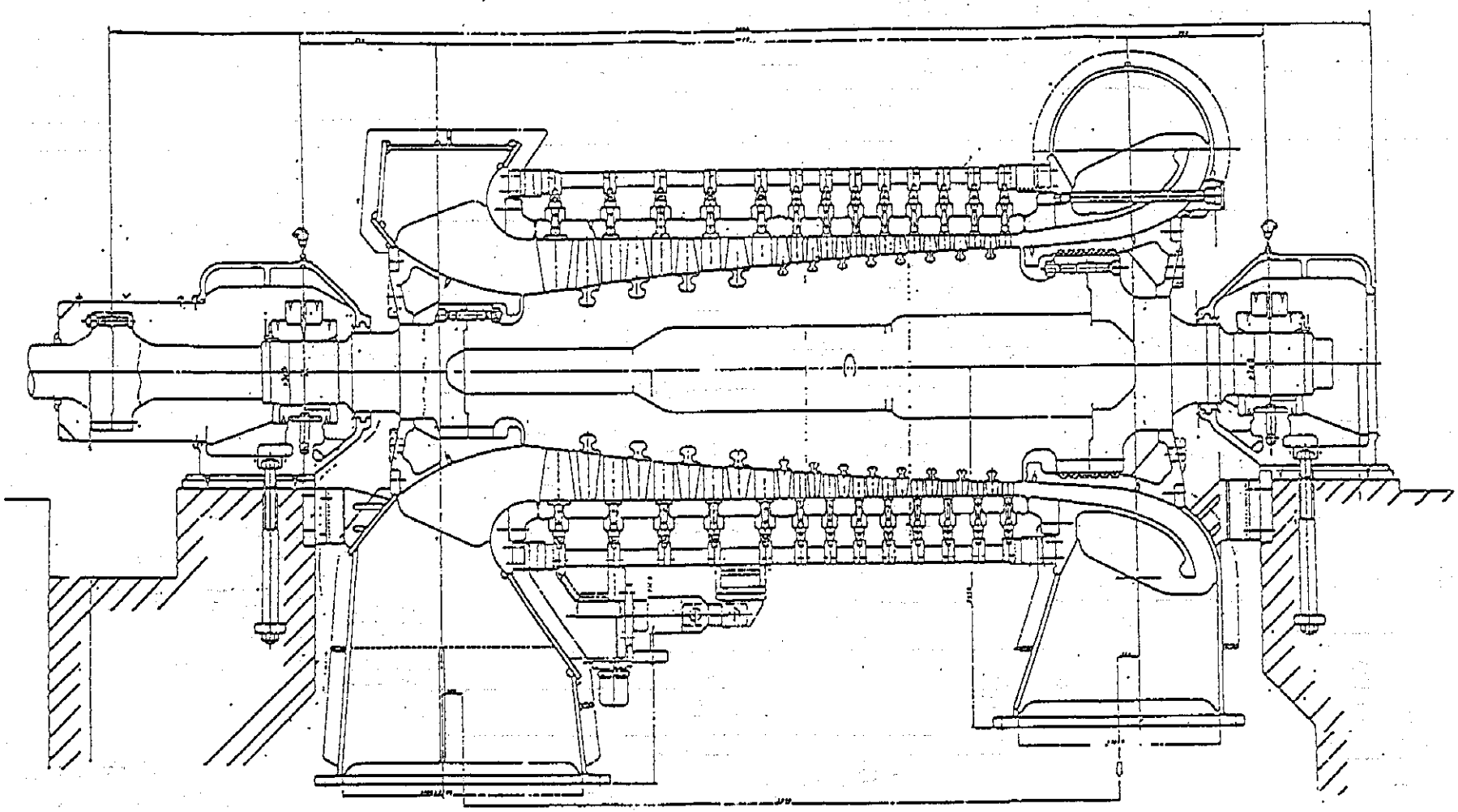


Fig.IV.5-5. SIDEX Blower heat balance diagram

				MITSUBISHI HEAVY INDUSTRIES, LTD. TAKASAGO MACHINERY WORKS	PROJECT
9th. 1994	ORIGINAL ISSUE	K.O	T.N	㐂神戸製鋼所／ルーマニア 高炉送風機用タービン	27700 KW STEAM TURBINE HEAT BALANCE DIAGRAM	SHEET TH-2387



FOR REFERENCE

Fig.IV.5-6. SIDEX Blower drawing for No.6 Blast furnace

FOR REFERENCE

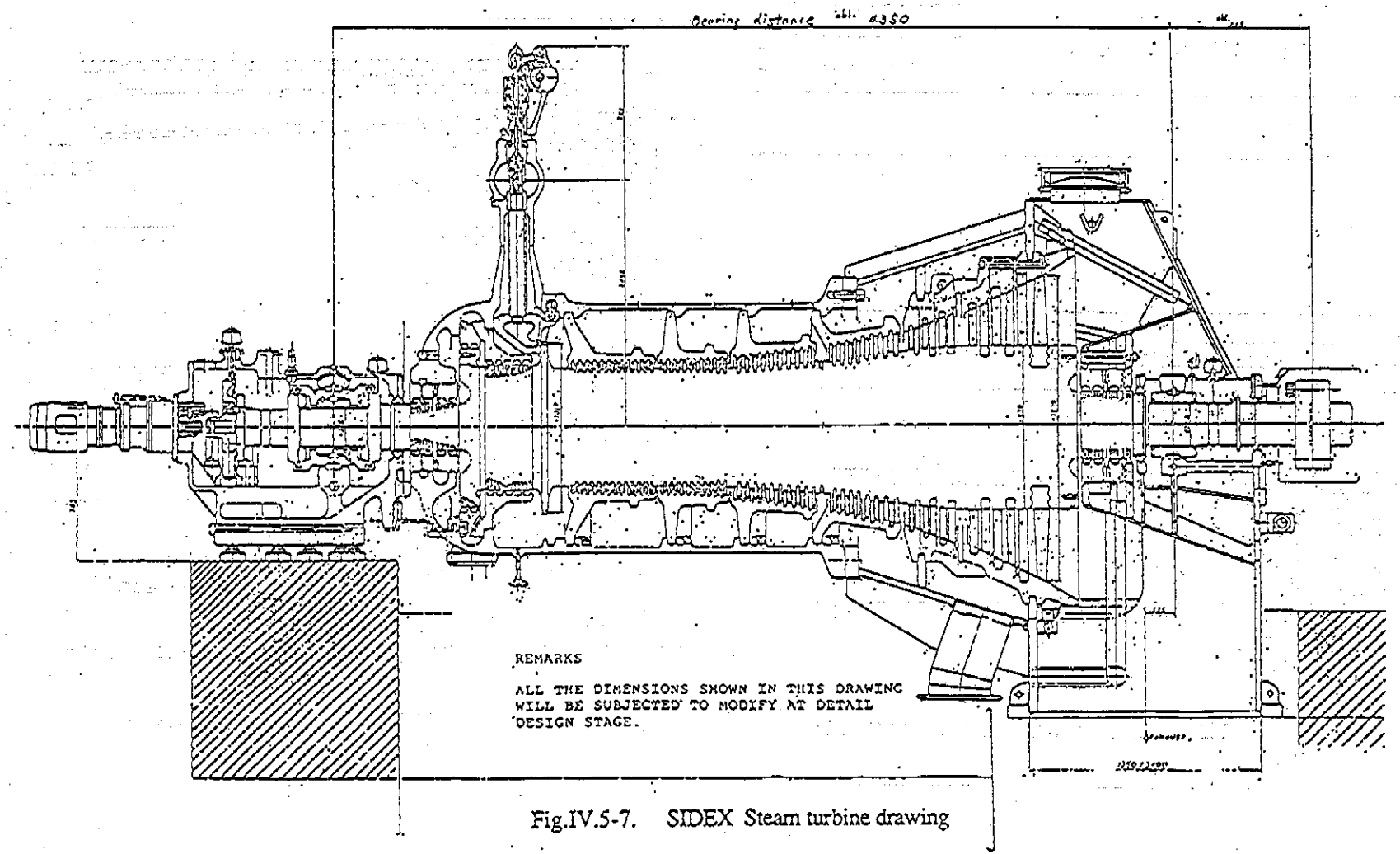


Fig.IV.5-7. SIDEX Steam turbine drawing

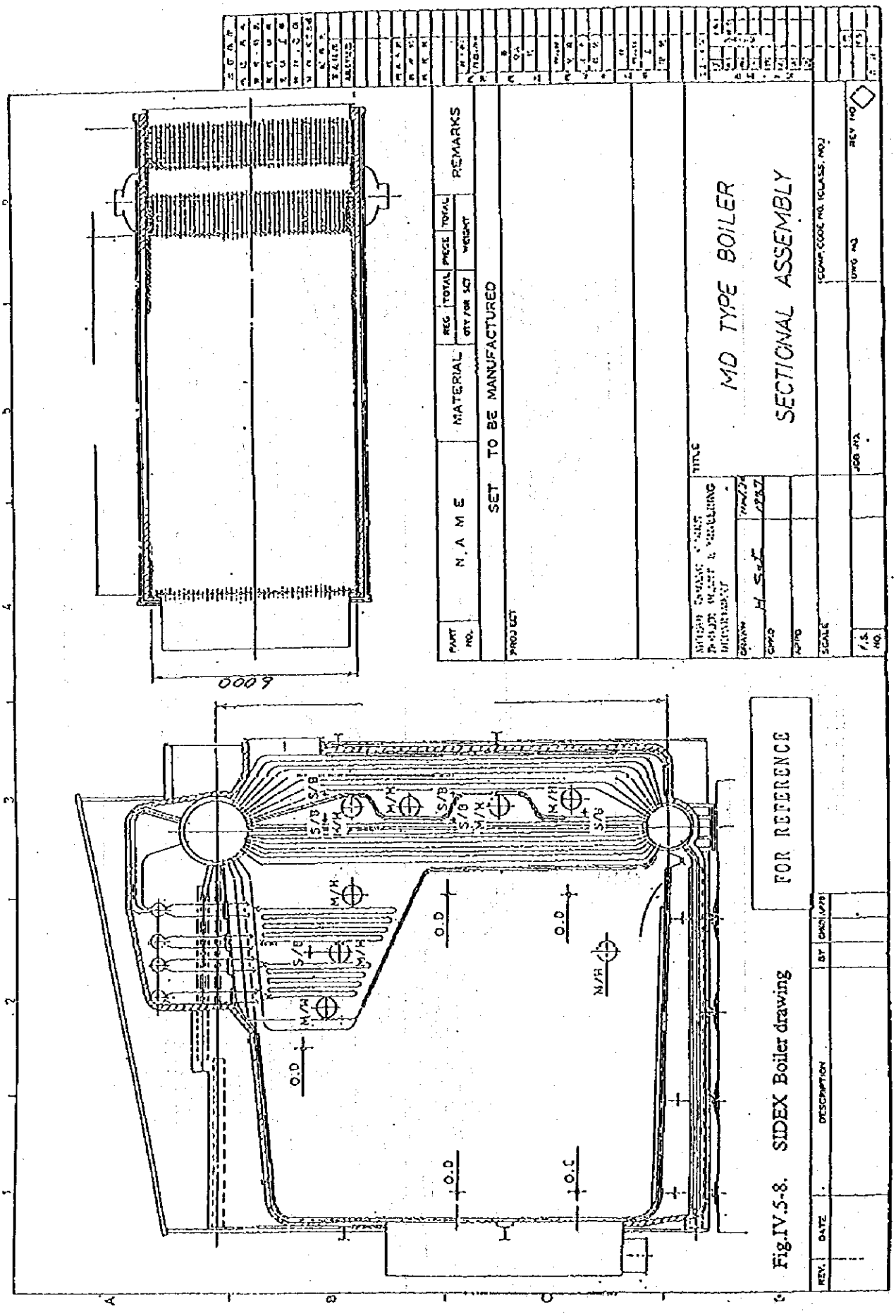


Fig.IV.5-8. SIDEX Boiler drawing

6. IMPROVING MEASURES WITH TECHNICAL TRANSFER

In Chapter II describing measures for energy saving, facilities without investment, that can save energy under only operation assistance, are classified. Besides, Table IV. 6-1 shows two plants, that need the technical assistance especially from other countries.

The effects of energy saving mentioned here is on condition that technology is 100 % transferred to the assisted party. As to the period of technical transfer, the mentioned values are indicated for experienced motivated persons with good knowledge.

Table IV.6-1 Technical transfer items by Operation assistance from outside

Name of Plant	Items of technical transfer	Expected effects for energy saving	Expected period for technical transfer
No.5 COB	(1) Reduction of fuel unit consumption by enhanced operation control and combustion control (2) Reduction of dust generating in extracting material from and charging into the furnace. (3) Reduction of troubles/accidents by improved repair method	Reduction of 35 Mcal/t-coal △COG = 6.88 x 10^6 Nm^3/y	6.2 Man-month
No.6 BF	(1) Reduction of BF fuel ratio owing to optimization of distributions of materials and gas in the furnace	Reduction of coke ratio 41 kg/t △Coke = 110,987 t/y	5 Man-month

7. INVESTIGATION OF APPLICABILITY OF MODEL PLANT MEASURES TO RELATED PLANTS

With regard to the aforesaid measures taken to the model plants, whether the measures are applicable to other plants (i.e. coke oven incl. CDQ, coke chemical plant, sintering plant, blast furnace), how the measures should be modified providing it is applicable and how much effects can be expected, and so on are investigated. As a result, the followings are obtained.

7.1 Coke oven (incl. CDQ) and coke chemical plant

Based on the operation plan in year 2002, the following plants are selected as subjects of investigation for the applicability of model plant measures.

	Model plant	Subject of investigation for applicability
Coke oven	No.5	No. 6, No.7
CDQ	No.2	No.3
Coke chemical plant	No.1	No.2

Table IV. 7-1 shows the results of applicability of model plant measures and of the effects when applied. No.2 coke chemical plant (for No.7 coke oven) differs very much from the model plant, and desulfurization facilities and sulfuric acid facilities should be renewed.

Table IV.7-1. Investigation results for applying the model plant measures to related coke plants

Item No.	Subjects	For energy saving	For environ. protection	Plants	Outline of measures for related plants			
					Measures	Main spec. of measures	Estimated effect	
111	Increase of amounts of recovery crude light oil	○		No.2 Coke chemical plant	The similar gas chromatography to No.1 Coke chemical plant is installed.	Gas chromatography 1 set and construction work	BTX recovery	+2,467 t/y
121	Exchange of kind of fuel	○		No.6 COB	As to No.7 COB, dual fuel can be used and BFG piping and gas mixer are already equipped.		COG	-7,700 Mcal/y
131	Application of automatic combustion system	○	○	No.6 & 7 COBs	The similar combustion system to No.5 COB is applied.		COG	-63,100 Mcal/y
141	Replace with a new CDQ	○		No.3 CDQ	A large-size CDQ, similar to No.2 CDQ, and a coke bucket car are newly installed.	CDQ : 100 t/h, 1 set and bucket car, 1 set	Recovery steam	+255.4 kt/y
151	Replace of pumps for injection of high pressure ammonia liquor		○	No.6 & 7 COBs	Pumps with similar spec. to No.5 COB are applied.	Capacity : 30 t/h, Pressure : 40 kg/cm2		
152	Improvement of ascension pipe sealing		○	No.6 & 7 COBs	The similar improvement (from mechanical seal to water seal) is applied.	For No.6 : Same as No.5, For No.7 : Single main		
161	Installation of dust collector		○	No.7 COB	The similar guide car and dust collector to No.5 COB are installed. (Dust collector is common to coke discharge and CDQ.)	Bag filter : 4,000 m3/min, 1 set and guide car : 1 set	Increased energy (Electricity)	+3,822 MWh/y
171	Improvement of activated sludge process		○	No.2 Coke chemical plant	The similar modification is applied.	Wastewater : 67 m3/h	Increased energy (Electricity)	+4,292 MWh/y
181	pH control of ammonia liquor		○	No.2 Coke chemical plant	The similar control system is applied.	Same as that for No.1 Coke chemical plant		
191	Desulfurization of COG		○	No.2 Coke chemical plant	Desulfurization system with FUMAKS-RODACS process is installed.	Capacity : 51,000 Nm3/h COG and H2S : from 5 to 0.05 g/Nm3	Increased energy (COG)	+2,453 kNm3/y
192	Installation of sulfuric acid plant		○	No.2 Coke chemical plant	Sulfuric acid plant with COMPACS process is installed.		(Electricity)	+6,377 MWh/y
193	Installation of new precipitator		○	No.2 Coke chemical plant	The similar facility to No.1 Coke chemical plant is installed.	Wastewater : 134 m3/h		