vii. S-2-A

Total No. of tubes : 1857

No. of tubes plugged : 117

% plugged : 6.3

viii. S-2-B

Total No. of tubes : 1857

No. of tubes plugged : 118

% plugged : 6.35

(g) Boiler Feed Pump

A minimum flow line to the deaerator is installed in common to T-BFP and M-BFP. This causes difficulty of repairing works. Therefore, this minimumflow line should be provided for T-BFP and M-BFP individually with orifice.

Since sticking of turning gear was experienced at T-BFP start-up, thorough inspection should be given at coming overhaul.

VISUAL INSPECTION, CLEANING UP AND INSPECTION FOR MAIN CONDENSER

1. Visual Inspection

Water box of main condenser should be inspected immediately after opening the manhole. The inspection items are as follows:

(1) Degree and location of contamination

(2) Kind and amounts of foreign matter

(3) Condition of lining

The inspeciton must be done at the presence of mechanical, electrical and chemical staff. The picture must be taken at the notable location.

2. Cleaning-up Inside Tube

Inside of the tube is now cleaned with rubber piece. This method is not so effective for cleaning inside, because the clearance between the tube and the piece is large. The use of brush is recommended for cleaning the tube internal.

3. Eddy Current Test

Actual testing procedure being carried out is not satisfactory. The following items should be done to make the test reliable:

(1) Adjust accurately the instrument

(2) Write number of the tube on the chart and put mark on the tube.

INSPECTION PROCEDURE OF CONDENSER TUBE LEAK

1. Preparation

The following equipment and materials should be prepared before works.

(1) Enough quantity of scaffolding materials in order to reach by hand the upper tubes.

(2) Safety portable lighting fixture

(3) Two (2) sets of big capacity fan for ventilation

(4) Washing equipment for water chamber

(5) Cork plugs for temporarily plugging (500 - 1000 ea)

(6) Powder soap

(7) Temporary telephone

(8) Two (2) sets of drawing of condenser tube arrangement

2. Inspection

Engineer in charge should direct the works, confirm activity maintain the schedule and should be a witness for major activities.

(1) To confirm complete draining of water chamber before carrying out inspection.

(2) Cut off the power source of cathodic protection.

(3) Cut off the power source of condenser back-wash valves and cross over valves motor

(4) Open the man-holes (Lower and upper, both front and rear sides, total of four (4) sets)

(5) Wash the water chamber while cooling by fan.

(6) Plug the tubes every section, each 500 pcs. to 1000 pcs., in order.(plugging should be done slightly so that after inspection, plugs can be removed.)

(7) Spray the liquid soap at the opposite side of plugged tube while contacting with the telephone in order to confirm the plugged section.

(8) If there is a tube sucking bubbles, contact the person at the other side by telephone and plug it.

(9) Carry out the procedure as mentioned above, section by section of the condenser tubes.

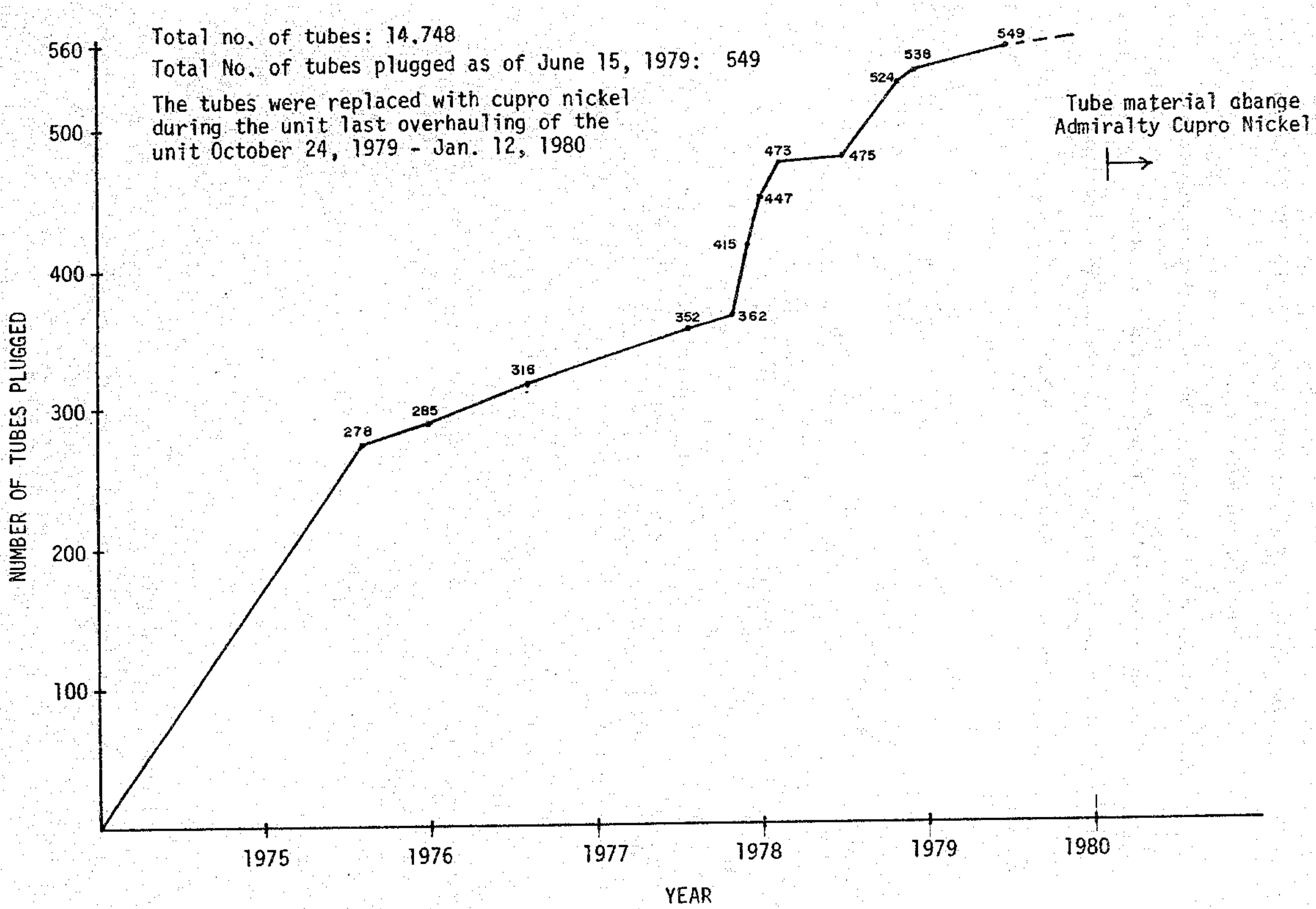


Fig. 5M-1 G-1 MAIN CONDENSER

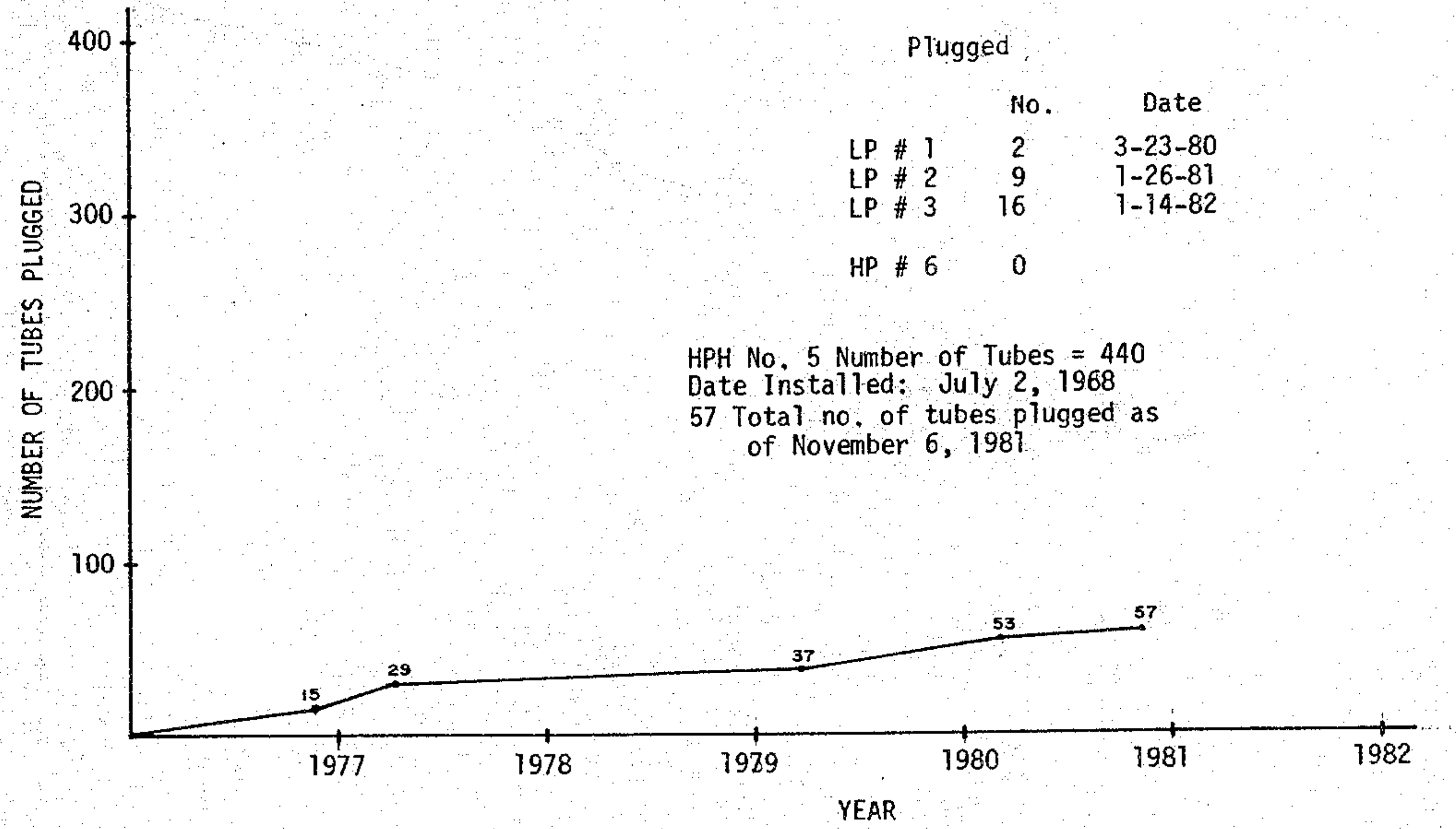


Fig. 5M-2 G-1 HIGH PRESSURE HEATER No. 5

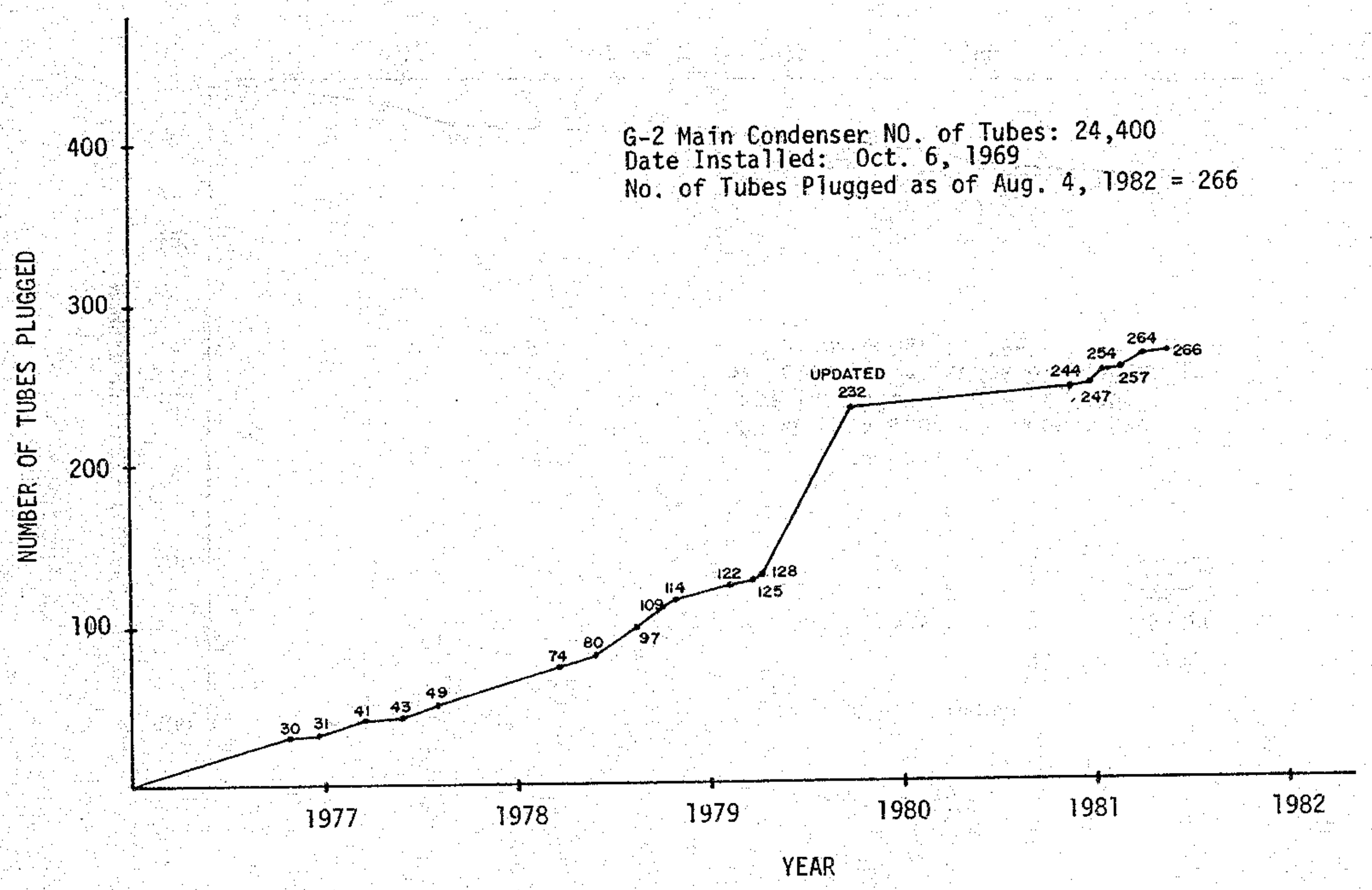


Fig. 5M-3 G-2 MAIN CONDENSER

Plugging

	No.
LP # 1	0
LP # 2	3

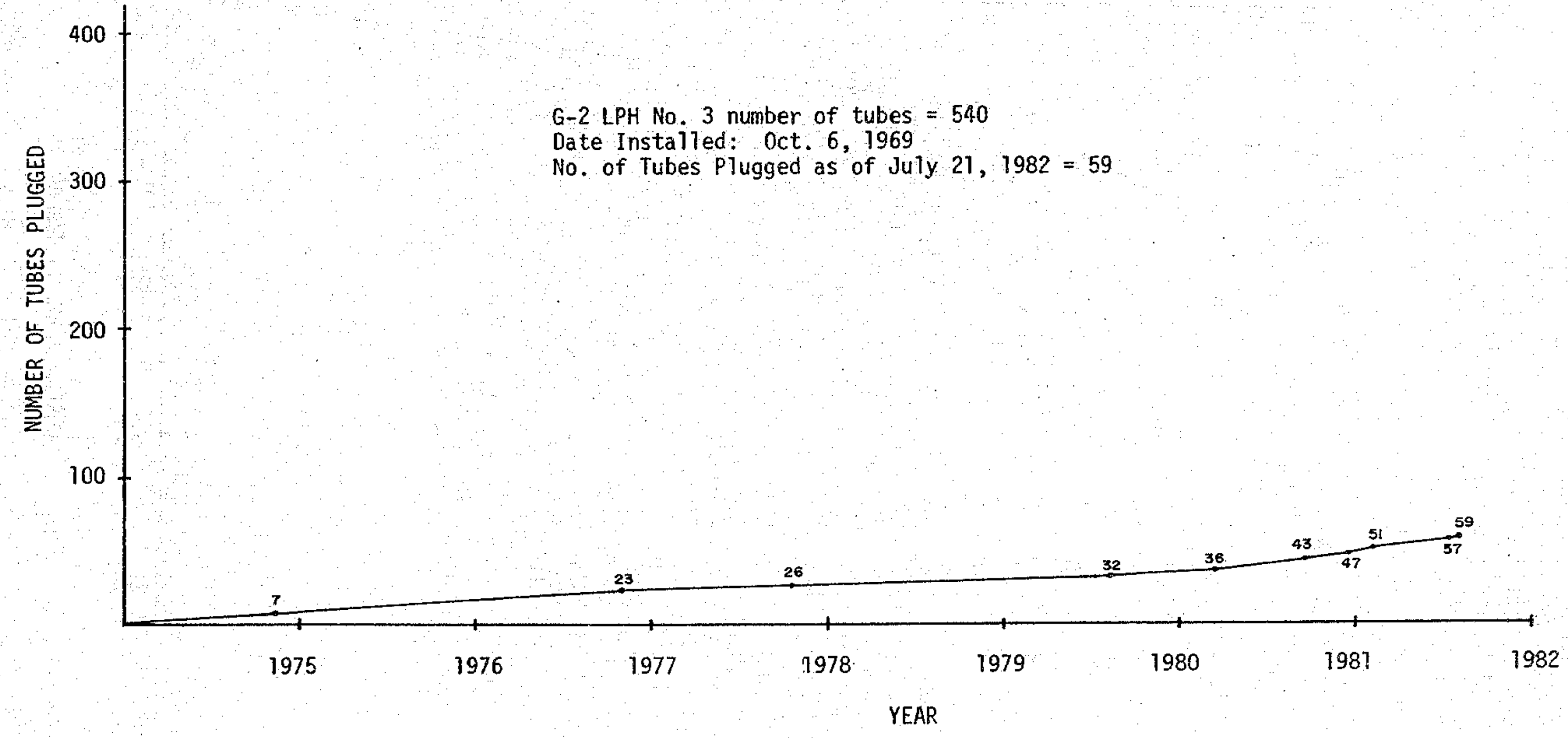


Fig. 5M-4 G-2 LOW PRESSURE HEATER No. 3

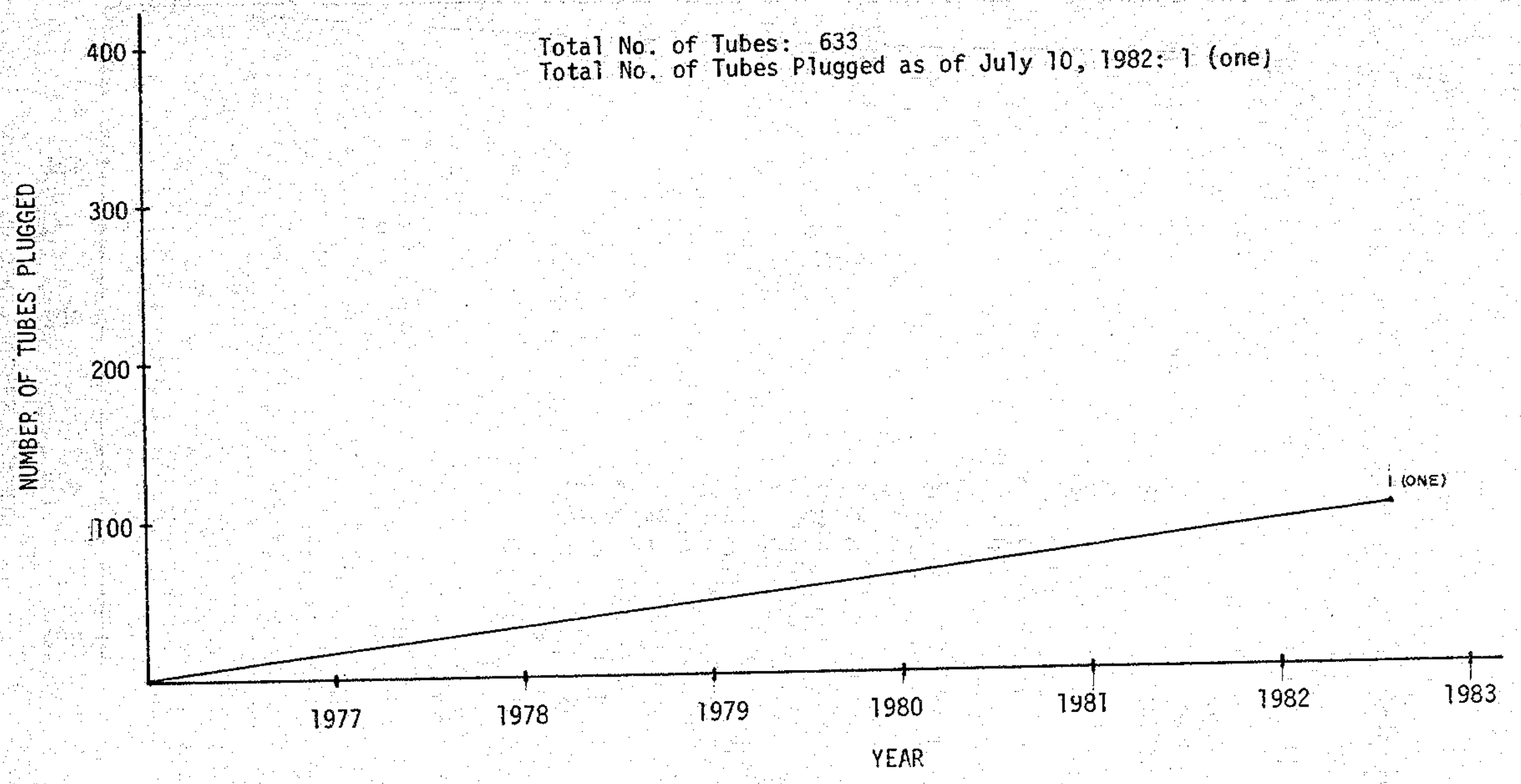


Fig. 5M-5 G-2 HIGH PRESSURE HEATER NO. 5A

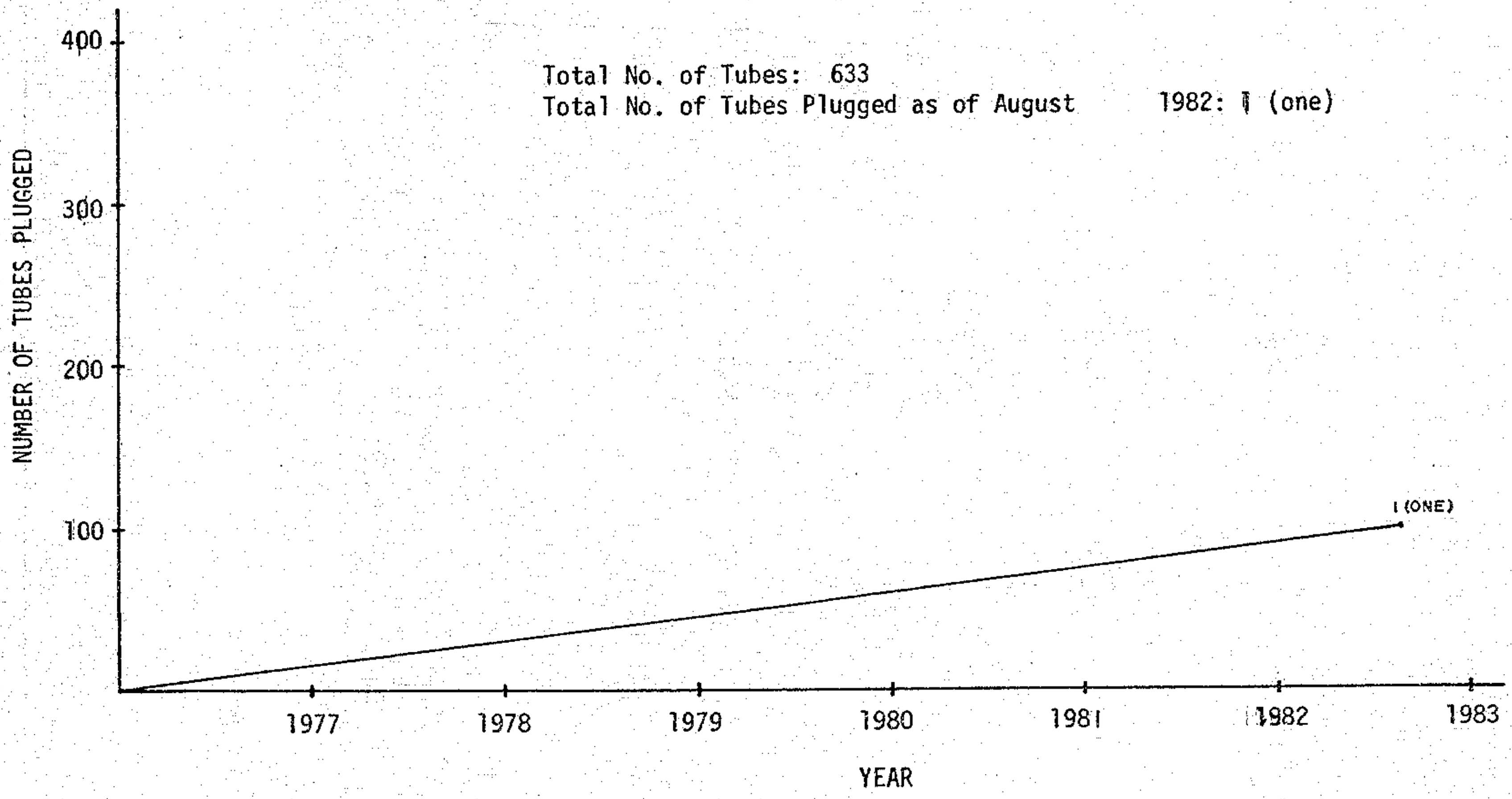


Fig. 5M-6 G-2 HIGH PRESSURE HEATER NO. 5B

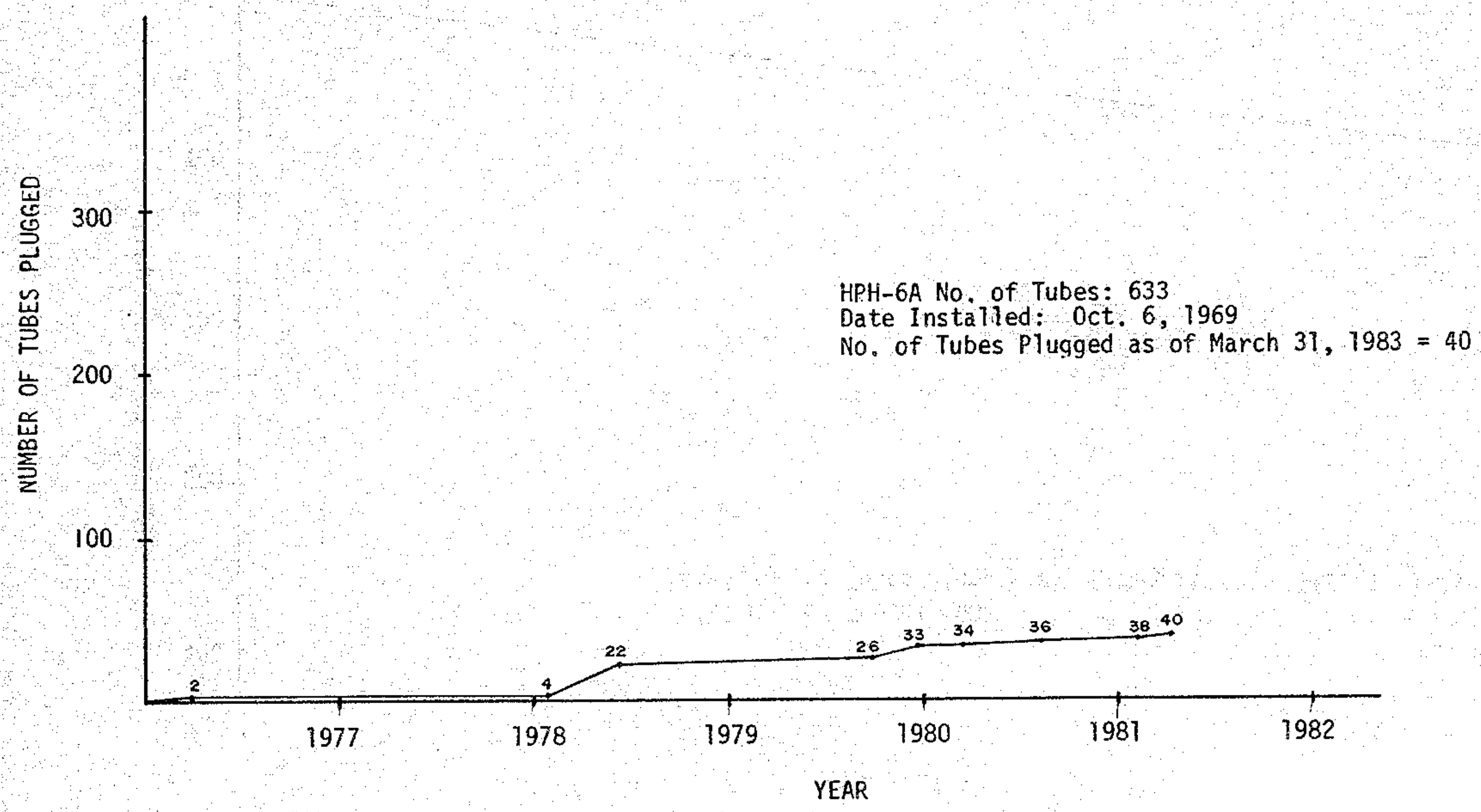


Fig. 5M-7 G-2 HIGH PRESSURE HEATER NO. 6A

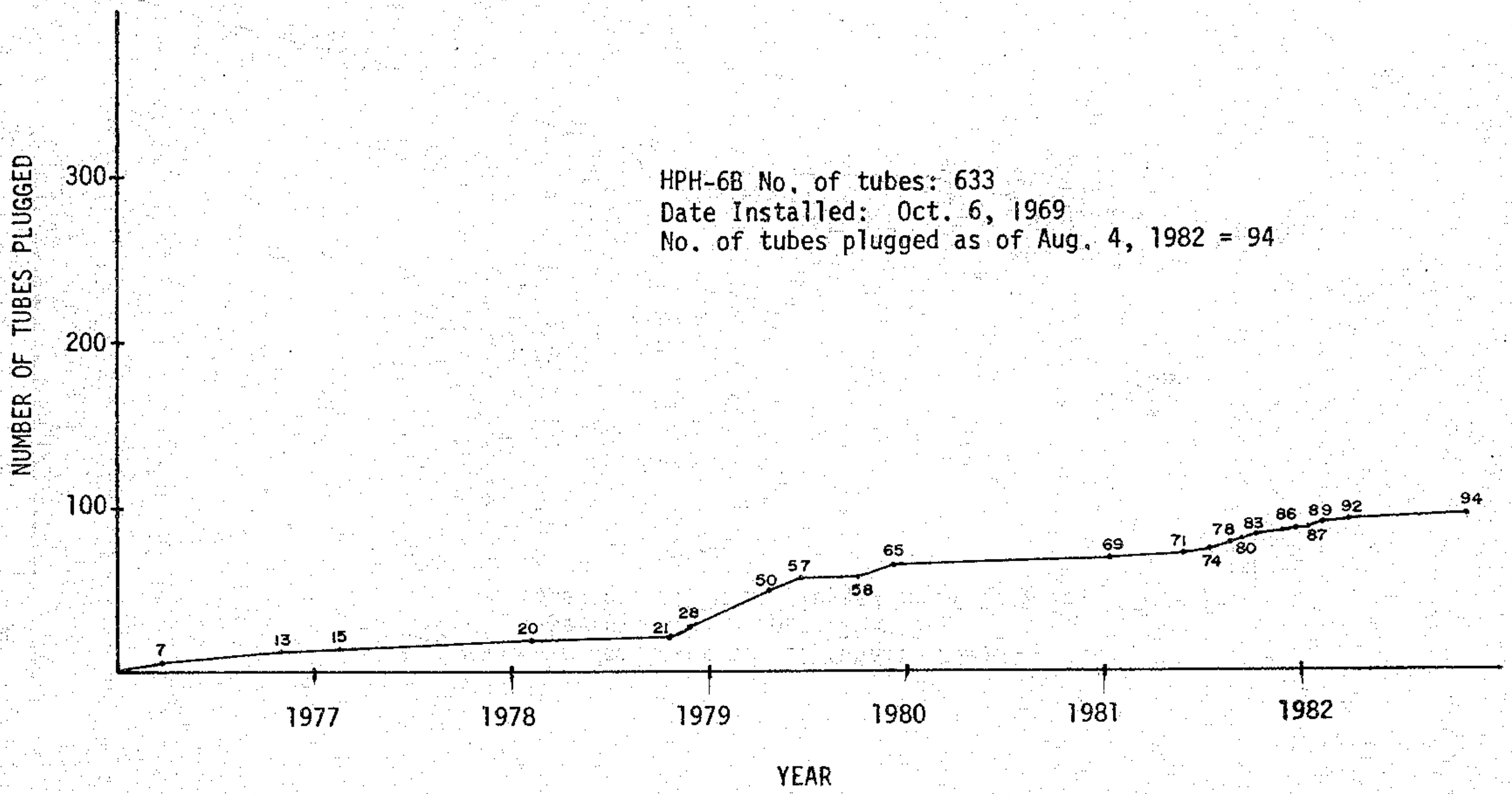


Fig. 5M-8 G-2 HIGH PRESSURE HEATER NO. 6B

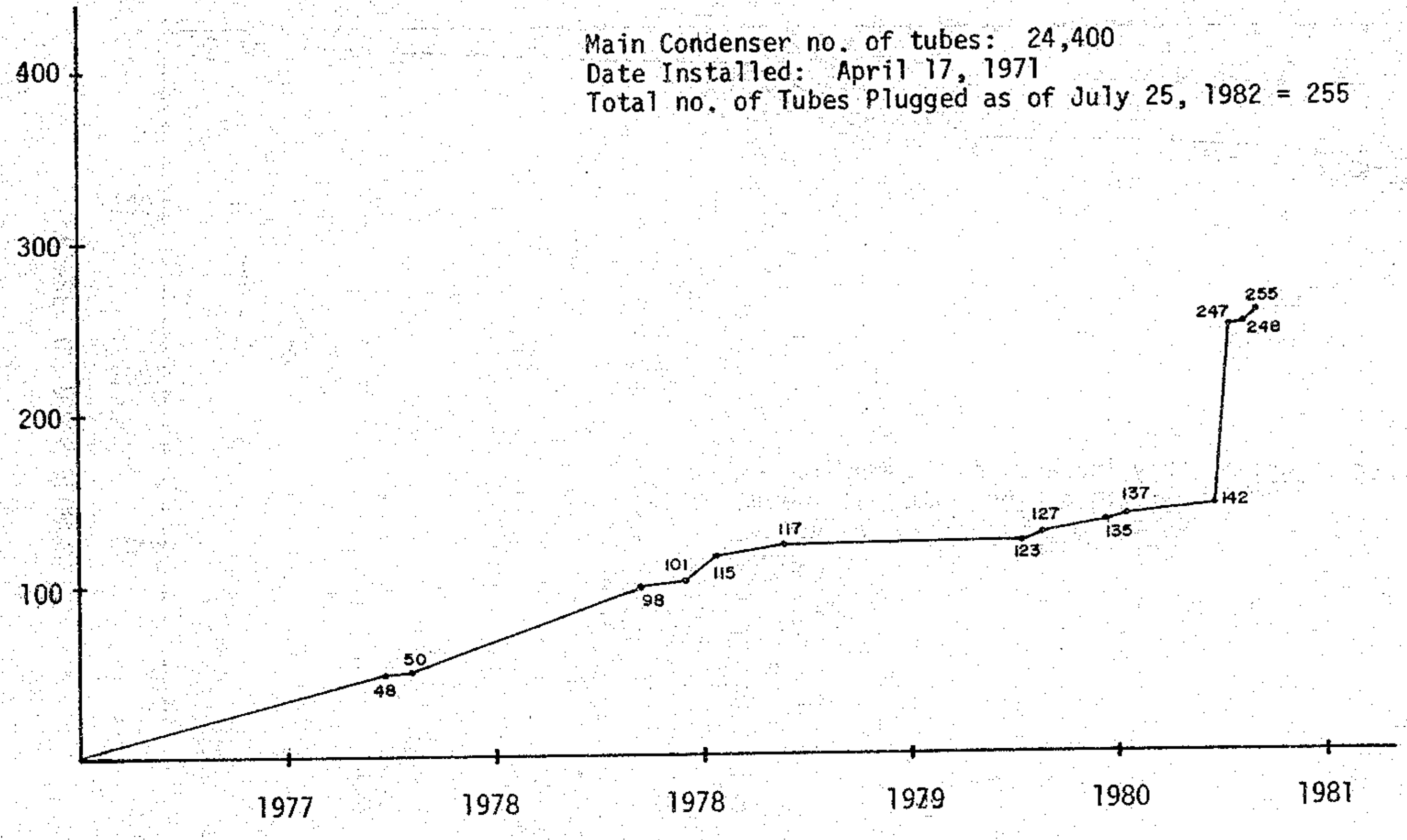


Fig. 5M-9 S-1 MAIN CONDENSER

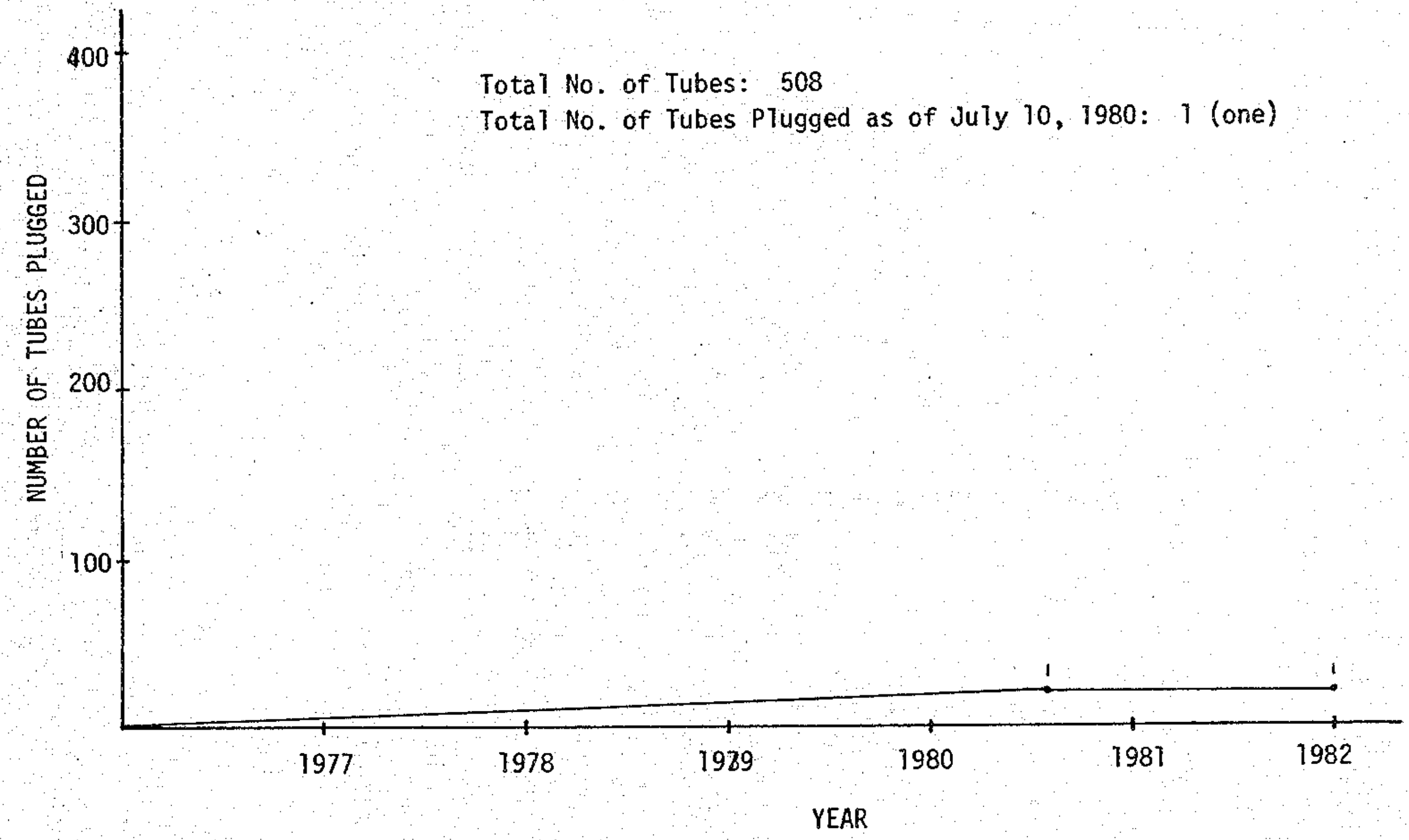


Fig. 5M-10 S-1 LOW PRESSURE HEATER NO. 1

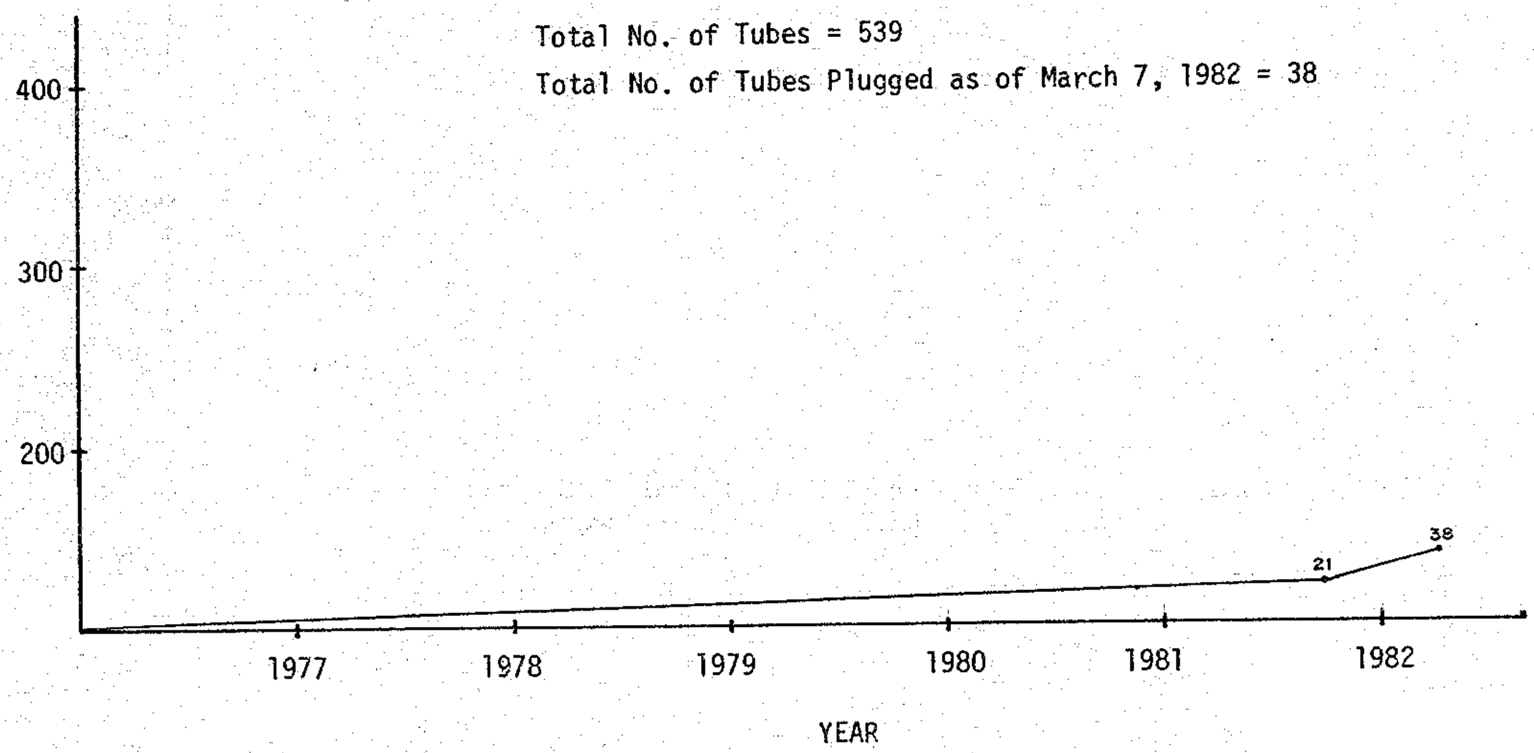


Fig. 5M-11 S-1 LOW PRESSURE HEATER NO. 2

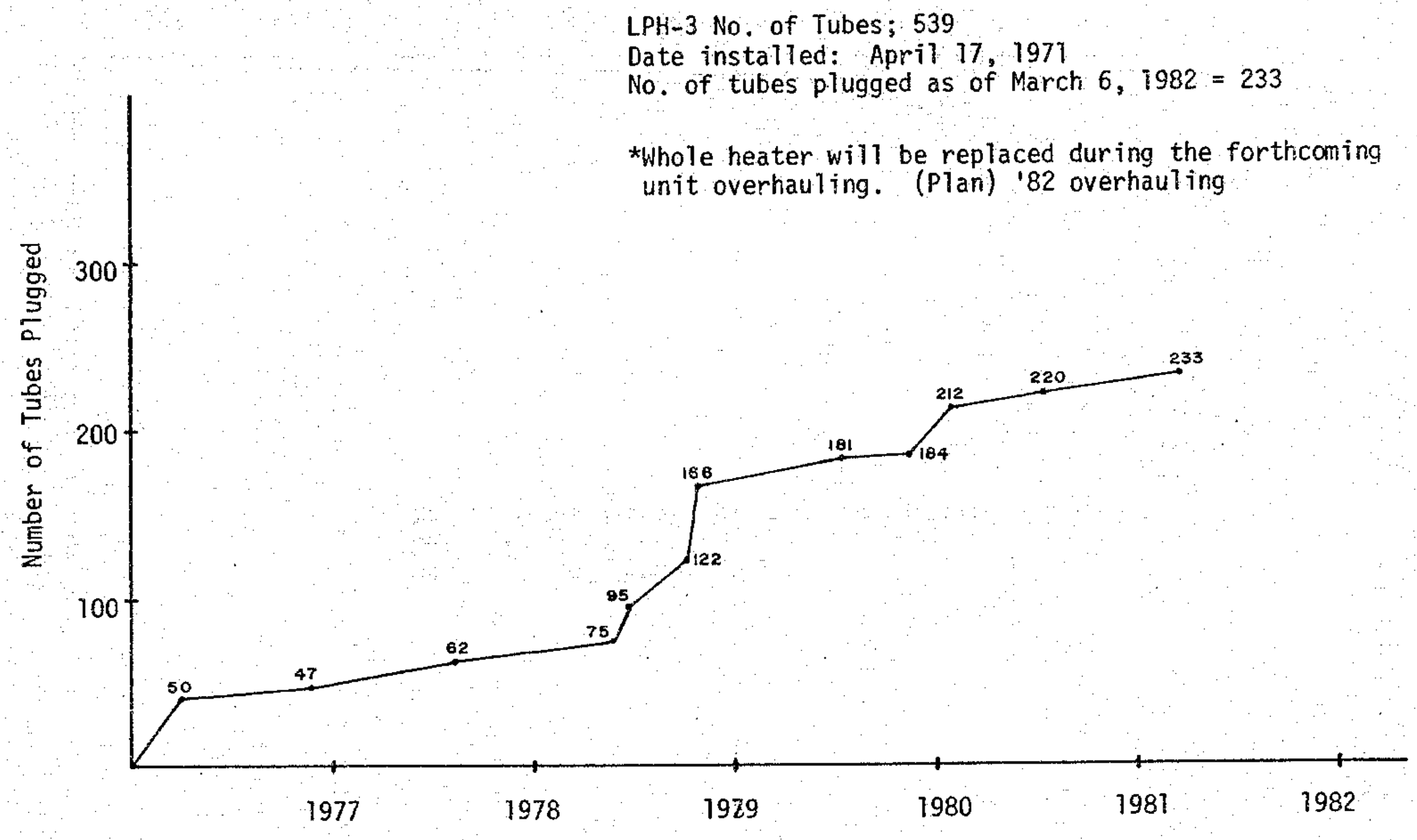


Fig. 5M-12 S-1 LOW PRESSURE HEATER No. 3

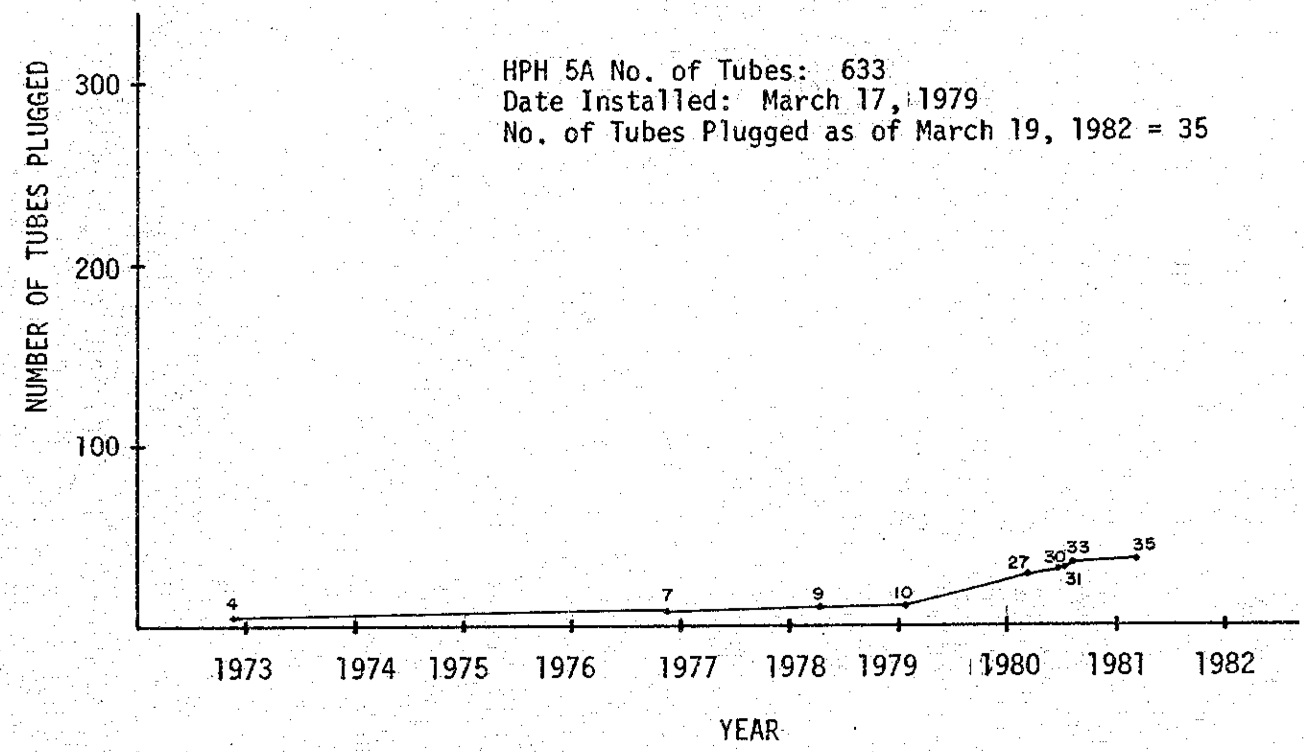


Fig. 5M-13 S-1 HIGH PRESSURE HEATER NO. 5A

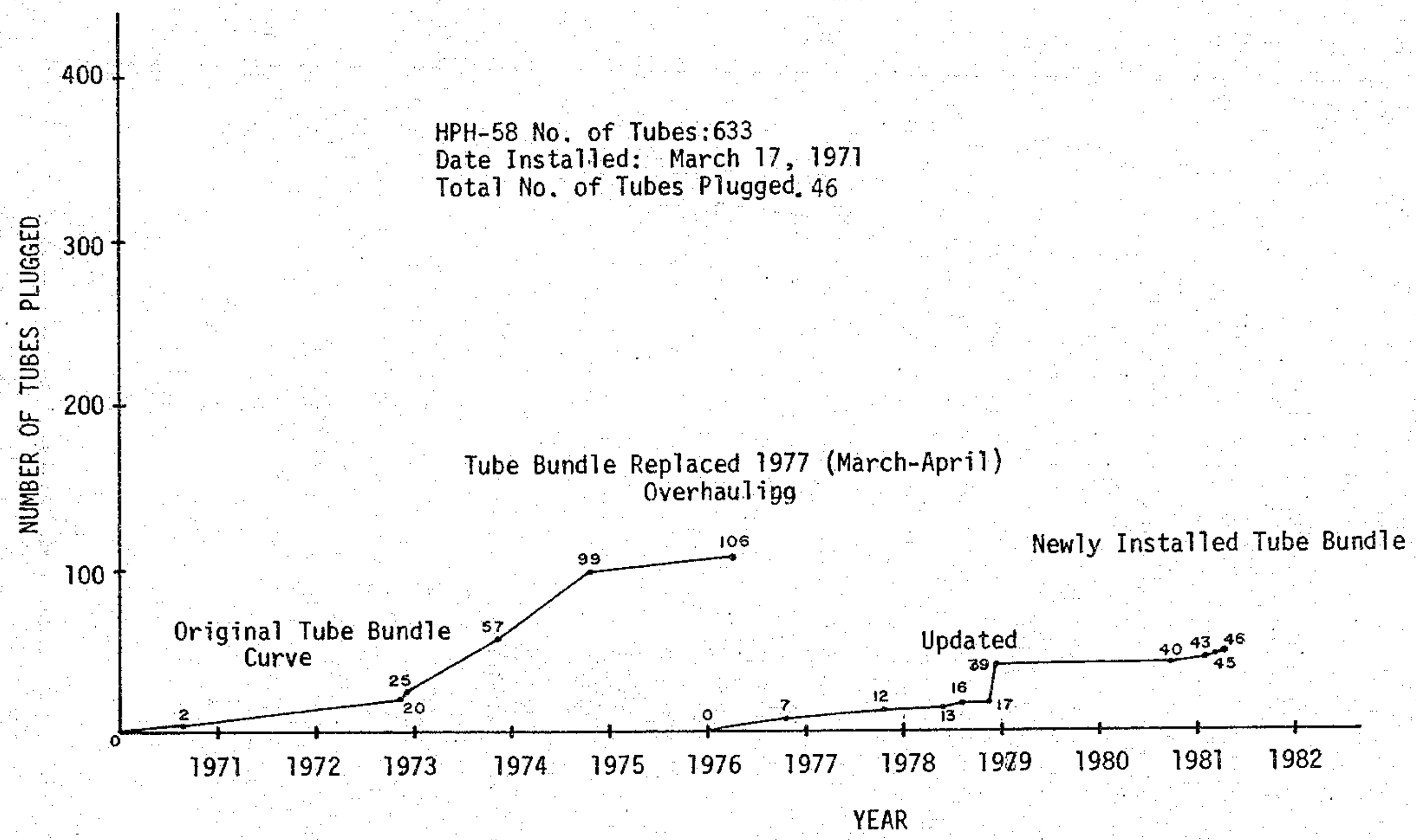


Fig. 5M-14 S-1 HIGH PRESSURE HEATER NO. 5B

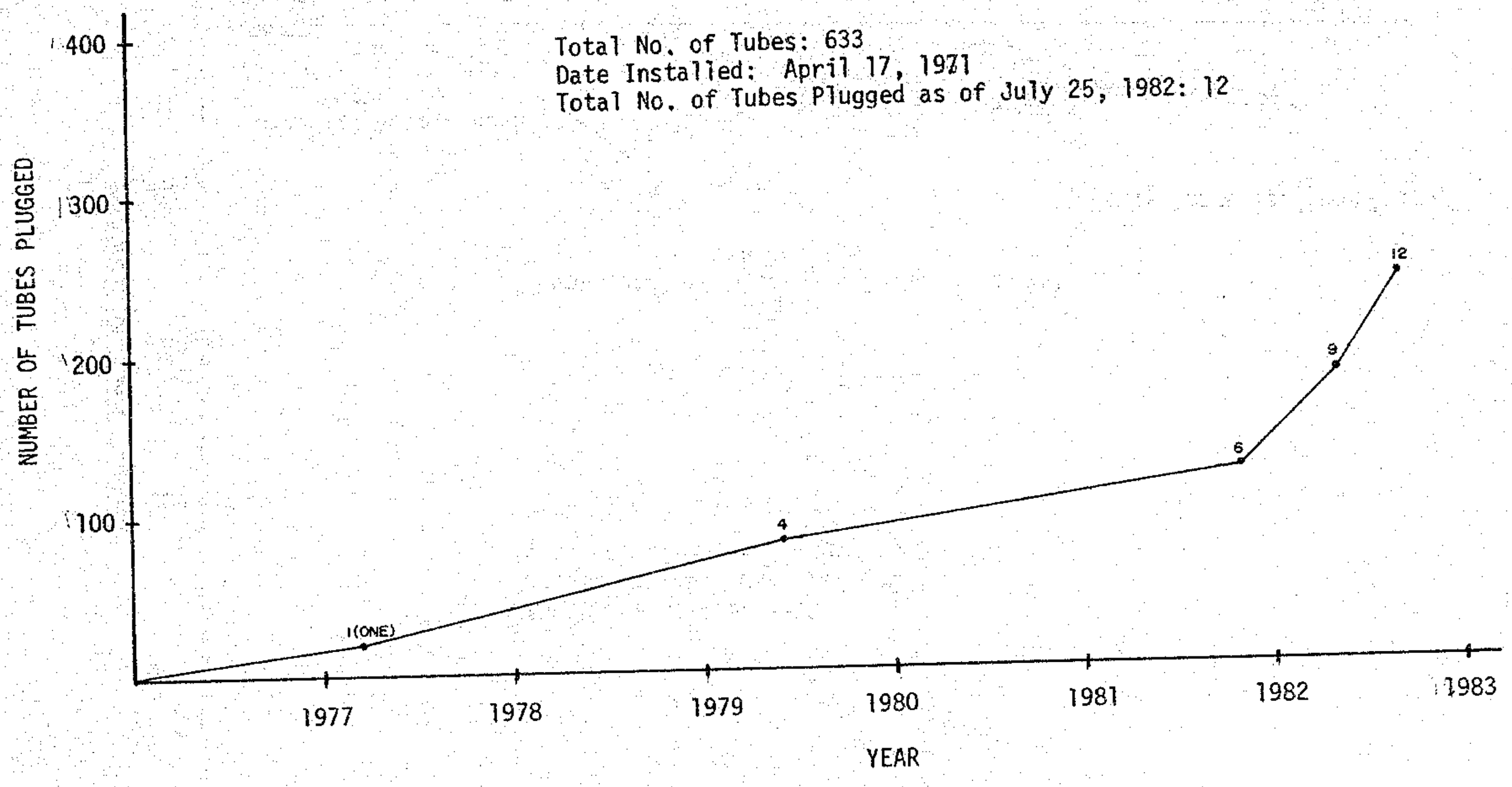


Fig. 5M-15 S-1 HIGH PRESSURE HEATER NO. 6A

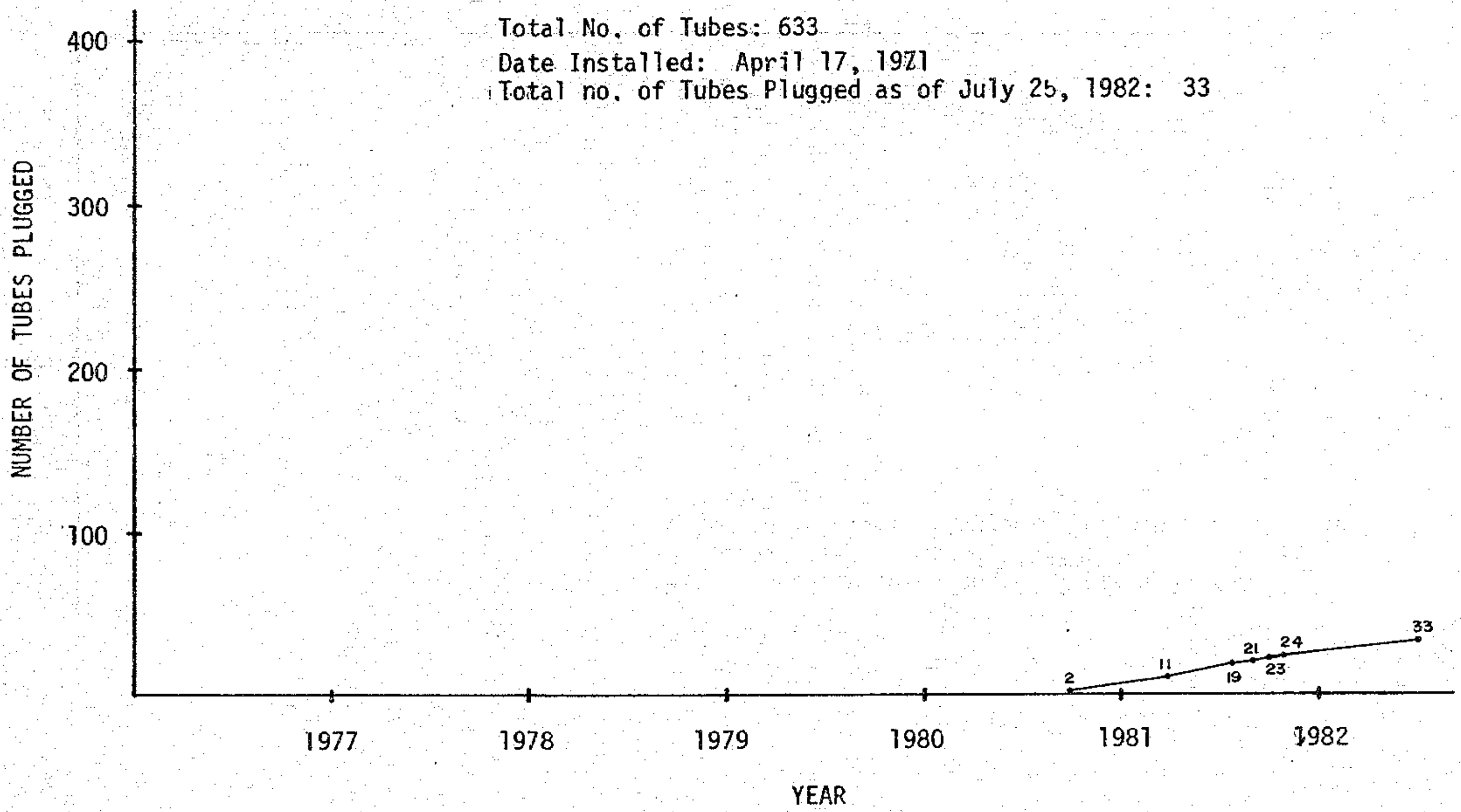


Fig. 5M-16 S-1 HIGH PRESSURE HEATER NO. 6B

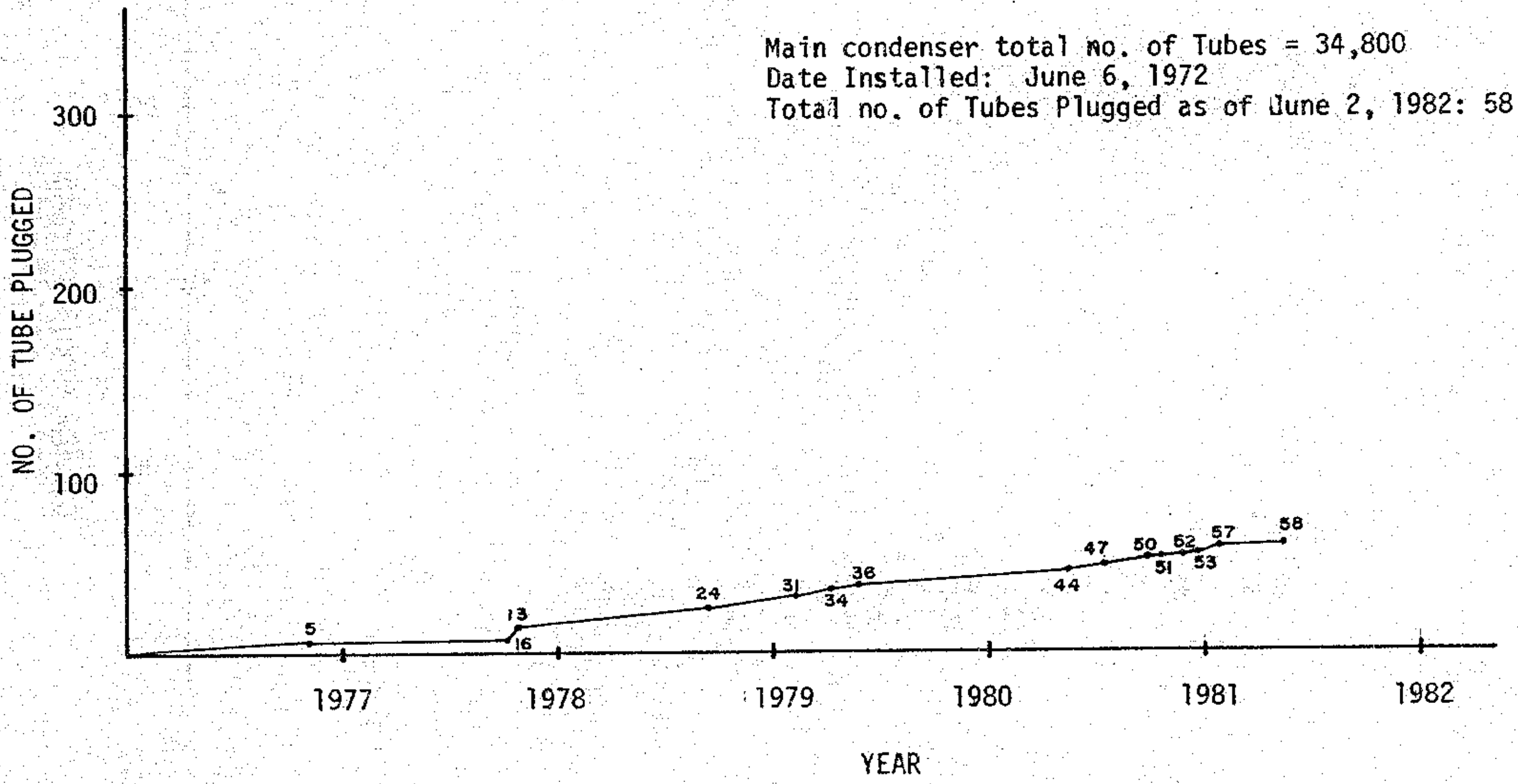
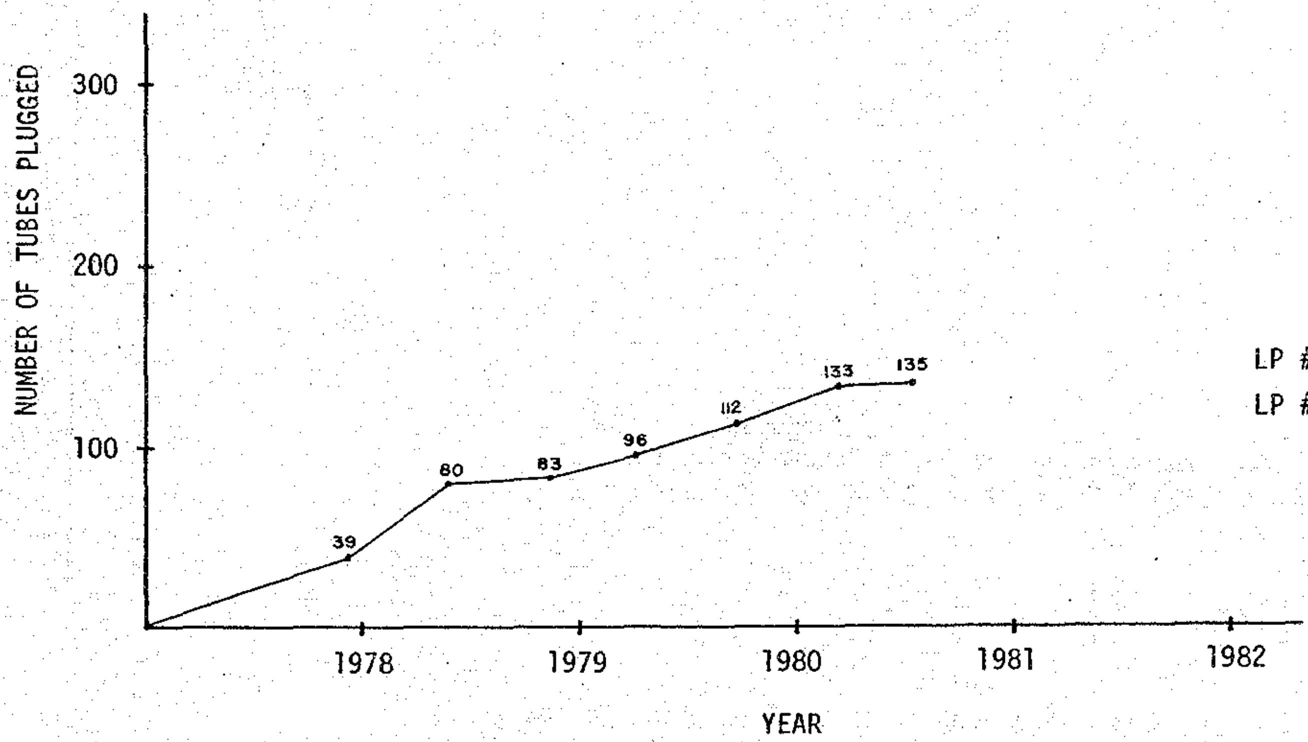


Fig. 5M-17 S-2 MAIN CONDENSER

LPH No. 2 Total number of tubes: 755
Date Installed: June 2, 1972
Total No. of tubes plugged as of July 24, 1981 = 135

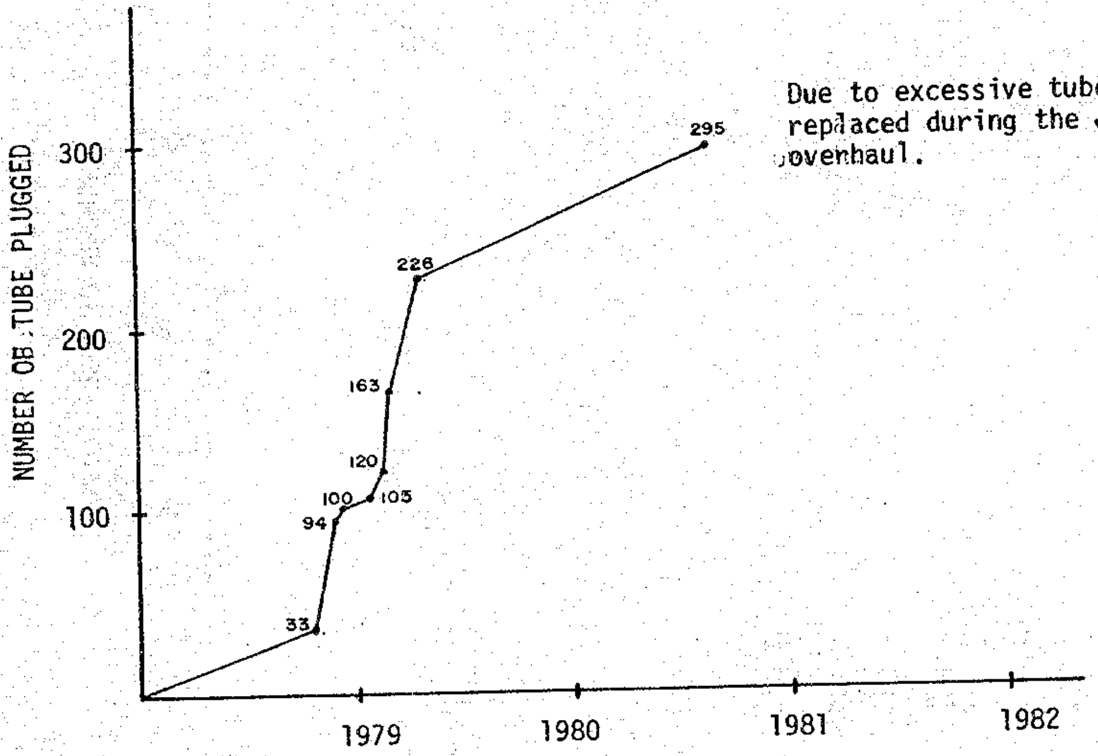


Plagging

	No.	
LP #1	0	
LP # 3	12	5-14-82

Fig. 5M-18 S-2 LOW PRESSURE HEATER No. 2

HPH-5A Total no. of Tubes: 749
Date Installed: June 2, 1972
Total no. of Tubes plugged as of Aug. 27, 1981 = 295



Due to excessive tube leak, whole heater was replaced during the June-August. 1979 Unit overhaul.

Fig. 5M-19 S-2 HIGH PRESSURE HEATER NO. 5A

HPH-5B Total No. of Tubes: 749
Date Installed: June 2, 1972
Total No. of Tubes Plugged as of Aug. 20, 1981 = 123

*Heater was repalced during the unit overhauling
March 1982.

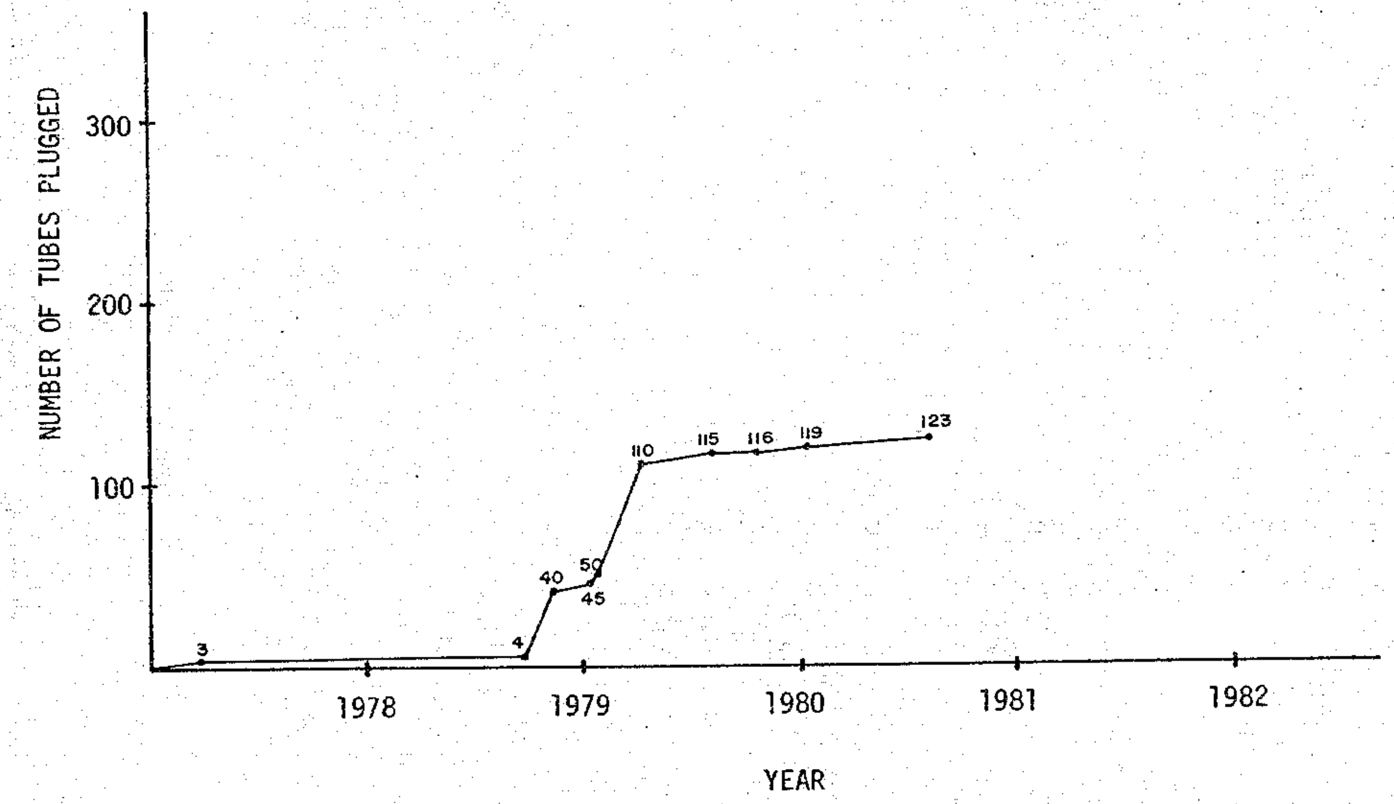


Fig. 5M-20 S-2 HIGH PRESSURE HEATER NO. 5B

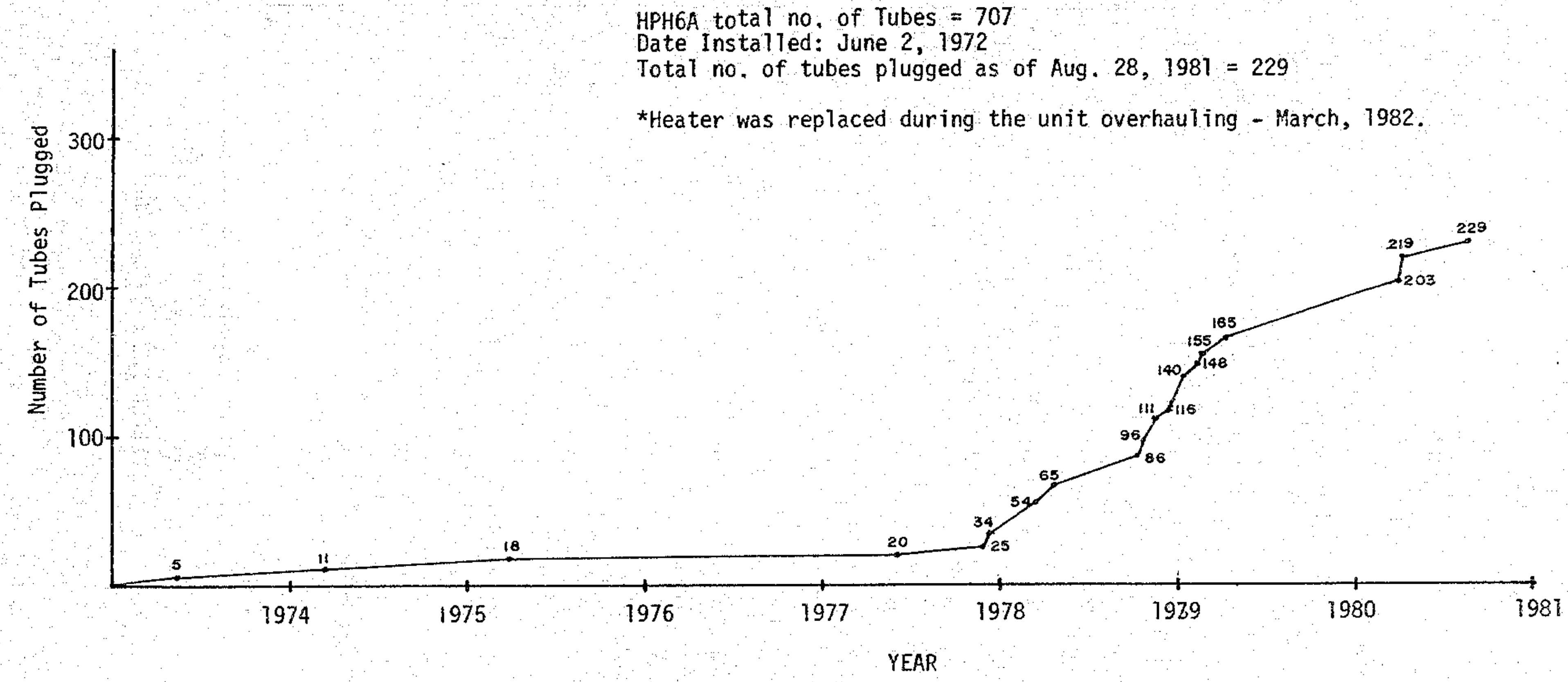


Fig. 5M-21 S-2 HIGH PRESSURE HEATER NO. 6A

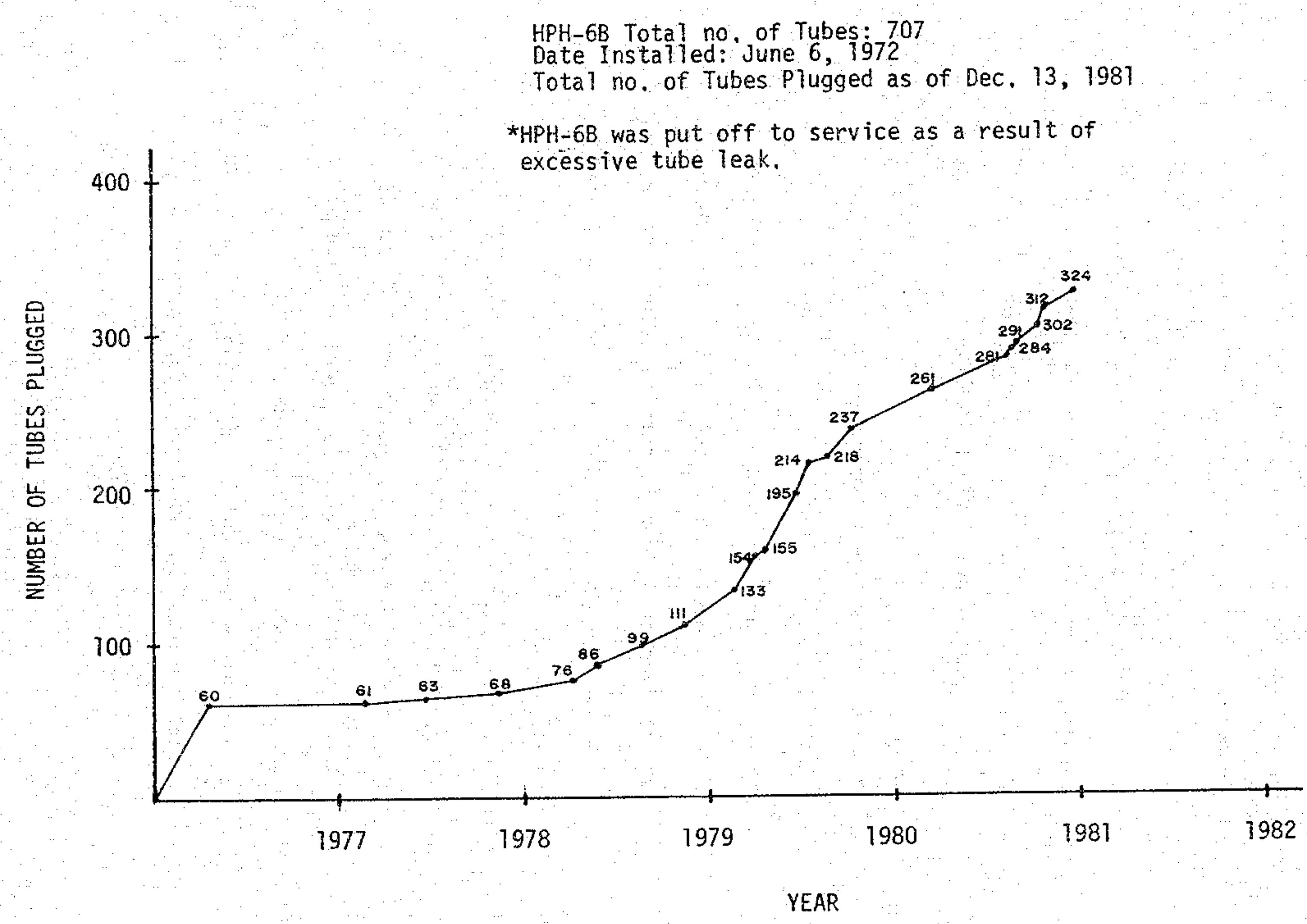


Fig. 5M-22 S-2 HIGH PRESSURE HEATER NO. 6B

e. Generator

(a) Generator Proper

i. KWU reported that hot spot on S-2 generator stator end which was seemed to occur in leading power factor operation was observed during last annul shutdown. Generator is still being operated under the increased H_2 pressure within new capability curve as recommended by KWU.

Detailed report and recommendations are shown in "PROBLEM ON HOT SPOT OF GENERATOR STATOR CORE END".

ii. Generator trips due to reverse power relay actuation were experienced nine times in the past. These trips are supposed to have been caused by defective turbine tripping interlock. Limit switches mounted on main turbine stop valves and auxiliary relays should be thoroughly inspected and adjusted.

iii. There were frequent unit tripping due to over excitation, or loss of excitation which seems to have been initiated by defective AVR pf G-1. Also at present it is operated manually. Defective parts replacement should be made as urgently as possible, and dust-proof type AVR cubicle should be considered for prevention of air entering into the cubicle.

iv. Troubles of generator proper and exciter:

According to the Forced Outage Record, troubles of generator propoer and exciter are as follows:

G-1 Unit

March 9, 1982	Unit shut-down	During overhauling, the generator seal ring at the collector end was found defective

G-2 Unit

September 22,1973	Unit shut-down	Inspection of 14.4 KV IPB
October 25, 1978	Unit shut-down	Repair of excessive hydrogen leak
November 6, 1978	Unit tripped	Failure of main exciter
June 9, 1982	Unit shut-down	Failure of main exciter

S-1 Unit

December 11, 1981	Unit shut-down	Check generator - LP coupling and found mis-aligned, generator H_2 seal ring found damaged.

S-2 Unit

November 5, 1977	Unit shut-down	DC hi-pot test of generator stator

G-2 generator had experienced main exciter failure due to burn out of diodes on June 9, 1982, and check of insulation resistance of exciter has been carried out at every shift. However, earth-fault relay can not detect the trouble unless the resistance becomes less than 1,000 ohm during normal operation. Therefore, insulation resistance should be measured by megger after the unit shut-down and before unit start-up.

(b) Generator protective relays

i. Setting of earth-fault protective relay for generator (64G)

*Earth-fault alarm setting

20V (20/138.5 x 100% = 14.4%)

*Earth-fault trip setting

68V + 0.1 second

68V (68/138.5 x 100% = 49.5%)

Alarm setting is adequate, but it is recommended that the trip setting of 64G should be 30% of perfect earth-fault voltage, plus 5 to 10 minutes timer.

40V + 10 minutes timer

When the ground occurs, operator can take measures to avoid generator trip (plant trip) within ten minutes.

Note: Perfect earth-fault voltage

$$\frac{14,400}{13} \times \frac{240}{14,400} = 138.5V$$

(c) Automatic voltage regulator (G-1, G-2, S-1 & S-2)

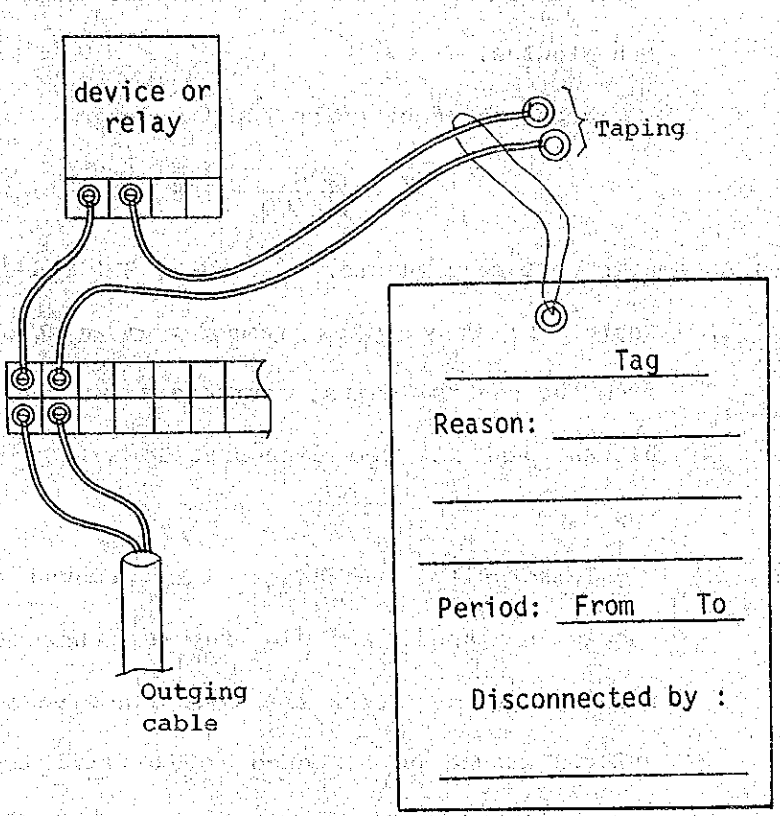
i. There are many wires temporarily disconnected from the control units, contactors and connecting blocks, and all the disconnected wires are not taped.

Temporarily disconnected or removed wiring should be taped, and for future connection or repair, tags on which the reason and period are written should be attached to it until complete repair (Refer to Fig. 5E-1, Tagging System).

ii. Open-type auxiliary relays are mounted on the panel. Seal-in type relays should be used especially in case of dirty, non-ventilated ambient conditions.

iii. Openings for cabling are not filled up with epoxy or fire-proof compound materials. The openings should be filled up with epoxy or fire-proof compounds to prevent from dust entering into the panel.

Fig. 5E-1 TAGGING SYSTEM



PROBLEM ON HOT SPOT OF GENERATOR STATOR CORE END

1. Progress of events

Progress of events studied on basis of documents handed over by NAPOCOR, is as follows:

July 14, 1978

Letter from KWU

A failure of stator coil due to hot spot in the generator stator which was designed similar to Snyder-2 and Malay-1. This hot spot was caused by leading power factor operation.

KWU recommended that hydrogen gas pressure must be increased from 45 psig. of design pressure to 60 psig., and generator load should be maintained within new capability curve on which narrow operating range is indicated.

July 16, 1979

Letter from KWU

KWU pointed out that the above recommendation was being neglected, and strongly recommended to perform the above recommendation.

July 16, 1979

Annex 4 of KWU letter

Parts required for increase of hydrogen gas pressure modification were quoted.

Dec. 11, 1979

Installation of under excitation protection device for Snyder-2 is agreed by KWU and NAPOCOR.

January 29, 1980

Hourly generator operation data was evaluated by KWU as follows:

Snyder-2 data shows no damage which might have occured before the evaluation period.

Malaya-1 data shows that very slight core insulation damage might not be excluded completely. And, KWU strongly recommended that hydrogen pressure for Snyder-2 and Malay-1 must not be dropped below 60 psig. and load must not exceed new characteristic curve.

February - July, 1980

M-1 annual overhaul was carried out.

July 17, 1980

As the result of inspection during annual overhaul KWU reported that hot spot was found at the core end and recommended an increase hydrogen gas pressure operation and limited operation within the new capability curve again.

February - August, 1981

Snyder-2 overhaul was carried out.

April 1, 1981

KWU reported that Snyder-2 also had hot spot and recommended an increase H_2 pressure and limited load operation within the new capability curve.

August 12, 1981

KWU submitted a report on Snyder-2 inspection in which hot spot exceeding that of Malaya-1 was found at the core end . KWU mentioned, it is reasonable to assume that the generator was under-excited on several occasions or operated in the leading power factor range and/or that the H_2 pressure of 45 psig. was not always maintained or the H_2 concentration was below the value specified.

November 8, 1982

NAPOCOR engineer reported to the President that 60 psig. operation was being carried out for Snyder-2 and it will be done as soon as the bigger seal oil pump motor will arrive at M-1.

As for the solution of hot spot problem, there are three alternatives. Alternatives 1 is to replace the generator stator, alternative 2 is to wait failure, then generator will be fixed, and alternative 3 is to replace end cores and coil at site.

As a conclusion, alternative 3 was recommended in view of shorter risk time and lower cost.

February 26, 1982

. Recommendation to perform alternative 3 was submitted with detailed investigation to NAPOCOR President by NAPOCOR Engineer.

September, 1982

There is no activity for hot spot problem.

2. Recommendation

In order to solve the hot spot problem of generator of Snyder-2 and Malay-1, NAPOCOR should have negotiated with KWU and should make question with regard to the following items to KWU in order to find out the first step of solution.

(1) If the hydrogen pressure is maintained at 60 psig., will it be possible to avoid damage of core ends?

(2) Are there any cases that no damage is observed in the same design generator?

(3) KWU is responsible to clarify the cause of over-heat theoretically.

(4) To make question on the new designed generator which may have some modification to solve the overheat problem.

(5) KWU should be requested to submit report regarding the circumstances of repairing works of the same type generator such as number of set already repaired, not repaired and on-going to be repaired, and degree of damage.

Especially, if there is a generator with same degree of overheat as Snyder-2 data of dielectric test of coil, photograph, etc., should be submitted.

(6) KWU should be requested to clarify the scope of replacement, means of replacement of core and coil, and schedule for repairing works in detail.

(7) KWU should be requested to restudy other countermeasures than measures now being taken (H_2 pressure increase, load limit operation within new load curve, under excitation protection), as follows:

a. Restudy on H_2 gas flow and modification of rotor fan, etc.

b. Partial modification on stator core/material and/or coil ends

c. Additional H_2 gas cooler

d. Additional installations of temperature measurement of hot spot

e. Others

(8) KWU should be requested to clarify that the capability curve can be recovered to the original one by partial replacement of coil and core.

f. Control and Instrumentation System

(a) Automatic operation of power plant

At present, only a part of control systems for Gardner-1 unit (Drum type boiler) is operated automatically, but the other parts of the systems can not be operated automatically. This is the present situation of Gardner/Snyder Power Station.

As a result of this survey, the principal cause why they can not be automatically operated can be summarized as follows:

First, Control drive units such as valves, vanes and dampers have lost their controlling functions.

Second, signal transmitters such as temperature, pressure, flow, level, etc. have already lost their signal catching functions, some of them defective, some of them already not installed, not repaired because of unavailability of spare parts.

Third, Power plant facilities proper has many defective parts such as leak, clogging and breakdown, therefore, the control systems are forced to stop automatic operation.

Some recommendations on replacement of the existing control system with new type one.

Replacement of the existing control system is planned by NAPOCOR at present. Taking the present conditions of control systems into consideration, NAPOCOR has a planning of replacement of the existing ABC control and start-up by-pass system control with new type. However, before the execution of replacement, following essential and basic conditions for automatic operation should be considered and arranged without fail.

i. Thorough environmental improvement so as to be suited for the new type

Electronic type control units composed of elements are more easily affected by heat, moisture, gas and chemical materials comparing to pneumatic type one. Therefore, adaptable environmental conditions should be established for the control system. At least, the following countermeasures should be taken to improve the present conditions.

(i) Improvement of air conditioning systems in the central control room and cubicle room

The instruments installed in the cubicle room are affected considerably by large dust quantities, high air temperature. Especially the high dust content together with high air humidity causes serious faults at the relay and switch contacts. Gas and dust leakages from the boiler also cause high temperature and poor electrical contact. Therefore, fresh air should be taken from the outside, not from the existing boiler yard for prevention of hot gas, air, and dust entering into the central control room and cubicle room. Openings for cable marshalling in the central control panels including newly installed control panels, especially for S-1 and S-2 units should be filled up with epoxy and steel plate.

Refer to concrete recommendation on the attachment sheet titled "Improvement of central control room" described on pages 5-247 to 5-251.

(ii) Environmental improvement of locally mounted control devices

The pollution of boiler area by large flue gas leakages from the furnace, especially from S-1 boiler furnace, together with the temporary water, drain and steam leakages of boiler (especially the secondary SH outlet drain and air vent valve station) reduces the service life of the locally mounted control devices substantially.

- Installation of instruments and control devices in newly installed local panel

- Complete heat insulation of pipes and vessels, etc. to prevent heat transfer to control devices.
- Rigid supporting of instrument and control devices
- Forced ventilation of local control panel by fresh air

ii. Considerations on future operating system of thermal power plants

In the near future, thermal power plants in Metro Manila will be operated by Automatic Frequency Control (AFC) from Central Load Dispatching Center under construction. In addition to the above, Fast Cut Back operations of power plants are considered in the future. Taking the above situations into consideration, selection of control devices should be made taking a long-range view of power plants operation including hydro, geothermal and nuclear power plants.

For AFC operations:

Review of load increase/decrease rates and load swing band (minimum load)

For FCB operations:

Adoption of automatic burner numerical control and follow-up rate

For modification of control systems:

Additional functions such as FCB and AFC operations have to be easily added to new type control system.

From the standpoint of easy modification selection of digital type control devices is very good because of less additional cabling and less alteration of panel wiring. Change in circuit of this type can be easily altered by program loader.

iii. Close contact, consultation and discussion with boiler and turbine manufacturers

Signal matching, controllability and various problems accompanying with the replacement should be solved prior to the commencement of the work between NAPOCOR and the manufacturers. Especially problems on Electro Hydraulic Governor control and start-up by-pass control should be solved thoroughly.

iv. Complete rehabilitation of local control loops

Local control loops assist major control systems such as bolier and turbine control systems in performing full automatic operation of power plant, and also play a very important role.

Therefore, local control loops should be thoroughly rehabilitated at the same time of replacement of ABC system. Especially the following local control loops should be rehabilitated with high priority.

- Auxiliary steam control loops
- Steam coil air preheater control loop
- Condenser hot well level control loop
- Fuel oil header pressure control loop
- HP, LP & Deaerator level control loops
- Deaerator level control

v. Retraining of operators and maintenance engineers

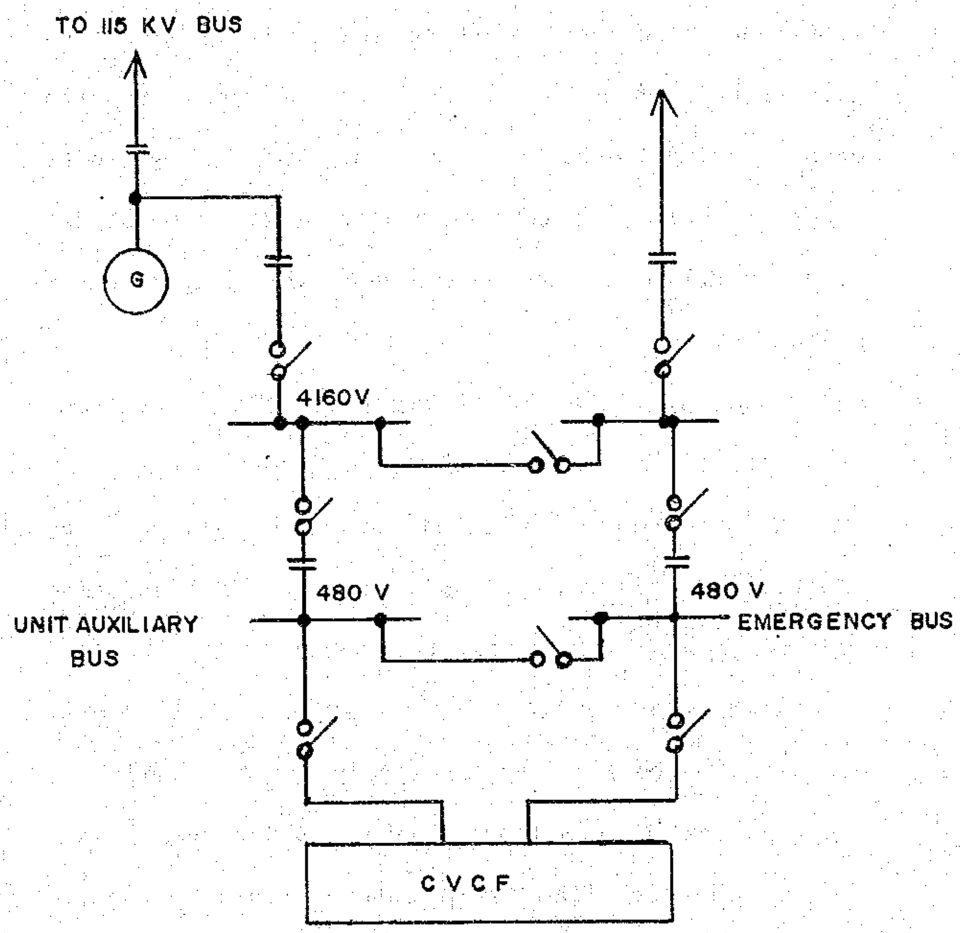
Before the commencement of the replacement, retraining of operators and maintenance engineers should be performed based on the on-the-job system. Maintenance engineers should be assigned to the manufacturing works at the designing and planning stage, and the operators should be assigned to actual plant similar to the existing power plants under operation.

vi. Additional installation of constant voltage constant frequency (CVCF) power supply unit (Power Inventer)

An electronic unit is generally affected by fluctuations of voltage and frequency. The existing control power supply is not adequate because of fluctuations of voltage and frequency. Therefore, additional control power supply unit, that is, constant voltage constant frequency power supply unit should be installed for safe, stable automatic operation. Power supply to the CVCF should be duplicated taking the power failure and upgrading the supply reliability into consideration.

In addition to the above, the CVCF should have a capacity for automatic burner control system to be installed in the future.

Fig. 5E-2 POWER SUPPLY TO CVCF



vii. Spare parts for new type

A complete set of different kinds of cards should be purchased as spare parts since the electronic control units consist of many integrated circuits, and thus the units cannot be repaired at plant side. These units should be repaired at the manufacturer's factory.

In addition to the above, the spare parts should be stored in the same ambient conditions as central control room or relay room.

(b) Fuel oil control system (G-1, G-2, S-1 & S-2)

i. Fuel oil storage tank bottom heater control

All the fuel oil storage tank bottom heater control devices are defective, some control air supply pipes are removed, some thermocouples not mounted on tank, some control valves closed manually and by-pass valve opened.

The following measures to be controlled satisfactorily should be taken.

- Replacement and repair of control valves
- Mounting of thermocouples or replacement with new ones.
- Measure supply air pressure, and check control output air pressure

  Instrument air is supplied from power plant air compressor, and the length of the supply air pipings is approximately 250 meters. After drain blowing-out from instrument air at the controller terminals, pressure of supply air should be measured. If the pressure is considerably low, the instrument air should be supplied from additional small capacity air compressor installed near the controllers like fuel oil booster pump yard.

- Auxiliary steam blowing-out and repair the steam traps

  Steam traps on the auxiliary steam for fuel oil heating are all defective, replace all steam traps.

  Minimum ambient temperature in the Philippines will decrease to about 20°C (68°F), and this system should be rehabilitated for keeping appropriate fuel oil temperature.

ii. Main fuel oil local control system

<u>Local instrument panel around oil pump</u>

At inlet and outlet of main fuel oil pump, oil strainer and constant differential fuel oil pump, the pressure gauges are all defective, and some of them are dismantled; some of them do not indicate correct readings.

The pressure gauges above-mentioned are at least needed for safe operation of power plant, and therefore, the pressure gauges should be replaced with new ones, and the pressure switch at oil supply header should be replaced with micro switch type so that the plant will not be tripped due to slight vibration of the mercury type pressure switch. Furthermore, at differential pressure between inlet and outlet of oil strainer micro switch type differential pressure switch should be additionally installed for the purpose of pre-alarm, "Oil strainer diff. press. high". Instrument such as pressure gauges, switches and controllers on fuel oil pipings should be of water pot type instead of direct sensing method.

iii. Fuel Oil Temperature Control (S-2)

Fuel oil temperature controller including temperature sensor is installed very close to oil heater and the controller is heated up considerably due to poor heat insulation of oil heater. This temperature breaks down the actuator diaphragm on the control valve.

Therefore, assure the heat insulation of oil heater or reinstall the controller in a place not affected by heat.

iv. Constant differential fuel oil pump (G-1 and S-1)

The CDFOP is not placed into operation.

The main fuel burners for G-2, S-1 & S-2 are designed as return flow atomizer not as straight mechanical atomizer. Using this burner without CDFOP possibly cause the long flame and imcomplete combustion in the furnace, resulting in AH burning out in the worst case due to unburnt carbon adhesion on the element, and also clogging of the element.

Repair the CDFOP motor during next overhauling without fail and place the pump into operation.

v. Fuel Oil Header Pressure Control (S-1 & S-2)

Fuel oil header pressure control is very important control to maintain the pressure suited for satisfactory fuel combusion, but the control systems for S-1 and S-2 are not operated automatically because of contamination of instrument air by moisture or drain. Complete drain blowing-out of instrument air pipe is required during forthcoming overhauling.

vi. Monitoring of burner header pressure (G-1, G-2, S-1 & S-2)

At present the fuel oil supply pressure is monitored at the outlet of constant differential fuel oil pump. To obtain precise oil pressure for burner light-off and shut-down, oil supply pressure nearer to oil burners as possible should be monitored at the central control room taking automatic load variation in the future into consideration. This monitoring unit should include information system such as annuciation and indicating lamps as well as burner header pressure indicator for facilitating the burner operations.

vii. Monitoring of Burner Flames

Burner flame scanners are not installed in the existing oil firing system, and so firing flames can not be monitored continuously.

To perform safe burners operation and to protect the boiler from oil leaks into furnace and furnace explosion, flame monitoring TV sets should be provided in the central control rooms for G-1 & G-2 and S-1 & S-2 units.

viii. Temperature Monitoring of fuel Oil Transfer Line in Gardner/Snyder Thermal Power Station

Temperature of fuel oil transfer line is not monitored because of no installation of temperature gauges. Furthermore, all the suction heater of fuel oil storage tanks are defective. And the fuel transfer pipings are partially installed underground. Fuel oil temperature should be maintained adequately for protection of solidification. For the purpose of maintaining constant oil temperature, temperature recorder should be provided in the "fuel oil booster pump monitoring room" situated near the storage tank yard. The temperature sensors should be provided on the line up to fuel oil supply pump every 50 meters length.

(c) Feed Water Control System

i. Local instrument panel around BFP (G-1, G-2, S-1 & S-2)

Pressure switches for BFP interlock are all the mercury type ones, and these type ones are easily affected even by slight vibration, and this may lead to BFP trip, finally to unit trip.

These existing pressure switches are used for:

Lube oil pump auto-start (PS-28)

Lube oil low pressure alarm (PS-14)

Lube oil pump trip (PS-15)

BTP starting interlock (PS-13)

Since BFP is the most essential component of power plant, all these existing pressure switches should be replaced with micro switch type ones for protection from mal-function due to slight vibration or thermal expansion. In addition to the above problem, the re-setting and adjustment of mercury type one is difficult. On the other hand, micro switch type one can be easily re-set, readjusted by the standard pressure tester.

ii. Feed water flow control valves

G-1 Unit

Disc and seat of the control valve were replaced with new ones during last overhauling. This control system has experience of load swing test by AFC, and the load changing rate was 3 to 5% MCR/min. during MERALCO days, 1978. Nowadays, the system is still controlled automatically in relatively good conditions.

G-2 and S-1 Units

Leakage from the feed water flow control valves for G-2 and S-1 units are considerably large. That for G-2 is under going overhauling and repair. At fully closed positions, both the valves allow feed water flow about 1/3 MCR. In this condition, feed water flow can not be controlled at all during the unit start-up. The feed water control valve for S-1 unit should be repaired, or replaced if necessary.

iii. BFP-T Speed Regulator (Feed water flow control)

G-2, S-1 and S-2 Units

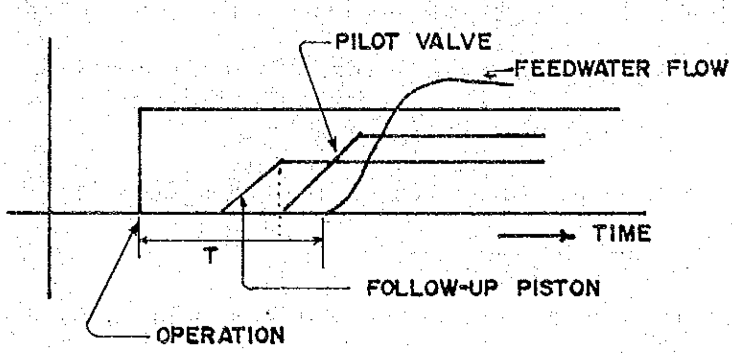
This regulating systems for three units have time lag. BFP-T speed regulator can not follow the load change automatically and can not be operated automatically.

This time lag should be clarified and checked by manual operation test as follows:

Increase or decrease the feed water flow manually with the aid of selector station.

Measure the time from operation to governor valve actuation, and at the same time check the movement of follow-up piston and pilot valve for governor valve control, and record the control oil pressure at follow-up piston outlet and pilot valve outlet, and feed water flow change.

Fig. 5E-3 TIME LAG IN BFPT GOVERNOR



iv. Minimum flow control valves

At present, operating conditions of minimum flow control valves of each units are as follows:

	G-1	G-2	S-1	S-2
BFP - T	No installation	Under replacement w/ hydraulic type	Under planning of replacement	Already replaced
°Control valve	-	hydraulic type	defective	Already replaced with hydraulic type
°Minimum flow transmitter	-	Good	defective	Good
°Operation	-		Manually opened	Automatic operation (closed)
BFP - M °Control valve	Defective	Replaced w/ new type	Under planning of replacement defective	Under planning of replacement defective
°Minimimum flow transmitter	defective	good	defective	defective
°Operation	manually opened (50% opening	good	manual	manual

Both minimum flow transmitters for BFP-Ms of G-1 unit are defective, and the root valves for the transmitters have been closed for long time. In addition to the above, minimum flow control valves are mechnically locked at intermediate opening (approximately 50%) and solenoid valves are disconnected. Especially regarding to G-1, the solenoid valves and control valves should be repaired, or replaced with new ones, and minimum flow control valves should be operated keeping fully closed conditions to reduce M-BFP's power consumption.

v. Valve handles for instrument root valves (G-1)

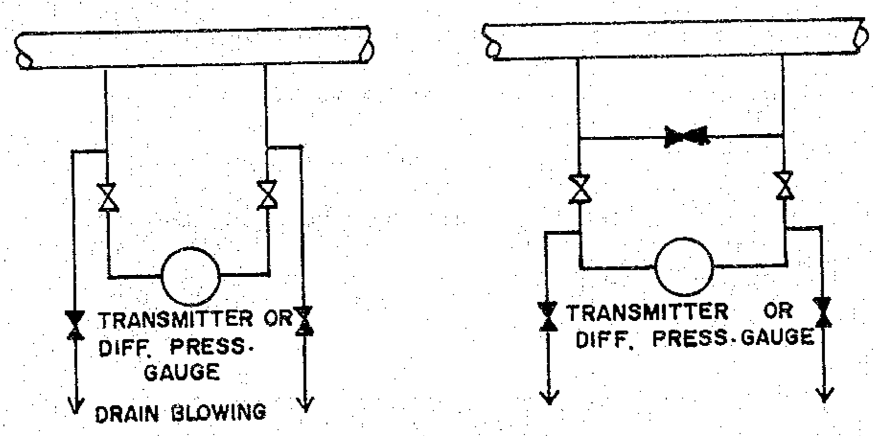
There are many defective valve handles especially on the feed water line of G-1, some of them are not mounted, some of them are defective, and valve spindles are distorted. These valve handles should be repaired or replaced with new ones for easy instrument tests, adjustment and maintenance.

vi. Instrument Piping for Differential Pressure and Flow Transmitter

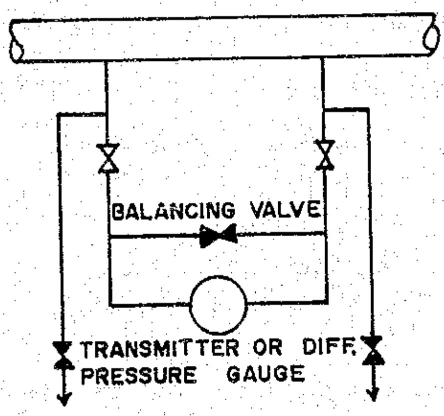
There are several kinds of instrument piping in differential pressure and flow transmitter lines. Method of instrument piping shown below are not correct. NAPOCOR must have his own design standards for instrument piping. For an example of wrong piping, refer to the sketch shown below.

For future installation, instrument piping for differential pressure transmitter is recommended as follows:

Fig. 5E-4 INSTRUMENT PIPING FOR DIFFERENTIAL PRESSURE DETECTION



EXISTING PIPING
(wrong piping)



RECOMMENDED PIPING

For reference, design standards for steam, water, fuel oil and air instrument piping in Japan is shown in Appendix 11

(d) Air flow control

i. G-1 Unit

As of August 30, 1982 air flow is not controlled automatically because of AH clogging. Operating conditions of AH (A/B air and gas draft pressure) at the load of 90 MW are as follows.

Table 5E-1 AIR & GAS DRAFT PRESSURE

Unit: inch H_2O

	Air Side		Gas Side	
	Inlet	Outlet	Inlet	Outlet
A	27~29	17~18	6~7	1.5~2.0
B	25~27	17~18	10~11	2.5~3.0

But before AHs clogging, the air flow was controlled automatically. There exists no problem except slight signal hunting of the flow transmitter.

Some recommendation to avoid the air flow signal hunting and to transmit smoother signal will be presented here.

<u>Stable Signal Transmission</u>

For a stable air flow signal transmission to a controller, the following two additional installations should be considered.

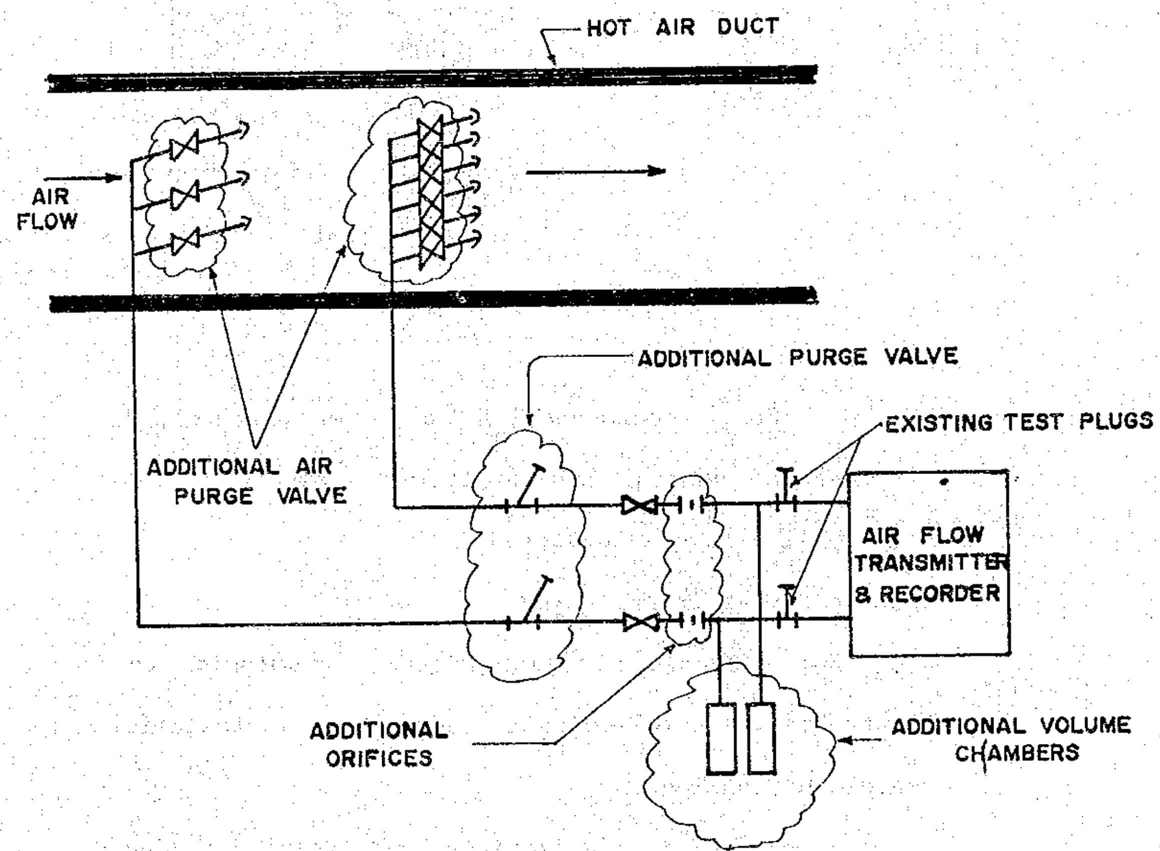
- Addition of orifices and volume chambers between the transmitter and instrument root valves (Refer to the sketch shown below.)

- Addition of purge air line from station service air system.

This line is very important for air flow detecting pipings, and one purging valve should be provided on each air detecting pipe line to purge out completely.

In addition to the above, the air purge should be done every week. It is an essential routine work for continuous automtic air flow control.

Fig. 5E-5 AIR FLOW TRANSMITTER FOR G-1



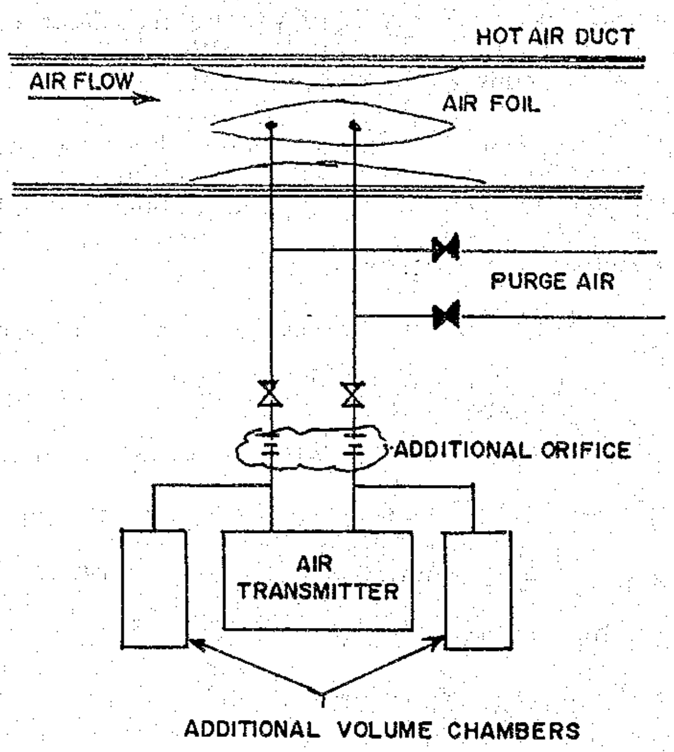
ii. G-2 and S-2 Unit

According to original design, air flow control should have been performed automatically ranging from 33% to 100% of maximum continuous rating. However, air flow control systems of G-2, S-1 and S-2 units have been manually operated for long time by the reason of signal hunting of air flow transmitter.

But spare parts for the existing transmitter are not available, and already obsolete. However, same recommendations should be applied to the existing transmitter pipings as G-1 unit.

- Additional installations of orifices and volume chambers
- Air purging every week

Fig. 5E-6 AIR FLOW TRANSMITTER FOR G-2 AND S-2



For easy maintenance and air purging, the existing detecting pipes should be re-installed on the grating.

iii. S-1 Unit

The air flow transmitters of both sides have already been put out of place. The detecting point of the air flow signal was changed to FDF suction air duct from the original point for the signal hunting and clogging of the pipes.

However, this detecting point should be changed to the original point, that is, to outlet of air preheater since air leakage of AH into the gas side is not considered, the signal is not adequate for combustion air measurement accordingly. The signal hunting and clogging of detecting pipes can be resolved by means of additional orifices and volume chambers, and weekly purge-out of the line respectively.

iv. Gas O_2 Transmitter (G-1, G-2, S-1 and S-2)

At present, O_2 transmitter including O_2 percentage recorder in the central control room is not functioning at all. The O_2 transmitter should be completely replaced with new ones for the purpose of satisfactory fuel combustion, reducing O_2 content in flue gas and preventing air pollution. The existing sampling pump is situated at second floor, but sampling points (4 points) are located at fifth floor about 40 meters away.

When the O_2 transmitter will be replaced, the gas sampling pump should be installed closely to sampling points as possible to prevent signal transmission time lag.

In addition to the above, the maintenance of the transmitter should be carried out every week as a routine work.

(e) SH spray control

These control systems for G-2, S-1 and S-2 units have not been placed into automatic operation. The spray control valves allow considerable flow at slight opening, and controls and instruments engineer tried to replace Cam B with Cam A of the flow transmitter. However, even slight improvement of flow characteristics could not be attained (see the sketch).

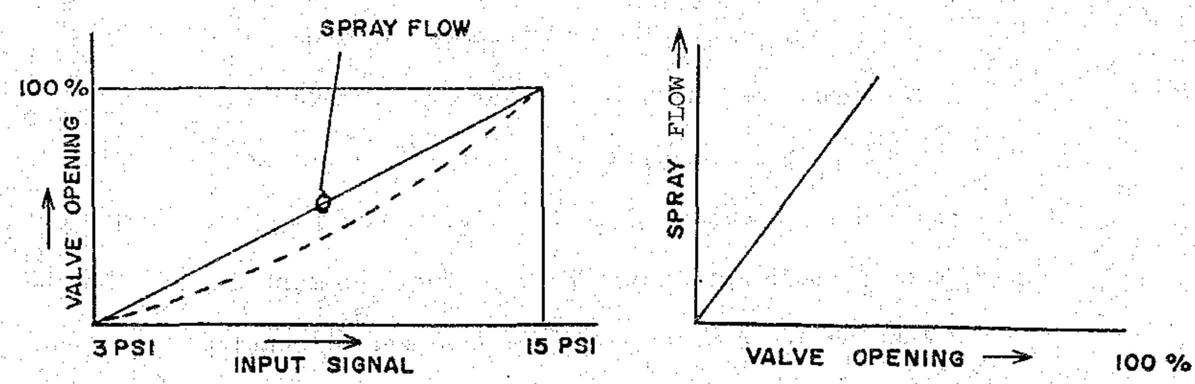


Fig. 5E-7 CHARACTERISTICS OF CONTROL VALVE

Taking the process of improvement into consideration, the problem on the systems may exist in the valve sizing, and reconsideration on valve sizing should be made in accordance with "Sizing of control valves" described in pages 11-27 of the "Preliminary Survey Report for Improvement of Operations of Thermal Power Plants". In addition to the above, the control valves play a role of shut-off valve in the event of emergency shut-down. Generally, control valve has no capacity to shut off water tightly. Additional shut-off valve should be installed for the purpose of tight shut at the emergency and repair of the control valve.

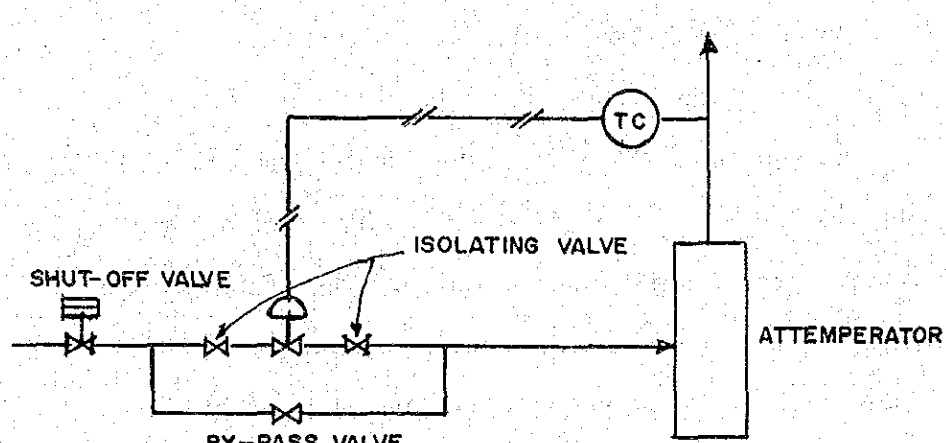


Fig. 5E-8 SPRAY CONTROL SYSTEM

(f) Start-up by-pass Control (G-2, S-1 and S-2)

G-2, S-1 and S-2 start up by-pass control systems are of set point control types except several control loops. During unit start-up boiler operator regulates the set point in accordance with start-up procedure. In addition to the above control valves, motor-driven valves are controlled by electrical interlock by pressure, level or valve opening of control valve. However, these motor-driven valves for start-up by-pass line are not operated automatically due to unsuitable design.

The name of the valves are as follows:

MV-3 Pressure reducing valve inlet stop valve

MV-4 Low pressure super heater by-pass valve

MV-5 Flash tank outlet motor operated Stop valve

For example, MV-3 valve is opened and closed by one valve limit switch of CV-103. However, as CV-103 controls section SH pressure the opening of the CV-103 changes in response to the section SH pressure. MV-3, therefore, at first opens fully, and then fully closes when the opening of CV-103 is less than 5%. In addition to the above, the valve stop switch is not mounted on the central control panel. There are no means to be taken by the operator other than to cut off the control center no fuse breaker.

The following improvements for the motor-driven valve should be made:

a) To provide "stop" switch

b) To provide "auto-manual" alternate type selector switch

c) Not to use a-contact and b-contact of same limit switch

For example of improvement:

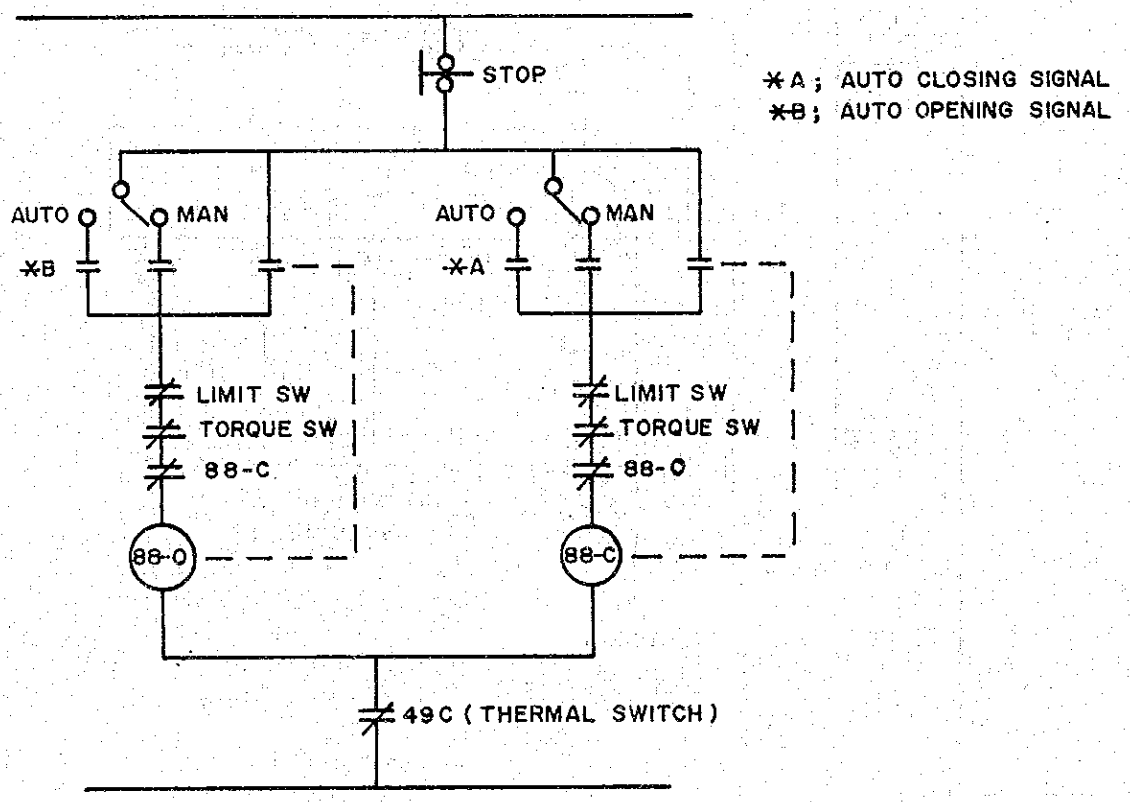


Fig. 5E-9 CONTROL CIRCUIT FOR MOTOR DRIVEN VALVE

For the other motor-driven valves, that is, MV-4 and MV-5 fine sequential control circuits like inching valve operation should be applied to start the unit.

In the start-up by-pass control system, several monitor switches for alarm and interlock are branched from one transmitter. In the event one transmitter is defective not only one valve could not be controlled, but also plant condition could not be monitored and supervised. Therefore, the transmitter should be separately installed for the purposes of control and monitoring.

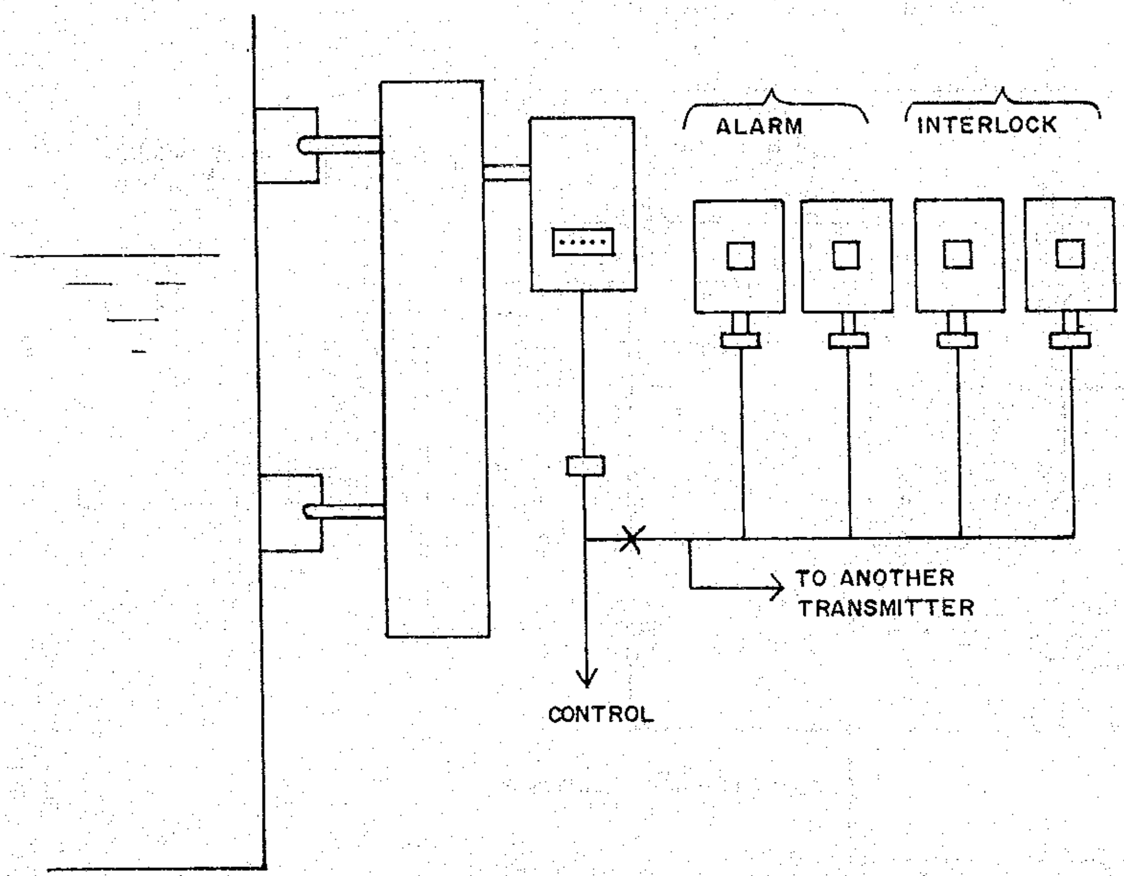


Fig. 5E-10 INSTRUMENTATION FOR CONTROL AND OTHER INTERLOCK

(g) Instrument air system (G-1, G-2, S-1 and S-2)

i. Instrument air compressor system

The existing instrument air compressor system has only one compressor at each unit excluding G-1 unit. Each instrument air compressor can not exert pressure up to unloading set point (90 psi.), and continuously operates. Therefore, the compressor can not be repaired during unit normal operation. In the even of air failure, instrument air will be supplied from station service air line as a back-up.

However, the station service air system has no dehumidifier, and so the back-up air is dirtier comparing to the instrument air. At least, the following improvement should be planned for S-1 and S-2 units.

- For clean air supply to instruments such as pneumatic type controllers, transmitters and solenoid valves, an additional instrument air compressor should be installed in common to S-1 and S-2 units as a back-up.
- In back-up line from the station service air compressor, one filter and one return valve should be, at least, additionally installed, and the existing back-up system should be used only in the worst case.

However, solenoid valve from emergency back-up from the station service air is defective at present, and that for S-2 is not installed.

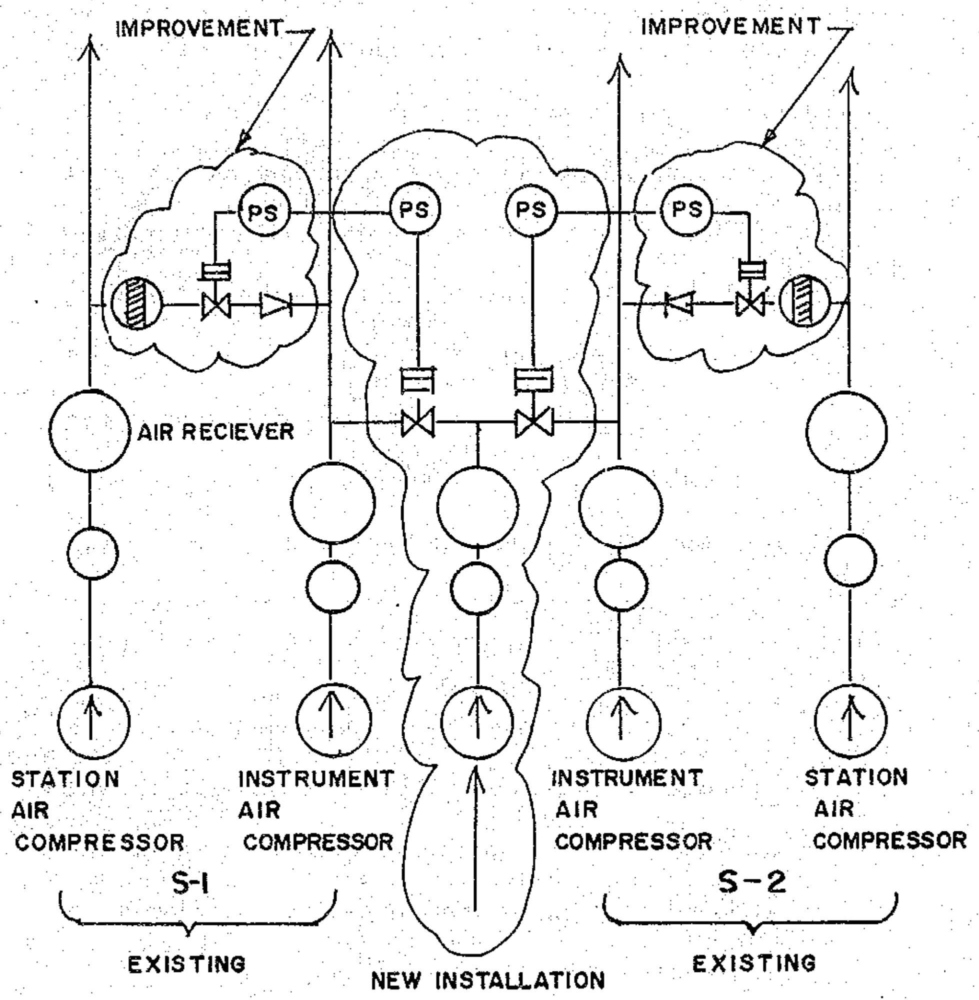
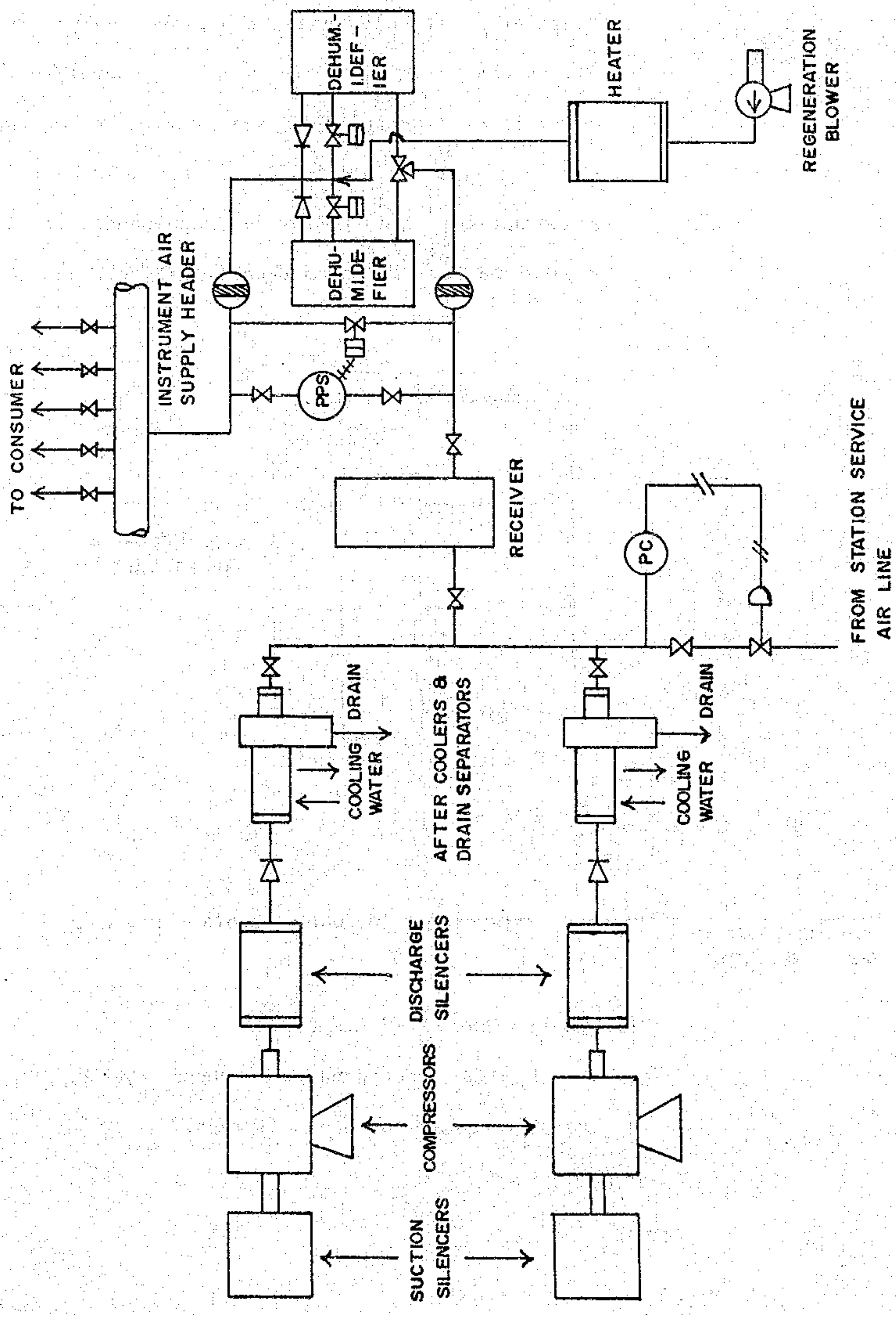


Fig. 5E-11 BACK-UP SYSTEM FOR INSTRUMENT AIR COMPRESSOR

For future installation, the following instrument air system should be adopted.

Fig. 5E-12 INSTRUMENT AIR COMPRESSOR SYSTEM



ii. Instrument air piping system

The existing instrument air supply pipes to instruments are branched from the other branched instrument pipes, and so very complicated. Therefore, if one branched pipe leaks, the downstream pipes are all unavailable, controllers, transmitters and control valve can not control automatically. To avoid this disadvantage, the following recommendation is rEpesented for long term rehabilitation.

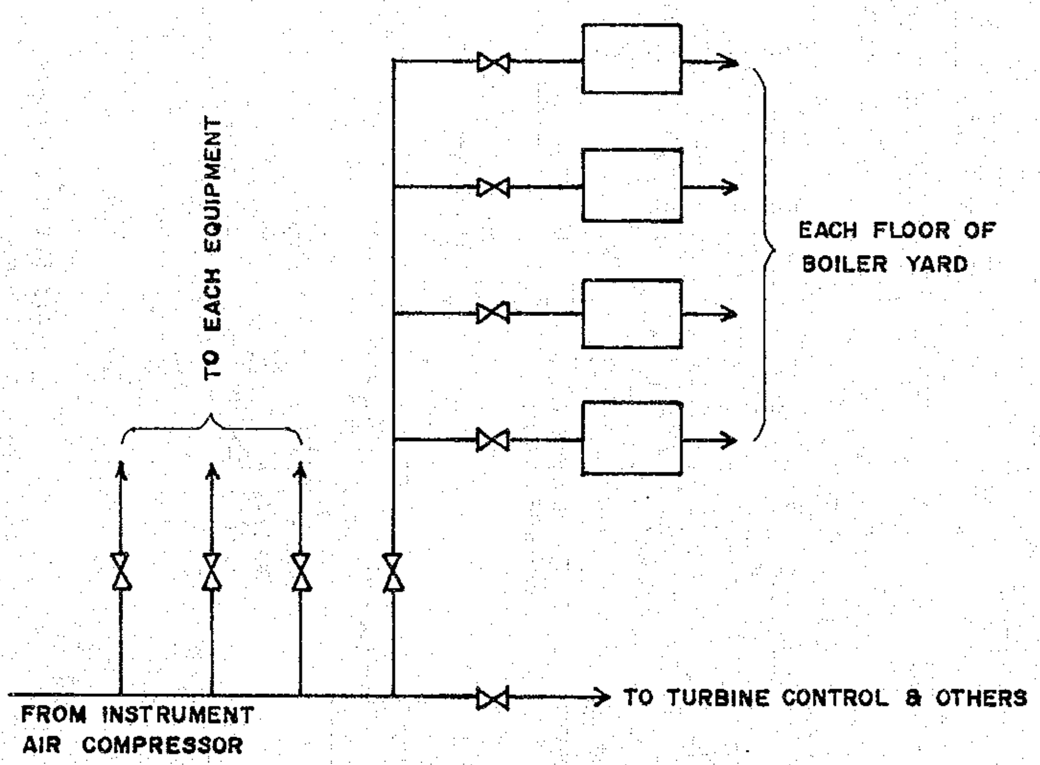


Fig. 5E-13 INSTRUMENT AIR PIPING

At least instrument air should be supplied from the header to each equipment.

Local air junction box should be installed at each floor of boiler yard near the controllers, transmitter and control valves as possible, and from the air junction box, control air should be supplied to control valves, etc.

Detailed piping system and design standards are described in Appendix-11.

Blowing out/purging of instrument air pipings for control units including locally mounted control units is required for satisfactory and safe operation of automatic control systems.

(h) Local control loops

Common items to all units to be rehabilitated

Almost all the local control loops for G-1, G-2, S-1 and S-2 are not operated automatically. Furthermore, since the by-pass valves and isolating valves for control valves are not installed, the control valves can not be repaired, and some of loops have control air leaks.

Defective parts of local control loops common to all units are listed below.

- Defective control valve opening indicator
- Defective air pressure gauges
    - Supply air pressure gauge
    - Controller output air pressure gauge
    - Input signal air pressure gauge

- Inferior control air pipings

  Supply air piping

  Signal air piping

- Defective signal transmitters
- Defective control valves

i. G-1

- Steam coil air preheater control

  The steam source is supplied only from auxiliary steam header commonly used to other units because the turbine extraction steam line was cut from the root.

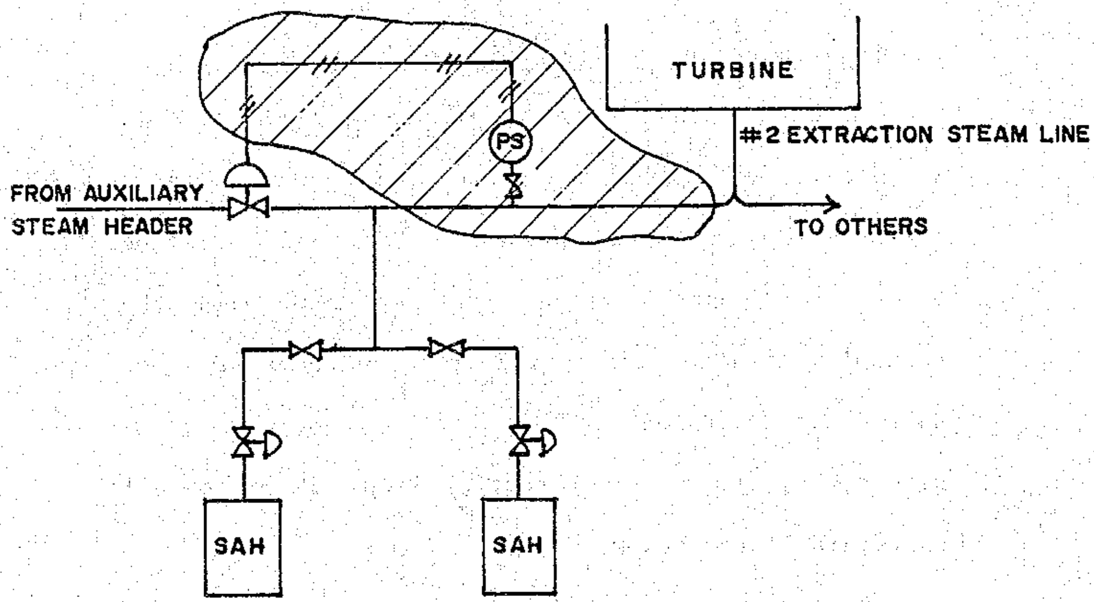


Fig. 5E-14 STEAM SOURCE FOR SAH

At present, combustion air is heated up only by auxiliary steam, however, the control valves (both sides) are defective completely, thus controlled by manual adjustment of inlet isolating valves. Temperature of hot air for combustion is not suited for stable oil firing of as shown in the data below.

TABLE 5E-2 SAH AIR TEMPERATURE CONTROL

	Inlet Air °F (°C)	Outlet air °F (°C)
A side	90 (32)	140 (60)
B side	94 (34)	140 (60)

This control system is essential for oil fired power plant for protection of AH, corrosion and plugging and so these valves should be urgently replaced with new ones.

- LP/HP Drip Regulator

Almost all the LP/HP drip regulators do not control the heater level adequately because the control valves or level transmitters are defective. In ddition to the above, even when control valves found defective the system can not be repaired because the isolating valves and by-pass valve are not provided.

Defective drip regulator are as follows:

- LPH No.3 drip regulator to LPH No.1
- LPH No.3 drip regulator to LPH No.2
- LPH No.2 drip regulator to LPH No.1
- FOH drip to LPH No.1
- HPH No.5 drip regulator to LPH No.2
- HPH No.5 drip regulator to LPH No.3

- HPH No.5 drip regulator to deaerator
- HPH No.6 drip regulator to deaerator

- Auxiliary steam pressure control

  Auxiliary steam pressure is controlled by manual adjusting of the by-pass valve because replacement parts are not available. This control valve is very important because it controls the auxiliary steam pressure used for all equipment.

  This control valve and pressure transmitter should be replaced with new ones.

- Condenser hotwell level control

  At present the condenser hotwell level control system is controlled automatically in relatively good condition.

ii. G-2

Local control valves are under overhauling and calibration, however, only control valves are calibrated and adjusted. During overhauling relations between the control valve opening and control signal should be checked, and during unit start-up and normal operation the control systems should be readjusted and tuned finally in accordance with plant conditions to be controlled, and the calibration and tuning records should be kept for future comparison and readjustment. If these procedures are not performed, the control system can not be automatically operated in spite of replacement with new one.

Before on-going overhauling the defective local control systems are listed up as follows:

- LPH No.3 heater drip regulator
- LPH No.2 heater drip regulator
- HPH No.6 A/B heater drip regulators
- HPH No.5 A/B heater drip regulators
- Deaerator spill-over regulator
- Hot well level regulator
- Regulator emergency make-up regulator
- Deaerator over-flow regulator
- Auxiliary steam pressure control
- Steam coil air preheater temperatures control

iii. S-1 unit

- Steam coil air preheater temperature control

  Steam coil air preheater temperature control valves have been already removed from the lines for long time and combustion air temperature is controlled with the aid of the by-pass valves of auxiliary pressure control valve. Furthermore, auxiliary steam pressure control loop is defective completely.

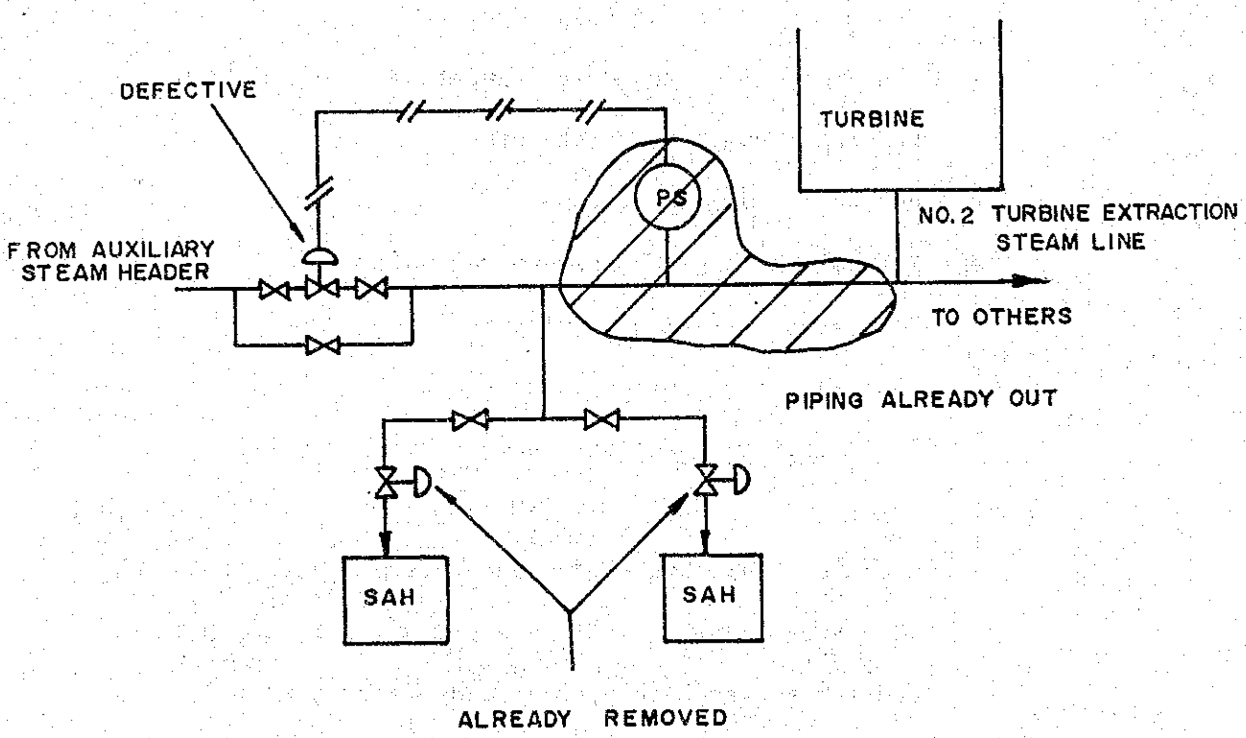


Fig. 5E-15 STEAM SOURCE FOR SAH OF S-1

- LP/HP drip regulator

  Defective control systems are as follows:

  - HPH No.5 A/B drip regulators to LPH No.3
  - HPH No.6 A/B drip regulators to HPH No.5 A/B
  - HPH No.6 A/B drip regulators to deaerator
  - Deaerator overflow control
  - Deaerator spill-over control

  These control systems should be repaired, calibrated and tuned by the procedures described in G-2 unit control loop.

- Auxiliary steam pressure control

  Same condition as G-1 unit.

iv. S-2

- Steam Coil air preheater control

  This control system is in the same condition as S-1 unit, except that the control actuators are still installed.

- LP/HP drip regulators

  - LPH No.3 heater drip regulator
  - LPH No.2 heater drip regulator
  - HPH No.5 A/B heater drip regulators

  The regulators listed above are all defective (control valves, supply air and controllers). Especially instrumentations around LP heaters are in very bad installation conditions, and maintenance area is very limited.

- Auxiliary steam control system

  Auxiliary steam pressure control valve and cold reheat steam pressure control valve are defective, and the pressures are controlled by manual adjustment of by-pass valves.

  Especially instrument air leaks considerably from the supply air reducing valve set for cold reheat steam pressure control valve. This leakage should be urgently repaired during normal operation to avoid unit trip due to air failure.

(i) Combustible gas alarm panel for G-1, G-2, S-1 and S-2

All indicators on the combustible gas alarm panels are defective, and also gas sampling pumps installed in boiler area around burners (6 points), fuel oil supply pump room (3 points) and waste oil basin (1 point) are all not operated.

There is relatively minor problem under bunker C oil firing outdoor type boiler, however, in case of indoor type boiler under poor ventilation, etc., combustible gas detectors should be installed both for unit start-up and normal operation. Therefore, the detectors including gas sampling pumps, pipings and indicators on the panel should be reparied, calibrated or replaced with new ones for power plant safety.

(j) Plant interlock system

i. Plant tripping interlock

Plant tripping interlock is provided for safe plant shutdown to protect the power plant from serious damages. The interlock is generally composed of three interlock systems.

- Electrical facilities troubles
  *Generator
  *Exciter
  *Main transformer
  *Auxiliary transformer
  *Transmission line bus
- Boiler and auxiliaries troubles
- Turbine and auxiliaries troubles

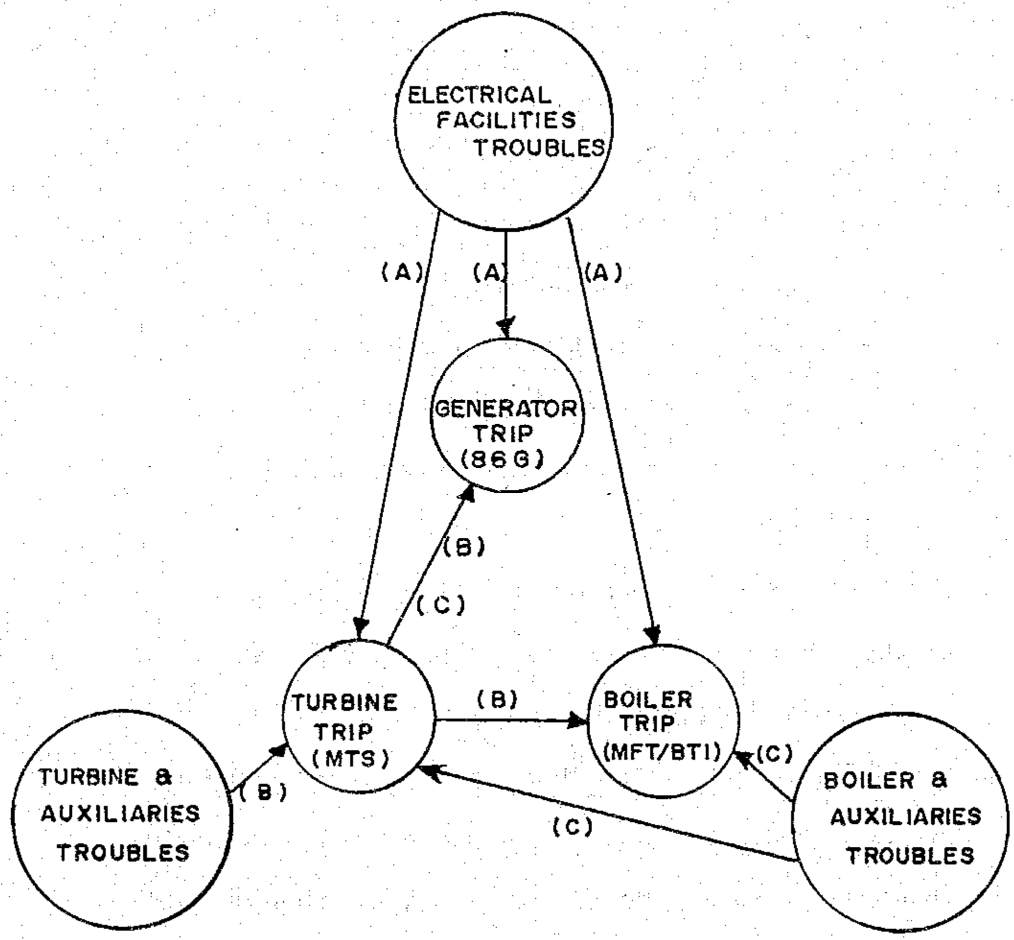
The above three systems should be interlocked with each other as follows:

(A) When electrical facilities troubles occur, generator breaker should be opened, boiler and turbine should be also tripped instantaneously.

(B) When turbine and auxiliaries troubles occur, generator breaker should be opened and boiler and auxiliaries should be tripped through Master Trip Solenoid (MTS) relay.

(C) When boiler and auxiliaries troubles occur, turbine and auxiliaries should be tripped instantaneously and generator breaker should be tripped through MTS relay.

In the plant interlocks for G-2, S-1 and S-2 units with once through boilers, boiler and auxiliaries are tripped by the signal of turbine trip relay plus reverse power auxiliary relay. This reverse power relay is not required for plant interlock. Boiler and auxiliaries should be directly tripped by turbine trip signal. The reverse power relay should be used only for the protection of generator motoring.



Note: Alphabets in ( ) accord with those shown in the previous page.

Fig. 5E-16 PLANT INTERLOCK SYSTEM

The boiler tripping interlock (BTI) relay is manually reset by operator. However, the relay should be reset automatically after the completion of furnace purge under the following operating conditions at least.

* No BTI signal
* Furnace purge completed
* All fuel oil shut-off valves closed
* All fuel oil burner valves closed
* All air resistor dampers opened
* Air flow ≥ 25% MCR
* All fuel oil lines free leak
* Feedwater flow ≥ 25% MCR

For the existing plant interlock system, the following additional tripping interlock should be considered.

- For boiler protection
  * All BFPs stopped
  * Main steam pressure extreme high
  * Main steam temperature extreme high
  * RH protection
  * Combustion condition unstable
  * All burner shut-off valves closed

Fig. 5E-17 BOILER TRIPPING INTERLOCK

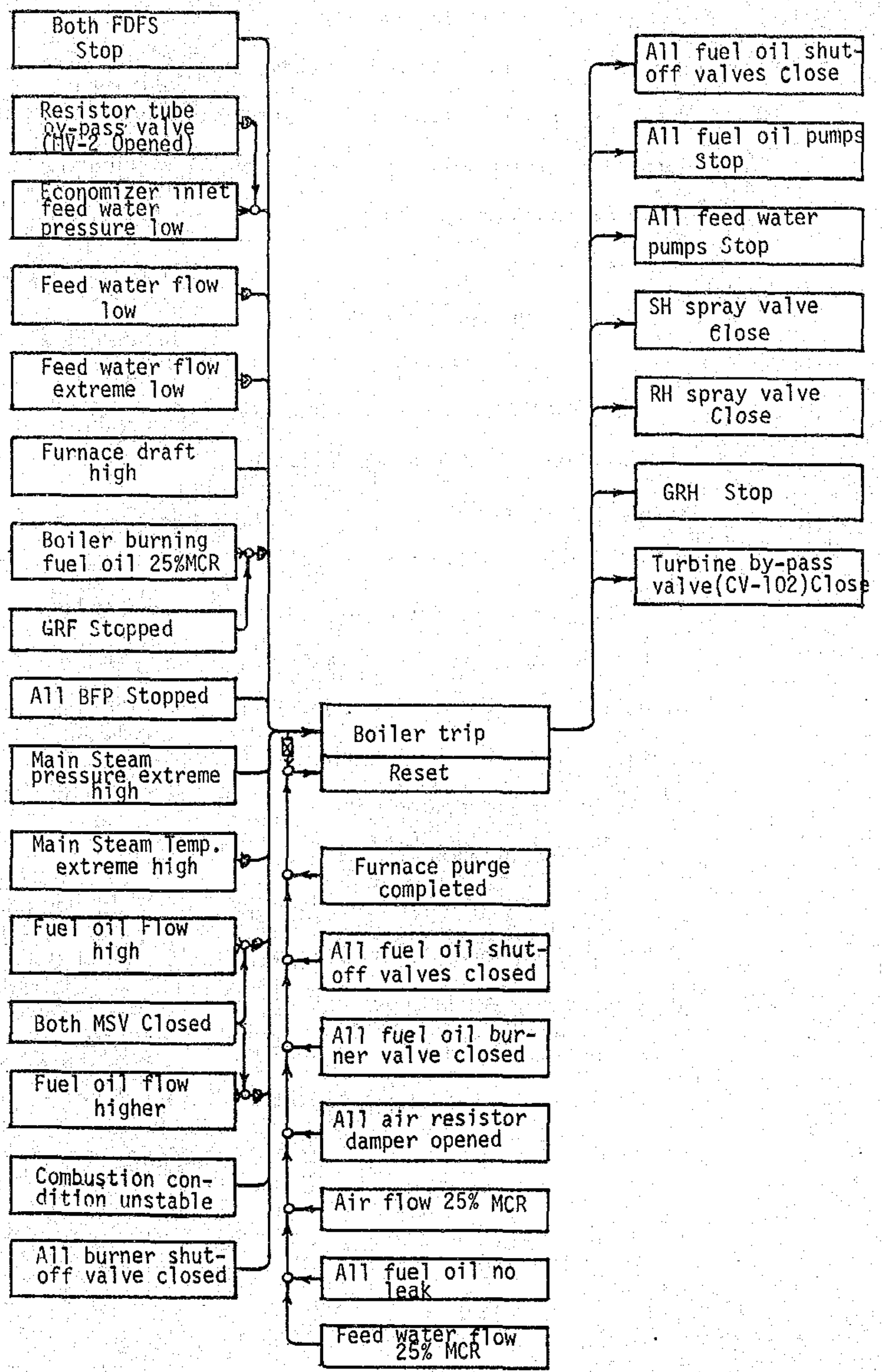
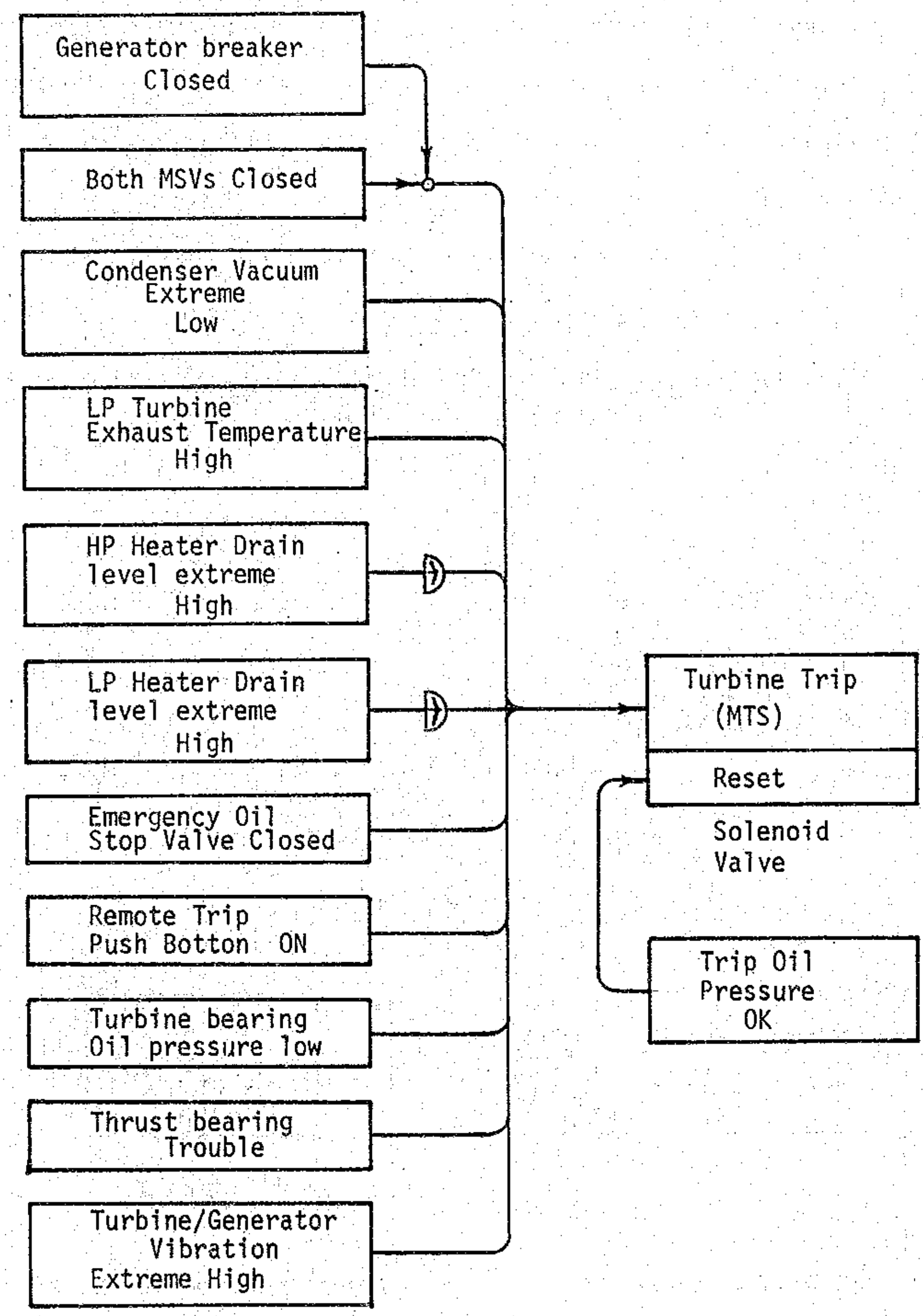


Fig. 5E-18 TURBINE TRIPPING INTERLOCK



In the event of trouble, plant tripping interlock should be surely actuated to stop the plant safely and smoothly. Furthermore, in case there is no trouble plant tripping interlock should not be caused due to self-malfunction of detectors. To avoid the above problems, reliable detectors should be selected and high reliable detecting system should be applied to the interlock.

For future improvement planning after the rehabilitation, tripping signals directly transmitted from the locally mounted sensors should be formed by 2 out of 3 system.

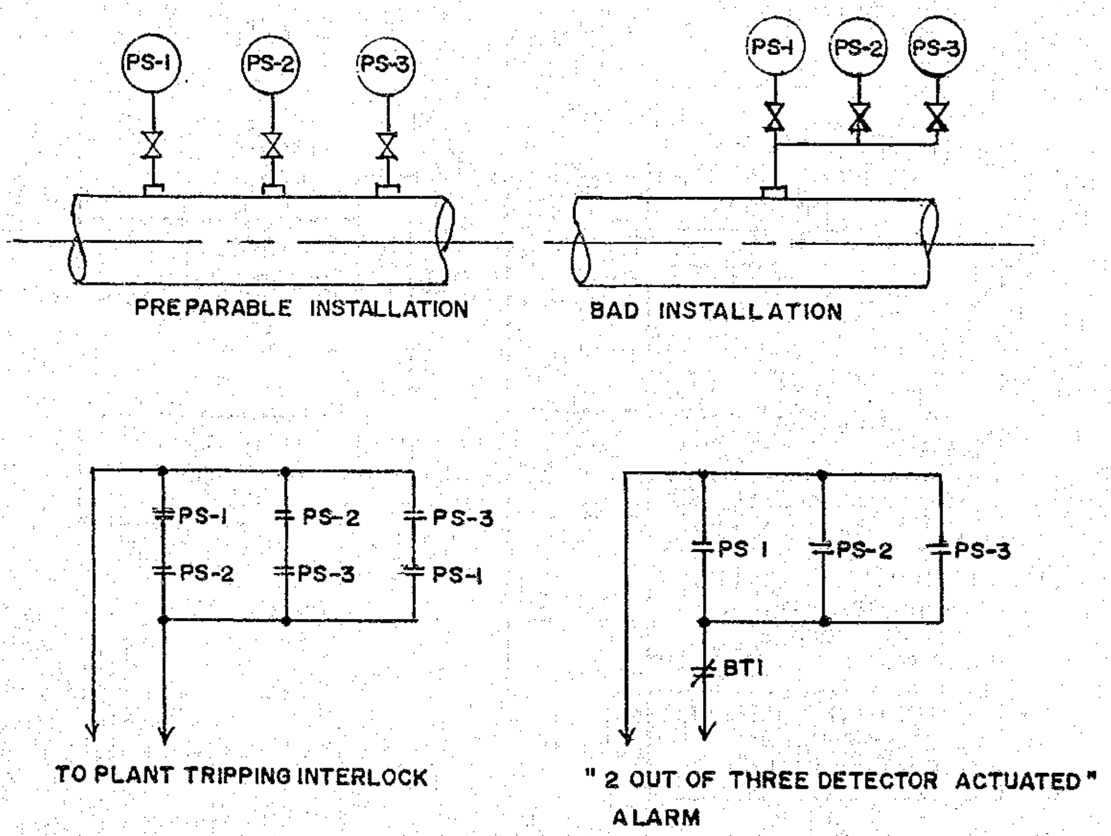


Fig. 5E-19 2 OUT OF 3 SYSTEM

In addition to the above, when only one sensor actuated alarm, "2 out of 3 detector actuated" should be provided in the central control room to give notice to the operators of detector malfunction.

2 out of 3 systems should be applied to the following detectors:

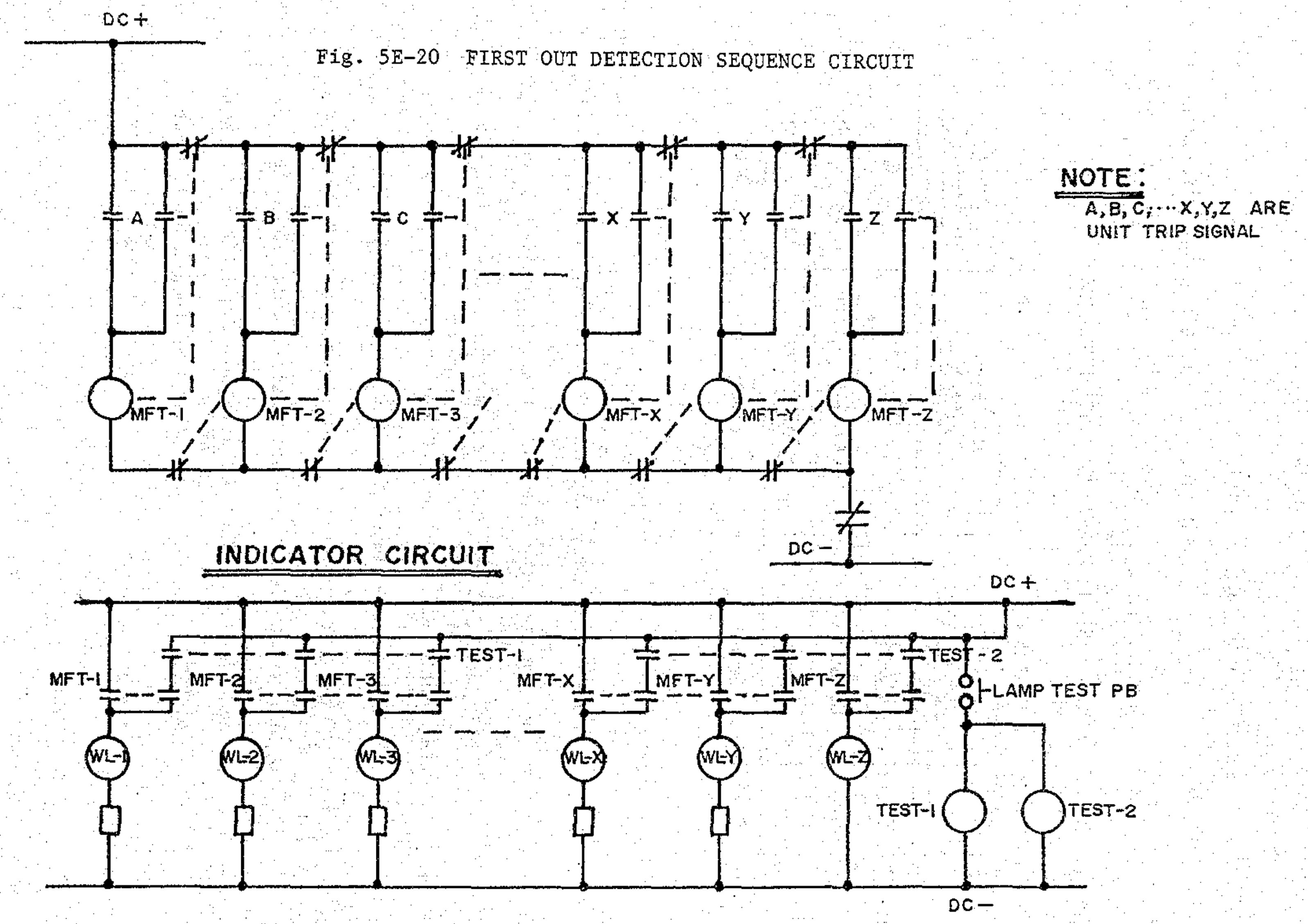
* Economizer inlet feed water pressure switch
* Feed water flow switch
* Furnace draft switch
* Boiler burning fuel oil flow switch
* Main steam pressure switch
* Main steam temperature switch
* Fuel oil flow switch
* Condenser vacuum switch
* LP turbine exhaust temperature switch
* Heater drain level switch
* Turbine bearing oil pressure switch

ii. First out indicator

Fault recorders are provided in Gardner/ Snyder Power Station to confirm the first cause of the unit trip. However, in the event of 3 units trips in September 8, 1982, the fault recorders did not function. First cause of the trip should be studied and analyzed thoroughly so as not to repeat same trouble and the countermeasures against the cause should be taken adequately. To know surely the first cause of unit trip it is recommended that first out indicator should be provided in central control room. This indicator indicates only first cause of the unit trip, and cannot be reset after completion of furnace purge. Outline of first out indicator is shown in the following sketch, and the following attention should be paid in design for first out indicator:

- Most reliable power should be applied to first out detection sequence circuit and the indicator circuit.
- Relays having same characteristics should be used so as not to indicate wrong sequence occurance order.
- In this circuit, all of unit trip signal should be adopted.

Fig. 5E-20 FIRST OUT DETECTION SEQUENCE CIRCUIT



iii. Furnace purge interlock

Present conditions of furnace purge interlock are as follows:

Table 5E-3 FURNACE PURGE INTERLOCK

	Purge Timer	Air Flow Switch	Purge Interlock
G-1	Good	Good	Good
G-2	Defective	Under simulation	Defective
S-1	Good	Defective	Defective
S-2	Good	Good	Good

The existing plant conditions for furnace purge do not include the GRF gas duct. Combustible gas is easily left in GRF gas recirculation duct, therefore this duct should be purged out completely to protect the boiler from furnace explosion.

In addition to the above, combustible gas detector should be additionally installed at the furnace bottom. The outline interlock block diagram of furnace purge at least should be formed as follows:

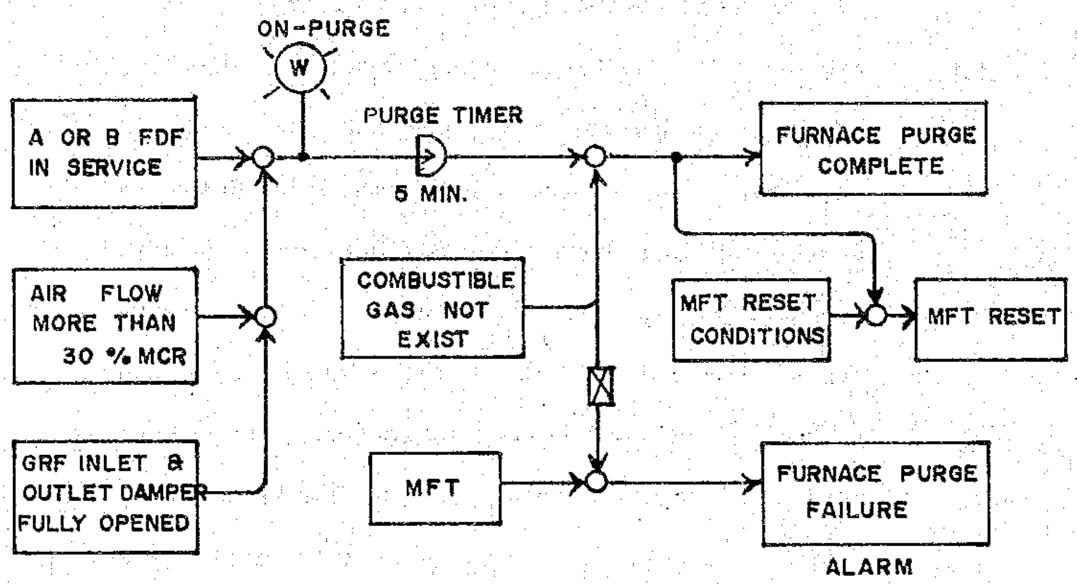


Fig. 5E-21 FURNACE PURGE BLOCK DIAGRAM

When the furnace purge can not be completed due to presence of combustible gas at the boiler bottom, alarm, "Furnace purge failure" should be provided in central control room so as not to light off burner. When the furnace purge completed successfully, MFT reset conditions are at least required for burner ignition to protect the boiler from furnace explosion. With respect to the conditions, refer to plant tripping interlock.

iv. Replacement of the existing auxiliary relays

In the existing sequential controls, interface circuits between analog and digital signals, and M/C, P/C and C/C circuits, open type electromagnetic auxiliary relays are used. Almost all of these relay contacts are fouled by dust and soot, and this causes poor electrical contact. Especially, the relays mounted on the racks behind the S-1 & S-2 central control room are fouled by soot and dust, and sequene drum switch used for automatic condensate demineralizer control is uncovered and considerable dusts are accumulated on the electrical contact.

In such situation, it is a matter of course that the automatic operation can not be performed at all.

Taking the situation of sequential control devices including plant interlock system into consideration, it is recommended that the following items should be carried out.

- To replace the existing electromagnetic auxiliary relays with seal-in or hermetic type relays. The seal-in or hermetic type relays should be of plug-in type for easy maintenance/replacement in the event of trouble/defectiveness.
- To mount the relays in the panels.

Two items described above should be applied to the following sequential control systems, units and panels.

- Turbine control and start-up control
- ABC control system
- AVR unit
- Plant interlock and furnace purge system
- Metal-clad switchgear unit
- Power center unit
- Control center unit
- Condensate demineralizer control panel
- Chemical injection control panel
- Water purifier control panel

v. Replacement of sensor switches

Mercury type sensor switches are used for interlock and alarm. This mercury type switch has difficulty for setting and unreliability for vibration. Therefore, micro switch type sensor switch should be used for plant interlock and critical alarm.

(k) Alarm annunciator system

Alarm annunciators are classified into three sections; boiler and auxiliaries, turbine and auxiliaries, and generator and auxiliaries/station service auxiliaries switchboard.

Alarm annunciator systems are relatively maintained in good conditions, and alarm test is carried out several times during every shift. However, several alarms have not been reset normally in each power plant. Alarms which have not been reset at designated power plant are as follows:

i. G-1

"Light fuel oil press low"
"Control air dryer"
"Station air press. low"
"Throttle steam press. low"
"CDSTE storage tank level high-low"
"CDSTE return storage tank level high-low"
"Sterile service water head tank level high-low"
"House service water head tank level high-low"
"4160 V Motor overload"
"440 V Motor overload"

ii. G-2

Under overhauling

iii. S-1

"Light F.O. press. low"
"MCB trip recorder"
"4160 V motor overload"
"Control Cub. Control voltage failure"
"MCB trip CB 125 V"

"House service water tank level high-low"

"Condensate storage tank high-low"

"Seal oil hydrogen supply failure:

iv. S-2

"Light F.O. press. low"

"Fuel oil temp. high-low"

"4160 V motor overload"

"Electric hydro governor failed"

"Flash tank level high-low"

"Wall stress influence off"

"Hydrogen supply failure"

Recommendations:

- Alarm Reset

The alarm, "Light fuel oil press. low" should be considerated of course because the light oil pump is not operated during normal operation. Therefore, the low pressure should not be treated as an alarm. This alarm should be reset during normal unit operation except unit start-up and the alarm circuit should be improved as follows:

Light fuel oil pressure
Light fuel oil pump operated
Light fuel oil shut-off valve opened

Same improvement should be applied to "Station air press low" alarm.