AUGMENTED OFF-GAS SYSTEM

REFERENCE TEXT

Revisions

Date	Rev #	Description
06/26/96	1	FRN 95-03-29 Removable jumpers for loop seal FRN 95-03-27 Drain traps at prefilters FRN 95-03-35 Removal of prefilter cartridge
04/15/97	2	LED readouts for H_2 Analyzers PDC 92-24 Add statement for switch S-15 - minor typos, FRN 96-04-46 Split loop seal annunciators.
10/10/00	3	Updated ARP nomenclature, setpoints
03/04/02	4	Incorporate FRN 01-04-32 "Change Time for Off-Gas Flow Annunciation", and PDC 00-24 "Replace AOG Level Controllers", pen and ink changes, changes based on System Engineer review
12/29/03	5	Incorporate FRN 00-42-03 "Input Point Bypass for TR-9250". Update information regarding current inputs to TR-9250. Update level switch and drain trap info to reflect current plant configuration. Incorporate CA-00014
12/22/05	6	Automatically disable alarms on the Off Gas condenser Lo Level and the Recombiner Inlet Temp Lo for the off gas train not in service.
5/15/2007	7	Added operator actions on low alarms for loop seals per ARPs. Added locations for loop seal controls.

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System Engineer Review by/Date: NA
(Enter N/A if not applicable)

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TABLE OF CONTENTS

REFERENCES

A. Piping and Instrument Diagrams

1. Air ejection and off-gas system,M-210
2. Augmented off-gas system, M-254
3. Chilled water system, M-255

B. Vendor Manuals

1. FSAR Section 9.4
2. Panametrics Hygrometer V-0160

C. Bechtel Drawings

1. 480 V load centers B-30, B-31, E-8
2. Schematic diagram off-gas valves E-111
3. Wiring block diagram H_2 recombiner, E-444
4. H_2 recombiner M.O. valves, E-461
5. Misc. augmented off-gas instrumentation, E-462
6. H_2 recombiner misc. schemes, E-466
7. H_2 recombiner misc. schemes, E-463
8. Retention building sump pumps, E-467
9. H_2 recombiner misc schemes, E-468
10. H_2 recombiner misc. valves, E-469
11. Augmented off-gas annunciation, E-470
12. H_2 recombiner misc. schemes (H_2 analyzer), E-471
13. H_2 recombiner misc. instrumentation, E-472
14. Wiring block diagram E-473
15. Wiring block diagram E-474
16. Misc. retention building systems, valves, E-488
17. Retention building glycol system E-489
18. Retention building misc. instrumentation, E-490
19. Off-gas process radiation monitoring E-492
20. Retention building HVAC, E-457
21. Retention building HVAC, E-458
22. Retention building HVAC, E-459
23. H_2 Recombiner HVAC annunciation E-460
24. H_2 Recombiner HVAC E-464
25. Retention building HVAC, E-465

D. General Electric Drawings

1. Off-gas system, 762El29
2. Off-gas system, ll5D64lONL
3. Off-gas system simplified diagrams, GEK-3956l, (figure 2-(3-6))

References (cont.)

E. PNPS Procedures

1. Augmented off-gas system, 2.2.106
2. Augmented off-gas system explosions, 2.4.55
3. AOG - Abnormal carbon vault temperatures, 2.4.136
4. AOG - Loss of coolant to the off-gas condenser, 2.4.138
5. AOG - Abnormal recombiner operation, 2.4.141
6. Augmented off-gas valves air purge flow check 8.C.9
7. Off-gas flow calibration 8.E.8
8. Augmented off-gas system inst. cal 8.F.8

F. Technical Specifications

1. Amendment No. 177, Relocation of the Radioactive Effluent Tech Specs (RETS) and the Radiological Environmental Monitoring Program to the ODCM
2. Section 3/4.8, Plant Systems
3. Section 5.5.1, ODCM
4. Section 5.5.4, Radioactive Effluents Control Program

F. FSAR

FSAR Section 9.4, Gaseous Waste System
Table 9.4-6, Equipment Malfunction Analysis

AUGMENTED OFF-GAS SYSTEM

A. OVERVIEW

The augmented off-gas system recombines disassociated hydrogen and oxygen and minimizes radioactive releases to the environment.

B. SYSTEM DESCRIPTION

1. System Purpose

The augmented off-gas system reduces the amount of gas to be treated by recombining disassociated hydrogen and oxygen. The AOG system delays the radioactive gases released to the atmosphere, to permit their decay to an acceptable radioactivity level. This system also filters out radioactive gas particulate daughter products, minimizing their release to the atmosphere. The hydrogen concentration is maintained less than 4 percent to prevent explosions.

2. Safety Basis

a. The holdup time permits significant radioactive decay of the activation gases and fission gases in the main condenser off-gas prior to release.
b. The design basis holdup is 22 days for xenon isotopes and 29 hours for krypton.
c. The design inleakage was established at 7 cfm (at 130°F, 1 atm.) per condenser shell. Leakage from two condenser shells (corrected to standard conditions) gives a total of 12.3 scfm.
d. Provide system isolation on high off-gas radioactivity level.
e. Maintain its system integrity for all expected operating conditions by conservative process design.
f. Designed to include equipment, instrumentation, and operating procedures so the gaseous radwaste can be discharged from the station at levels as low as reasonably achievable.

3. **System Components (Figures 1 and 2)**

   a. Jet compressor
   b. Preheater
   c. Catalytic recombiner
   d. Off-gas condenser
   e. Water separator
   f. Hydrogen analyzer
   g. 30 minute holdup pipe
   h. Cooler condenser
   i. Moisture separator
   j. Prefilter
   k. Charcoal adsorber

4. **Basic System Operation (Figure 1)**

The augmented off-gas system minimizes radioactive gases released to the atmosphere. Controlled recombination of radiolytic hydrogen and oxygen reduces the gas volume thereby extending the gas holdup time. A second 30-minute holdup pipe and charcoal beds create additional hold up time, which further reduces radioactivity released to the stack.

The augmented off-gas system begins after the second stage steam jet air ejectors. However, the main condenser air ejectors are an integral part of the system as they extract the off-gas (non-condensibles) from the main condenser and condition the process gas before it passes through the augmented off-gas system. The steam jet compressors reduce the hydrogen concentration to less than 4 percent (by volume) by steam dilution and provide 2 to 5 psid to force the process gas through the system.

In passing through the augmented off-gas system, the extracted gases pass through the pre-heater where the gas temperature is increased to a superheated state (350°F). The recombiner changes gaseous hydrogen and oxygen to water by a catalytic recombination process. The gases exit the recombiner at approximately 700°F to 800°F. The gases then pass through an off-gas condenser (where the temperature of the gas is reduced to approximately 130°F to 140°F) and a water separator where moisture is removed. Condensate is returned to the main condenser hotwell. Hydrogen content is monitored at this point by the hydrogen analyzers. (These analyzers are operated by the Chemistry

Department.) The system low point drain (AO-9362) removes water prior to the gases entering into the AOG 30-minute holdup line to provide time for the isotopes N-16, N-13, and O-19, which have short half-lives, to decay.

The gas flow from the AOG 30-minute holdup line passes through the cooler condenser, utilizing glycol refrigerant as a cooling medium, and then through the moisture separator having a 45°F exit temperature. Xenon and krypton isotopes are attracted and adhere to the activated carbon beds in the adsorber vaults, further reducing the gas activity level before the gases are released through the off-gas holdup line and after-filters at the main stack.

In the augmented off-gas system, various temperatures, flow rates, and level signals are continuously monitored to detect system malfunctions.

C. COMPONENT DESCRIPTION

1. Jet Compressor (X-345-A/B) (Figure 2)

The AOG system begins after the steam jet air ejector (SJAE) after-condenser in the condenser vacuum and air removal system. However, the SJAE are an integral part of the system in that they extract gases (noncondensibles) from the main condenser and process the extracted gases before passage through the AOG system.

The mixture through the system includes radioactive gases, hydrogen and oxygen from disassociated water, hydrogen and oxygen added by HWCCS, air which has leaked into the feedwater/steam cycle, and dilution steam used to maintain hydrogen gas concentration at or below 4 percent (by mixture volume). There are two, 100 percent capacity, jet compressors, that drive gases through AOG at approximately 2 to 5 psig. Normally one is in service, with the other in standby. The jet compressors are in the turbine building in the Recombiner Rooms.

The jet compressor driving steam is supplied from the main steam system through a pressure control valve (PCV-9238). It maintains 36 psig supply steam when "AUTO" is selected by its control switch on panel C-75. A pressure switch (PS-9242) activates an alarm at panel CP-600 if jet compressor steam pressure is too high (42 psig) or too low (30 psig). A pressure indicator (PI-9238) on panel CP-600 will indicate whether the pressure is high or

low. Motor operated valves MO-9204 and 9206 isolate the jet compressor steam supply to trains "B" and "A", respectively. MO-9204 is in the B recombiner room and controlled from panel CP-600. MO-9206 is in the A recombiner room and controlled from panel CP-600 also.

Motor-operated valves isolate the off-gas supply to each jet compressor train. Isolation valve MO-9205 isolates train "B," and isolation valve MO-9207 isolates train "A". These valves are in the recombiner room lower elevation. They are controlled from panel CP-600.

A jet compressor supply steam flow of 4500 lbs/hr (decreasing) actuates an alarm on CP-600, and activates an off-gas system isolation to vapor valves AO-3703, 3704, 3710, and 3711, when sensed by flow indicating switch (FIS-9262) and can be bypassed with a BYPASS/NORMAL selector switch on panel C-10 (discussed in condenser vacuum and air removal system). Normal flow is 5100 to 6250 lbs/hr.

2. Preheater (E-305 A/B) (Figure 3)

The preheaters are located in the turbine building in the Recombiner Rooms. The preheaters are downstream of the jet compressors. Two 100 percent capacity preheaters are provided. They are shell and tube type heat exchangers that preheat the off-gas mixture to approximately 350°F for efficient catalyst operation. The preheater is designed for 900°F at 1050 psig; normal operating temperature is 350°F.

The preheaters utilize steam as a heat source. Main steam is reduced to 300 psig by PV-9239 and is further reduced to 250 psig by pressure control valves (PCV-9251 and PCV-9252 for trains "A" and "B", respectively). Steam at this pressure in the preheater limits temperature in the heat exchanger to 400°F upon an off-gas flow loss. Steam enters the preheater tube side and heats the gaseous mixture in the shell to 350°F at the preheater exit.

After the steam gives up its heat to the preheater, it drains through air operated valves AO-9210 and AO-9211, the isolation valves for the condensate into the main condenser. SV-9210 and SV-9211, which control AO-92II and AO-92I0, are controlled from panel CP-600 for preheaters "A" and "B" respectively, and are in the lower recombiner room at the drain traps. Preheater drain valves AO-92I4(92I5) are backup drain isolations for AO-92I0(92II). These backup isolation drain valves are between AO-92I0(92II) and the main condenser. They are controlled from panel CP-001 with a handswitch and are normally open.

The preheater tube side is protected from overpressure by relief valves PSV-F093B (train "B") and PSV-F093A (train "A"). These relief valves return to the main condenser. Preheater inlet lines have drain valves to prevent excessive moisture accumulation. The inlet drain line valves are air-operated valves controlled from panel CP-600. AO-9255, for preheater E-305A, is in the recombiner room "A" at the drain traps. AO-9275, for preheater E-305B, is in the recombiner room "B" at the drain trap. Preheater drain valves AO-9212 (9213) are backup drain isolations for AO-9255 (9275). These backup drain valves are between AO-9255 (9275) and the main condenser. They are controlled from CP-001 with a handswitch. These normally open inlet drain lines drain to the main condenser.

3. Catalytic Recombiner (T-326 A/B) (Figure 2)

The catalytic recombiners are in the turbine building recombiner rooms. They accept the preheated radioactive gases, radiolytic hydrogen and oxygen, hydrogen and oxygen from HWCCS, air in-leakage, and dilution steam mixture, and remove hydrogen and oxygen by recombination. The recombiner combines sufficient hydrogen and oxygen to reduce the final hydrogen concentration to less than 1 percent by volume. Since H_2 recombination with 0_2 is an exothermic reaction, the recombiner produces superheated steam. As power level increases, the amount of H2 produced increases, which raises the recombination rate with O2, and recombiner exit temperature (figure 6). Normal recombiner exit temperature is approximately 790°F. The catalyst is protected from the freon, excess moisture, halogens and oils (which poison the catalyst element) by controlling inlet moisture and temperature. This reduces the possibility of requiring factory reactivation.

Recombiner vessel temperature is maintained by heater element tracing attached to the recombiner shell. Temperature is automatically regulated by temperature controllers (TC-R012 A/B) on panel CP-001. The heat tracing has 6 individually fused heaters, which supply sufficient heat to maintain the insulated vessel at a 350°F minimum. The temperature controller is fed signals from temperature elements TE-N040 A and B.

The replaceable catalyst of platinum-palladium is instrumented to furnish temperature information to a multi-point recorder TR-9250 on control room panel CP-600. The recorder is fed by thermocouples TE-N003 A(B), N004 A(B), and N005 A(B) (from lower to upper positions in the catalyst mass). Procedurally the recorder is reprogrammed to read input

from the Recombiner in service. Points from the standby Recombiner are bypassed. The thermocouples allow long term temperature profile and catalyst element life determination. If catalyst temperature swings outside the 240°F-875°F range, recorder TRS-R602 activates an alarm on panel CP-600.

Off-gas inlet temperature is monitored by temperature element N-002A(B), which actuates the recombiner inlet low temperature alarm temperature switch (TS-N600) at 250°F decreasing. Recombiner inlet pressure is monitored by PI-R002A(B) on panel CP-001.

To maintain proper vapor/gas concentrations in the system, a pressure control valve (PCV -9280) maintains sufficient air purge to make up for reduced air inleakage during system startup and provide motive force for heating the recombiner. It also serves to cool the recombiners after shutdown. Flow indicators (FI-9288 A/B) provide air purge supply flow indication, and a pressure indicator (PI-9288) provides air purge supply pressure indication. An operator controls air-operated valves to regulate the purge supply. A 4 cfm service air purge is provided through AO-9216 for recombiner "A" and AO-9217 for "B". A I2 cfm purge is supplied through AO-9276 and AO-9277 for train "A" and "B" respectively. The control switches for these valves are at panel CP-600; the valves are normally closed.

4. Off-Gas Condenser (E-306 A/B) (Figure 3)

The off-gas condensers are in the recombiner room at the 37 ' level. The off-gas condenser cools the recombiner effluent and allows water vapor to be condensed. This reduces the remaining volume of gas to be treated. The remaining noncondensibles are mostly krypton, xenon and air. The condenser cools the processed gas to I30°F. Condenser discharge temperature is monitored by temperature element TE-N008A(B). An indicating switch, TIS-R005A(B), initiates an alarm at panel CP-600 if condenser discharge temperature increases to 140°F.

The off-gas condenser is cooled by condensate (from the condensate demineralizers) flowing through the U-tubes and returning to the main condenser through air-operated valve AO-9230. AO-9230 can be closed by placing its control switch on panel CP-600 to the CLOSED position. With AO-9230 fully closed, a limit switch sends signals to AO-9221(20) (cooler condenser inlet isolations) to shutdown process line flow to the cooler condensers following a 1 second time delay. [Originally, AO-9230 had a companion valve FV-9231 which

automatically regulated condensate flow through the off-gas condenser to the suction of the reactor feed pumps. FV-9231 was removed and the line capped but the electronics remain in place. AO-9230 acted as an emergency bypass to the main condenser, which would open on low flow to ensure flow of condensate through the off-gas condenser.]

The cooling flow through the off-gas condenser is arranged such that the coolest water enters the condenser gas section and exits through the off-gas condensate section. This enhances off-gas subcooling so that gas flow exiting the off-gas condenser is primarily noble and particulate gases and minute air leakage. The off-gas condensate collects in the off-gas condenser shell lower portion and is then drained to the main condenser.

The condenser tube side has a vent valve, drain valve, and relief valve (set to lift at 600 psig) that discharge to CRW. The vents (FO-I7A/B), tube side drains (FO-I8A/B), and the relief valves (FO-94A/B), are in the steam jet compressor rooms. The condenser shells vent to the main condenser through 2 inch manually operated valves.

Condenser shell level is automatically controlled using solenoid-operated valves. SV-9252 is normally controlling level at 6" and backup SV-925I controls level at 8". These drain valves are controlled by switches on panel CP-600 which selects CLOSE, AUTO or OPEN. In AUTO the drain valves are controlled by the level controller (LIC-R004) selected to maintain the condenser subcooler section covered (6" water). An "A", "B" selector switch on panel CP-600 determines which off-gas condenser level controllers will maintain condenser level. Air operated drain valve LV-9251, is controlled by level controller LIC-R004 C(D) as determined by the "A", "B" selector switch , to maintain less than the high level setpoint (8"). Drain valve LV-9252 is controlled by level controller LIC-R004 A(B), to maintain level the normal level setpoint (6"). Controllers "A" and "C" control levels in off-gas condenser "A", and controllers "B" and "D" maintain level in off-gas condenser "B". The normal and high-level setpoints are adjusted on the individual controllers on panel CP-001 (see discussion below). Off-gas condenser low level closes the drain valves. Level transmitters (LT-N006 A, B, C and D) send signals to the level indicating controllers, where it is compared with the signal representing the desired condenser water level. An electro-pneumatic (E-P) converter changes the resulting level signal (electric) into a position signal (pneumatic) for air-operated valve positioning, allowing it to open and close on varying condensate levels. If level fluctuates beyond the programmed band, the level indicating controllers will actuate a HI/LO

alarm on panel CP-600. In this way, both a "normal" and "backup" drain system are incorporated, they are electrically identical, but with different setpoints. These valves fail closed on loss of air or power.

a. AOG Digital Level Controllers (Figure 6, 7)

There are four level indicating controllers on panel CP-001, LIC R004A and LIC R004C for "A" off-gas condenser, and LIC R004B and LIC R004D for "B" off-gas condenser. These level indicating controllers provide the operator with detailed information from an alphanumeric, digital/touch pad type controller (figures 7 and 8). There are three vertical L.E.D. bars, which provide information about AOG level control signals. Each increment of the bar, which is illuminated, represents 2% level (the total range of the controller is from 0 to 100%). The right hand bar is the Demand Signal, this shows the output from the controller to the drain valve. The output signal can be controlled either directly by the operator when the controller is in manual mode, or from the "operator setpoint" (OSP) when the controller is in auto. The left hand bar is the Operator Setpoint. This shows the setting, which the controller will maintain if placed in the automatic mode. The center bar shows the actual level of the AOG off-gas condenser. This signal is feed back from the level transmitter.

The information of each "bar" (to the nearest one tenth % demand/level) can also be displayed in the alphanumeric section (above the bar) of the controller by placing the "selector ball" over the desired bar. The ball is positioned from the touch pad button labeled "SEL". One push of the SEL button will move the ball one bar to the left. The positioning of the selector ball also determines which controller function is controlled by the UP and DOWN arrow touch pads. For example, if the selector ball is positioned above the Demand Signal bar, the demand signal (to the nearest one tenth of % speed) will be displayed and the operator can use the UP and DOWN touch pads to either raise or lower this setting.

The remaining touch pad push buttons are A / M, TAG, and ACK. The A / M pushbutton switches the controller from the Manual to Automatic mode. A subsequent push places the controller back to Manual. An "A" or "M" will be displayed on the right side of the controller to allow the operator to determine which mode the controller is in. The ACK key is used to acknowledge diagnostic alarms associated with the controller. When a controller alarm is received, a red E is displayed on the lower right hand corner of the controller digital display.

By depressing the ACK touch pad, the diagnostic code for the highest priority alarm is displayed (up to a total of two alarms). Depressing the TAG button will display any remaining controller alarms.

The controllers may operate in either the MANUAL or AUTOMATIC mode (AUTO is the preferred mode). In the MANUAL mode, the operator directly adjusts the controller output from the controller to the drain valve by positioning the selector bar above either the demand bar (right hand bar) OR the % level bar (middle bar) and uses the UP and Down arrow button to change controller output and thus drain valve position. In the AUTOMATIC mode, the operator first must null out the deviation, if any, between the OSP (left hand bar) and the demand signal. The A / M button is then depressed to shift the controller to AUTOMATIC. The operator then places the selector bar above the OSP bar and uses the UP and DOWN buttons to adjust the desired level to maintain. This signal is then used by the controller to automatically adjust the controller output signal to maintain AOG condenser level constant.

5. Water Separator (T-327 A/B) (Figure 3)

The water separators work in conjunction with the off-gas condenser to remove entrained moisture from the process gas flow. The water separators are in the turbine building in the Recombiner Rooms.

The water separators have no moving parts and are essentially pressure vessels containing a stainless steel demister. The moisture collects in the demister and drops to the vessel bottom to a drain, into a loop seal, which in turn fills and overflows to the shell side off-gas condenser drain. The drains continue to the Main Condenser. The loop seals have drains to the radwaste collecting system. The separator drain and separator discharge drain header loop seals are self-filling. The 1-inch globe valve (FO-69 A/B) must be shut in the water separator loop seal drain line.

The discharge header is equipped with a 1" drain line to remove additional condensation. The drain line is equipped with a drain pot that drains to chem rad waste. Level switch LS-9362B must be in service with the hand switch on panel CP-003 for LS-9362 in AUTO. LS-9362B controls SV-9362 which opens/closes AO-9362, the discharge header drain loop seal isolation. A low level signal energizes SV-9362 to close AO-9362 to fill the drain pot.

The low level alarm on CP-600 is illuminated by LS-9362A. Upon receiving the PIPING DRAIN POT LEVEL LO alarm the following actions are taken:

Confirm Alarm by checking the position of the AOG Offgas Line Drain Pot to Chem Radwaste Discharge Valve AO-9362. The normal position is open at panel CP003 in the Retention Building, but the valve should be closed due to low level. The loop seal should automatically refill and the valve should reopen. Check loop seal level locally on LI-9362 at the Condenser Bay west wall. Perform corrective actions to get the loop seal to refill. Close AO-9362 from the control switch on CP003 or close the manual valve 8-HO-180. When the low alarm clears reopen the valves and the loop seal is reestablished.

The water separator discharge lines have isolation valves AO-9278 and AO-9279. These isolations are in the lower recombiner room and are controlled from CP-600.

6. Hydrogen Analyzer (N009A/B) (Figure 4)

Gases leaving the water separator are continuously monitored for hydrogen content during plant operation by one of two General Electric hydrogen analyzers that have an LED readout on the front of the panel and at CP-600. Each analyzer can perform independent sample collection, and analysis for hydrogen (in percent) from the off-gas process line.

The analyzers are controlled from panel CP-600 or locally at the analyzer panel, which is in the recombiner room. This four-position control switch allows purge, zeroing, calibration, and sampling. The analyzer output is printed out at panel CP-600 and alarms if H_2 content in the sample exceeds 2 percent as detected by devices N-009 A(B).

The hydrogen analyzers are placed in service 24 hours prior to placing the augmented off-gas system in service. Loop seals are self-filling, using a check valve in the line to maintain the seal. The hydrogen analyzer sample chamber is supplied by demineralized water. The demineralized water is first cooled by "water chillers" to ensure the demineralized water adequately cools the hydrogen sample to maintain proper analyzer performance. Sample inlet temperature is maintained between 40°F and 100°F. The refrigerant of the water chiller is cooled by TBCCW. Demineralized water flow through the hydrogen analyzer coolers is adjusted to 2 gph.

The hydrogen analyzers are powered from 115 V lighting panel, 32L.

7. AOG 30 Minute Hold-Up Pipe

The 30 minute holdup pipe provides a time delay for the off-gas mixture to allow shorter-lived radioactive isotope decay (principally N-13, N-16, O-19, and certain isotopes of xenon and krypton) to non-radioactive isotopes, or radioactive particulate daughter products. The holdup pipe is sloped to drain condensate to the cooler condensers. The holdup pipe is in the charcoal vault in the retention building. Normal process line flow is 16 scfm.

8. Cooler Condenser (E-307A/B) (Figure 4)

Gases exiting the holdup line are directed to the cooler condensers where entrained moisture is condensed from the effluent for gas drying. The design specification for the system is < 5 percent moisture carryover to the adsorber vessels. There are two, 100 percent capacity, cooler condensers. The cooler condensers are in the off-gas retention building, southeast corner.

Gases passing through the cooler condenser are cooled by 34 degree ethylene glycol (33 percent by weight), which in turn is cooled by a freon refrigeration system. The temperature monitoring point is the moisture separator outlet. The glycol cooler system has a 3000 gallon storage tank in the off-gas retention building, an agitator, two identical pumps, and two complete and independent refrigeration systems. The glycol cooler tank receives chilled glycol from refrigerant machines, which are cooled by TBCCW. The off-gas moisture content is critical to the charcoal adsorber operating efficiency.

The off-gas enters the cooler condenser through air-operated valves AO-9220 and AO-9221. Hand switches on panel CP-600 allow selection of CLOSE or OPEN control of AO-9220 and AO-9221. Process gas enters the heat exchanger shell side and makes four passes over the tubes. These valves are automatically closed three seconds after AO-9230, condensate cooling out of off-gas condenser, begins to close.

Drains are routed from cooler condenser and moisture separator drains to drain valves AO-9256 and AO-9222 for trains "A" and "B" respectively. They are in the cooler condenser rooms. These loop seal drain valves are controlled from panel CP-600 by a hand switch and

respective solenoid valves. The loop seal drain valve for the cooler condenser in service is normally open.

Overpressure protection in the non-operating heat exchanger shell is provided by a relief valve, which relieves at 350 psig to the holdup line. The pressure in the shell is sensed by PSV-F100 A(B).

The glycol solution makes six passes in the condenser before exiting through an outlet isolation valve. The tubes are protected from overpressure by a relief valve (PSV-101) set at 100 psig that relieves back to the glycol storage tank. Tube pressure is sensed and controlled by PSV-101 A(B).

A glycol storage tank level switch (LS-N042) provides a low level alarm on panel CP-600, at 87 inches from the bottom. Isolation valves are provided between the glycol system and the cooler condenser.

9. Moisture Separator (T-328A/B) (Figure 4)

The moisture separator works in conjunction with the cooler condenser to remove moisture from the cooled off-gas. There is one separator on each cooler condenser outlet. The separators are in the retention building at the 5 foot level.

Except for piping size to and from the separators (4" on the moisture separator vs. 6" for water separators) the moisture separators are identical to the water separators. The moisture separator and cooler condenser share a common drain line loop seal. The loop seal has an isolation valve (AO-9259), which is controlled by a hand switch on panel CP-003. When in "AUTO", low level switch LS-9259B, and hi level switch LS-9259C control SV-9259 which open/closes AO-9259 to maintain a preset water level band in the seal. Water drained from the loop seal is directed to clean radwaste. LS-9259 A, B and C are located in the retention building lower level. A low level alarm is provided on CP-600 by a third level switch LS-9259A. Upon receipt of a low level alarm operators are directed to check the position of Cooler Cond Drain AO-9259 at panel C-003 in the Retention Building and check the loop seal level locally on LI-9259. If necessary direct I&C maintenance to refill the loop seal with an external hose from Demin Water.

10. Prefilter (X-349A/B) (Figure 4)

The filters have been removed. The vessels are still in place. This change was made to address the high D/P in the AOG system and water accumulation in the filter. The water in the filter could not be adequately drained and removed without opening the filter vessel. Since the filtration ability of the vessel is not needed due to low particulate loading, as well as the ability of the down-stream charcoal beds to remove any particulate matter. The prefilters now have a drain trap to automatically drain water to Radwaste.

11. Charcoal Adsorber (T-329 A/B) (Figure 5)

The 12 charcoal adsorber vessels are 49" diameter cylindrical tanks, approximately 21 feet 4 inches high, and contain 36 tons (3 tons per vessel) of granulated charcoal. Flow enters the vessel bottom through a distribution pipe and flows out through a similar pipe at the top.

The adsorber vessels contain activated carbon in granular charcoal form. The carbon is a medium, which retards passage of the xenon and krypton noble gases in the off-gas stream, allowing the radioactive isotopes to decay to radiation levels acceptable for and prior to atmospheric release. The solid daughter products from noble gas decay are removed by filtration and/or are retained on the charcoal; therefore, particulate activity release is expected to be negligible. Final charcoal adsorber effluent filtration precludes releasing charcoal fines. The adsorbers are in the off-gas retention building on the 5 foot level in the charcoal vault.

There are two adsorber trains aligned in parallel with six beds per train. The trains can operate in series or parallel operation depending on system process gas flow and adsorber train differential pressure. The adsorber vessels may be bypassed until high radiation level from the post-treat PRMs is reached. Bypass capability is controlled from panel CP-600 with keylock switch S-15, which in turn, controls both the charcoal adsorber train inlet and bypass valves, AO-9227 and AO-9228. Switch S-15 has three positions: 1) Bypass - will open AO-9228 and close AO-9227 which will bypass AOG flow around the charcoal beds. 2) Treat - will close AO-9228 and open AO-9227 to send AOG flow through the charcoal beds. 3) Auto - will maintain the bypass lineup with AO-9228 open and AO-9227 closed. If a hi rad signal comes in from AOG post treat PRM 1705-5 A/B, then the bypass valve AO-9228 will close and the charcoal bed inlet valve AO-9227 will open. An interlock between these two valves

prevents both being opened simultaneously. Limiting criteria for bed alignment operations is that condenser backpressure remains stable and adsorber train D/P remains below high alarm setpoint.

Charcoal efficiency is aided by maintaining the charcoal adsorber vault at an essentially constant temperature; i.e., optimum charcoal adsorption temperature. A separate air conditioning system maintains the vault at 77 ± 2°F. While the charcoal beds are bypassed in the automatic mode, the bypass valve will close and the charcoal bed inlet valves will open on any radiation alarm from the off-gas post-treatment radiation monitors.

Eliminating moisture intrusion to the charcoal vessels and prevention of "poisoning" is extremely important in this system. Moisture entrained in the carbon media diminishes noble gas retention efficiency. "Poisoning", such as coating with oil products, etc., causes localized "hot-spots", which could lead to a fire in the charcoal media.

A moisture element at the inlet of the charcoal adsorber vessels indicates process gas dewpoint at moisture transmitter MT-N019 at CP003 in the A.O.G. Retention Building. dewpoint exceed 48 degrees, an alarm "Gas reheater outlet dewpoint Hi temperature" annunciates on CP600 (B-6) in the main control room.

A multipoint temperature recorder (TR-9250) and alarms on panel CP-600 monitor temperature in selected vessels to alert personnel of abnormal conditions. A high temperature alarm (adsorber vessel high temperature) will annunciate on panel CP-600 when any recorder point exceeds 80°F.

Charcoal vault temperature is monitored at a recorder (TRS -615) on panel CP-600 as sensed by a temperature element (TE-NO29). A high temperature alarm is activated when vault temperature reaches 81°F and a low temperature annunciator alarms at 73°F. A charcoal adsorber train high differential pressure alarm on panel CP-600 activates at 40" H2O, as sensed through transmitter DPT-N020. DPT-N020 also supplies an indicator DPIS-R612 on panel CP-600.

Upon exiting the charcoal vault, the process flow returns to the off-gas system through the off-gas filter and to the stack. The stack valve AO-3751 and the drain valve AO-3750 will

isolate after a 13 minute time delay on hi-hi activity. If the OFFGAS ISOL CH PRM SEL switch is in MON-1, then the post treat PRM (1705-5A/B) will start the 13 min. timer. The post treat PRM is measuring activity at the outlet of the charcoal vault. If the OFFGAS ISOL CH PRM SEL switch is in MON-2, then the pre treat PRM (1705-3A/B) will start the 13 min. timer. The pre treat PRM is measuring the activity at the air ejectors (see the PRM Text for more detail).

D. INSTRUMENTATION AND CONTROLS

1. Control Room Instrumentation

Instrument/Location	Description
Off-gas pressure to "A" ("B") preheater PI-600 A (B) on panel CP-600	0-15 psig (normal 2 psig) Receives input from PT-N001A (B)
Recombiner A (B) gas inlet temperature TI-601A (B) on panel CP-600	0-700°F Receives input from TE-N002A (B)
Steam supply to jet compressors PI-9238 on panel CP-600	0-100 psig (normal 50) Receives input from PT-9238
Main steam pressure after PV-9239 PI-9239 on panel CP-600	0-600 psig (normal 300) Receives input from PT-9239
Cooling flow to off gas condensers FI-9231 on panel CP-600	0-1500 gpm Receives input from FT-9231
Glycol pumps discharge pressure PI-R605 on panel CP-600	0-50 psig (normal 10) Receives input from PT-N012
Off-gas reheater outlet dewpoint temperature recorder MRS-R609 on panel CP-600	0-100°F Receives input from MT-N017
Hydrogen analyzer A (B) percent hydrogen recorder AR-603 on panel CP-600	0-5 percent Receives input from AE-N009 A (B)
Glycol storage tank temperature recorder TRS-R606 on panel CP-600	0-100°F Receives input from TE-N013
Adsorber vessel area/temperature recorder TRS-R615 on panel CP-600	0-100°F (normal 77) Receives input from TE-N029
Recombiner temperature recorder TR-9250 on panel CP-600	0-1000°F Recombiner A (B) level temperatures received from TE-N003 A (B) TE-N004 A (B), TE-N005 A (B)

1. **Control Room Instrumentation (cont.)**

Instrument/Location	Description
Charcoal adsorber vessel temperature multipoint recorder TR-9250 on panel CP-600	0-100°F Train 1 vessel temperature received from TE-N021, N022, N023 Train 1 second vessel temperature received from TE-N024. Train 1 third vessel temperature received from TE-N025. Train 1 last vessel temperature received from TE-N026A. Train 2 last vessel temperatures received from TE-N026B. Train 2 first vessel temperatures received from TE-N027
Off-gas prefilters differential pressure meter DPIS-R611 on panel CP-600	0-12" H_20 Received from dPT-N019
Off-gas adsorber trains differential pressure meter DPIS-R612 on panel CP-600	0-60" H_20 Received from dPT-N020
Off-gas filters in main stack differential pressure meter DPIS-R616 on panel CP-600	0-12" H_20 (reading X5) Received from dPT-N031
Hi H2 Alarm A (B) Panel CP-600	Red lights below hydrogen analyzer recorder indicate high hydrogen level when illuminated
Vacuum pump running A (B) Panel CP-600	Red lights below hydrogen analyzer recorder indicate hydrogen analyzer vacuum pump energized
Detector level hi/lo A (B) Panel CP-600	Red lights below hydrogen analyzer recorder indicate excessively high or low level in analyzer's sample detection chamber
Detector Vacuum/Temperature hi/lo A (B) Panel CP-600	Red lights below hydrogen analyzer recorder indicate high water temperature in analyzer's sample detection chamber
Detector No flow A (B) Panel CP-600	Red lights below hydrogen analyzer recorder indicate no flow to the analyzer
Adsorber bypass valve position indication Panel CP-600	Two lights actuated by limit switch on AO-9228 valve stem, Red (OPEN) Green (CLOSED)
Adsorber inlet valve position indication Panel CP-600	Two lights actuated by limit switch on AO-9227 valve stem. Red (OPEN) Green (CLOSED)

2. Local Instrumentation

Instrument/Location	Description
Off-gas to preheater A (B) pressure R-001 A (B) on panel CP-001	0-15 psig Receives input from PT-N001 A(B)
Recombiner A (B) inlet pressure R-002A (B) on panel CP-001	0-15 psig Pressure gauge
Condenser A (B) off-gas outlet temperature TIS-R005A (B) on panel CP-001	50-150°F Receives input from TE-N008 A (B)
Gas reheater outlet moisture transmitter MT-N017 on panel CP-003	25-100°F dewpoint Receives input from ME-N016A or B. Switch at MT-N017 selects primary element position (1) or backup element position (3)
Pre-filter differential pressure transmitter dPT-N019 on panel CP-003	0-12" H_20 Receives input from dPIS-R611
Adsorber differential pressure transmitter dPT-N018 on panel CP-003	0-12" H_20 Receives input from dPIS-R618
Gas reheater outlet temperature transmitter TT-N034 on panel CP-003	35-85°F (10-50 ma) Receives input from TE-N018
Adsorber vault temperature TI-R010 on panel CP-003	50-150°F Receives input from TE-N039
H_2 Analyzers LED AE-N009A and B CP-003	LED readout % H_2 Receives input from signal conditioner package

3. Alarms

Title/Location	Setpoint/Initiating Device
VAPOR VALVE NOT FULL OPEN Panel CP-600L A1	AO-3703, 3704, 3710 or 3711 not full open ZS-3703, 3704, 3710, 3711
OFF GAS PRESSURE HI Panel CP 600L A2	35 psig (increasing) PS-3718A, PS-3718B
STEAM JET COMPRESSOR STEAM FLOW LO Panel CP 600L A3	4500 lbm/hr (decreasing) **AND** Offgas Low Flow Bypass Switch (C10) in Normal FIS-9262
RECOMBINER TEMP HI/LO Panel CP 600L A4	1) HI: 875°F (increasing) 2) LO: 330°F (decreasing) TR-9250, RECOMBINER & ADSORBER TEMPERATURES (Channels 1-6)
CONDENSER A LEVEL HI/LO Panel CP 600L A5	1) HI: 40.6% (10.8 inches) 2) LO: 9.0% (2.4 inches) N62-N007A-2 (LIC R004 A) N62-N007C-2 (LIC R004 C) Disabled when B train in service from MO-9406 close limit switch.

3. **Alarms (cont.)**

Title/Location	Setpoint/Initiating Device
AFTER CNDSR LOOP SEAL LVL HI/LO Panel CP 600L A8	1) -5.5" (decreasing) 2) 14.05 psig (increasing) 1) LS-9071, LS-9072 2) LS-9078
GLYCOL TANK LEVEL LO Panel CP 600L A9	87 inches (decreasing) LS-N042
RETENTION BUILDING HVAC TROUBLE Panel CP 600L A10	various Aux Relay 70X1 (Panel C132)
OFF GAS TEMP HI Panel CP 600L B2	250°F (increasing) TS-3717A, TS-3717B
STEAM JET COMPRESSOR STEAM PRESS HI/LO Panel CP 600L B3	1) 30 psig (decreasing) 2) 42 psig (increasing) 1) PS-9242A 2) PS-9242B
RECOMBINER A INLET TEMP LO Panel CP 600L B4	250°F (decreasing) TS-N600A. Disabled when B train in service from MO-9406 close limit switch.
CONDENSER B LEVEL HI/LO Panel CP 600L B5	1) HI: 40.6% (10.8 inches) 2) LO: 9.0% (2.4 inches) N62-N007B-2 (LIC R004 B) N62-N007D-2 (LIC R004 D) Disabled when A train in service from MO-9404 close limit switch
H2 ANALYZER B H2 CONC HI Panel CP 600L B7	2% (increasing) N009B (CH B H2 ANALYZER)
COOLER CNDSR LOOP SEAL LVL LO Panel CP 600L B8	2.5 inches or 12.5% (decreasing) LS-9259A
GLYCOL TANK TEMP HI Panel CP 600L B9	40°F (increasing) TRS-R606, GLYCOL TEMP Recorder
RETENTION BUILDING TBCCW PRESS LO Panel CP 600L B10	70 psig (decreasing) PS-9274
OFF GAS OUTLET FLOW HI Panel CP 600L C2	170 SCFM (increasing) with a 10 sec time delay (located in Beta SER) flow recorder 8-FR-1705-14 (Panel C902)
STEAM SUPPLY PRESSURE HI/LO Panel CP 600L C3	1) 270 psig (decreasing) 2) 330 psig (increasing) 1) PS-9240A 2) PS-9240B
RECOMBINER B INLET TEMP LO Panel CP 600L C4	250°F (decreasing) TS-N600B. Disabled when A train in service from MO-9404 close limit switch

3. **Alarms (cont.)**

Title/Location	Setpoint/Initiating Device
CONDENSER A OUTLET TEMP HI Panel CP 600L C5	140°F (increasing) TIS-R005A
PIPING DRAIN POT LEVEL LO Panel CP 600L C8	2 inches (decreasing) or 8.7 inches below Drain Pot center line LS-9362A
GLYCOL TANK TEMP LO Panel CP 600L C9	34°F (decreasing) TRS-R606, GLYCOL TEMP Recorder
CONDENSER B OUTLET TEMP HI Panel CP 600L D5	140°F (increasing) TIS-R005B
HOLDUP LINE LOOP SEAL LVL LO Panel CP 600L D8	-5.5" (decreasing) LS-9073, LS-9074
GLYCOL REFRIG UNIT A/B OVERLOAD Panel CP 600L D9	high current 1) overload device - REFRIG UNIT, X-346A 2) overload device - REFRIG UNIT, X-346B
PRE-FILTER DP HI Panel CP 600R A1	8" WC (increasing) DPIS-R611, PRE-FILTER d/P meter
ADSORBR INLET DEWPOINT TEMP HI Panel CP 600R A2	48°F (increasing) MRS-R609, DEW PT REHEATER OUTL Recorder
MAIN STACK ISOL VALVE CLOCED Panel CP 600R A3	AO-3751 closed ZS-3751B (limit switch)
PRE-TREATMENT RAD HI-HI Panel CP 600R A4	2500 mR (increasing) **AND** keylock switch (17A-S12) in "POSITION-2" (Panel CP600) Log Rad Monitors 1705-3A, B (Panel C910)
POST-TREATMENT RAD HI-HI Panel CP 600R A5	90,000 cps (increasing) 1) Log Rad Monitors RM-1705-5A, B (C910) 2) RR-1705-22 (Panel C902)
MAIN STACK RAD HI-HI Panel CP 600R A8	5000 cps (increasing) Process Rad Monitors 1705-18A, B (C910)
ADSORBR TRAIN DP HI Panel CP 600R B1	40" WC (increasing) DPIS-R612, ADSORBER VESSELS d/P meter
ADSORBR VESSEL TEMP HI Panel CP 600R B2	80°F (increasing) TR-9250, RECOMBINER & ADSORBER TEMPERATURES (Channels 6-13)
13 MIN TIMER INITIATED Panel CP 600R B3	Both channels of selected Rad Mon above upscale trip **OR** both channels downscale 1) Log Rad Monitors 1705-3A, B **OR** 2) Log Rad Monitors 1705-5A, B
PRE-TREATMENT RAD HI Panel CP 600R B4	1250 mR (increasing) Recorder 40-RR-1705-13 (Panel C902)

3. **Alarms (cont.)**

Title/Location	Setpoint/Initiating Device
ADSORBR VAULT RAD HI Panel CP 600R B5	800 mR/hr (increasing) ARM Ind/Trip Unit RIS-1705-60
POST-TREATMENT RAD HI Panel CP 600R B6	45,000 cps (increasing) Log Rad Monitors RM-1705-5A, B (C910)
MAIN STACK RAD HI Panel CP 600R B8	2500 cps (increasing) Process Rad Monitors 1705-18A, B (C910)
AFTER FILTER DP HI Panel CP 600R C1	8" WC (increasing) 1) PSID-3756 (Stack Bldg) 2) DPIS-R616, OFF-GAS FILTERS d/P meter
ADSORBR VAULT TEMP HI Panel CP 600R C2	81°F (increasing) TRS-R615, ADSORBER VAULT TEMP Recorder
PRE-TREATMENT RAD MONITOR DNSCL/INOP Panel CP 600R C4	1 mR (decreasing) Log Rad Monitors 1705-3A, B (C910)
ADSORBR VAULT RAD MONITOR DNSCL/INOP Panel CP 600R C5	0.3 mR/hr (decreasing) ARM Ind/Trip Unit RIS-1705-60
POST-TREATMENT RAD MONITOR DNSCL/INOP Panel CP 600R C6	1) 3 cps (decreasing) 2) 50V DC less than normal (decreasing) Log Rad Monitors RM-1705-5A, B (Panel C910)
MAIN STACK RAD MONITOR DNSCL/INOP Panel CP 600R C8	1) 1.3 cps (decreasing) 2) 50V DC less than normal (decreasing) DNSCL/INOP Process Rad Monitors 1705-18A, B (C910)
ADSORBR VAULT TEMP LO Panel CP 600R D2	73°F (decreasing) TRS-R615, ADSORBER VAULT TEMP Recorder
ADSORBR TRAINS BYPASSED Panel CP 600R D3	FLOW CONTROL keylock switch in ADSORBER BYPASS position FLOW CONTROL keylock switch (CP600)
PRE-TREATMENT SAMPLE FLOW HI/LO Panel CP 600R D4	Contact 1: 17.9" Hg (increasing vacuum) Contact 2: 2" Hg (decreasing vacuum) 8-1789-DPS-1
POST TREATMENT SAMPLE FLOWHI/LO Panel CP 600R D6	1) low flow: 2.5" Hg (dec vac) 2) high flow: 11" Hg (inc vac) 16-PS-1 (Rack C1790)
MAIN STACK SAMPLE FLOW HI/LO Panel CP 600R D8	1) 18" Hg (inc vac) **OR** 1" Hg (dec vac) 2) 8" Hg (dec vac) 1) 8-2247-PS1 2) 8-2247-PS2

4. Interlocks and Trips

Interlock or Trip	Functions
Cooler condenser inlet valves cooling water interlock	If AO-9230 is closed for 1 second, AO-9220 and AO-9221 will close
Off-gas high radiation isolation	Off-gas discharge valve to main stack (AO-3751, 3750) closes on high activity after 13 minutes. Logic for the trip is both radiation monitors high-high, one high-high with other downscale, or both downscale. (For more detail see condenser vacuum and air removal system text.)
Adsorber bypass valve high radiation isolation	Adsorber inlet valve (AO-9227) opens and adsorber bypass valve (AO-9228) closes on off-gas high radiation signal from RM-1705-5A(B) if the associated keylock switch is in AUTO
Low steam jet compressor steam flow isolation	Low steam flow to steam jet compressors of 2750 lbm/hr decreasing, as sensed by FIS-9262 thru FE-9262, closes off-gas system isolation "vapor valves" 3703, 3704, 3710 and 3711 (may be bypassed)
Alarms disabled for the off gas train out of service.	When Steam Jet Compressor steam supply valve MO-9206 is closed alarms CONDENSER A LEVEL HI/LO and RECOMBINER A INLET TEMP LO alarms will be disabled. When Steam Jet Compressor steam supply valve MO-9204 is closed alarms CONDENSER B LEVEL HI/LO and RECOMBINER B INLET TEMP LO alarms will be disabled.

5. Control Room Controls

Item/Location	Functions of Position	
Off-gas inlet to steam jet compressor A(B) control switch	OPEN	Opens MO-9205 (9207), energizes a green indicating light
	NORM	Spring return neutral position
	CLOSE	Closes MO-9205 (9207), energizes a red indicating light
Main steam supply to jet compressor A (B) control switch	OPEN	Opens MO-9206 (9204), energizes a red open indicating light
	NORM	Spring return neutral position
	CLOSE	Closes MO-9206 (9204), energizes a green closed indicating light

5. **Control Room Controls (cont.)**

Item/Location	Functions of Position	
Preheater A(B) inlet drain to main condenser control switch	OPEN	Opens AO-9255, energizes
	DRN A	Red open indicating light
	CLOSE	Closes both drains, energizes a green closed indicating light
	OPEN	Opens AO-9275, energizes
	DRN B	A red open indicating light
HP service air to steam jet compressor A(B) 4 cfm control switch	CLOSE	Closes AO-9216 (9217), energizes a green closed indicating light
	OPEN	Opens AO-9216 (9217), energizes a red open indicating light
HP service air to steam jet compressor A(B) 12 cfm control switch	CLOSE	Closes (AO-9276 (9277), energizes a green closed indicating light
	OPEN	Opens AO-9276 (9277), energizes a red open indicating light
Preheater A(B) outlet drain valve control switch	CLOSE	Closes AO-9210 (9211), energizes a green closed indicating light
	OPEN	Opens AO-9210 (9211), energizes a red open indicating light
Off-gas condenser A/B gas side drain to main condenser (50 percent)	CLOSE	Closes AO-9252, energizes a green closed indicating light
	OPEN	Opens AO-9252, energizes a red open indicating light
	AUTO	Position of AO-9252 controlled by LIC-R004A(B)
Off-gas condenser A/B gas side drain to main condenser (70 percent)	CLOSE	Closes AO-9251, energizes a green closed indicating light
	OPEN	Opens AO-9251, energizes a red open indicating light
	AUTO	Position of AO-9251 controlled by LIC-R004 C and LIC-R004 D

5. Control Room Controls (cont.)

Item/Location	Functions of Position	
Off-gas condenser level detector selector switch	A	Selects condenser A level to be monitored
	B	Selects condenser B level to be monitored
Recombiner A (B) temperature control switch R-012A (B)	OFF	Removes temperature controller R-012A (B) from service
	ON	Places temperature controller R-012A (B) in service
Off-gas cond. condensate cooling to main condenser, control switch	OPEN	Opens AO-9230 when FIS-9232 sensed less than 800 gpm to the main condenser
	CLOSE	Closes AO-9230 and AO-9220/21 close 1 seconds after AO-9230 starts to close
Off-gas condenser A (B) condensate cooling outlet block valve control switch	CLOSE	Closes MO-9271 (9272), energizes a green closed indicating light
	NORM	Spring returns to neutral position
	OPEN	Opens MO-9271 (9272), energizes a red open indicating light
H_2 recombiner condenser A (B) process drain valve control switch	CLOSE	Closes AO-9269 (9270), energizes a green closed indicating
	OPEN	Opens AO-9269 (9270), energizes a red open indicating light
Off-gas condenser A (B) water separator outlet block valve control switch	CLOSE	Closes valve F-089A-9278 (E089B-9279), energizes a green closed indicating light
	OPEN	Opens valve F-089A-9278 (E089B-9279B), energizes a red open indicating light

5. Control Room Controls (cont.)

Item/Location	Functions of Position	
Cooler condenser A(B) off-gas inlet block valve control switch	CLOSE	Closes valve AO-9220 (9221), energizes a green closed indicating light
	OPEN	Opens valve AO-9220 (9221), energizes a red open indicating light (interlock with AO-9230)
Glycol refrigeration unit A (B) control switch	START	Starts refrigeration machine operation, energizes a red operating light
	AUTO	Normal position of the switch following a START
	STOP	Stops refrigeration machine operation, energizes a green stopped light
	AMBER	Indicates an inoperative condition when illuminated
Glycol pump A (B) control switch	START	Starts pump, energizes a red operating light
	STOP	Stops pump, energizes a green stopped light
	AMBER	Indicates an inoperative condition when illuminated
Cooler condenser A (B) and moisture separator A (B) drain to CRW	CLOSE	Closes AO-9256 (9222), energizes a green closed indicating light
	OPEN	Opens AO-9256 (9222), energizes a red open indicating light
H_2 analyzer A (B) control switch	PURGE	Places analyzer in purge mode
	CALIB	Places analyzer in its calibration mode. Gas with known H_2 concentration passes through system
	SAMPLE	Places analyzer in normal service mode. Off-gas sample passes through system
	ZERO	Places analyzer in zero calibration mode. Gas with zero H_2 content passes through system

5. Control Room Controls (cont.)

Item/Location	Functions of Position
H_2 analyzer A (B) control switch	AUTO Places analyzer in automatic mode, actuating its cycle timer MANUAL Inhibits automatic cycle timer operation
Adsorber inlet keylock switch (S-15) CP-600	BYPASS Opens AO-9228 and closes AO-9227, bypassing the adsorber vault TREAT Closes AO-9228 and opens AO-9227 placing adsorber vault in service AUTO Opens AO-9228 and closes AO-9227 same as bypass lineup. A hi rad on post treat PRM will cause AO-9228 to close and AO-9227 to open.

6. Local Controls

Location	Functions
AOG steam supply pressure indicating controller PIC-9251 on panel C-75	MANUAL A potentiometer allows varying steam supply pressure to the AOG system AUTO The Foxboro controller maintains 40-50 psi steam supply pressure
Preheater steam drain A (B) control switch on panel CP-100	OPEN Opens AO-9212 (9213), energizes a red open indicating light CLOSE Closes AO-9212 (9213), energizes a green closed indicating light
Preheater steam drain A (B) control switch on panel CP-001	OPEN Opens AO-9214 (9215), energizes a red open indicating light CLOSE Closes AO-9214 (9215), energizes a green closed indicating light
Off-gas cond. normal level controller LIC-R004A(B) on panel CP-001	VARIOUS A potentiometer allows varying the level setpoint to be maintained by the controller (normally 50 percent). The controller to be operational is determined by a selector switch (S-28) on panel CP-600. (Controller "A" is for train "A")

6. Local Controls (cont.)

Location	Functions	
Off-gas cond. high level controller LIC-R004C(D) on panel CP-001	VARIOUS	A potentiometer allows varying the level setpoint to be maintained by the controller (normally 70 percent). The controller to be operational is determined by a selector switch (S-28) on panel CP-600 which selects "A" or "B". This is a ganged switch. If "A" is selected normal level is maintained by controller "A" and high level by controller "C". (controllers "B" and "D" work together)
Off-gas condenser flow indicating controller FIC-9231 on panel C-75 (FV-9231 has been removed and the pipe openings have been closed with blind flanges)		
Catalytic recombiner temperature controller (TIC-R012 A/B) on panel CP-001	VARIOUS	A potentiometer allows varying the temperature setpoint to be maintained by the controller
(> 350°F). This temperature is sensed by elements TE-N040A(B)		
Cooler condenser A and B drain control switch on panel CP-003	OPEN	Opens AO-9259 if low level in condenser does not exist, energizes a red open indicating light
	CLOSE	Closes AO-9259 if high level in condenser does not exist, energizes a green closed indicating light
Moisture element selector switch for MT-N017 dew point indication at CP003	POSITION: (1) Primary moisture detector ME-N016A (2) Backup moisture detector ME-N016B	

E. SYSTEM INTERRELATIONSHIPS

1. Standby gas treatment (SGT) system

If both main stack dilution fans are lost, both SGT fans will be put in service to provide dilution air for the off-gas stream until subsequent action is taken. Lack of dilution fans or SGT fans could result in inadequate dilution of any hydrogen that may be present during various plant evolutions such as start up or shutdown when the recombiners are bypassed.

2. Main condensate system

The main condensate system provides condensate supply to the off-gas condenser to be used as a coolant. A condensate failure or isolation would cause an increase in moisture content into the catalyst bed, this would reduce catalyst efficiency. The main condenser also accepts drains from loop seals and traps.

3. Glycol system

This system provides cooling of the glycol solution that is used in the cooler condensers. There are two +34°F glycol coolers available, one for each train. A glycol cooler failure would result in moisture intrusion to the charcoal adsorber and decreased noble gas retention (hold up) time.

4. TBCCW

TBCCW cools the demineralized water that fills the hydrogen analyzer bubble chamber to ensure proper analyzer operation, and ensures minimum moisture content in the hydrogen sample. TBCCW also cools the glycol medium which in turn cools the cooler condenser gases. Loss of TBCCW to the cooler condenser cooling medium (glycol) would cause moisture intrusion to the charcoal adsorber and decreased noble gas retention (hold up) time.

5. Main Steam supply

Steam is supplied to the steam jet compressors to provide dilution steam and driving force for the gases. Inadequate steam flow to the steam jet compressors will cause recombiner overheating and catalyst deterioration. Hydrogen and oxygen concentrations above 4 and 26 volume percent, respectively, cause a combustible gas mixture. Alarms are provided for low steam flow and low steam pressure. An increased steam flow to recombiner could be caused by ejector steam supply nozzle wear. This would reduce the recombination degree at low power levels. At 4500 LBM/Hr the condenser vapor valves isolate.

Steam is also supplied to the preheaters to maintain inlet temperature to the recombiner greater than 350°F. If steam pressure drops too low, recombiner performance would fall at low power levels and the recombiner gas discharge hydrogen content would increase, eventually to a combustible mixture.

6. Instrument air

Instrument air is provided for pneumatic valves remote operation such as: temperature, pressure or flow control. A loss of this control will result in a loss of the AOG system.

7. Service air system

The service air system provides purge air to the AOG system when main condenser inleakage is low. This maintains proper dilution of the off-gas process line to prevent combustible oxygen and hydrogen mixtures. It also supplies a sealing media for AOG valves.

8. Radwaste collection system

The radwaste equipment drain system receives liquid removed from the cooler drains, hydrogen analyzers, and the moisture drains.

9. Power supplies

a. MCC B-30 receives power from 480V bus B-8, and supplies power to the following loads:

1. H_2 recombiner room unit coolers
2. Steam jet compressor inlet valves MO-9204(9206)
3. Steam jet compressor off-gas inlet valves
4. Off-gas condenser cooling water discharge valves MO-9271(9272)

A loss of MCC B-30 would result in high moisture dewpoint in the recombiner and result in a less efficient recombination.

b. MCC B-31 receives power from 480V bus B-8, and supplies power to the glycol system components. Loss of MCC B-31 would result in high moisture dewpoint into the vault, resulting in less efficient adsorber operation.

c. Lighting panel 31-L supplies power to; panel CP-003, glycol panel (CP-002), panel CP-600, H and V panel. Loss of panel 31-L would result in loss of panel indication and controls from the associated panels listed.

d. Lighting panel 32-L supplies power to; panel C-75, recombiners A(B), panel CP-001 and H_2 analyzers N009A(B). If lighting panel 32-L was lost the abnormal operating procedures for recombiner failure (2.4.141) and H_2 analyzer failure should be followed. H_2 analyzer operation must be re-instated within 7 days.

F. SYSTEM OPERATIONAL SUMMARY

NOTE: This section outlines the major steps performed during system operations and is not intended to be substituted for plant operating procedures.

1. Normal System Operation

a. System start-up (2.2.106)

Through station start-up, operation, and shutdown, gaseous radioactive wastes are produced. Thus, the off-gas system continuously collects, allows decay, filters, and discharges these products.

The augmented off-gas treatment system adds more delay to the radioactive gases discharged to the atmosphere in the off-gas stream, reducing the activity level still further prior to atmospheric venting. Therefore, for normal plant operation to be maintained, the AOG system must be operating in conjunction with the off-gas system.

During startup, the mechanical vacuum pump is put into service to remove the gases from the main condenser and create a condenser vacuum.

As the condenser vacuum rises the SJAEs may be readied and put into operation. Once the SJAEs are operating and the condenser vacuum is assured, the mechanical vacuum pump may be isolated and removed from service. (Note: The mechanical vacuum pump is not to be operated when the reactor is above 5 percent rated thermal power. The major concern (FSAR) is radioactive gas release).

The AOG system requires adequate time to purge the prefilters and preheater, stabilize the 34°F glycol system, and to preheat the catalytic recombiner. Main steam is slowly introduced to warm up the system.

When placing the off-gas condensers in service the condenser is vented, then the off-gas condenser cooling water return to the main condenser valve (AO-9230) is opened by placing its control switch on panel CP-600 to AUTO. MO-9271 or MO-9272 is jogged off its seat to purge air from the off-gas condenser tubes to the main condenser, then opened to establish 900 gpm flow through the condenser to be placed in service.

To help establish the off-gas flow, bleed air (service air) is also supplied to the system when condenser in-leakage is low. This purge air ensures proper process line dilution and maintains sufficient process flow rate, transmitting heat from the preheater to the recombiner.

To place the steam jet compressors in service the steam supply pressure reducing station PCV-9239 is positioned to obtain 300 psig. The low flow selector switch is placed in OVERRIDE until steam flow pressure exceeds 300 psig. Pressure reducing station PCV-9238 is adjusted to maintain 36 psig downstream of reducer. Purge air to the jet compressor must be shut off. The train water separator discharge valve (AO-9278/9279) is opened. Then the jet compressor steam supply isolation valve (MO-9206/9204) is opened. The 4 cfm dilution air line is utilized until normal condenser vacuum is achieved.

Before the off-gas stream can be introduced to the AOG system the hydrogen analyzers must be in service. Hydrogen monitoring is required at all times when the AOG system is in operation.

b. Operation

With the plant operating at high power, the AOG system is operating to reduce the quantity of hydrogen gas passing through the off-gas system.

During glycol cooler operation, one glycol pump operates continuously. The refrigeration machines operate alternately, switching from one machine to the other automatically every 24 hours. Coolant is continuously circulated through both machines, but is cooled only by the operating machine. The in-service refrigeration machine maintains the coolant solution temperature at 34 $\pm$ 5°F. When coolant temperature exceeds this range a temperature indicating controller (TIC-R013) sequentially loads the

in-service refrigeration machine to correct the temperature. Temperature element TE-N014A sends signals to TIC-R013. If temperature rises to 36°F, the standby refrigeration machine is brought on line. If coolant temperature drops to 34°F, the hot gas bypass valve (internal to the refrigeration machine) is opened to stop further cooling until coolant temperature is brought back into operating range. At 33°F the refrigeration machine will be shutdown and the low temperature alarm on panel CP-600 is activated. A refrigeration machine inoperative alarm is also provided when the machine trips. Temperature in the glycol storage tank is monitored by TE-N013 which supplies signals to recorder TRS-R606 on panel CP600. A high temperature alarm is activated by TE-N014A at 40°F increasing.

c. Shutdown

1. Normal System Shutdown (2.2.106)

The integrated system cannot operate on a partial shutdown basis; therefore, when shutdown is desired, the whole system must be shutdown. The in-service steam jet compressor is removed from service by securing the main condenser steam jet air ejectors, vapor valves and applicable steam jet compressor steam supply. The preheaters are shutdown by reducing the setpoint on PIC-9239 at panel C-75. The charcoal adsorber bed bypass valve is opened and inlet valve shut. If the adsorber is purged too close to shutdown, stack limits may be exceeded, therefore, monitor the AOG process radiation monitors at the radiation monitor on panel 902. Secure the condensers and cooling water systems after proper cooldown is completed.

2. Automatic System Shutdown

The AOG system integrated operation is automatically secured upon the following conditions:

a) Main stack isolation valve AO-3751 closure from high radioactivity in off-gas at the steam jet air ejectors.

b) Cooler condenser "A" and "B" inlet valves AO-9220 and AO-9221 closure from losing condensate cooling water, activated by condensate cooling water valve AO-9230 starting to close (3 second TD).

c) Main condenser vapor valves AO-3703, AO-3704, AO-3710, and AO-3711 (covered in the condenser vacuum and air removal system text) closure due to one of the following conditions:

1) Low steam pressure to the SJAE inlet regulator (<40 psig).
2) High temperature in the off-gas 30 minute holdup line (250°F).
3) High pressure in the off-gas 30 minute holdup line (35 psig).
4) Low dilution flow to the steam jet compressors (<4500 lbm/hr).

If the AOG system is automatically shutdown, immediately attempt to determine and correct the cause and restore the affected component to service. AOG pressure should be maintained at less than 15 psig as read on PI-R600 at panel CP-600. Stop compressed gas addition as soon as possible.

2. Abnormal System Operation

a. Abnormal carbon vault temperature (2.4.136)

Abnormal vault temperature is indicated on TRS-R615, and associated alarm. Normal vault temperature is 77°F ± 2°F. Vault ventilation system should be restored to proper operation and bring vault temperature to normal within 48 hours. Closely monitor the off-gas release rate. If temperatures are increasing beyond the first bed in each train the charcoal beds should be bypassed and drained and the moisture source is removed. The AOG system operation and performance should be monitored hourly until vault temperature is within specifications.

b. Loss of coolant to the off-gas condenser (2.4.138)

Loss of coolant to the off-gas condenser is indicated by increasing temperature and dewpoint, and decreased flow reading, or for a rapid loss of coolant, indication is provided by associated alarms. Immediate actions are to verify AO-9230 is open, along with MO-9271 and 9272 open/closed as appropriate for on service cooler. If gas outlet

temperature approaches 212°F, reduce power below 50% and then bypass the AOG system. Attempts are made to reestablish cooling water flow. If successful, AOG flow is restored. If not, power is maintained below 50% due to effluent tech. spec. limitations.

c. Recombiner malfunction (2.4.14.1)

A recombiner malfunction is indicated by abnormal recombiner differential temperatures or exit temperatures or elevated AOG radiation and/or hydrogen levels. The preheater operation and dilution steam flow is checked. If recombiner temperature exceeds 1000°F, the reactor is immediately scrammed.

If dilution steam flow to the jet compressor is lost at high reactor power combined with a isolation logic failure on valves AO-3703, 04, 10, and 11 on the main condenser, the recombiner temperature would exceed normal temperature limits and damage the catalyst.

Normally if the recombiner temperature is high for a specific reactor power level, the problem could be attributed to a loss of dilution steam to the jet compressor. On the other hand, if the recombiner temperature is too low, there are three possible causes: low H_2 production, high dilution steam flow, H_2 and O_2 not recombining; therefore, little or no heat production, or moisture in the recombiner.

d. Augmented Off-gas explosion (2.4.55)

An off-gas explosion is indicated by: a loud or unusual noise in the turbine building, AOG retention building or off-gas stack; a high temperature or pressure in the off-gas line; automatic condenser vapor valve closure; or high radioactive gas release from the reactor building vent as indicated by the process radiation monitor recorder 1705-24 on panel 902. The vapor valves close automatically on off-gas high pressure (35 psig) or high temperature (250°F). When the vapor valves shut, condenser vacuum will begin to degrade. At 26 inches vacuum the condenser high pressure alarms are actuated, and turbine trips at 20 inches vacuum and at 7 inches the bypass valves close.

If an off-gas explosion does occur, and the vapor valves have closed and there are indications of system damage, the reactor is immediately scrammed and the plant shutdown. Monitor the reactor building process radiation monitor for radioactive gas release rate.

e. Loss of a nonredundant AOG system component

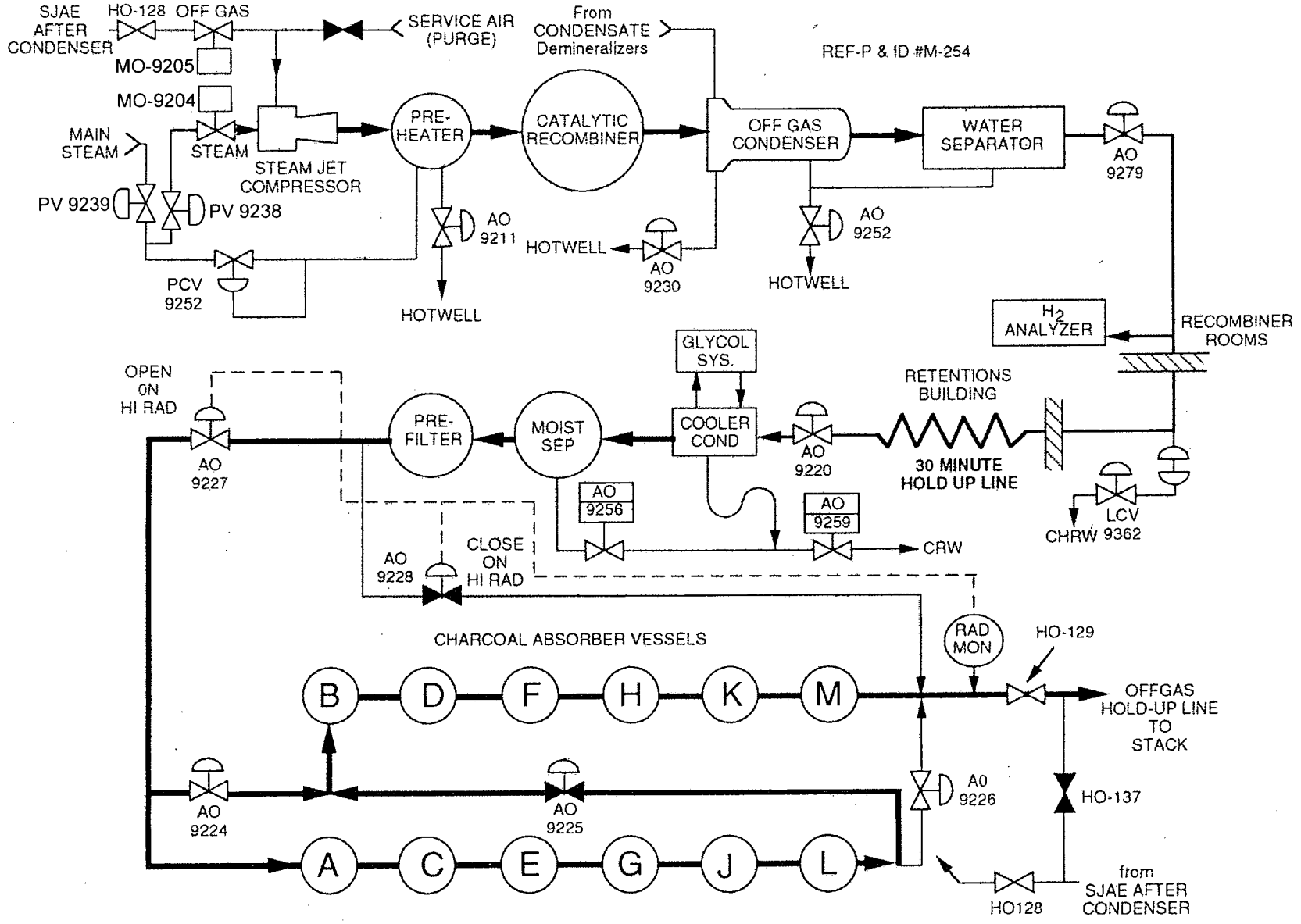
If a nonredundant augmented off-gas system component fails provisions are made to bypass the augmented off-gas system and operate the station using the installed 30 minute off-gas holdup system until augmented off-gas system maintenance can be completed.

G. INDUSTRY LESSONS LEARNED

None

H. LIST OF FIGURES

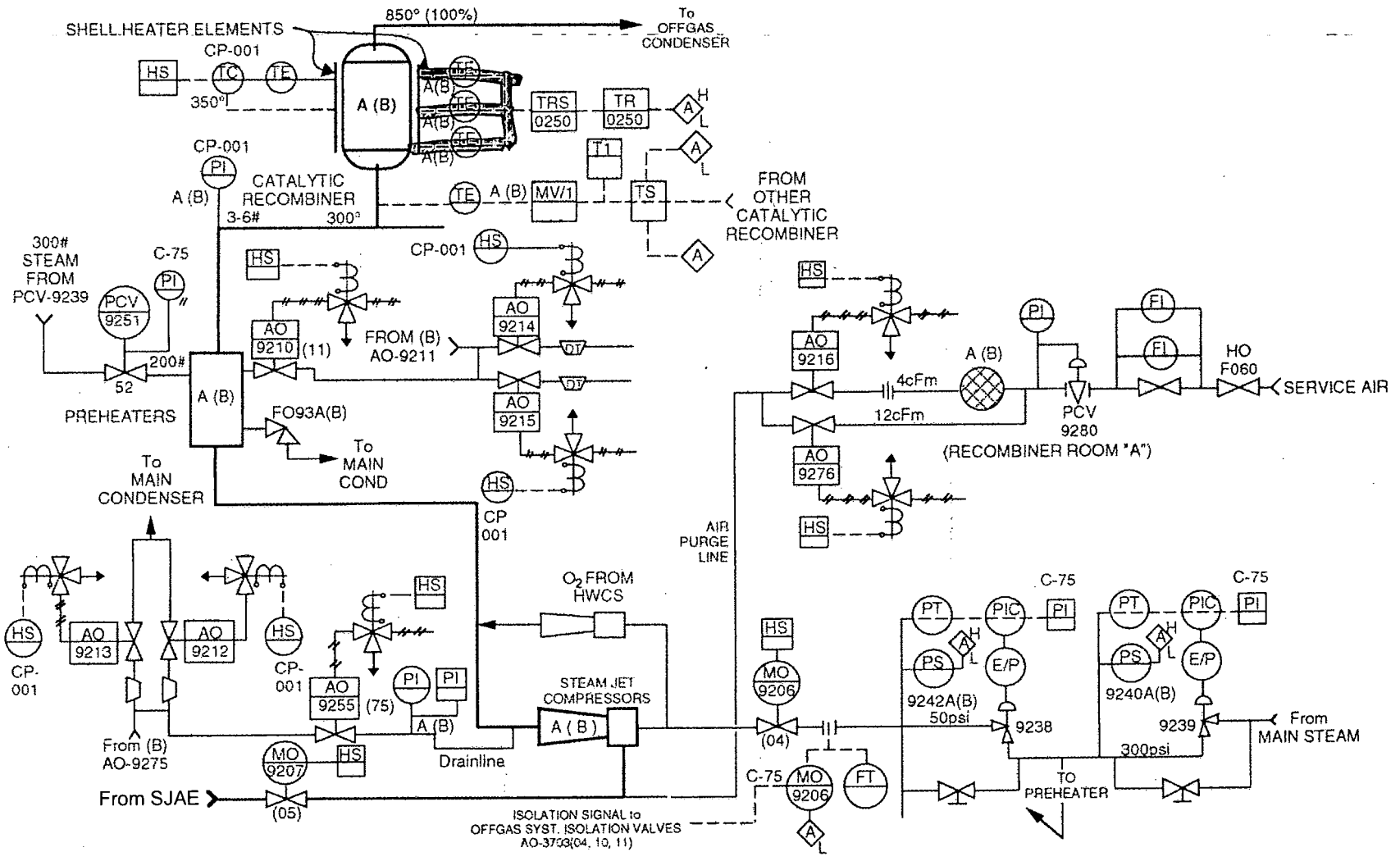
1. Augmented Off-Gas System (Train "B")
2. Augmented Off-Gas System
3. Augmented Off-Gas
4. Augmented Off-Gas
5. Augmented Off-Gas
6. AOG Level Controllers
7. AOG Level Controllers



AUGMENTED OFF-GAS SYSTEM (TRAIN "B")

FIGURE 1

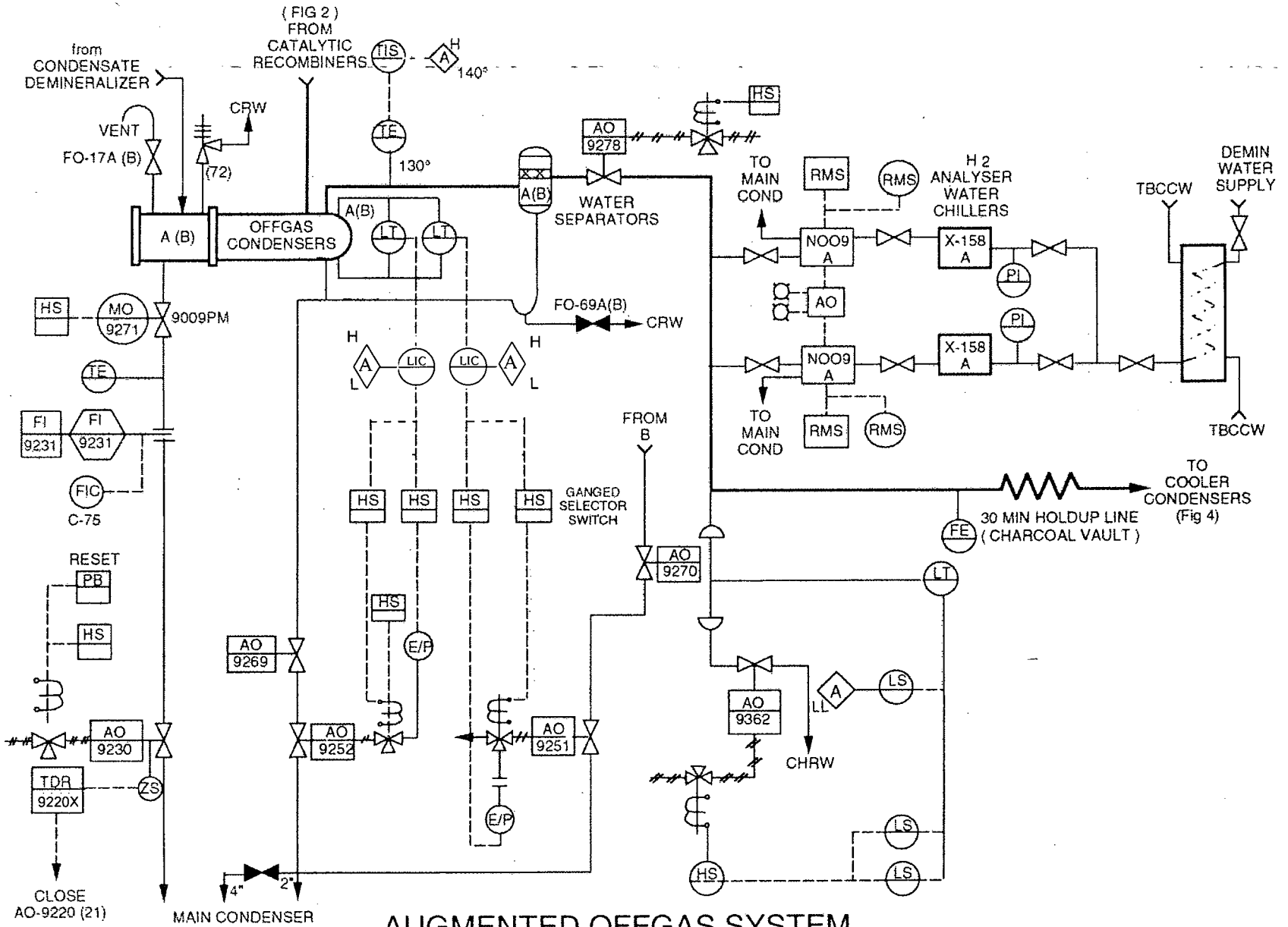
21OP819b



AUGMENTED OFFGAS SYSTEM

FIGURE 2

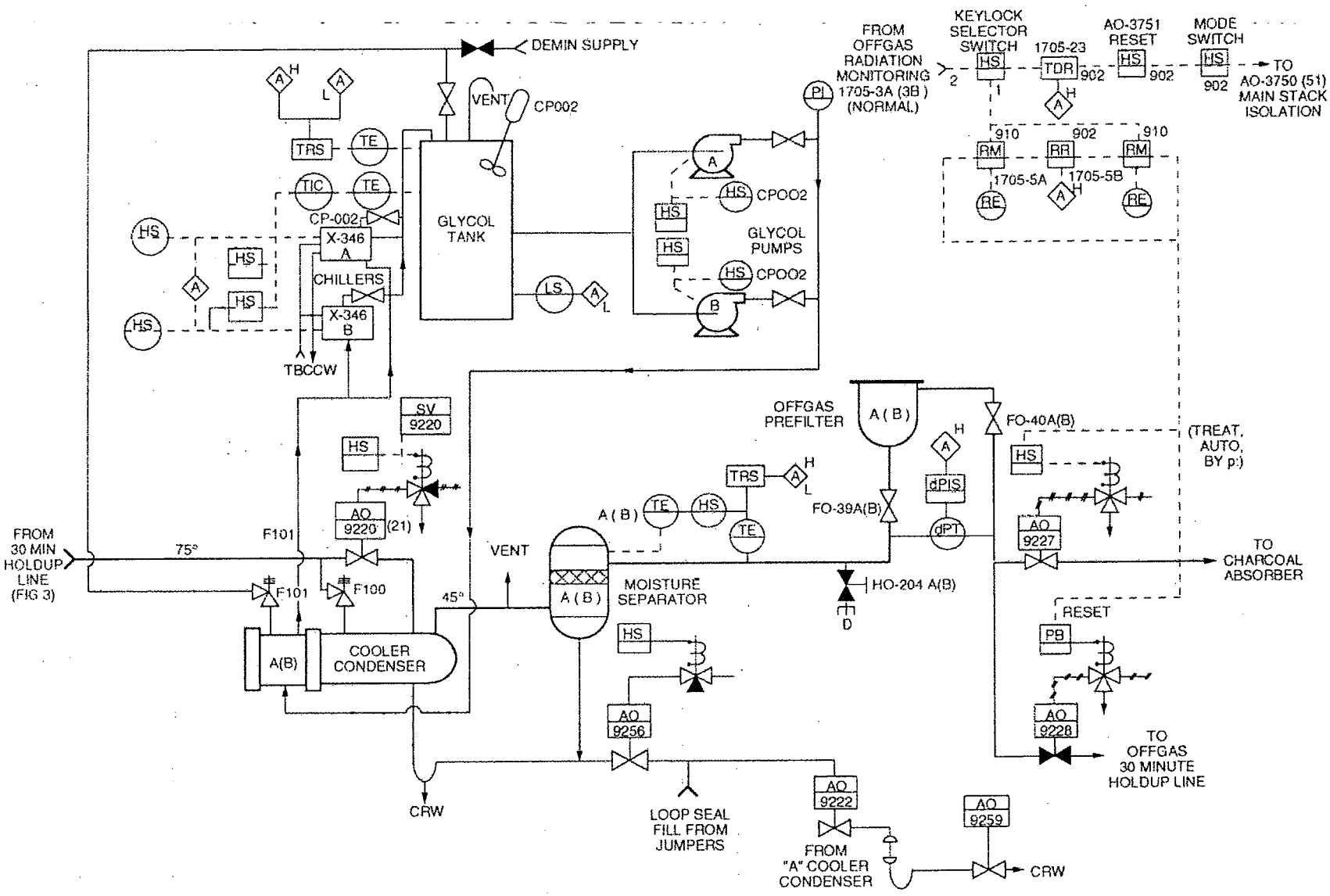
21op8119



AUGMENTED OFFGAS SYSTEM

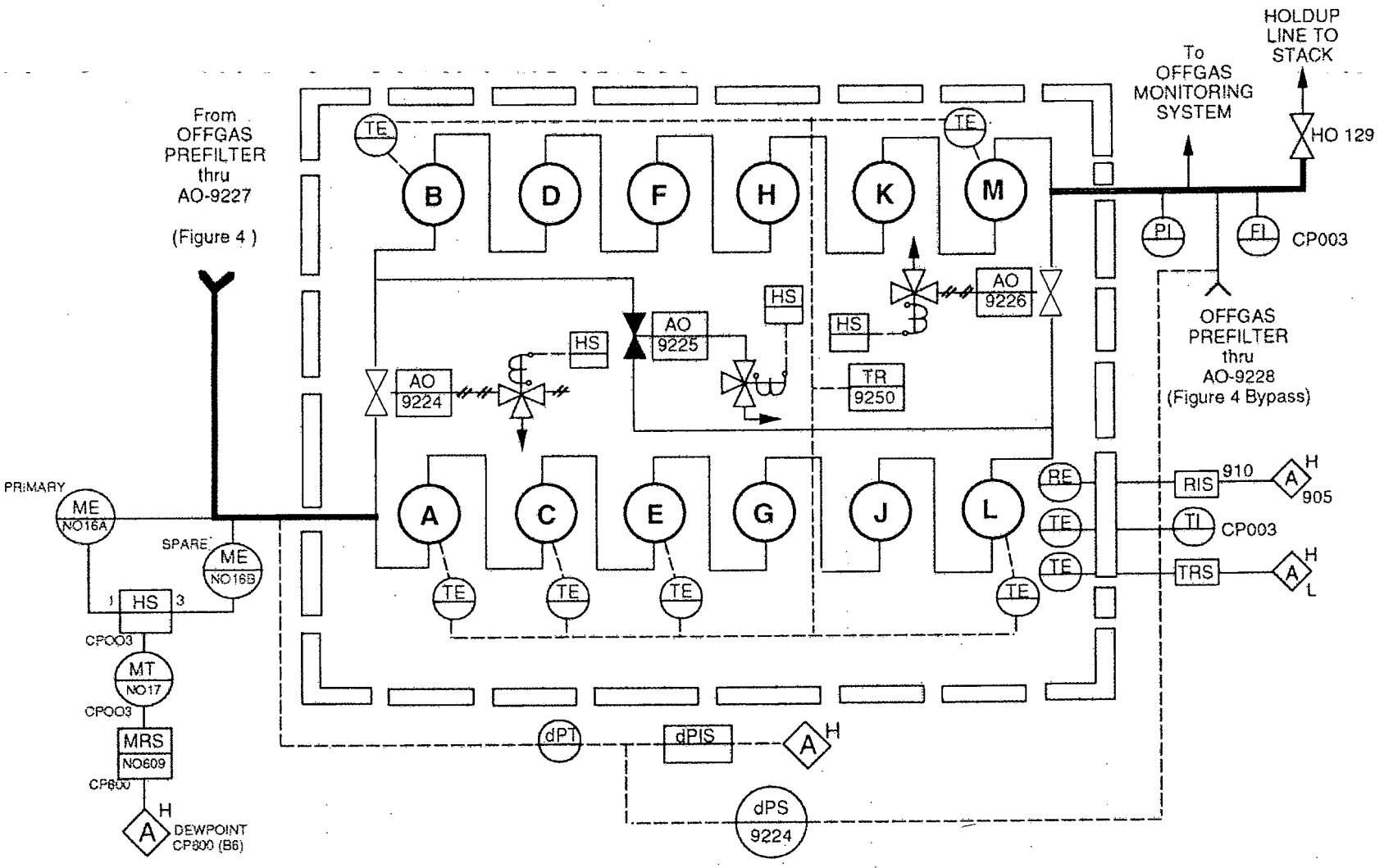
FIGURE 3

21OP849A



AUGMENTED OFFGAS SYSTEM 21OP889a

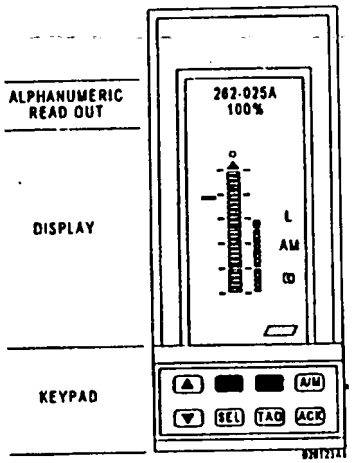
FIGURE 4



AUGMENTED OFF-GAS SYSTEM

FIGURE 5

21OP819c



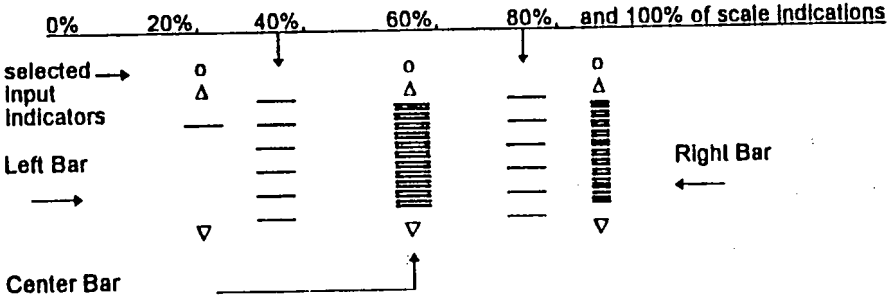
- An "L" will be illuminated to the right of the bar graphs. This is for local display and will always be illuminated.
- An "A" and/or "M" will be illuminated to the right of the bar graphs. This is for AUTOMATIC or MANUAL modes of operation.
- An error "E" will be illuminated to the right of the bar graphs anytime a diagnostic problem develops within the digital control system. This is normally not illuminated.

ALPHANUMERIC READOUT

- The device number is programmed into the top portion of the alphanumeric readout. This is displayed whenever the controller is powered up.
- The readout below the device number can display the following data, depending upon which variable is selected:
  - Operator level setpoint - % level (OSP XX.X %)
  - Actual level - % level (XX.X %)
  - Output level - % level (OUT XX.X %)
  - Various process alarm codes

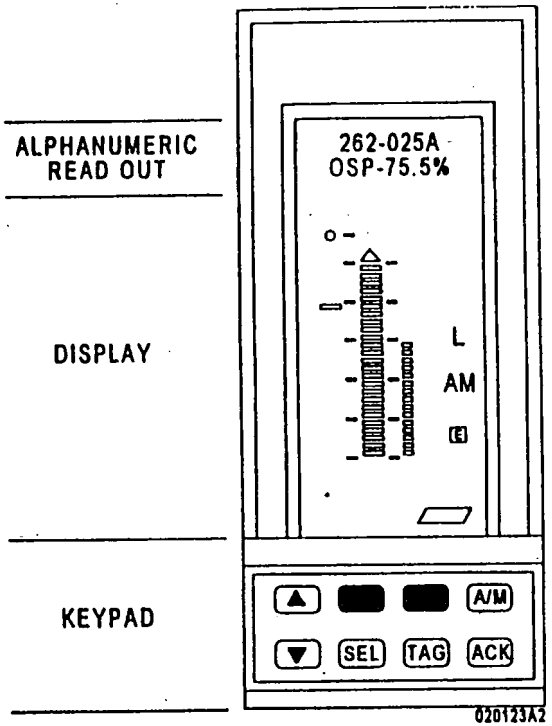
DISPLAY

- The controller display is made up of three bar graphs on the front of the station. The display format is as follows:



- LEFT BAR
  This illuminates the desired operator setpoint, and is used when in the AUTOMATIC mode.
  0% to 100%
- CENTER BAR
  This illuminates the actual level in AUTOMATIC or MANUAL mode (0% to 100%).
- RIGHT BAR
  This illuminates the output demand signal and is used in the MANUAL mode
  0% to 100%

FIGURE 6



KEYPAD

A/M AUTOMATIC OR MANUAL MODE
Depressing the A/M key transfers control between AUTOMATIC and MANUAL modes.

ACK ACKNOWLEDGE KEY
Depressing and holding the ACK key illuminates the diagnostic trouble code (highest priority system alarm message) in the alphanumeric readout if an error exists.

TAG TAG KEY
Depressing the TAG key illuminates the next diagnostic error, if more than one error was received.

SEL SELECT KEY
Depressing the SEL key will change the variable selected. This is indicated by an illuminated "dot" above selected bar graph. The select variable will be indicated in the alphanumeric display.

Δ UP ARROW
Depressing the "UP" arrow key increases the selected variable.

∇ DOWN ARROW
Depressing the "DOWN" arrow key decreases the selected variable.

- The selected variable is indicated by the illuminated "dot" above the selected variable.
- The up/down keys are "time sensitive", wherein the longer the key is depressed, the faster the selected variable will change.

FIGURE 7

Entergy **ENTERGY NUCLEAR** **LESSON PLAN**

TRAINING PROGRAM:

LICENSED OPERATOR

***LESSON PLAN TITLE:**

AUGMENTED OFF GAS

***COURSE NUMBER:**

O-RO-02-04-11 **Revision 4**

APPROXIMATE TIME REQUIRED: 4 Hours

PREREQUISITES: {None

SUPPORTING LESSONS: {None or Laboratory lesson / Simulator scenario course numbers}

[ ] New Material [X] Minor Revision [ ] Major Revision [ ] Cancellation

REASON FOR REVISION:
Update format

REVIEW / APPROVAL (Print Name): [ ] Electronic Approval (TEAR #_____)

Prepared By:	David Long Preparer	March 27, 2008 Date
Reviewed By:	 Technical Reviewer (e.g., SME, line management)	 Date
Instructional Adequacy Determined By:	Mark Santiago Qualified Instructor	03/27/08 Date
Approved By:	Mark Santiago **Discipline Training Superintendent	03/27/08 Date
Approval Date:	03/27/08 *Date	

**Indicates that the LP has been reviewed by the Training Superintendent for inclusion of Management Expectations and items referenced on TQF-201-DD06, "Training Material Checklist"

FLEET PROGRAM CONCURRENCE: X Not Applicable

ANO	N/A	**NP**	N/A
BRP	N/A	**PLP**	N/A
CNS	N/A	**PNPS**	N/A
GGNS	N/A	**RBS**	N/A
HQN	N/A	**VY**	N/A
IPEC	N/A	**W3**	N/A
JAF	N/A		

* Indexing Information

Augmented Off Gas

aka: "*Gaseous Rad Waste*"

O-RO-02-04-11 Rev 4

Terminal Objectives

- Given access to the control room, shift off-gas recombiners per PNPS procedure 2.2.106. (271-01-01-008)
-
- Given access to the control room, bypass the augmented off-gas system per PNPS procedure 2.2.106. (271-01-01-012)
-
- ~~Given access to the control room, respond to abnormal off-gas recombiner operation per PNPS procedure 2.4.141. (271-04-01-008)~~
-
- Given access to the control room, respond to augmented off-gas system explosions per PNPS procedure 2.4.55. (271-04-01-009)

Terminal Objectives

- Given access to the control room, purge the augmented off-gas line per PNPS procedure 2.2.106. (271-01-01-016)
- Given access to the control room, respond to a loss of coolant to the augmented off-gas condenser per PNPS procedure 2.4.138. (271-04-01-005)
- Given access to the control room, respond to a loss of AOG Hydrogen Analyzers per 2.2.106. (271-04-01-002)

Terminal Objectives

- Given access to the control room, startup the offgas system per PNPS procedure 2.2.93 and 2.2.106.
  (271-01-01-002)
- Given access to the control room, secure the offgas system per PNPS procedure 2.2.93 and 2.2.106.
  (271-01-01-007)
- Given access to the control room, monitor the offgas system per PNPS procedure 2.2.93 and 2.2.106.
  (271-01-01-004)
- 11. Given access to the control room, reset the offgas isolation valves per PNPS procedure 2.2.93 and 2.2.106.
  (271-01-01-013)

Enabling Objectives

1. State the purpose of the augmented off-gas system.
2. Describe the flowpaths through the augmented off-gas system for the following plant conditions:
   a. **System startup prior to preheat**
   b. **Preheat**
   c. **Charcoal bed series operation**
   d. **Charcoal bed parallel operation**
   e. **Purge**

Enabling Objectives

3. **Describe the purpose and operation of the following AOG components:**
   a. **Steam jet compressor**
   b. **Preheater**
   c. **Catalytic recombiner**
   d. **Off-gas condenser**
   e. **Water separator**
   f. **Hydrogen analyzer**
   g. **30 minute holdup line**
   h. **Cooler condenser**
   i. **Moisture separator**
   j. **Off-gas prefilter**
   k. **Charcoal adsorber**

Enabling Objectives

4. State the location of the following AOG components:
   a. Steam jet compressor
   b. Preheater
   c. Catalytic recombiner
   d. Off-gas condenser
   e. Water separator
   f. Cooler condenser

Enabling Objectives

5. State the power supplies to the following AOG System components:
   a. recombiner heaters
   b. glycol refrigeration units
   c. glycol pumps
   d. hydrogen analyzers

Enabling Objectives

6. Describe how the following systems interrelate with AOG:
   a. **Condensate**
   b. **Condenser Air Removal System**
   c. **Glycol**
   d. **TBCCW**
   e. **Main Steam**
   f. **Instrument and Service Air**
   g. **Radwaste**
   h. **Radiation Monitoring Systems**
   i. **Hydrogen Water Chemistry System**
   j. **AC Distribution**

Enabling Objectives

7. For the systems listed below describe how their loss will impact AOG System operation:
   - **a. Condensate**
   - **b. Condenser Air Removal System**
   - **c. Glycol**
   - **d. TBCCW**
   - **e. Main Steam**
   - **f. Instrument and Service Air**
   - **g. Radwaste**
   - **h. Radiation Monitoring Systems**
   - **i. Hydrogen Water Chemistry System**
   - **j. AC Distribution**

Enabling Objectives

8. Predict the effect a loss of the AOG System will have on main condenser vacuum.
9. Predict the operational implications of the following AOG abnormal conditions on AOG operation:
   a. **AOG System low steam flow**
   b. **AOG System high pressure**
   c. **hi hi radiation levels in the off gas effluent**
   d. **water in the off gas system (charcoal beds)**
   e. **combustible mixtures of air and hydrogen in the off gas system**

Enabling Objectives

10. Given a set of plant and/or equipment conditions and Technical Specifications, identify applicable Limiting Conditions of Operation

11. Given a set of plant and/or equipment conditions and Technical Specifications, determine required actions for applicable LCO. (SRO ONLY).

Enabling Objectives

12. Describe the bases for Limiting Conditions of Operations which pertain to this system. (SRO ONLY).

13. State the actions required for a loss of AOG Hydrogen Analyzers.

AOG Purpose

- Reduce the amount of gas to be treated by recombining radiolytic hydrogen and oxygen
- Delays radioactive gas release to the atmosphere to permit decay as low as reasonably achievable
- Filters out radioactive gas particulate daughters, minimizing their release to the atmosphere
- Maintain hydrogen concentration less than 4 percent to prevent explosions

(EO 1)

AOG Design Basis

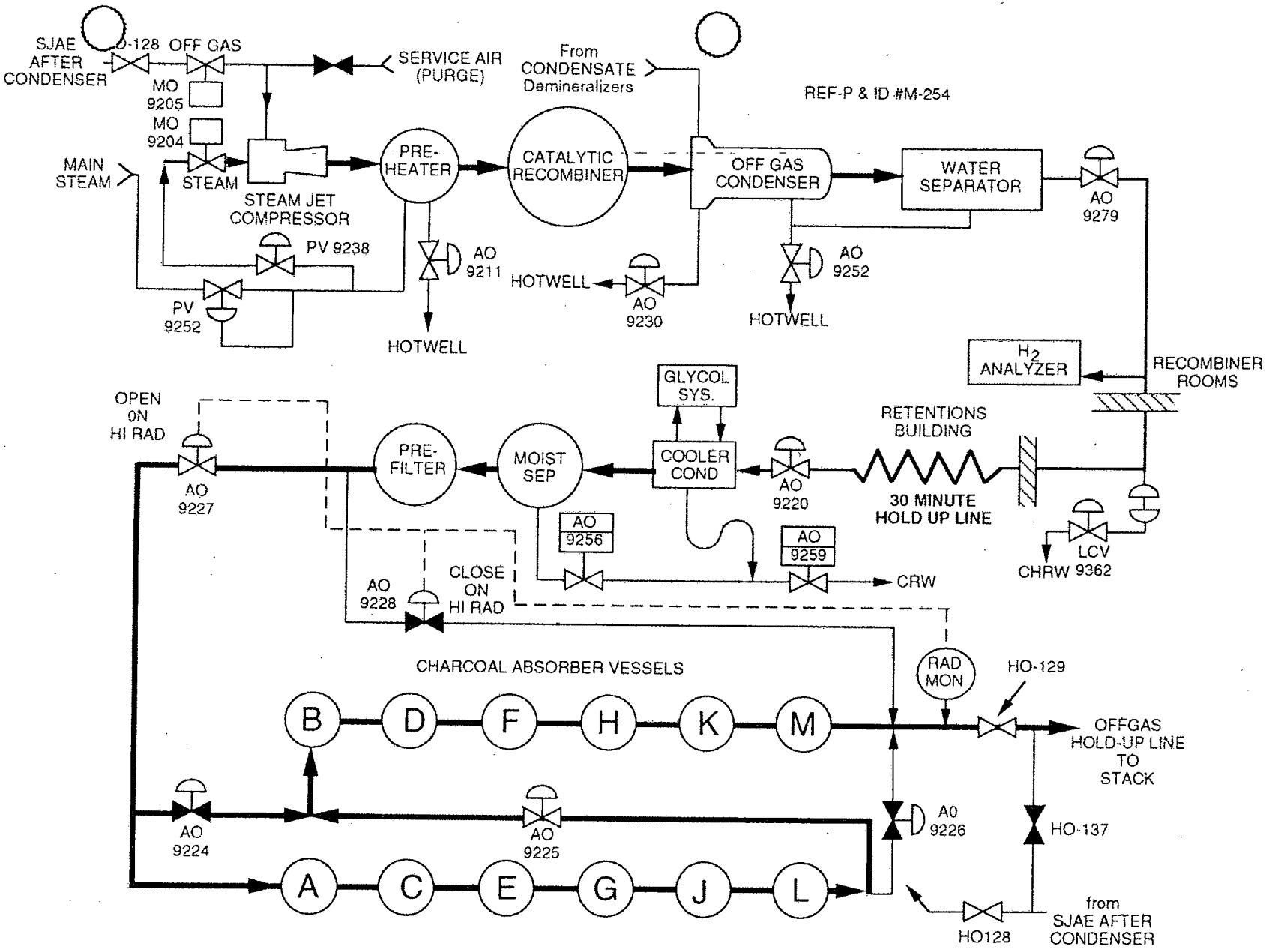
AOG (aka *gaseous radwaste system*) reduces amount of gas to be treated by recombining the hydrogen and oxygen into non-flammable offgas.

- Delays noble gas passage through the system for a time period (holdup) sufficient to allow optimum radioactive decay before release.

- AOG initiates Offgas System isolation from condenser if steam flow to catalytic recombiner becomes too low.

- System is designed and operated to preclude accumulating flammable offgas mixtures.

(EO-01)



AUGMENTED OFF-GAS SYSTEM (TRAIN "B")

FIGURE 1

21OP819b

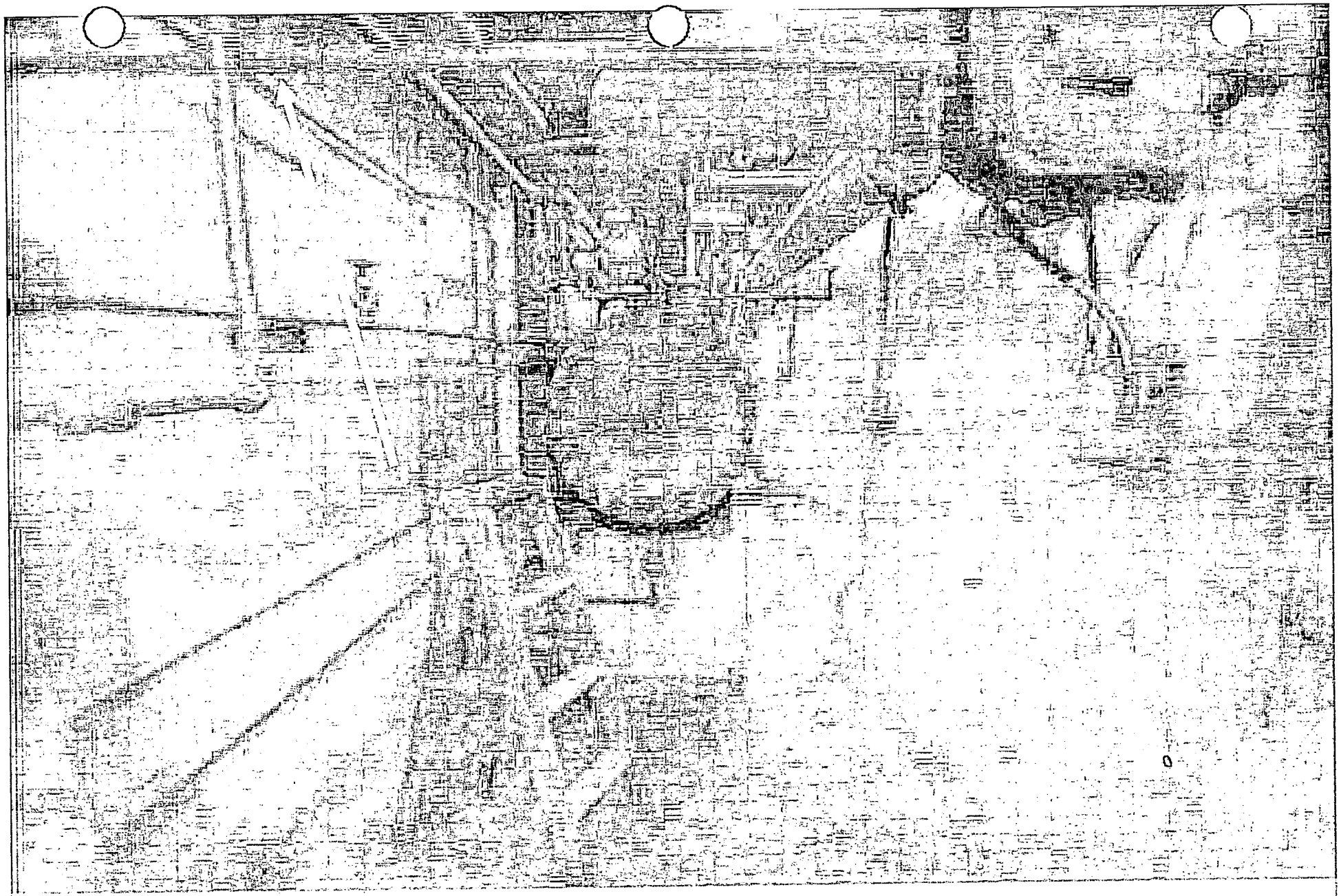
EO-02

AOG Main Components

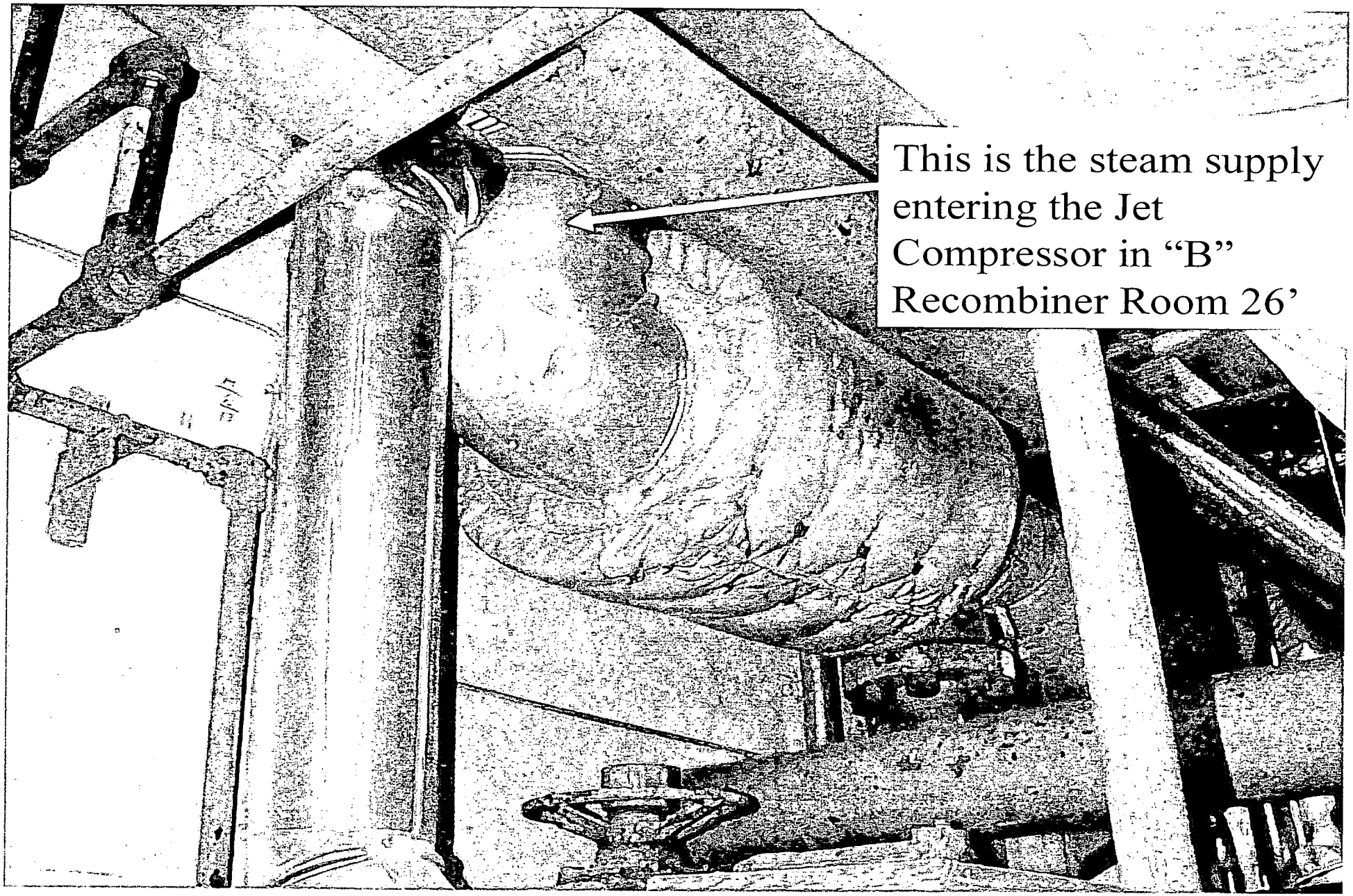
- Steam Jet Compressor
- Pre-heater
- Catalytic Recombiner
- Off Gas Condenser
- Water Separator
- Hydrogen Analyzer
- 30 Minute Holdup Line
- Cooler Condenser
- Moisture Separator
- Pre-filters
- Charcoal Adsorber Vessels

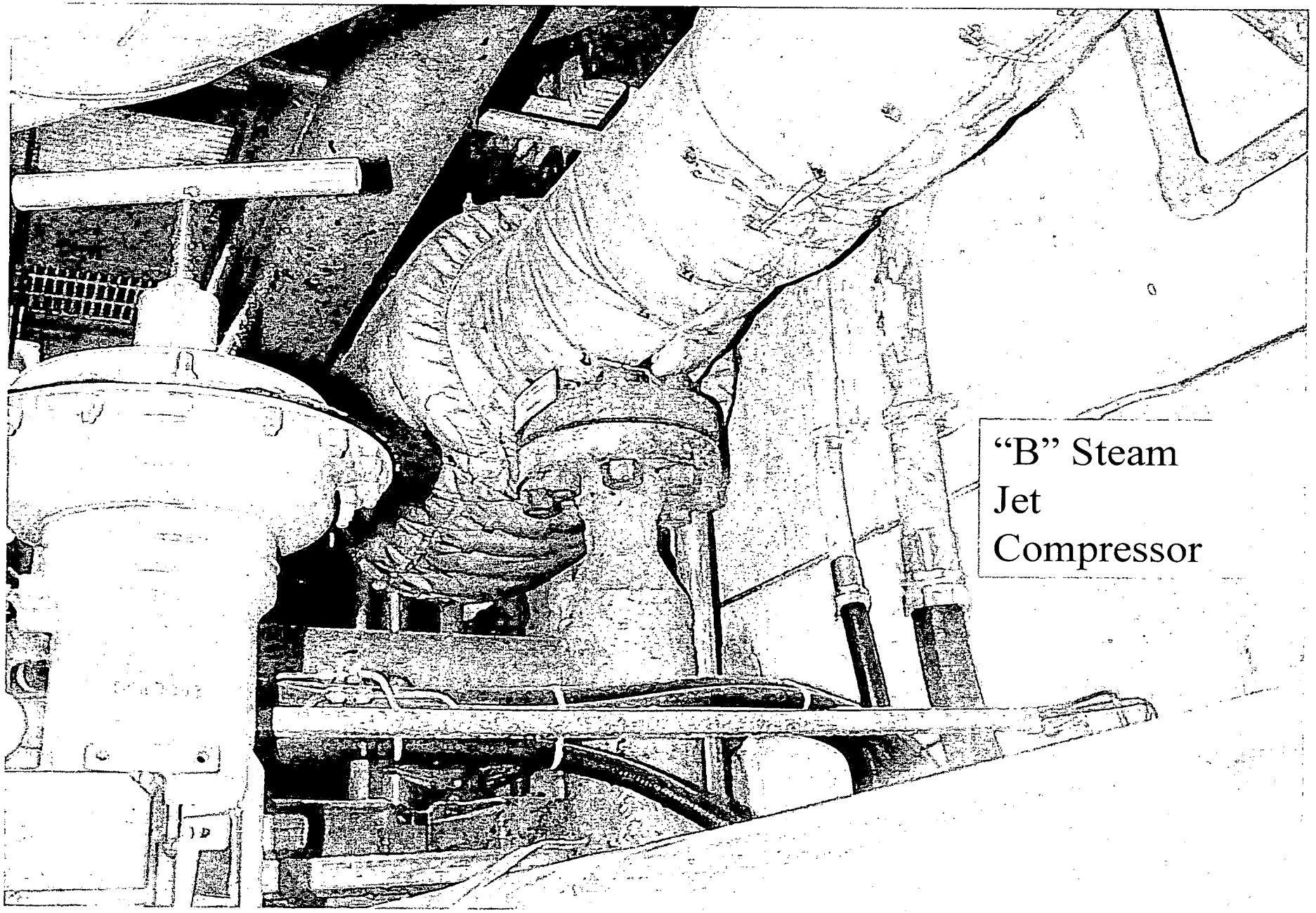
Steam Jet Compressor

- Dilution steam provides motive force to compress offgas up to atmospheric pressure.
- Water vapor inhibits hydrogen detonation.
- Steam removes heat from recombiner to maintain the ASME pressure vessel below material design temp. limit. Procedural control directs a manual Rx scram at 1000ºF to preclude spontaneous ignition.
- 40 psig regulator controls dilution steam pressure to the AOG jet compressors
- Low dilution steam flow <4500 lbs/hr initiates an Offgas System isolation (vapor valves close) to prevent accumulating a detonable hydrogen concentration.

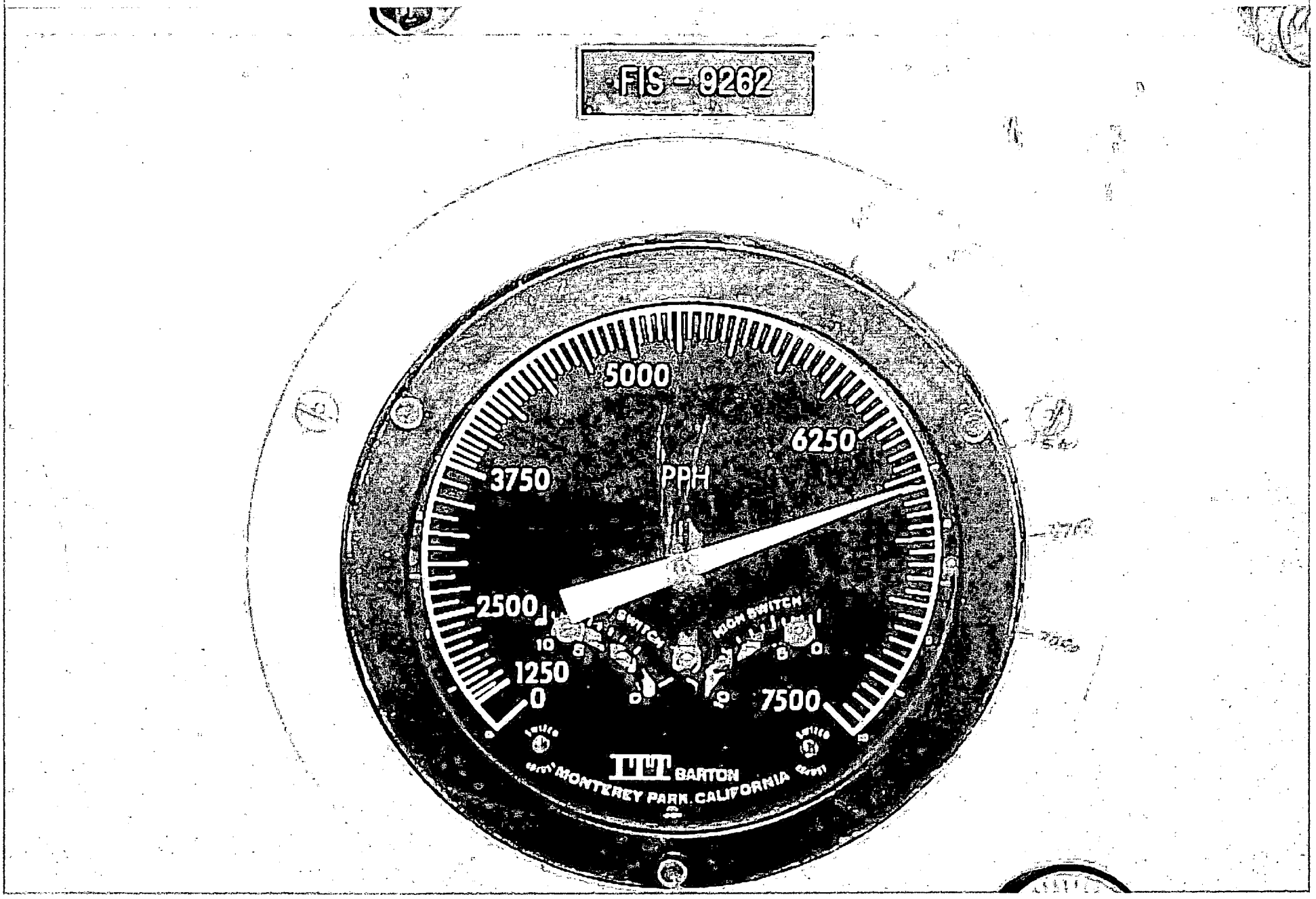


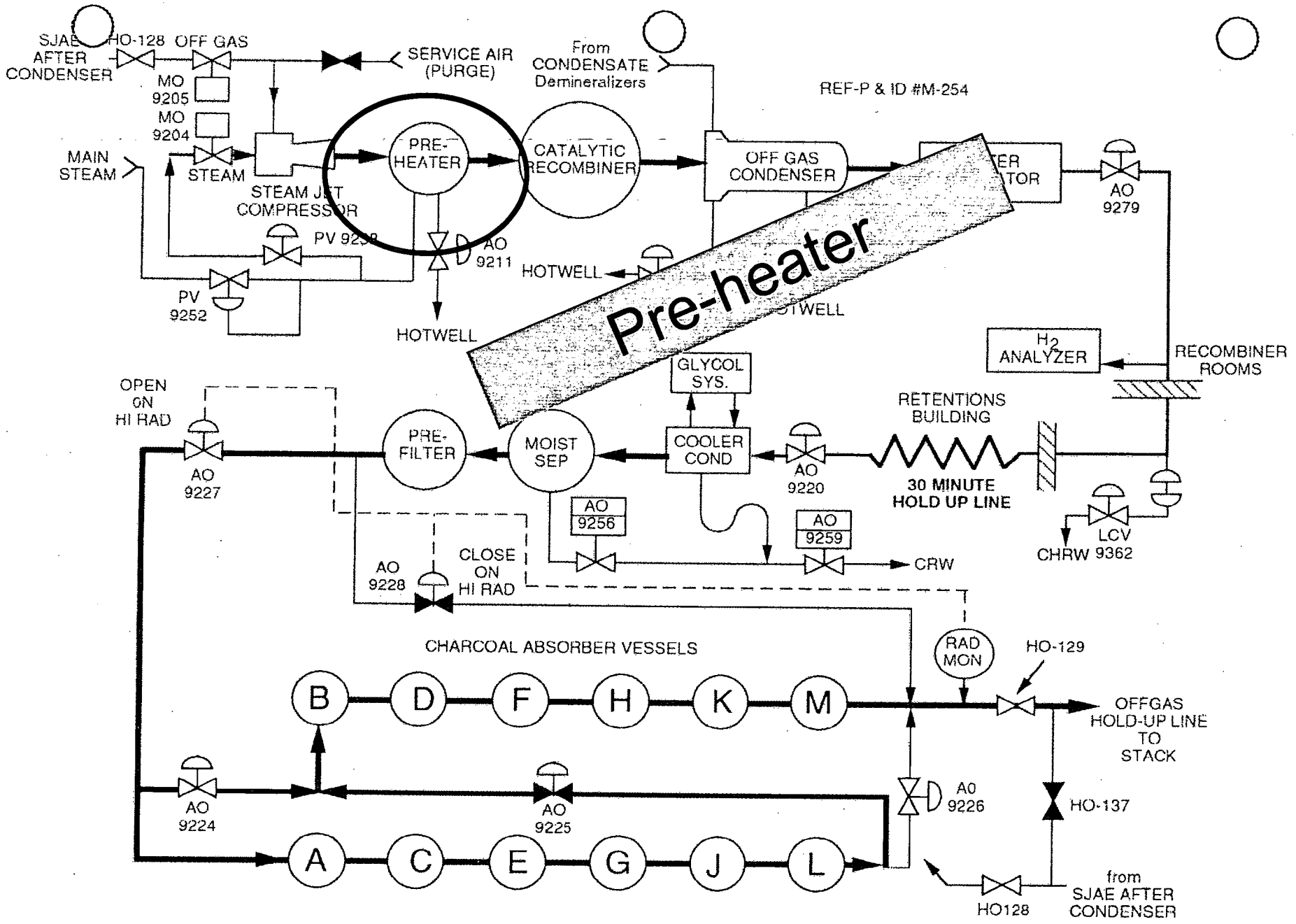
This is the 26' in Recombiner Room A. Steam Jet Compressor is located in the overhead above step-ladder


This is the steam supply entering the Jet Compressor in "B" Recombiner Room 26'


"B" Steam
Jet
Compressor

Dilution steam flow < 4500 lbm/hr closes vapor valves





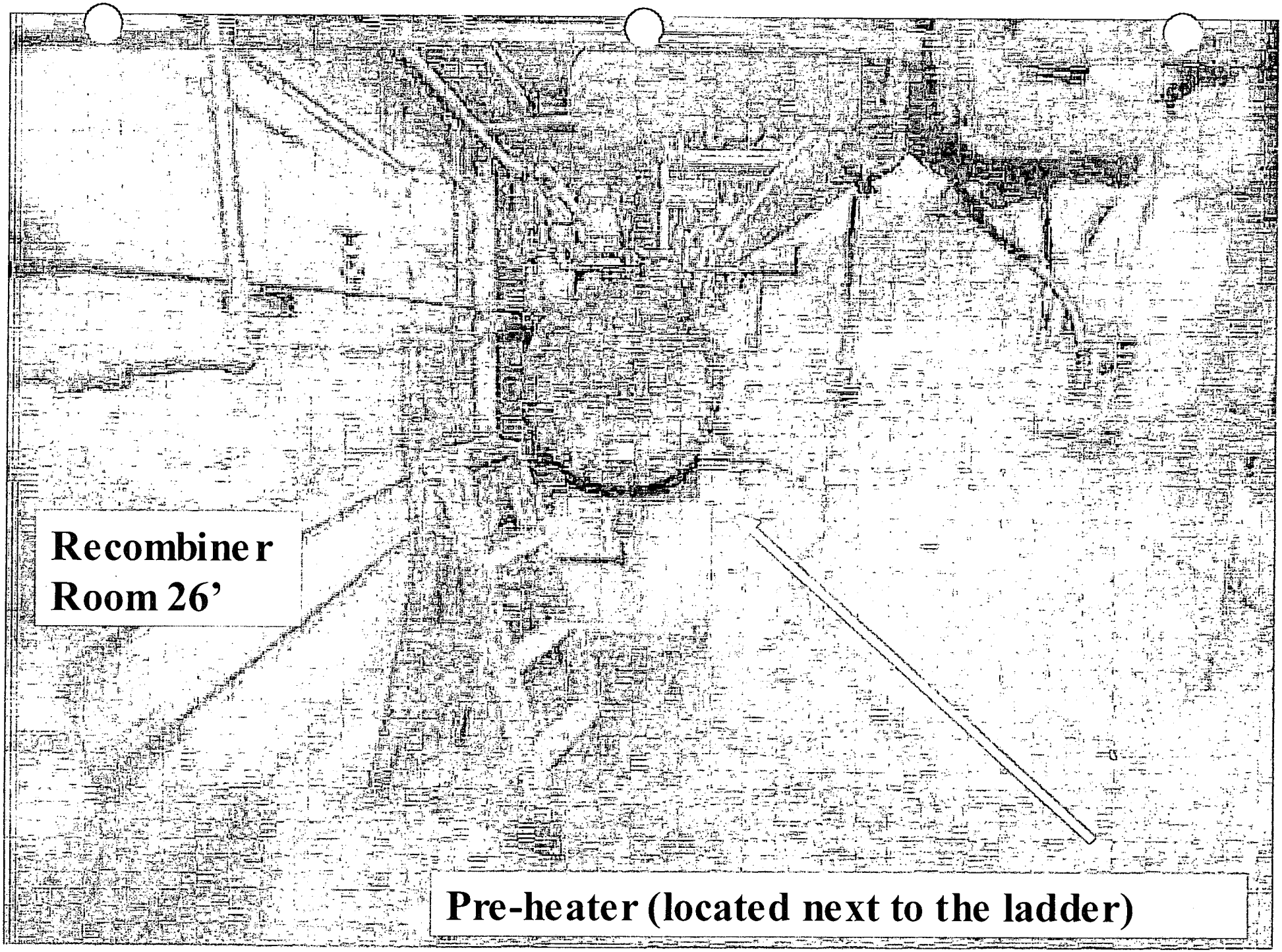
AUGMENTED OFF-GAS SYSTEM (TRAIN "B")

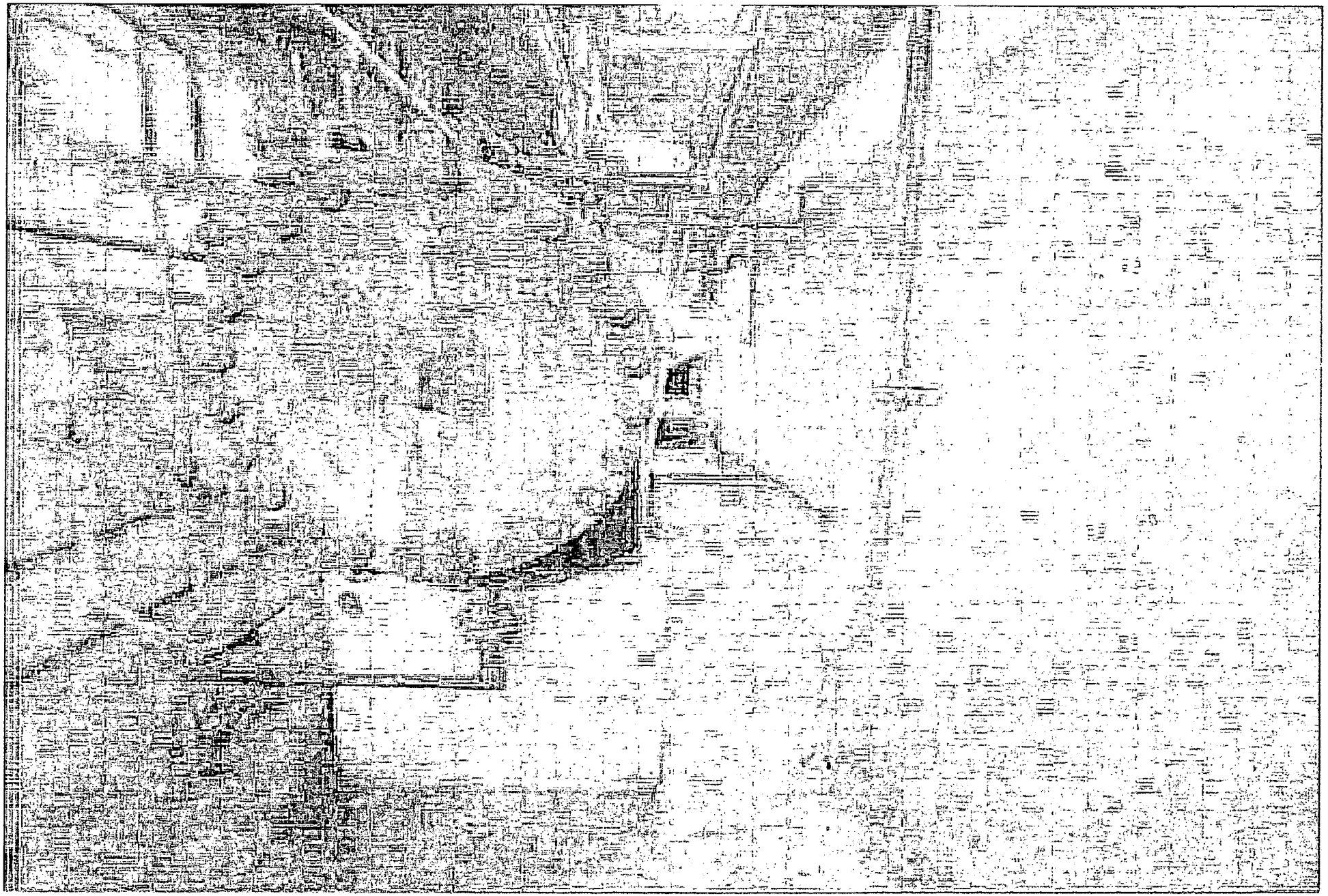
FIGURE 1

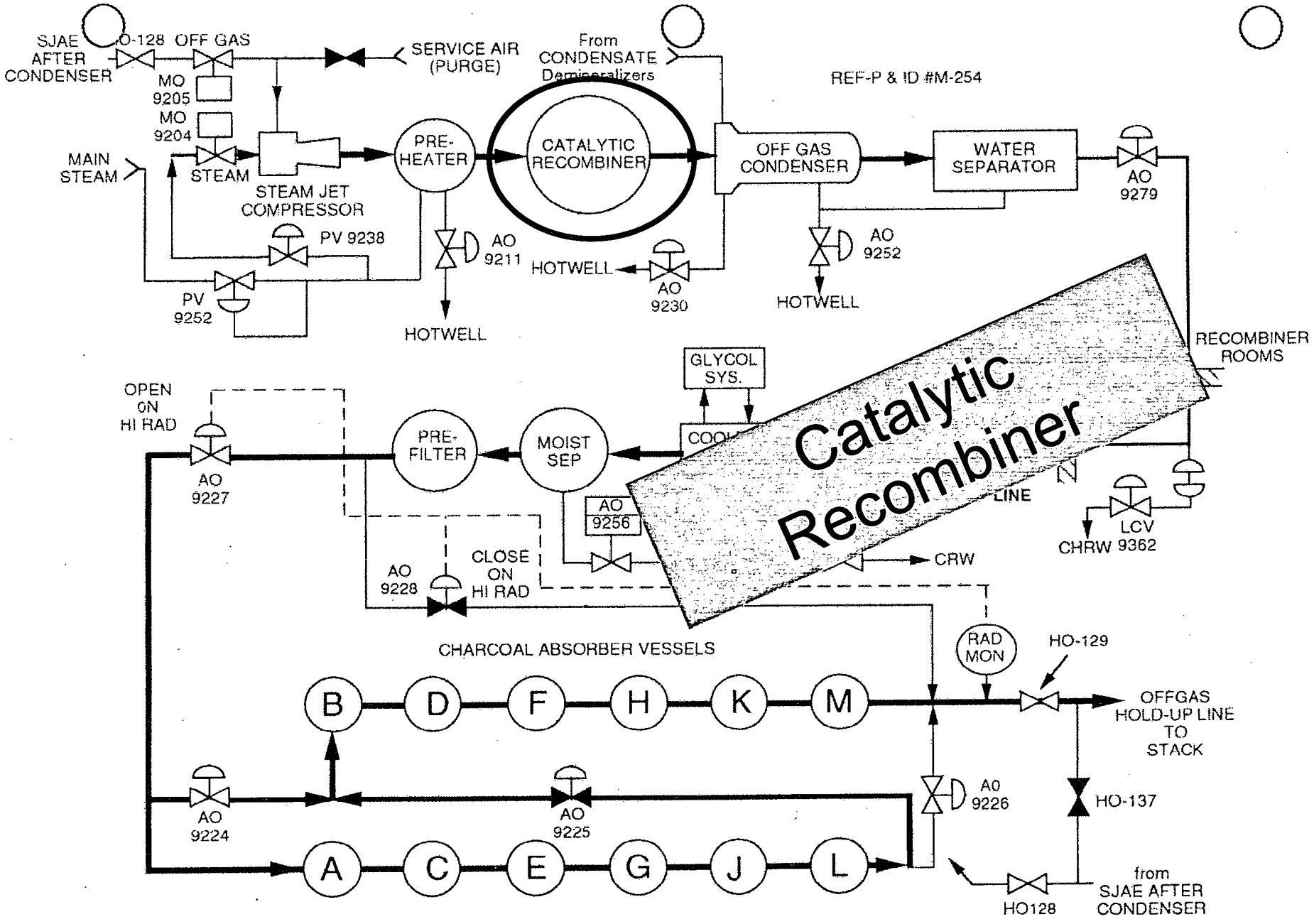
21OP819b

Pre Heater

- Shell and tube type heat exchanger that utilizes steam from the 300 psig regulator to superheat offgas.
- Heats offgas to 350ºF to maintain recombiner catalyst above saturation temperature (218ºF @ 16.5 psia). Prevents condensation on recombiner catalyst surface (keeps it dry) which would otherwise degrade chemical reaction.
- Condensed steam is vacuum dragged to main condenser.


Recombiner
Room 26'
Pre-heater (located next to the ladder)





AUGMENTED OFF-GAS SYSTEM (TRAIN "B")

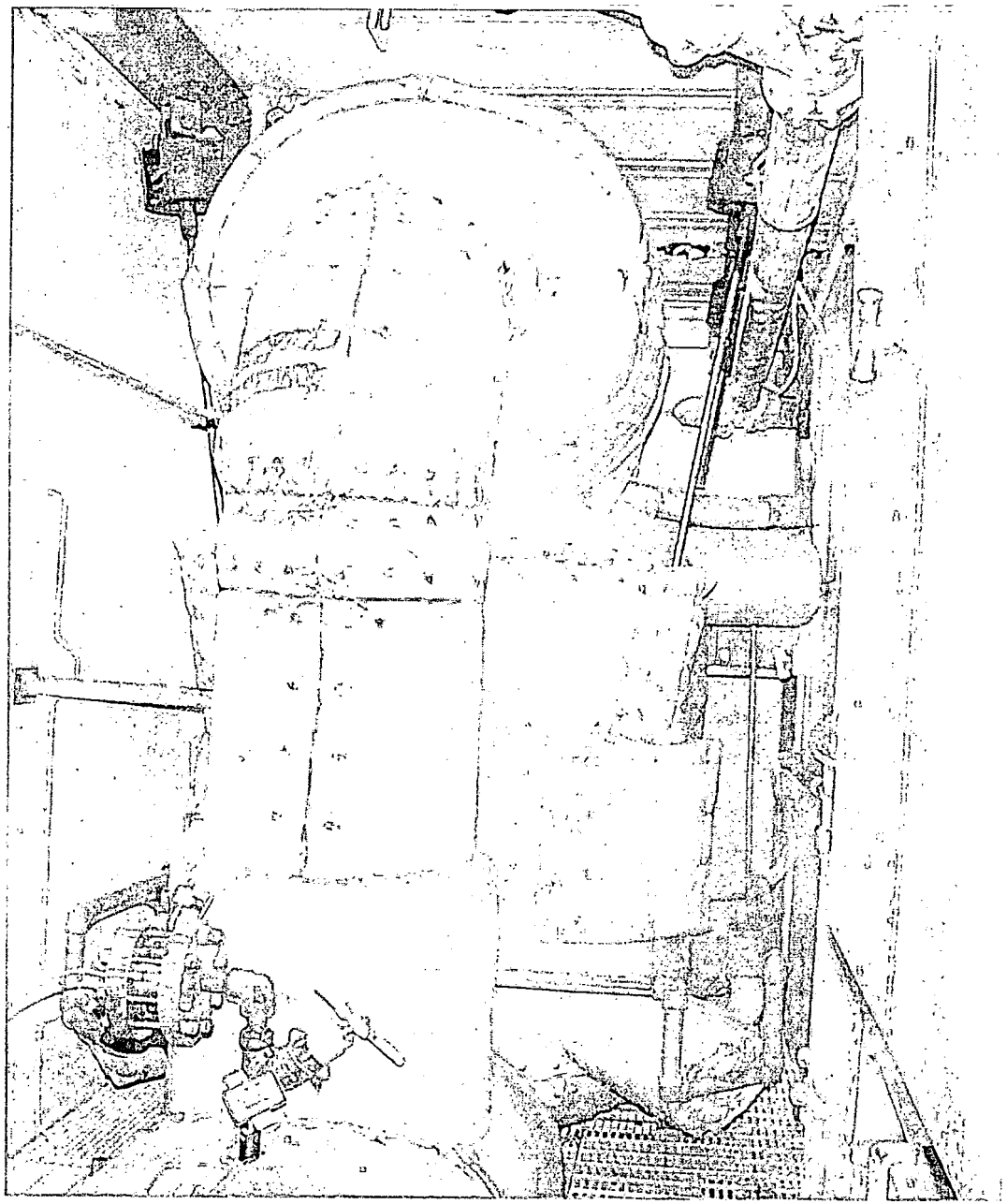
FIGURE 1

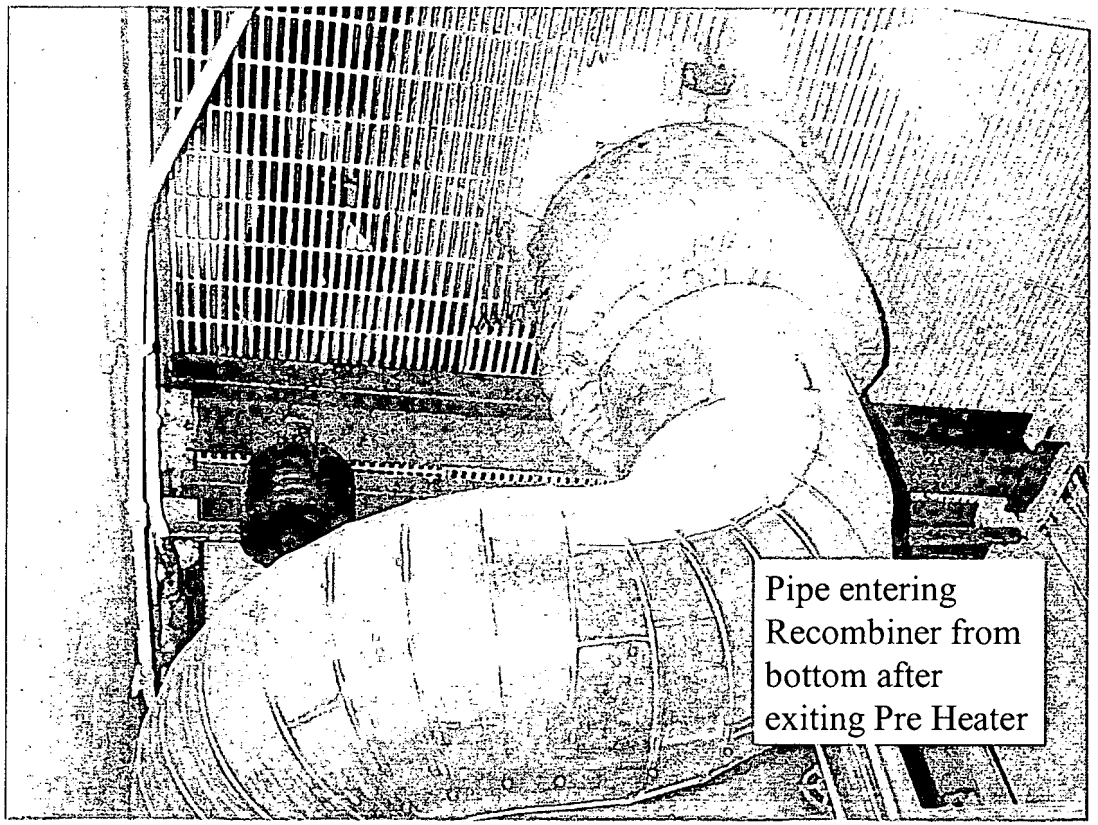
21OP819b

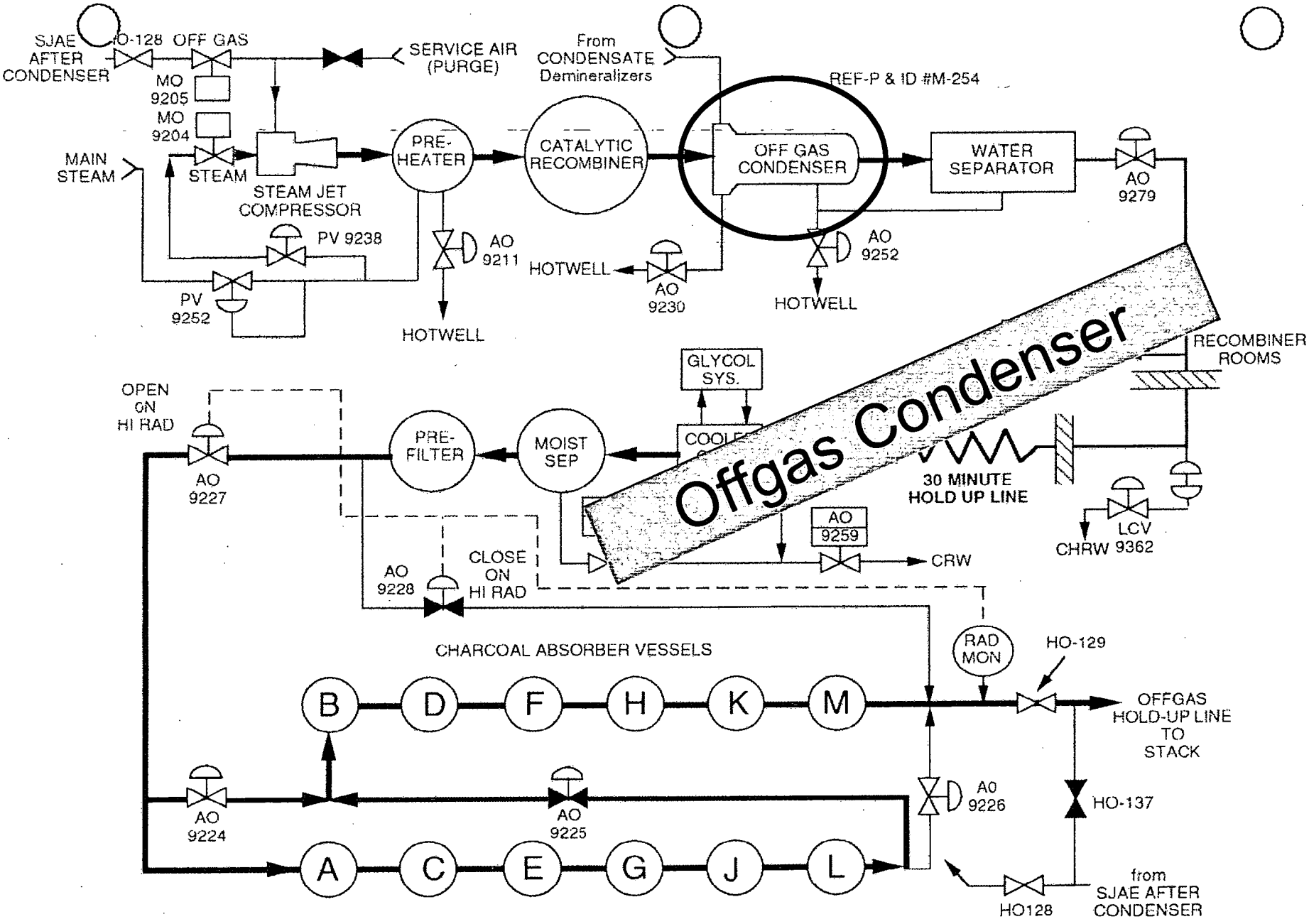
Catalytic Recombiners

- H_2 and O_2 flows through catalyst - platinum-palladium coated nickel-chromium wire ribbon.
- An exothermic chemical reaction - 62K BTU/lb H_2 - forms super-heated steam. 710° F @ atmospheric pressure.
- Recombination occurs in 1st inch or two of 2-foot catalyst bed depth.
- Total offgas volume is greatly reduced.
- Recombiner discharges a non-flammable mixture of air and noble gas with < 1.0 % hydrogen concentration.

Catalytic Recombiner




Pipe entering
Recombiner from
bottom after
exiting Pre Heater



AUGMENTED OFF-GAS SYSTEM (TRAIN "B")

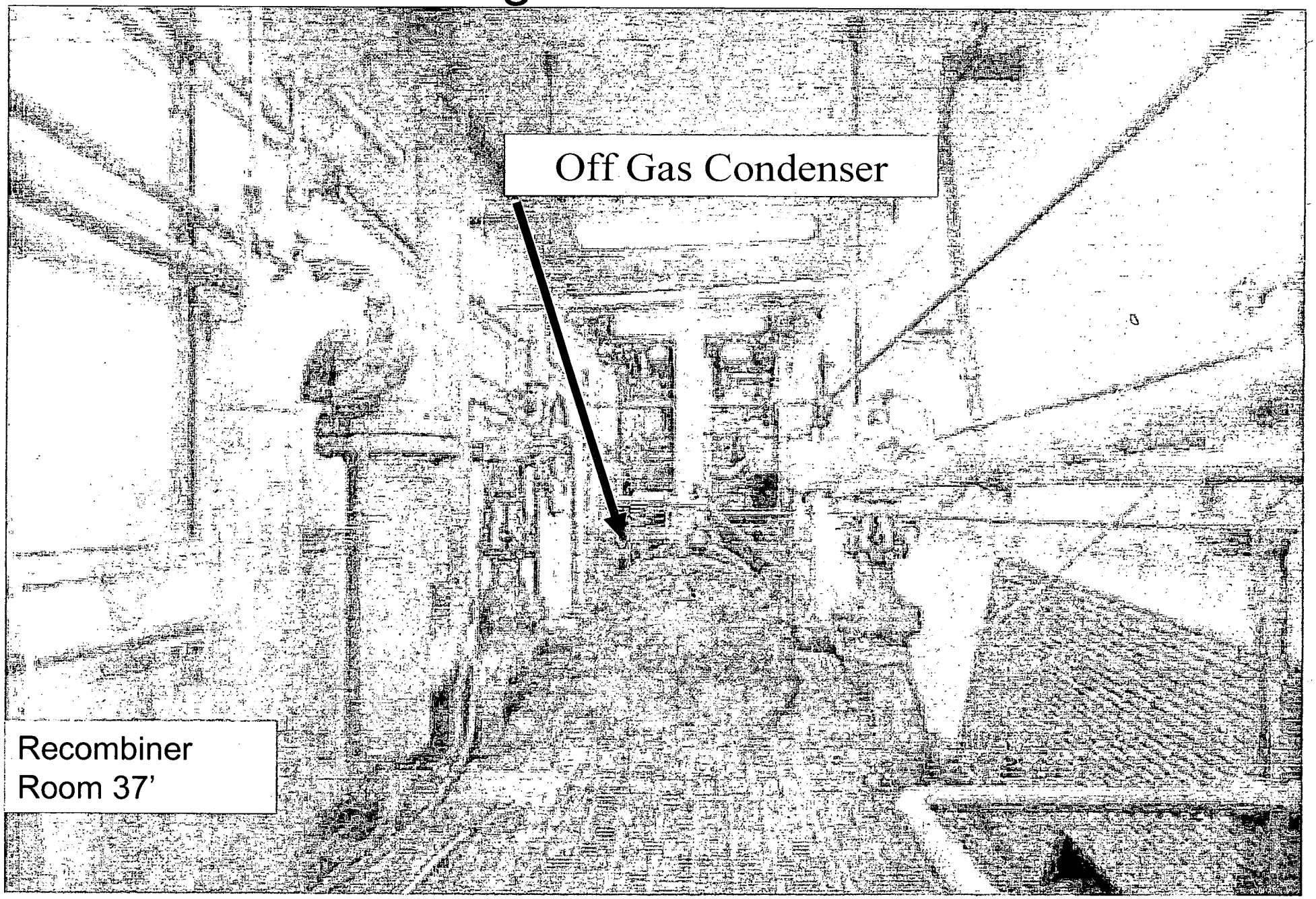
FIGURE 1

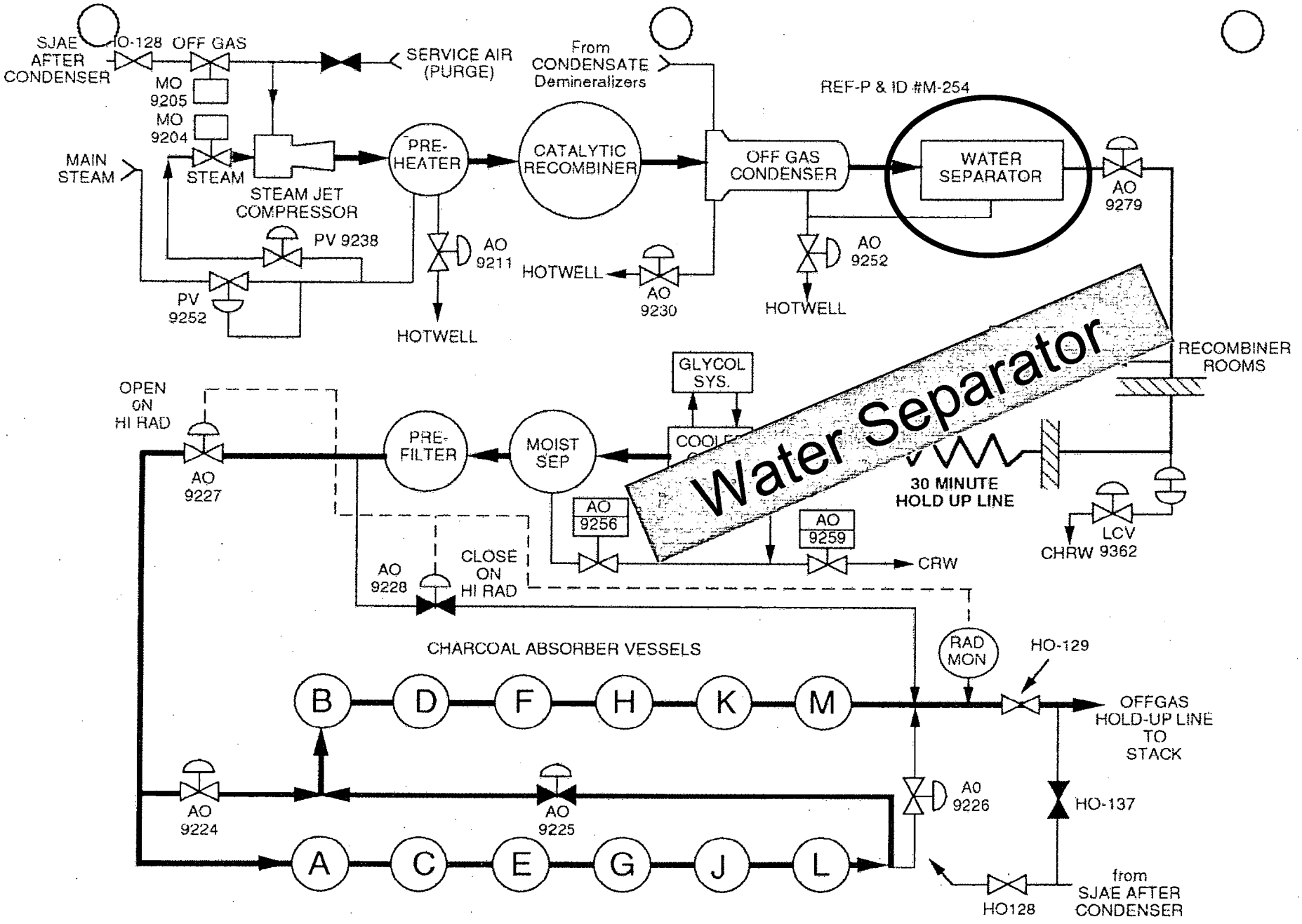
21OP819b

Off Gas Condenser

- Uses condensate system H_2O (cond-demin effluent) to condense superheated steam.
- Condensed steam collects in shell and drains (vacuum dragged) back to main condenser.
- Shell level maintained by level valves and controllers to form water seal against main condenser vacuum. Seal prevents offgas recirculation back to the main condenser.

Offgas Condenser





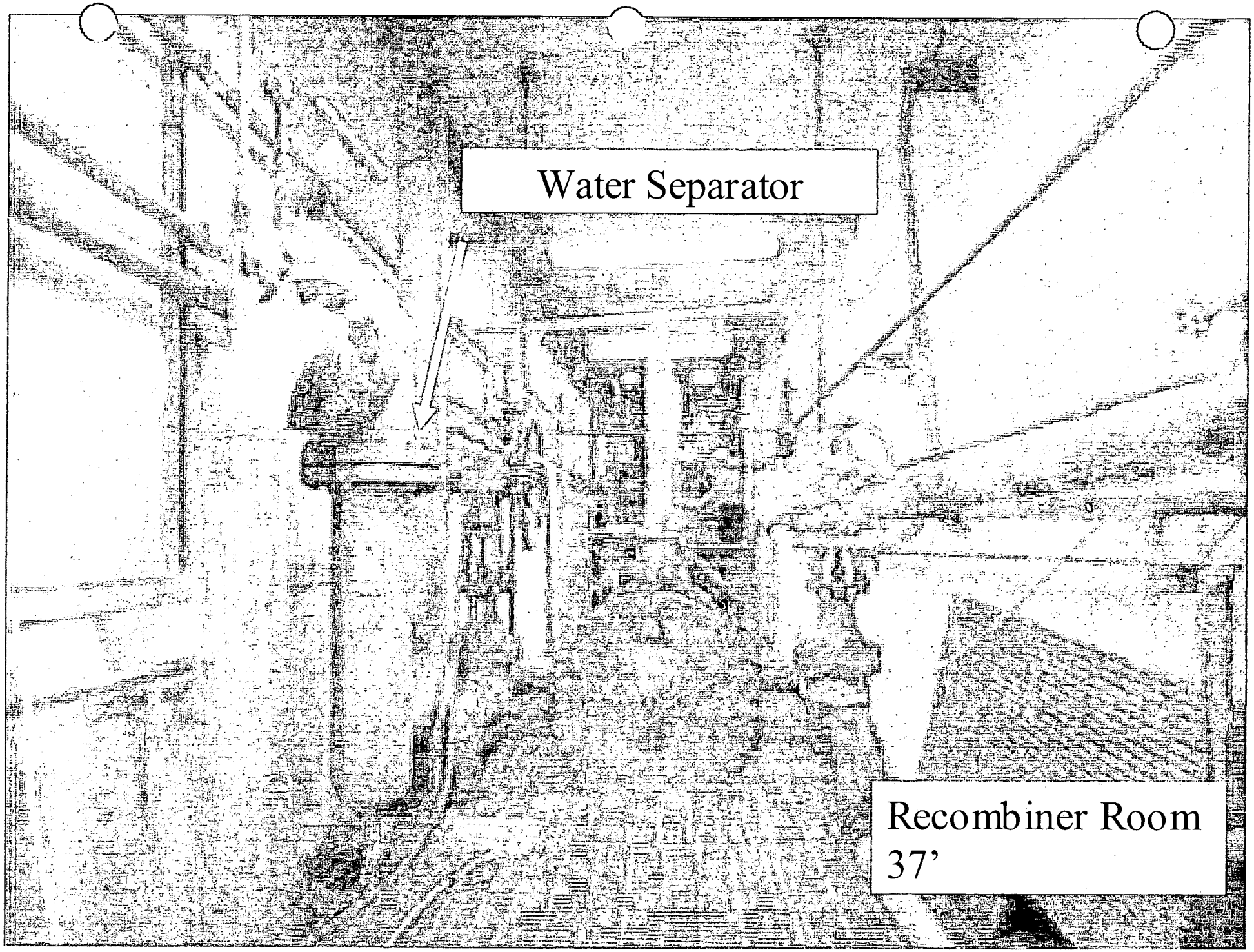
AUGMENTED OFF-GAS SYSTEM (TRAIN "B")

FIGURE 1

21OP819b

Water Separator

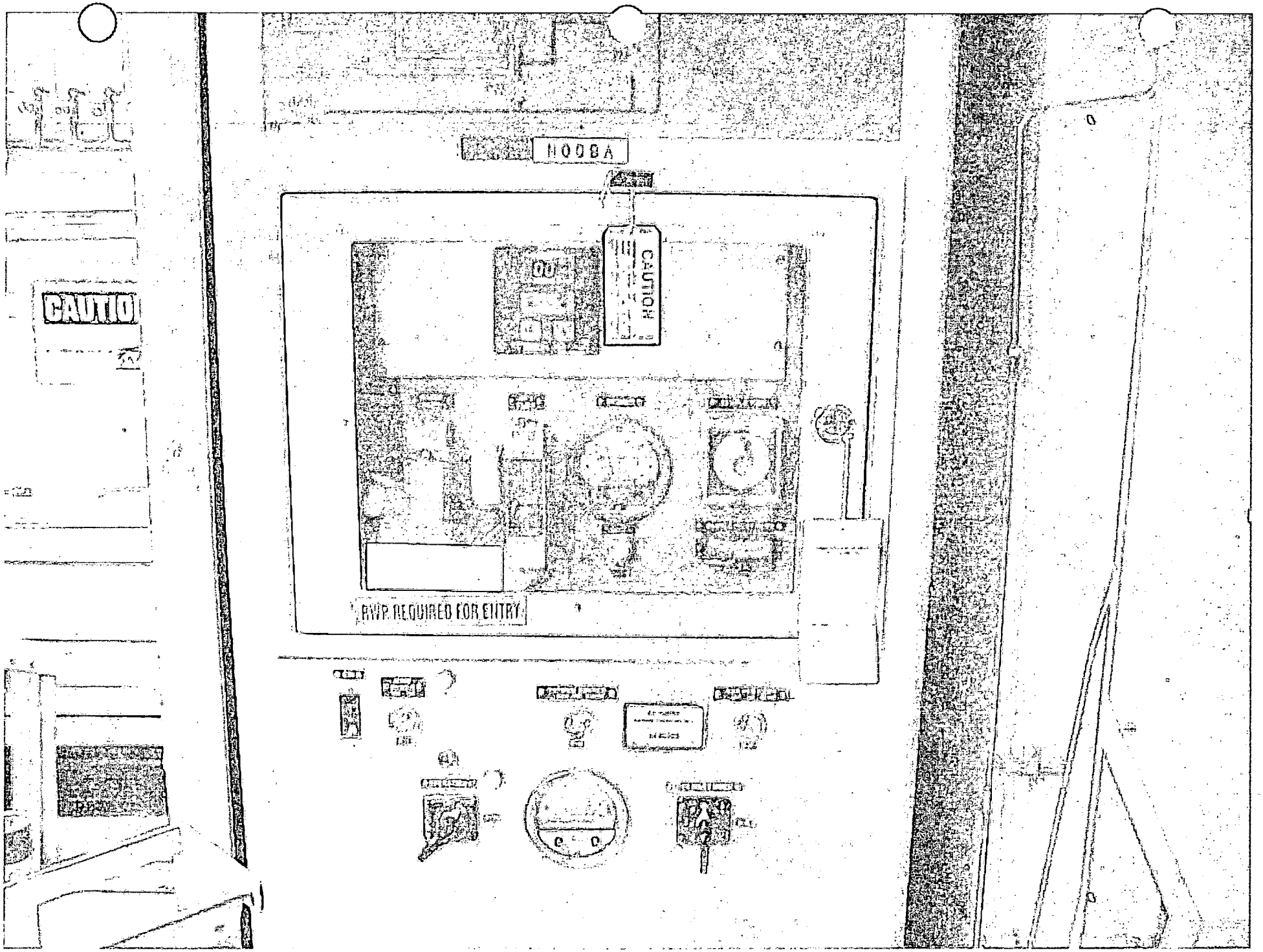
- Stainless steel mesh inside pressure vessel
- Moisture droplets in cooled process gas collect on mesh and fall to vessel bottom
- Drains to Offgas Condenser shell which drains to the main condenser.

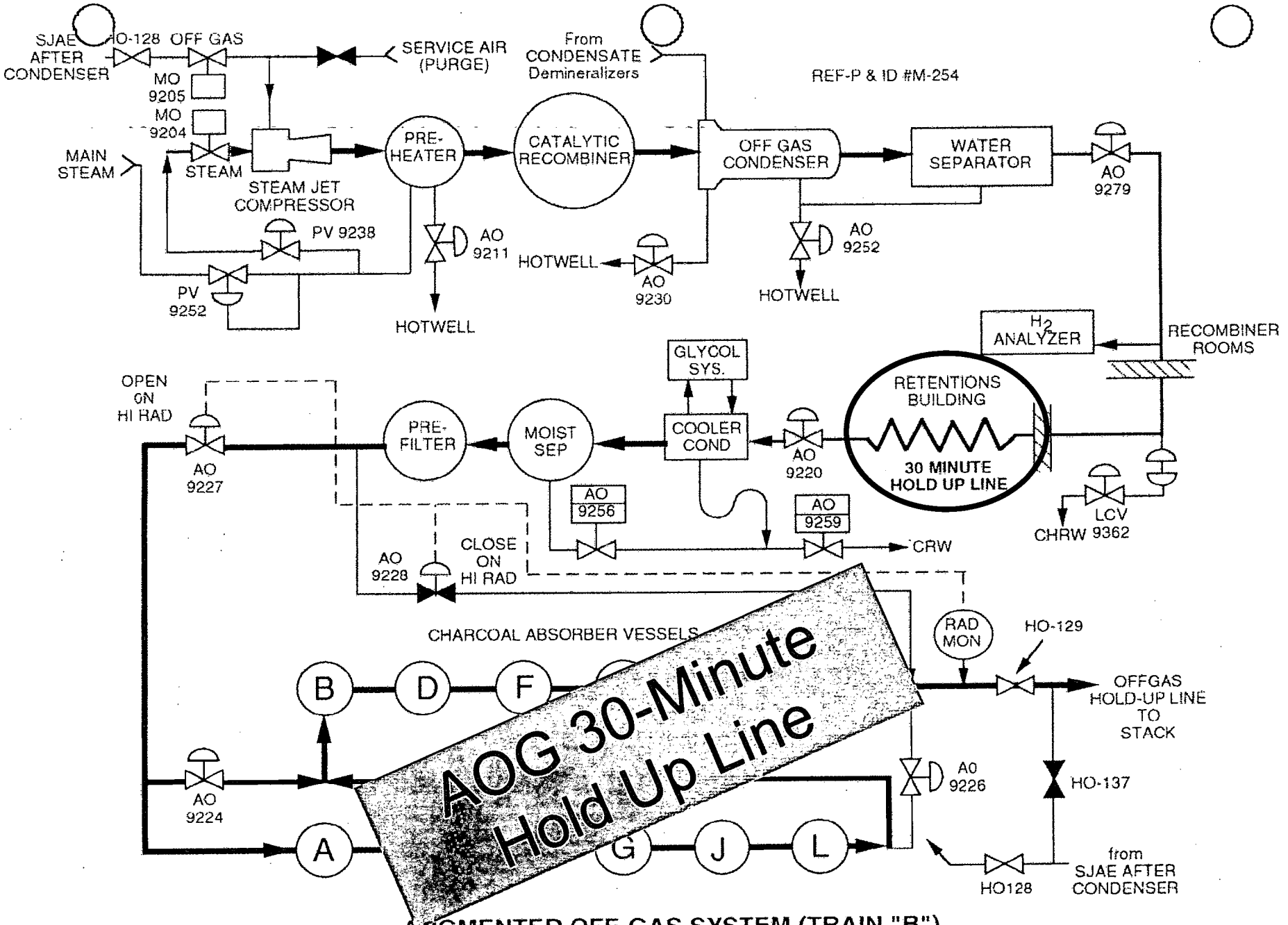

Water Separator
Recombiner Room
37'

Hydrogen Analyzer

- Two hydrogen analyzers continuously sample offgas and monitor for hydrogen concentration.

- High alarm at 2% hydrogen concentration.


CAUTIO
NOOBA
CAUTION
AWP REQUIRED FOR ENTRY



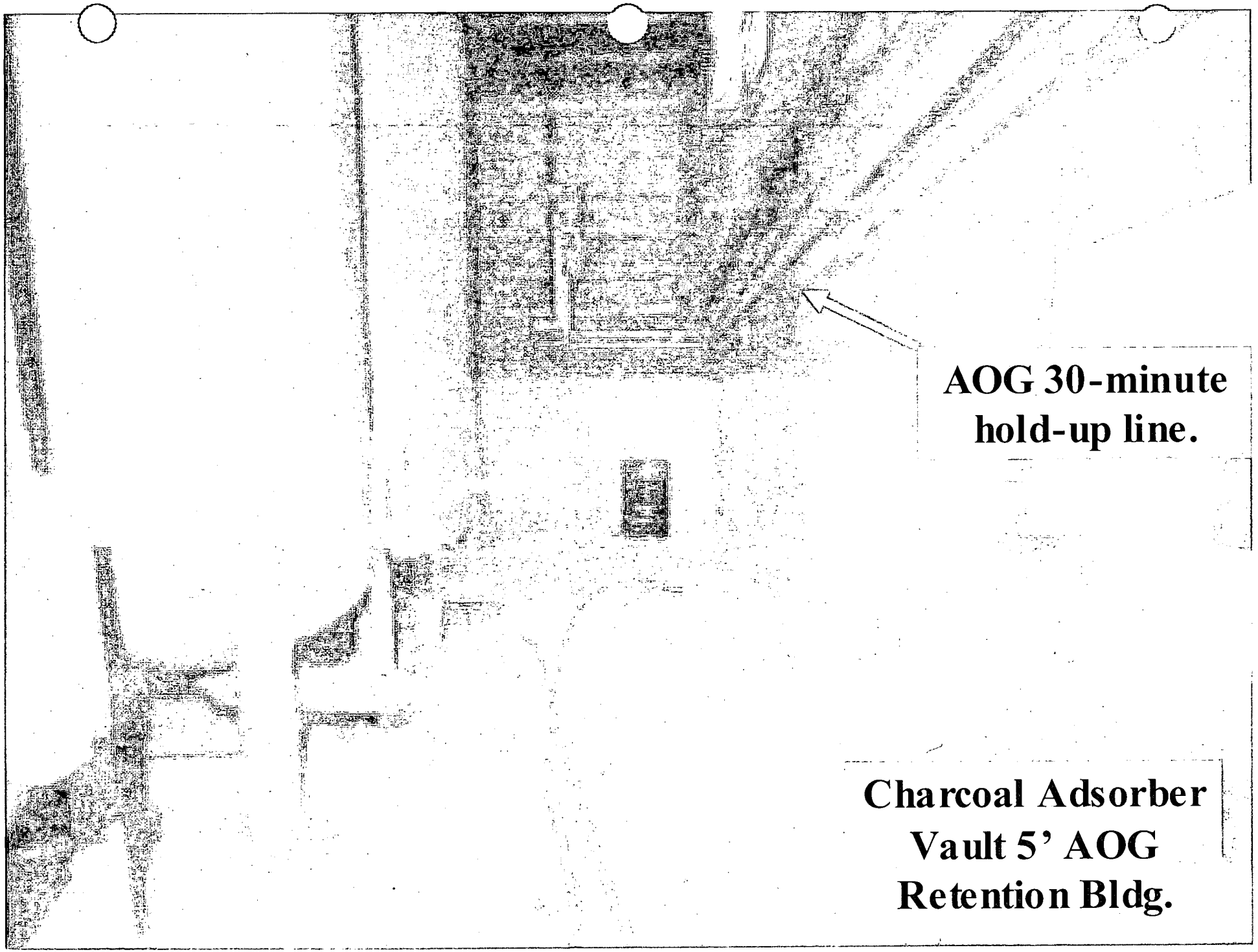
AUGMENTED OFF-GAS SYSTEM (TRAIN "B")

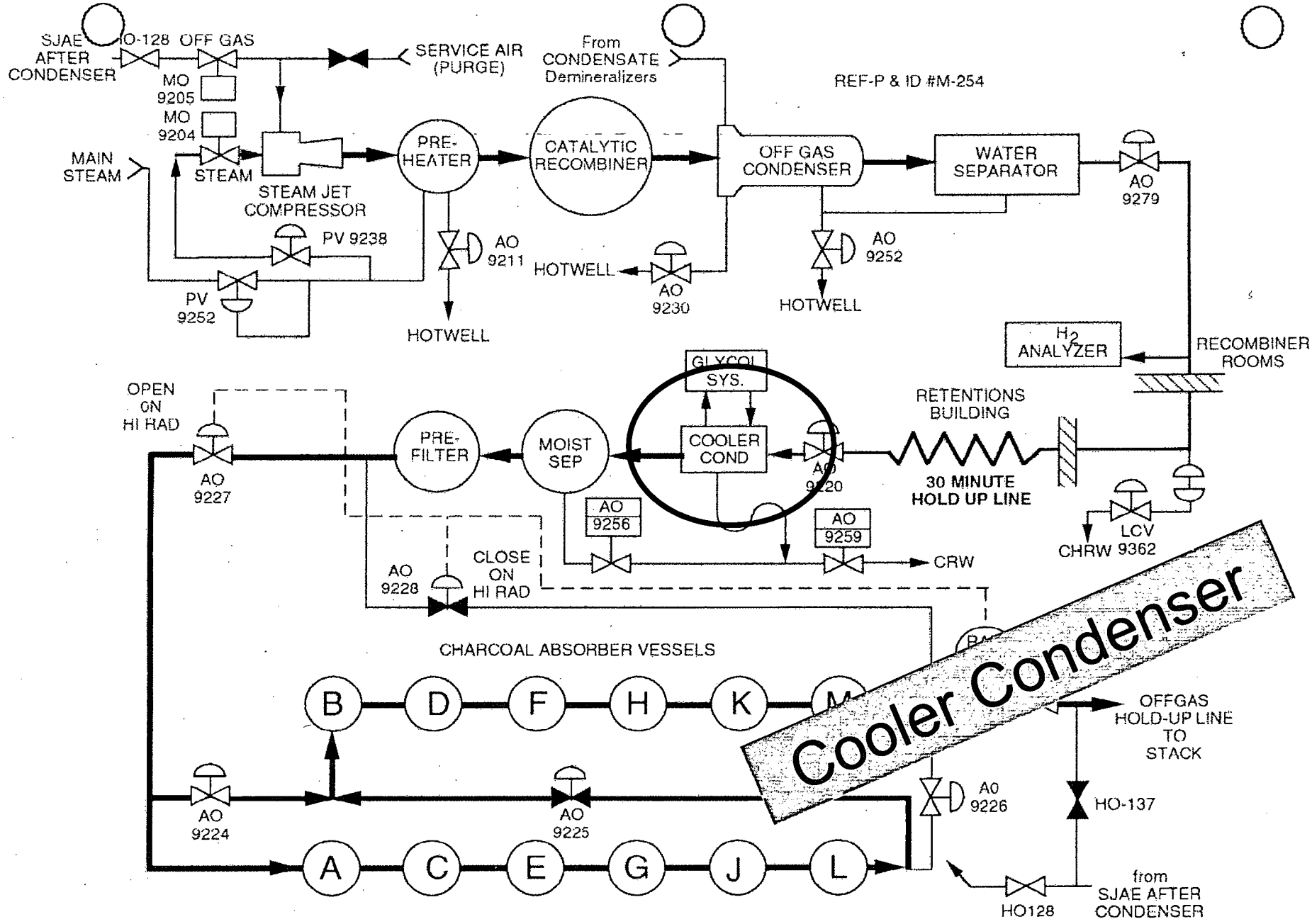
FIGURE 1

21OP81Sb

30-Minute Hold-up Line

- Process gas exits turbine building (south wall) and enters AOG Retention Bldg via pipe chase. The gas enters a 30-minute hold-up line.
- 8" diameter pipe, 1746 feet long. Makes 11 passes around perimeter of the charcoal adsorber vault in retention building.
- Hold-up time delays release of process gas to allow time for shorter lived isotopes (N-13, N-16, O-19 & some Xe and Kr) to decay to non-radioactive isotopes or radioactive particulate daughter products.


AOG 30-minute
hold-up line.
Charcoal Adsorber
Vault 5' AOG
Retention Bldg.



AUGMENTED OFF-GAS SYSTEM (TRAIN "B")

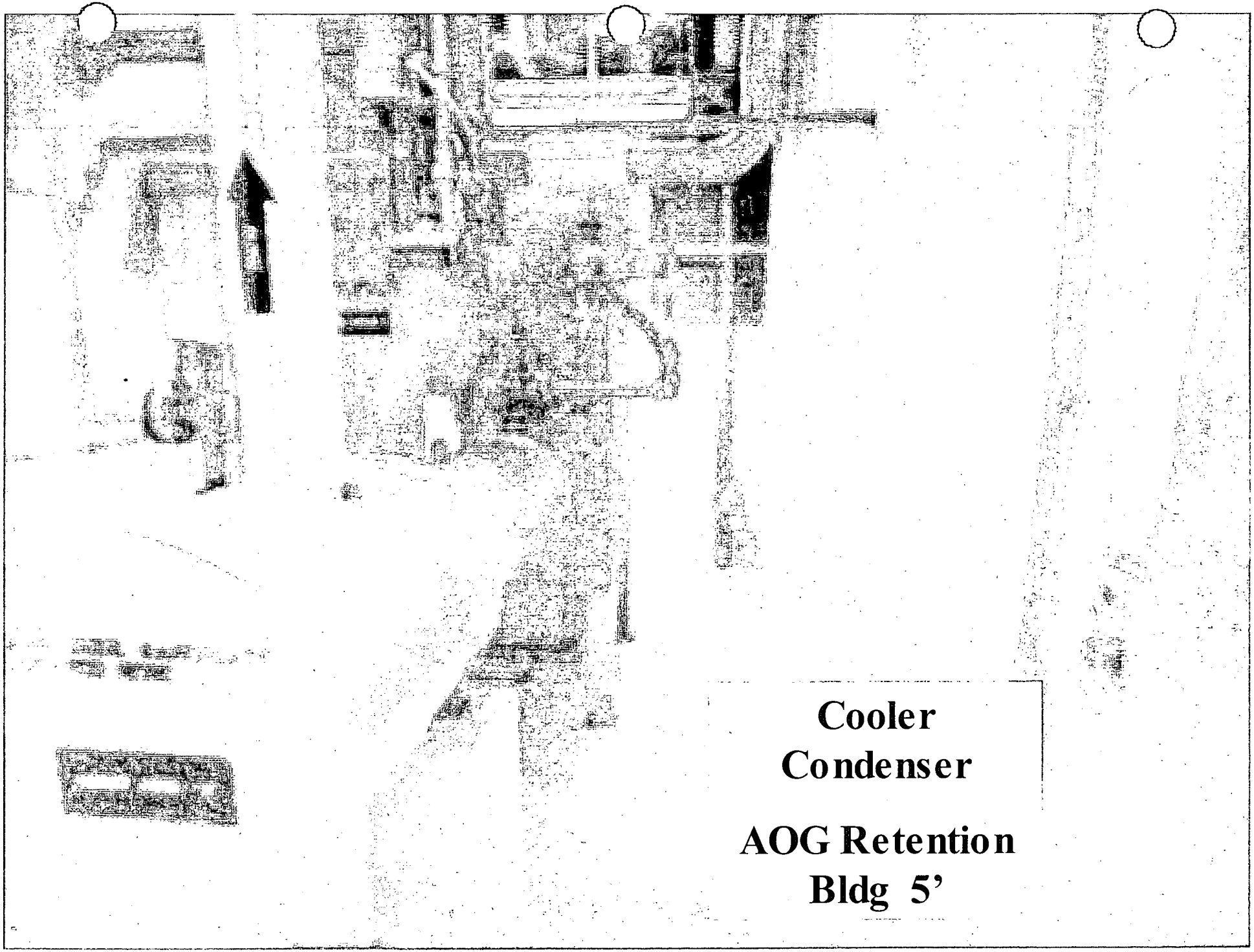
FIGURE 1

21OP819b

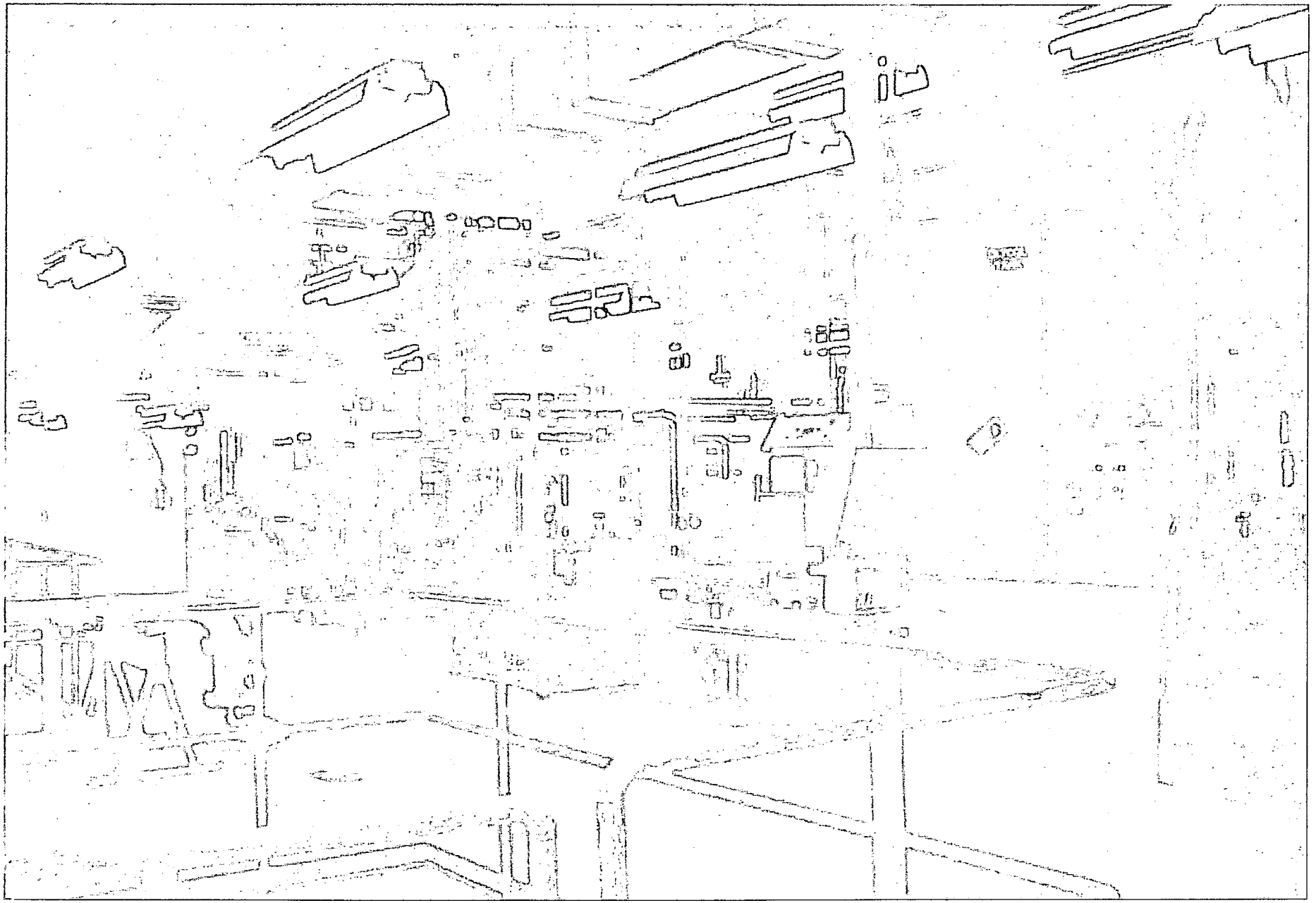
Cooler Condensers

- Dries process gas by cooling gas below its dew point and condensing water vapor.
- Dried offgas adds no moisture to charcoal media in order to maintain activated charcoal.

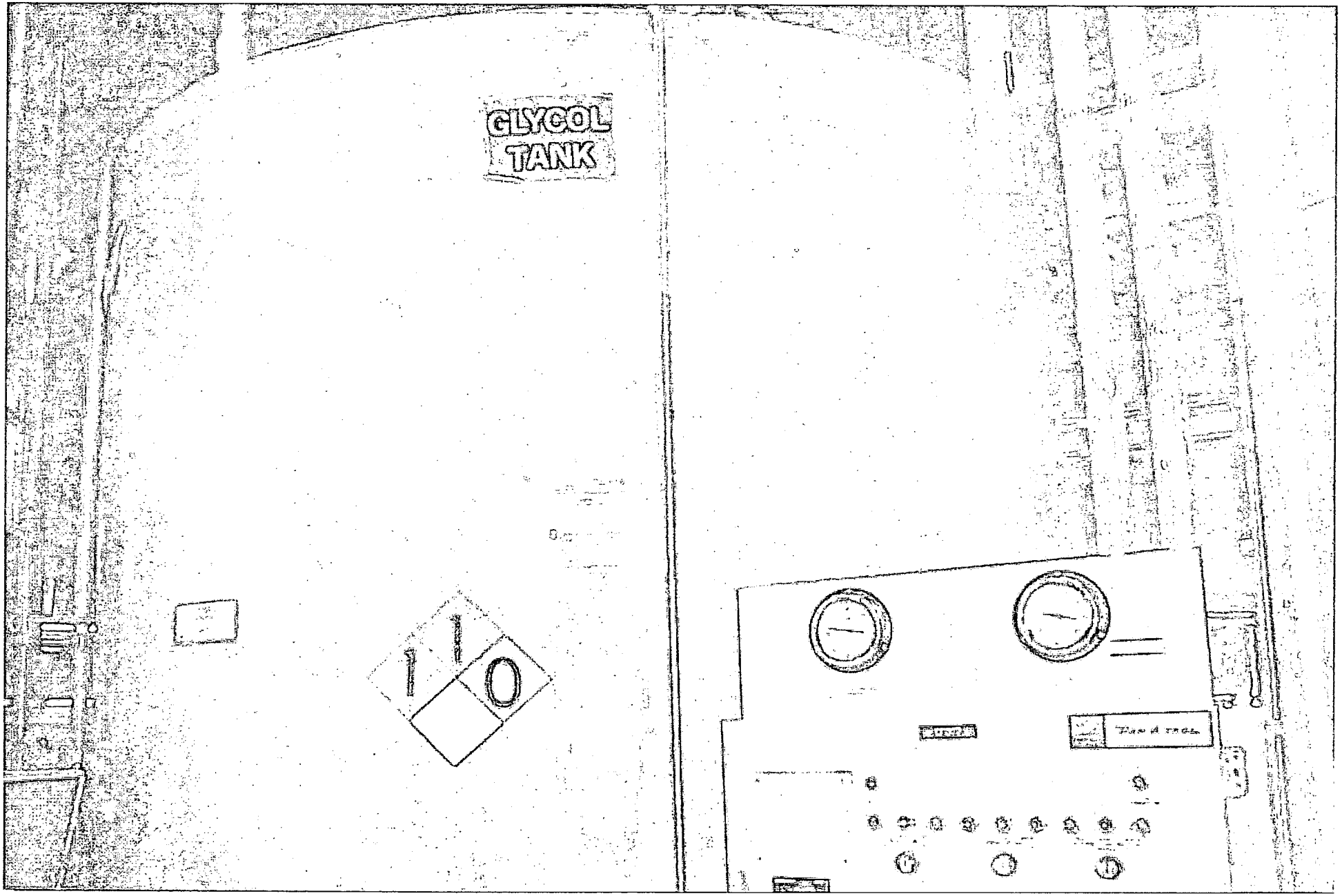
  Process gas flowing through shell is cooled by chilled ethylene glycol passing through the tubes.


Cooler
Condenser
AOG Retention
Bldg 5'

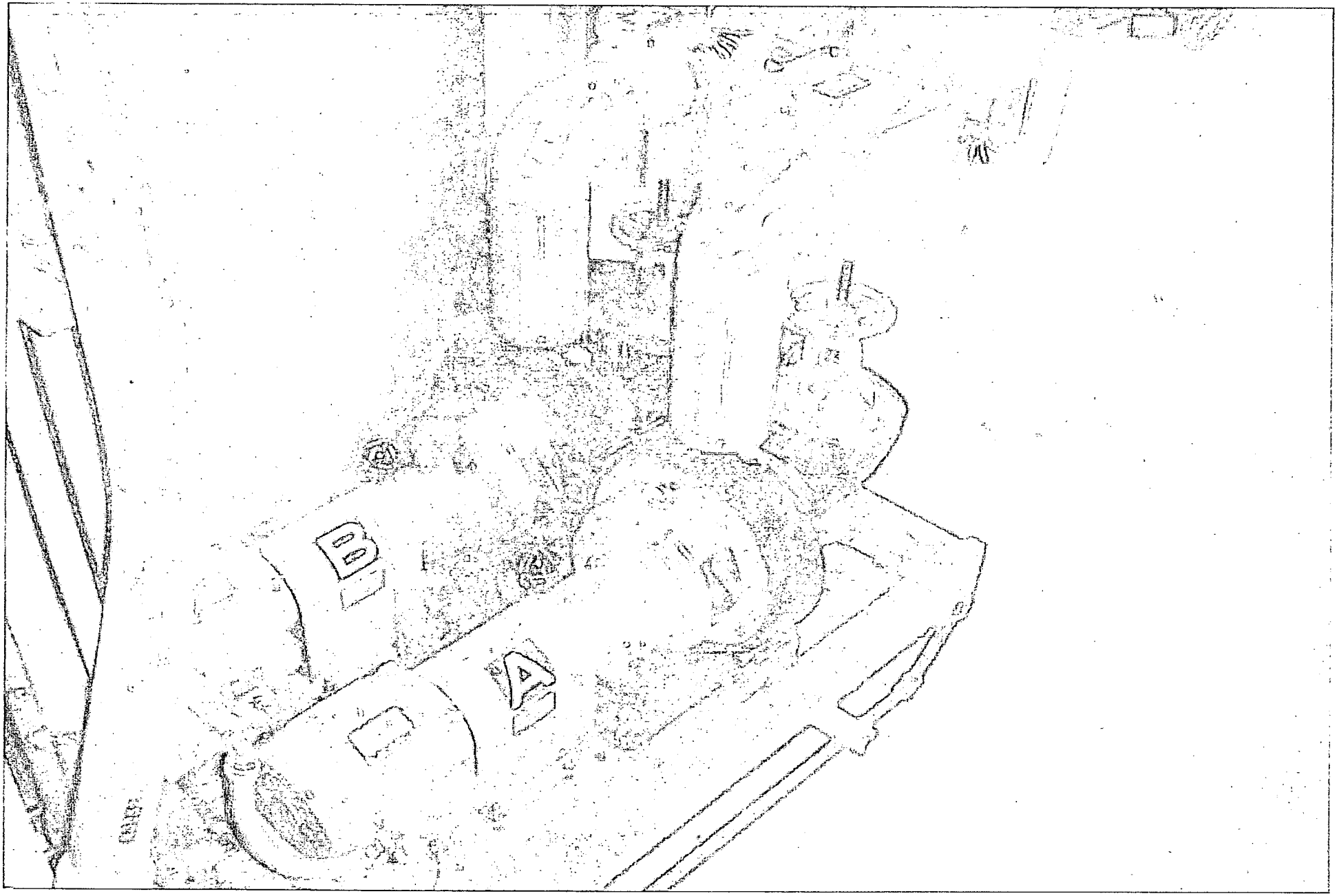
Retention Building



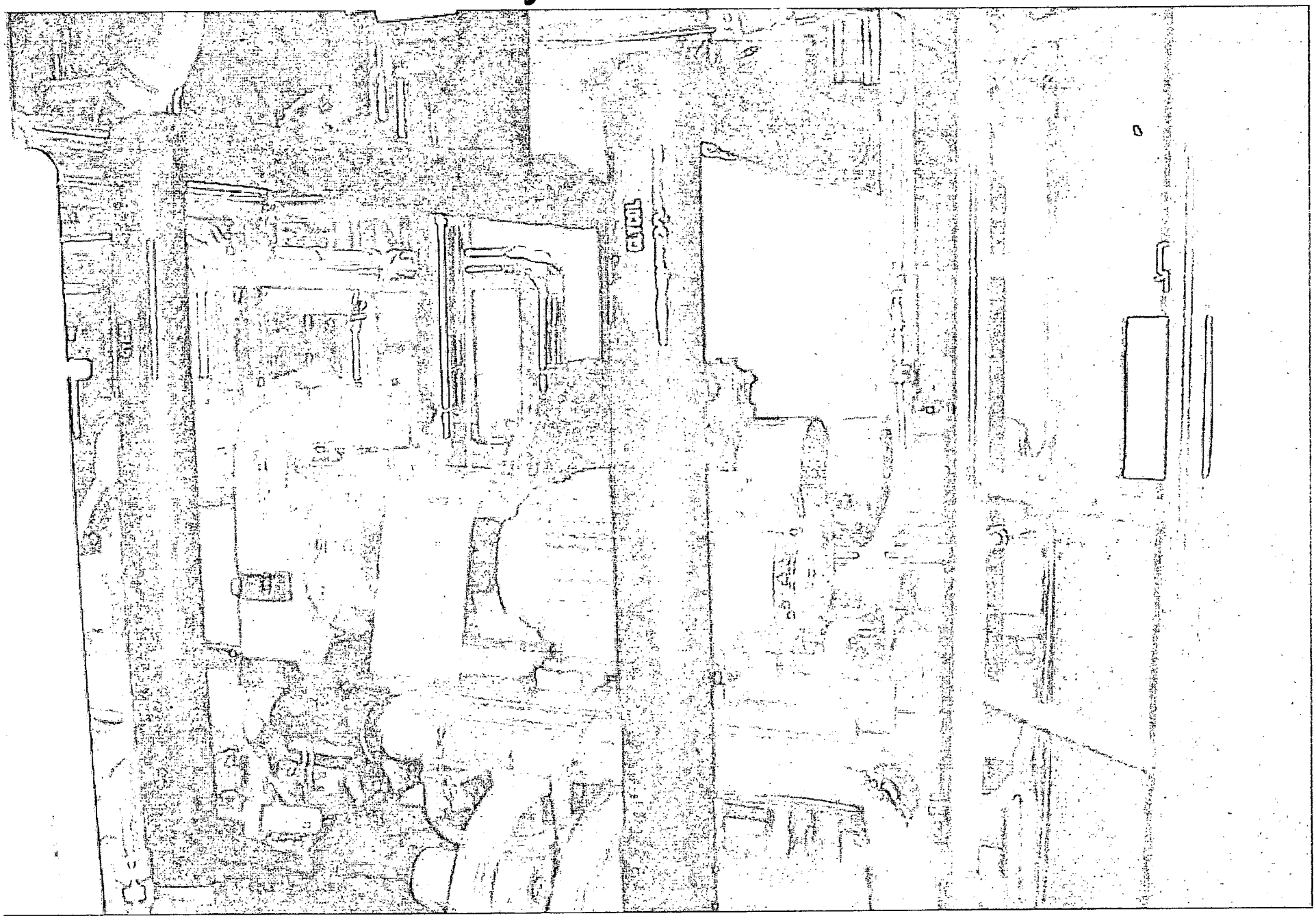
Glycol Storage Tank

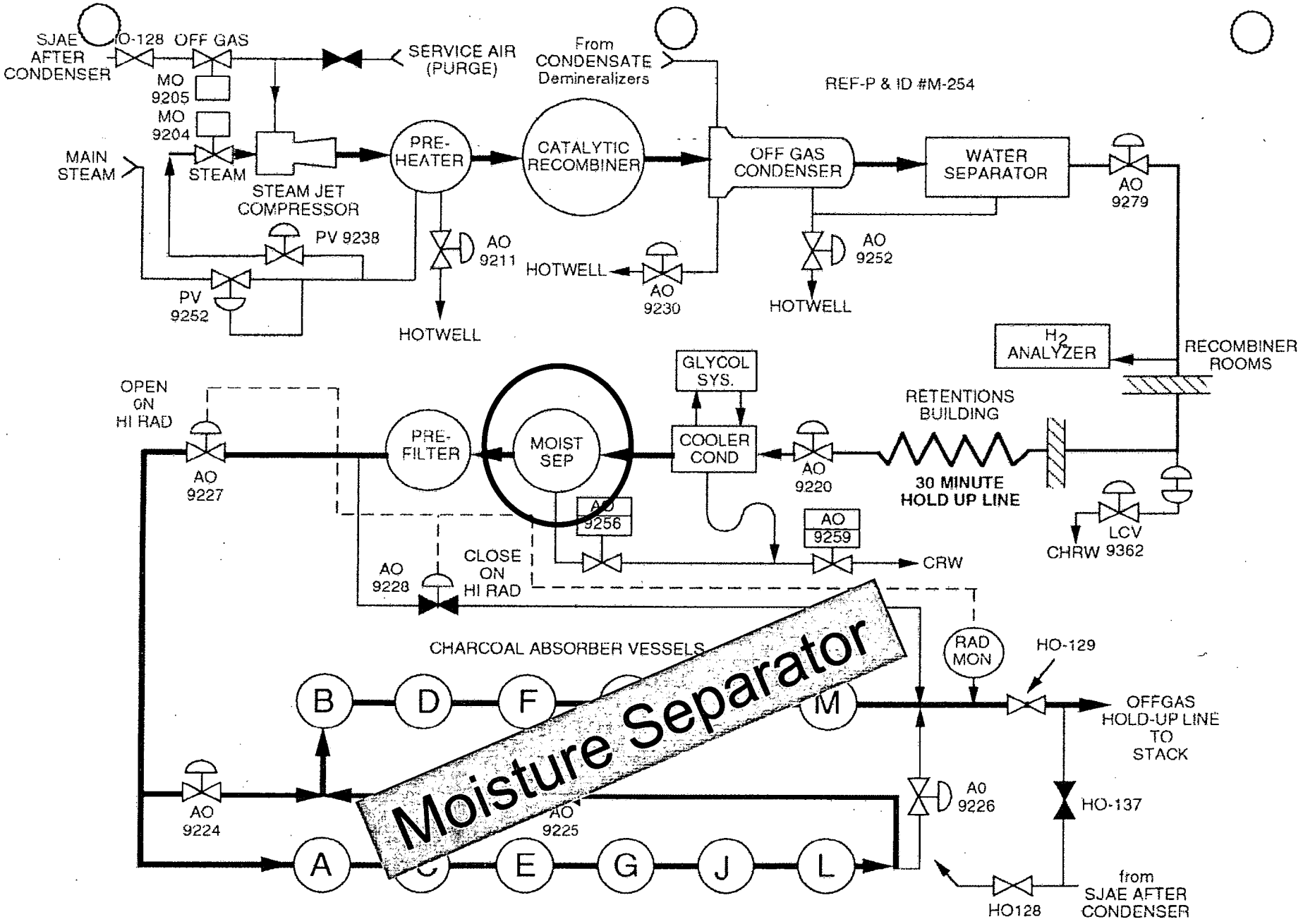


Glycol Pumps



Glycol Chillers





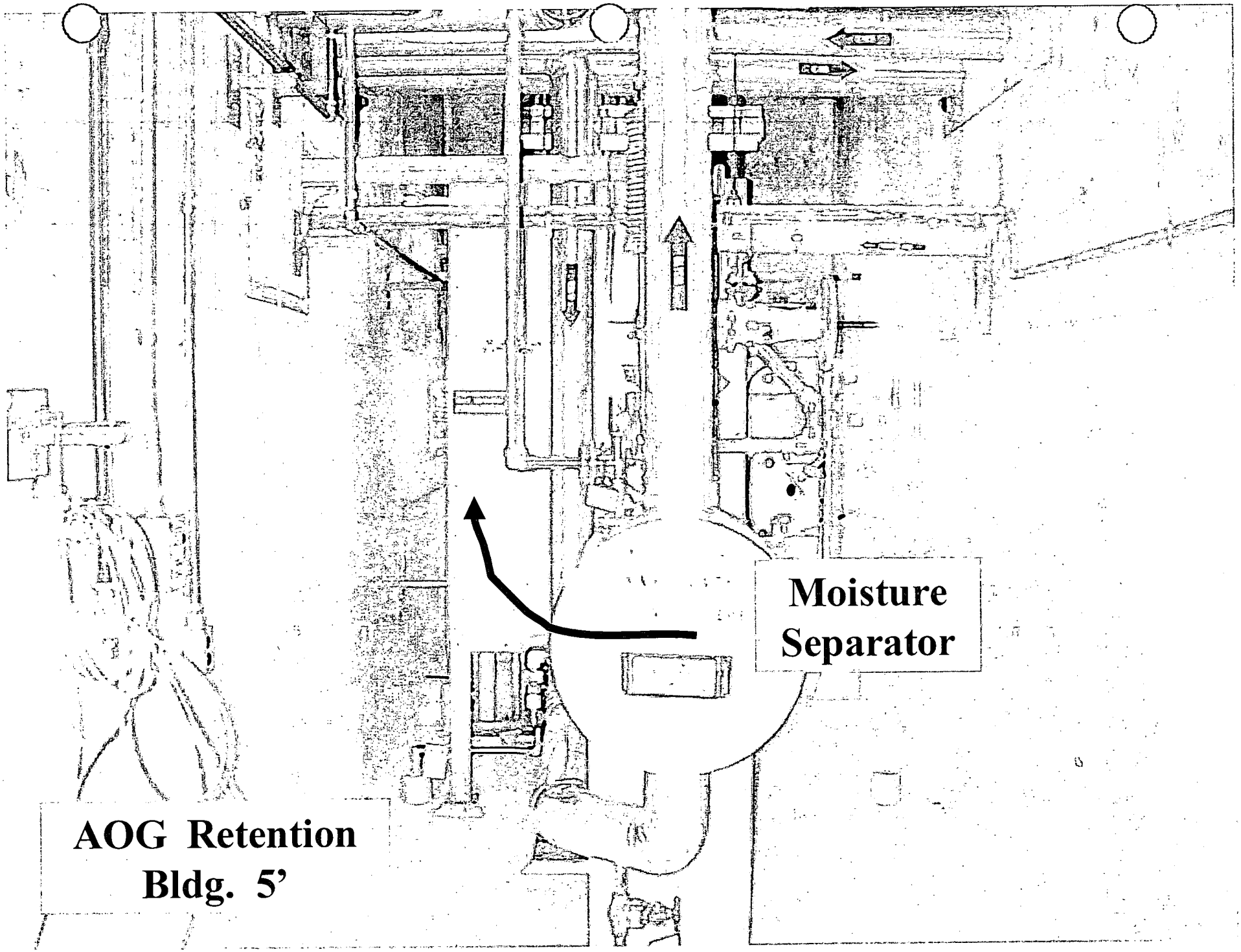
AUGMENTED OFF-GAS SYSTEM (TRAIN "B")

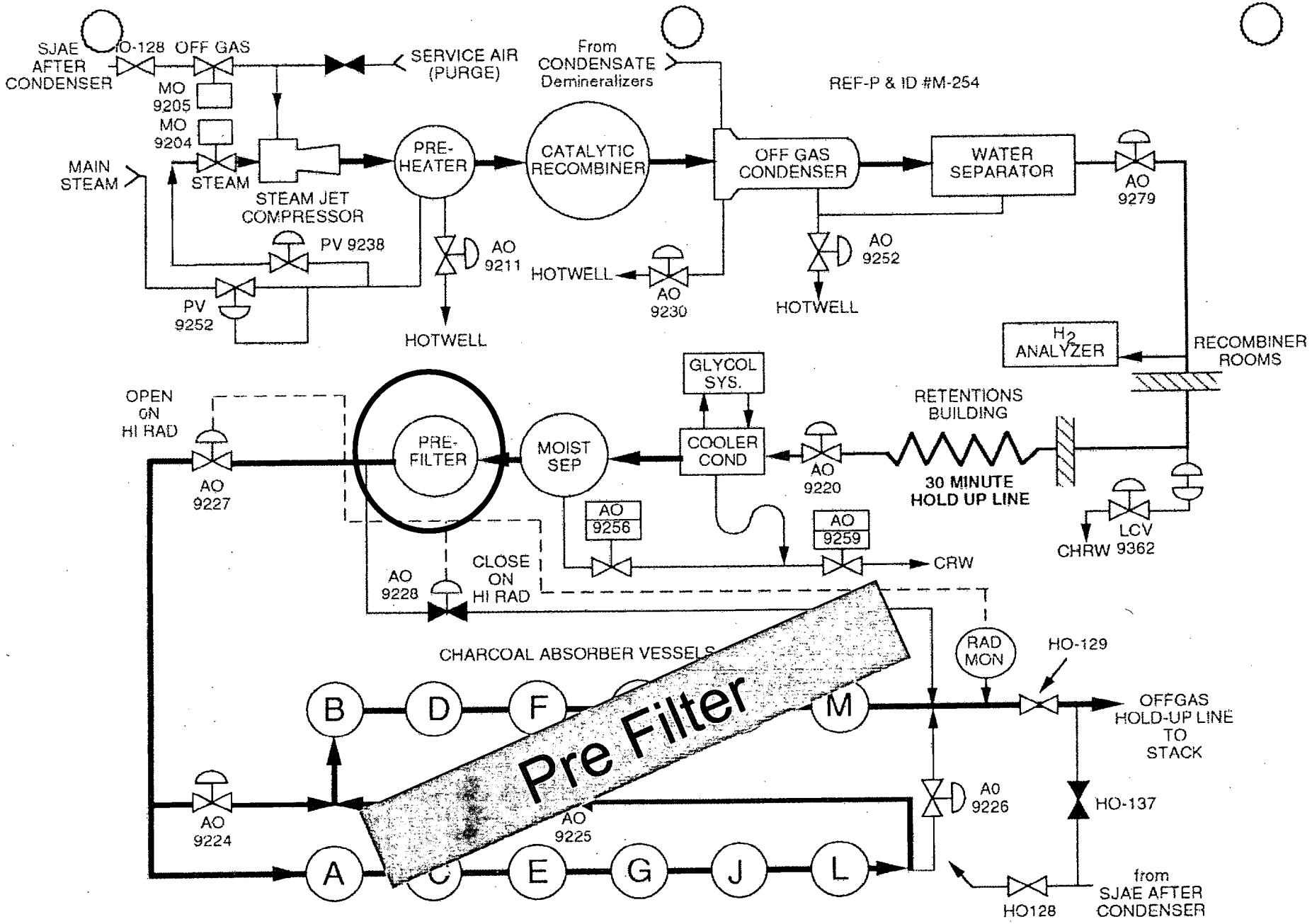
FIGURE 1

21OP81Sb

Moisture Separators

- Moisture droplets in cooled process gas collect on mesh and fall to vessel bottom and drain to radwaste. Similar function to water separator in recombiner room but larger vessel.


Moisture
Separator
AOG Retention
Bldg. 5'



AUGMENTED OFF-GAS SYSTEM (TRAIN "B")

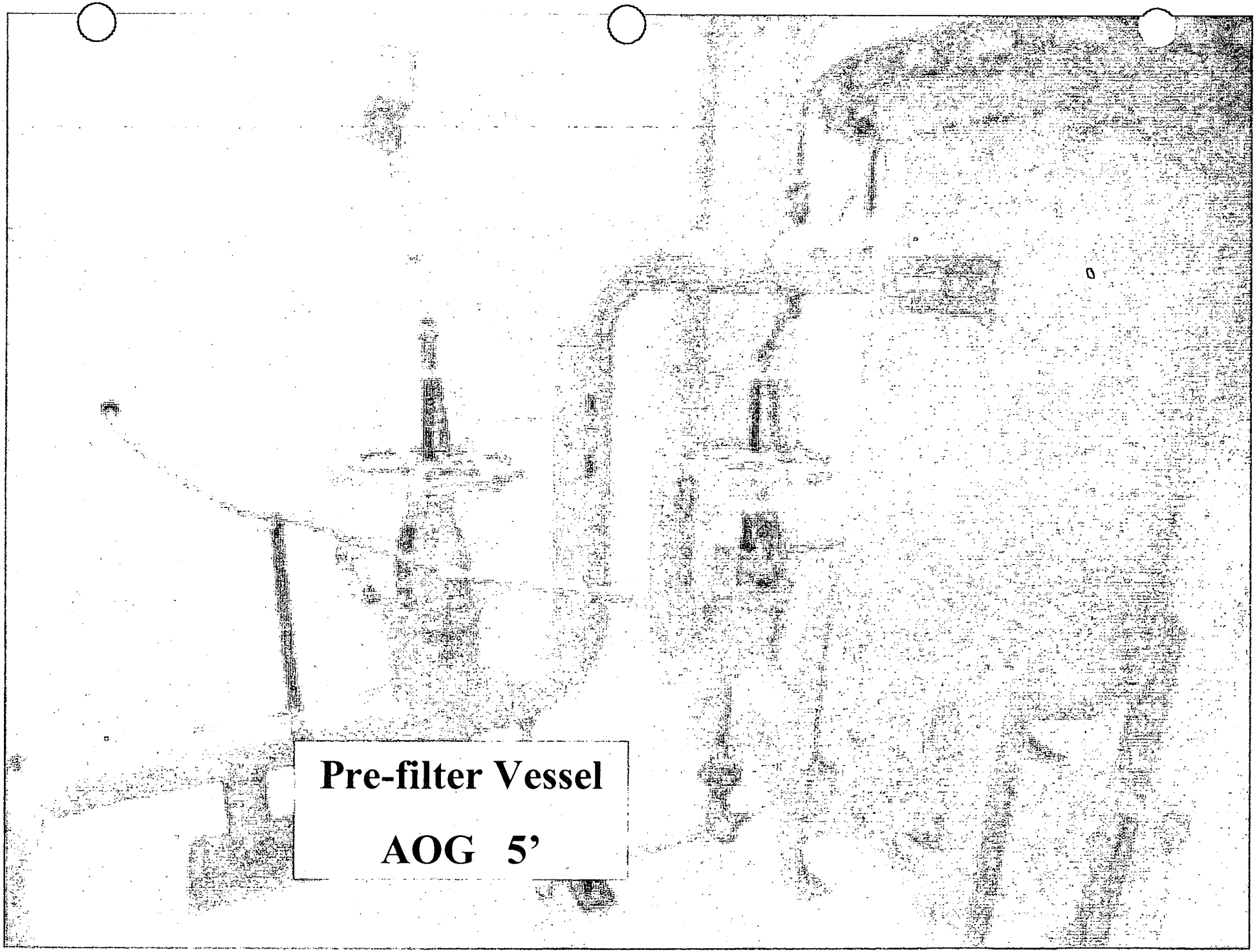
FIGURE 1

21OP819b

Pre-filter

- The pre-filter removes radioactive particulate daughters resulting from the decay of short-lived isotopes in the 30-minute hold-up line.

- The filter elements were removed to reduce the high D/P across the pre-filter caused when water soaked the filter media.


Pre-filter Vessel
AOG 5'

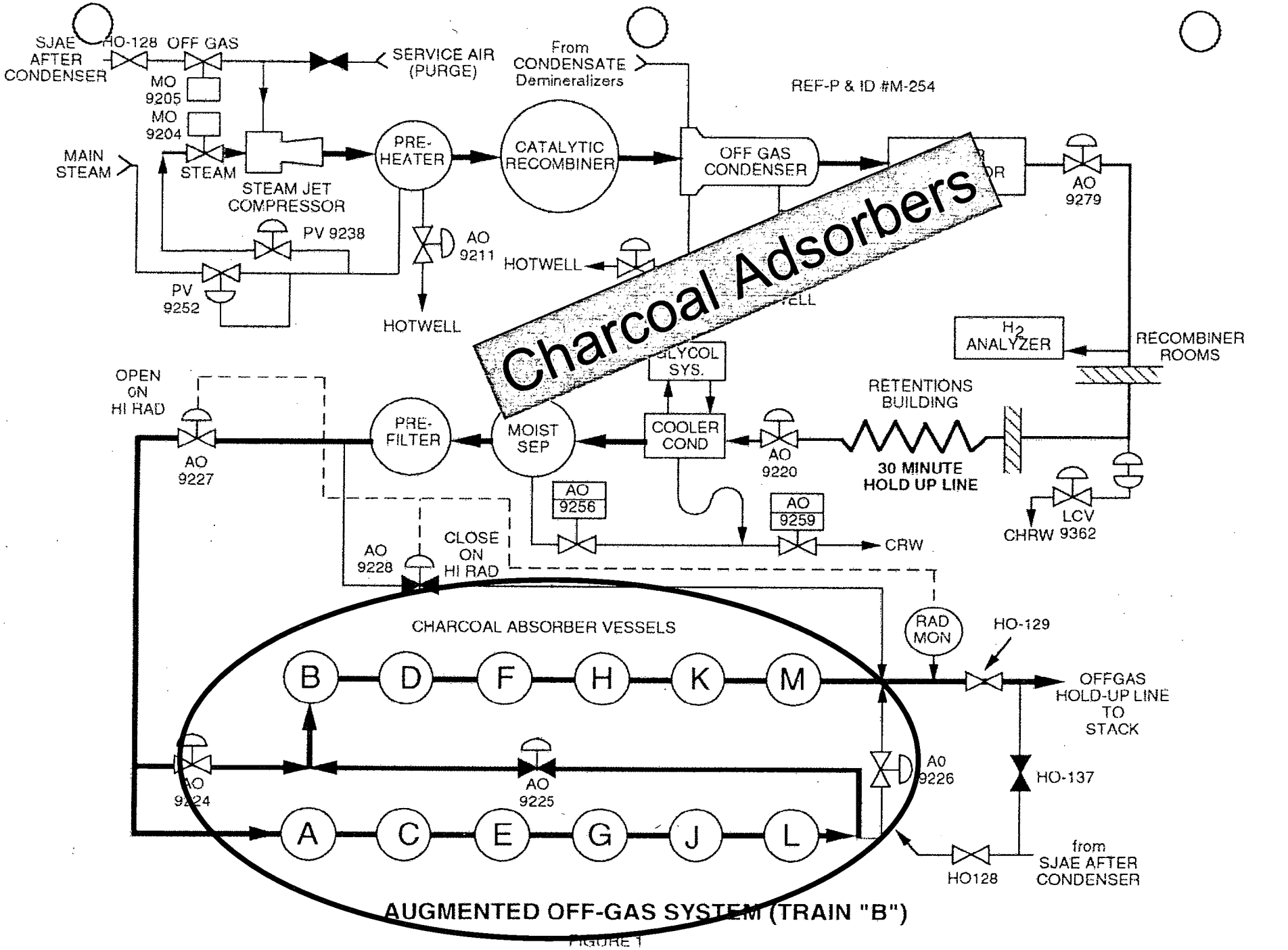
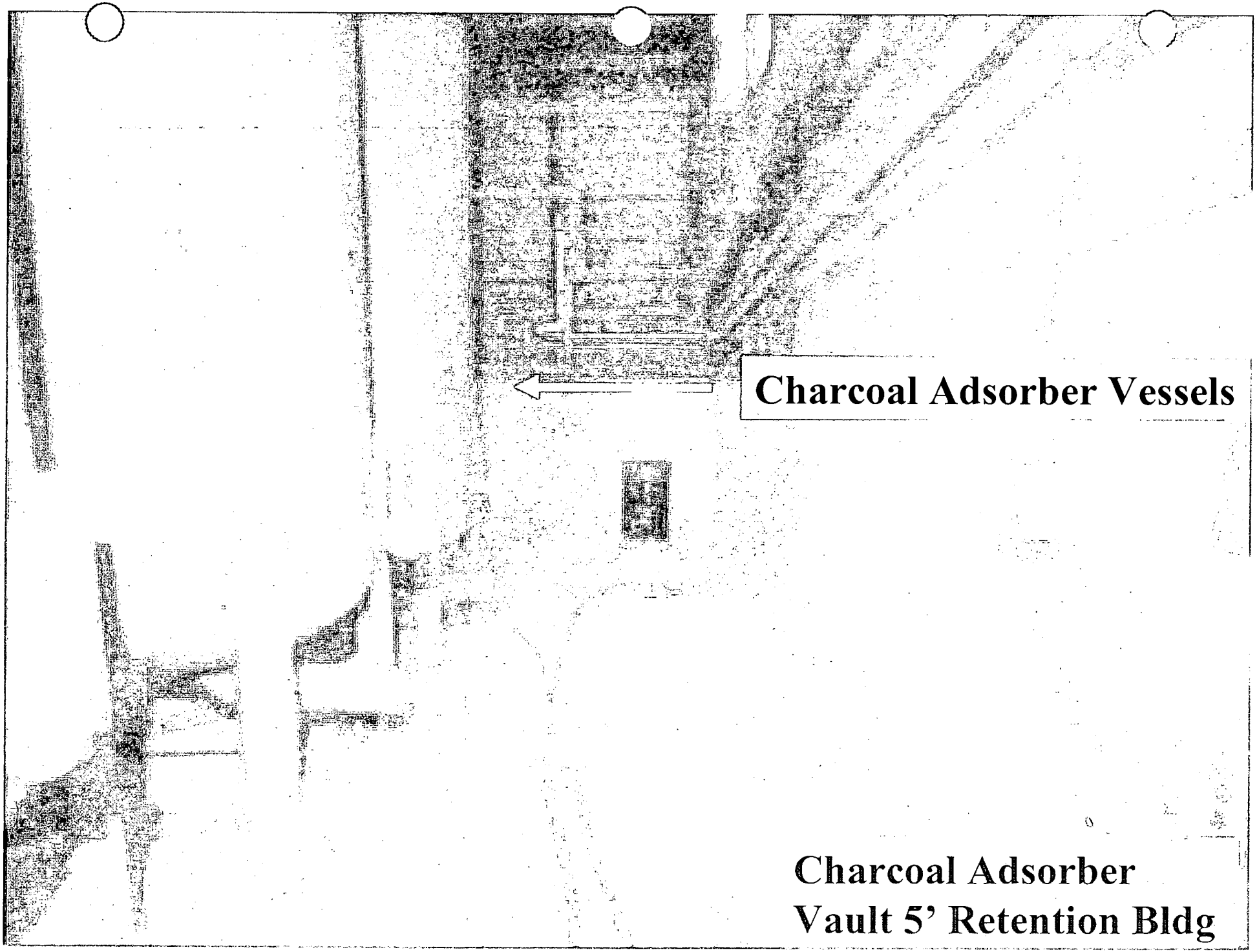


FIGURE 1

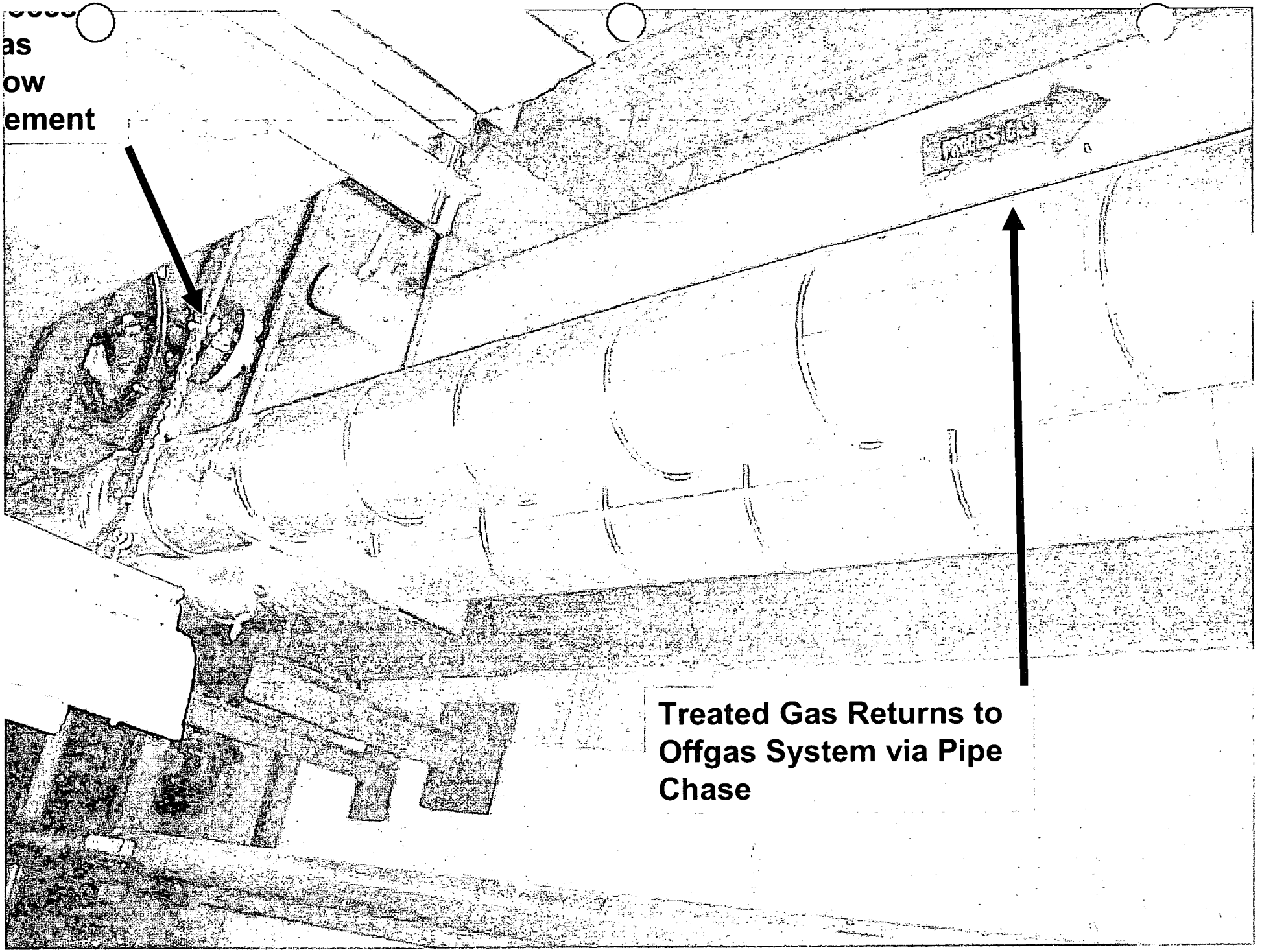
21OP819b

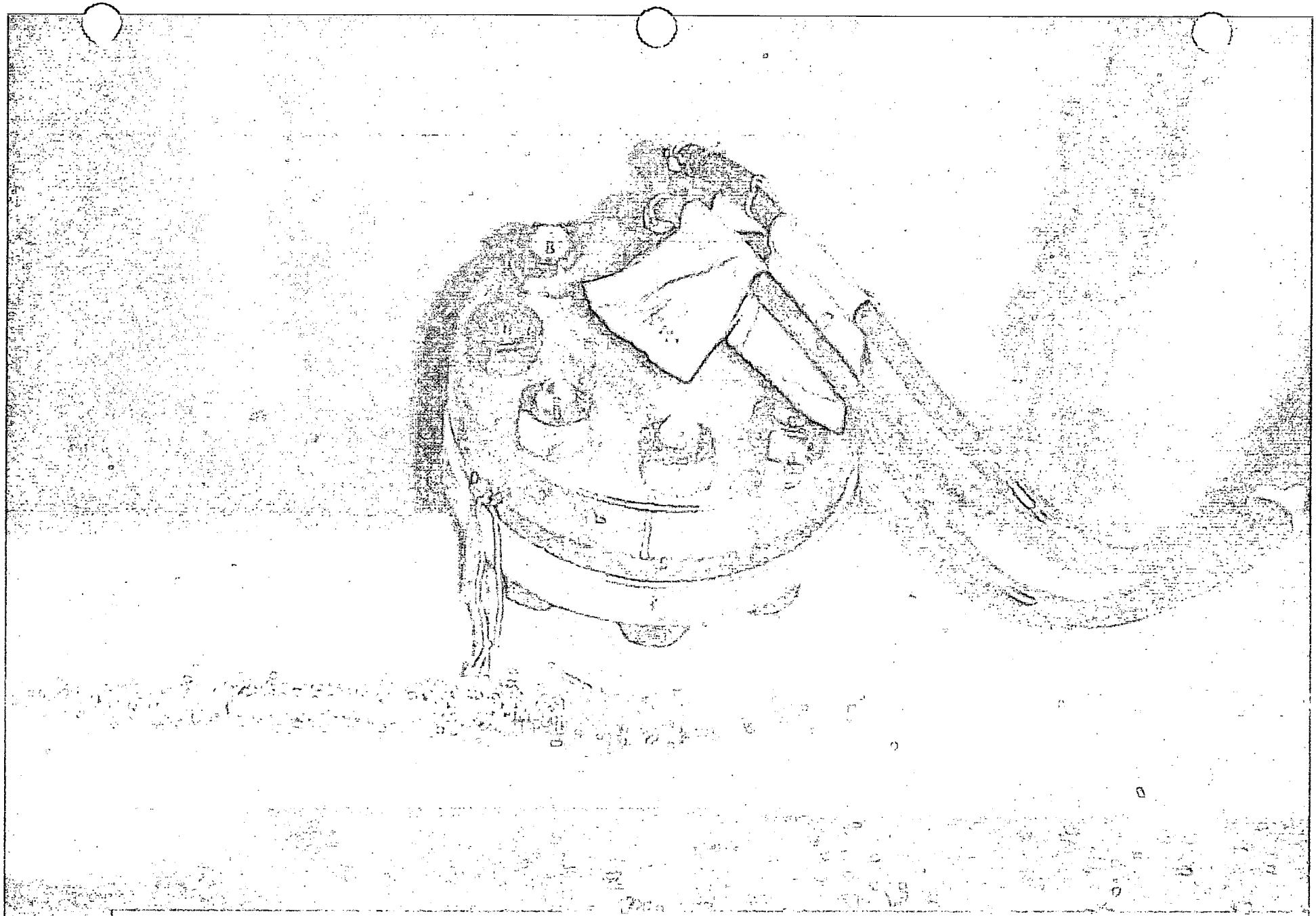
Charcoal Adsorbers

- 12 vessels ea. with 3 tons activated (dry) media
- Activated charcoal surface attracts "adsorbs" noble gas molecules. This delays "holds up" noble gas passage through the charcoal.
- Delay allows gas time for radioactive decay into particulates to be trapped in the charcoal.
- Air passing through charcoal sweeps along noble gases and decreases their holdup time. Low air in-leakage increases noble gas holdup time and improves decontamination factor.
- Water vapor is a competing sorbate. Moisture de-activates charcoal and degrades adsorption.


Charcoal Adsorber Vessels
Charcoal Adsorber
Vault 5' Retention Bldg

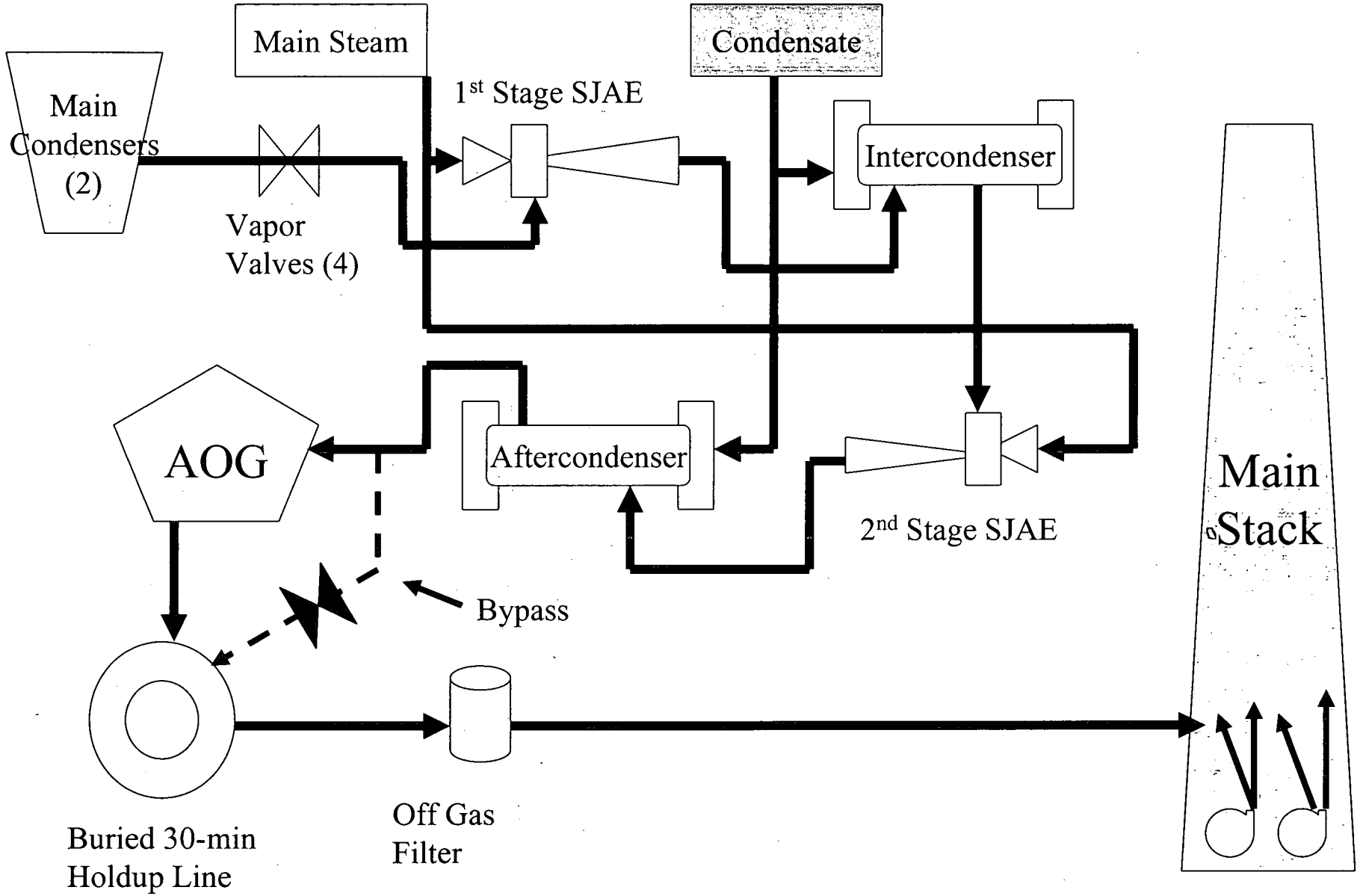
- Process gas exits AOG retention building via pipe chase and returns to condenser bay; re-entering Offgas system at the entrance to the buried 30-minute hold-up line.


as
ow
ement
Treated Gas Returns to Offgas System via Pipe Chase



Process Gas Flow Element i.e. Air In-leakage

Offgas Basic Flow Path



- Bypassing AOG system results in flammable offgas with a higher gaseous radwaste content flowing out to the main stack release point.

Technical Specifications (EO 6)

- Gross gamma activity rate of noble gases measured at the pre-treat rad monitors (Offgas Σ 6) shall not exceed 500,000 micro-curies per second.
- Per ODCM, Reactor power not to exceed 50% without AOG in service.
- Mechanical vacuum pump operation permitted at reactor power < 5%.
- The ODCM is referenced in TS 5.5.4 Radioactive Effluent Controls Program.

Power Supplies

- MCC B-30 receives power from B-8
  - B-30 powers H2 recombiner area coolers
  - Steam Jet compressor inlet valves (MO-9204 & 9206)
  - Steam Jet compressor off gas inlet valves
  - Off Gas condenser cooling water discharge valves (MO-9271 & 9272)

  Loss of B-30 results in high moisture and less efficient recombination

Power Supplies

- MCC B-31 is powered from B-8
  - B-31 powers the glycol cooling system

Loss of B-31 also results in high moisture and less efficient adsorber operation.

Normal System Operation

- AOG is put into service before 50% power
- Off Gas system must be in service
- H2 analyzer must be in service for AOG
- The following will isolate AOG/Off gas
  - Low Steam to the SJAE inlet reg (<40psi)
  - Hi Temp off gas 30 min hold up line (250 F)
  - Hi press off gas 30 min hold up line (35psig)
  - Lo dilution flow to Steam Jet Compressor (< 4500lb/hr)

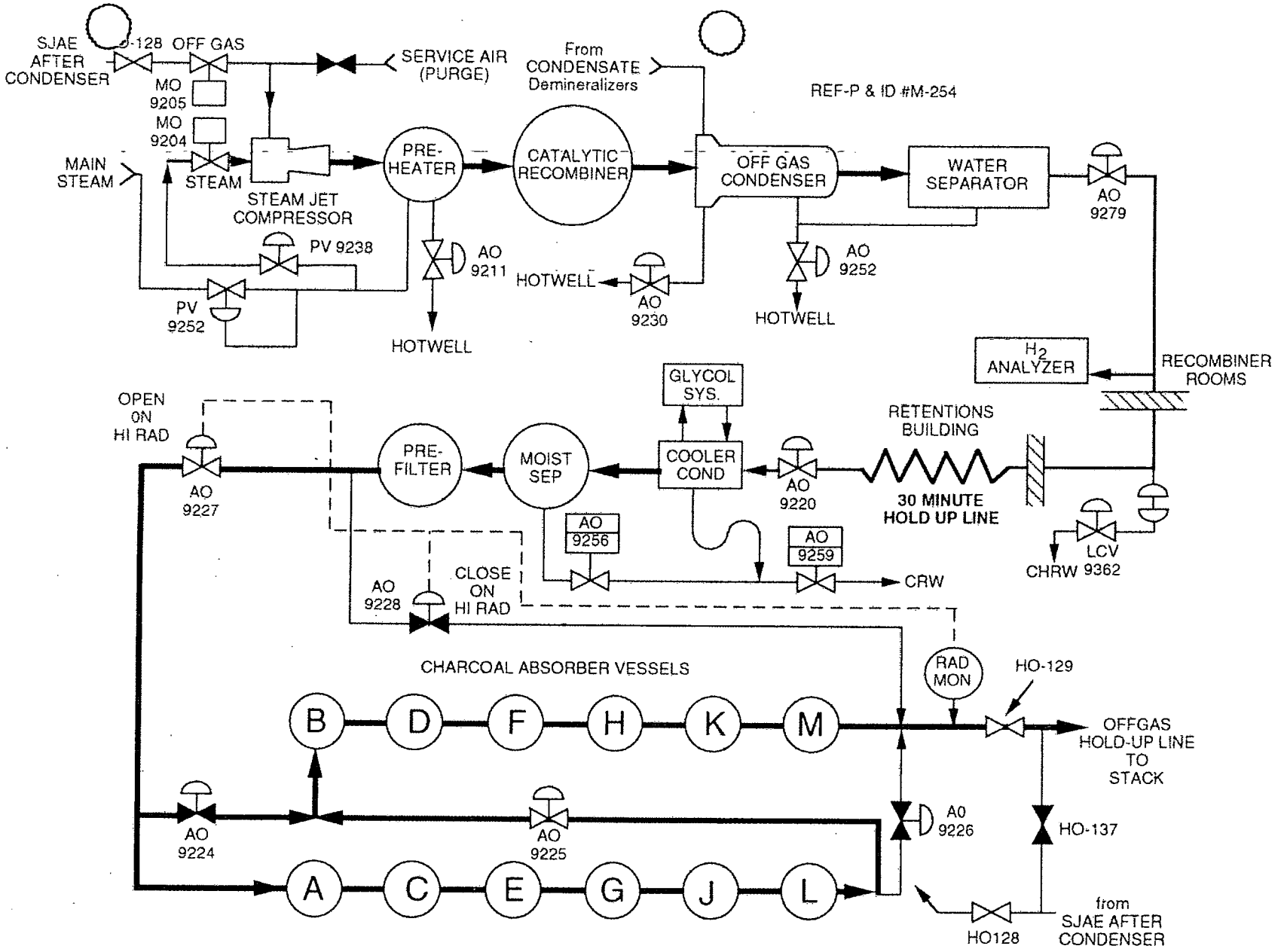
System start up

Normal System Operation

System Shutdown

Abnormal Operation

Operation Experiance



AUGMENTED OFF-GAS SYSTEM (TRAIN "B")

FIGURE 1

21OP819b

EO-02

Abnormal Operations

System Interrelationship

- TBCCW – Cools H2 analyzer and Glycol
- Radwaste – receives drains from coolers
- Inst Air for Air operated valves
- Main steam for Jet compressor and preheater
- Rad Monitors

Industry OE

Human Performance Moment

Safety Moment

Review