

TURBINE-GENERATOR AND ACCESSORIES

TURBINE-GENERATOR AND ACCESSORIES

A. NO. 1 TURBINE-GENERATOR AND ACCESSORIES

GENERAL

THE GENERAL ELECTRIC TURBINE-GENERATOR UNIT IS A 50,000 KW TANDEM COMPOUND, DOUBLE-FLOW, CONDENSING, 3600 RPM STEAM TURBINE DESIGNED FOR INITIAL STEAM CONDITIONS OF 1250 PSIG, 950 DEGREE F., EXHAUSTING TO 1" HgA WITH PROVISION FOR DOUBLE AUTOMATIC EXTRACTION OF STEAM AT 475 PSIG AND 235 PSIG AND UNCONTROLLED EXTRACTION AT VARYING PRESSURE.

THE TURBINE IS DIRECTLY CONNECTED TO THE HYDROGEN COOLED, 14,400 VOLT 3600 RPM, THREE PHASE, TWO-POLE, 60 CYCLE GENERATOR WHICH IS RATED AT 58,824 KVA AT 0.85 POWER FACTOR AND 30 PSIG HYDROGEN PRESSURE. FIELD EXCITATION IS SUPPLIED BY A MAIN EXCITER MOTOR-GENERATOR SET; THE MOTOR RUNS ON THREE PHASE 2300 VOLT, 60 CYCLE POWER; THE GENERATOR IS RATED 200 KW AT 250 VOLTS DC. AN IDENTICAL SPARE IS ALSO PROVIDED.

NO. 1 TURBINE

THE LOW PRESSURE CASING OF THE TURBINE IS SUPPORTED ON LEVEL SOLE PLATES AND THE FRONT STANDARD IS SUPPORTED ON FOUR VERTICAL FLEX PLATES WHICH ALLOWS FOR LONGITUDINAL EXPANSION. AS EXPANSION TAKES PLACE, THE MACHINE GROWS FORWARD FROM THE HIGH PRESSURE END OF THE LOW PRESSURE TURBINE WHERE THE EXHAUST SUPPORT FOOT IS KEYED TO THE SOLE PLATE WHICH CAUSES THE FLEX PLATES TO BEND IN A FORWARD DIRECTION. EXPANSION OF THE LOW PRESSURE TURBINE CAUSES THE CASING TO MOVE TOWARD THE GENERATOR.

THE TURBINE CASINGS ARE SPLIT HORIZONTALLY AT THE SHAFT CENTERLINE. ALL JOINTS HAVE METAL-TO-METAL SCRAPED SURFACES WHICH ARE SEALED ANY TIME THEY ARE RE-ASSEMBLED WITH A HEAVY COATING OF TRIPLE BOILED LINSCEOIL. STEAM ADMISSION VALVES (V1) ARE CONTAINED IN THE UPPER AND LOWER STEAM CHESTS LOCATED ON THE OUTER SHELL AT THE FRONT OF THE HIGH PRESSURE CASING. INTERNAL STEAM EXTRACTION VALVES (CALLED SPOOL VALVES) ARE LOCATED AT THE SIXTH (V2) AND NINTH (V3) STAGES. THE FRONT STANDARD PROVIDES SUPPORT FOR THE NUMBER ONE BEARING (WHICH SUPPORTS THE FRONT END OF THE HIGH PRESSURE TURBINE), THE THRUST BEARING, MAIN SHAFT DRIVEN OIL PUMP AND SOME OF THE GOVERNING AND CONTROL MECHANISM.

THE TURBINE ROTORS ARE MADE FROM SOLID ALLOY STEEL FORGINGS SOLIDLY BOLTED TOGETHER BY A SO-CALLED "MARRIAGE" COUPLING BETWEEN THE HIGH AND LOW PRESSURE ELEMENTS. THE ROTOR SHAFT, SEAL AREAS, BEARING JOURNALS AND COUPLING FLANGES ARE MACHINED FROM THESE FORGINGS TO FORM TWO SOLID ROTORS. THE TURBINE END OF THE GENERATOR COUPLING IS ALSO MACHINED FROM THIS FORGING.

~~between the high-pressure casing and front standard is covered with metal lagging as is that area between the generator end bearing and collector ring housing.~~

Refer to Procedures Manual for Turbine startup procedure.

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STEAM PATH

STEAM FROM THE 1250# MAIN STEAM HEADER FLOWS INTO THE TURBINE MAIN STOP VALVE WHICH CONTAINS A REMOVABLE, CLEANABLE STEAM STRAINER. THIS VALVE IS HYDRAULICALLY OPERATED AND IS DESIGNED FOR QUICK CLOSING UPON EITHER EMERGENCY OR HAND TRIP OPERATION. STEAM ENTERS THE UPPER AND LOWER TURBINE STEAM CHESTS THROUGH TWO STEAM LEADS FROM THE STOP VALVE. THE LINE TO THE UPPER HALF OF THE TURBINE CASING IS COUPLED TO FACILITATE REMOVAL OF THE UPPER SHELL FOR MAINTENANCE. FROM THE STEAM CHESTS, STEAM IS ADMITTED THROUGH THE UPPER AND LOWER INLET VALVES (V1) TO THE FIRST PRESSURE STAGE OF THE TURBINE. THE STEAM THEN EXPANDS THROUGH FIVE MORE PRESSURE STAGES TO THE SIXTH-STAGE SHELL WHERE THE 475# (V2) VALVES ARE LOCATED. THE STEAM THAT IS NOT EXTRACTED PASSES THROUGH THREE MORE PRESSURE STAGES INTO THE NINTH-STAGE PRESSURE SHELL WHERE THE 235# (V3) VALVES ARE LOCATED. THE STEAM THAT IS NOT EXTRACTED MIXED WITH ANY THAT IS ADMITTED AT THIS POINT PASSES THROUGH TWO MORE STAGES AND ANY THAT IS NOT EXTRACTED THROUGH THE UNCONTROLLED EXTRACTION PASSES THROUGH THE CROSS-OVER PIPE INTO THE DOUBLE-FLOW LOW PRESSURE TURBINE. THE STEAM, AFTER EXPANDING THROUGH TWELVE MORE STAGES (SIX IN EACH DIRECTION) EXHAUSTS TO THE CONDENSER WHERE IT IS CONVERTED INTO CONDENSATE.

SHAFT SEALING SYSTEM

STEAM LEAKAGE OUT OF THE MACHINE AND AIR LEAKAGE INTO THE MACHINE ARE PREVENTED BY STEAM LABRYINTH PACKING SEALS AT BOTH ENDS OF THE HIGH PRESSURE SHELL AND BOTH ENDS OF THE LOW PRESSURE SHELL. SEALING STEAM OVER AND ABOVE THAT WHICH COMES FROM THE V1, V2 AND V3 PACKING LEAK-OFF IS PROVIDED BY 235# STEAM FROM PROCESS CONTROLLED BY A SEAL STEAM PRESSURE CONTROL VALVE AND DUMP VALVE ARRANGEMENT. THE SEAL STEAM PRESSURE IS CONTROLLED AT 2 TO 3 PSI ABOVE ATMOSPHERIC TO PREVENT AIR LEAKAGE INTO THE CONDENSER WHICH WOULD RESULT IN LOSS OF CONDENSER VACUUM. WHEN OPERATING AT ANY LOAD, THE TURBINE INTERNAL PRESSURE AT THE FRONT END OF THE HIGH PRESSURE TURBINE IS CONSIDERABLY ABOVE ATMOSPHERIC AND SOME STEAM WILL ESCAPE TO THE ATMOSPHERE AT THIS POINT. A GLAND EXHAUST SYSTEM CONSISTING OF A TUBE-TYPE SURFACE CONDENSER AND AIR REMOVAL EQUIPMENT IS USED TO PROVIDE A MEANS FOR DISPOSING OF STEAM THAT LEAKS PAST THE PACKING RINGS. THE GLAND EXHAUSTER MAINTAINS A SLIGHT VACUUM IN THE TURBINE PACKING RING ANNULUS CLOSEST TO THE ATMOSPHERE; THIS PULLS THE LEAKAGE STEAM DOWN INTO THE GLAND CONDENSER WHERE IT IS CONDENSED BY CONDENSATE FLOWING THROUGH THE TUBES AND IS RETURNED TO THE MAIN CONDENSER HOTWELL BY FLOAT TRAPS. IF THE ESCAPING STEAM WAS ALLOWED TO FLOW TO ATMOSPHERE IT WOULD CONDENSE OUT ON COOLER PORTIONS OF THE TURBINE LAGGING CAUSING CORROSION AND ALSO POSSIBLY TRAVEL PAST THE BEARING OIL DEFLECTORS, MIXING WITH THE BEARING OIL WHERE IT WOULD BE CONVERTED INTO WATER AND CONTAMINATE THE SYSTEM.

admitted to the low-pressure packing to prevent air leakage into the condenser. When operating at normal load, the turbine internal pressure at the high pressure and intermediate packing is considerably above atmosphere and, therefore, at this condition steam will escape from the turbine at these points.

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TURBINE-GENERATOR AND ACCESSORIES (cont'd)

A gland exhauster, ^{system} consisting of a shell and tube-type surface condenser and air removal equipment, is used to provide means for disposing of steam that leaks past the packing rings. This exhauster system maintains a slight vacuum in the turbine shaft packing rings closest to the atmosphere, thus preventing steam from escaping to the atmosphere. The turbine can be operated without the air removal equipment, but this is not desirable. The escaping steam would condense out on the cooler metal surfaces in the area and cause corrosion. It is also possible, and sometimes it does happen, that the escaping steam vapors will get past the bearing oil seals and become entrained in the oil, thus contaminating the system.

Control Mechanism and Governor

Under normal operating conditions, the speed and load of the unit are controlled by the TS-500 located in the Control Room. The Tri-Sen Speed Processor is a dedicated microprocessor subsystem used to monitor and analyze pulse input signals from up to four magnetic pickups (two on the turbine and 2 on the generator). These speed probes are located in the front standard of the turbine and on the outboard end of the generator rotor. These signals are converted by the microprocessor to a digital word proportional to speed (rpm) and transmitted to the main computer system for use in its control program. The speed of the machine prior to synchronizing are controlled from the TS-500 front panel which is the principal operator interface.

~~In case the speed governor fails to operate and the machine overspeeds.~~ In the case of overspeed, the emergency governor releases a valve controlling oil supply to the emergency stop valve, causing it to close and thus shutting off the supply of steam to the turbine. The emergency stop valve is of the quick closing type and functions primarily by being tripped to close either by hand or by overspeed of the turbine. The valve is fully open when oil pressure from the turbine hydraulic system is permitted to flow past the emergency tripping mechanism pilot valve to the operating cylinder piston of the stop valve. The valve is fully closed when oil pressure is not maintained under the operating cylinder piston as the result of either failure of the hydraulic system or overspeeding of the turbine. In the latter case, the emergency governor pilot valve shuts off the oil supply to the stop valve and at the same time opens a dump thereby relieving the oil pressure under the operating cylinder piston which results in closing the stop valve by spring action.

The operating cylinder of the emergency stop valve is equipped with a test ~~valve~~ ^{VALVE} to permit periodic testing to make

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sure that the valve stem is not sticking. This test is made by operating the test valve on the ~~control casing~~ *front stand* thereby allowing ~~the relay in the stop valve to bleed~~ oil *to bleed* from under the piston. Since in operation the piston of the operating cylinder is at a position above the drain to the test ~~relay~~ *valve*, with this relief in oil pressure the piston will start to travel in the valve closing direction until the *Valve* ~~relay~~ port is covered by the piston. At this point, the piston and main disc will again travel in an upward direction due to full oil pressure on the bottom of the piston.

A cutout switch is mounted on the stop valve to operate the generator ~~field circuit~~ breaker when the stop valve closes.

Load-limiting and synchronizing devices provide means of changing the speed or load on the unit. The load-limiting mechanism is used for starting the unit, bringing it up to speed in combination with the speed-changing or synchronizing device, for limiting the steam flow and KW load, and for shutting down the unit. The synchronizing or speed-changing device is used to regulate speed or load in combination with or independently of the load-limiting mechanism, depending upon whether the unit is operating isolated or in parallel with other units.

Prior to starting the turbine, several items must be verified. (Refer to Safe Work Procedure "Starting up Steam Turbine #1). With the stop valve open and 1200 psig steam chest pressure, the start sequence "Ready" light will be flashing, indicating that the unit is ready to operate. The amount of time recommended to bring the unit to rated speed is dependent on the time the unit has been shut down. (Refer to curve in G. E. Manual). The starting sequence is done automatically in 3 stages with the operator initiating each stage of the sequence. The 3 stages of the starting sequence are: 1) Slow roll, 2) energize field, and 3) ramp to synchronous speed. The first ramp rate controls the amount of time to reach the slow roll level of 500 rpm. The second ramp rate controls the ramp speed from 500 rpm to 3600 rpm with a hold in the startup sequence at 800 rpm to energize the field. Shutdown of the unit is done from the TS-500 panel in the Control Room. (See Safe Work Procedure "Turbine 24" - Steam Turbine 1, 2 & 3 Shutdown).

Servo amplifier provides low power electrical actuating signal (difference between command input and feedback signals).

Servo valves respond to low power actuating signal to control hydraulic fluid flow to piston cylinders and other actuating devices. A feedback transducer measures actuator position and converts the measurement into a proportional signal which is sent to the servo amplifier.

The extraction control setpoints are set from the TS-500. These ^{pressure} controllers have the capability to be run in manual or automatic. The 475# and 235# pressure controllers allow the operator to equalize the steam pressure on both sides of the block valves in the extraction lines before steam flow is initiated. The TS-500 receives inputs from the speed governor and extraction pressure controllers and through its programming allows for minimum disturbance from changes in extraction demands when the machine is under control of the speed governor.

	V_1	V_2	V_3	← Valve position
speed / Load ↑	↑	↑	↑	↑ - increase
speed / Load ↓	↓	↓	↓	↓ - decrease

(3) with the extraction system available and the turbine operating with all steam flow from inlet and exhaust, the governor mechanism can be readjusted with the economy linkage which opens the extraction valves wider than normal and the pressures at the turbine extraction stages (and also those preceding) are corrected to obtain improved efficiency of the unit relative to normal.

To guard against ^{uncontrolled} entry of steam into the turbine through the extraction lines each extraction line is provided with an air operated, free flow reverse current valve which is interconnected with the turbine oil hydraulic system of the trip and overspeed protection mechanism by means of the non-return valve trip relay. In the event the turbine trips, a double seated valve in the relay which moves in response to oil pressure on a spring opposed piston cuts the air supply to the non-return valves thus closing it. Hand operated air test valves are provided to permit routine operating checks to insure that the non-return valves are ready to function when called upon to do so.

A low vacuum trip which also is an element of the trip and overspeed mechanism functions to shut off the steam supply of the turbine in case of loss of vacuum. If the vacuum drops to 15 inches the relay will dump the oil pressure in the governor system and so shut off the steam supply at the stop valve. An alarm signal which is annunciated on the mechanical vertical board is provided to indicate that it is low vacuum which has tripped to close off the oil supply.

Lubrication System

The turbine is provided with a

LUBRICATION AND HYDRAULIC OIL SYSTEMS

THE TURBINE IS PROVIDED WITH A SELF-CONTAINED OIL PRESSURE SYSTEM CONSISTING OF A LUBE OIL RESERVOIR, PUMPS, COOLERS, FILTERS AND PIPING FOR SUPPLYING OIL AT A PRESSURE SUITABLE FOR BOTH THE HYDRAULIC AND LUBRICATION NEEDS OF THE UNIT. THE SYSTEM CONSISTS OF THREE PUMPS WHICH ARE INTERLOCKED; THE MAIN CENTRIFUGAL PUMP DRIVEN BY THE TURBINE SHAFT, A SEPERATE STEAM TURBINE DRIVEN AUXILLARY PUMP AND A TURNING GEAR MOTOR DRIVEN PUMP.

BOTH THE HYDRAULIC AND LUBRICATING SYSTEMS ARE NORMALLY SUPPLIED BY THE SHAFT DRIVEN PUMP LOCATED WITHIN THE TURBINE FRONT STANDARD. THIS PUMP DELIVERS OIL AT 200 PSIG FOR ACTUATING THE HYDRAULIC CONTROL APPARATUS AND ALSO SUPPLIES HIGH PRESSURE OIL TO THE OIL TURBINE DRIVEN BOOSTER PUMP IN THE LUBE OIL RESERVOIR. THE BOOSTER PUMP PROVIDES THE SHAFT DRIVEN PUMP WITH SUCTION OIL AT ABOUT 15 PSIG. THE 200 PSIG OIL THAT IS USED TO DRIVE THE HYDRAULIC TURBINE IS REDUCED IN PRESSURE TO ABOUT 65 PSIG AS IT ACCOMPLISHES THIS WORK; IT IS THEN REDUCED IN PRESSURE TO 25 PSIG BY THE BEARING PRESSURE REGULATOR WHICH IS LOCATED INSIDE THE RESERVOIR. THE BEARING OIL THEN FLOWS THROUGH THE FULL FLOW FILTER, THROUGH THE OIL COOLER AND INTO THE BEARING SUPPLY HEADER FOR LUBRICATION OF TURBINE-GENERATOR BEARINGS, A BACK-UP SUPPLY TO THE GENERATOR HYDROGEN SEAL OIL SYSTEM AND TO OTHER SMALLER COMPONENTS THAT REQUIRE OIL AT REDUCED PRESSURE.

The booster pump is located in the main oil tank and consists of a conventional pump casing, housing a rotating element, comprised of a shaft with a bucket wheel mounted on one end and a pump

THE BOOSTER PUMP, WHICH IS LOCATED INSIDE THE RESERVOIR, CONSISTS OF A RATHER CONVENTIONAL CENTRIFUGAL PUMP CASING HOUSING A ROTATING ELEMENT WITH AN IMPELLER ON ONE END AND A TURBINE BUCKET WHEEL ON THE OTHER END. THE BUCKET WHEEL ACTS AS AN HYDRAULIC TURBINE AND IS DRIVEN BY A PORTION OF THE HIGH PRESSURE DISCHARGE OF THE SHAFT DRIVEN PUMP. THE ROTATING MOTION DRIVES THE IMPELLER ATTACHED TO THE OTHER END OF THE SHAFT, PUMPING OIL FROM THE RESERVOIR TO THE SUCTION OF THE MAIN SHAFT DRIVEN PUMP. THE ENTIRE CYCLE IS INITIALLY STARTED BY THE STEAM DRIVEN AUXILIARY OIL PUMP WHICH IS USED FOR START-UP BUT IT IS ALSO CAPABLE OF DOING THE EXACT SAME JOB AS THE SHAFT DRIVEN PUMP.

THE AUXILIARY STEAM TURBINE DRIVEN OIL PUMP IS USED TO SUPPLY LUBRICATING OIL TO THE BEARINGS, TO OPEN THE STOP VALVE AND FOR CONTROL OF THE V1, V2 AND V3 VALVES DURING THE STARTING OPERATION WHEN TURBINE SPEED IS TOO LOW FOR THE SHAFT DRIVEN PUMP TO ACCOMPLISH THIS TASK. THIS PUMP IS ALSO IN A STANDBY MODE DURING NORMAL OPERATION OF THE TURBINE SUBJECT TO THE CONTROL OF THE AUXILIARY OIL PUMP PRESSURE GOVERNOR, WHICH IF CORRECTLY ADJUSTED, WILL START THE PUMP AUTOMATICALLY ANYTIME THE STEAM BLOCK VALVE TO THE PUMP IS OPEN AND THE HIGH PRESSURE OIL SYSTEM DROPS BELOW THE SETTING OF THE PRESSURE GOVERNOR. A BY-PASS VALVE IS PROVIDED FOR USE IN APPLYING STEAM TO THE PUMP TURBINE IN CASE OF FAILURE OF THE PRESSURE GOVERNOR. A "T" HANDLE ARRANGEMENT IS PROVIDED FOR CHANGING THE SET POINT OF THE PRESSURE GOVERNOR CAUSING THE PUMP TO COME ON AUTOMATICALLY AT A HIGHER OR LOWER PRESSURE. A TEST VALVE LOCATED ON THE NORTH SIDE OF THE RESERVOIR CAN BE USED TO TEST THE OPERATION OF THE PRESSURE GOVERNOR DURING NORMAL OPERATION OF THE TURBINE. THE TURNING GEAR MOTOR DRIVEN OIL PUMP IS JUST WHAT THE NAME IMPLIED; IT IS USED WHEN THE TURBINE IS DOWN AND ON TURNING GEAR FOR THE PURPOSE OF SUPPLYING OIL TO THE BEARING SUPPLY HEADER. IT WILL COME ON AUTOMATICALLY UPON LOSS OF PRESSURE IN THE SYSTEM.

TWIN OIL COOLERS, EACH CAPABLE OF COOLING THE TOTAL OIL DEMANDS OF THE TURBINE, ARE PLACED AT ONE END OF THE RESERVOIR. WATER FLOW FROM THE PLANT COOLING WATER SYSTEM IS CONTROLLED BY THE VIDEO-SPEC SYSTEM IN THE CONTROL ROOM. THE COOLERS, ONE IN SERVICE AND ONE ON STANDBY, CAN BE TAKEN IN AND OUT OF SERVICE BY A COOLER TRANSFER VALVE LOCATED WITHIN THE RESERVOIR.

~~There are~~
All turbine bearing drains
THE DUAL, FULL FLOW OIL FILTERS LOCATED SOUTH OF THE RESERVOIR (ONE ELEMENT IN SERVICE AND ONE ON STANDBY) CAN BE SWAPPED WITH THE TURBINE ON LINE BY ROTATING A TRANSFER VALVE LOCATED BETWEEN THE TWO ELEMENTS. THE UNIT CAN ALSO BE BY-PASSED BY A MANUAL GATE VALVE LOCATED IN THE PIPING.

~~As a~~
In the event of an explosion damage, the reservoir is
equipped with two hinged relief doors. A motor driven vapor extractor

is mounted on the lube oil reservoir to exhaust water vapor to the atmosphere and to provide ventilation of the entire lubrication system. Approximately one-half inch of water vacuum is maintained in the reservoir by the vapor extractor. A high pressure alarm indicates loss of vacuum in the reservoir.

The generator bearings are equipped with a seal oil system to prevent the escape of hydrogen from the casing along the rotor shaft or the entrainment of hydrogen in lube oil returned to the reservoir. Oil from the air side of the seals drains to bearing drain enlargement which is used as a chamber where air entrained in the oil may be liberated and vented to atmosphere. The drain oil then passes through a loop seal to a connection box where it mixes with the drain oil from the outboard side of the generator bearings and is returned to the main oil tank. The loop seal provides a wet barrier between the bearing drain enlargement and the oil storage tanks, and in the event of failure of the shaft seals, hydrogen is vented to atmosphere from the bearing drain enlargement instead of passing on to the main oil reservoir. The oil flowing to the hydrogen side of the shaft seals passes into the drain lines and thence to the seal drain enlargement, which consists of a horizontal length of closed pipe divided by a baffle into two equal sections. Both sections are pipe connected at the bottom and drain through a loop seal to the seal-oil control unit storage tank. This arrangement prevents the circulation of oil vapor through the seal drain piping from any difference in fan pressure existing at opposite ends of the generator. The seal drain enlargement provides a large surface area for the oil, and this permits the removal of large bubbles of hydrogen from the oil before it passes into the storage tank. The seal oil unit is an assembly, mounted on a common base, comprising the storage tank, float trap, seal-oil pumps, pressure governors, oil filters, high oil level alarm switch, oil pressure relief valve and gauge board. The storage tank is provided as additional source of oil for the seal oil control unit pumps when the seal-oil pressure demand exceeds that being supplied by the bearing header. The float trap prevents the loss of hydrogen through the seal oil storage tank vent line when operating at elevated hydrogen pressure. Whenever seal-oil pressure is needed in excess of that being supplied by the bearing header the additional seal-oil pressure is supplied through the operation of one of the two seal-oil pumps. The differential pressure governor is adjusted to maintain a seal-oil pressure slightly higher than the gas pressure in the generator casing. The second pressure governor is adjusted for a seal-oil pressure of about 1/2 lb. lower than the first pressure governor. This second pressure governor is used as a standby in case the first pressure governor fails to operate. Two cleanable oil filters, connected in parallel, prevent foreign matter in the oil lines from passing to the shaft seals. Differential pressure switches are mounted on the gauge board, and these switches are electrically connected to actuate either the main seal-oil pump, the emergency seal-oil pump, or the low differential pressure alarm. The switches

sense the seal-oil pressure with respect to the gas pressure in the casing, and bring the pumps into operation as needed. An electrical interlock is provided in the wiring of each seal-oil pump motor so that when either motor is running, the other motor is prevented from coming into operation. Another pressure switch senses the main seal-oil pump discharge pressure. If this pressure dropped to some predetermined value, and the main motor pump ceased to function, the discharge pressure switch would override the interlock on the main seal-oil pump, and bring the emergency pump into operation. A seal-oil pressure relief valve is connected into the discharge side of the seal oil pumps. The oil, in excess of what is necessary for shaft sealing, is discharged through the valve to the suction side of the pumps. A float switch and sight flow gauge are incorporated in a pipe line from the seal drain enlargement and when the level of the oil in the seal drain enlargement rises sufficiently, the float switch closes an alarm circuit which indicates that abnormal condition exists which prevents proper draining of the seal drain enlargement. The gauge board is mounted on the seal-oil control unit and carries gauges for measuring seal-oil pressure, and hydrogen seal drain enlargement. The gauge board also carries

Lube Oil Conditioning and Storage

For conditioning the turbine lubricating oil, a continuous by-pass system is employed in which a centrifuge type purifier with attached feed and discharge pumps is used. bearing oil passes through a full-flow filter before entering the bearing header. Lube oil flows by gravity from the turbine oil reservoir into the suction of the centrifuge feed pump. Oil is discharged to the centrifuge where water and solids are separated, water flowing to the waste system and clean oil to the centrifuge discharge pump which returns the oil to the reservoir. The amount of incoming clean oil to the reservoir displaces the same amount of dirty oil which flows to the purifier.

centrifuge -

The amount of incoming clean

amount of dirty oil which flows through purifier.

A lube oil storage tank with three compartments is provided for storing a reserve of fresh oil in one compartment, a change of purified oil in another and for receiving a full change of dirty or contaminated oil in the last. Each compartment has an electric heater to keep the oil at maximum temperature of 140°. ~~A steam smothering line in case of fire is also provided.~~

A 50 gallon per minute lube oil transfer pump is installed for pumping oil from either compartment of the storage tank into the turbine reservoir or back into either storage tank compartment. A 50 gallon per minute lube oil return pump is provided for pumping oil from the turbine reservoir into either compartment of the lube oil storage tank.

Turning Gear

The turning gear and drive motor are mounted in the number three turbine bearing housing. The turbine shaft is driven by an induction

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To supply indications and records on important functions of turbine operation and control, the unit is equipped with instruments for measuring ~~shell and differential~~ expansion and vibrations. The unit is also equipped with a vibration trip system that will trip the machine if vibration exceeds a predetermined setting. Shell and differential expansion is also monitored and is displayed on the CRT in the Control Room. This instrument is used to provide periodic indication and recording of the expansion of the turbine shell and of the difference in expansion between the turbine shell and shaft. Measurement of this difference in expansion gives an indication of operating clearances between the rotating and stationary elements of the turbine and provides information for setting up proper starting and operating procedures.

- B. Speed and Cam Position Indicator - This instrument provides a permanent record of the speed of the unit during starting and shutting down periods and a record of rotation of the control valve cam-shaft while the unit is connected to the line. Since valve opening and load on the machine are functions of cam position, the effects of system disturbances, which are not discernible on a speed record, are clearly shown on the cam position record. The instrument automatically switches from speed recorder to cam position recorder when the main generator breakers are closed. The speed signal is transmitted from a tachometer generator located on the end of the turbine shaft within the front standard. Cam position is transmitted through a wire wound voltage divider and arm mounted on the end of the control valve cam-shaft.
- C. Eccentricity Recorder - A continuous indication and record of shaft eccentricity is kept by this instrument. The eccentricity is measured in mils during turning gear operation. This information is particularly valuable during the starting operations in determining the amount of shaft bow. A detector coil is mounted within the front standard housing on a rigid bracket with the pole tips spaced a specified distance from a concentric ring on the turbine shaft. Any variation in this gap caused by shaft eccentricity is transmitted to the recording instrument. Excessive eccentricity is annunciated on the mechanical vertical board.
- D. Vibration amplitude recorder - This recorder provides a periodic record, in mils, of the transverse vibration occurring at each of the main turbine generator bearings. A-C signals, generated by detectors mounted on each of the bearing caps, are transmitted in sequence to the recording instrument. Excessive vibration is annunciated on the mechanical vertical board.

Details of operation, calibration, installation and maintenance of all supervisory instruments are contained in the manufacturers' instruction book.

No. 1 Generator

The hydrogen-cooled generator is completely enclosed for operation with hydrogen gas as a cooling medium. The ventilation system is completely self-contained, including gas coolers and fans, thus preventing the entrance of dirt and moisture. The separately excited rotating field, driven by the steam turbine, rotates inside the stationary armature and is supported by bearings located in the end shields mounted on the generator frame. The stator, according to the manufacturer's description, is made sufficiently strong to withstand safely the force of a hydrogen-air explosion.

The stator frame consists of a gas tight cylindrical casing of welded plate construction, reinforced internally in the radial direction by stationary web plates, and in the axial direction by spring bars and braces. The stator frame is supported on the foundation by feet welded to the sides of the frame. Heavy end shields which contain the generator bearings are bolted to the ends of the frame. The frame also serves as the support and enclosure for the gas coolers. The stator cone is made up of segmental, annealed, insulated punchings of high quality silicon steel to give minimum electrical loss. The punching insulation is a varnish which maintains its insulating value under the most abnormal effects of heat.

The stator winding is composed of insulated bars, which are made up of insulated copper conductors or strands and are assembled in the stator slots, joined at the ends to form coils, and connected in the proper phase belts by bus rings.

The stator and rotor are ventilated by axial flow type fans with individual blades that are fastened to fan hubs near the ends of the rotor.

The rotor is machined from a single alloy steel forging with longitudinal slots machined radially in the body which contain the field coils. Additional slots are machined in the teeth to provide ventilation for the rotor body.

The field winding consists of rectangular copper bars, edgewise bent and formed into coils. Several turns in one pair of slots around a pole form a coil. Several coils are assembled around each pole to form the winding.

Connections, Excitation Switchgear, Metering and Generator Protection

These are all described in the Electrical Section.

Exciters

Field excitation is provided by an indoor type, filtered air cooled, main exciter motor generator set, 200 KW at 250 volts d-c exciter and 2300 volt, 3 phase, 60 cycle motor. Spare excitation is provided by an identical motor-generator set. This exciter is also a spare for #2 generator. Refer to Procedures Manual for starting up, paralleling, and securing exciters.

Cooling System

Hydrogen is used as the cooling medium for the generator because of the smaller windage loss and because of its higher rate of heat transfer. Also, with hydrogen, less maintenance is required since dirt and moisture are excluded and less deterioration of insulation occurs due to corona.

Hydrogen within the sealed generator stator is circulated to all parts of the stator and rotor by the fans mounted on each end of the rotor. The hydrogen is cooled by circulation through four generator gas coolers that are mounted vertically at the four corners of the stator frame and using plant cooling water as the coolant. A gas dryer is provided to insure a dry atmosphere in the generator.

To prevent leakage through the bearings, the generator shaft is sealed by a floating ring oil seal. Oil is supplied under pressure to create an oil film between the sealing rings and the shaft to prevent leakage of hydrogen along the shaft. ~~The seal oil supply and scavenging system is described under the lubrication system on page 624 of this section.~~

Piping and control equipment are provided so that carbon dioxide may be admitted into the generator casing prior to filling the generator with hydrogen to prevent formation of an explosive hydrogen-air mixture. The air is first purged by carbon dioxide after which hydrogen is admitted.

The hydrogen instruments and alarms are mounted on the hydrogen control panel. A complete alarm system including reset switches, audible alarms, trouble indicating lights and alarm voltage failure circuits is provided to operate on low pressure, high temperature, low purity, low hydrogen supply and low seal oil pressure. Operation of the hydrogen panel alarm system also annunciates ~~in the mechanical vertical board in~~ the control room.

on turbine #1 annunciator panel

The generator hydrogen system is completely described in the General Electric Turbine-Generator Manual.

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B. NO. 2 TURBINE -GENERATOR AND ACCESSORIES

General

The General Electric turbine-generator unit no. 2 is a 60,000 kw tandem compound, double flow, condensing, 3600 rpm steam turbine designed for initial steam conditions of 1250 psig, 950° f., exhausting to 2" HgA with provisions for single automatic extraction of steam at 235# and uncontrolled extraction at varying pressure depending on load. This unit was de-rated to approximately 62 mw in 1988 for economy reasons.

The turbine is direct connected to a 75,000 kw, h2 cooled, 14,400 volt, 3600 rpm, 3 phase, 60 cycle generator which is rated 88,253 kva at 0.85 power factor at 30 psig hydrogen pressure. Field excitation is identical to #1 unit and they share a common spare exciter.

*Thru center line
approx. 12-11-74*

60 cycle motor. The same spare exciter is utilized for this unit.

No. 2 Turbine

The turbine exhaust casing and the turbine front end standard are supported on a level sole plate. As expansion takes place, the machine slides forward on these plates from a transverse anchor key located between the center exhaust sole plate and exhaust casing support footing. The turbine casings are split horizontally at the shaft centerline. All joints have metal-to-metal scraped surfaces. Steam admission valves are contained in the upper and lower steam chests located on the outer shell at the front of the high pressure casing. Steam extraction valve is located at the eighth stage. The front standard provides support for the high pressure casings, the number one main bearing, thrust bearing, the main oil pump, and the 400 cycle generator for governing and control.

The turbine rotors are made from solid, alloy steel forgings solidly bolted together between the high and low elements. The rotor shaft, seals, bearing journals, and coupling flanges are machined from these forgings to form a solid rotor.

The outdoor unit is protected against adverse weather conditions by sheet metal lagging provided with weatherproof joints. An enclosure is provided over the turning gear and adjacent machine parts. This enclosure is provided with a door for access to the turning gear controls and to permit observation of the turning gear engaging and running operations. The area between the high pressure casing and front standard is covered with metal lagging as is that area between the generator end bearing and collector ring housing.

Steam Path

Steam from the boiler superheater outlet passes through the main turbine stop valve, in which is located a steam strainer. This

B. NO. 2 TURBINE-GENERATOR AND ACCESSORIES (Contd.)

General (Contd.)

valve is hydraulically operated and is arranged for quick closing upon either emergency or hand trip operation. Steam enters the upper and lower turbine steam chests through two steam leads from the stop valve. Steam is admitted to the turbine nozzles by the control valves. These valves control the flow of steam through separate passages in the turbine shell to particular sections of the nozzles. They are raised and lowered in proper sequence through action of their levers which ride on cams mounted on a camshaft. The camshaft is rotated by the hydraulic operating mechanism through a lever with a gear segment and a pinion. The camshaft for the lower valves is actuated by a rod fitted with a rack. The rod and rack assembly is connected to the lever driving the camshaft. During starting, the movement of the controlling valves is under hand control of the operator through the load limit mechanism. When operating speed is reached, the speed governor controls the movement of the inlet valves.

From the control valves the steam is admitted into the first pressure stage and to the first stage shell. The steam then passes through 5 more stages into the 7th stage where the 235 psig extraction valves are located. There are provisions for extracting steam at either the 8th or 10th stages for deaerators heating also. The steam then expands to the 12 stage, through the crossover pipe and into the center of the low pressure double-flow section. The steam after expanding through four more stages exhausts to the condenser.

Leakage of steam along the shaft between stages is minimized by labyrinth special bronze metallic alloy packing placed at the shaft base of the diaphragms and having close clearances between the rotor and packing teeth.

The turbine exhaust casing and condenser are protected against excessive back pressure by an atmospheric relief diaphragm located on the top of the exhaust casing. This diaphragm is designed to relieve at 5 psig and to pass maximum throttle flow.

Shaft Sealing System

SAME AS #1 TURBINE

Glenn Tech. Section
Same as #1 turbine

A gland ~~exhauster~~, consisting of a shell and tube type surface condenser and air removal equipment, is used to provide means for disposing of steam that leaks past the packing rings. This exhauster system maintains a slight vacuum in the turbine shaft packing rings closest to the atmosphere, thus preventing steam from escaping.

Control Mechanism and Governor

There are essentially two major sections which comprise the control system of No. 2 Turbine. They consist of turbine control console containing the "electronic computer section" and the high pressure hydraulic power pack which makes up the "hydraulic fluid power" section.

The computer is composed of a number of simple, electrical, solid state circuits which are capable of providing the "intelligence" functions needed to control the position of the turbine control valves. The "muscle" power required to move the control rams, in correspondence with the computer command signals, is provided by the companion high pressure hydraulic system.

Under normal operating conditions, the speed of the turbine rotor is sensed by a permanent magnet generator (PMG) driven directly by the turbine rotor. There are two purposes of the PMG: first, it serves as the source of power for the computer when the turbine rotor speed exceeds 3300 RPM and second, it serves as the source of frequency signal which controls turbine speed. PMG frequency signal is converted to DC control voltage. Hence, changes in turbine speed will show up as a change in DC level. Speed control is thus effected since the position of the turbine control valves is sensitive to the magnitude of the DC control signals.

Once the unit is electrically synchronized the speed load control mechanism establishes the KW power level of operation. This function is accomplished by varying the magnitude of the DC reference signal - the higher the DC signal, the farther the control valves are open, hence the larger the load. The adjustment of the DC load can be made locally, at the control console panel, or remotely by energizing the mechanically connected positioning motor.

The emergency or overspeed governor operates independently of the speed governor and is designed to shut down the unit in case the speed governor fails to operate and the machine overspeeds. When overspeed occurs, the plunger of the emergency governor moves outwardly to strike a trigger to unlatch the steam inlet valve to close off the steam supply to the turbine. This emergency governor may also be tripped at rated speed by a manually operated valve which injects a stream of oil into the governor to upset the balance of the plunger and makes it move outwardly to trip.

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This turbine has a "stop-valve test" device similar to that on No.1 Turbine. It is also equipped with a shutout switch on the stop valve which opens the generator breaker when the stop valve closes.

Steam flow to the turbine is controlled by the turbine load limiting and speed changing mechanism. The load limiting device is used for starting and stopping the unit; bringing it up to speed in combination with the speed changing as synchronizing device; and for limiting the steam flow and KW load. The synchronizing or speed changing device is used in combination with or independent of the load limiting mechanism, depending upon whether the unit is operating isolated or in parallel with other units.

This turbine is also equipped with air-operated, free flow reverse current valves on the extraction lines which guard against steam re-entry into the turbine in event of a trip. These valves are similar to those on No. 1 unit. A low vacuum trip will shut off the steam supply to the turbine in case of loss of vacuum. This device is similar also to that on No. 1 unit.

Lubrication System

Turbine No. 2 is provided with a self-contained lubrication system which consists of a supply tank, pumps, coolers, strainers, gauges, piping, etc.

The main oil tank provides the oil supply and houses most of the components pertinent to the lubrication system. This tank is equipped with high and low level alarms and also a high temperature alarm. As a protection against hydrogen explosion damage, the reservoir is equipped with hinged relief doors. A motor driven vapor extractor is mounted on the top of the lube oil tank for the purpose of exhausting water vapor to the atmosphere and to provide ventilation for the entire lubrication system. Approximately $\frac{1}{2}$ " to 1" of water vacuum is maintained in the reservoir. The extraction is equipped with an alarm in case of low vacuum in the reservoir.

During normal operating conditions the turbine's lubrication needs are supplied by a centrifugal pump driven by the turbine shaft. This pump takes suction at approximately 18 psi from a turbine driven booster pump located in the main oil tank and supplies 190# oil to the emergency trip mechanism, emergency governor exerciser, steam seal regulator, the booster pump and various alarms and pressure switches. This 190# oil, after leaving the booster pump, is reduced to 75 psi by means of a relief valve before going through the lube oil coolers to the seal oil system and bearing oil regulator.

An auxiliary steam driven centrifugal pump located on and within the main oil tank is provided to initially establish oil pressure in the system when starting or stopping the turbine and to supple-

ment the main shaft driven pump. This steam driven pump is subject to the control of a pressure governor which operates in response to pressure changes in the system, starts auxiliary pump when main pump pressure is insufficient, and stops it when pressure is restored. Lubrication of this pump is by means of passages from the pressure side of the pump to the bearings. A centrifugal turbine driven booster pump is provided to supply suction pressure to the main oil pump and is located in the main oil tank. This turbine driven oil pump is moved by a portion of the main pump output pressure (or auxiliary oil pump) and is adjusted to produce 18 psi output to the main oil pump suction. Adjustment is by means of a baffle valve to increase or decrease oil flow against the turbine oil pump buckets to vary speed and thereby vary output pressure.

75# oil from the relief valve, on the driving end of the booster pump, after going through the coolers is further reduced by means of a pressure regulator before going to the turbine shaft bearing. This 75# oil also goes to the turning gear interlock and the grounding brush nozzle.

An alternate source of bearing oil is supplied, if needed, by a motor driven centrifugal pump located on and within the main oil tank. This pump will start automatically, or can be started manually, upon loss of bearing oil pressure. It is used mainly to supply bearing oil and seal oil when the turbine is on turning gear and situations where isolation of the 190# system is necessary.

A two-way valve located in the main oil tank will allow the motor driven bearing and seal oil pump to bypass the lube oil cooler and feed only the seal oil unit when in the tripped position.

Oil Coolers

During normal operation, proper temperature of oil to the bearing and seal oil system is obtained by means of an oil cooler where the oil temperature is reduced by passing the oil over tubes through which water is circulated. There are two oil coolers and each is capable of cooling full capacity lube oil flow. A two position valve on top of the main oil tank is provided for switching coolers. Oil temperature is regulated from the mechanical console by a control valve in the outlet cooling water line.

The oil level of the main oil tank should not be permitted to drop below the operating level. On the other hand, it should not be filled to a point where the level will obstruct the oil drain lines.

Most turbine oils at a temperature of 120° F. or less will maintain water in suspension, but at 130° F. or above, they will not. Water carried in suspension by the oil circulates through the system may cause corrosion of the ferrous parts. It is therefore advisable to maintain the oil temperature in the tank at or above 130° F. Temperature to the bearings should be kept from 110° to 120° F. and temperature from the bearings should hold between 140° and 160° F.

A motor driven pump along side of the reservoir is piped to the reservoir to flow oil through a filter and through manipulation of valves this pump is also used to empty the reservoir, if the need arises, to the Bowser storage tank.

A centrifuge is also piped to the reservoir for removal of water and is alternated on a weekly basis with the filter and return pump.

Lube Oil Conditioning & Storage

For conditioning the No. 2 turbine lubricating oil, a Delaval centrifuge type purifier with attached feed and discharge pumps is used. Oil feed system is the same as No. 1 unit.

Turning Gear

The turning gear and drive motor are mounted in the number three turbine bearing housing. The turbine shaft is driven by an induction motor, through a link belt and gear train, at about $2\frac{1}{2}$ revolutions per minute. The turning gear must be operated at least one hour prior to starting the unit and immediately after the unit is shut down so that the turbine shaft will not bow due to temperature differentials within the casing.

Oil is admitted to the gear from the bearing supply header by a manually operated valve. An oil pressure switch controls the electric circuit to the turning gear motor and prevents operation of the motor in case of insufficient oil pressure.

The gear is engaged with the turbine rotor by means of a hand lever. This cannot be done, however, unless the driving motor is running. The gear is automatically disengaged as soon as the turbine is rolled with steam, however, it is necessary to manually stop the turning gear motor and shut off the oil supply to the turbine gear.

Lubrication is provided by a separate motor driven oil pump which supplies oil from the main oil tank to the turning gear and to the bearings through the main bearing header. The hand valve in the oil supply line from the bearing header must be opened before the turning gear is started and should be closed when the turning gear is not in use.

Supervisory Instruments

To supply indication and records on important functions of turbine operation and control, the unit is furnished with the following supervisory instruments:

1. Shell and Differential expansion recorder.
2. Speed and Cam Position Indicator

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3. Eccentricity Recorder
4. Vibration Amplitude Recorder

Details of operation of these instruments are contained in the manufacturers instruction books.

No. 2 Generator

This machine is practically identical to No. 1 Generator except in physical size and load capability.

Connections, Excitation Switchgear, Metering and Generator Protection

These are almost identical to No. 1 Generator.

Exciter

Field excitation is provided by an indoor type, filtered air cooled exciter motor generator set, 250 KW at 250 volts d-c exciter and 2300 volt, 3 phase, 60 cycle motor. Spare excitation is provided by a unit identical to No. 1 Exciter and is a common spare for both generators. Refer to Procedures Manual for paralleling exciters.

Cooling System

Hydrogen is used as the cooling medium for the generator because of the smaller windage loss and because of its higher rate of heat transfer. Also, with hydrogen, less maintenance is required since dirt and moisture are excluded and less deterioration of insulation occurs due to corona.

Hydrogen within the sealed generator stator is circulated to all parts of the stator and rotor by the fans mounted on each end of the rotor. The hydrogen is cooled by circulation through four generator gas coolers that are mounted vertically at the four corners of the stator frame and using plant cooling water as the coolant. A gas dryer is provided to insure a dry atmosphere in the generator.

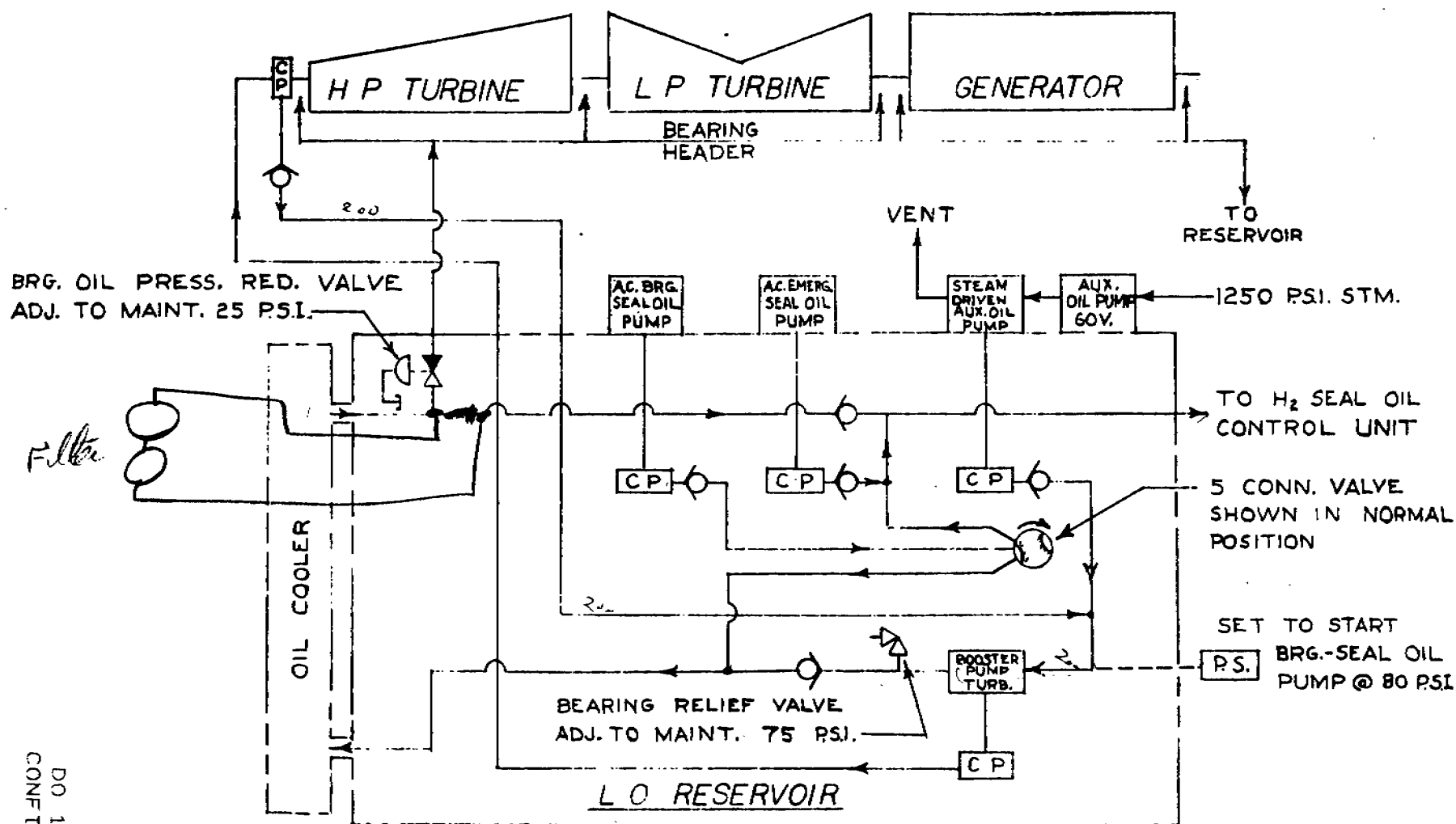
To prevent leakage through the bearings, the generator shaft is sealed by a floating ring oil seal. Oil is supplied under pressure to create an oil film between the sealing rings and the shaft to prevent leakage of hydrogen along the shaft. The seal oil supply and scavenging system is described under the lubrication system on page 645 of this section.

Piping and control equipment are provided so that carbon dioxide may be admitted into the generator casing prior to filling the generator with hydrogen to prevent formation of an explosive hydrogen-air mixture. The air is first purged by carbon dioxide after which hydrogen is admitted.

The hydrogen instruments and alarms are mounted on the hydrogen control panel. A complete alarm system including reset switches, audible alarms, trouble indicating lights and alarm voltage failure circuits is provided to operate on low pressure, high temperature, low purity, low hydrogen supply and low seal oil pressure. Operation of the hydrogen panel alarm system also annunciates in the mechanical board in the control room.

The generator hydrogen system is completely described in the General Electric Turbine-Generator Manual for No. 2 Turbine-Generator.

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NO 2 GENERATOR
OIL DIAGRAM

C. NO. 3 TURBINE-GENERATOR AND ACCESSORIES

General

The General Electric Turbine-Generator Unit No. 3 is a 60,000 KW tandem compound, double flow, condensing, 3600 RPM steam turbine designed for initial steam conditions of 1250 PSIG, 950°F, exhausting to 2" HgA with provisions for single automatic extraction of steam *Admission* at 235 PSIG and uncontrolled extraction ~~at 160 PSIG, and 7.5 PSIG~~ for feedwater heating. The turbine ~~is direct connected to the generator.~~

The turbine is direct connected to the 75,000 KW, H₂ cooled, 14,400 volt, 3600 RPM, 3-phase, two-pole, 60-cycle generator which is rated at 96,000 KVA, at 0.85 power factor and 30 PSIG hydrogen pressure. Field excitation is supplied by a static exciter-regulator. The same spare exciter is utilized for this unit.

No. 3 Turbine

The turbine exhaust casing and the turbine front end standard are supported on a level sole plate. As expansion takes place, the machine slides forward on these plates from a transverse anchor key located between the center exhaust sole plate and exhaust casing support footing. The turbine casings are split horizontally at the shaft centerline. All joints have metal-to-metal scraped surfaces. Steam admission valves are contained in the upper and lower steam chests located on the outer shell at the front of the high pressure casing. Steam extraction valves are located at the eighth stage. The front standard provides support for the high pressure casings, the number one main bearing, thrust bearing, ~~the main oil pump, and the 600 psi generator cooling water pump and control.~~

The turbine rotors are made from solid, alloy steel forgings solidly bolted together between the high and low elements. The rotor shaft, seals, bearing journals, and coupling flanges are machined from these forgings to form a solid rotor.

The outdoor unit is protected against adverse weather conditions by sheet metal lagging provided with weatherproof joints. An enclosure is provided over the turning gear and adjacent machine parts. This enclosure is provided with a door for access to the turning gear controls and to permit observation of the turning gear engaging and running operations. The area between the high pressure casing and front standard is covered with metal lagging as is that area between the generator end and bearing and collector ring housing.

Steam Path

Same as No. 2 Turbine

Shaft Sealing System

Same as Turbine No. 1

DO 125317
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Control Mechanism and Governor

This governor is made by Triconex in California and is sup Tri-Sen. The TS-3000 governor is a triplicated system. I main processors (computers) and all Input/Output modules a triplicated. Each Input/Output module has 3 legs which ti to the 3 processors. If a failure occurs on one or two pr an alarm will sound but the process will not be affected. if one or two legs on a module goes bad, the process will i affected even though the module shows a failure.

The programming language is a combination of a basic-like language and a ladder logic. Programming changes are permi through a personal computer to a user who has access to the

Start-Up

The turbine start-up sequence is done automatically and acc the program. The Operator controls the process by pushing buttons as "start", "hold" and "continue". The Metra provi Operator with the governor interface. If all start permiss satisfied, the Operator will be allowed to push "start". I warm-up" is selected, the governor will automatically go th 12 steps of warm-up. The Operator can select "manual warm- chooses. After warm-up, the Operator can roll the turbine l "continue". The turbine will automatically ramp up to 500 then pause. When the Operator is ready, he can press "cont: the turbine will automatically ramp up to 3200 rpm. During interval, the turbine will pass through the "critical" speed 3200 rpm, the neutral and field breakers are closed and the is flashed. Afterward, the turbine will ramp up to synchron speed of 3600 rpm, ready to be synchronized. At any time du this start-up sequence, except while going through "critical the turbine can be held an any speed by pressing the "hold"

Critical Speed

All objects have a natural frequency at which they will vibr an excitation force is applied, similar to a tuning fork whe struck. The critical speed of rotating equipment is when th frequency (in revolutions per second) is equal to the natural of the shaft, casing, support system or any other component system. This critical speed can also be affected by blade v: in the case of a turbine or bending of the shaft by dynamic or a bow. The effects of critical speed are evident in the equipment by large lateral (sideways) vibration amplitudes wh equipment is rotating at a critical speed.

The tube bundle is the cooler element with water through the tubes. The oil to be cooled flows outside the tubes through the oil tank.

Full cooling load at rated temperature or below can be carried with one section out of operation.

The oil level of the main oil tank should not be permitted to drop below the operating level. On the other hand, it should not be filled to a point where the level will obstruct the oil drain lines.

Most turbine oils at a temperature of 120°F or less will maintain water in suspension, but at 130°F or above, they will not. Water carried in suspension by the oil circulated through the system may cause corrosion of the ferrous parts. It is therefore advisable to maintain the oil temperature in the tank at or above 130°F. Temperature to the bearings should be kept from 110° to 120°F. and temperature from the bearings should hold between 140° and 160°F.

A motor driven pump along side of the reservoir is piped to the reservoir to flow oil through a filter, and through manipulation of valves this pump is also used to empty the reservoir, if the need arises, to the Bowser storage tank.

A centrifuge is also piped to the reservoir for removal of water, and ~~is alternated on a weekly basis with the filter and return pump.~~

Lube Oil Conditioning & Storage

For conditioning the No. 3 Turbine lubricating oil, a DeLaval centrifuge type purifier with attached feed and discharge pumps is used. Oil feed system is the same as No. 2 unit.

~~No. 3 Turbine oil temperature is regulated from No. 4 Boiler Console by a control valve in the outlet cooling water line.~~

Turning Gear

The turning gear and drive motor are mounted in the front standard housing. The turbine shaft is driven by an induction motor through a link belt and gear train at about 2 1/2 revolutions per minute. The turning gear must be operated at least one hour prior to starting the unit and immediately after the unit is shut down so that the turbine shaft will not bow due to temperature differentials within the casing.

~~Oil is admitted to the gear from the bearing supply header by a manually operated valve.~~ An oil pressure switch controls the electric circuit to the turning gear motor and prevents operation of the motor in case of insufficient oil pressure.

The gear is engaged with the turbine rotor by means of a push-button located on the front standard. This cannot be done, however, unless the driving motor is running. The gear is automatically disengaged as soon as the turbine is rolled with steam, however, it is necessary to manually stop the turning gear motor and shut off the oil supply to the turbine gear.

Lubrication is provided by a separate motor driven oil pump which supplies oil from the main oil tank to the turning gear and to the bearings through the main bearing header. The hand valve in the oil supply line from the bearing header must be opened before the turning gear is started and should be closed when the turning gear is not in use.

Supervisory Instruments

To supply indication and records on important functions of turbine operation and control, the unit is furnished with the following supervisory instruments:

1. Shell and Differential expansion recorder.
2. Speed and Position Indicator
3. Eccentricity Recorder
4. Vibration Amplitude Recorder

Details of operation of these instruments are contained in the manufacturers instruction books.

No. 3 Generator

This machine is practically identical to No. 2 Generator.

Exciter

Field excitation is provided by the arrangement of the static exciter-regulator equipment using AC machine terminal voltage and line current.

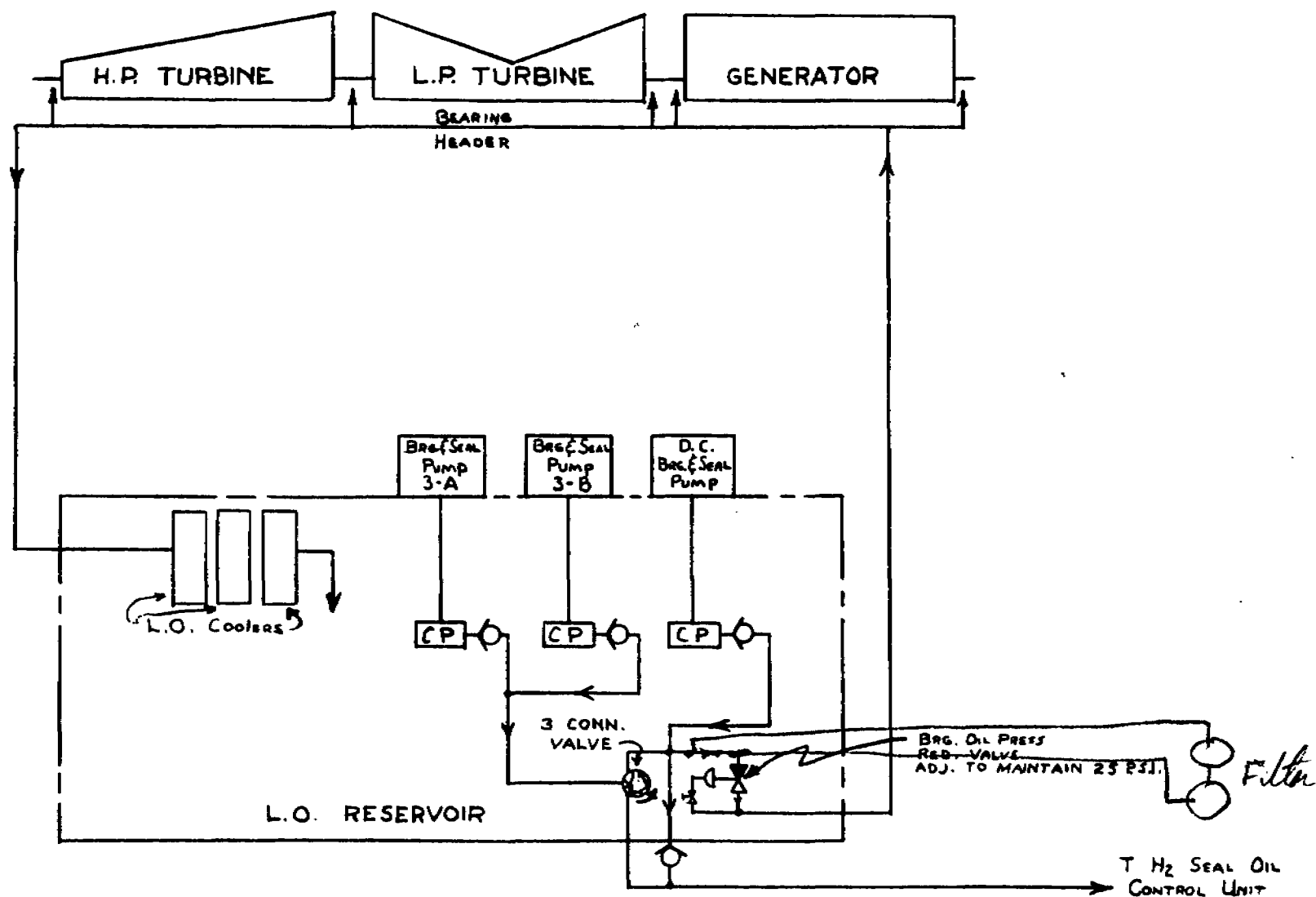
Spare excitation is obtained through the common spare exciter which is also used for Nos. 1 and 2 Generator. *but unlike #1 & #2 the spare cannot be paralleled with the unit on line.*

The metering, automatic and manual controls are located in the main Control Room.

~~Refer to G.E. Manual for paralleling exciters.~~

Cooling System - Same as No. 2 Generator

January 1974



NO 3 GENERATOR
OIL DIAGRAM

D. NO. 4 TURBINE - GENERATOR AND ACCESSORIES

General

The General Electric Turbine-Generator No. 4 is a ^{40,000}~~50,000~~ KW rated, 3600 rpm, single-automatic extraction of 475 psig, non-condensing steam turbine, exhausting to ~~back pressure~~ ^{60 to 150 psig}.

The Turbine is direct connected to the 85,000 KVA, H2 cooled, 14,400 volt generator. Field excitation is supplied by a static exciter regulator. The motor driven spare exciter is used for this unit also.

This Turbine was designed to meet the specific needs of this plant. It provides large quantities of process steam at two controlled pressures and flows. The higher pressure process steam is supplied by extraction at 475 psig and the lower process steam by the exhaust at ~~back pressure~~ ^{60 to 150 psig}. This lower pressure steam is ~~used for deaerator feedwater heating in the water plant and process at Vinyl and Glycol~~ ^{piped directly to the Caustic Plant}.

Turbine No. 4 construction and materials are basically the same as the other three units.

TURBINE

1. Steam Path

Steam from the boiler superheater outlet passes through the main turbine stop valve, in which is located a steam strainer. This valve is hydraulically held open and is arranged for quick closing, by spring action, upon either emergency or hand trip operation. Steam enters the upper and lower turbine steam chests through two steam leads from the stop valve. Steam is admitted to the turbine nozzles by the upper and lower inlet control valves. These valves control the flow of steam to the Turbine. They are opened and closed in proper sequence through action of levers which ride on cams mounted on a camshaft. The camshafts are rotated by the hydraulic rams through a rack and pinion gear arrangement. During start-up the movement of the controlling valves is under hand control of the control room operator through the load limit mechanism. When operating speed is reached, the speed governor controls the movement of the inlet valves.

From the inlet control valves, the steam is admitted to the first stage diaphragm (the diaphragms are the stationary stages of an impulse type turbine) which re-directs the flow of steam so it impinges on the first stage rotor blades at the proper angle. There is one diaphragm (stationary stage) ahead of each rotating stage of the turbine. Steam then passes through four more stages into the fifth stage cavity where the 475 psig extraction valves are located. The steam then passes through six more stages and exhausts to the ~~header~~ ¹⁵⁰ header.

Leakage of steam along the shaft between stages is minimized by special bronze alloy metallic labyrinth packing placed at the shaft base of the diaphragms and having close clearances between the rotor and packing teeth.

The turbine exhaust is protected against excessive back pressure by several relief valves located on the exhaust discharge line. These valves are sized to pass maximum throttle flow.

D. No. 4 Turbine - Generator and Accessories (C ntd.)

Turbine (Contd.)

2. The gland exhaustor system prevents steam from escaping past the outer shaft packing rings to atmosphere at each end of the turbine shaft. By maintaining a slight vacuum in the outer leakoff chamber, the system continuously removes any leakoff steam. This system is quite similar to Turbines 1 and 2.

The basic system consists of a surface condenser, motor-driven air blower, and desuperheater connected to the leakoff piping to the packing glands. Manometer connections in the leakoff piping permit measurement of system vacuum. Adjustable regulation dampers (butterfly valves) balance the leakage flow from the glands. ~~A water strainer on the inlet side of the desuperheater protects the spray nozzle from clogging and erosion by rust or scale.~~

A blower throttle valve is used to regulate system vacuum.

A water-loop seal on the outlet side of the blower prevents condensate from running back to the blower from the vent piping. The loop seal on the drain side of the blower prevents air from being pulled into the system.

By-pass piping around the condenser to a blowoff tank permits an uninterrupted flow steam leakage from the gland in the event the condenser has to be opened for maintenance. The water-loop seal at the bottom of the condenser acts as a tell-tale to show a clogged drain or broken condenser tube. In either case, the loop will discharge a steady flow of water.

The desuperheater is not normally used during system operation but only when the condenser and/or blower is taken out of service. At such times, the desuperheating water spray is turned on to cool the steam and air mixture thereby creating a slight vacuum at the glands.

For further details of the packing and leak-off system, refer to G.E. Dwg. 2130596.

3. Turbine Control Mechanism and Governor

Turbine 4 has essentially the same two major sections which comprise the control system as Turbines 2 and 3. They consist of (1.) the turbine control console located in the main control room which contains the electronic computer section and (2.) the high pressure hydraulic power unit which provides the mechanical force.

No. 4 Turbine Servo System unit is located at the west end of the Auxiliary Bay under No. 4 Turbine. This self-contained high pressure hydraulic system has two parallel pumping systems, a fluid reservoir, two fluid coolers, and an auxiliary heating system. Either pumping system can be used as the on line pump while the other remains on standby and will come in on low pressure. Hydraulic fluid is supplied directly from the hydraulic unit to the power actuator assemblies to operate the control valves on the turbine. It should be remembered that this system supplies high pressure hydraulic fluid only and is completely separate from the turbine lubrication system.

D. No. 4 Turbine - Generator and Accessories (Contd.)

Turbine (Contd.)

3. Turbine Control Mechanism and Governor (Contd.)

The computer is composed of a number of simple, electrical, solid state circuits which are capable of providing the "intelligence" functions needed to control the position of the turbine control valves. The "muscle" power required to move the control rams, in correspondence with the computer command signals, is provided by the high pressure hydraulic system mentioned above.

Under normal operating conditions, the speed-load control subsystem compares actual turbine speed, sensed by the permanent magnet generator (PMG) driven by the turbine rotor, with a speed reference and provides one command signal to the flow control sub-system. The console is energized from 60 cycle, 115 VAC "house" power whenever turbine speed is below 3300 RPM. At speeds above 3300 RPM, the PMG produces a 420-cps signal as well as AC power for the computer. PMG frequency signal is converted to DC control voltage by the computer. Hence, changes in turbine speed will show up as a change in DC voltage level. Speed control is thus effected since the position of the turbine control valves is sensitive to the magnitude of the DC control signals.

Turbine 4 is different from Turbines 2 and 3 in that it is a non-condensing unit (therefore it has no low pressure section as do 1, 2 and 3) which exhausts into the main 30# header. Our deaerators are designed so that they must have a steady, stable supply of steam in order to safely accomplish their functions. If No. 4 turbine cannot supply the required steam to maintain deaerator pressure, the other turbines will make up the difference through uncontrolled extraction points or through reducing stations. This will also occur while No. 4 turbine is down or operating at low loads.

Once the Board Operator puts this turbine on automatic back-pressure and extraction control, the KW power level output is secondary to changes in extraction and back pressure control. In other words, should deaerator or process steam demand decrease, the computer would sense the slight rise in exhaust pressure and thus call for a reduction in throttle steam through the control valves. Unless there would be a corresponding increase in 475# extraction demand, KW output would drop slightly. Turbines 1, 2 and 3 are designed to maintain the required KW output of the generator with extraction and exhaust being secondary.

4. Lubrication System

This turbine is provided with a lubrication system which consists of a supply tank, two AC driven Bearing and Seal Oil Pumps, one DC driven Emergency Bearing and Seal Oil Pump, three coolers, strainers, gauges, piping, etc. This system is almost identical to Turbine #3.

The main oil tank provides the oil supply and houses most of the components pertinent to the lubrication system. This tank is equipped with high and low level alarms and also a high temperature alarm. As a protection against hydrogen explosion damage, the reservoir is equipped with hinged relief doors. A motor-driven vapor extractor is mounted on the top of the lube oil tank for the purpose of exhausting water and H2 vapors to

D. No. 4 Turbine - Generator and Accessories (Contd.)

Turbine (Contd.)

4. Lubrication System (Contd.)

the atmosphere and to provide ventilation for the entire lubrication system. Approximately 1/2" to 1" of water vacuum is maintained in the reservoir.

During normal operating conditions, the lubrication and seal oil requirements are taken care of by either of the AC driven pumps. Provisions for automatic startup of the standby AC pump and/or DC pump are made in event of failure of running pump to satisfy the demand or allows oil pressure to drop to a predetermined level.

Bearing oil is supplied from the discharge of the pump through a 3-way valve (which can allow flow to the seal oil system only in event turbine is down and bearing oil not required) to the Bearing Oil Pressure Reducing valve. This reducing valve is located in the main oil tank and is set to maintain approximately 25 psig on the bearing oil header. See sketch of Bearing Oil System.

Hydrogen seal oil is supplied from the discharge of the pump through the 3-way valve to the seal oil Differential Pressure Regulators. These regulators are located at the Seal Oil unit and are set to maintain approximately 4.5 pounds differential between seal oil and generator hydrogen pressure. (See drawing of Seal Oil System following).

5. Oil Coolers

The three gravity flow lube oil coolers are finned type and mounted horizontally in the lube oil tank. The principal parts of the Cooler are the tube bundle, tube sheets, water boxes, distribution baffle, gaskets and hardware. The tube bundle is the cooler element with water flowing through the tubes. The oil to be cooled flows outside the tubes through the oil tank.

Full cooling load at rated temperature or below can be carried with one cooler out of operation, dependent of course, on river water temperature and cleanliness of the remaining coolers.

The oil level of the main oil tank should not be permitted to drop below the operating level. On the other hand, it should not be filled to a point where the level will obstruct the oil drain lines.

Most turbine oils at a temperature of 120°F or less will maintain water in suspension, but at 130°F or above, they will not. Water carried in suspension, by the oil circulated through the system may cause corrosion of the ferrous parts. It is therefore advisable to maintain the oil temperature in the tank at or above 130°F. Temperature to the bearings should be kept from 115° to 120°F. and temperature from the bearings should hold between 140° to 160°F.

A motor driven pump along side of the reservoir is piped to the reservoir to flow oil through a filter, and through manipulation of valves this pump is also used to empty the reservoir, if the need arises, to the Bowser storage tank.

D. No. 4 Turbine - Generator and Accessories (Contd.)

Turbine (Contd.)

5. Oil Coolers (Contd.)

A centrifuge is also piped to the reservoir for removal of water and solids and is alternated on a daily basis with the filter and return pump.

No. 4 Turbine oil temperature is regulated from No. 4 Turbine Control Board located in the main control room by a control valve in the outlet cooling water line. This system is identical to No. 3 Turbine.

6. Lube Oil Conditioning and Storage

For conditioning No. 4 Turbine lubricating oil, a Delaval centrifuge type purifier and a 50 GPM pump and cartridge type filter are used. Both are located just north of the oil reservoir. (An instruction manual on the operation and maintenance of the centrifuge is available in the control room.)

The centrifuge is a high-speed sensitive piece of equipment which must be properly cleaned and lubricated. The operating principal involved is that of subjecting a mixture of dirty oil and water to high centrifugal force. This causes the water to separate from the oil because water is heavier than oil. The dirt and sludge are also separated from the oil. High centrifugal force, many times greater than the force of gravity, is accomplished by revolving the "bowl" many thousand revolution per minute. The bowl is so constructed that the purified oil and water each have a separate discharge. The dirt and sludge remains in the bowl and must be cleaned out at regular intervals.

The height of the lube oil in the centrifuge base should be checked at least once a day with the oil level stick located on the underside of the oil filler cap. This should be done while the purifier is not running. Remove the oil filler cap, wipe the rod clean and replace. Again remove the cap, this time noting the height of the oil on the gauge. There are two lines on the gauge, the lower one is the danger mark, the the upper one is the full mark. The oil level should be checked in this manner before each starting also. Fill with DELAVAL POWER OIL or alternate.

See photographs on following pages for centrifuge and oil manifold piping arrangements.

7. Turning Gear

Identical to #3
The turning gear and drive motor are mounted in the front standard housing. The turbine shaft is driven by an induction motor through a link belt and gear train at about $2\frac{1}{2}$ revolutions per minute. The turning gear must be operated at least one hour prior to starting the unit and immediately after the unit is shut down so that the turbine shaft will not bow due to temperature differentials within the casing.

An oil pressure switch controls the electric circuit to the turning gear motor and prevents operation of the motor in case of insufficient oil pressure to the turbine and generator bearings.

D. No. 4 Turbine - Generator and Accessories (Contd.)

7. Turning Gear (Contd.)

add a manual lever
The gear is engaged with the turbine rotor by means of a push-button located on the front standard. This cannot be done, however, unless the driving motor is running. There is also a "T" handle linkage protruding from the front standard lagging for manually engaging the turning gear. The turning gear should never be engaged (either mechanically or electrically) until the rotor has come to a complete stop. The gear is automatically disengaged as soon as the turbine is rolled with steam, however, it is necessary to manually stop the turning gear motor. This system is identical to No. 3 Turbine.

NO. 4 GENERATOR

Except for size, this generator is practically identical to Nos. 1, 2 and 3. Generator Design Data Sheet follows.

H2 Cooling System

Hydrogen is used as the cooling medium for the generator because of the smaller windage loss and because of its higher rate of heat transfer. Also, with hydrogen, less maintenance is required since dirt and moisture are excluded and less deterioration of insulation occurs due to corona.

Hydrogen within the sealed generator stator is circulated to all parts of the stator and rotor by the fans mounted on each end of the rotor. The hydrogen is cooled by circulation through four generator gas coolers that are mounted vertically at the four corners of the stator frame and using plant cooling water as the coolant. A gas dryer is provided in the event the H2 becomes contaminated with moisture. This system is almost identical to the other turbines.

Safety Precautions

The importance of frequent checks and a thorough understanding of the Hydrogen system cannot be overemphasized. Under normal operation in hydrogen, the atmosphere in the generator will be non-inflammable. However, a mixture of between 5 and 75 percent hydrogen in air will explode if ignited in an enclosed space. To ensure complete safety operation of the hydrogen cooled generator, a hydrogen purity between 93 and 95 percent is maintained in the generator casing at all times, thus making an explosion within the casing normally impossible. Causes of low H2 Purity can be found on page of this manual under Section of Gas Purity Alarm.

When completely assembled and operated in the proper manner, the generator housing, which forms the hydrogen container, will be a gas-tight, self-ventilated enclosure strong enough to limit the destructive effects of an explosion of the hydrogen contents to the generator frame, housing and enclosed parts.

The hydrogen equipment of the generator is so arranged that ample ventilation is provided for the parts from which hydrogen leakage to atmosphere might occur.

Any abnormal condition should be checked immediately to determine the cause. If for any reason, you cannot find the problem, be sure to inform the supervisor and ask his assistance.

D. No. 4 Turbine - Generator and Accessories (Contd.)

No. 4 Generator (Contd.)

Shaft Sealing System

1. Shaft Seals

Hydrogen must be held within the generator casing to be effective. Therefore, shaft seals are required at each end of the generator where the rotor extends through the casing. A radial oil film type seal is used for the purpose. The shaft seal at each end of the generator consists of a seal housing containing a pair of segmental bronze rings. The segments are positioned against the side walls of the housing and are held concentric with the shaft by a garter spring. The rings which have a bore diameter of only a few mils greater than the shaft journal, are free to float radially but are prevented from rotating with the shaft by a stop in the upper half of the housing. This housing is bolted to the end shield. Oil from the seal-oil control unit at a pressure of 4.5 psi above the hydrogen pressure in the generator is supplied to the seal housing. The oil then passes radially through the space between the rings and axially along the shaft in both directions. It is this thin film of oil between the shaft surface and the rings that actually seals the hydrogen within the casing.

The total oil flow to the inner or hydrogen side rings of the two shaft seals is less than one gallon per minute, while the flow from the outer or air side rings may be several times that amount. A large air-side flow is needed to cool the rings while a low hydrogen-side flow is essential for satisfactory operation of the continuous scavenging system.

2. Seal Oil Control Unit (Same as #2, 3 and 4)

Pressure oil for the seals is supplied from the main oil system intermediate pressure header to the seal oil control unit where it is filtered and regulated to maintain the 4.5 psi differential. Also the quantity of the total seal flow can be read directly in the flowmeter.

3. Oil Filter

The oil filter is a duplex bag type unit which permits either or both sides of the filter to be placed into service. Each filter is sized to continuously handle the full seal-oil requirements.

4. Differential Pressure Regulator

A differential pressure regulator is provided for controlling the seal-oil pressure at the shaft seal. The valve in the pressure regulator is actuated by a diaphragm.

The upper connection to the diaphragm is piped to the seal drain enlargement and senses the gas pressure in the generator casing. The lower connection of the diaphragm is piped to the seal-oil supply line at the shaft seal and senses oil pressure being supplied to the shaft seals. Once adjusted, the regulator will maintain a constant 4.5 psi differential through the complete range of hydrogen differential pressures.

D. No. 4 Turbine - Generator and Accessories (Contd.)

No. 4 Generator (Contd.)

5. Flow Meter

The flow meter is provided for obtaining an instantaneous reading of the total seal-oil flow.

6. Instrumentation

A differential pressure gauge and two differential pressure switches are mounted on the gauge board. These instruments sense seal-oil pressure at the seals with respect to gas pressure in the casing. The switches are electrically connected to actuate both the DC emergency seal-oil pump located on the oil tank and the annunciator drop in the hydrogen control cabinet on low differential pressure. Valving is provided for adjusting and testing these switches.

The seal-oil differential pressure as read on the differential pressure gauge will be the same at the two seals due to the natural hydraulic balance obtained by oversized pressure feed piping to the generator and a balanced piping circuit to each seal.

7. Bearing Drain Enlargement

The air side seal-oil and the generator bearing oil drains to a detraining chamber mounted under the generator casing. This detraining chamber, which has been designated as the Bearing Drain Enlargement, provides a large surface area for detraining the oil before it is returned through the loop trap to the main oil tank. The bearing drain enlargement is vented to the roof.

In addition to the natural draft in the vent line, an exhauster is also provided to maintain a slight negative pressure in the enlargement. In the event of failure of the shaft seal oil supply, hydrogen will pass from the generator into the bearing drain enlargement and be vented to the roof. The liquid loop trap provides a barrier to prevent the hydrogen from entering the main lubrication oil tank.

8. Seal Drain Enlargements

Two small detraining chambers, known as seal drain enlargements, are provided for removing entrained hydrogen gas from the oil which drains from the hydrogen side seal rings. One of these enlargements is mounted on each end shield and the two are drained through a common line to a float trap. The float trap, which is required to prevent the loss of hydrogen with the drain oil when operating at elevated hydrogen pressures, drains to the bearing drain enlargement where further detraining takes place before the oil returns to the main oil tank.

A vertical pipe open at the top terminates in the upper part of each section of the seal drain enlargement. The other end of this line connects to a control valve and flow meter in the hydrogen control cabinet. This arrangement permits a small amount of hydrogen to be continuously discharged to atmosphere from each seal drain enlargement. This discharge of hydrogen causes a small flow of hydrogen past the inner oil deflector of the generator casing. The flow prevents air liberated from the hydrogen

D. No. 4 Turbine - Generator and Accessories (Contd.)

No. 4 Generator (Contd.)

8. Seal Drain Enlargements (Contd.)

side seal-oil as it passes through the drain chamber of the seal housing from passing into the generator casing. Since this scavenged hydrogen must be continually replaced with pure hydrogen, the purity of the gas in the generator casing is maintained at a high value.

Another vertical pipe open at the top is also installed in one of the seal drain enlargements to collect the oil which results from an abnormal oil level in the enlargement. This overflow is piped to a high level alarm switch. Since the two enlargements are connected by a common drain line, a high level in either would normally result in the operation of the alarm. Abnormal oil level is usually caused by incorrect operation of the drain valves.

FOLLOWING THIS IS A DIAGRAM OF "SHAFT SEAL ADJUSTMENT DIAGRAM"

GAS CONTROL SYSTEM

The oil supplied to the shaft seals is taken from the turbine lubrication system and contains an appreciable amount of air in solution, about one percent by volume. The air will be largely given up to the hydrogen as the oil from the seals enters the hydrogen atmosphere. If all of the air liberated from the seal-oil were permitted to pass into the generator casing, a large amount of fresh hydrogen would have to be continuously wasted in order to maintain the hydrogen purity in the casing at a satisfactory value. However, if most of the air liberated from the seal-oil can be removed before it can pass, by diffusion, into the generator casing through the space between the oil deflector and the shaft, a considerably smaller amount of hydrogen will be required to maintain the hydrogen in the casing at a satisfactory value.

The removal of the air is accomplished by continuously scavenging a small quantity of hydrogen and discharging it to atmosphere from the two ends of the seal drain enlargement. The scavenged hydrogen is piped through flowmeters and control valves in the hydrogen control cabinet in order that the rate of scavenging can be controlled. This outward flow of hydrogen from the seal drain lines induces a corresponding outward flow of hydrogen from the generator casing through the radial clearance between the oil deflector and the shaft, thereby reducing to a very small value the inward diffusion of air from the seal-oil into the generator casing. Through the operation of this system of continuous scavenging, a hydrogen purity of approximately ninety-seven percent is maintained in the generator casing, and a purity of about eighty-five percent is maintained in the space between the oil deflector and the shaft seal, with the waste of a relatively small amount of hydrogen.

CARBON DIOXIDE SYSTEM

It is necessary to avoid an undesirable hydrogen-air mixture when initially charging the casing with hydrogen, or after removing the hydrogen from the casing before opening it to atmosphere. An inert gas is used to purge the casing of air before admitting hydrogen, and also to purge the casing of hydrogen before admitting air.

D. No. 4 Turbine - Generator and Accessories (Contd.)

Carbon Dioxide System (Contd.)

Carbon Dioxide is usually used for this purpose and is let into the casing through a perforated distribution pipe extending the length of the inside of the casing. Commercial bottles of carbon dioxide are connected to the distribution pipe through a manifold. This manifold assembly includes a pressure gage, relief diaphragm, and the hand valve which controls the flow of gas to the casing. During the purging operation several bottles of carbon dioxide are discharged simultaneously into the casing. The generator can also be purged using the portable liquid CO2 trailer and vaporizer.

When removing either air or hydrogen from the casing, carbon dioxide is admitted to the bottom of the casing through the carbon dioxide feedpipe and the air or hydrogen in the casing is discharged to atmosphere through the hydrogen feed pipe. Carbon dioxide is admitted until a mixture of seventy percent carbon dioxide in air is obtained in the gas discharge to atmosphere. Hydrogen is then admitted to the casing through the hydrogen feed pipe and the carbon dioxide in the casing is discharged to atmosphere through the carbon dioxide feed pipe. When a mixture of ninety-five percent hydrogen in carbon dioxide is obtained in the gas discharged from the casing, the generator may be placed in operation.

For removal of hydrogen from the casing with carbon dioxide before opening the casing to atmosphere, carbon dioxide is admitted until a mixture of ninety percent carbon dioxide in hydrogen is obtained in the discharge gas. The carbon dioxide in the casing may then be removed by admitting air to the bottom of the casing and discharging the carbon dioxide to atmosphere through the carbon dioxide feed pipe. The valves in the hydrogen and carbon dioxide feed piping for control of the purging operation are located adjacent to the gas manifolds.

PURGING CONTROL GAS ANALYZER

A portable gas analyzer is used to supervise the purging operations. The gas analyzer operates on the principle of thermal conductivity, and must be calibrated before each phase of the purging operation. Connections are available from both the carbon dioxide manifold and from the hydrogen manifold for calibrating the analyzer.

The principle of operation of the analyzer is explained in the insert covering the portable gas analyzer.

LIQUID DETECTOR

Water or oil can collect in the generator casing as the result of a leaky tube in the gas cooler, or from excessive oil flow to the gas side of the shaft seals. A liquid detector is connected in the drain line from the bottom of the generator casing, and this device is a float actuated switch which operates an alarm at the hydrogen control cabinet. A sight glass permits visual detection of any accumulation of liquid from the generator casing.

GAS PURITY ALARM

The indicating instrument mounted on the front panel of the hydrogen control cabinet is equipped with an alarm circuit that will operate on either high or low purity.

D. No. 4 Turbine - Generator and Accessories (Contd.)

Gas Purity Alarm (Contd.)

The contacts for this alarm system are set by adjusting the knobs on the front of the indicating instrument.

Generator casing Purity Alarm Contacts: The low purity alarm should be set at ninety percent and the high purity alarm set at 98 percent.

In addition to indicating the hydrogen purity in the respective areas, the low purity alarm may indicate (a) loss of AC supply to the cabinet; (b) failure of the thermal cells in the detector unit; (c) moisture in the detector unit cells; (d) failure of the vacuum tube in the alarm amplifying relay.

If the source of the alarm is the generator casing, observe reading of the fan-pressure gage. If this also indicates low hydrogen purity, admit hydrogen to the generator casing from the connected bottles to restore the purity to a satisfactory value. Then determine the cause of the decrease in purity and correct (low purity is usually an indication that the scavenging rate is too low). If the seal housing is indicated as the source of the alarm, the scavenging rate should be increased until a satisfactory purity is obtained. Failure (a) would be denoted by extinguishing of AC pilot lamp. Failure (b) would be indicated by an appreciable reduction in the readings of the milliammeter.

The high purity alarm may indicate (a) incorrect calibration; (b) failure of one coil of the thermal cell in detector unit; or (c) too high a current through the thermal cell.

Condition (a) may be checked by passing pure hydrogen through the detector unit by way of the calibration valve. Failure (b) would be indicated by an appreciable reduction in the reading of the milliammeter. Condition (c) would denote adjustment of rheostat.

FLOW CONTROL AND SCAVENGING RATE

The rate of hydrogen flow through the gas analyzer cell should be maintained between 100 cc and 700 cc per minute for satisfactory operation. In general a flow of 400 to 700 cc per minute should be maintained when operating with hydrogen pressure in the generator casing below 15 psig and 200 to 400 cc per minute when operating with hydrogen pressure in the generator above 15 psig. Higher flow rates induce flow error in the purity readings obtained and may increase maintenance of the cell by introducing foreign matter into the cell block.

The gas analyzer is independent of flow error over a wide range. However, if flow is increased beyond a certain amount the reading will change indicating an apparent increase in hydrogen purity. The gas analyzer may be checked for flow error by decreasing or shutting off the flow for a short time. Any change in the reading will be flow error.

The required flow is obtained during operation of the generator from the differential pressure across the generator fan. The flow rate is controlled by adjustment of the needle valve and needle by-pass valve. With the generator at standstill, the flow of hydrogen from the generator casing to the analyzer unit is obtained by allowing hydrogen from the flowmeter to

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Flow Control and Scavenging Rate (Contd.)

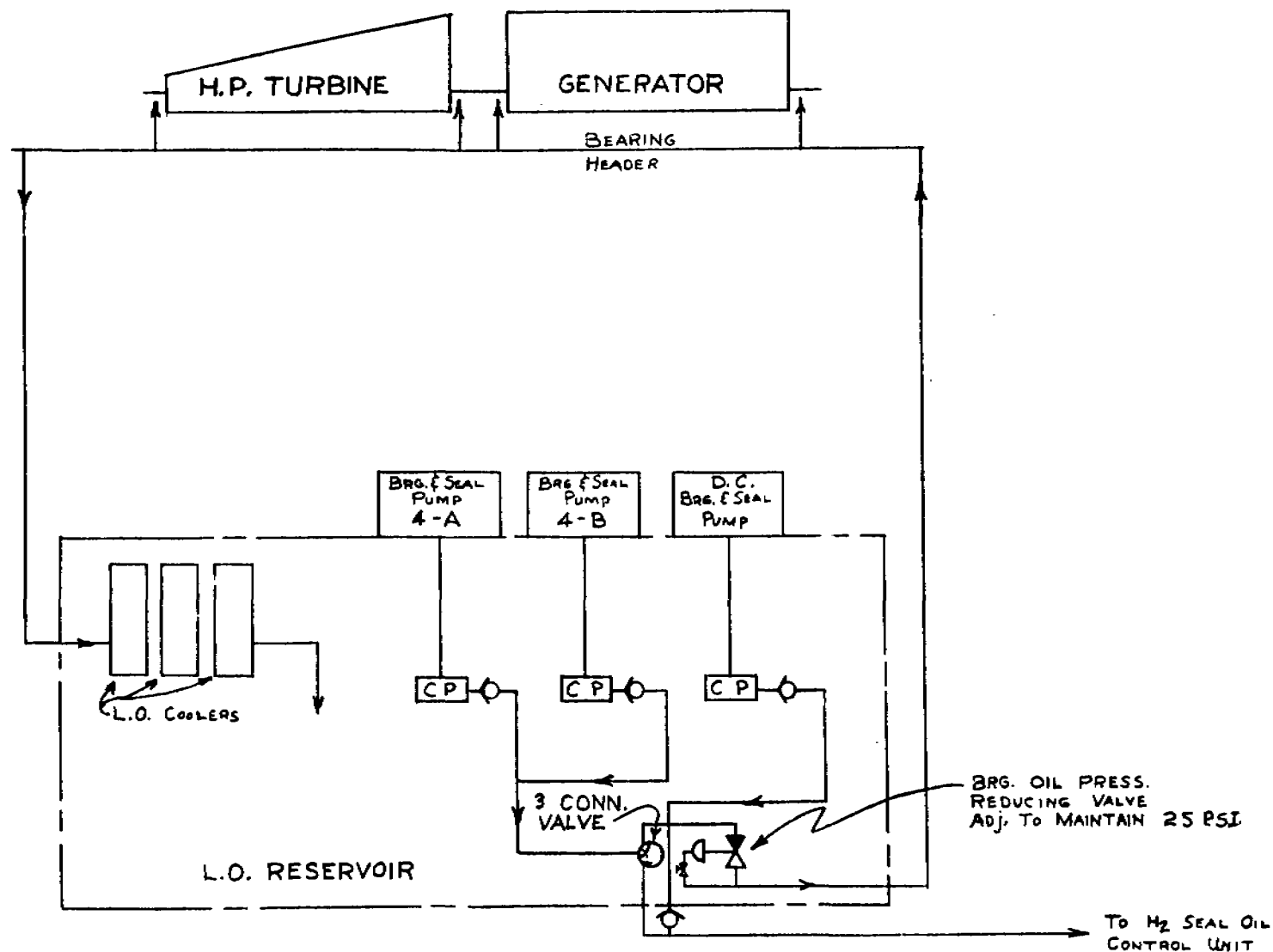
be discharged to atmosphere through the vent piping. Since under this condition of operation the hydrogen is wasted, it is desirable to reduce the flow to a minimum value for which satisfactory operation of the analyzer can be obtained. This value is between 100 cc and 200 cc.

The filter dryer unit is filled with approximately four ounces of activated alumina. A light blue is the normal color of the drying agent which turns to light pink and then to white when expended. The expended drying agent can be replaced.

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