UNITED STATES
ATOMIC ENERGY COMMISSION
DIVISION OF COMPLIANCE
REGION I
970 BROAD STREET
NEWARK, NEW JERSEY 07102

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October 30, 1970

R. T. Carlson, Senior Reactor Inspector
Region I, Division of Compliance

JERSEY CENTRAL POWER & LIGHT COMPANY (OYSTER CREEK 1)
CO REPORT NO. 219/70-6

I was satisfied with the performance of the facility's management and the review by PORC and GORB of the events discussed in the report. I recommend the following:

1. CO should establish that GE does supply modified control linkages, as appropriate, for the BWR's of common design (identified in the report).

2. CO should establish that adequate maintenance practices and procedures are in effect for the EPR oil filters to ensure that other BWR's do not experience similar transients, from dirt in the Moog valve.

I intend to follow up on the metallurgical studies that will be performed by GE on the broken linkage and also follow closely the results that the new cams (planned for installation in late October, 1970) have on steam pressure control and stability.

R.J. McDermott
R. J. McDermott
Reactor Inspector

D/438

U. S. ATOMIC ENERGY COMMISSION
REGION I
DIVISION OF COMPLIANCE

Report of Inspection

CO Report No. 219/70-6

Licensee: JERSEY CENTRAL POWER AND LIGHT COMPANY
Oyster Creek 1
License No. DPR-16
Category C

Dates of Inspection: September 23-25, 1970

Dates of Previous Inspection: May 18-22, 1970

Inspected by: R. J. McDermott 10/30/70
R. J. McDermott, Reactor Inspector Date

Reviewed by: R. T. Carlson 11/2/70
R. T. Carlson, Senior Reactor Inspector Date

Proprietary Information: None

SCOPE

Type of Facility: Boiling Water Reactor

Power Level: 1600 Mwt

Location: Forked River, New Jersey

Type of Inspection: Special, Announced

Accompanying Personnel: Mr. W. Farmer, TSB, CO:HQ accompanied on September 24 and 25, 1970, and assisted in the writing of this report.

Scope of Inspection: A special inspection was made at the site to review reported instances of malfunctions of the main turbine initial pressure regulator and a control linkage breakage that would have affected the turbine bypass valve operation. GE representatives from APED, San Jose, California and Large Steam Turbine Generator (LSTG) Division in Schenectady, New York, were interviewed at the site to determine the cause and significance of the malfunctions and the generic considerations for other BWR's.

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SUMMARY

Safety Items - None

Noncompliance Items - None

Unusual Occurrences - The Oyster Creek facility has experienced six disturbances to steam pressure control during the period of September 17-28, 1970. They have been exhibited as spikes or oscillations in electrical output and steam flow and pressure. The measured magnitudes of the transients have been in the range of 5 - 70 Mwe. On two occasions, main steam line high flow instruments have tripped but the combinations of sensor trips was not sufficient to initiate the closure of the main steam isolation valves. On one occasion, however, low pressure (850 psi) in the main steam line did initiate main steam isolation valve closure and resulted in a reactor scram. The events appeared to be caused by, and were reported by JC to be caused by, malfunctions or design inadequacies in the initial pressure regulator (IPR) controls, but one of the disturbances that was experienced was directly related to a malfunction in the feedwater control system. Three scrams have resulted from these transients, and in all cases, all post-scram functions were reported to have operated normally. During the system check-out following one of the scrams, a broken control linkage was observed that would have prevented the turbine steam bypass valves from opening when required.

Corrective measures employed by the licensee to eliminate the malfunctions have included: (1) the cleanup of the control oil system; (2) the installation of an additional filter in the oil supply for the electric pressure regulator (EPR) portion of the IPR; (3) changing of two wire-wound rheostats in the EPR control to composition-type rheostats; (4) the replacement of two amplifiers in the EPR portion of the IPR with amplifiers of a similar design; (5) an inspection and check-out of all wiring within the EPR control system for solid connections; (6) eliminating unwanted grounds and assuring zero resistance grounds where appropriate within the EPR control system; and (7) repairing the broken turbine bypass valve operating linkage. GE personnel assisted in the repairs and the checkout of the malfunctions observed. Personnel from the GE, Installation and Service Engineering (I&SE) Group and the GE, LSTG Group in Schenectady, New York visited the plant to review first-hand the observed malfunctions.

Future planned changes for the facility include the replacement of the broken control linkage that was repaired with one of a new design, the addition of cover plates for the control linkages where appropriate, the changeout of the amplifiers within the EPR to a new design with extended service life, and the replacement of the turbine control cams to provide for more stable steam pressure control for both the current licensed power limit and the mini-stretch power increase (1690 Mwt application which has been submitted to DRL and is currently pending). JC-GE are currently evaluating the need to install damping capacitors within the EPR control system to eliminate steam line "noise" from feeding through the control system.

The generic considerations for other BWR's may be influenced by the results of the planned metallurgical examination of the broken control leakage. This examination will be performed by GE, Schenectady, New York in late October, 1970.

During the site management meeting which was held with JC and GE representatives, the inspectors were informed that GE is also planning to supply new control valve cams to the Nine Mile Point plant. Two additional plants (not identified but thought by GE representatives to be foreign BWR's) were reported to also be under consideration for new cams. It was also disclosed that the hydraulic oil filter installation that is utilized to filter the oil supply to the hydraulic control valve (Moog valve) in the EPR control system is not of the same design at all BWR's. OC-1 modified their oil filter installation as a result of the recent disturbances. Other BWR's utilizing mechanical-hydraulic turbine control schemes, such as Oyster Creek, were reported by GE representatives to include Nine Mile Point, Millstone 1, Monticello, Vermont Yankee, and Pilgrim. GE personnel from the LSTG Group have stated that it is GE's policy to initiate any required changes to all nuclear power plants of a common design when a corrective change is made to any one of these plants. It should be noted that the Dresden II turbine control is of a different design concept (no mechanical linkages) than the Oyster Creek plant.

The results of the discussions with JC and GE personnel on the recent disturbances, including the broken control linkage did not disclose any possibility for a more severe transient to occur than that previously analyzed, i.e., turbine trip-out without bypass valve opening.

Listed below is a summary description of the disturbances and the causes which the licensee attributes the disturbances to:

1. <u>Turbine-Generator Oscillations</u> - Following a "backwash" (tube cleaning) operation of the main condenser, on September 17, 1970, the generator load began to oscillate 10-15 Mwe. The station load was reduced from 530 to 400 Mwe by operator action and the load reduction resulted in a turbine trip followed by a reactor scram from high flux. The turbine trip was caused by an indicated high moisture level in the moisture-separator drain tank and was assumed by the licensee to be caused by "flashing" of the moisture in the drain tank that resulted from the load reduction. Following a checkout of the initial pressure regulator controls by GE and JC personnel, the reactor was restarted on September 18, 1970. JC considered the instability in the initial pressure regulator to be caused by improperly designed turbine control valve cams (non-linear operation) and that the backwash operation may have aggravated the situation by changing condenser efficiency and hence, control valve position and steam flow and pressure.

2. <u>Turbine-Generator Spike</u> - During operation at 525 Mwe on September 20, 1970, the electrical output of the generator suddenly increased $\approx$ 20 Mwe followed by a decrease of $\approx$ 30 Mwe. The station load was reduced by operator action to approximately 450 Mwe and control was transferred from the EPR to the mechanical pressure regulator (MPR). The licensee has attributed this spike to dirt in the Moog valve in the EPR control system.

3. <u>Turbine-Generator Spike</u> - During operation at 495 Mwe on September 21, 1970, (1:33 a.m.) the electrical output of the generator suddenly increased 55 Mwe and then decreased approximately 70 Mwe. The station load was reduced by operator action to 450 Mwe and control was transferred from the EPR to the MPR. The licensee attributes this spike to dirt in the Moog valve in the EPR control system.

4. Turbine-Generator Oscillations - During operation at 455 Mwe on September 21, 1970 (9:22 a.m.), turbine vibrations were noted and load was reduced by operator action to 390 Mwe. Vibrations returned to normal but during attempts to recover the load, the station output began to oscillate slowly at 410 Mwe with a magnitude of 40 - 50 Mwe. Power was reduced by operator action to 350 Mwe, but the load swings continue for approximately 30 minutes before a stable system was obtained. Control of the initial pressure regulator was then transferred to the MPR.

5. Turbine Trip and Reactor Scram - During operation on September 22, 1970, at 500 Mwe with the EPR in service, the generator load increased suddenly ±5 Mwe and reactor steam pressure decreased from 1000 to 970 psi. The operator was instructed to reduce load to 470 Mwe and to transfer control to the MPR. Steam pressure continued to decrease after transferring control to the MPR and attempts were made to regain control of the EPR. Steam pressure continued to decrease and the main steam isolation valves closed at 850 psi to initiate a reactor scram. The turbine generator was then manually tripped. Investigation disclosed dirt in the Moog valve in the EPR system. During a checkout of the turbine controls following the scram, the turbine steam bypass valves would not respond. A control linkage was found to be broken and was repaired before resuming operation. The exact cause for the broken linkage could not be established. The effect of the breaking of this linkage would not impair normal turbine control, but would have prevented the turbine steam bypass valves from opening when required.

6. Feedwater Control System Malfunction - During operation on September 28, 1970, at 450 Mwe with the MPR in service, a loss of a feedwater pump flow signal was experienced. The feed pumps continued to run but the control system, which then saw a mismatch of steam and feed flow, called for additional makeup to the reactor. Reactor level increased from 80 to 85 inches before the level input to the 3-element controller overrode the steam-feedwater flow mismatch. The operator reduced power from 450 to 400 Mwe and following the load reduction, the turbine tripped from a high level in the moisture separator drain tank - the reactor scrammed on high reactor pressure.

Status of Previously Reported Problems - None

Other Significant Items - None

Management Interview - An exit interview was held with Messrs. McCluskey, Ross, and Carroll at the conclusion of the inspection. The inspectors questioned Mr. McCluskey relative to further planned action if additional generator load disturbances were observed. Mr. McCluskey stated that if further disturbances were observed, the station load would be reduced to a level that would permit stable operation. The inspectors stated that it appeared that there were two types of unrelated problems with the turbine generator - one being a critical cam position near full generator load and the other being dirt in the control oil system. In regard to the former, the inspector (Mr. McDermott) stated that it would appear prudent not to operate near the critical cam position. Mr. McCluskey responded by stating that the plant had operated during the summer at full load without IPR stability problems. He further stated that based on this history, he intended to return the plant to full load. He also stated that the backwashing of the main condenser that preceded the instability problem on September 18, 1970, had also been routinely performed during the summer months at full generator load conditions without instability resulting but that it was his plan to reduce load prior to either turbine valve testing or condenser backwashing to prevent introducing disturbances into the system when near the critical cam position.

The reportability aspects of these recent events were discussed with Mr. McCluskey and he stated that he did not consider these events reportable by license requirements. The inspector stated that the reportability requirements were not clearly defined on this issue but encouraged JC to voluntarily submit an information report of these events. Mr. McCluskey notified the assigned inspector by telephone the following day that a report would be submitted to DRL during the week of October 4, 1970.*

DETAILS

A. Persons Contacted:

Jersey Central Power & Light Company

Mr. T. McCluskey, Station Superintendent, OC-1
Mr. D. Ross, Technical Supervisor, OC-1
Mr. J. Carroll, Operations Supervisor, OC-1

General Electric Company

Mr. P. C. Callan, Controls Engineer, LSTG Division, Schenectady, NY
Mr. R. J. Dickinson, Controls Engineer, LSTG Division, Schenectady, NY
Mr. W. Popov, I&SE Group, Millburn, NJ
Mr. R. Seimer, Transient Analysis Engineer, APED, San Jose, California
Mr. J. Benson, Licensing Activities Group, APED, San Jose, California

C. Operations

1. Description of Events

Following the May, 1970 rod work outage, the reactor was restarted and has been operated continuously with three exceptions. Two unscheduled plant shutdowns resulted on July 11 and August 1, 1970, from heavy sea grass accumulation on the main circulating water intake screens. One additional unscheduled shutdown occurred on September 15, 1970, due to a high moisture accumulation rate (unidentified leakage) in containment which was caused by a leaking packing on a recirculation pump discharge valve. Reactor operations resumed on September 17, 1970, and a series of steam pressure disturbances have occurred since that time.

*Letter, Finfrock to Morris, dated October 8, 1970.

Listed below is a description of the events as obtained from operations logs and discussions with operating personnel:

September 17, 1970 (Event No. 1)

Time	Sequence of Events
0448	Reactor startup.
2215	100% power - 530 Mwe.
2230	Started condenser backwash.
2250	Turbine electrical load began swinging 10-15 Mwe. Operator started to reduce load by reducing recirculation flow. A loud rumbling noise from the turbine was noted but its source could not be established.
2300	The plant was at 400 Mwe and stable.
2301	Turbine trip and resulting reactor scram followed by a main steam line valve isolation. The isolation condensers were placed in service manually to control system pressure.

All control rods scrammed fully except 30-03 which was valved out of service at position 48. Scram times of monitored rods ranged from 2.53 to 3.06 seconds. The reactor was brought critical at 0522 on September 18, 1970, and the plant was maintained in the hot standby condition while the cause of the turbine trip and turbine oscillations was being investigated by JC operating personnel and Mr. W. Popov, GE I&SE representative. Investigation disclosed that the level controller for moisture separator drain tank 1-6 was out of adjustment (proportional band) and the instrument department corrected and reset this instrument. It was assumed that the cause of the turbine trip was flashing in the moisture-separator drain tank following the load reduction. A hydraulic pilot valve (Moog valve) in the EPR portion of the IPR was disassembled and cleaned, control linkages were checked from the front standard on the turbine to the control valves, EPR control system and shock absorber (mounted on the torque tube in the front standard) response times were checked, and the control oil supply filters were changed. Nothing was observed during this checkout that could be associated with the turbine-generator oscillations.

Just prior to the scram, the main condensers were being backwashed which caused the load to decrease, then increase as each condenser half's flow was reversed. It is thought that these power swings might have contributed to the start of the oscillations. The turbine cams were reported to have shown a tendency toward instability at the full power position whenever something occurs to swing the load. Mr. McCluskey informed the inspectors that OC-1 had previously experienced poor main steam pressure control when the turbine-generator was operating in the range of 530-535 Mwe. He attributed this to a poor design of the four cams that position the four turbine control valves through the IPR linkages. Mr. McCluskey further stated that the currently installed cams were the third set of cams to be installed at OC-1 and that another set of cams would be installed during the next scheduled outage in October, 1970. The installation of the new cams is intended to eliminate the poor control characteristics at or near the full load and to accommodate the planned mini-stretch and final stretch power increases.

The operators were instructed to decrease load to a more stable cam position before backwashing condensers and the turbine-generator was returned to service and raised to 380 Mwe when oscillations began again at 2050 on September 18, 1970. Load was increased to 450 Mwe and the 10-15 Mwe oscillations continued. Control was then transferred to the MPR at 2335 on September 18, 1970, and the oscillations vanished. The oil filters for the EPR were cleaned and control on the EPR was re-established at 1125, September 19, 1970. Load was then increased to 520 Mwe by 1500 with no oscillations.

Graphs of selected parameters were obtained for this transient and are included as Figures 1-4 attached. The scales for the variables recorded on the graphs are as follows:

Electrical output - 0-800 Mwe

Totalized steam flow - 0 to 8 x 10^6 lbs/hr

Wide range steam pressure - 0 to 1600 psi

Feed flow - 0 to 8 x 10^6 lbs/hr

Reactor level - 0 to 8 feet above 0 datum - (The 0 datum level was reported to correspond to ≈ 8 feet above the top of the active fuel)

APRMS - 0 to 150%

Narrow range reactor pressure - 950 to 1050 psi

Turbine first stage steam flow - 0 to 8 x 10^6 lbs/hr

Control valve and bypass valve position indication - 0 to 100% open

September 20, 1970 (Event No. 2)

Time	Sequence of Events
0240	With the plant operating at 525 Mwe, the operator received the following alarms: turbine excess vibration, APRM high alarm (all channels except No. 8), and two main steam line break high steam

flow alarms (points 15 and 45 in the events recorder), accompanied by a sudden up-spike of ≈ 20 Mwe on the turbine-generator output. The four turbine control valve positions swung from 81 to 89% open and back and this was accompanied by a steam flow change of 5.6×10^6 to 6.4×10^6 lbs/hr and back.

0245	The operator commenced load reduction with recirculation flow to 500 Mwe and then inserted control rods to reduce the power further to 450 Mwe. The turbine initial pressure regulator was being controlled by the EPR at this time.

Mr. W. Popov (GE) and Mr. J. Carroll (JC) informed the inspectors that they attributed this spike to dirt in the Moog valve. The small internal tolerances of this valve, coupled with inadequate filtering of the supply oil, were considered to be the cause for its sticky operation. Sticky operation prevents the Moog valve internals from immediately responding. When this valve does respond, it will then overshoot its control position and result in sudden control valve motion and finally manifest itself in generator power spikes.

Load was increased to 500 Mwe on the EPR with no problems by 1208 on September 20, 1970. Charts of this event are attached as Figures 5 - 8.

<u>September 21, 1970 (Event No. 3)</u>

Time	Sequence of Events
0133	With the load at 500 Mwe the plant experienced an uncontrolled steam flow transient due to turbine control valve movement. The operator received one alarm of main steam line break high steam flow. Indicated electrical output spiked up by 55 Mwe followed rapidly by a 70 Mwe down-spike.
0134	Load reduction was commenced by reducing recirculation flow.
0150	450 Mwe reached and the operator held this load controlling on the EPR.
0350	Excessive vibration was noted on the turbine oil return lines following the transient experienced at 0133.
Start of 8:00 a.m. to 4:00 p.m. shift	Observed vibrations on turbine oil lines and oil tank, as well as on the torque tube and the shock absorber. The vibration was stopped by applying a firm pressure on the shock absorber weight. Mr. Popov (GE) informed the inspector that erratic control valve motion (slight 'hunting') would account for the vibrations.

Graphs of the selected parameters for this event are shown in Figures 9-12 attached.

September 21, 1970 (Event No. 4)

Time	Sequence of Events
0922	Began generator load reduction to 400 Mwe with recirculation flow due to turbine front standard (control system) and control oil system vibrations. EPR in control.
0942	Began increasing generator load to 450 Mwe with recirculation flow.
1000	Generator load at 410 Mwe and the load began to slowly swing ± 25 Mwe.
1006	Transferred control from the EPR to the MPR to clean the Moog valve and change the oil filters.
1020	Began raising power with recirculation flow to 450 Mwe controlling the turbine and the MPR.
1401	Transferred control to the EPR.
1445	Reached 500 Mwe.
1803	515 Mwe - experienced swing in feedwater flow from 5.9 to 4.7 and back to 6.8 x 10^6 lbs/hr. Alarm received for feed pump runout, but alarm did not lock in. Also received a 3% spike on the APRM due to the cold water injection.
2200	Commenced power reduction to 500 Mwe.

Charts of this event are attached as Figures 13-16.

September 22, 1970 (Event No. 5)

Time	Sequence of Events
0828	"Maximum emergency generation" order given to all stations by grid load dispatcher.
0928	"Voltage warning" given to all stations by the grid load dispatcher.
0939	At 500 Mwe, the reactor scrammed from closure of the main steam isolation valves. Reactor steam pressure initially experienced a decrease

to approximately 970 psi. The operator was instructed to reduce load to 470 Mwe and to transfer control to the MPR. Pressure continued to decrease due to the reactor power cut and when 850 psi was reached, the main steam isolation valves closed. Prior to the MSIV closure, attempts were made to regain pressure control while controlling the EPR but pressure continued to decrease. The power supply to the EPR was turned off in an attempt to force the transfer to the MPR, but the control system did not respond. The turbine generator was manually tripped following the scram.

Prior to the scram, the reactor was operating at approximately 1520 Mwt. The first indication of a problem was a very small swing up in electrical load accompanied by a decrease in reactor pressure. The operator immediately started to reduce load to reach a more stable position on the control valve cams, but steam pressure continued to drop. The power supply to the EPR was shut off in hopes of effecting a change over to the MPR. It was later discovered that it would not have been possible to change to the MPR in this manner.

Upon investigation of the EPR and the Moog valve, it was found that the internal filter in the Moog valve was plugged. The plugged filter caused the internal piston in the Moog valve, and hence the control valves, to remain in the position they took just prior to the scram. As this position had opened the control valves slightly, this caused the pressure to start decreasing. The operator, by dropping load, reduced the pressure even further. The pressure continued to decrease until the 850 psig set point for the main steam line low pressure was reached, at which time the main steam isolation valves closed and scrammed the reactor.

The plugging of the Moog valve nozzle was believed to be caused by dirt which was left in the system from the last pre-filter cleaning operation (September 17, 1970). During this investigation it was also found that a rubber gasket was missing from the normal pre-filter which would have allowed some oil to bypass the filter when in service. This dirt would normally be caught by a second filter (sintered metal) but one of the sealing gaskets on these filters was found to be pinched in a manner such that it could also have been bypassing oil and particulate matter.

The Plant Operations Review Committee (PORC) reviewed both the scram and the mechanical lockup of the Moog valve. They determined that the only way control could have been transferred to the MPR would have been to increase the recirculation flow and reactor power until the steam pressure met the MPR set point pressure, or to lower the MPR set point pressure to the system pressure. As the MPR can only be placed in service when the system pressure increases to the MPR set point or the set point reduces to the steam pressure, the transfer could not have been made as the system pressure was dropping faster than the MPR set point could be reduced. Note: There is a physical limit incorporated in the set point controls for the MPR that controls the rate of set point change.

Other corrective action taken included a checkout of the EPR system. All electrical connections were checked for tightness, response times and control action of the Moog valve were checked at the turbine front standard, some minor repairs were made to correct the mechanical binding that was discovered on the DT-1 Moog position feedback sensor and the spiral orifice of the DT-4 pressure transducer was cleaned. The orifice did contain some solid deposits of foreign material, but it was not plugged. The output of the EPR control amplifiers were checked with an oscilloscope with varying input signals into the amplifiers. No spiking or unusual operation was noted.

During the course of this investigation, it was discovered that the turbine steam bypass valves would not respond. It was discovered that one of the linkages in the control system had cracked.* The crack in the tube was almost 360° around the circumference and would have prevented proper operation of the bypass valves, but would not impair the normal operation of the control valves. The exact cause of the failure of the rod was not determined. It was thought that the rod may possibly have been damaged by someone stepping on the rod or hanging a chain hoist from it during the construction period of the plant. The rod is mounted horizontally on a span of approximately 12 feet. Metallurgical examination of the rod will be completed as soon as the rod is made available to the GE company. It was stated by Mr. McCluskey that the rod will be removed during the October 18-25, 1970, outage and shipped to GE for a metallurgical examination. He further stated that the results of the examination would be made available to Compliance. The damaged rod or linkage was repaired by inserting a hollow steel sleeve inside the original bar and fastening this with bolts. It was established during discussions with GE that a failure of this linkage or any other linkage within the turbine controls would result in closure of either the control valves or bypass valves as these valves are mechanically biased closed. Several of the other control linkage tubes were dye penetrant inspected for cracks without discovering any additional cracking. GE now plans to provide a replacement linkage for the damaged linkage. The replacement linkage will have a thicker tube wall or be constructed of a stronger material.

Charts of this event are attached as Figures 17-20.

<u>September 23, 1970</u>

Time	Sequence of Events
1157	Reactor critical.
2300	Turbine-generator on bus.

*Discussed further in paragraphs C.3 and C.4.

September 25, 1970

Time	Sequence of Events
0030	At 510 Mwe the turbine-generator experienced several 10-15 Mwe swings. The load was reduced to 450 Mwe by operator action and control was transferred to the MPR to check out the EPR system. The unit remained at 450 Mwe until two wire-wound rheostats in the EPR control system were replaced with composition type rheostats.

September 26, 1970

Time	Sequence of Events
Swing Shift	Control was transferred to the EPR and the generator loading was increased 530 Mwe. Several small (2-5 Mwe) spikes were experienced and the load was reduced to 450 Mwe and control transferred to the MPR. While on the MPR, several small spikes in the generator output also resulted.

September 28, 1970 (Event No. 6)

Time	Sequence of Events
1930	450 Mwe, MPR in control - At this time, a flow signal from the B feedwater pump was lost. The feedwater pumps continued to operate and the feedwater flow control valves responded to the indicated mismatch in steam-to-feed flow by increasing flow to the reactor. The operator began a load reduction to 400 Mwe to enable the two remaining feed pumps (it was thought that the pump was lost) to supply the feed flow demand. The reactor level increased from 80 to 85 inches before control was re-established. The cause for the loss of indicated feedwater flow signal was reported to be a cold solder connection in the temperature compensation circuit for the B feed pump flow signal. The load was increased to 450 Mwe following the repair and checkout of this failure.

September 30, 1970

Sequence of Events

Continued operating at 450 Mwe while inspecting the EPR controls.

October 1, 1970

Sequence of Events

Load increased to 530 Mwe on the EPR after replacement of two amplifiers on the EPR, checking all control system wiring, and eliminating grounds from the control system wiring. No additional problems with the turbine controls or the feedwater controls systems had been experienced during the period of October 1 thru October 18, 1970.

2. Description of the Turbine Inlet Valve Control System (IPR)

The turbine valve control system is detailed in attached Figures 22 and 23 which were supplied in Amendment 11 to the FSAR for Oyster Creek 1 (copies of which are attached). The EPR electronic module and pressure transducer are shown on Figure 22 at drawing position 16 by A thru B. This system supplies the electrical signal to the pilot valve (or Moog valve) shown on Figure 23 at drawing location 5 by K. The hydraulic pilot valve controls the positioning of the master hydraulic servo motor shown adjacent to it. The hydraulic filter plugging and pilot valve port plugging problems reported above occurred in that portion of the hydraulic system shown on Figure 23 at drawing location 2 thru 5 K. The hydraulic servo motor of the EPR system, through levers, controls the rotation of the tube at drawing location 2 thru 8 by L on Figure 23.

The rotation of this tube is transmitted to the turbine inlet valve and bypass valve controls by mechanical linkage. The mechanical linkage which has a run length of 20 to 30 feet is shown in the attached drawing labeled Figure 24.

The EPR system is backed up by the MPR identified as the Forced Restored Regulator on Figure 23 in drawing location 2 thru 5 by F thru H. The MPR control set point is normally a few psi above the EPR set point so that it will take over on pressure increases. The MPR actuates the turbine inlet valve and bypass valve controls through the same linkage and valve actuation controls as the EPR.

The turbine inlet control cams are shown on Figure 22 in drawing location 25 thru 27A. It is to be noted that these cams are on a rotating bar at the opposite end of the mechanical linkage from the EPR and MPR controls. The cams, through a mechanical linkage system, position the hydraulic servo pilot valve which positions the main hydraulic servo motor which then opens or closes the steam inlet valves through a mechanical lever system.

The cylinder that fractured or cracked in the mechanical linkage system to the turbine bypass valves is identified as link 34 on Figure 24. This link is about in the middle of the drawing. This tube moves in a horizontal plane transmitting motion from the rotating bar and lever on one end to the rotating bar and lever on the other end. The tube is always under a compressive load. The tube is made of aluminum with a diameter around 2-1/2 inches, a wall thickness around 0.150 inches and a length around 12 feet. (These were approximate dimensions obtained during visual inspection). Complete failure of this tube would immobilize the turbine bypass valves but have no effect on the linkage to the turbine inlet valves.

3. Review of Control Problems and Linkage Failure

The turbine control difficulties and linkage failure were reviewed with representatives of GE and the JC operations staff at Oyster Creek 1. The GE representatives stated that it was their opinion that the steady cyclic instability experienced when operating in EPR control was caused by the profile on the turbine inlet control valve cams not matching the valve characteristics in the high load range. Thus when a slight plant upset occurs there is not sufficient damping in the system to prevent oscillation.

The spikes and large amplitude oscillations shown in the operating events described above are believed by GE to result from particulates plugging up the filters in the hydraulic system supplying oil to the hydraulic pilot control valve (or Moog valve) or plugging the port of the valve. When these particulates break loose, the pilot valve is postulated to overshoot its new control position resulting in the turbine inlet valve overshooting its position. The particle size capable of plugging the filter is almost visible to the "naked" eye. The existing hydraulic oil supply system has a filter system as shown on Figure 23. The pre-filter is a cuno cartridge 1/2 micron size and the after-filter a 10 micron sintered metallic unit. In addition, there are internal filters in the Moog valve sized for 20 to 40 microns. The clearances and ports in the Moog valve are extremely small so that the valve will stick if particles accumulate. When the Moog valve sticks the EPR control system is unable to activate either the turbine inlet or bypass valves. However, both valves would be closed at slightly higher steam pressure by the MPR system which operates independently of the EPR. In addition, the valves can be closed by an independent vacuum or manual trip.

The failure of the aluminum tube representing link 34 in the mechanical linkage to the bypass valves was discussed next with GE. The tube was stated to be perfectly straight but had a crack through the wall around almost 360° of the circumference. The tube is under compression from the linkage system at all times. The highest compressive load occurs when the bypass valves open. The failure was noted to appear as a brittle fracture. There were a couple of marks on the tube but no evidence of deformation. Since aluminum is a ductile material and the tube was straight, it did not appear as if it had failed under axial load or through a bending mode.

The GE service personnel had attached strain gages to the repaired tube. No measurements had been made up to the time of the meeting. However, the LSTG personnel of GE who were present stated that on learning of the failure they completely reviewed their stress calculations. The mechanical design calculations took into account stall forces which would lead to peak stresses and found no deficiency in the design.

It was stated that this type of mechanical linkage has been used on several hundred turbines supplied in prior years for fossile plants. This was the first case where a mechanical fracture had occurred.

The failure mode of the linkage to both the bypass valve and turbine inlet valve was discussed. Failure of a link in either system would result in the valve going to its closed position. The bypass valve would close in about five seconds under these conditions. The mechanical linkage to the bypass valves is distinct and separate from that to the control valves, except for the rotating bar connected by independent levers to the EPR and MPR hydraulic controls. The failure of the mechanical linkage to either valve system would not prevent the operation of the other valve system.

The question of safety review was discussed with both the JC and GE personnel. The events and linkage failure discussed above had been reviewed by the JC Plant Operations Review Committee (PORC) and the General Operations Review Board (GORB). Both were satisfied that there was not an unreviewed safety question involved and agreed to resuming operation after repairs had been made. They recommended that the plant be operated under close supervision and the committee be promptly informed of any further or continuing problems.

The GE safety personnel from APED had examined the problems at Oyster Creek and also concluded there were no unreviewed safety questions. The consequences of a failure resulting in the simultaneous closure of both the turbine inlet valves and the bypass valves had been considered in the FSAR, Section IV-2. The results were still believed by the licensee to be valid. Further, the main steam isolation valve had been closed in 3 to 10 seconds while at power during the plant test program. This test simulates to some degree total closure of both turbine inlet and bypass valves.

Questions were asked of JC and GE concerning past occurrences of a similar nature to those recently experienced with the turbine inlet valve control system. JC personnel stated that the plant had run very smoothly and at full power (530 Mwe) since starting back up after a maintenance shutdown in the spring. The oil filters on the hydraulic system supplying the servo pilot valve had been replaced infrequently and no significant dP increases had been observed across the filters. There had been a few spikes and control valve cycling of a minor nature observed earlier in the year. The recent unstable control events that occurred on September 17, 1970, had been initiated, they believed, by backwashing the condensers. Backwash operations had been conducted during the summer while at full power without "upsets". JC informed us that they intended to reduce power to an appropriate level prior to backwashing the condenser in subsequent operations.

The EPR control system has given trouble at various times since the Oyster Creek 1 startup. Some of the earlier experiences with EPR controller malfunction, dirt in the pilot valve and mechanical linkage binding are discussed in Reactor Operating Experiences (ROE) 70-9, "Pressure Regulator Tuning."*

*Also discussed in CO Report No. 219/69-9, Section C; CO Report No. 219/70-5, Section H.; Inquiry Memorandum 219/69-B, and Letter from JC to Dr. Morris dated November 3, 1969.

The amplifiers in the EPR system were giving difficulties earlier this year and were to be replaced by GE. At the time of the current problems in the period September 17-24, 1970, the replacement amplifiers had been delivered but had been returned to GE for correction.

4. Corrective Actions

During the week of September 21, 1970, the hydraulic supply system filters were cleaned and replaced. An additional set of 1/2 micron filters were installed in series with and after the existing after-filter. These changes were made to eliminate the pilot valve plugging difficulties.*

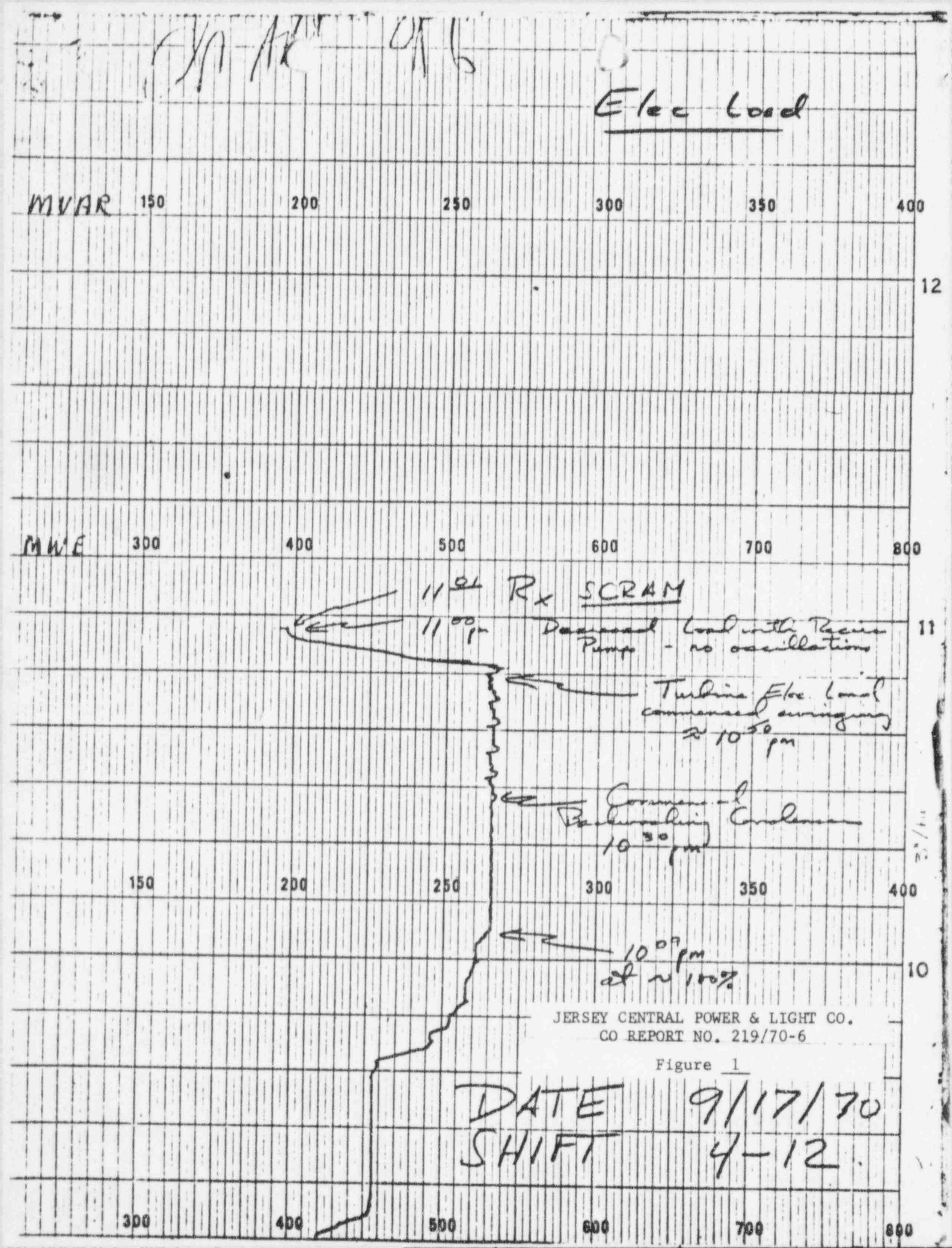
The GE service representative had taken new data on valve travel versus steam flow. New cams are to be supplied by GE and be installed during the next outage. The new cams are supposed to provide proper control in the higher power range involved in reaching stretch capacity. This will hold for both the mini-stretch and maxi-stretch.

The JC - Oyster Creek maintenance personnel have visually checked all of the mechanical linkage in the bypass valve and turbine inlet valve control systems. They also dye checked the links for evidence of any cracks. GE is planning to make a careful review of their mechanical linkage design. They plan to install bigger links or use steel in place of aluminum for added strength. These changes are to be made in the next extended outage.

They also are considering placing covers over the linkage to protect them from inadvertent damage. (They are now open and running between steam pipes below the front standard of the turbine.) The broken tube is to be returned to Schenectady for metallurgical examination in the next shutdown. Hopefully, this will enable them to determine the cause of failure. They have already reviewed their mechanical stress calculations for the linkage. They plan to check these against the strain gage measurements on the broken link. The personnel from the LSTG of GE indicated a report on the results of their evaluation of the linkage failure would be made available to JC and the Compliance inspector would be permitted to review it.

Recognizing that the same cams were still present, the JC operating staff indicated that they would drop back load to around 450 Mwe and go on the MPR if they continued to have trouble with the EPR.

*See Figure 24 attached.



JERSEY CENTRAL POWER & LIGHT CO.
CO REPORT NO. 219/70-6

Figure 1

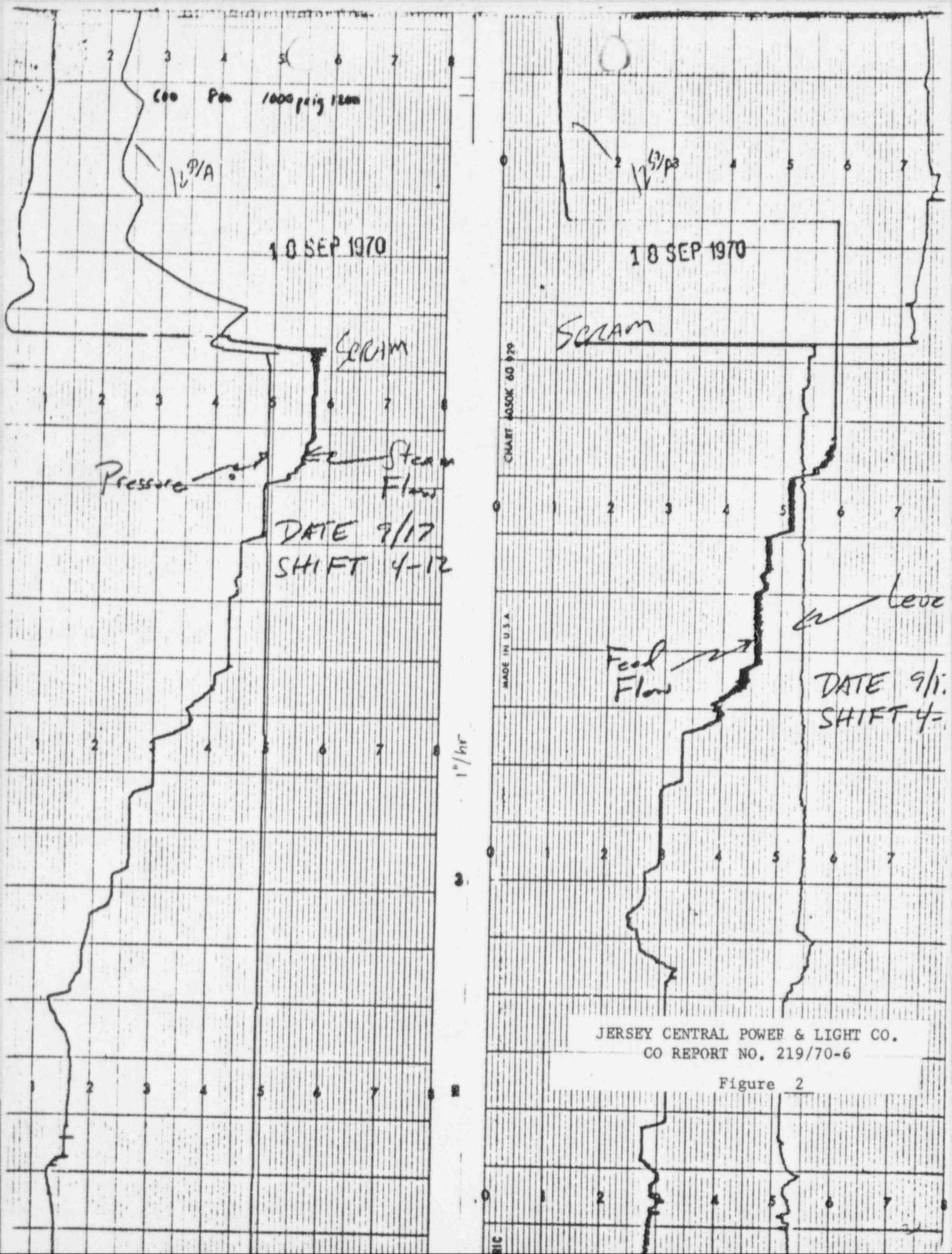


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Figure 2

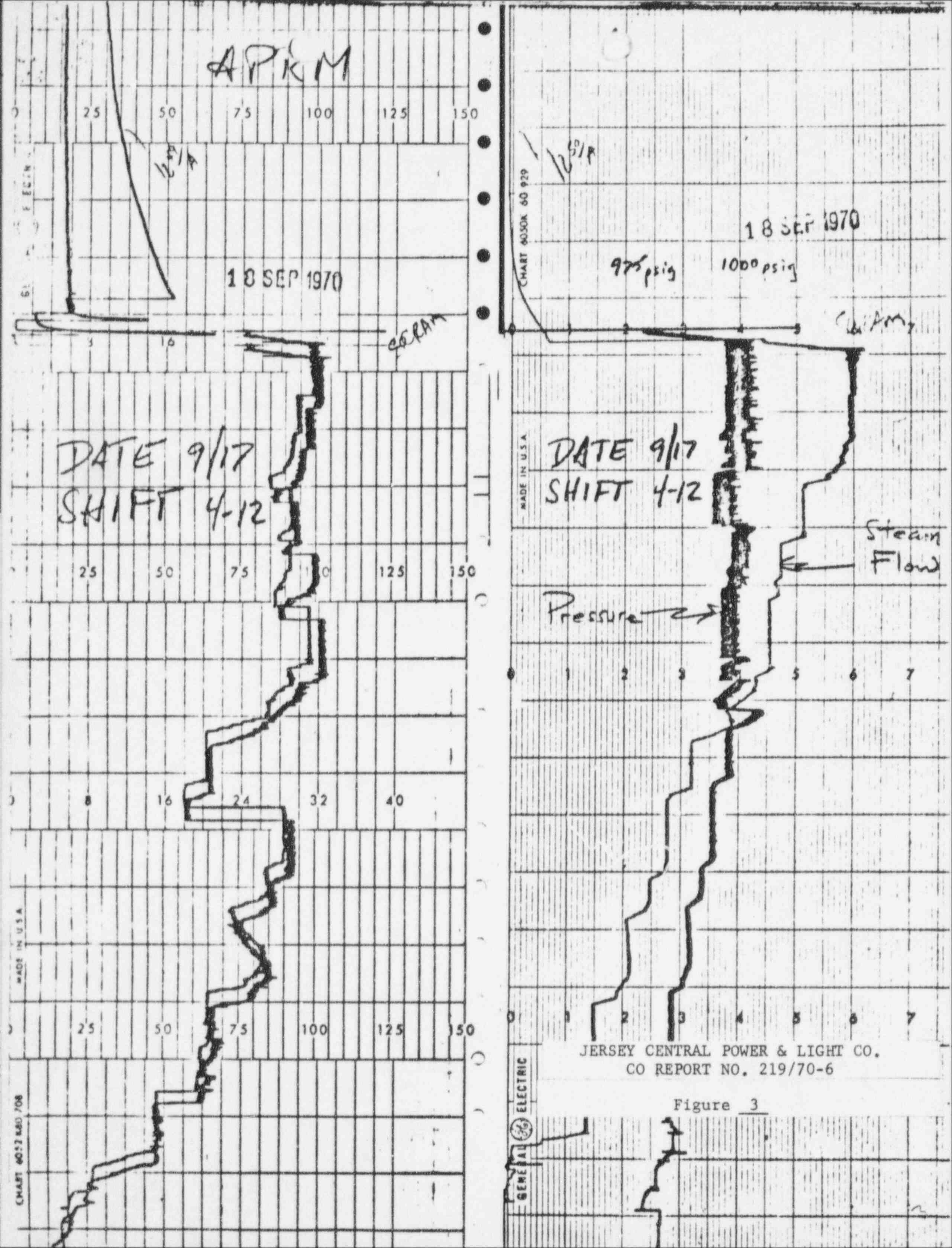

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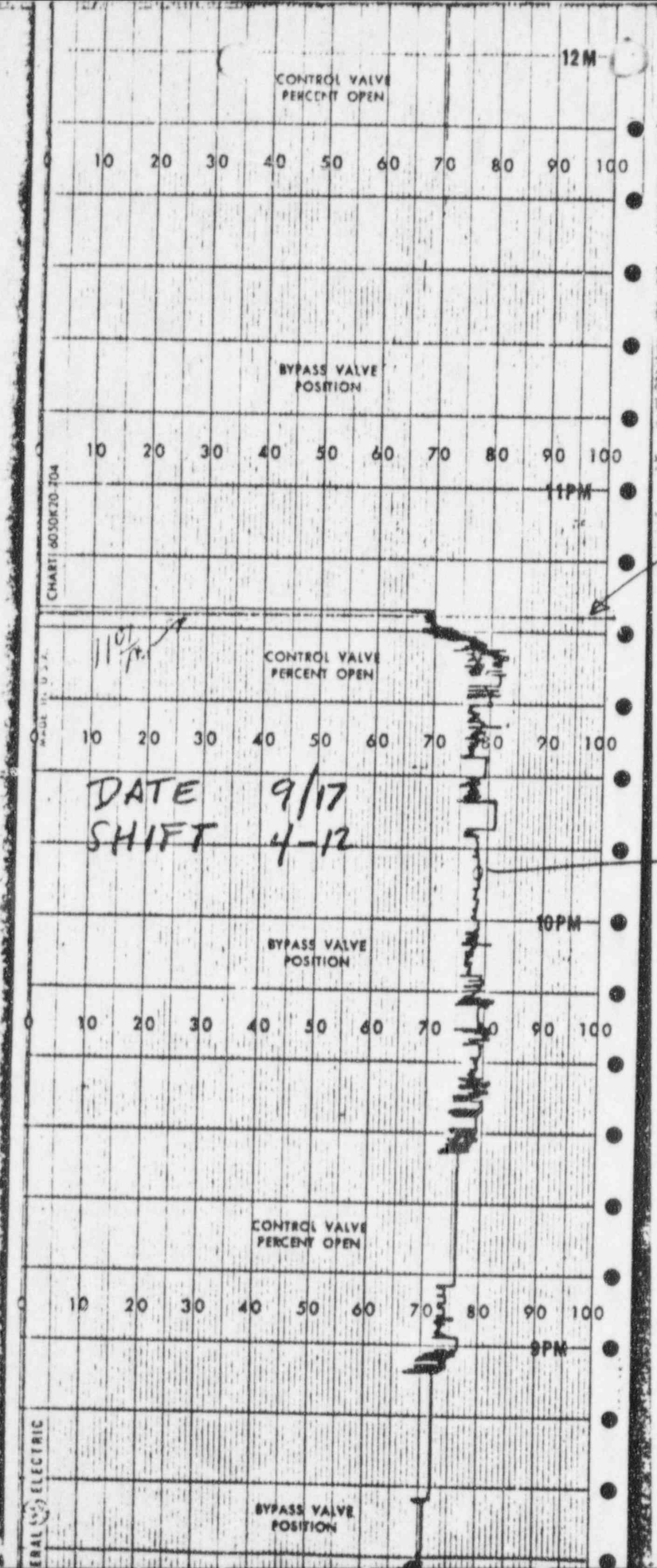
Figure 3



JERSEY CENTRAL POWER & LIGHT COMPANY
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Figure 4

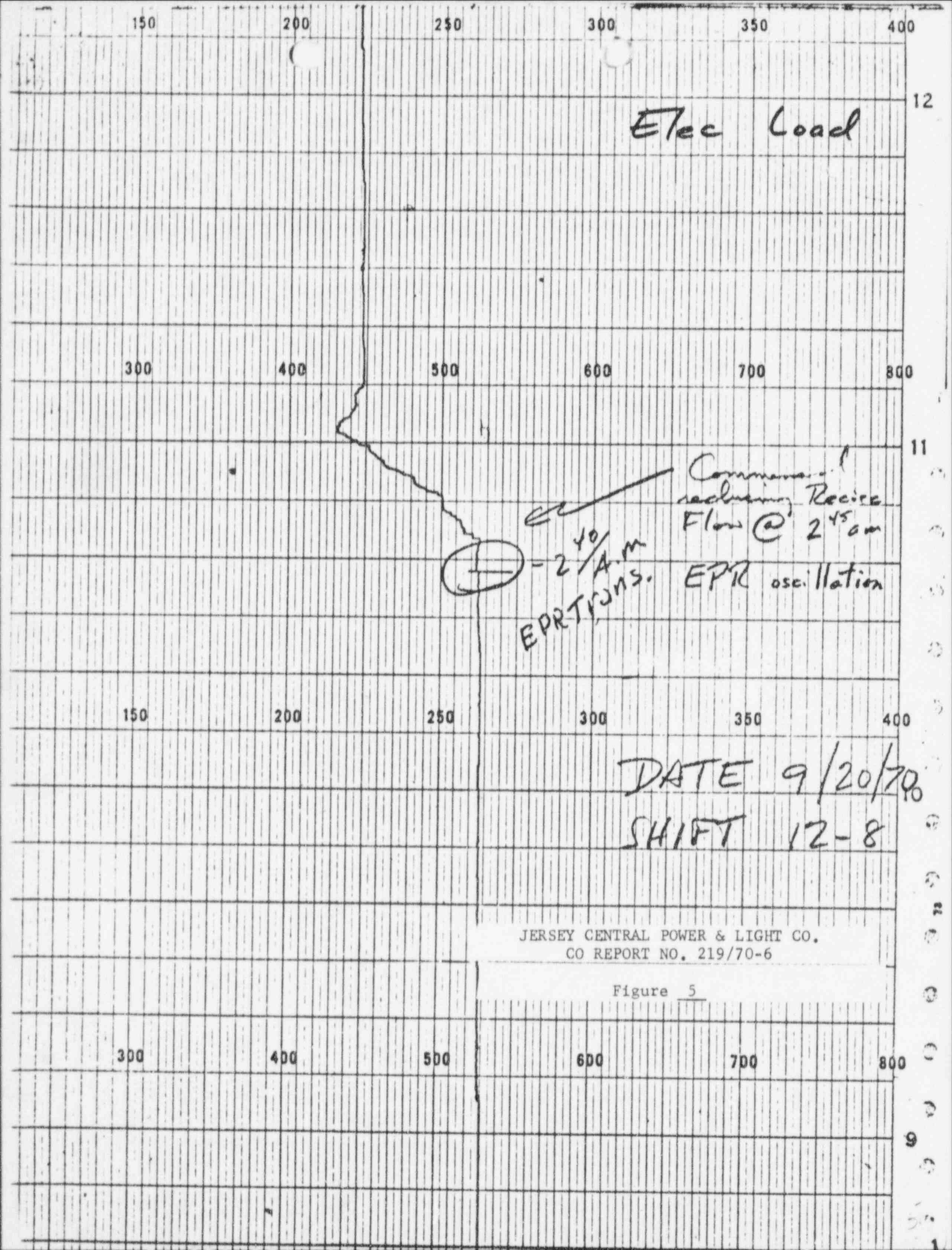

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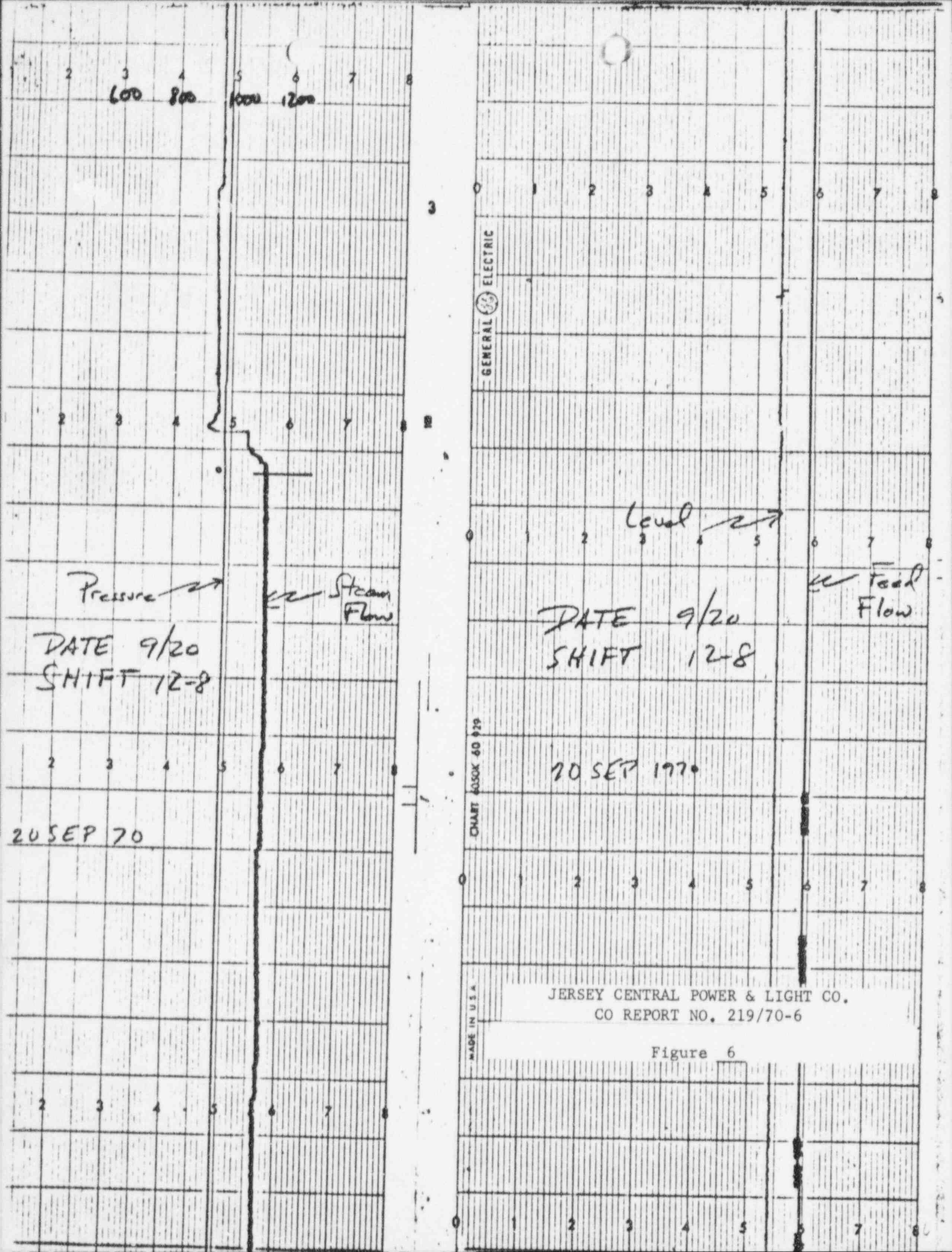
Figure 5



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CO REPORT NO. 219/70-6

Figure 6

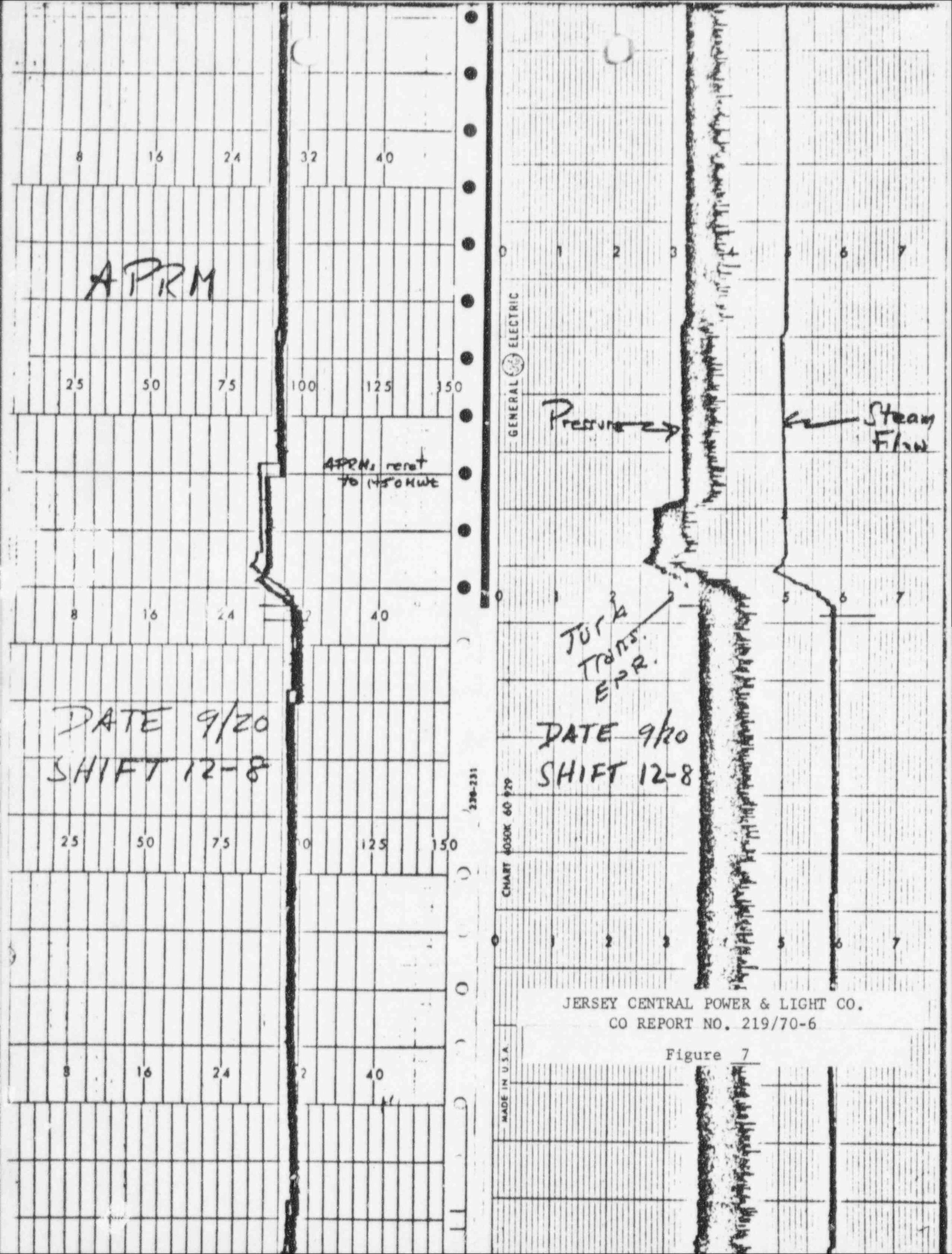

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Figure 7

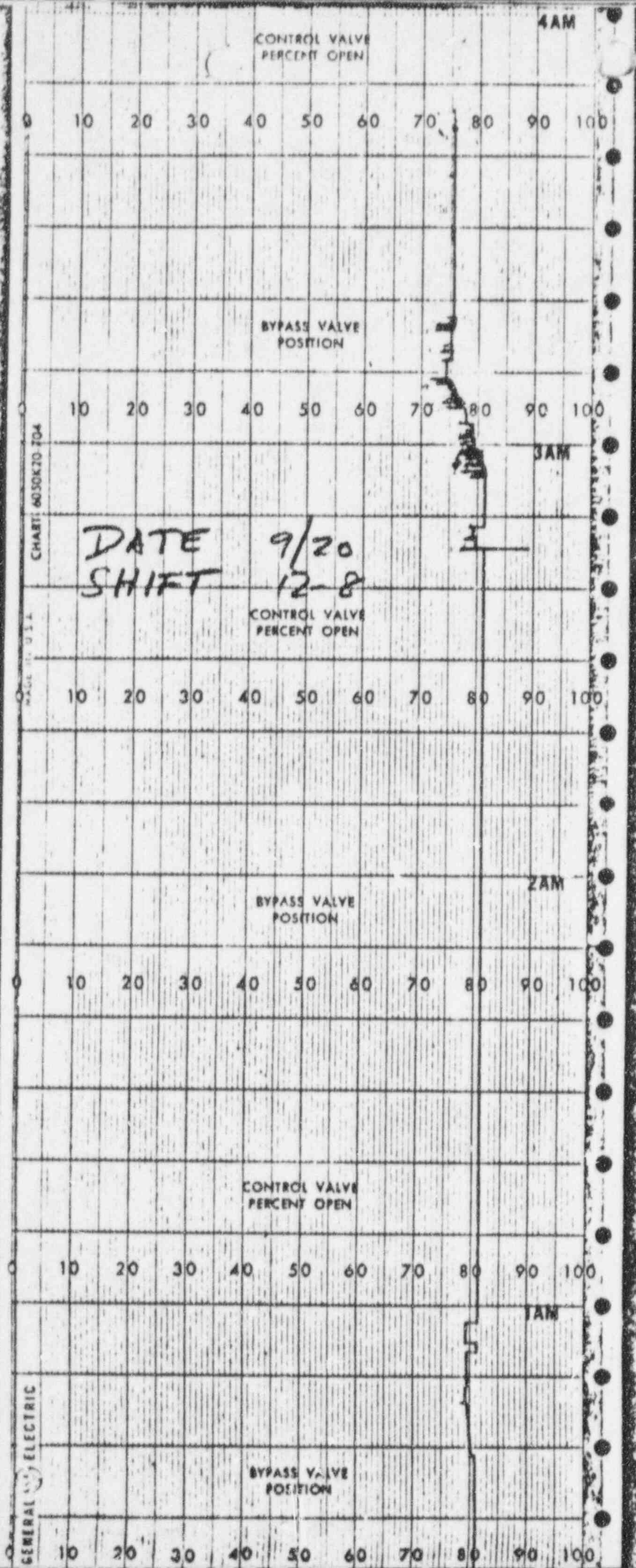

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Figure 8

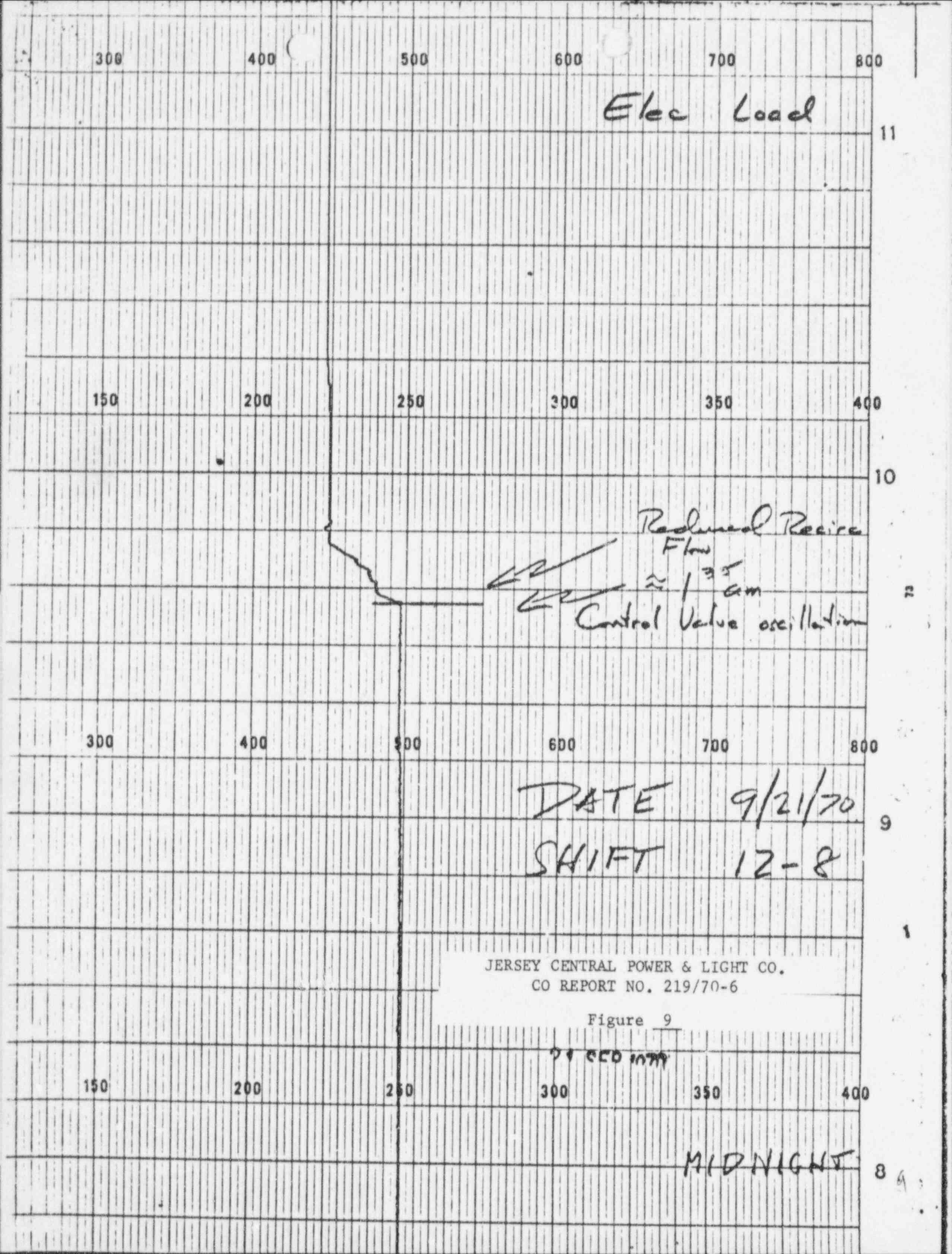

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Figure 9

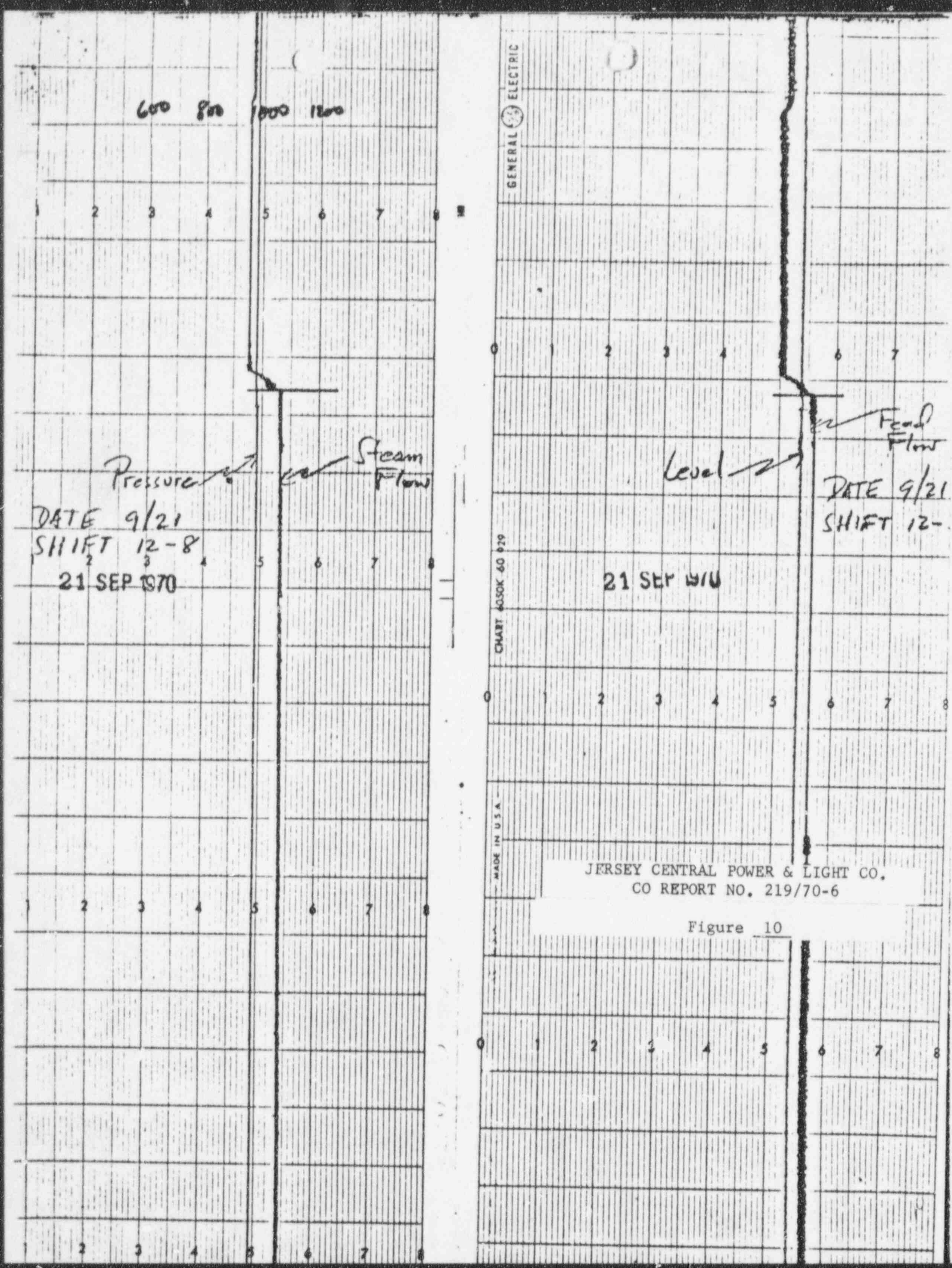

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Figure 10

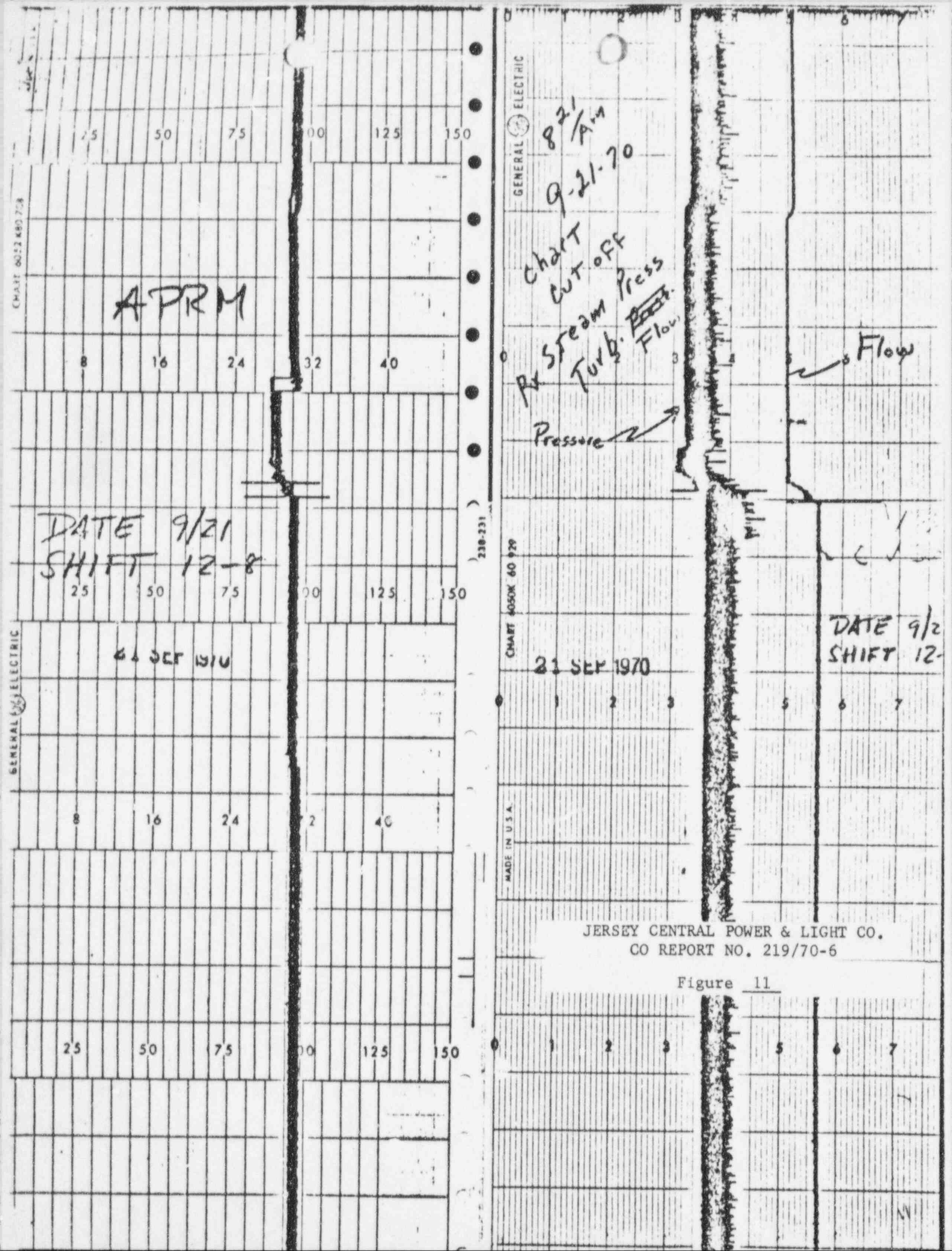

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Figure 11

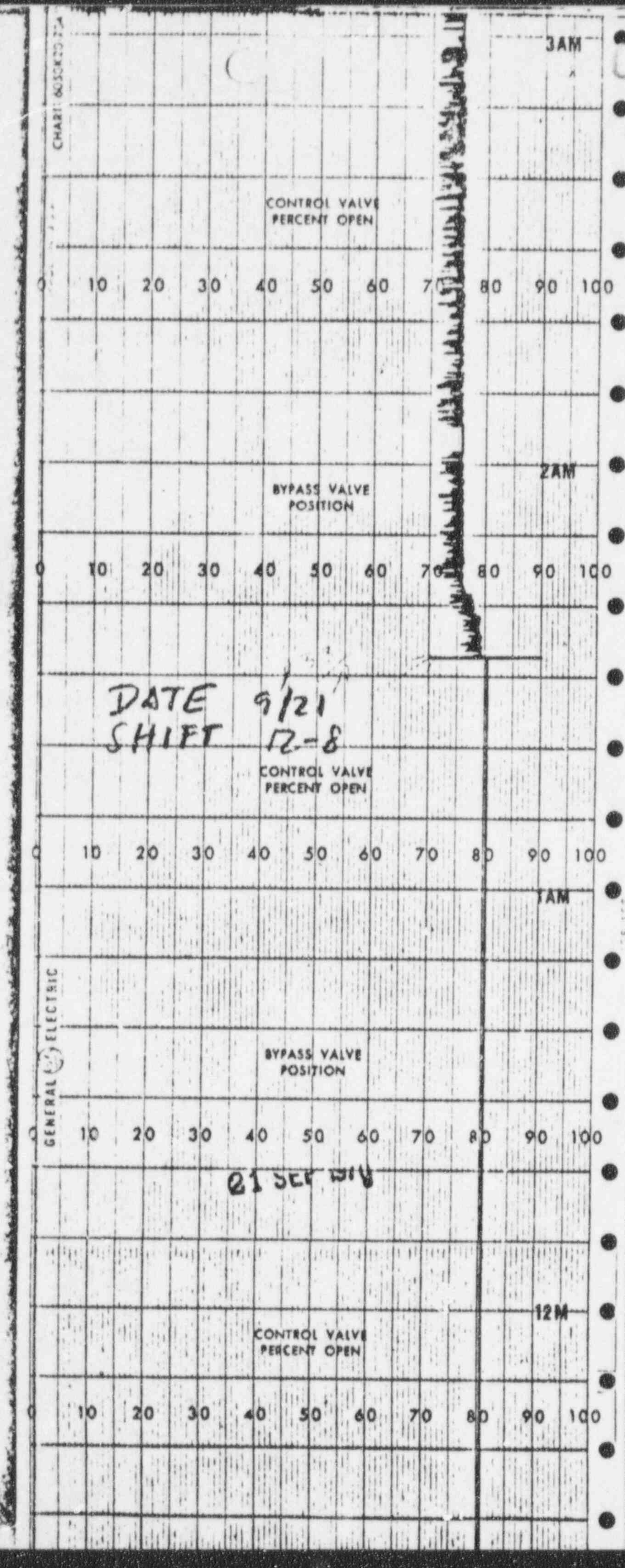

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Figure 12

12

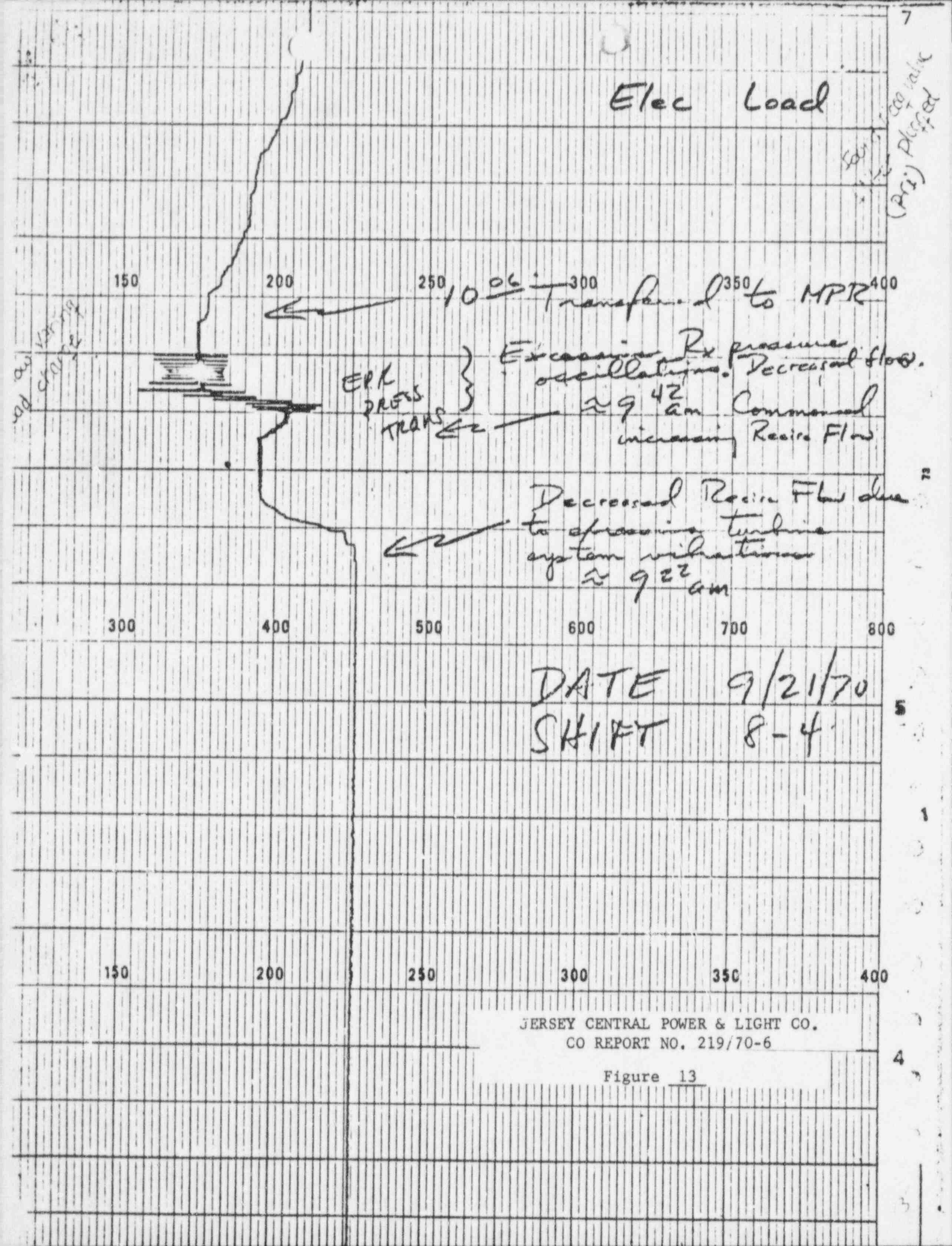

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Figure 13

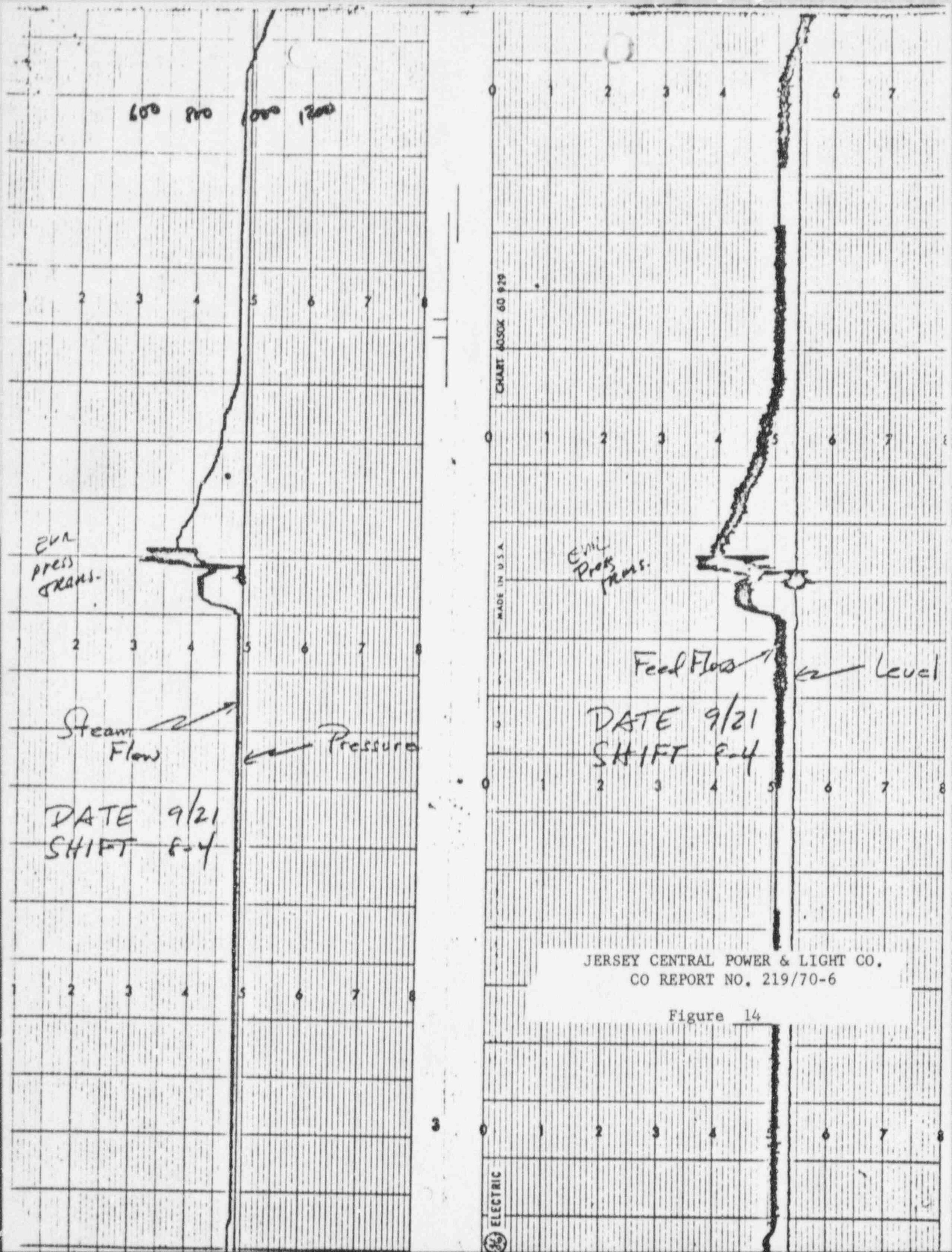

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Figure 14

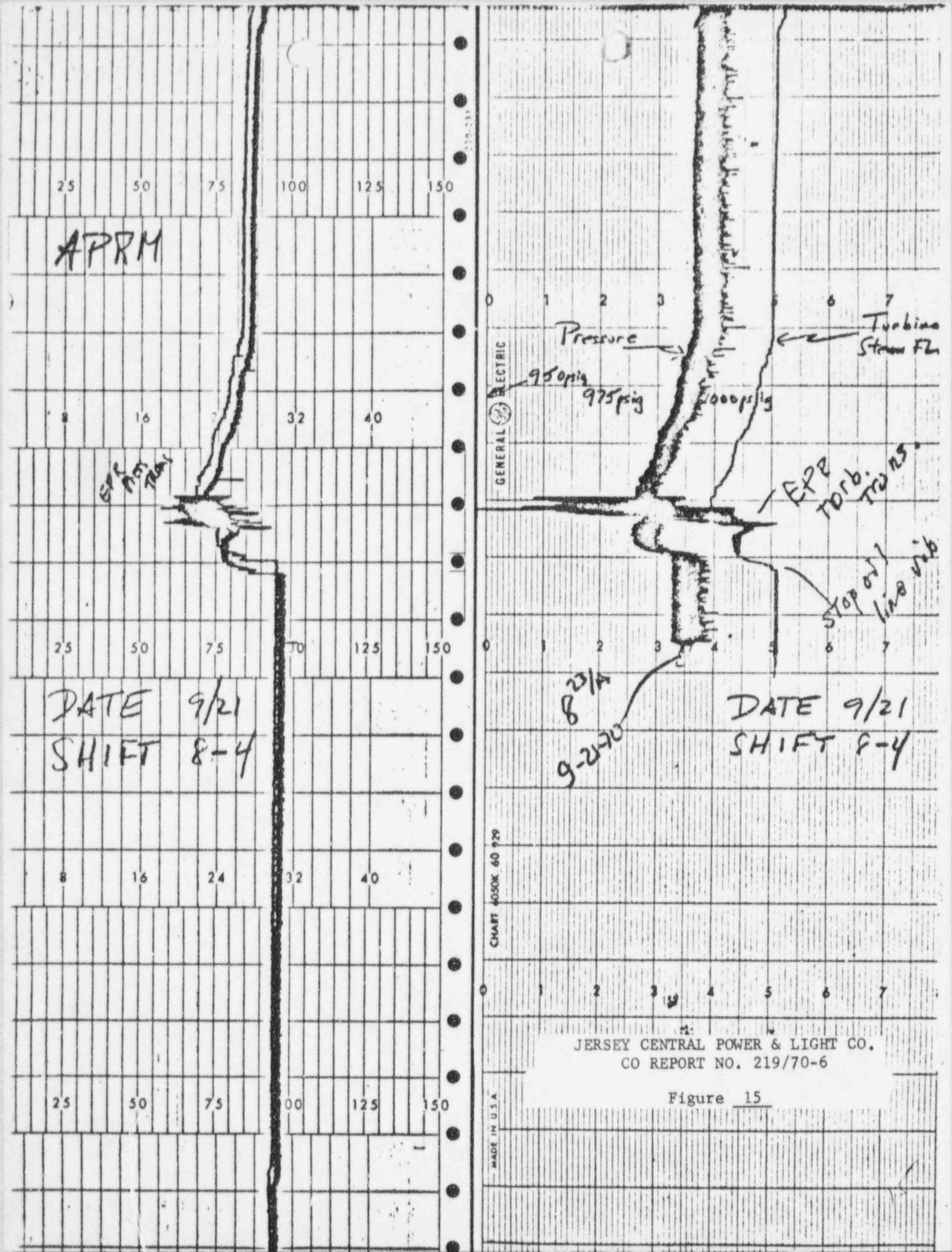

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Figure 15

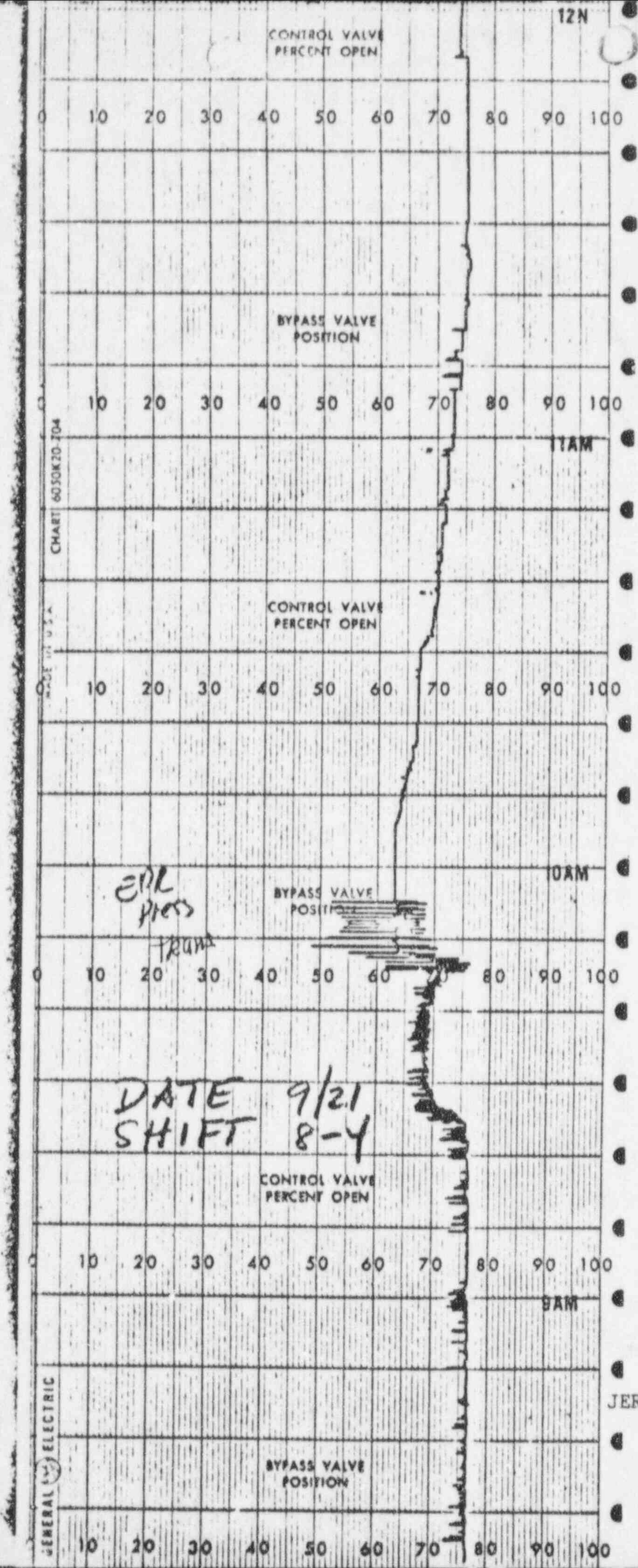

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Figure 16

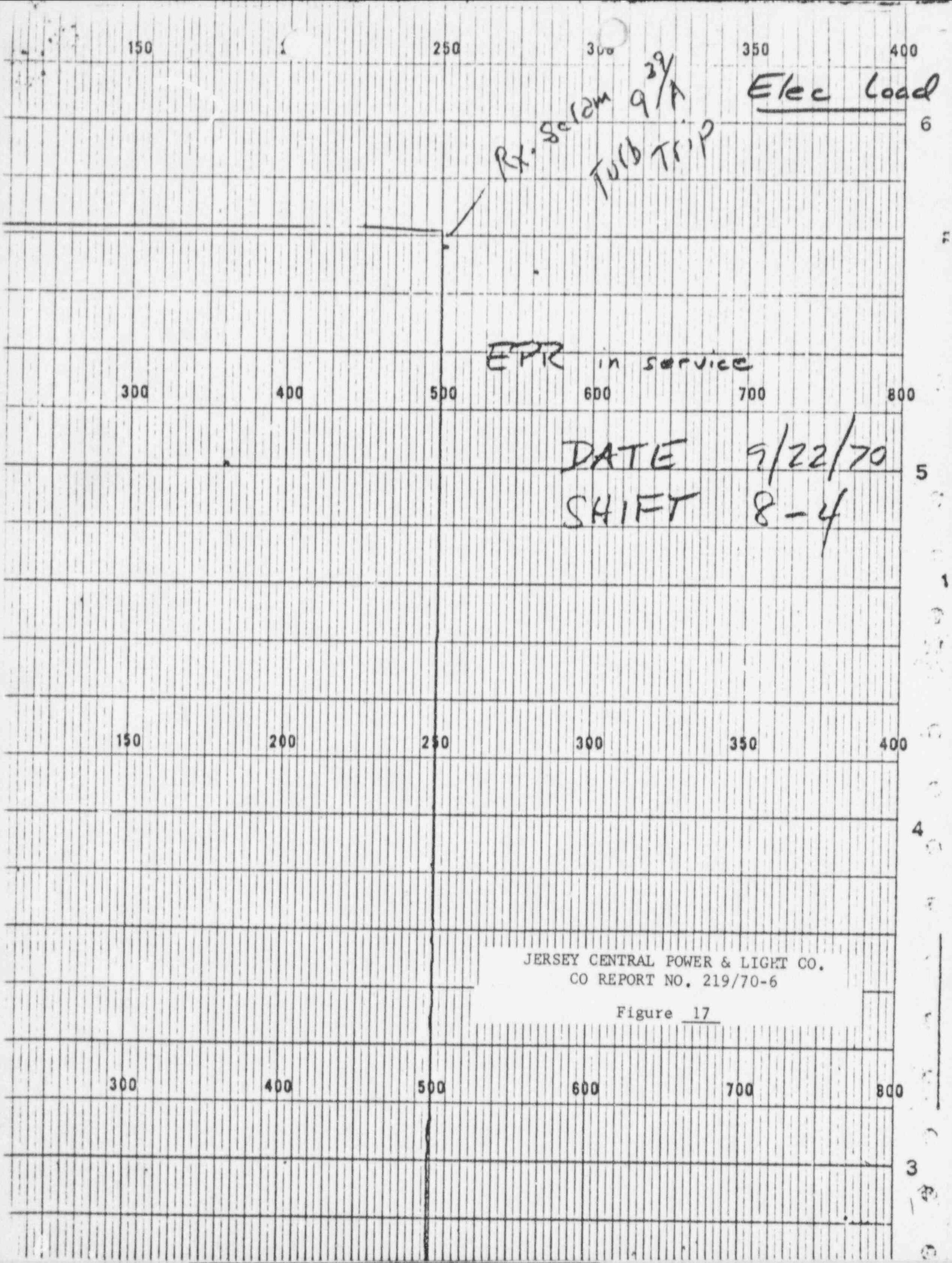

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Figure 17

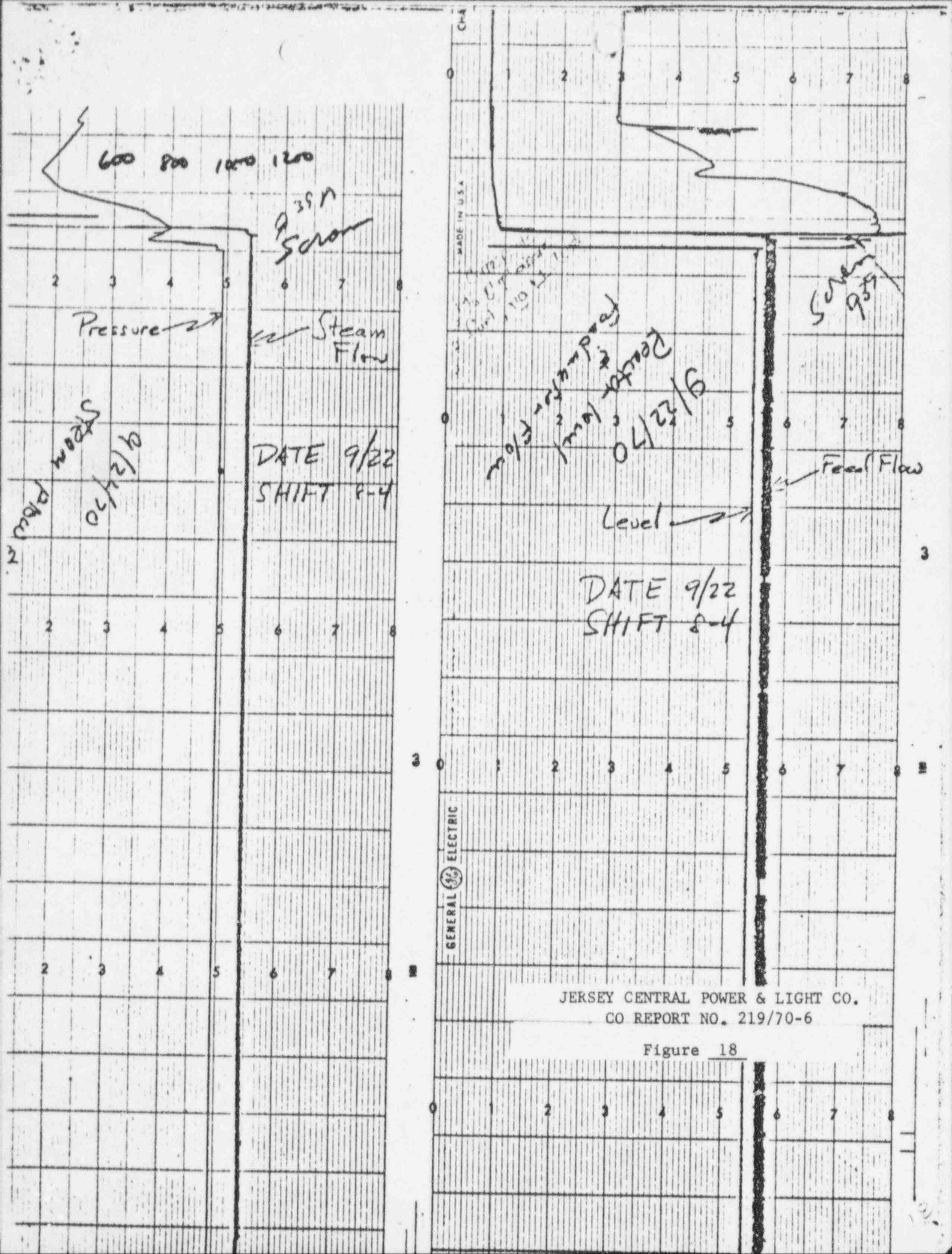

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Figure 18

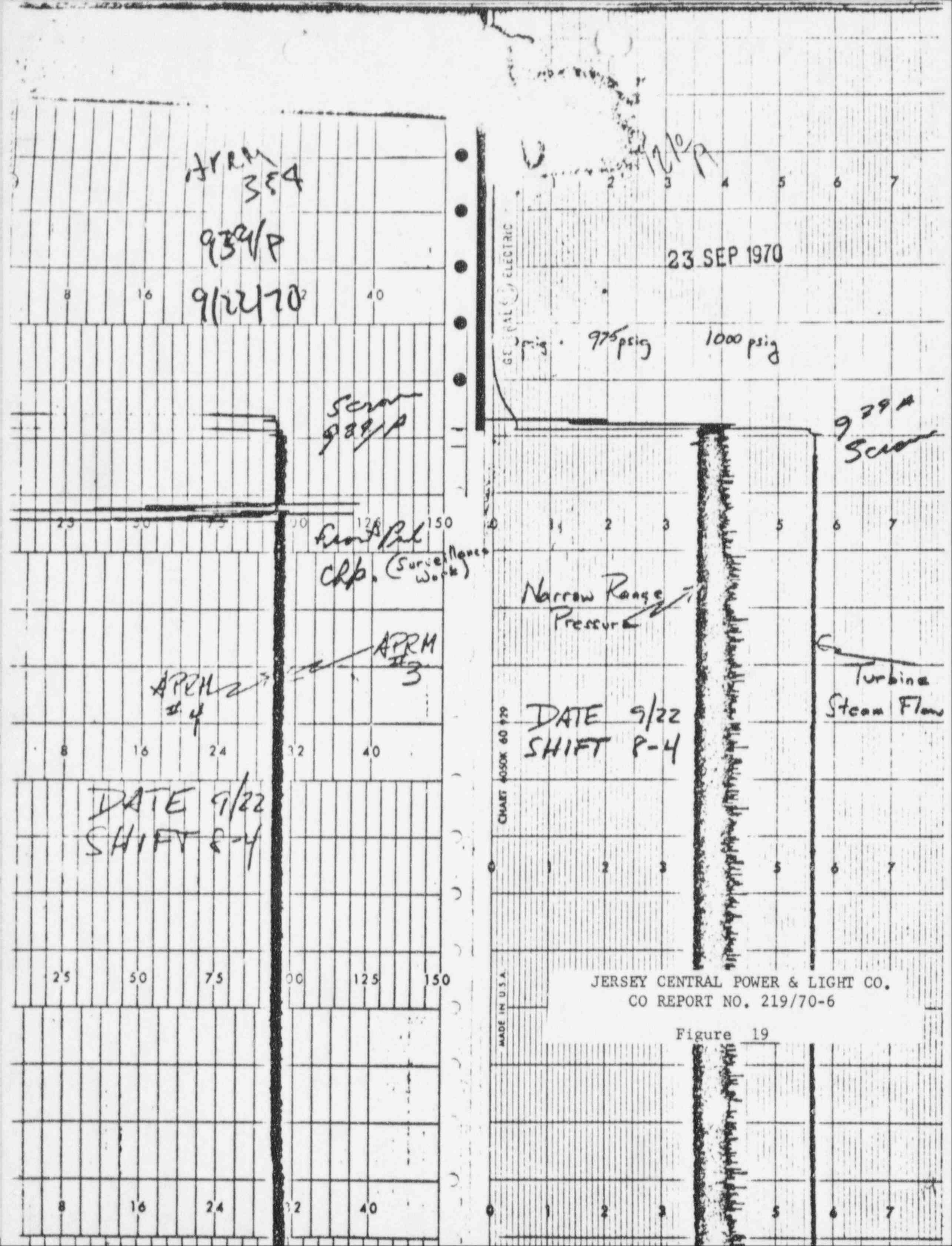

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Figure 19

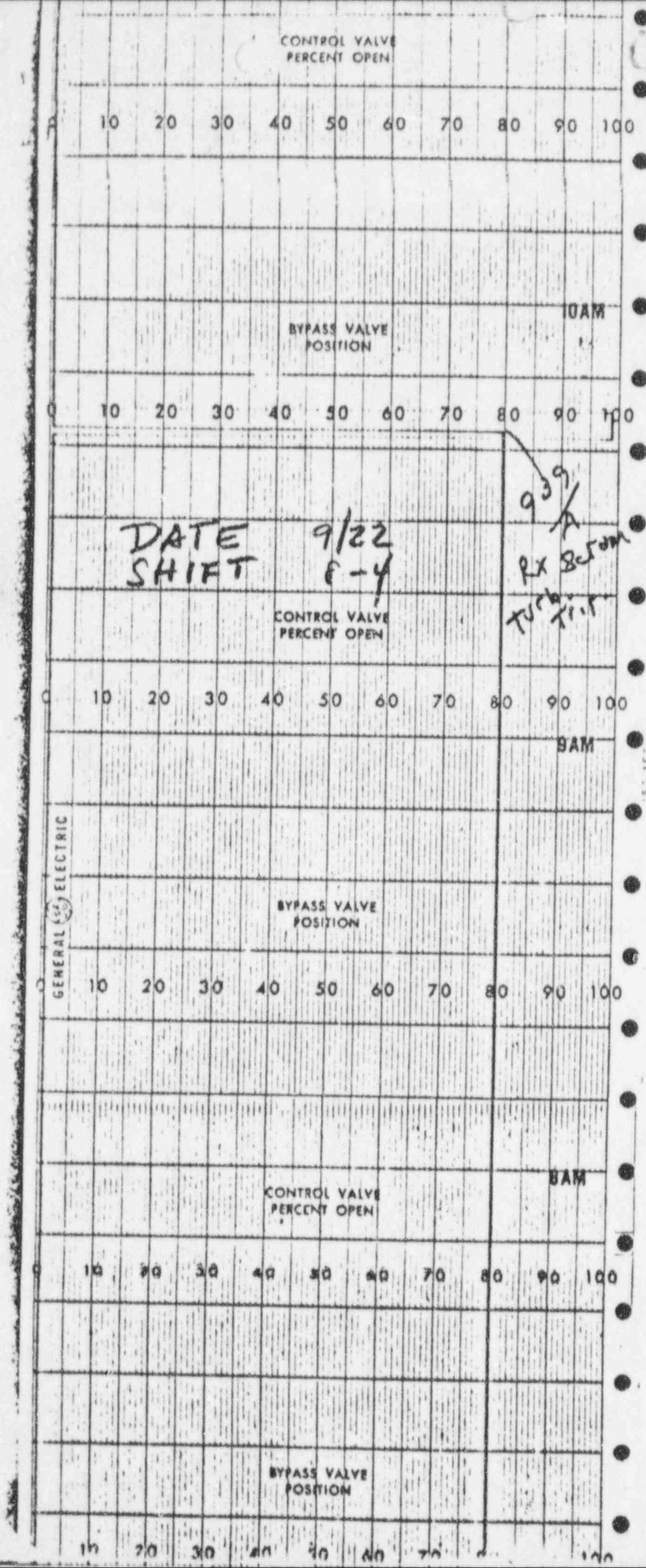

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Figure 20

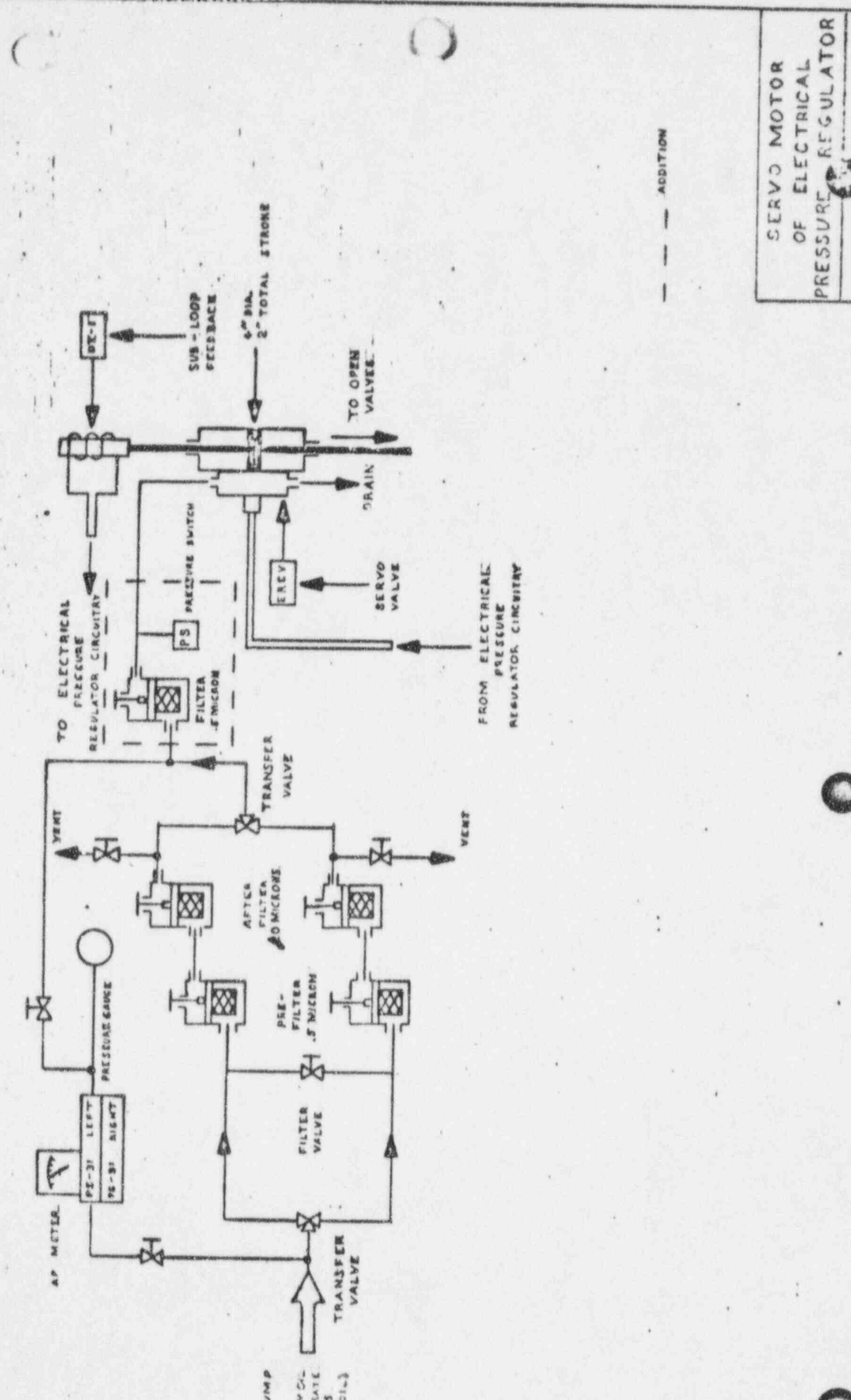

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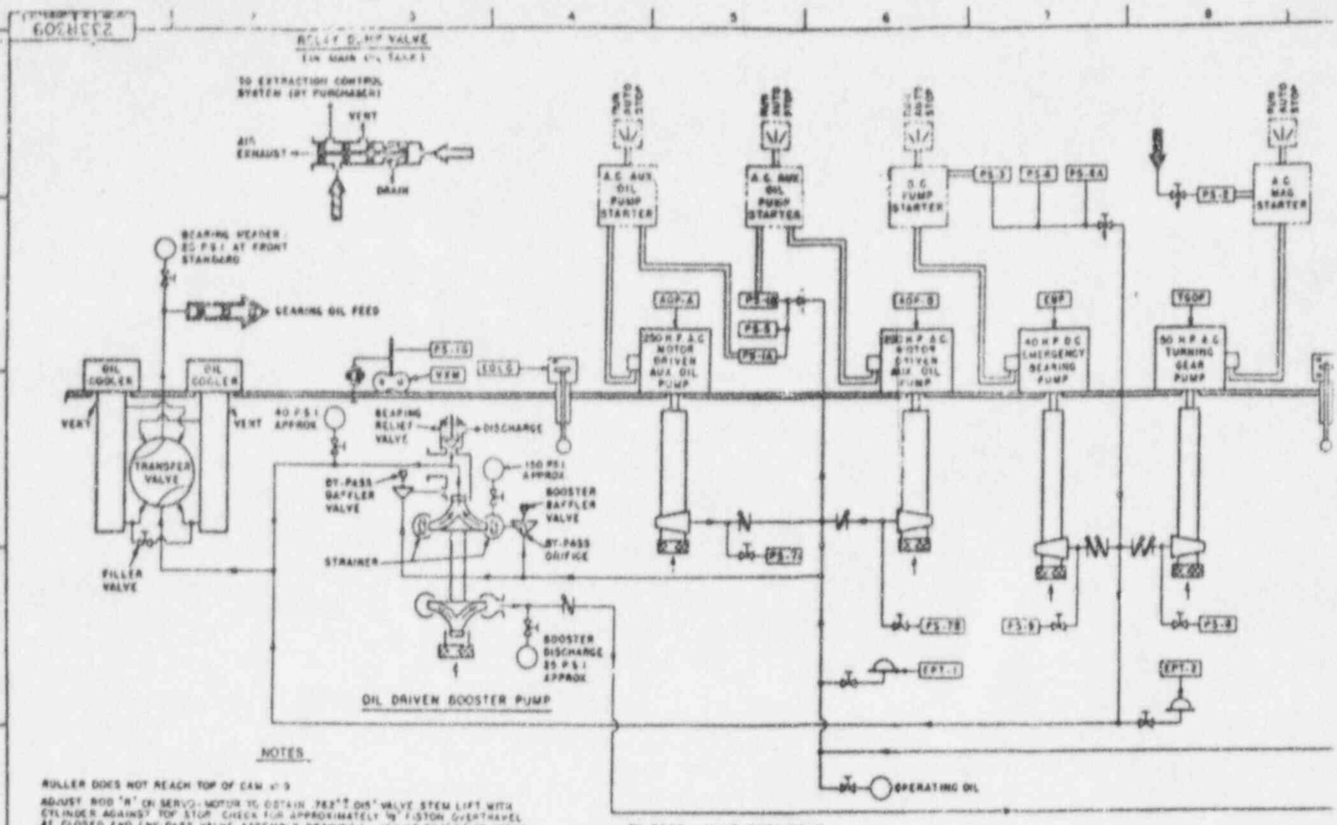
Figure 21



NOTES

ROLLER DOES NOT REACH TOP OF CAM #9

ADJUST ROD 'R' ON SERVO-MOTOR TO OBTAIN .762" ± .015" VALVE STEM LIFT WITH CYLINDER AGAINST TOP STOP. CHECK FOR APPROXIMATELY 1/8" PISTON OVERTRAVEL AT CLOSED END (BY-PASS VALVE ASSEMBLY DRAWING). ADJUST ROD 'T' TO OBTAIN 1/16" ROLLER TO CAM CLEARANCE WITH BY-PASS RELAY AND TEST CYLINDER IN CLOSED POSITION. ADJUST ROD 'S' SO VALVE STEM JUST STARTS TO LIFT WHEN ROLLER TO CAM CLEARANCE IS 1/32".

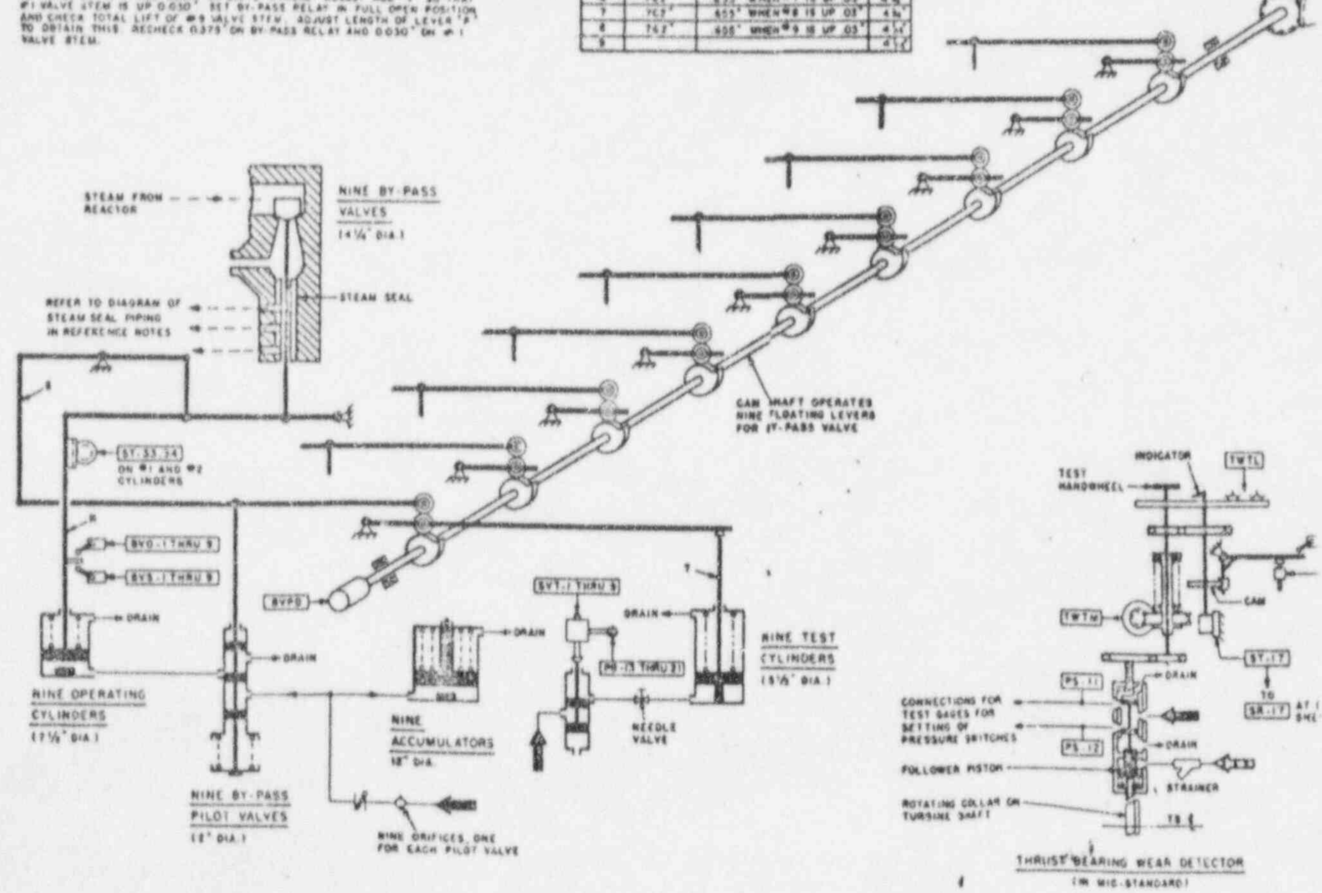
CHECK INTERCEPT POINTS ON VALVES #2 THRU #9 AS FOLLOWS: #2 VALVE STEM SHOULD BE UP 0.030" WHEN #1 VALVE STEM IS UP 0.655" AND SO ON FOR ALL VALVES AS SHOWN ON LIFT CHART. CORRECT LENGTH OF LINK 'S' IF NECESSARY.

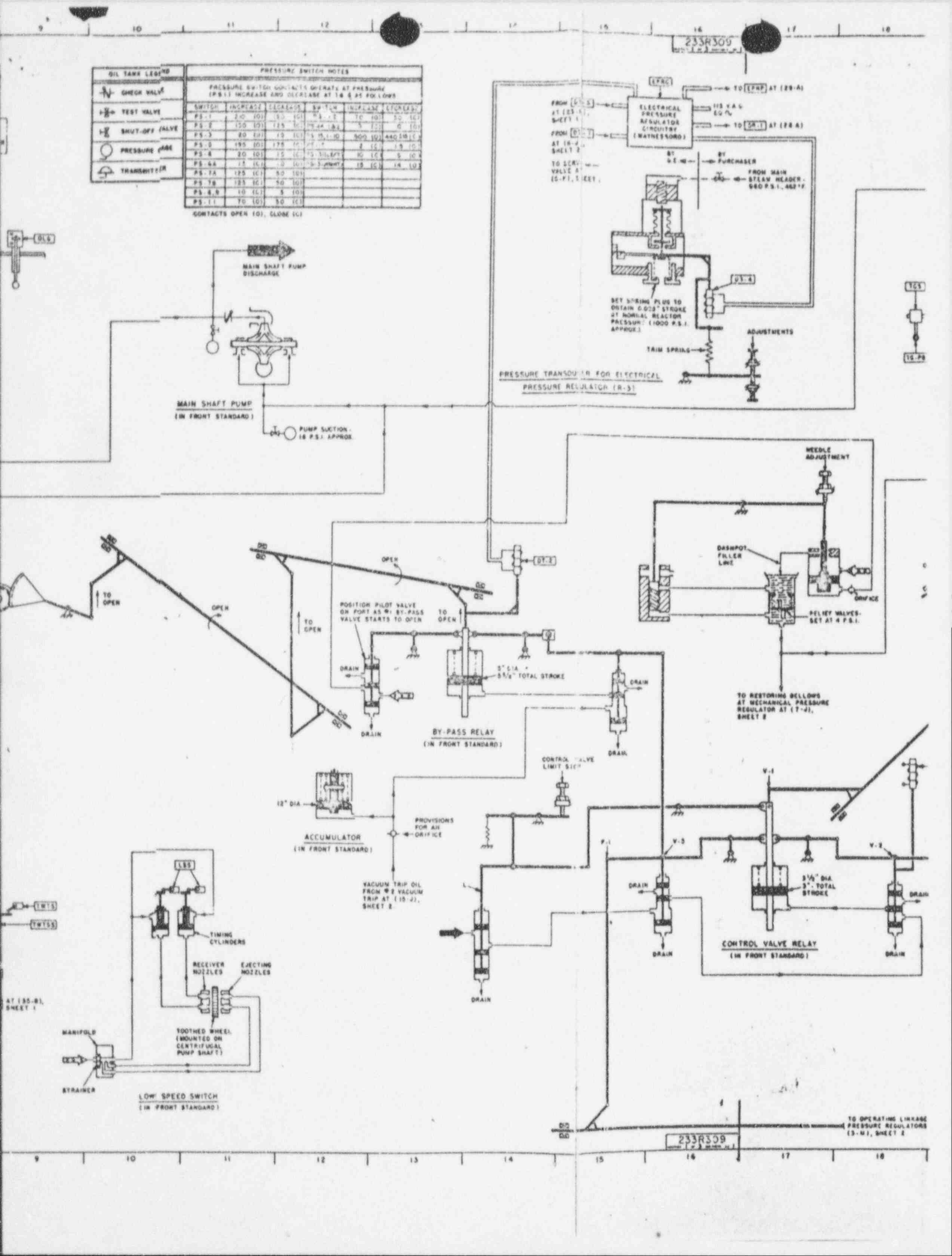
IN FACTORY, SET A CAM SHAFT ROTATION INDICATOR AT 12° WHEN #1 VALVE STEM IS UP 0.030". ROTATE CAM SHAFT TO 280° AND CHECK TOTAL LIFT ON #9 VALVE STEM.

IN FIELD, SET BY-PASS RELAY AT 0.375" STROKE. ADJUST ROD 'Y' SO THAT #1 VALVE STEM IS UP 0.030". SET BY-PASS RELAY IN FULL OPEN POSITION AND CHECK TOTAL LIFT OF #9 VALVE STEM. ADJUST LENGTH OF LEVER 'P' TO OBTAIN THIS. RECHECK 0.375" ON BY-PASS RELAY AND 0.030" ON #1 VALVE STEM.

BY-PASS VALVE DATA TABLE

VALVE NO	TOTAL STEM LIFT	VALVE STEM LIFT (TURBINE HOT)	VALVE DIA
1	.762"	.655" WHEN #2 IS UP .03"	4 1/4"
2	.762"	.655" WHEN #3 IS UP .03"	4 1/4"
3	.762"	.655" WHEN #4 IS UP .03"	4 1/4"
4	.762"	.655" WHEN #5 IS UP .03"	4 1/4"
5	.762"	.655" WHEN #6 IS UP .03"	4 1/4"
6	.762"	.655" WHEN #7 IS UP .03"	4 1/4"
7	.762"	.655" WHEN #8 IS UP .03"	4 1/4"
8	.762"	.655" WHEN #9 IS UP .03"	4 1/4"
9			4 1/4"



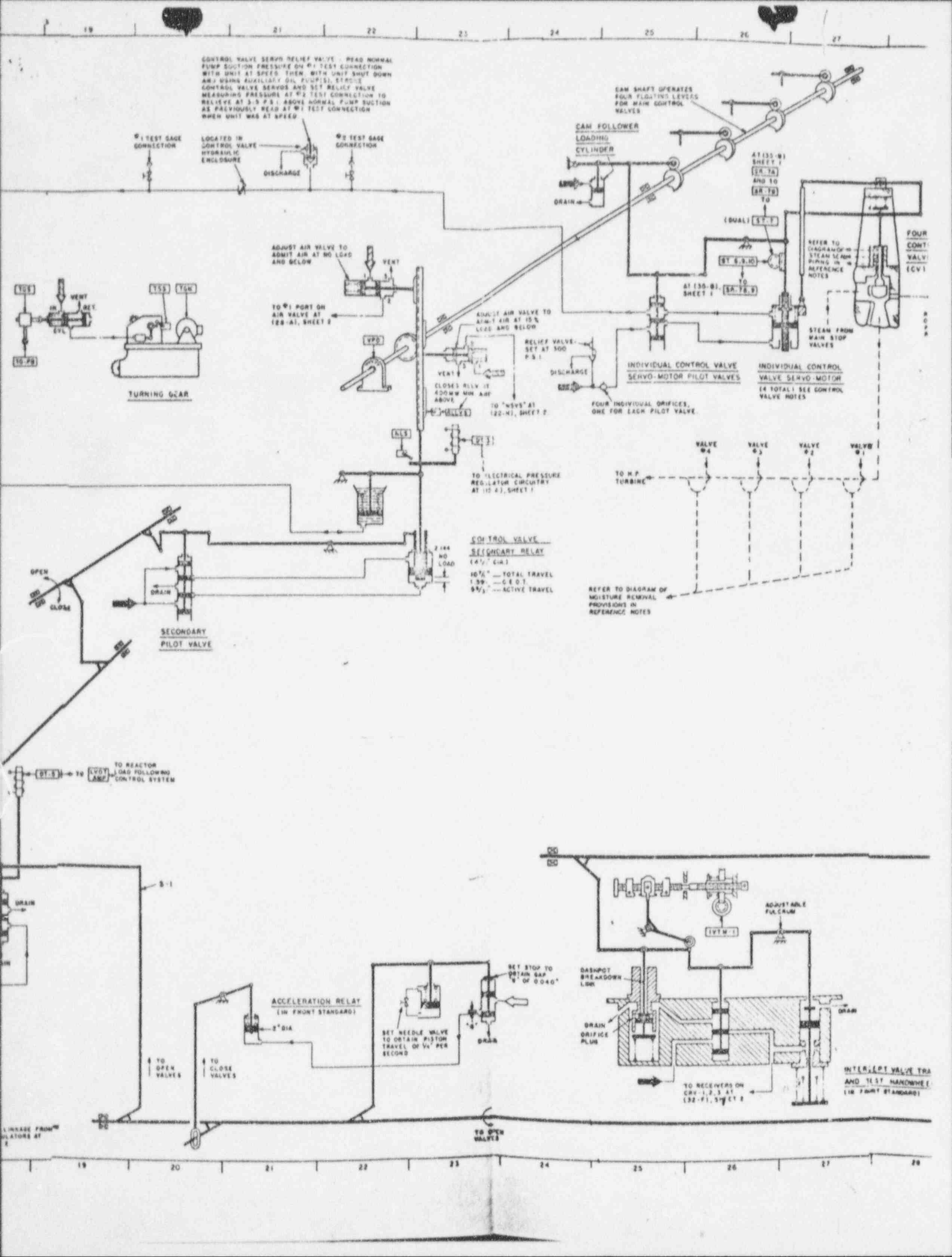


PRESSURE SWITCH NOTES

PRESSURE SWITCH CONTACTS OPERATE AT PRESSURE (P.S.I.) INCREASE AND DECREASE AT 1 & 25 FOLLOWS

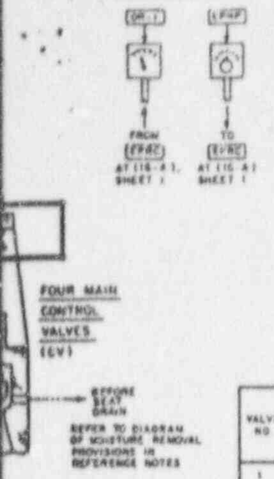
SWITCH	INCREASE	DECREASE	SWITCH	INCREASE	DECREASE
PS-1	210 (O)	150 (C)	PS-12	70 (O)	50 (C)
PS-2	150 (O)	125 (C)	PS-4A (B)	5 (C)	0 (O)
PS-3	20 (O)	10 (C)	PS 15,1-10	500 (O)	440 [illegible]
PS-5	195 (O)	175 (C)	PT-1	2 (C)	1.5 (O)
PS-6	20 (O)	15 (C)	PS-31,LEFT	10 (C)	5 (O)
PS-6A	15 (C)	10 (O)	PS-3,RIGHT	15 (C)	14 (O)
PS-7A	125 (C)	50 (O)			
PS-7B	125 (C)	50 (O)			
PS-8,9	10 (C)	5 (O)			
PS-11	70 (O)	50 (C)			

CONTACTS OPEN (O), CLOSE (C)



CONTROL VALVE SERVO RELIEF VALVE - READ NORMAL PUMP SUCTION PRESSURE ON #1 TEST CONNECTION WITH UNIT AT SPEED. THEN, WITH UNIT SHUT DOWN AND USING AUXILIARY OIL PUMP(S), STROKE CONTROL VALVE SERVOS AND SET RELIEF VALVE MEASURING PRESSURE AT #2 TEST CONNECTION TO RELIEVE AT 3-5 P.S.I. ABOVE NORMAL PUMP SUCTION AS PREVIOUSLY READ AT #1 TEST CONNECTION WHEN UNIT WAS AT SPEED
#1 TEST GAGE CONNECTION
LOCATED IN CONTROL VALVE HYDRAULIC ENCLOSURE
DISCHARGE
#2 TEST GAGE CONNECTION
CAM SHAFT OPERATES FOUR FLOATING LEVERS FOR MAIN CONTROL VALVES
CAM FOLLOWER LOADING CYLINDER
DRAIN
(DUAL)
REFER TO DIAGRAM OF STEAM SEAL PIPING IN REFERENCE NOTES
ADJUST AIR VALVE TO ADMIT AIR AT NO LOAD AND BELOW
VENT
TO #1 PORT ON AIR VALVE AT (28-A), SHEET 2
TURNING GEAR
VENT
RET.
ADJUST AIR VALVE TO ADMIT AIR AT 15% LOAD AND BELOW
RELIEF VALVE SET AT 300 P.S.I.
DISCHARGE
INDIVIDUAL CONTROL VALVE SERVO-MOTOR PILOT VALVES
INDIVIDUAL CONTROL VALVE SERVO-MOTOR
(4 TOTAL) SEE CONTROL VALVE NOTES
STEAM FROM MAIN STOP VALVES
FOUR INDIVIDUAL ORIFICES, ONE FOR EACH PILOT VALVE
TO ELECTRICAL PRESSURE REGULATOR CIRCUITRY
VALVE #4
VALVE #3
VALVE #2
VALVE #1
TO H.P. TURBINE
CONTROL VALVE SECONDARY RELAY
NO LOAD
OPEN
CLOSE
DRAIN
SECONDARY PILOT VALVE
REFER TO DIAGRAM OF MOISTURE REMOVAL PROVISIONS IN REFERENCE NOTES
TO REACTOR LOAD FOLLOWING CONTROL SYSTEM
DRAIN
ADJUSTABLE FULCRUM
DASHPOT BREAKDOWN LINK
DRAIN
ORIFICE PLUG
ACCELERATION RELAY
(IN FRONT STANDARD)
SET STOP TO OBTAIN GAP
SET NEEDLE VALVE TO OBTAIN PISTON TRAVEL OF 1/4" PER SECOND
TO OPEN VALVES
TO CLOSE VALVES
TO RECEIVERS ON CRV-1,2,3 AT (32-F), SHEET 2
INTERCEPT VALVE TRIP AND TEST HANDWHEEL
(IN FRONT STANDARD)
TO OPEN VALVES
19
20
21
22
23
24
25
26
27
28

JERSEY CENTRAL POWER & LIGHT
(OYSTER CREEK #1)
TS # 170K290

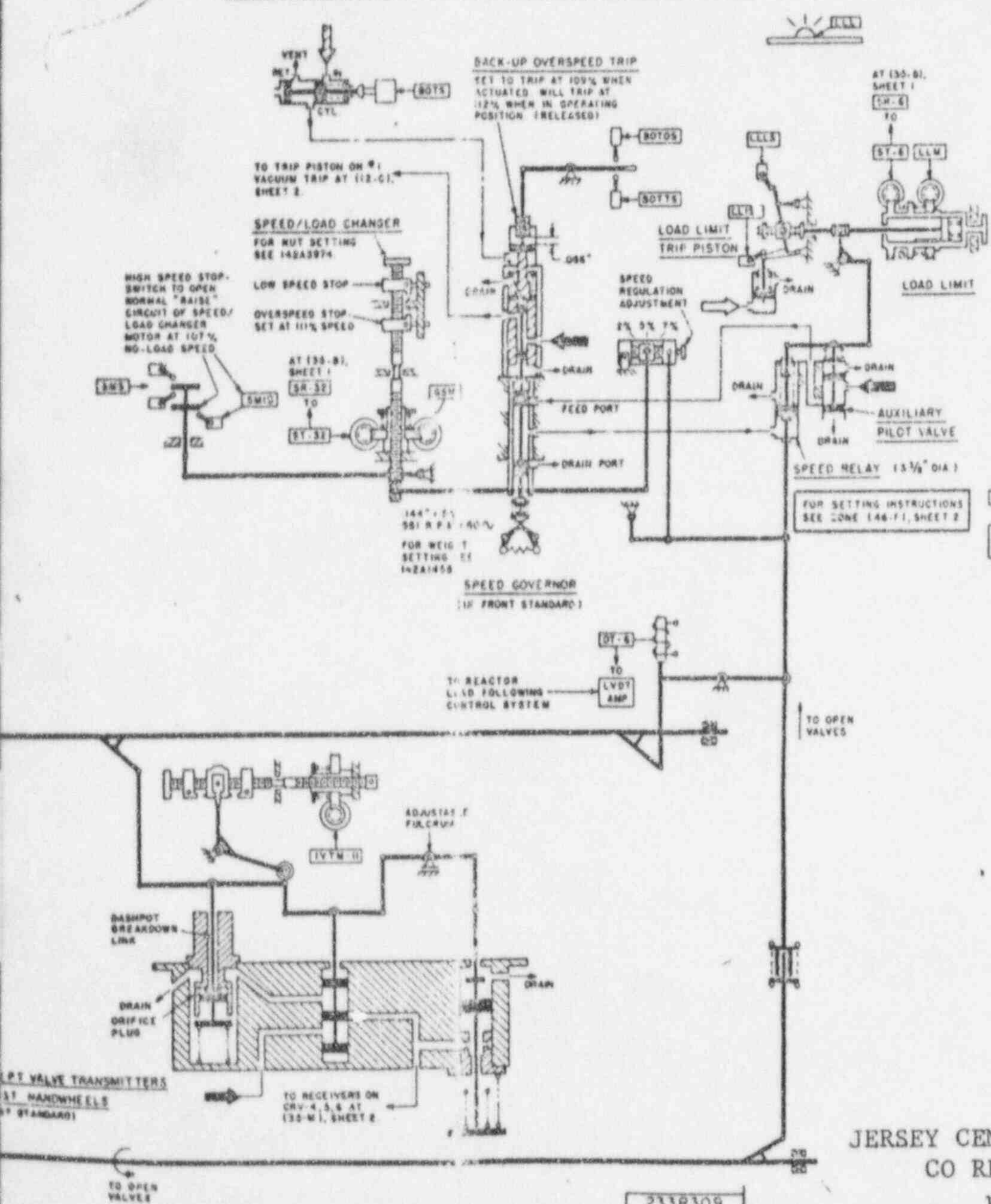


NOTES

1. ADJUST TENSION RODS BETWEEN UPPER LEVERS AND SERVO-MOTORS TO MAKE UPPER LEVERS HORIZONTAL FOR VALVES #2 AND #3. TENSION IN TWO RODS ON EACH VALVE SHOULD BE EQUAL. ADJUST TENSION ROD BETWEEN LOWER LEVER AND SERVO-MOTOR TO DIMENSION SHOWN ON CONTROL VALVE ASSEMBLY FOR VALVES #1 AND #4.
2. ADJUST SERVO-MOTOR PISTON ROD TO GIVE CLOSED END OVERTRAVEL LISTED IN DATA TABLE. THIS ADJUSTMENT SHOULD BE MADE WITH OIL PRESSURE ON SERVO-MOTOR TO LIFT VALVE STEM .001" OR .002" TO REMOVE ALL PIN CLEARANCES AND LEVER DEFLECTIONS IN THE OPENING DIRECTION. NOTE THAT THE CLOSED END OVERTRAVELS WILL BE SMALLER WITH OIL PRESSURE REMOVED FROM SERVO-MOTOR.
3. SET LINKAGE BETWEEN SECONDARY RELAY AND CONTROL VALVE SERVO-MOTORS SO THAT LEVERS ARE HORIZONTAL AT MID-POINT OF DESIGN STROKE AND ADJUST SLIGHTLY TO OBTAIN STARTING POINT ACCORDING TO LIFT "A". THEN CHECK INTERCEPT POINTS WITH REGARD TO LIFT "B". IF READINGS ARE WITHIN .050" SETTINGS ARE SATISFACTORY.
4. THE VALVE STEM LIFTS AT THE INTERCEPT POINTS AND THE TOTAL LIFTS MUST BE CHECKED AFTER THE TURBINE IS COMPLETELY ASSEMBLED.

CONTROL VALVE DATA TABLE

VALVE NO	HYDRAULIC CYLINDER: CYLINDER DIA	OPEN END OVERTRAVEL (HOT & COLD)	CLOSED END OVERTRAVEL (HOT & COLD)	DESIGN STROKE	STOP STROKE	EFFECTIVE STROKE	CONTROL VALVE LEVER RATIOS	TOTAL STEM LIFT	SECONDARY SPEED RELAY LIFT "A" WHEN VALVE STEM IS UP .062	INTERCEPT POINTS STEM LIFT (HOT) "B"
1	15"	0"	1.12"	14"	14"	12.750"	5.00"	2.550"	1.595"	.234 WHEN # 2,3 AND 4 ARE UP .062
2	15"	0"	1.12"	14"	14"	12.750"	5.00"	2.550"	2.36"	
3	15"	0"	1.12"	14"	14"	12.750"	5.00"	2.550"	2.36"	
4	15"	0"	[illegible]	14"	14"	12.750"	5.00"	2.550"	2.36"	



SELSYN RECEIVERS

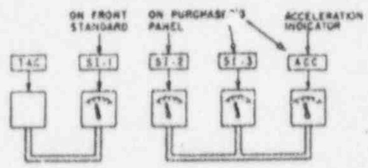
SINGLE — DUAL

ON PURCHASER'S PANEL

SELSYN RECEIVER	TYPE	FROM SELSYN TRANSMITTER	LOCATION
1	DUAL	1	(20-D), SH 2
		2	(22-E), SH 2
3	DUAL	3	(20-D), SH 2
		4	(20-D), SH 2
5	SINGLE	5	(25-B), SH 2
6	SINGLE	6	(33-E), SH 1
7-8	DUAL	7	(24-B), SH 1
		8	(26-C), SH 1
9	DUAL	9	(26-C), SH 1
		10	(28-C), SH 1
17	SINGLE	17	(8-L), SH 1
21	DUAL	11	(33-E), SH 2
		21	(34-D), SH 2
22	DUAL	12	(33-E), SH 2
		22	(34-D), SH 2
23	DUAL	13	(33-E), SH 2
		23	(34-D), SH 2
24	DUAL	14	(36-L), SH 2
		24	(37-L), SH 2
25	DUAL	15	(36-L), SH 2
		25	(37-L), SH 2
26	DUAL	16	(36-L), SH 2
		26	(37-L), SH 2
27	DUAL	77	(7-F), SH 2
		78	(1-E), SH 2
31	SINGLE	31	(9-K), SH 2
32	SINGLE	32	(30-F), SH 1
33	SINGLE	33	(1-J), SH 1
34	SINGLE	34	(1-J), SH 1

ON FRONT STANDARD

SELSYN RECEIVER	TYPE	FROM SELSYN TRANSMITTER	LOCATION
7A	SINGLE	70	(26-B), SH 1
11A	DUAL	11	(33-E), SH 2
		16	(36-L), SH 2
13A	DUAL	12	(33-E), SH 2
		15	(36-L), SH 2
15A	DUAL	13	(33-E), SH 2
		14	(34-L), SH 2



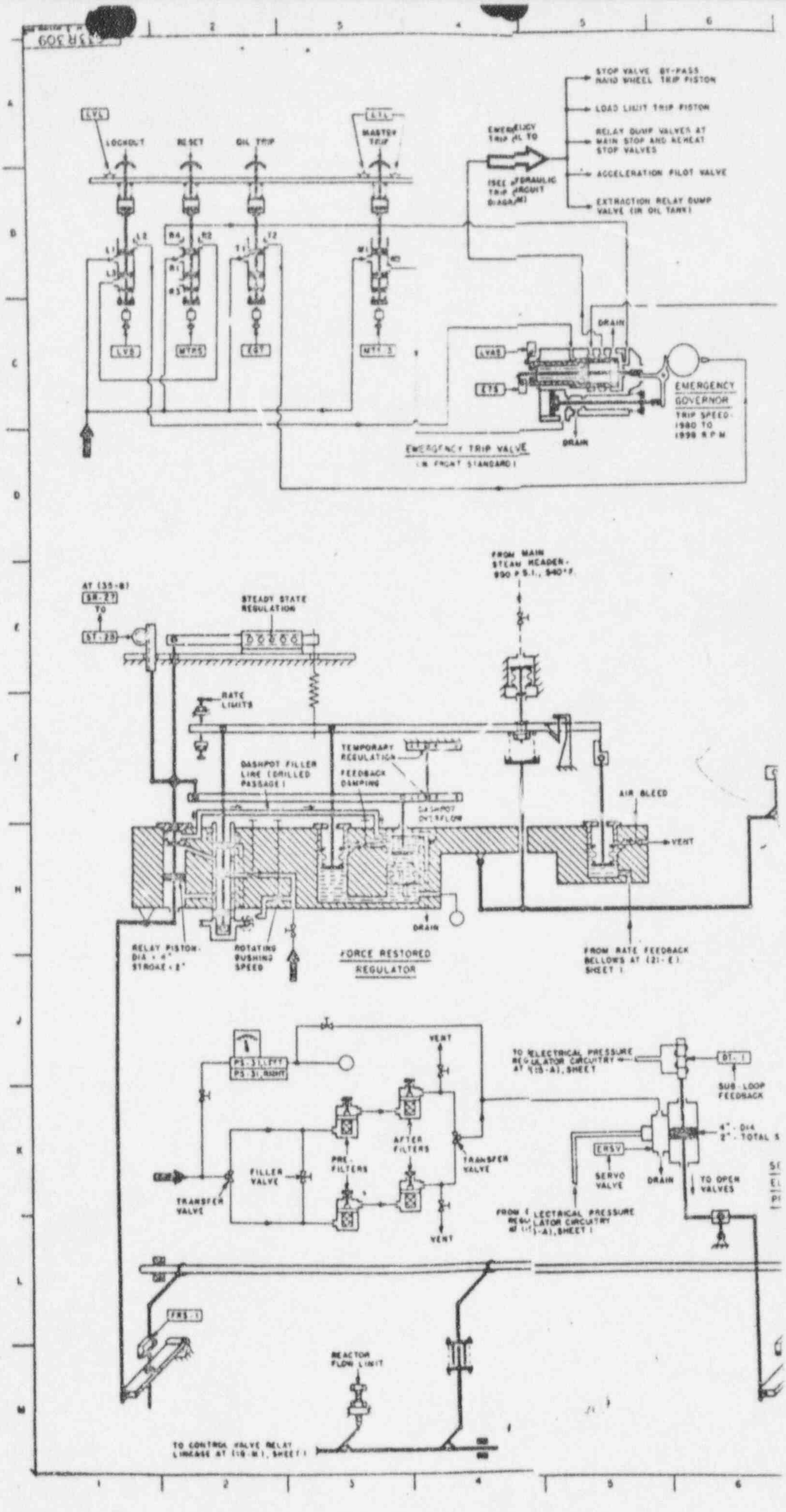
LEGEND

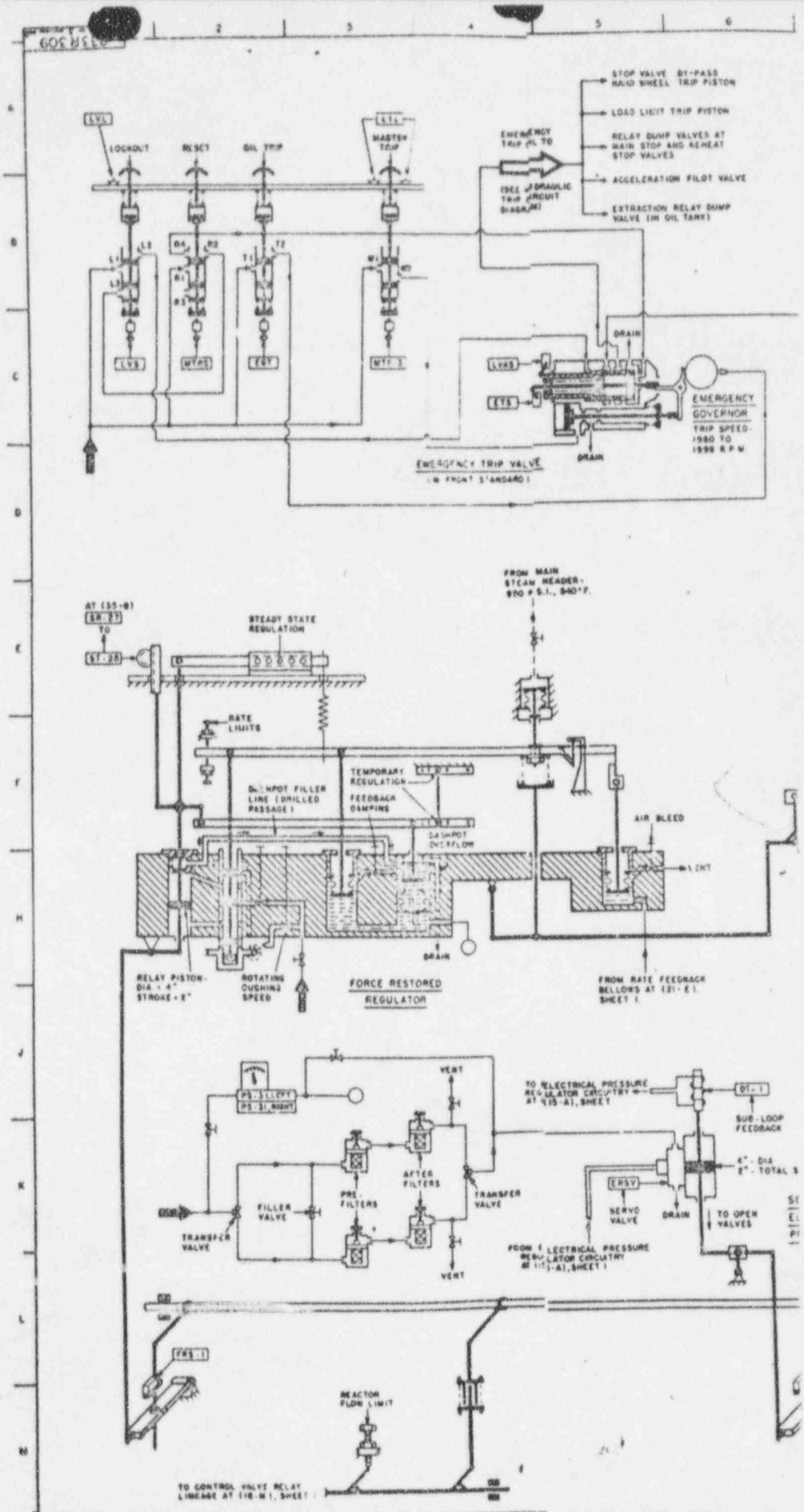
- OIL LINE
- ELECTRICAL CONNECTION
- AIR LINE
- WATER LINE
- STEAM LINE
- EMERGENCY TRIP OIL
- MAIN SHAFT PUMP DISCHARGE-225 P.S.I. MINIMUM OIL PRESSURE TO OPERATING MECHANISMS (OPERATING OIL)
- BEARING OIL - 25 P.S.I. AT TO ℄
- PURCHASER'S AIR SUPPLY-80-100 P.S.I.

233R309

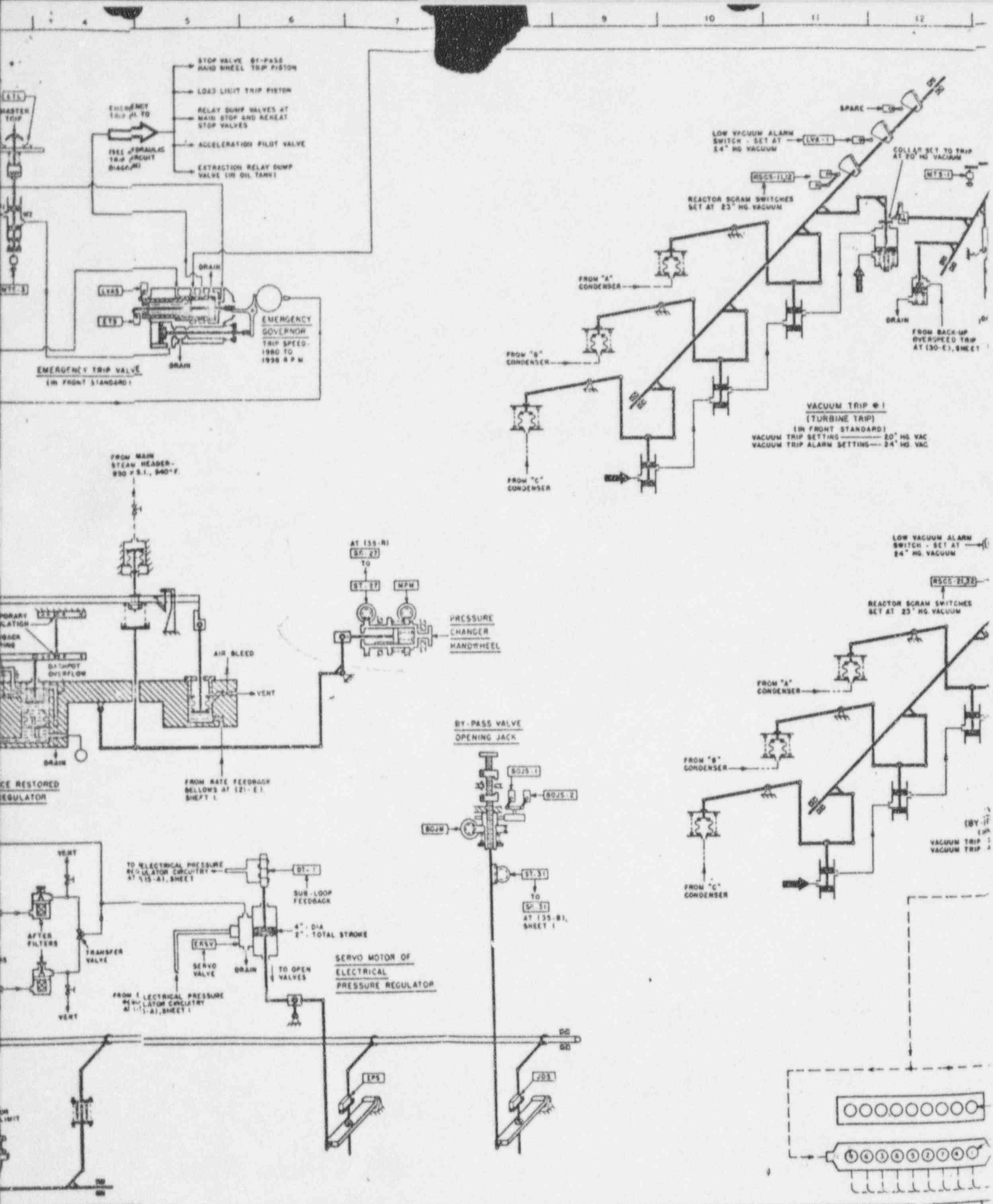
JERSEY CENTRAL POWER & LIGHT CO.
CO REPORT NO. 219/70-6
Figure 22

Diagram of control mechanism
Dwg. 233R309 sh 1 (rev 3)

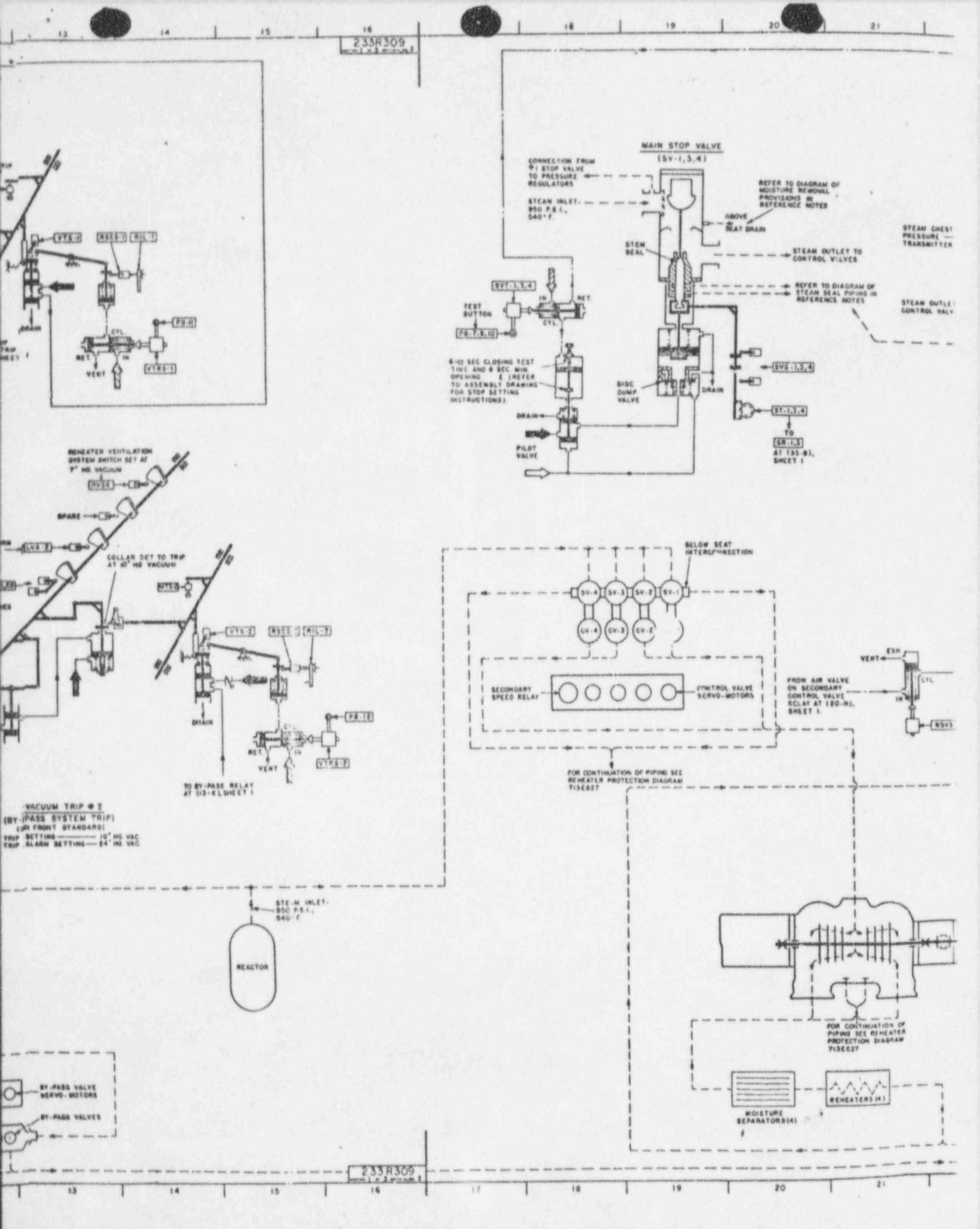

LOCKOUT
RESET
OIL TRIP
MASTER TRIP
LVS
MTPS
EOT
STOP VALVE BY-PASS
LOAD LIMIT TRIP PISTON
RELAY DUMP VALVES AT
MAIN STOP AND REHEAT
STOP VALVES
ACCELERATION PILOT VALVE
EXTRACTION RELAY DUMP
VALVE (IN OIL TANK)
DRAIN
LVAS
ETS
EMERGENCY
GOVERNOR
TRIP SPEED:
1980 TO
1998 R.P.M.
EMERGENCY TRIP VALVE
(IN FRONT STANDARD)
FROM MAIN
STEAM HEADER-
990 P.S.I., 540°F.
STEADY STATE
REGULATION
RATE
LIMITS
TEMPORARY
REGULATION
DASHPOT FILLER
LINE (DRILLED
PASSAGE)
FEEDBACK
DAMPING
DASHPOT
OVERFLOW
AIR BLEED
VENT
DRAIN
RELAY PISTON:
DIA = 4"
STROKE = 2"
ROTATING
BUSHING
SPEED
FORCE RESTORED
REGULATOR
FROM RATE FEEDBACK
BELLOWS AT (21-E)
SHEET 1
VENT
TO ELECTRICAL PRESSURE
REGULATOR CIRCUITRY
SUB-LOOP
FEEDBACK
AFTER
FILTERS
PRE-
FILTERS
FILLER
VALVE
TRANSFER
VALVE
TRANSFER
VALVE
ERSV
SERVO
VALVE
DRAIN
TO OPEN
VALVES
VENT
FRS-1
REACTOR
FLOW LIMIT
TO CONTROL VALVE RELAY
LINKAGE AT (10-M), SHEET 1

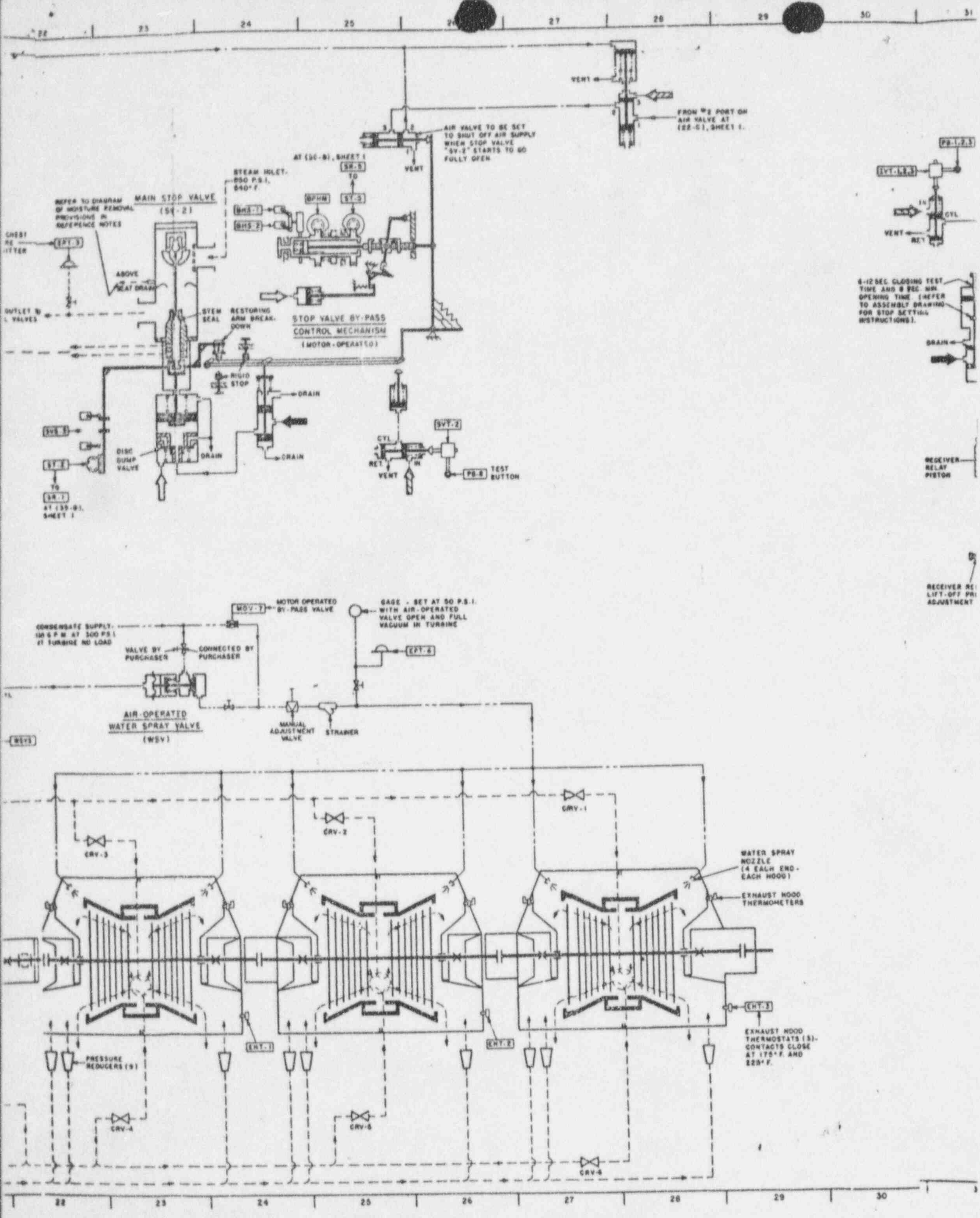


LOCKOUT
RESET
OIL TRIP
MASTER TRIP
EMERGENCY TRIP OIL TO
STOP VALVE BY-PASS HAND WHEEL TRIP PISTON
LOAD LIMIT TRIP PISTON
RELAY DUMP VALVES AT MAIN STOP AND REHEAT STOP VALVES
ACCELERATION PILOT VALVE
EXTRACTION RELAY DUMP VALVE (IN OIL TANK)
DRAIN
EMERGENCY GOVERNOR
TRIP SPEED-
1980 TO
1998 R.P.M.
EMERGENCY TRIP VALVE
(IN FRONT STANDARD)
FROM MAIN STEAM HEADER-
STEADY STATE REGULATION
RATE LIMITS
TEMPORARY REGULATION
FEEDBACK DAMPING
DASHPOT OVERFLOW
AIR BLEED
RELAY PISTON-
ROTATING BUSHING SPEED
FORCE RESTORED REGULATOR
FROM RATE FEEDBACK BELLOWS
VENT
TO ELECTRICAL PRESSURE REGULATOR CIRCUITRY
SUB-LOOP FEEDBACK
PRE-FILTERS
AFTER FILTERS
TRANSFER VALVE
FILLER VALVE
SERVO VALVE
TO OPEN VALVES
REACTOR FLOW LIMIT
TO CONTROL VALVE RELAY LINKAGE

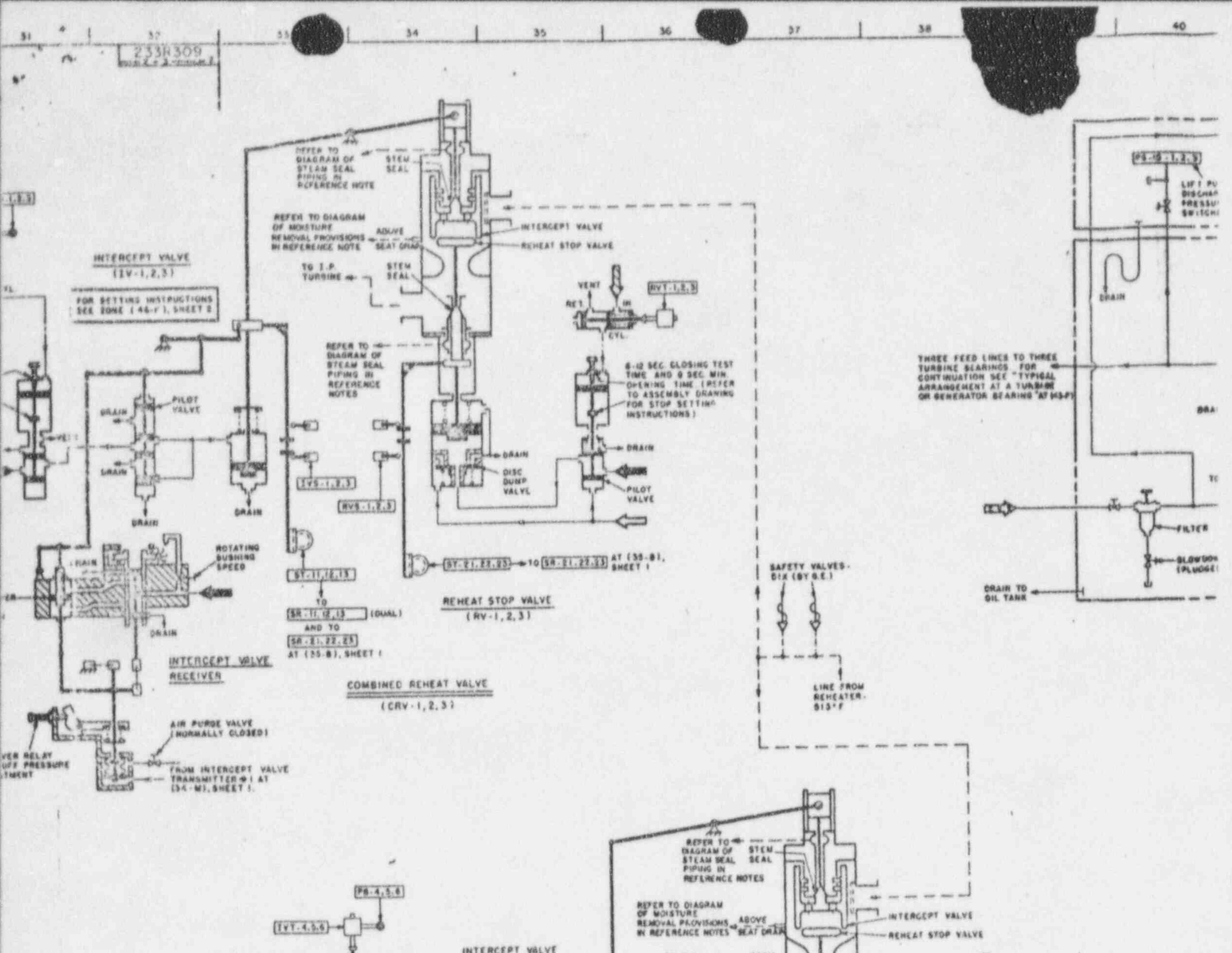


STOP VALVE BY-PASS HAND WHEEL TRIP PISTON
LOAD LIMIT TRIP PISTON
RELAY DUMP VALVES AT MAIN STOP AND REHEAT STOP VALVES
ACCELERATION PILOT VALVE
EXTRACTION RELAY DUMP VALVE (IN OIL TANK)
MASTER TRIP
DRAIN
EMERGENCY GOVERNOR
TRIP SPEED 1980 TO 1998 R.P.M.
EMERGENCY TRIP VALVE
(IN FRONT STANDARD)
SPARE
LOW VACUUM ALARM SWITCH - SET AT 24" HG VACUUM
COLLAR SET TO TRIP AT 20" HG VACUUM
REACTOR SCRAM SWITCHES SET AT 23" HG VACUUM
FROM "A" CONDENSER
FROM "B" CONDENSER
FROM "C" CONDENSER
FROM BACK-UP OVERSPEED TRIP AT (30-E), SHEET
VACUUM TRIP # 1
(TURBINE TRIP)
(IN FRONT STANDARD)
VACUUM TRIP SETTING 20" HG VAC
VACUUM TRIP ALARM SETTING 24" HG VAC
FROM MAIN STEAM HEADER
DASHPOT OVERFLOW
AIR BLEED
VENT
FROM RATE FEEDBACK BELLOWS AT (21-E), SHEET 1
PRESSURE CHANGER HANDWHEEL
BY-PASS VALVE OPENING JACK
TO ELECTRICAL PRESSURE REGULATOR CIRCUITRY AT (15-A), SHEET
SUB-LOOP FEEDBACK
AFTER FILTERS
TRANSFER VALVE
4" - DIA
2" - TOTAL STROKE
SERVO VALVE
TO OPEN VALVES
SERVO MOTOR OF ELECTRICAL PRESSURE REGULATOR
FROM ELECTRICAL PRESSURE REGULATOR CIRCUITRY AT (15-A), SHEET 1
VACUUM TRIP


233R309
MAIN STOP VALVE
(SV-1,3,4)
CONNECTION FROM #1 STOP VALVE TO PRESSURE REGULATORS
STEAM INLET- 950 P.S.I., 540°F.
REFER TO DIAGRAM OF MOISTURE REMOVAL PROVISIONS IN REFERENCE NOTES
ABOVE SEAT DRAIN
STEM SEAL
STEAM OUTLET TO CONTROL VALVES
REFER TO DIAGRAM OF STEAM SEAL PIPING IN REFERENCE NOTES
STEAM CHEST PRESSURE TRANSMITTER
TEST BUTTON
SVT-1,3,4
PB-7,9,10
6-12 SEC CLOSING TEST TIME AND 6 SEC MIN. OPENING TIME (REFER TO ASSEMBLY DRAWING FOR STOP SETTING INSTRUCTIONS)
DISC DUMP VALVE
DRAIN
PILOT VALVE
SVS-1,3,4
ST-1,3,4
TO SR-1,3 AT (35-B), SHEET 1
VTS-1
RSCS-1
RIL-1
PB-11
VTRS-1
VENT
RET.
IN
CYL.
REHEATER VENTILATION SYSTEM SWITCH SET AT 7" HG. VACUUM
RVSS
SPARE
LVA-2
COLLAR SET TO TRIP AT 10" HG VACUUM
VTS-2
RSCS-2
RIL-2
PB-12
VTRS-2
TO BY-PASS RELAY AT (13-K), SHEET 1
VACUUM TRIP # 2
(BY-PASS SYSTEM TRIP)
(IN FRONT STANDARD)
TRIP SETTING 10" HG. VAC
TRIP ALARM SETTING 24" HG. VAC
BELOW SEAT INTERCONNECTION
SV-4 SV-3 SV-2 SV-1
CV-4 CV-3 CV-2
SECONDARY SPEED RELAY
CONTROL VALVE SERVO-MOTORS
FOR CONTINUATION OF PIPING SEE REHEATER PROTECTION DIAGRAM 713E627
FROM AIR VALVE ON SECONDARY CONTROL VALVE RELAY AT (20-H), SHEET 1.
VENT
EXH
STEAM INLET- 950 P.S.I., 540°F.
REACTOR
FOR CONTINUATION OF PIPING SEE REHEATER PROTECTION DIAGRAM 713E627
MOISTURE SEPARATORS (4)
REHEATERS (4)
BY-PASS VALVE SERVO-MOTORS
BY-PASS VALVES
233R309



VENT
FROM #2 PORT ON AIR VALVE AT (22-C), SHEET 1.
AIR VALVE TO BE SET TO SHUT OFF AIR SUPPLY WHEN STOP VALVE "SV-2" STARTS TO GO FULLY OPEN
MAIN STOP VALVE
(SV-2)
REFER TO DIAGRAM OF MOISTURE REMOVAL PROVISIONS IN REFERENCE NOTES
ABOVE SEAT DRAIN
STEM SEAL
RESTORING ARM BREAK-DOWN
STOP VALVE BY-PASS CONTROL MECHANISM
(MOTOR-OPERATED)
RIGID STOP
DRAIN
DISC DUMP VALVE
CYL
RET
TEST BUTTON
6-12 SEC. CLOSING TEST TIME AND 8 SEC. MIN. OPENING TIME. (REFER TO ASSEMBLY DRAWING FOR STOP SETTING INSTRUCTIONS).
RECEIVER RELAY PISTON
MOTOR OPERATED BY-PASS VALVE
GAGE - SET AT 50 P.S.I. WITH AIR-OPERATED VALVE OPEN AND FULL VACUUM IN TURBINE
VALVE BY PURCHASER
CONNECTED BY PURCHASER
AIR-OPERATED WATER SPRAY VALVE
(WSV)
MANUAL ADJUSTMENT VALVE
STRAINER
CRV-1
CRV-2
CRV-3
CRV-4
CRV-5
CRV-6
WATER SPRAY NOZZLE (4 EACH END-EACH HOOD)
EXHAUST HOOD THERMOMETERS
EXHAUST HOOD THERMOSTATS (3)- CONTACTS CLOSE AT 175° F. AND 225° F.
PRESSURE REDUCERS (9)
EHT-1
EHT-2
EHT-3



233R309
REFER TO DIAGRAM OF STEAM SEAL PIPING IN REFERENCE NOTE
STEM SEAL
REFER TO DIAGRAM OF MOISTURE REMOVAL PROVISIONS IN REFERENCE NOTE
ABOVE SEAT DRAIN
INTERCEPT VALVE
REHEAT STOP VALVE
TO I.P. TURBINE
INTERCEPT VALVE
(IV-1,2,3)
FOR SETTING INSTRUCTIONS SEE ZONE (46-F), SHEET 2
VENT
RET.
IN
CYL.
RVT-1,2,3
REFER TO DIAGRAM OF STEAM SEAL PIPING IN REFERENCE NOTES
6-12 SEC. CLOSING TEST TIME AND 8 SEC. MIN. OPENING TIME. (REFER TO ASSEMBLY DRAWING FOR STOP SETTING INSTRUCTIONS)
PILOT VALVE
DRAIN
DISC DUMP VALVE
IVS-1,2,3
RVS-1,2,3
ROTATING BUSHING SPEED
ST-11,12,13
TO
SR-11,12,13 (DUAL)
AND TO
SR-21,22,23
AT (35-B), SHEET 1
ST-21,22,23
TO SR-21,22,23 AT (35-B), SHEET 1
REHEAT STOP VALVE
(RV-1,2,3)
INTERCEPT VALVE RECEIVER
COMBINED REHEAT VALVE
(CRV-1,2,3)
AIR PURGE VALVE (NORMALLY CLOSED)
FROM INTERCEPT VALVE TRANSMITTER # 1 AT (34-M), SHEET 1.
SAFETY VALVES-DIX (BY G.E.)
LINE FROM REHEATER-513°F
THREE FEED LINES TO THREE TURBINE BEARINGS. FOR CONTINUATION SEE "TYPICAL ARRANGEMENT AT A TURBINE OR GENERATOR BEARING" AT (43-F)
PS-15-1,2,3
DRAIN
FILTER
DRAIN TO OIL TANK
PS-4,5,6
IVT-4,5,6
INTERCEPT VALVE
(IV-4,5,6)
FOR SETTING INSTRUCTIONS SEE ZONE (46-F), SHEET 2
RVT-4,5,6
IVS-4,5,6
RVS-4,5,6
RECEIVER RELAY PISTON
ST-14,15,16
TO
SR-11,12,13 (DUAL)
AND TO
SR-24,25,26
AT (35-B), SHEET 1
ST-24,25,26
TO SR-24,25,26 AT (35-B), SHEET 1
REHEAT STOP VALVE
(RV-4,5,6)
COMBINED REHEAT VALVE
(CRV-4,5,6)
RECEIVER RELAY LIFT-OFF PRESSURE ADJUSTMENT
AIR PURGE VALVE (NORMALLY CLOSED)
FROM INTERCEPT VALVE TRANSMITTER # 2 AT (28-M), SHEET 1
31
32
33
34
35
36
37
38
39
40

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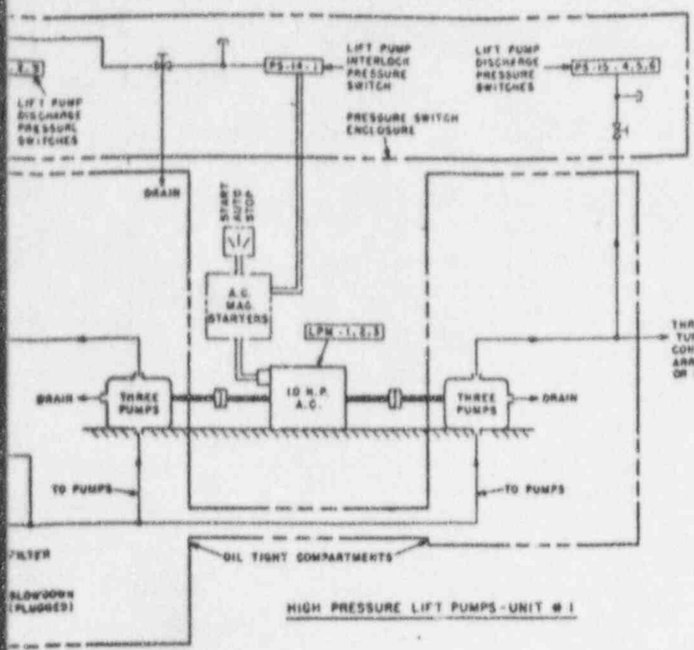
(OYSTER CREEK #1)
TB # 170 X 290



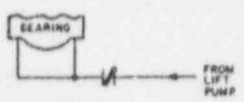
HIGH PRESSURE LIFT PUMPS - UNIT # 1

FOR ELECTRICAL SYMBOL DESIGNATION REFER TO THE TURBINE WIRING DIAGRAM

REFERENCE SHOULD ALSO BE MADE TO THE FOLLOWING SUPPLEMENTARY DIAGRAMS
- ARRANGEMENT OF EXTRACTION CONTROL SYSTEM.
- HYDRAULIC TRIP CIRCUIT.
- DIAGRAM OF STEAM SEAL PIPING - 713E802
- DIAGRAM OF MOISTURE REMOVAL PROVISIONS - 713E808
- REHEATER PROTECTION DIAGRAM - 713E827
- MOISTURE SEPARATOR & REHEATER DRAIN DIAGRAM - 713E683

LEGEND

- OIL LINE
- ELECTRICAL CONNECTION
- AIR LINE
- WATER LINE
- STEAM LINE
- EMERGENCY TRIP OIL
- MAIN SHAFT PUMP DISCHARGE - 225 P.S.I. MINIMUM OIL PRESSURE TO OPERATING MECHANISMS (OPERATING OIL)
- BEARING OIL - 25 P.S.I. AT T.B. ₵
- PURCHASER'S AIR SUPPLY - 60-100 P.S.I.



TYPICAL ARRANGEMENT AT A TURBINE OR GENERATOR BEARING

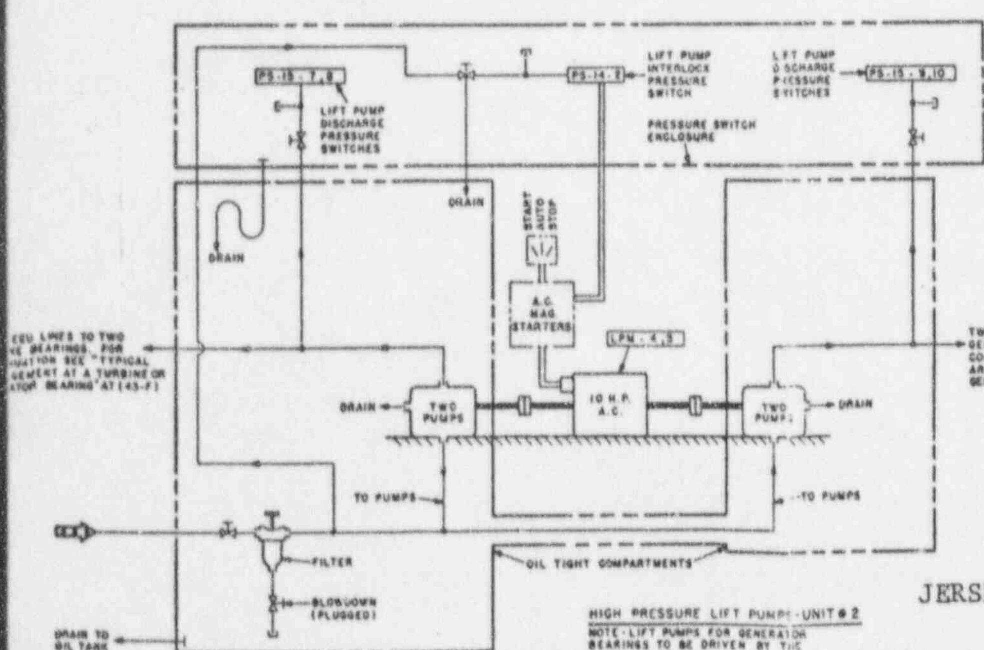
SETTING INSTRUCTIONS

FOR FRONT STANDARD SETTINGS SEE DWG. NO.

FOR INTERCEPT VALVE SETTINGS SEE DWG. NO.

FOR CONTROL SETTING CURVES SEE DWG. NO.

FOR LINKAGE DIAGRAM SEE DWG. NO.



HIGH PRESSURE LIFT PUMPS - UNIT # 2

NOTE - LIFT PUMPS FOR GENERATOR BEARINGS TO BE DRIVEN BY THE SAME MOTOR.

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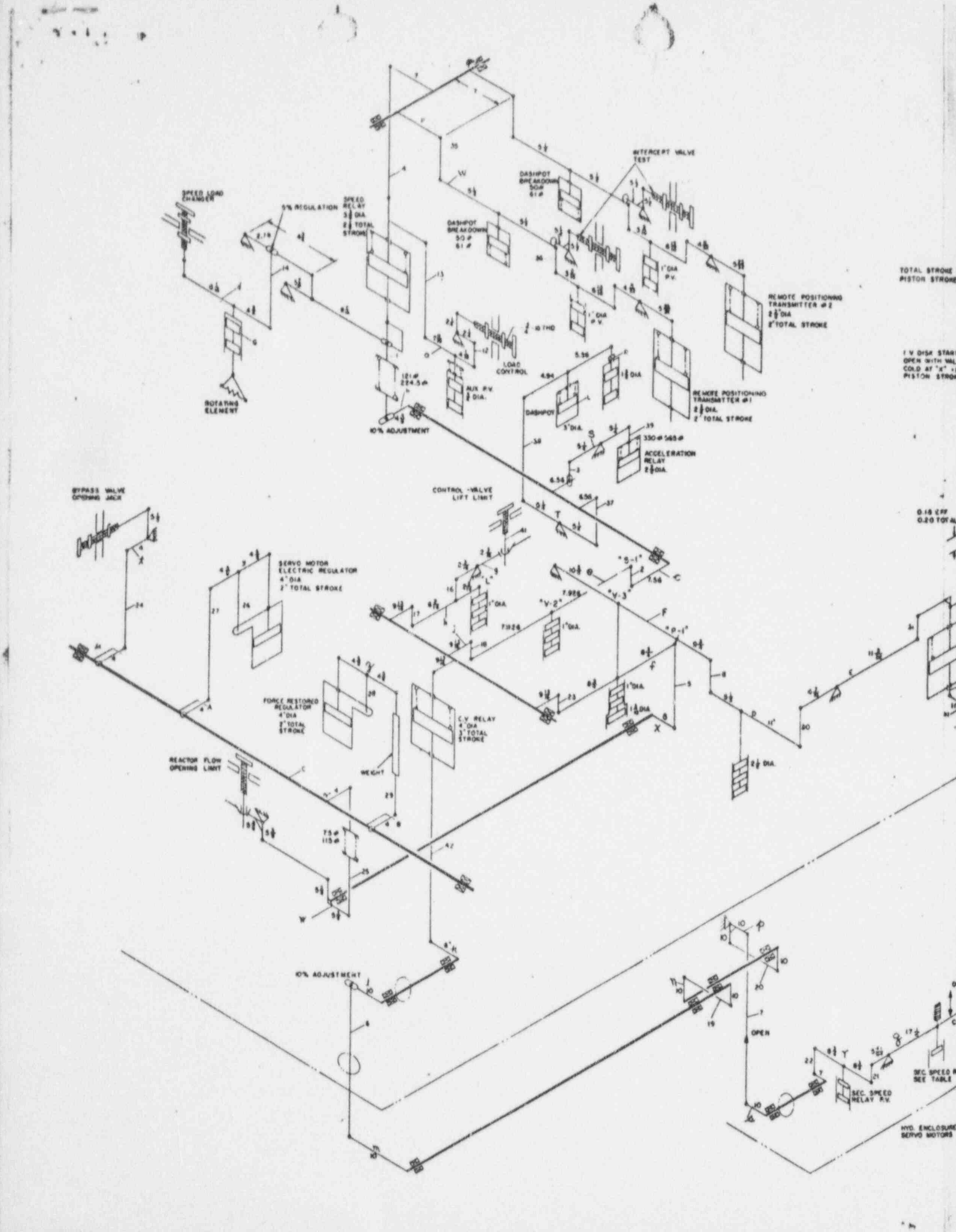
CO REPORT No. 219/70-6

Figure 23

233R309

Diagram of control mechanism
Dwg. 233R309 sh 2 (rev 3)


SPEED LOAD CHANGER
5% REGULATION
SPEED RELAY
ROTATING ELEMENT
DASHPOT BREAKDOWN
DASHPOT BREAKDOWN
INTERCEPT VALVE TEST
LOAD CONTROL
AUX P.V.
REMOTE POSITIONING TRANSMITTER #2
2" TOTAL STROKE
REMOTE POSITIONING TRANSMITTER #1
2" TOTAL STROKE
10% ADJUSTMENT
DASHPOT
ACCELERATION RELAY
CONTROL-VALVE LIFT LIMIT
BYPASS VALVE OPENING JACK
SERVO MOTOR ELECTRIC REGULATOR
4" DIA
2" TOTAL STROKE
FORCE RESTORED REGULATOR
C.V. RELAY
WEIGHT
REACTOR FLOW OPENING LIMIT
10% ADJUSTMENT
OPEN
SEC. SPEED RELAY P.V.
HYD. ENCLOSURE SERVO MOTORS
TOTAL STROKE
PISTON STROKE

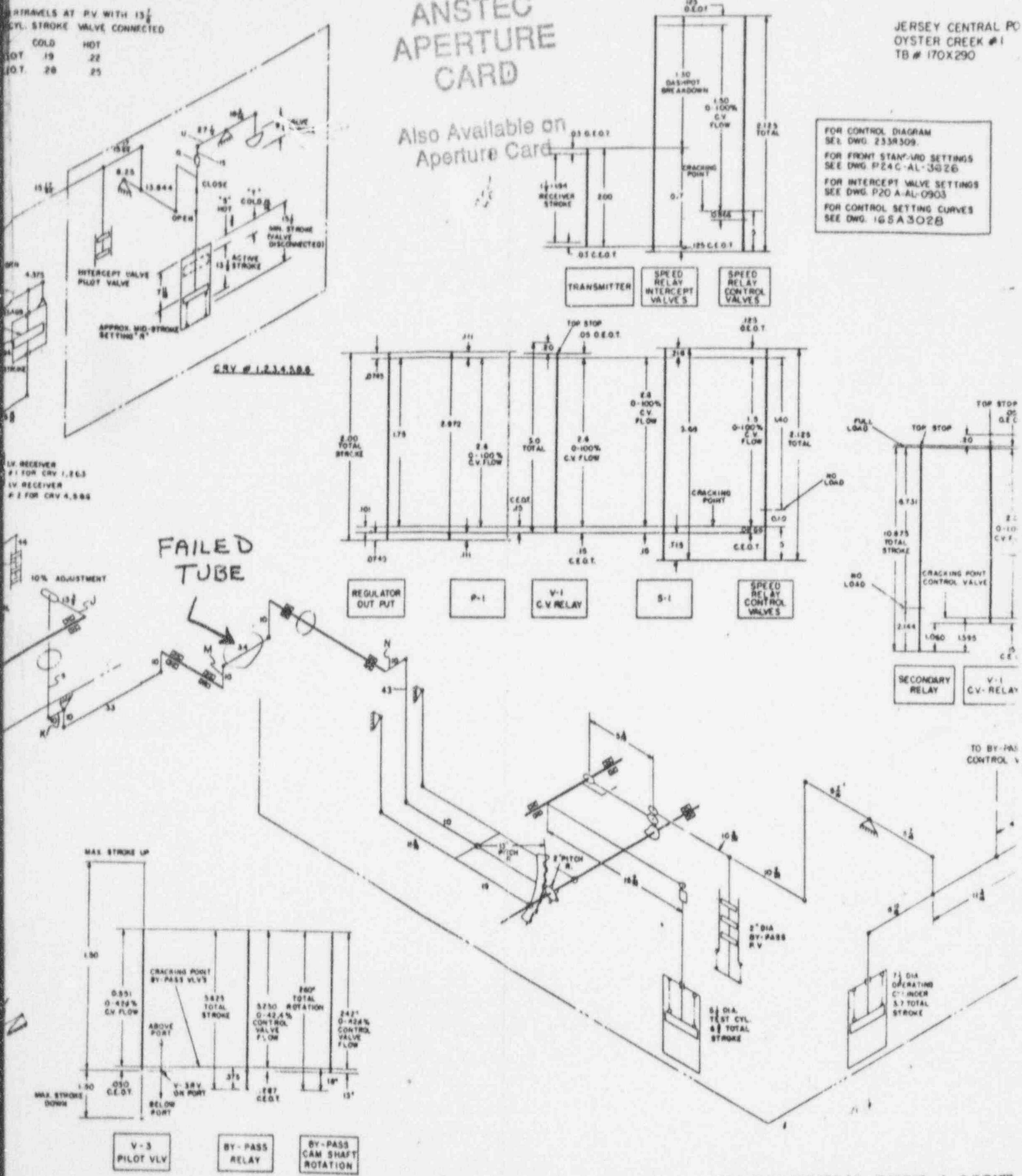


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Figure 24

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