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UNITED STATES GOVERNMENT

Memorandum

TO : Files
(Thru) Roger S. Boyd, Chief
Research & Power Reactor Safety Branch

DATE: MAY 1 8 1964

FROM : Donald F. Sullivan Donald F. Sullivan
Research & Power Reactor Safety Branch
Division of Reactor Licensing

SUBJECT: SUMMARY OF MEETING HELD AT BETHESDA ON MAY 12, 1964 CONCERNING SAFETY SYSTEM INSTRUMENTATION PROPOSED FOR THE JERSEY CENTRAL (OYSTER CREEK) NUCLEAR POWER PLANT, DOCKET NO. 50-219

I. On May 12, 1964 representatives of the Jersey Central Power and Light Company and of the General Electric Company met at Bethesda with members of the Division of Reactor Licensing and ACRS consultant, Mr. E. P. Epler, to describe and discuss the safety system instrumentation proposed for installation in the JCP&L Nuclear Power Plant at Oyster Creek, N. J.

The meeting consisted essentially of a presentation by Mr. E. P. Peabody of G. E. followed by a question-and-answer period.

Briefly, the proposed safety system is based on the coincident tripping of two independent logic scram channels, A and B. Each channel, however, is subdivided into two independent (except for voltage source) subchannels, A1 and A2, and B1 and B2. Tripping of at least one subchannel trips the associated channel. A subchannel trip is accomplished by de-energizing two parallel-connected relay coils associated with the subchannel. Within each subchannel there are at least two independent tripping elements per parameter.

Associated with each rod are two solenoid-operated pilot valves and two air-operated scram valves. The pilot valves are, in turn, associated respectively with Channel A or Channel B. The scram valves are associated only with the respective rods. When both channels are tripped, the pilot valves act to remove control air pressure from the respective scram valves. Removal of air pressure causes the scram valves to admit high pressure water to the scram pistons and to vent cylinder water to the dump tank. Operation of only those pilot valves associated with one channel will not initiate a scram.

Several solenoid-operated "back-up" valves, which are energized via an emergency d.c. power supply and normally closed relay contacts whose coils are connected to the trip channels, serve to initiate rod motion in the event of failure of one or more pilot valves.

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A complete summary of Mr. Peabody's presentation is contained in an informal report "Reactor Protection System" dated May 8, 1964, copies of which were distributed to all persons in attendance.

II. During the question-and-answer period the following points were discussed:

a) Mr. Epler questioned the need for interlocks within the subchannels which would cause a trip should more than one element within a subchannel be bypassed at any one time. He felt that the redundancy of elements precluded the need since such redundancy allows one element to be tested (tripped) or removed for maintenance without scramming the reactor. He further felt that bypass jacks could conceivably short in such a manner as to disable an entire logic string of elements and thereby prevent a subchannel trip should an element within the subchannel experience a bona fide trip.

b) G. E. was asked to defend the absence of period scram, and the consequent reliance on scram signals generated by variable range picoammeters. Since, it appears, no through analysis of this problem has been made, the results of the discussion were inconclusive. Mr. Epler suggested that we pursue the matter further until a decision based on conclusive data can be reached.

c) The relationship between reactor recirculation flow and the possible failure of a scram back-up valve with the resulting slow insertion of a portion of the control rods was discussed. The problem centers on the fact that the variable recirculation flow would tend to increase reactivity to compensate for the rod insertion, and it is therefore possible that distortions in flux patterns could cause local overheating within the core.

G. E. explained that each scram back-up valve is associated with a group of rods which are distributed evenly within the core and that this would tend to preclude local overheating.

Further, rod motion could be detected by the operator by observation of the rod position indicators, and this would enable him to take early, corrective action.

The representatives were asked to describe the measured parameters which determine recirculation flow rates. They were unable to give a definite answer.

d) The subject of testing of components during operation was discussed at some length. It was pointed out to the representatives that the instrumentation must have adequate provisions for conducting tests at a frequency consistent with the known or suspected failure rates of components. It was also emphasized that the manner of testing should not compromise system safety.

e) In response to a question dealing with testing (tripping) of scram channels during operation it was brought out that the test consists ultimately of detecting the removal of voltage at the solenoid valves and does not sense actual valve operation. Thus, there is no provision, short of injecting a full scram signal, for checking valve operation.

f) It was suggested that, as an operational procedure, the Diesel generator should be started and synchronized immediately upon loss of the 23KV generator rather than wait until both the 23KV and 230KV sources are lost.

Answers given to questions regarding the number and kind of loads to be connected to the Diesel generator under emergency power conditions were inconclusive.

III. A preliminary evaluation of the proposed instrumentation system by Mr. Epler and members of DRL subsequent to the meeting indicated that the logic scheme on which it is based is acceptable. The subdivisions of channels coupled with additional element redundancy apparently serves to render the scram capability of the system immune to failures of single components. The possibilities of such scram-preventing failures had been prevalent within several safety systems previously designed by G. E. and had given rise to some concern within DRL prior to the meeting.

Prepared by E. P. Peabody
May 8, 1964

REACTOR PROTECTION SYSTEM

The reactor protection system provides for rapid shutdown (scram) of the reactor in the event of system transients or malfunctions which could lead to a potentially unsafe condition. Conditions which do not pose a threat to plant or personnel safety should not cause a scram.

The protection system must perform a dual role having directly conflicting requirements. First, it must scram the reactor for any potentially unsafe condition. Second, it should not scram the reactor because of malfunction of an instrument or failure of a device in the system which does not impair the ability of the system to scram when required to do so. The system described here provides the necessary high degree of safety while still preventing spurious or unnecessary scrams from failure or malfunction of any single element in the system.

The system selected is of the dual channel type. Each channel has at least two independent tripping elements from each measured variable. The operation of one element will trip the channel in which it is connected. A simultaneous trip in each channel causes a scram. Failure of an element will not impair the ability of the other elements to trip. Any single element operating falsely cannot cause a scram since it trips only one channel.

The plant conditions which are monitored by the reactor protection system and used to cause a scram are summarized in the following table and are also listed. Unless otherwise noted, two independent tripping elements from each measured variable are connected to each of the two protection channels.

REACTOR PROTECTION SYSTEM FUNCTIONS

Sensors	Number of Detectors Per Channel	Channel Trip Logic	Scram Reactor	Start Emergency Cooling
High pressure in reactor drywell	2	1/2	X	
Low water level in reactor vessel	2	1/2	X	
High reactor pressure	2	1/2	X	X
Primary steam isolation valves closed(a)	2	2/2(c)	X	
High neutron flux	3	1/3	X	
High level in scram dump tank	2	1/2	X	
Low condenser vacuum(b)(d)	2	1/2	X	
Loss of plant auxiliary power			X	X
Steam line high activity	2	1/2	X	
Manual			X	X

(a) Bypassed during startup, refueling and valve closure testing.

(b) Bypassed during startup and refueling (below 350 psig reactor pressure).

(c) Assumes two valves. Both must partially close to scram.

(d) Initiates closure of main steam line isolation valves.

1. High Pressure in the Reactor Drywell

   A positive pressure inside the reactor drywell indicates a possible primary system rupture within the drywell.

2. Low Water Level in the Reactor Vessel

   Low water level scrams the reactor before the water level falls below a point where improper cooling of the fuel elements might result.

3. High Reactor Pressure

   High reactor pressure is an indication of abnormal conditions in the primary system. Normal transient pressures will not cause a scram.

4. Primary Steam Isolation Valves Closed

   Partial closure of one valve in each steam line scrams the reactor in anticipation of resulting high reactor pressure and loss of the principal heat sink for the reactor.

5. High Neutron Flux

   High neutron flux indicates a reactor power output in excess of the intended level of operation.

6. High Level in Scram Dump Tank

   High water level in the scram dump tank prevents high speed insertion of the control rods. Scram is initiated before a level is reached which would prevent high speed insertion of the rods.

7. Low Condenser Vacuum

   The condenser is the main heat sink for reactor heat output. The reactor is scrammed when the vacuum indicates that the condenser system may be failing.

8. Loss of Plant Auxiliary Power

   Reactor scram results following a total loss of power to the auxiliary power system buses for a period of about one-half second. This delay allows time for relays to clear faults and restore service when a total power outage does not result.

   Loss of power to the protection system motor generators also scrams the reactor after the output voltage decays and allows the scram pilot valves to drop out (approximately 3 seconds).

9. Steam Line High Activity

Steam line gamma monitors detect an excessively high release of fission products. Steam line and off-gas line valves are closed to limit release from the reactor and to confine fission products in the turbine, condenser and off-gas line.

10. Manual Scram

A manual control is readily available to the operator to scram the reactor.

Bypass and Interlock

Most protection system bypassing is accomplished by the selector switch which has four mode positions: "Shutdown", "Refueling", "Start", and "Run".

A bypass switch is provided to bypass the "high-water level in scram dump tank" trip so that the dump tank can be emptied after a scram. This bypass is interlocked so as to prevent control rod withdrawal while this is bypassed.

A bypass switch is provided to allow bypassing one of the six power range monitors for maintenance. This still leaves two operating units in whichever channel a monitor is bypassed.

Interlocks are provided on the power range monitors to assure that all units are operating properly and "on scale" As a precaution, if any two monitors in either channel are operating below 5% of the selected scale, (except on lowest range) control rod withdrawal will be blocked. If the three monitors in one channel are below 5% of scale, that channel will be tripped.

Reactor Protection System Operation

The reactor protection system is a dual channel relay type system. High reliability relays are used for both the logic functions and as the main trip relays to control power to the scram pilot valve solenoids.

All relays associated with channel tripping or reactor scram are energized during operation. Since most relay failures such as open or shorted coils or broken leads result in returning the relay to its deenergized position and deenergizing the circuit, this arrangement provides a "fail safe" type of system for the majority of failure conditions. Burned or sticking contacts which might cause an unsafe failure are minimized by limiting the current through each contact to not more than 50% of its normal rating. Care in selection will result in relay types which are free from the possibility of mechanical binding.

The logic relays are sensitive, fast operating relays such as the mercury wetted contact type. These relays are energized from a 24 volt d-c supply which is compatible with the power requirements of several of the monitors. The main trip relays are industrial type, heavy duty size 2 magnetic contactors with 115 volt a-c coils. Drawing 846D206 shows the proposed connections of the system. Note that all logic relays are connected in series so that deenergizing any single relay will interrupt power to the main trip relays. Four trip relays are used in each channel to keep the contact current within limits. Contacts on separate relays are in series in each solenoid group circuit so that any single relay failing to open will not prevent a scram. Separate relays are used to initiate operation of the emergency condenser, to close isolation valves and to initiate other auxiliary functions.

Reactor scram results when both channels trip to deenergize both solenoids of the pilot valves and interrupt instrument air to the main scram valves. A single channel trip does not interrupt instrument air so no scram results.

System testing is accomplished by tripping one channel at a time from each sensor. This tests all functions up to the final scram valves. Periodic tests are normally conducted during plant operation without loss of plant protection.

The dual channel protection system described above results in a system having high reliability and with excellent safety features combined with a very low expected incidence of false operations due to component failure. It uses standard components with simplicity in design which result in reduced maintenance. A better comprehension of system operation by maintenance personnel results.

Reset and Annunciation

A trip of either channel causes that channel to lock out and to annunciate. The channel must be manually reset to reenergize the scram pilot valve solenoids. Annunciation of individual trip signals is provided in sufficient number for the operator to determine the actual source of a channel trip or scram. An operational recorder gives a continuous time sequence record of all annunciations.

Backup Protection

One or more three-way solenoid valves (not shown on attached drawings) are installed in the instrument air line to provide backup protection in the unlikely event of failure of one of the scram pilot valves to open. The solenoids are normally deenergized. Auxiliary relays in the protection system energize the d-c solenoids of the backup valves to interrupt air to the pilot and scram valves and bleed off air from any scram valves where pilot valve failed to operate. Insertion time of the rod will be longer than normal, but a safe shutdown is still assured since not all the rods are required to initially shut down the reactor.

Auxiliary Tripping Function

A low-low water level trip is provided on the reactor to prevent the core from being uncovered in case of excessive loss of water or feedwater failure. Four sensors are provided in a conventional two bus arrangement. A trip in each of the two buses closes the steam line isolation vlaves and initiates operation of the core spray system.

Indication of a steam line break causes closure of the steam line isolation valves. Temperature and/or pressure sensors in proximity to the steam lines will indicate a possible break. The conventional arrangement of four sensors and two buses is used.

'eactor Protection System Power Supply

Drawing 846D285 shows the power supplies for the protection and reactor control systems. Each protection channel is supplied from a motor-generator set with a flywheel. The motors are induction type and are fed from separate sources in the plant auxiliary electrical system. The flywheel provides sufficient stored energy to maintain an operable voltage and frequency for about three seconds following total loss of station auxiliary power so that momentary voltage dips caused by system transients or faults will not cause a reactor scram.

Each generator provides power for one protection channel, half the in-core monitors, one air ejector monitor and a charger/power supply which feeds half the neutron monitors. An alternate source of power is provided through a regulating transformer so that a motor-generator can be removed from service for maintenance.

A 24-volt battery supplies the control rod position indicators and supplies power to half or all of the neutron monitors during loss of auxiliary power. The battery is normally connected to one of the two charger/power supplies.

The balance of the reactor instrumentation is connected to a reliable source of 115-volt a-c power. When auxiliary power is not available, the plant emergency generator will supply power to these systems.

E. P. Peabody

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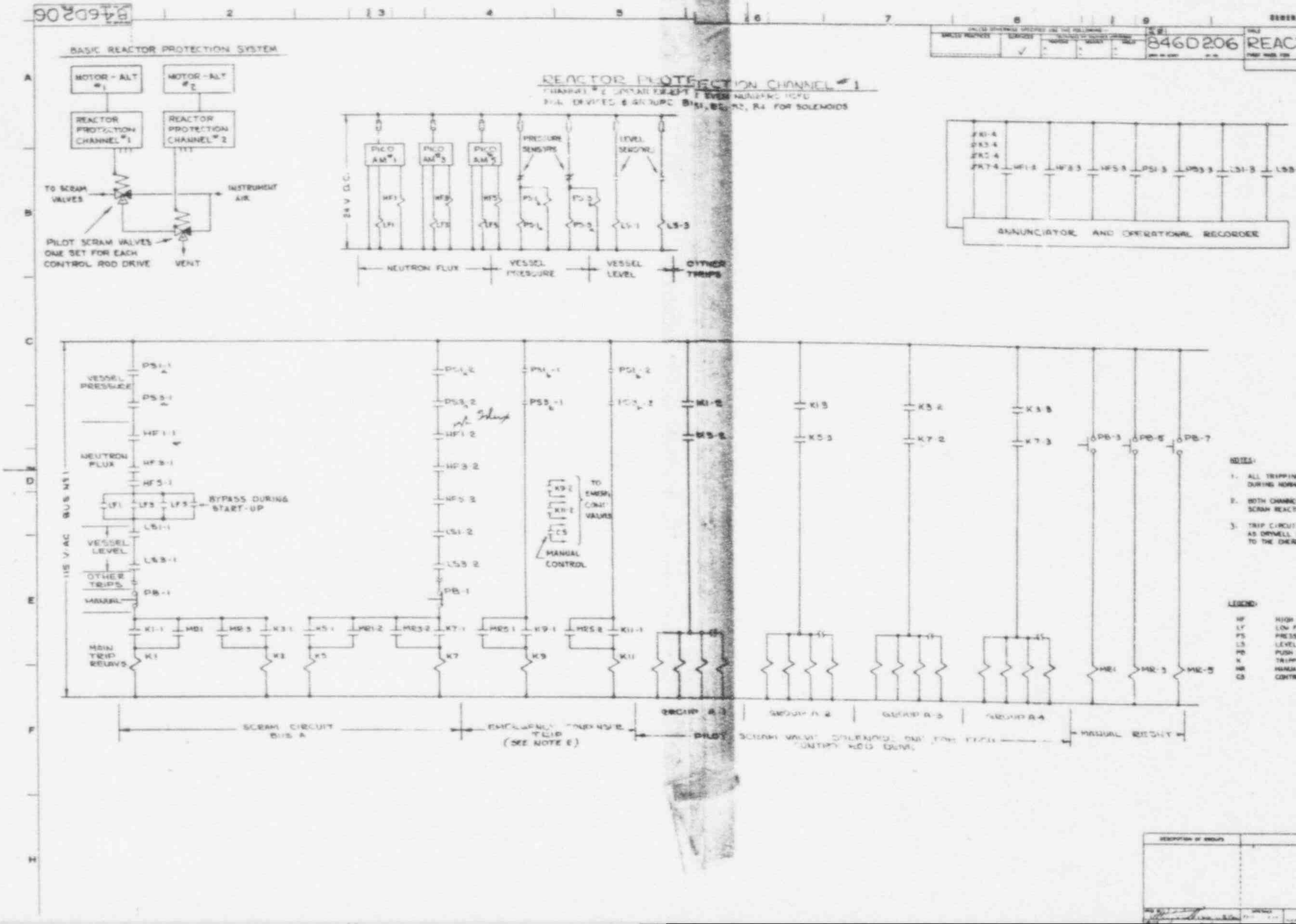
REACTOR PROTECTION S



NOTES:

1. ALL TRIPPING RELAYS AND SOLENOIDS ENERGIZED DURING NORMAL OPERATING CONDITIONS
2. BOTH CHANNEL #1 AND CHANNEL #2 MUST TRIP TO SCRAM REACTOR
3. TRIP CIRCUITS FOR AUXILIARY FUNCTIONS SUCH AS DRYWELL ISOLATION WILL BE ARRANGED SIMILAR TO THE EMERGENCY CONDENSER TRIPS.

LEGEND:

HF HIGH FLUX
LF LOW FLUX OR DOWNSCALE
PS PRESSURE SWITCH
LS LEVEL SWITCH
PB PUSH BUTTON
K TRIPPING CONTACTOR
MR MANUAL RESET RELAY
CS CONTROL SWITCH

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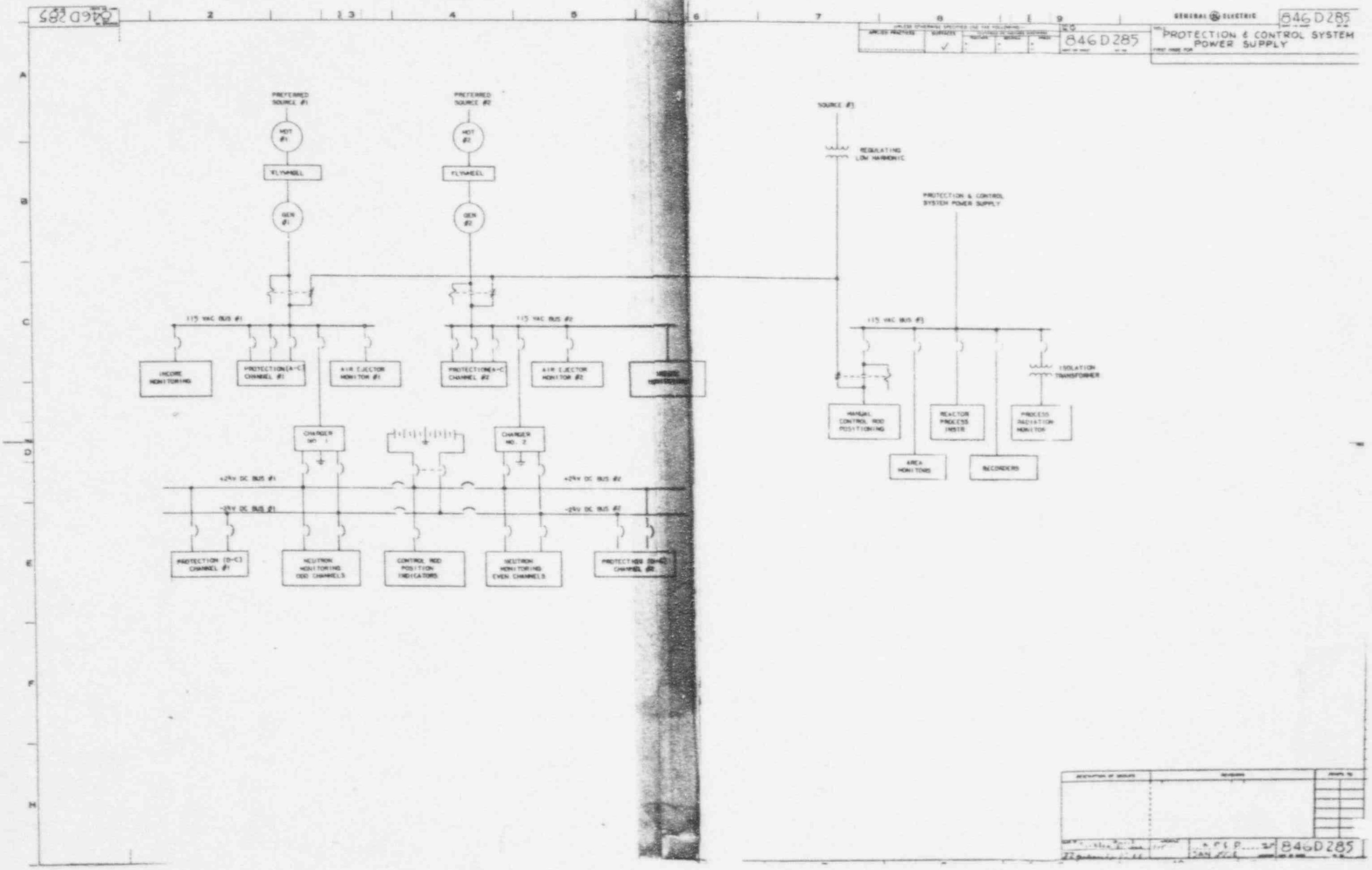

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PROTECTION & CONTROL SYSTEM POWER SUPPLY