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GEAP 0915

DRESDEN NUCLEAR POWER STATION

GRUNDY COUNTY, ILLINOIS

FOR

COMMONWEALTH EDISON COMPANY

AND NUCLEAR POWER GROUP, INC.

50-10 file cy.

DESIGN SCOPE DOCUMENT

DECEMBER 3, 1956

GENERAL ELECTRIC COMPANY

ATOMIC POWER EQUIPMENT DEPARTMENT

SAN JOSE, CALIFORNIA

GEAP 0915

DESIGN SCOPE FOR THE

DRESDEN NUCLEAR POWER STATION

Revision 0, December 3, 1956

Engineering Information Furnished by Power Reactor Engineering Personnel and by Bechtel Corporation.

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ATOMIC POWER EQUIPMENT DEPARTMENT

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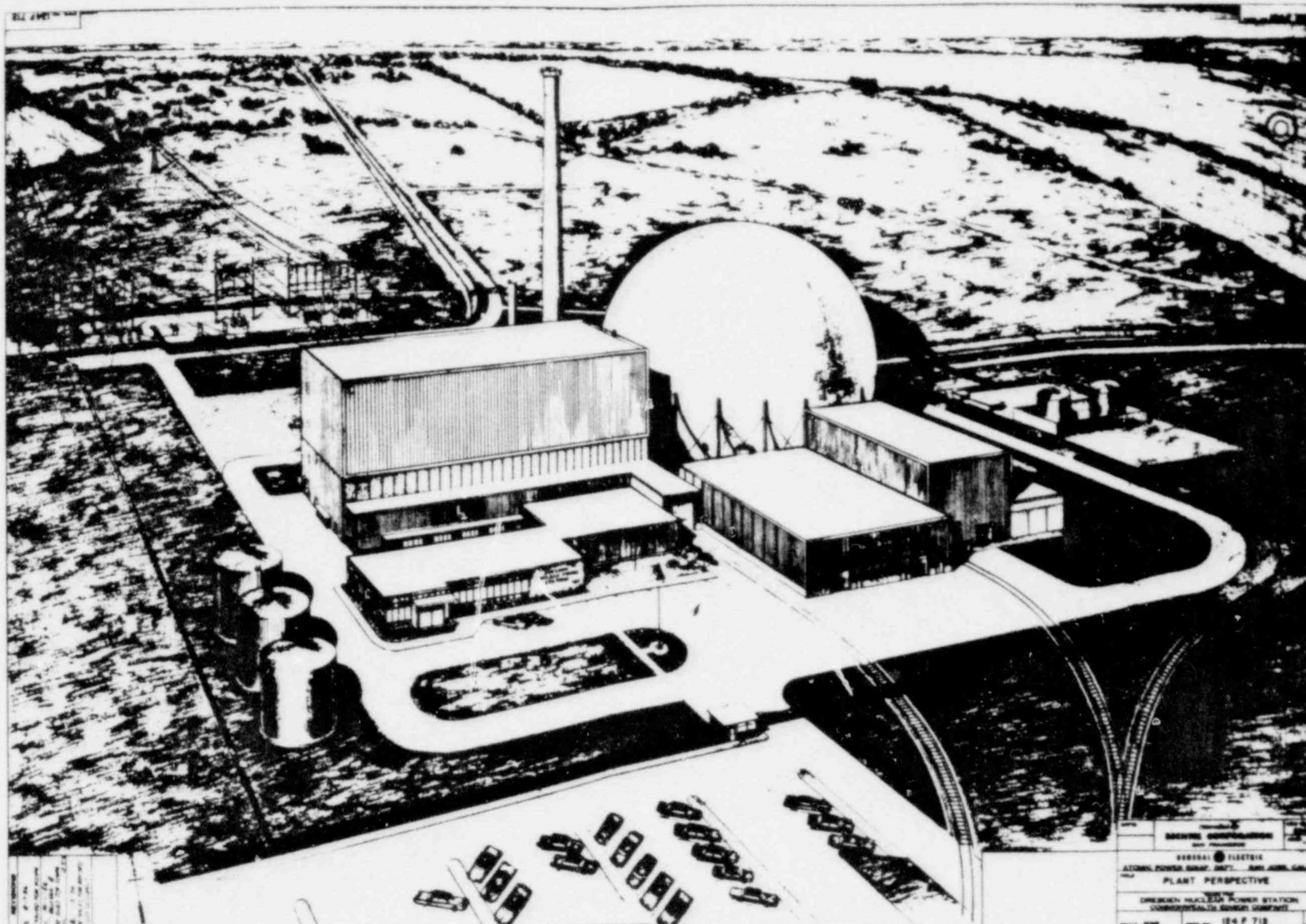
GENERAL ELECTRIC
PLANT PERSPECTIVE
DRESDEN NUCLEAR POWER STATION

SCOPE DOCUMENT

DRESDEN NUCLEAR POWER STATION

GENERAL INDEX

DRESDEN NUCLEAR POWER STATION

INTRODUCTION

SECTION I

In July of 1955, the General Electric Company entered into a contract with the Commonwealth Edison Company of Illinois under which the General Electric Company agreed to furnish the research, design, engineering, and all other services necessary for the construction of, and to furnish, erect and technically supervise placing in service of a nuclear power plant. The plant is to be located approximately 50 miles southwest of Chicago, and is to be known as the Dresden Nuclear Power Station.

General Electric Company has initiated the research, design, and procurement necessary to fulfill the above contract. It is the purpose of this document to:

A. Present a comprehensive basis for the preparation of the necessary detailed design for the Dresden Nuclear Power Station.

B. Form a basis for contractual relationships between the General Electric Company and the Engineer-Contractor, the Bechtel Corporation.

C. Furnish the Commonwealth Edison Company and the Nuclear Power Group a description of the plant to be designed and constructed.

A previous document, "Preliminary Description 180,000 kw Dual Cycle Boiling Water Reactor Power Plant, Atomic Power Study No. X-GEAP-042" issued May 20, 1955, described the Dresden Nuclear Power Station as visualized at that time. Document X-GEAP-042 is now obsolete and is replaced by this document.

As additional results of the research and development program become available, it is probable that issuance of revisions to parts of this document will be made. Until the issuance of such revisions, this document is to be used to fulfill the purpose listed above.

DRESDEN NUCLEAR POWER STATION

PLANT DESCRIPTION SUMMARY

SECTION II

The Dresden Nuclear Power Station will be located on a 940 acre site south of and adjacent to the Dresden Lock on the Illinois River. This location, at the juncture of the Des Plaines and Kankakee Rivers, is approximately 50 miles southwest of Chicago. The ultimate development of the site by Commonwealth Edison will include plants other than the plant described in this document. Drawing 124F713, General Site Plan, shows the arrangement of this facility on the site and a possible arrangement of future units.

The net electrical capacity of the plant will be 180,000 kw. The turbine generator will be rated 192,000 kw at 2.5 inches of mercury exhaust pressure and 30 psig hydrogen pressure. The turbine will be an 1800 rpm machine engineered specifically for operation in this plant.

The Dual Cycle Boiling Water Reactor System will include the reactor, steam drum, secondary steam generators, circulating pumps, and connecting piping. Fuel for the reactor will be a slightly enriched uranium oxide pellets encased in zirconium alloy tubes to form 0.5 inch diameter rods.

Drawing 193E816, Plant Flow Diagram - Main Power Loop, shows the process flow arrangement. Steam will be produced in the two cycles and admitted to the turbine at separate inlets. In the primary cycle the steam-water mixture from the reactor will go to the steam drum; the separated steam at 965 psia will pass to the high pressure admission of the turbine. The water from the drum will drop through downcomers to the suction header of the reactor recirculating pumps, to be pumped through the secondary steam generators where part of its heat is transferred to the secondary system, producing secondary steam, and then back to the inlet of the reactor. The secondary cycle of the dual cycle system will provide steam to the turbine from the secondary steam generators at a full load pressure of 475 psia.

The turbine condensate and feedwater system will be a dual path arrangement corresponding to the reactor system dual cycle. The feed to the reactor will be routed through the primary feedwater heaters and the feed to the secondary steam generators will be routed through the secondary feedwater heaters.

The nuclear steam supply system will be installed in a spherical steel enclosure which will be designed for containment purposes. The turbine-generator, feedwater pumps, heaters, control room and plant auxiliaries are to be arranged in an adjacent building of reinforced concrete and steel construction. Spent fuel storage, new fuel storage and all fuel handling, except that required for actual refueling of the reactor, will be done in a separate fuel handling building. These three facilities will constitute the major process buildings. Additional facilities will be furnished for administration, personnel control, maintenance, warehousing, waste disposal and laboratory activities.

DRESDEN NUCLEAR POWER STATION

PLANT PERFORMANCE AND DATA

SECTION III

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PLANT PERFORMANCE AND DATA

SECTION III

The following plant performance and equipment data provide the bases for the detail design of the Dresden Nuclear Power Plant as described in the remaining sections of the Scope Department.

A. POWER

Reactor Power	kw	627,500
Gross Generation	kw	192,000
Net Electric Output	kw	180,000
Net Plant Heat Rate	Btu/kwh	11,900

B. REACTOR

1. CORE ASSEMBLY

Diameter (Max.O.D.)	ft	10.7
Height (Channel subassembly)	ft	9.9
Fuel Element Geometry	Cylindrical Rods in Sq. Array	
Rod Spacing (centers)	in.	0.74
Subassembly Channel (square)	inside	3.78
Zr. Channel Thickness	in.	0.03
Control Rod Guide Thickness	in.	0.06
Channel Clearance	in.	0.28
Fuel Rods/Normal Subassembly		25
Fuel Rods/Control Rod Subassembly		16
Total Subassemblies/Reactor		712
Fuel Rods Replaced by Instruments		24
Fuel Rods/Reactor		17,002
Zr. in Channels	Lbs/ Reactor	9,600
Zr. in Control Rod Guides	Lbs/ Reactor	2,200
Water Volume/UO_2 Volume		2.1:1

2. FUEL

Rod Construction	UO_2 Pellets within Zr. Jacket	
Total Rod Length	in.	112
Total Active Rod Length	in.	106
Rod Diameter (Jacket O.D.)	in.	.56
Number of Segments/Rod		4
Segment Connections	Threaded Zr. segment ends	
UO_2 Pellets/Segment		52
UO_2 Density	% of theoretical	95
Pellet Size	in.	0.493 Dia. x 0.500
Zr. Jacket Thickness	in.	0.03
Zr. in Rod	Lbs.	1.8
UO_2 in Rod	Lbs.	7.8
U in UO_2 Rod	Lbs.	6.9

U in Reactor	Tons	58.5
Enrichment (required at 5,000 MWD/T AVG. Irradiation)	% U_{235}	1.5
Refueling Schedule	mos	6
U Total Thru-put (70% load factor)	lbs/yr	32,000
Zr. Jacket Thru-put (70% load factor)	lbs/yr	8,900
Irradiated Fuel Storage Capacity	% Reactor Load	120
Unirradiated Fuel Storage Capacity	% Reactor Load	100

3. HEAT TRANSFER

Avg. Heat Flux	Btu/hr-ft^2	97,000
Max. Heat Flux	Btu/hr-ft^2	385,000
Max. Heat Flux/Average Heat Flux		3.95
Max. Power/Central Rod (rated power)	kw	53.5
Avg. Power/Rod (rated power)	kw	37.6
Avg. Power Density (in core coolant volume)	kw/ft^3	1,580
Max. Fuel Temperature (center-rated power)	^oF	2,800
Rod Heat Transfer Area	Ft^2/Rod	1.28

4. FLUID FLOW

Recirculating Water Flow (reactor coolant)	Lbs/hr	25,602,000
Inlet Temperature	^oF	505
Inlet Velocity (center channel)	fps	5.2
Sub-cooling	Btu/lb	51.4
Flow Area/channel	Ft^2	0.057
Exit Temperature	^oF	546
Exit Velocity (center channel)	fps	9.9
Vessel Steam Pressure	psia	1,015
Avg. Steam Quality (by wt., at outlet)	%	5
Steam Quality (by vol., Standard center channel)	%	48
Steam-Water Relative Slip Velocity	fps	3

5. REACTIVITY AND CONTROL

Max. Neutron Flux (thermal)	n/cm^2 sec.	5×10^{13}
Neutron Life	Sec.	5×10^{-5}

6. HOT REACTOR REACTIVITY REQUIREMENTS

Steam Voids	%	2.5
Xenon and Samarium	%	4.0
Maneuvering	%	2.0
Margin	%	1.0
Total	%	9.5

7. TOTAL REACTIVITY CHANGES-XENON OVERRIDE

Cold to Hot	%	3.0
Steam Voids*	%	0.5
Xenon and Samarium	%	6.0
Maneuvering	%	2.0
Margin	%	1.0
Total	%	12.5

*Full steam void reduction (reactor at about half power) required for Xenon override only when full maneuvering term required just before refueling.

8. CONTROL RODS

Total Number (bottom entry)		86
Type		Cross
Composition		40% Cd-60% Ag
Length (poison)	Ft	9.7
Total Width	in.	3.125
Total Thickness	in.	0.312
Clad (347 Stainless Steel)	in.	.05
Rod Spacing (centers)	in.	9.2
Drive (Normal)		Mechanical
Drive (Scram)		Hydraulic
Avg. Velocity (Normal Operation)	fps	0.5
Avg. Velocity (Scram)	fps	9

9. PRESSURE VESSEL

Diameter (I.D.)	ft	12.17
Height (Inside)	ft	39.5
Design Pressure	psia	1,250
Shell Material		ASTM A-302 Steel
Shell Thickness Opposite Core	in.(less clad)	5.250
Clad Material		AISI 304ELC Steel
Clad Thickness	in.	0.375

10. POISON SYSTEM

Poison Material (Sodium Pentaborate)		$Na_2B_{10}O16$ $10H_2O$
Total Solution in Storage	lb	3,760
Total Boron Content	lb	437

Temperature Maintained in Storage	°F	250
Operation	Gravity Feed, Pressure Equalized	

11. REACTOR ENCLOSURE

Sphere Diameter	ft	190
Sphere Design Pressure	psig	29.5
Sphere Steel Thickness	in.	1.25-1.4
Leakage (Max.Permissible)	%/Day @ 37 psig	0.5
Emergency Cooling System Capacity	% Rated Heat	6.0

C. POWER PLANT

1. PRIMARY STEAM DRUM

Dimensions	7 feet, 11½ inches I.D. by 60 feet long	
Pressure	psia	990
Primary Steam Rate	lbs/hr	1,407,000
Downcomer Fluid Rate	lbs/hr	24,295,000

2. SECONDARY STEAM GENERATORS

Number		4
Type	"U" Vertical Tube Single Shell	
Fraction of Reactor Heat Removed		.46
Secondary Steam Rate	lbs/hr	1,188,000
Fraction of Turbine Steam Supplied		.46
Total Coolant Rate	lbs/hr	24,195,000
Pressure (Discharge)	psia	510
Heating Fluid Inlet Temp.	°F	543
Heating Fluid Outlet Temp.	°F	510

3. TURBINE

Type	Dual Admission Tandem Compound Double Flow	
Guaranteed Capacity (At 2.5" Hg Absolute)	kw	192,000
Make Up	%	0.5
Speed	rpm	1,800
Primary Steam Inlet Pressure (Dry and Saturated)	psia	965
Primary Steam Inlet Temperature	°F	541
Secondary Steam Inlet Pressure (Dry and Saturated)	psia	475
Secondary Steam Inlet Temperature	°F	461

4. GENERATOR

Capacity (At .85 P.F. and at 30 psig H_2)	kva	245,500
Voltage	volts	14,400
H_2 Pressure	psig	30
Speed	rpm	1,800

5. CONDENSER

Type	Horizontal, single pass surface condenser with divided water boxes and de-aerating hotwell.	
Design Pressure (Absolute)	Inches of Mercury	2-1/2
Design Steam Flow	Lbs/hr	1,524,490
Cooling Water Temperatures	^oF	75
Tube Cleanliness Factor	%	70
Hotwell Capacity	Gals.	40,000

6. FEEDWATER HEATERS

Number, Primary Stream with Integral Drain Coolers		3
Number, Primary Stream with Condensing Surface only		2
Number, Secondary Stream, with Condensing Surface only		5
Separate Drain Cooler, in Primary Stream only		2
Type	Surface "U" Tube, Vertical with Channel Up	
Number of Extraction Points		5
Final Temperature of Feed-water	^oF	405

7. PUMPS

Name	Required Operating	No. of Spares	Type (Centrifugal)	Capacity (GPM Each)	Rating (HP Each)
Reactor Recirculation	4	0	Single-Stage	17,500	650
Primary Feed	2	1	Multi-Stage	1,650	1,750
Condensate	2	1	Multi-Stage	3,100	350
Secondary Feed	2	1	Multi-Stage	1,400	800
Condenser Circulating	2	0	Vertical, Single Stage	90,000	500

8. DEMINERALIZERS

Name	Required Number	Type	Capacity (GPM Total)
Reactor Clean-Up	2	Mixed Bed	400
Condensate	3	Mixed Bed	3,200
Make-Up Water	2	Cation, Anion, Mixed Bed	90
Waste	2	Mixed Bed	400

DRESDEN NUCLEAR POWER STATION

SAFEGUARD DESIGN CRITERIA

SECTION IV

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SAFEGUARD DESIGN CRITERIA

SECTION IV

Detailed specification of the safeguard design criteria for the Dresden Nuclear Power Station is outside of the scope of this document. However, the basic safeguard philosophy guiding the design of the plant is summarized in this section. The embodiment of this philosophy in specific design of features is reflected in the subsequent portions of this document.

A. NORMAL OPERATION

All phases of the normal operation of the plant, including disposal of all radioactive materials produced, must be such that,

1. These operations do not result in exposure of any persons on or off the plant premises to radiation in excess of the permissible limits; and

2. They do not result in radioactive contamination of terrain, surface or ground water, or atmosphere outside the plant boundaries in excess of permissible limits.*

B. SAFEGUARDS AGAINST ACCIDENTS

The design, construction, and manner of operation of the plant must be such that the likelihood of infraction of the above-mentioned normal-operation provisions--by any mechanism, including attainment of excessive nuclear-fuel temperatures--through operating error, equipment malfunction, or otherwise, is kept sufficiently low in relation to the magnitude of the industrial hazards involved that the net danger to personnel on or off the plant premises is not appreciably greater than the dangers associated with the operation of fossil-fuel-fired power plants.

The following are examples of the general means to be employed in furtherance of this purpose:

1. A nuclear reactor of such design that the reactor will tend to shut itself down upon a potentially dangerous increase in its power--that is, a temperature increase and excessive

*The operation of any one plant may contribute some small fraction, such as one-fourth, of the permissible limit. The exact value of this fraction for any one plant is not significant except that the total contributions of all nuclear plants, which might be located in the vicinity in the future, must not exceed the permissible limits.

steam formation both tend to shut the reactor down.

2. At least two separate and independent safety systems to shut the reactor down. One system is to contain a set of control-safety rods capable of fast shutdown of the reactor by signal from any one of several (approximately eleven) potentially unsafe operating conditions. The second, primarily to act as an emergency backup to the first system, is to introduce a liquid "poison" to the steam-water mixture in the reactor vessel to shut the reactor down.

3. At least two separate and independent systems for cooling the reactor. The primary system must have a capacity capable of cooling the reactor under design operating conditions. The secondary system must be capable of cooling the reactor following "scram" and isolation from its normal cooling system.

4. Design of safety devices in such a way that their malfunction would shut the reactor down rather than cause or permit an increase in its power.

The provision of specific features to minimize the possibility of nuclear accidents is based on analysis and evaluation of the general types of contingencies that have a reasonable possibility of occurrence.

C. ENCLOSURE

Although the possibility of a nuclear accident to the plant is extremely remote, by virtue of the provisions indicated under B above, the reactor and associated equipment will be housed in a vapor-tight enclosure to confine the radioactive vapors that might be liberated from the reactor in the event of a reactor rupture accident to prevent extensive radioactive contamination of the environment.

For a description of the enclosure (a 190 foot diameter spherical steel shell), reference is made to Section VI of this document.

D. SAFEGUARD EVALUATIONS AND REPORTS

The specific safeguard features of the plant are being evaluated and described in a series of reports being prepared for submittal to the United States Atomic Energy Commission in compliance with licensing regulations (Section 50.34 of Part 50 of Title 10 of the Code of Federal Regulations) and the provisions of the construction permit (No. CPPR-2).

The following series of reports have either been submitted or are contemplated:

1. Enclosure Section of the Hazards Summary Report

2. Preliminary Hazards Summary Report

3. Operating Specifications

4. Disaster Plan

5. Final Hazards Summary Report (Superseding the preceding submittals and any revisions of them).

DRESDEN NUCLEAR POWER STATION

PLANT LAYOUT AND EQUIPMENT ARRANGEMENT

SECTION V

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PLANT LAYOUT AND EQUIPMENT ARRANGEMENT

SECTION V

The purpose of this section is to present the basic criteria governing the location of the plant, the functional requirements governing the design of the process and service buildings, and the location of the equipment therein.

The following reference drawings are applicable to these criteria:

General Site Plan	124F713	Print 1
Plant Area Arrangement	124F714	Print 3
Plant Access Control Plan	124F715	Print 4

A. LOCATION OF PLANT ON SITE

The Dresden Site will comprise 940 acres of land along the Illinois and Kankakee Rivers. The area of the site, the cooling water supply and its general location in the Commonwealth Edison System are such that an ultimate capacity of 1000 megawatts of electric power can be attained. The location and arrangement of Unit Number 1 on the site will therefore be based on future expansion to four nuclear steam power units, or alternatively a lesser number of nuclear steam units, with the balance of the ultimate capacity in coal-fired steam units.

A nuclear plant must afford protection to the adjacent area against nuclear hazards. This protection includes necessary shielding to protect the public against injury from gamma rays and an enclosure capable of withstanding probable forces and preventing the escape of radioactive gases or particles resulting from a nuclear incident.

The following criteria have been established for locating the four-unit nuclear plant on the site.

1. Any unshielded containment structure of steel not encased in concrete will be located at least 0.5 mile from Skinner Island in the Kankakee River east, from the navigation channel in the Illinois River north, and from the south and west land boundaries of the site.

2. Additional power plant units at the Dresden Site will be spaced not less than 600 feet center to center of the spherical containment.

3. In the case of containments, the construction of which involves the blasting of rock, the clear distance between any two containments will not be less than 300 feet.

On the basis of the above criteria, the location of the sphere and future plants on this site was selected as shown on Drawing 124F713, General Site Plan.

B. BUILDING AND EQUIPMENT ARRANGEMENT

In addition to the spherical enclosure, the plant will include the Turbine Building, Access Control Building, Fuel Building, Radioactive Waste Building, Warehouse, Machine Shop, and Administration Building. A large stack will discharge the ventilating system exhaust high into the air. An intake structure will supply cooling water to the plant.

1. CRITERIA FOR ARRANGEMENT OF THE BUILDING AND EQUIPMENT

The arrangement of the buildings and equipment will be based on the following criteria which were developed as a guide for the design of this plant.

a. The plant will operate at a high load factor and provide a reliable source of electric power comparable in all respects to a conventional power plant.

b. Shielding and ventilation will be adequate to keep personnel exposures within the permissible limits; all access to potentially contaminated areas will be under rigid control; and automatic and remote controls will be provided for radioactive equipment.

c. All equipment associated with the generation of primary steam will be enclosed in a gas-tight sphere. Access to the sphere will be through gas-tight locks. All steam and water lines and ventilation ducts penetrating the sphere which may permit possible leakage of vapor out of the sphere following an incident will be equipped with automatic quick closing isolation valves.

d. Auxiliary equipment containing radioactive materials associated with the main turbine will be arranged in shielded compartments. These compartments will be grouped together in the main section of the turbine building.

e. Controls and instruments will be shielded from operating equipment. In general, duplicate pieces of equipment will be separated by shield walls and isolation valves.

f. The design of the plant will be aimed at minimizing the spread of radioactive material.

g. Spent fuel and contaminated fuel racks will be handled and stored under water. Facilities will be provided for returning spent fuel to a processing plant and for storing new fuel in a fireproof vault.

2. GENERAL BUILDING ARRANGEMENT

The arrangement of the buildings is shown on Drawing 124F714, Plant Area Arrangement. The Turbine Building will adjoin the Reactor Enclosure on the west side. The Administration and Access Control Buildings will be adjacent to and south of the Turbine Building. The Shop and Warehouse, and Fuel Building will be located south of the Enclosure, while the Radioactive Waste Building will be to the east. The Intake Structure and the Switchyard will be north of the Turbine Building.

3. EQUIPMENT ARRANGEMENT

a. Reactor Enclosure

The sphere will contain the Nuclear Steam Supply System which will include the reactor vessel, primary steam drum, secondary steam generators, recirculating pumps, clean-up demineralizer, fuel transfer facilities and other reactor auxiliaries. Two pressure-tight locks will be provided for access of personnel and equipment. A pressure-tight emergency exit opening will likewise be provided as well as a removable service opening seventeen feet in diameter through the sphere wall. Adequate shielding is to be provided so that personnel may check on the performance of equipment and work on one secondary steam generator or one recirculating pump while the remainder of the plant is operating. A 50-ton bridge crane will serve the reactor vessel and fuel handling equipment. A vertical tube through one side of the sphere will permit fuel to be transferred between the fuel building and the reactor. The sphere will be ventilated by external supply and exhaust fans.

b. Turbine Building

The Turbine Building will contain the remainder of the main power plant equipment and auxiliaries. In a group of compartments shielded by thick concrete walls will be the turbine-generator, condenser, feedwater heaters, air ejectors, condensate pumps, secondary feed pumps, condensate demineralizers and radioactive process piping. The turbine axis will be radial to the sphere. The feedwater heaters, turbine-generator, and railroad spur will be served by a 100-ton overhead bridge crane. The crane will be provided with adequate pendant and cab controls. Non-radioactive equipment, the control room and the shift offices will be arranged around the periphery of the shielded area. This will be accomplished by extending the main turbine bay westward and providing auxiliary bays on the north and south sides of the main bay. The extension of the main building will provide a laydown area on the turbine floor. On the intermediate floor directly below this area will be the control room, auxiliary instrument room and switchgear. Battery rooms, the two exciters, switchgear and instrument shop will be located on the ground floor. The south auxiliary bay will extend nearly the entire length of the turbine building and will contain shift offices, air conditioning equipment, ventilation supply fans, primary feed pumps, make-up water treating equipment, service air compressors and other items. The north auxiliary bay will be much smaller and will contain turbine lube oil equipment, auxiliary heating boilers and ventilation exhaust fans.

c. Fuel Building

The Fuel Building will contain equipment and facilities for storing new fuel, assembling fuel assemblies, stripping re-usable zirconium channels from spent fuel assemblies, storing the spent fuel and loading the spent fuel into casks for shipment to a processing plant. The fuel will be transferred to and from the reactor through a water-filled underground tunnel and the vertical tube through the sphere. The Fuel Building is to be equipped with a 75-ton overhead bridge crane for handling shipping casks and two small cranes for handling new and spent fuel.

d. Radioactive Waste Building

The Radioactive Waste Building will contain equipment for removing radioactive matter and chemical impurities from the contaminated waste water. Section XIV, Waste Treatment and Disposal System, will discuss this layout and equipment in more detail.

e. Shop and Warehouse

The Machine Shop will be served by a 10-ton overhead bridge crane and will be divided into a contaminated equipment disassembly and decontamination area, a contaminated shop, and an uncontaminated shop. The warehouse will be adjacent to the shop and separated from it by a row of offices and tool cribs.

f. Access Control Building

The Access Control Building will contain laboratories, a first aid station, locker room and health monitoring facilities. All personnel entering or leaving the controlled area must normally pass through this building. It is to be centrally located to facilitate the flow of traffic. Sheltered access corridors will lead to the other buildings.

g. Administration Building

The Administration Building will contain the reception desk, offices, switchboard, space for clerical personnel and a meeting room. A direct access between the Administration Building and the control room will be provided.

h. Personnel and Equipment Transfer Area

A weatherproof structure will provide a sheltered passageway for personnel and equipment between buildings. A large overhead covered corridor will connect the equipment transfer lock in the shell of the sphere with the Turbine Building approximately forty feet above grade. It will provide protection from the weather while transferring equipment from the sphere and Turbine Building to the Machine Shop.

DRESDEN NUCLEAR POWER STATION

STRUCTURAL AND ARCHITECTURAL CRITERIA FOR PROCESS BUILDINGS

SECTION VI

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STRUCTURAL AND ARCHITECTURAL CRITERIA FOR PROCESS BUILDINGS

SECTION VI

The purpose of this section is to present the functional requirements, the architectural and structural considerations, and the shielding requirements governing the design of the process buildings of the Dresden Plant.

The following reference drawings are applicable to these criteria:

Fuel Building	124-F-727	Print 25
Radioactive Waste Building	124-F-728	Print 26
Turbine Building General Arrangement	124-F-760 thru 766	Prints 18-24
Reactor Enclosure	7368-E-61 thru 81	Prints 5-15

A. RADIATION SHIELDING

1. RADIATION SOURCES

The radiation which must be attenuated consists of neutrons from the core, gamma rays from the Nitrogen-16 and Oxygen-19 from water which has passed through the core, gamma rays from corrosion products from the entire system, gamma rays from ruptured fuel element fragments, and gamma rays from materials which have induced activity from neutron capture. The source controlling the shielding around the reactor vessel is fast core neutrons. The 6 mev gamma rays originating from Nitrogen-16 (created by a fast neutron reaction in the water) control the shielding for pipes carrying reactor water and steam, downcomers, heat exchangers, pumps, valves, and the turbine. In some locations, corrosion products and/or ruptured fuel particles will dominate, for example, the demineralizers and clean-up equipment.

For the bases of shielding calculations the Nitrogen-16 activity is assumed to go entirely with the water in the primary loop. It is also assumed that all the Nitrogen-16 goes with the steam to the turbine. It is further assumed that the nitrogen is taken out through the air ejectors and held up before going out of the stack. Appropriate decay times are allowed for the Nitrogen-16 in its travel time to the several components. A hold-up time of three minutes in the hotwell allows the Nitrogen-16 to decay to a very low level. Beyond the hotwell, activity sources are principally corrosion product build-up.

2. RADIATION DESIGN REQUIREMENTS

The National Committee on Radiation Protection has recommended 300 mrem/week as the basic maximum permissible dose for occupational exposures. Areas where access is not controlled or continuous occupancy may be expected shall have radiation levels not exceeding 0.5 mr/hr. Shielding for all other areas will be determined by access requirements.

3. SHIELDING REQUIREMENTS

Shielding wall locations and thicknesses are indicated on the reference drawings by dimensions in block outlines. Shielding material will be standard density concrete unless specified otherwise.

B. REACTOR ENCLOSURE

The purpose of the reactor enclosure is to prevent the escape of radioactive material in the event of rupture of the reactor or connected piping. Secondarily, it provides weather protection for the Nuclear Steam Supply System and Auxiliaries.

1. ENCLOSURE DESIGN REQUIREMENTS

The enclosure is to be a steel sphere 190 feet in diameter with the equator elevated 56 feet above grade. During plant operation the sphere will be supported partially at the equator by 20 tubular steel columns and partially below grade by a concrete saucer-shaped foundation.

The enclosure will be designed for an internal pressure of 29.5 psig with a temperature rise of 250 F plus dead, snow, and wind loads; for non-simultaneous earthquake load; and uniform external load of 1 psig. The shell will be fabricated from steel conforming to ASTM A-201, Grade B, Firebox Quality produced to ASTM A-300 specification with guaranteed Charpy valves from transverse specimens. The plate thickness will vary from 1.25 to 1.40 inches. The structure will be pneumatically leak tested at 10 psig and strength tested at 37 psig to demonstrate its integrity.

The exterior of the enclosure above grade will be covered with insulation and water-proofing.

2. ENCLOSURE PENETRATIONS

Pressure locks will provide access into the enclosure during plant operation. These locks each will have 2 doors in series, interlocked so that one door must be closed at all times. A personnel and equipment lock with 8 feet by 8 feet doors is to be located 37 feet 6 inches above grade. This lock can accommodate a 20 ton load 20 feet long. Two locks are to be located 12 feet 6 inches above grade. One will be a personnel entrace with 2 feet 6 inches by 6 feet 0 inches doors and the other, a personnel escape lock 30 inches in diameter. A bolted access door, 17 feet in diameter, will permit the movement of large pieces of equipment during periods of plant shutdown.

In addition, there are to be penetrations for fuel handling piping, ventilation, instrumentation and electrical leads. These penetrations will be sealed or provided with sphere isolation valves.

3. EQUIPMENT ROOMS BELOW GRADE

The space in the sphere below grade will be comprised or rooms, tunnels, and corridors. Equipment such as flux monitoring instrumentation, core flow monitoring instrumentation, reactor demineralizer equipment, and drain tanks are to be housed in these rooms. Access to these rooms will be provided by means of stair wells and hatches.

4. PASSENGER ELEVATOR

A passenger elevator for access to various operating levels within the sphere will be provided. The cab will be sized to handle a minimum of one operator and one 200 ampere welding machine.

C. TURBINE-GENERATOR BUILDING

The Turbine-Generator Building will be adjacent to the sphere on the west side, with the centerline of the Turbine-Generator bisecting the sphere. It will be approximately 92 feet by 200 feet by 90 feet high. A south auxiliary bay is to be 39 feet by 186 feet by 25 feet high. The north auxiliary bay will be 48 feet by 104 feet by 25 feet high.

From the foundations on rock to the Operating Floor 34 feet above grade, the major portion of the structure will be reinforced concrete which serves both shielding and structural requirements. Above that level, a combination of reinforced concrete shield walls, structural steel crane columns and roof trusses will form a rigid frame.

The west end of the main structure and the south auxiliary bay are to be of structural steel framing above the ground level. The north auxiliary bay will be reinforced concrete, both walls and roof. The steel framed portions of the structure are to be covered with siding and steel roof deck with insulation and built-up roofing.

D. FUEL BUILDING

The Fuel Building lies immediately south of the sphere and will be bounded on the west by the warehouse. The structural steel framed structure above grade is to be 95 feet by 60 feet by 52 feet high. Siding is to be used; the steel roof deck is to be covered with insulation and built-up roofing.

the concrete floor will be 4 feet 3 inches above grade, which is to be loading dock height above the railroad track. Length of track within the building will accommodate one freight car.

A reinforced concrete fuel unloading pool will be connected by an underground tunnel to the fuel lock on the sphere. Adjacent to this pool and connected to it is to be a spent fuel storage pool. Provision will be made for future expansion of this pool outside the present building.

A new fuel storage vault 32 feet by 38 feet by 25 feet high, entirely of reinforced concrete, will be attached on the east side, with access only through a vault door from within the fuel building.

E. RADIOACTIVE WASTE BUILDING

The Radioactive Waste Building is to be located east of the fuel building. The structure will be below grade with the exception of the control room, and demineralizer and filter compartments which are at grade. The control room is to be of light steel frame construction with metal siding, steel roof deck and a built-up roof. The below-grade portion will consist of a series of reinforced concrete cells housing the process equipment, and tankage with a shielded personnel access corridor to the cells for inspection and maintenance. The elevation of the process cells will be determined by the requirements of the various drain lines feeding the tanks.

F. PAINTING AND PROTECTIVE COATINGS

Leakage and sprays of process fluids from valves, flanges, and equipment during maintenance or operation in various process areas are a potential source of contamination to floor and wall surfaces. In order to minimize retention of contamination on these surfaces and to make them amenable to various decontaminating procedures, it will be necessary to protect them with resistant paints or coatings. Surface treatment given to various process areas will be one of the following four types.

Type A - The floor, walls, and ceiling of the area will be coated with a chemically resistant paint such as Amercoat #33, or approved equal. Application of the paint shall be in accordance with manufacturers recommended procedure. It will be used in areas susceptible to gross contamination of all surfaces by sprays of contaminated water or steam. Not only will this surface minimize retention of contamination from highly radioactive liquids, but it may also be cleaned with strong decontaminating solutions.

Type B - This coating will be identical to Type A except that it will be applied only to the floor and a four foot wall dado. This type will be used in areas not as susceptible to gross contamination of surfaces by sprays of liquid or vapors.

Type C - All surfaces shall present a true and uniform surface free of dust and loose particles. Form marks shall be ground even with the surface.

The concrete shall be treated with standard commercial colorless concrete paints or conditioners to make its surface relatively impervious to water. This type of protective coating will be used in areas susceptible to leakage or sprays of slightly contaminated steam or water. The prime function of this treatment is simply to shed water and prevent wetting of the concrete surface. Traces of contamination will be removed by hosing down and scrubbing instead of using decontaminating solutions which would require application of chemically resistant paints to the surface.

Type D - This type shall be a natural concrete finish. All form marks shall be ground even with the surface. The surface shall present a true uniform surface free of dust and loose particles. This surface is to be used in operating areas not subject to exposure to contaminated liquids or vapors. Floors are to be hard finished.

1. REACTOR ENCLOSURE

   Surfaces in this building shall be finished as noted below.

   a. Type A

      Control rod removal space, tunnel, and accumulator room
      Fuel handling canal

   b. Type B

      Core flow monitor room
      Flux monitor room
      Scram room
      Instrument rooms
      Reactor clean-up demineralizer room
      Valve areas in shielded pipeways to Turbine Building
      Secondary steam generator rooms
      Nuclear steam instrument room
      Operating floor around fuel handling canal and reactor

   c. Type C

      Unloading heat exchanger area
      Feedwater valve rooms
      Floor and wall area around primary steam drum

d. <u>Type D</u>

All external surfaces of structural and shielding concrete exposed to atmosphere of the Reactor Enclosure
Remainder of concrete in shielded pipeway to Turbine Building
All corridors similar to those servicing the flux and flow monitor rooms, control rod rooms, etc.
Floor drain and system drain tank rooms

2. <u>FUEL BUILDING</u>

The finish schedule for this building will be as follows:

Tunnel to Reactor Enclosure	Type B
Pool for channel stripping	Type A
Decontamination Area	Type B
Spent Fuel storage	Type D
All other areas	Type D

3. <u>TURBINE BUILDING</u>

All cells containing equipment which handle contaminated process solutions will treated with a Type B finish.

4. <u>RADIOACTIVE WASTE BUILDING</u>

Only cells with process equipment will be treated with Type B finish.

All other areas not specified above will be treated by standard industrial finishing practice.

DRESDEN NUCLEAR POWER STATION

REACTOR

SECTION VII

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REACTOR

SECTION VII

This section presents a design description of the major components that make up the reactor, including the fuel rods, fuel bundle, core assembly, control rods and their drive mechanism, the back-up safety system, and the reactor vessel.

The following reference drawings are applicable to these criteria:

Fuel Assembly	141F322 Print 27
Control Fuel Assembly	139F184 Print 28
Isometric Core Assembly	193E810 Print 29
Control Rod Poison	196E230 Print 30
Control Rod Piping - Schematic Diagram	537D497 Print 32
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A. GENERAL DESIGN CRITERIA

The overall design objective is a reactor having the lowest capital and operating costs compatible with mechanical design limitations, reliability of operation, satisfactory performance, long life, and adequate safety margins. The design of the reactor core and vessel permits complete removal and replacement of components and equipment installed within the vessel.

Several operating, physics, and safety requirements affect the design bases of the various components. The core assembly geometry must satisfy the demands of physics, mechanical design limitations, and economics. The control rods must be of a size and shape compatible with the fuel configuration. The number of control rods must satisfy overall control requirements and the number of penetrations that can be made in the vessel. The control rod drive system must provide for normal control rod movement as well as scram operation. The liquid poison system must provide control to hold the reactor sub-critical in the event of some failure of the control rod system.

The vessel must provide for all of the penetrations which are necessary for piping and core components, must operate safely at the operating pressure, and must be of such size as to contain the core assembly and other core components.

B. FUEL ROD

A fuel rod will consist of four connected segments. Each segment will contain uranium dioxide fuel pellets encased in a zircaloy tube capped at both ends with connectors to act as fasteners.

1. DESIGN REQUIREMENTS

a. Number of Segments

The selection of the number of segments and how they are attached together must represent a compromise between the following factors: economy, which favors one segment; operating stability, which favors a large number of segments; and ease of fabrication and assembly.

b. Length of Service

To attain long irradiation, the fuel rods must be capable of operating in the reactor core environment for one to four years depending on their location. Uranium dioxide has been selected as the basic fuel. Zircaloy-2 has been selected as a jacket material since this material has a low neutron capture cross section as well as a high corrosion resistance.

c. Optimum Dimensions

The fuel rod diameter of 0.56 inches has been established on the basis of economics and practicality. An analysis was made of fuel cost as a function of rod diameter. For small rod diameters, the number of rods required per year becomes large, which increases, relatively, the cost of zircaloy jackets. For large fuel rod diameters, the fuel temperature limitations require lower heat flux intensities, which, in turn, require a relatively larger number of rods and a larger fuel inventory. Depending upon the cost of zircaloy, a minimum cost occurs between 0.5 to 0.6 inch diameter fuel rods.

d. Temperature

The maximum fuel temperature is at the center of the fuel rod in the region of highest neutron flux. It is calculated to be 2800°F.

2. DESIGN DESCRIPTION

Arrangements and dimensions of fuel rod components are shown on Information Drawings, 141F322 and 139F184. The basic fuel will be slightly enriched uranium dioxide fabricated as a sintered, solid, cylindrical pellet (0.50 inches long, 0.493 inches O.D.). A series of these pellets are to be encased in an 0.03 inch wall, Zircaloy-2, tubular jacket to form a 28 inch rod. The outside diameter of the clad rod will be 0.56 inches. Four such fuel rod segments are joined by screw connections to make up the basic 9-foot 4-inch rod.

Fuel jacket to pellet clearances are established by optimum compromise of heat transfer, structural stability, and economical component tolerances. This clearance arrangement allows for independence of jacket and pellet in the operating condition, thereby making pellet binding and differential expansion of adjacent fuel rods unlikely.

C. FUEL ASSEMBLY MECHANICAL ARRANGEMENT

The regular fuel assembly will consist of 25 fuel rods in a 5 x 5 array mechanically tied together into an integral unit and encased in a removable square zircaloy channel. The bottom of the fuel bundle will terminate in a round nose piece which fits into mating holes in the core support plate. A combination orifice plate and nose piece will screw into the lower transition section of the channel assembly.

1. DESIGN REQUIREMENTS

a. Geometry and Flow Requirements

Twenty-five fuel rods are to be handled as a unit. The square array will satisfy the requirements of the overall water to uranium dioxide volume ratio and spacing between the fuel rods and will allow the use of flat fuel plates if later required.

The geometrical arrangement of the fuel rods and the method of attaching them together must provide adequate flow area to allow passage of the required quantity of coolant with minimum friction head loss. Flow restrictions adjacent to heat generating surfaces must be avoided to reduce the possibility of film boiling and attendant fuel burnout.

b. Structural Requirements

Sufficient structural support must be designed into the fuel assembly to prevent excessive vibration of each fuel rod as well as displacement of the fuel bundle as a whole. Fuel assemblies must be sufficiently stiff to resist distortion during handling and irradiation so that refueling operations can be carried out smoothly.

c. Control Rod Pentrations

Since the core will be penetrated by control rods and various instrument elements, access must be provided in the fuel assemblies for their accommodation. The channels must provide stiff guide surfaces for control rods at all positions within the core.

d. Orificing

Adequate orificing must be provided within each fuel channel to allow the regulation of coolant flow. The orifice pieces must be interchangeable.

e. Thermal Expansion

The average heat generation of individual fuel rods within a given fuel assembly may vary from rod to rod. Provisions must be made to accommodate the resulting relative axial expansion.

f. Interchangeability

The core channel sections of fuel assemblies are to be re-used as many times as their condition allows. Therefore, provisions must be made to permit interchanging of channel sections on a routine basis.

2. DESIGN DESCRIPTION

The basic configuration of both regular and control rod bearing fuel assemblies is shown on Information Drawings, 141F322 and 139F184. The regular fuel assembly will consist of 25 individual 0.56 inch diameter fuel rods spaced 0.735 inches between centers in a square pattern. The assembled fuel rods will be loaded in a square zircaloy channel 3.76 inches on the inside edge with a wall thickness of 0.03 inches. In addition, special fuel bundles will be arranged to accommodate control rods. The present control rod displaces nine fuel tubes, thereby reducing the number of active fuel rods to 16 (2 x 2 in each corner). Should it be determined at a later date that additional control is required, an alternate design is being developed which will accommodate a larger control rod.

Individual fuel rods in each of the two basic configurations will contain a total of 8-feet 10 inches of fissionable material, and, in addition, several short lengths of zircaloy connector pieces totaling approximately 6 inches. The fuel rods are segmented into four separate lengths, each complete with end plugs and connector fittings. The adjoining shoulders formed by abutting rod segments will provide seating surfaces for spacer plates which hold each rod into proper alignment and maintain the required rod array. Fuel bundles will be stiffened and shrouded by a square channel tube to which they are mechanically attached at the lower end. Slip guides in the form of centering nodes will be positioned at alternate intermediate points--specifically at the fuel tube segment junctions--to provide for relative movement of the fuel bundle and channel component during thermal transients. The force of the fuel bundle centering nodes acting on channel walls will tend to maintain proper centering alignment and provide positive contact between potential sliding surfaces.

All fuel tubes will terminate in a common base support or transition piece located at the lower end of the assembly. This base forms a holder for replaceable orifice and nose piece units. The resulting fuel bundle is attached to its mating channel unit at the upper end by means of cap screws. This arrangement allows stripping of the channel from a given fuel bundle to be performed by a simple mechanism acting down into a shielded vertical cell.

Fuel rods are supported through expansion springs to a common member at the base support piece and act through expansion springs against a common tie plate at the top. All relative thermal expansion between fuel rods is referenced from a rigid center spacer plate at the mid-elevation of the assembly. This arrangement enables such relative deflection acting against flexible spacer plates at the quarter elevation to be reduced to an insignificant value. Lifting bails are provided at the upper end of each fuel bundle assembly for handling.

D. CORE ASSEMBLY MECHANICAL ARRANGEMENT

The core assembly will consist of a core support plate which will rest on a ring supported on columns attached to the vessel bottom. A core guide support, which also acts as a thermal shield, will rest on the support ring at the bottom and will be attached to the upper core guide assembly. Fuel assemblies will rest on the core support plate and will be held in transverse alignment at the top by the core guide. The core assembly unit consisting of the core guide support, a core support plate, a core guide, and the fuel assemblies will be supported through columns to the bottom of the vessel.

1. DESIGN REQUIREMENTS

a. Geometry

The primary function of the core assembly is to maintain the proper geometrical array of fuel assemblies. The support must be stable and firm while maintaining sufficient flexibility to provide for load deflections and thermal movement. Areas of high vibration and instability must be avoided in order to prevent the possibility of undue wear and fretting corrosion.

b. Refueling Provisions

Provision must be made for remote refueling and maintenance operations on a routine basis. Adequate clearances must be provided throughout the core structure to enable ease in handling without the presence of galling or distortion.

Supporting structures within the core assembly must be of sufficient strength to allow for minor misalignment of fuel bundle assemblies during refueling operations. Entry points and guide surfaces must be tapered and faired to enable simple positioning of fuel bundle assemblies during refueling.

c. Flow Regulation

Each fuel bundle assembly must be capable of providing self flow regulation. The core assembly must accommodate this requirement by directing monitored flow into channel sectors through the lower core support structures. In addition, guide members at the core exit must allow unrestricted flow into the discharge plenum above.

d. Penetrations

Control and instrument element penetrations must be provided within the core assembly. Support and guide structures must provide adequate clearance for such penetrations without sacrificing core strength and rigidity. Instrument elements must be supported within the core assembly in a stable manner and by methods allowing simple maintenance. The core assembly must provide guide surfaces for control units and prevent control rod misalignment and distortion.

e. Material of Construction

Materials of construction must conform to all required design standards of strength, corrosion resistance, neutron adsorption and workability under continuous operating conditions of saturation temperature and high level gamma and neutron bombardment. Wherever possible, standard materials must be used.

f. Thermal Expansion

The core assembly must contain sufficient inherent structural flexibility to accommodate relative thermal expansion between its component parts. Provision must be made to tie the core assembly to the vessel supports in a stable manner. Dissimilar thermal expansion coefficients between various material types must be considered in the determination of index points and the location of guide surfaces. Support and guide members must be located to allow ease of replacement and handling of fuel assemblies.

g. Core Assembly Size

In order to establish the core asembly size, the number of fuel bundle assemblies required and their geometry must be known. The following factors are involved.

1.) Heat Flux

A peak heat flux of 385,000 btu/hr-ft^2 allows for a total hot spot factor of 1.3 during full-load operation at expected flux distributions.

2.) Flux Distributions

The flux distributions which can be attained reasonably with proper enrichment and the existing bubble distribution are as follows: (a) axial - an approximate cosine flux distribution which gives a peak to average specific power along the fuel rod of 1.64 (b) radial - flattened flux out to about 0.5 of the radius. This gives a peak to average fuel rod power ratio of 1.43. The axial flux distribution may be attained by (a) use of control rods in the non-boiling region, (b) variation in axial fuel density, (c) variation in axial enrichment. The radial flattening may be attained by one or a combination of (a) control rods in the central flattened region, (b) re-fueling schedule which moves irradiated fuel from the outer region to the central region of the core, (c) variation of enrichment and/or fuel density in the radial direction.

3.) Hot Spot Factors

The hot spot factor allowance is 1.3. This factor includes local effect on control rods lack of uniformity of enrichment, flux perturbations due to control rod withdrawal, and fuel burn-up.

The hot spot factor, the heat flux design limit, and the flux distributions, set the number of fuel rods required at about 17,000. The number of flow channels required, considering the fuel rods displaced by control rods and instruments, is 712.

4.) H_2O/UO_2 Volume Ratio and Mechanical Design Limitations

The water to uranium dioxide volume ratio is 2.1:1.

This selection represents a compromise between considerations of physics, economics, and mechanical design limitations.

The requirements of 712 channels, the water to uranium dioxide volume ratio above, and mechanical arrangement limitations, fixes the dimensions of the core assembly.

2. DESIGN DESCRIPTION

The general isometric view of the core assembly showing the entire arrangement is shown on Information Drawing 193E810. The dimensions of the fuel assemblies are given in Information Drawing 141F322, and are described under Section VII-C on Fuel Assemblies.

The reactor core assembly will consist of 626 regular fuel assemblies and 86 fuel assemblies designed to accommodate the cross-type control rods. These assemblies are to be arranged in a vertical cylindrical array. Each fuel bundle will be supported at its lower end by the bottom core support plate. This plate will be 131 inches in diameter and 8 inches thick. Circular holes in the bottom support plate will act as locators for fuel assemblies and will provide flow passages for the coolant. The holes are to be 2.125 inches in diameter in the case of the 626 regular channels and 4 inches in diameter for the 86 channels containing control rods. The fuel assemblies will be guided and positioned at the top by a core guide. The core guide is to be assembled in egg-crate fashion with a diameter of 137 inches. The individual cross pieces will be 4 inches deep and 0.2 inches thick. This thickness controls the spacing between channels in the core. The resulting grid cells through which the fuel assemblies may expand, will be 3.92 inches on the side. Clip springs from the top of the fuel assembly will maintain alignment within the grid cell. The core guide will be held in place by a core guide support which will rest on the ring supported by columns to the vessel bottom. This core guide support will extend around the entire core from the base support ring to the upper core guide. The core guide support will be 140 inches inside diameter and 2 inches thick.

E. CONTROL RODS

The control rod will consist of a cadmium-silver poison section encased in stainless steel.

1. DESIGN REQUIREMENTS

a. Control Requirements

Eighty-six control rods in the shape of a three inch cross provides more than adequate control for the hot reactor. To provide adequate control for long shutdowns with the reactor cold, additional control strength may be required. Some additional strength can be obtained by redesigning the control rod bearing channels to accommodate a cross rod, placed diagonally in the channel, with a one-inch greater width. This will provide 12.5%Δk for the cold reactor case.

b. Material of Construction

Selection of material for the control portion of the rod depends on its neutron absorbing properties, mechanical properties, and cost. The rod must withstand severe tensile stresses during the deceleration period of a scram. This material must contribute to tensile strength and rod stiffness, if possible. The thermal expansion rate of the poison and cladding must be compatible. Corrosion resistance can be obtained either by alloying the poison material with a corrosion resistant material, or by cladding.

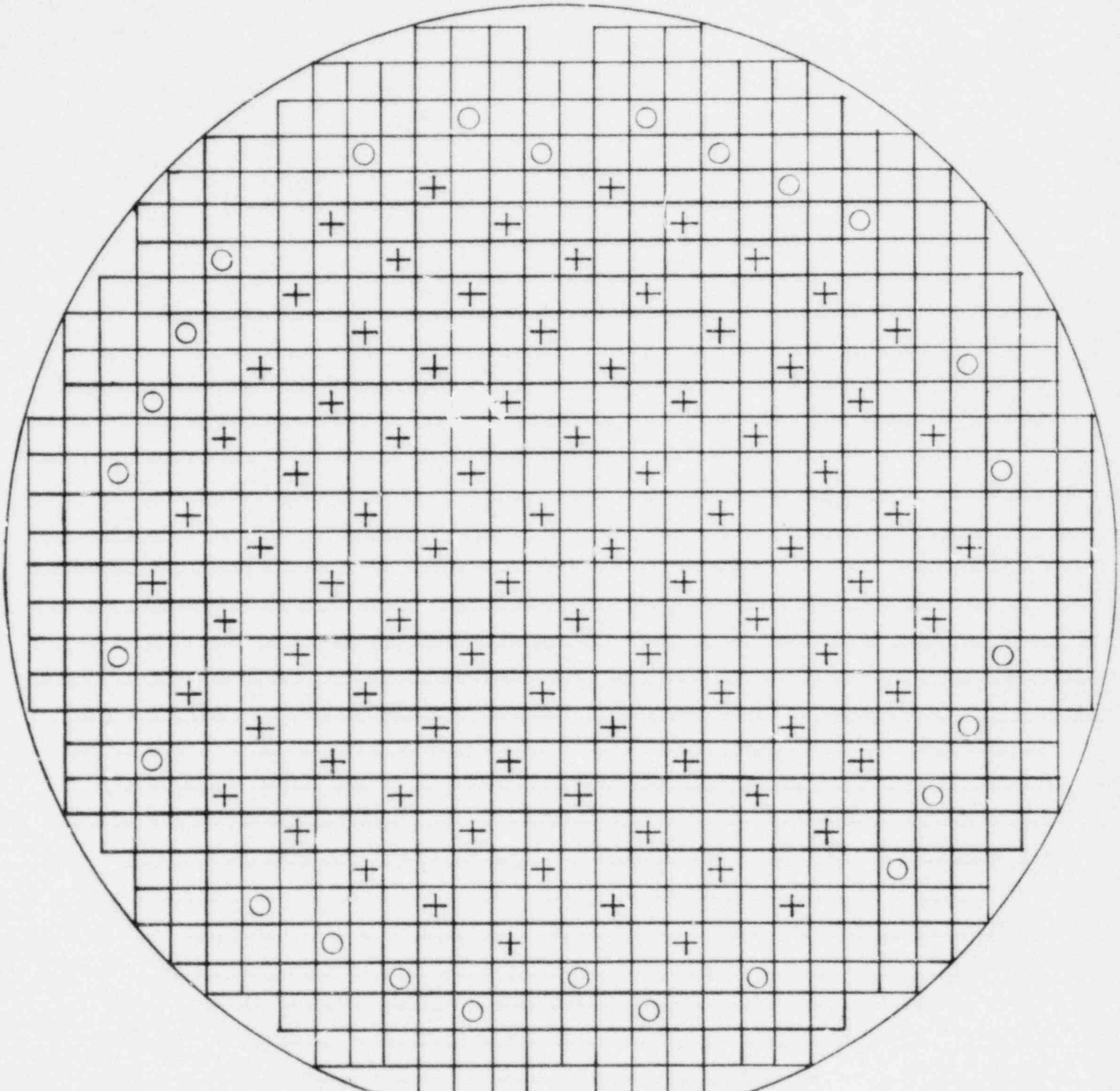
The clad used on the rod must be able to run at relatively high speeds against the zirconium channel provided as part of the fuel bundle-channel assembly. Lubrication is provided by the cooling water and steam flow.

2. DESIGN DESCRIPTION

The control rod is shown on Information Drawing 196E230. Each of the 86 rods is a cross 3.125 inches in total width and 0.312 inches in thickness. The cadmium-silver alloy (40% cadmium-60% silver) is 0.212 inches thick clad with 0.05 inches of 347 stainless steel. The cross is centered in a fuel channel and displaces nine fuel rods. The control rod is separated from the remaining 16 fuel rods by a zirconium wall of 0.03 inches thickness. The poison section of the control rod is 9 feet 8 inches long. The control rods are spaced 9.2 inches center to center. They are located in an 8.5 foot diameter pattern centered in the core. The pattern is shown on the sketch on the following page.

F. CONTROL ROD DRIVE MECHANISM

The rod drive mechanism will consist of an hydraulic cylinder containing a piston attached to the lower end of the control rod element. The cylinder, together with a mechanically positioned lower stop, will be contained in a thimble extending down from the bottom of the vessel. The lower stop will be a ball-nut positioned by an electric motor turning a ball screw. An accumulator tank in addition to the reactor vessel will provide the pressure for scram.



VESSEL PENETRATIONS

+ CONTROL RODS (86)
o INSTRUMENTATION (26)

1. DESIGN REQUIREMENTS

All control rods normally must be inserted or withdrawn one at a time at a speed of six inches per second. During a scram, no less than one-half of the control rods must be capable of being inserted in not over 1.5 seconds. The scram rod drives operate only full-in or full-out and must all be withdrawn before the continuous positioning rods are used. The remainder of the drive mechanisms may be continuous positioning to aid in flux adjustments and for fine control. The continuous positioning drives need not scram fast; however, they must all be capable of driving in simultaneously at their normal rate of speed.

2. DESIGN DESCRIPTION

There is to be an individual control rod drive mechanism for each of the 86 control rods. The control rod drives will be positioned by a motor drive and will operate on scram by a hydraulic system. A drive motor will permit the operator to position the rod along its stroke while the hydraulic system will scram the rod in 1.5 seconds.

A control rod drive mechanism is shown on Information Drawing 196E235. The control rod hydraulic system is shown on Information Drawing 537D497.

a. Thimble Enclosure

A thimble will extend downward from the vessel about 12 feet. This thimble will be 4 inches in diameter where it penetrates the vessel and 4.75 inches in diameter below the vessel. The entire drive including the motor will extend about 15 feet below vessel bottom. A drive system which is essentially a package unit will be inserted in this thimble and attached to a flange at the bottom of the thimble. Provisions will be made for the replacement of the unit drive system.

b. Unit Drive

The unit drive will consist of a double acting piston operating in a cylinder 2.75 inches inside diameter and about 10 feet long. Stellite piston rings will be used for the piston and piston rod seals. The piston section will be held by hydraulic pressure against a mechanical stop which consists of a ball-nut driven by a screw operated from an electric motor. The electric motor will be coupled immediately beneath the unit drive. The motor will be a reduction gear assembly which is to be "canned" into the control drive housing. Independent of the drive mechanism the piston will be free to drive the control rod rapidly when a scram signal is received.

c. Guide Tube

A guide tube will be installed to guide the control rod in the area between the core support plate and the vessel bottom. The guide tube will be prevented from turning by a key in the core support plate and will be perforated to allow necessary cooling water to enter the fuel channel containing the control rod guide. During maintenance, the guide tube may be lifted to uncouple the poison element from the drive. Further handling will be done with the poison element contained in the guide tube.

d. Accumulator Tanks

Twelve accumulator tanks will be provided. Each accumulator will operate 7 rods (in two cases 8). Two accumulators are paired to operate 14 rods for additional reliability. Loss of air charge on one accumulator will result in a slower scram rate for the 14 rods only if it occurs during start-up operation. This effect is seen only during start-up operation.

3. DRIVE MECHANISM SYSTEM PROCEDURE

During normal operation, an excess of pressure will be maintained on the upper side of the piston holding it against the mechanical stop. This pressure will be supplied directly from the primary feedwater pumps through appropriate valving. This pressure will be transmitted to the piston through a line which enters the drive system through the flange at the base of the thimble and will be directed to the upper side of the piston through an annular space. A lesser pressure will be maintained on the lower side of the piston by pressure from an accumulator tank. The accumulator pressure will be maintained at a fixed ratio above vessel pressure, being 80 psi above vessel pressure during normal operation and at 410 psi at 0 vessel pressure. This pressure will also be transmitted to the drive system through a line entering in the flange which is a part of the thimble. A shuttle valve arrangement built in the flange will allow vessel pressure to operate against the lower side of the piston in case the accumulator pressure ever drops below vessel pressure.

The piston, held against the mechanical stop, may now be driven up or down by means of the electric motor driving the mechanical stop. The motor will turn the screw which raises or lowers the ball-nut. The ball-nut will be prevented from turning by a spline.

The rod may be scrammed from any position upon a scram signal which releases the pressure on the upper side of the piston. Cushioning of the rod at the end of a scram stroke will be accomplished by orificing the water being displaced when the piston moves upward. A latch will be incorporated in the upper end of the piston rod to hold the piston rod in the up position. When a scram occurs and the rods are inserted, the pawls will open and will engage notches which will hold the rod in the up position. The drive motor, which also drives in upon receiving a scram signal, will move the ball-nut up until it will be in contact with the piston. This action will withdraw the pawls leaving the piston section able to be withdrawn when pressure is again supplied to its upper side and the motor is operated down.

G. LIQUID POISON SYSTEM

The liquid poison system will consist of an accumulator type reservoir which contains the poison solution, and equalizing line which connects the top of the reservoir to the top of the reactor vessel, and a feed line which will run from the bottom of the reservoir to a sparger system located immediately below the core support plate in the reactor.

The purpose of the liquid poison system is to provide control to hold the reactor subcritical in the event of some failure of the control rod system.

Since fast action is not a requirement, the backup system is to be actuated by the operator. The system must be capable of inserting the poison either during operation or during shutdown with the vessel lid removed.

1. DESIGN REQUIREMENTS

a. Boron Concentration

The boron concentration required in the reactor coolant is dictated by the amount of reactivity which must be absorbed. The cost to attain a large safety factor in the amount of boron is small and thus the total reactivity possible to control is to be 18%.

The boron concentration required is 0.84 pounds of boron per 1000 pounds of water. Since a total of 520,000 pounds of cold water will be contained in the system and will be continually recirculating, the total amount of boron which must be introduced is 437 pounds.

b. Injection Rate

In order to poison all water entering the reactor core, the poison is to be injected at a constant rate compatible with the reactor coolant flow rate. At the maximum reactor flow rate of 8,000 pounds per second, the boron flow rate is 6.7 pounds per second.

The poison is to be injected by gravity feed with pressure being equalized by a line to the top of the reactor vessel. Thus, a constant head will be maintained regardless of reactor pressure.

2. DESIGN DESCRIPTION

Sodium pentaborate has been selected for the poison on the basis of the high boron concentration it provides in solution. All lines and equipment which hold the poison will be maintained at all times at 250°F.

The system design is represented schematically on Information Drawing 537D485.

a. Reservoir

The reservoir is to be fabricated from stainless steel with a formed flexible separator. The tank will be spherical, 4.5 feet inside diameter with a wall of 1.75 inches. The volume is approximately 50 cubic feet. The reservoir will be located 50 feet or more above the core support plate to provide the head necessary to give the correct solution flow.

b. Feed Line

The feed line will be a 6-inch pipe which runs vertically downward from the bottom of the reservoir to a pneumatically operated 4-inch plug valve which opens in less than one second. From the valve will be a 3-inch pipe line which penetrates the vessel wall. Inside the vessel the line will divide into two 2.5-inch pipes which will connect at diametrically opposite points to a pipe circling the control rod system just under the core support plate. The sparger system will consist of five 1.5-inch pipes which will be drilled on both sides along the length and will pass between the control rods to connect at either end of the circular pipe.

c. Equalizing Line

A 1.5 inch equalizing pipe line will connect the top of the reservoir with the reactor vessel. A manually operated gate valve will be placed in the line for maintenance and reservoir filling operations.

d. Mixing Tank

The mixing tank will be a closed vessel capable of withstanding 100 psig pressure and having a capacity of 600 gallons. The tank is provided with an electric motor driven agitator, a sight glass, a solution return inlet, a service water connection, an outlet valve, a pressure relief valve, and a vacuum breaker.

e. Pumps

Two pumps are provided; one for filling the system at atmospheric pressure and one for maintaining level in the tank at reactor operating pressures. The filling pump is centrifugal type and delivers 20 gpm at an 80-foot head of liquid; the make-up pump is positive displacement type and delivers 15 gph at 1200 psig.

H. VESSEL

The reactor vessel is to be the container for the core and control assemblies and reactor coolant with a top opening for refueling and servicing.

1. DESIGN REQUIREMENTS

The reactor vessel is to be a component of the primary system for supporting and containing under all operating conditions, the core assembly, control assemblies, reactor coolant and portions of the instrumentation and piping.

The vessel must be designed to withstand corrosion, erosion, material fatigue and changes due to radiation during the life of the plant.

2. DESIGN DESCRIPTION

The reactor pressure vessel arrangement is shown on Drawing 193E815. The vessel will be stainless steel clad on the internal surface and will be designed for a normal operating pressure of 1015 psia. The vessel will contain and support the core assembly mounted on top of the core support ring. The control rod assemblies will be mounted in the bottom head. Access into the vessel for refueling, changing control rods, and servicing of instrumentation will be made through the head closure at the top of the vessel. The head closure will permit access for changing the complete core and control assemblies if this becomes necessary. The reactor cooling water will enter through four 22-inch inlets and will pass up through the core asembly where it is to be heated and partially vaporized. This steam-water mixture will leave the vessel through twelve 16-inch outlets located near the top of the vessel (a forced convection system).

a. Size

The size of the vessel will be determined from the size of core that must be enclosed. The 12-foot 2-inch inside diameter will accommodate a 10-foot 9-inch outside diameter core. Two inches of the 8.5 inch annulus will be taken up by the upper core guide support which will also function as a thermal shield; the remainder will be filled with water which will act as a reflector.

b. Thermal Shield

Provisions will be made for a thermal shield to be installed on the under side of the closure to reduce induced radioactivity in the closure if this should become necessary. The top head closure will be a gasketed closure and must be able to undergo repetitive removal and replacement cycles routinely.

c. Inlet Plenum

The space beneath the core assembly will be an inlet plenum where the reactor coolant from the four 22-inch inlet lines will combine and high local coolant velocities will be reduced before the coolant enters the core assembly.

d. Penetrations

Penetrations through the vessel wall will be provided for thermocouples, flux monitoring devices, fuel rupture detectors, pressure taps, steam and noncondensable vent drains, and poison injection. The vent nozzle will provide the means for venting noncondensable gases to the steam drum. While shutting down, the vent will be used to vent steam so that more uniform cooling of the top closure will be possible.

A machined surface will be provided on the outside of the top head closure vessel body flange to accommodate a removable water seal for overhead reactor basin.

e. Vessel Weights

The weights of the vessel components will be as follows:

Head Closure	50 tons
Vessel Body	235 tons
Vessel Support	25 tons
Vessel Internals	40 tons
Weight of Vessel	350 tons

DRESDEN NUCLEAR POWER STATION

FUEL HANDLING SYSTEM

SECTION VIII

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FUEL HANDLING SYSTEM

SECTION VIII

The fuel handling system will include all components and facilities necessary to receive and inspect fuel, to transfer the fuel to and from the core, to store unirradiated fuel, and to store irradiated fuel for radiation decay.

The following reference drawings are applicable to these criteria:

Fuel Handling Scheme-Plan	196-E-209	Print 35
Fuel Handling Scheme-Section AA	196-E-210	Print 36
Fuel Handling Scheme-Section BB	196-E-211	Print 37
Operational and Functional Flow Sheet	625-C-148	Print 38

A. Design Requirements

1. REMOVAL AND REPLACEMENT OF REACTOR CORE COMPONENTS

Provision for the removal and replacement of all components of the reactor core must be made. Fuel bundles and control rods must be able to be removed. The top grid support plate, lower support plate and instrument sensing elements must be subject to removal on an emergency basis only. Other parts of the core will be a permanent part of the reactor pressure vessel and will not require replacement. The necessary tools and equipment to replace essential parts of the reactor core are to be included.

2. REUSE OF CHANNELS

It is necessary to provide for the disassembly of irradiated fuel channels and bundles in order to reuse the zirconium channel. This must be a remote operation because of the activity of the irradiated fuel. The spent fuel is to be removed from the zirconium channel and fresh fuel added in its place.

3. RETURN TO REACTOR OF USED BUNDLES

Provision must be made for the return of the partially spent fuel to the core.

4. IRRADIATED FUEL STORAGE

On site irradiated fuel storage capacity will be provided for 120 percent of the reactor loading to allow for complete fuel bundle removal from the core if so required for equipment repairs. Provisions for additional storage space as an extension of the first storage basin must be included. On-site unirradiated fuel storage for one reactor loading must also be provided.

5. REFUELING TIME REQUIREMENT

As a target the total refueling operation should be accomplished in 55 hours (on a weekend from 12:01 am Saturday morning to 7:00 am Monday morning). This 55 hours is broken up into 15 hours for system cooling and startup, 8 hours for Reactor Vessel Head removal and replacement, and 32 hours for transfer of fuel bundles. The total amount of fuel replaced in the core during one refueling operation should be 20%.

6. MECHANICAL SIMPLICITY

The mechanical design of the fuel handling system must be kept simple and manually operated wherever possible. Standard devices and parts which are commercially available are to be used in preference to new designs.

7. RUPTURED FUEL ELEMENT HANDLING

Because of the possibility of fuel elements becoming ruptured during reactor operation, it will be necessary to provide for their removal from the sphere in a sealed container. The container is to be placed over the suspected element as soon as possible after the opening of the vessel. The reactor service hoist carrier and the cover over the fuel handling canal are to be provided with a ventilation exhaust system to keep fission gas release to a minimum.

8. FUEL SHIPMENT

Provisions must be made for placing irradiated fuel in casks for shipment to a reprocessing facility. The design must provide for loading the casks underwater, decontaminating and placing them on railcars for shipment to the processing facility.

B. SYSTEM DESCRIPTION

In the "visual-grapple" fuel handling method, personnel will load and unload the reactor core using pole-type grapples assisted by crane lifting. Operations will be accomplished through approximately 40 feet of water with visual guidance. The fuel is to be withdrawn from the reactor into a water basin above it and is then to be moved horizontally through a canal to a point near the side of the enclosure, down through a water lock to a level below grade, and horizontally into the storage area outside the enclosure. The fuel will be kept underwater at all times after it is irradiated and will be transported to and from the storage area in groups of fuel assemblies.

New fuel is to be brought from the storage area to the reactor by the reverse route. The reactor will be prepared for refueling by removing the head of the reactor vessel and other components above the core and filling the fuel handling canal with water. Operators will grapple through the water to refuel the core. This operation is shown on Scope Drawing, 196-E-210.

Except for the actual refueling operation, all other fuel procedures will take place in the fuel storage area outside of the sphere. The Fuel Building will provide for receiving, inspecting, and storing new fuel and channels and for storing, stripping, casking and shipping spent fuel.

C. EQUIPMENT DESIGN DESCRIPTION

The fuel handling layouts are shown on Scope Drawings 196-E-209, 196-E-210 and 196-E-311. The description of the major equipment for fuel handling is as follows:

1. REACTOR SERVICE CRANE

A 50 ton bridge crane with a 5 ton auxiliary hook positioned inside the sphere to service an area 16 feet wide and 125 feet long will be used for handling the head closure and for lifting the fuel rack basket.

2. REACTOR SERVICE HOIST CARRIER

This carrier will provide the working platform on which operators stand to withdraw fuel from the reactor. It will be power driven and will support a one-ton hoist over a three foot slot in the surface of the carrier. All grappling and handling of fuel is to be done by grappling tools working through this slot. The hoist will be powered for two speed vertical motion.

3. REACTOR HEAD HOLDING FIXTURE

A fixture will be required to support the head closure in the fuel handling canal so that there will be no danger of damaging the sealing surface.

4. GRAPPLING TOOLS

Many of the refueling and maintenance operation procedures will require a special grapple. The grapples are to be relatively simple in design. Separate tools and appropriate racks will be provided for the Reactor Enclosure and Fuel Buildings.

5. STORAGE POOL CRANE

This will be a one ton bridge crane designed to handle individual fuel assemblies or racks in the storage area. The operator's bridge is to be suspended from the crane trolley to perform the underwater handling operations in this area.

6. CASK CRANE

A bridge crane of 75 ton capacity will be required for lifting the heavy shipping cask, for loading the fuel rack basket, and for other general service in this area.

7. VAULT CRANE

A one ton capacity bridge crane will be used in the new fuel storage vault for the general handling of bundles and racks: This crane will be standard in all respects.

8. FUEL RACK

A minimum of 24 fuel racks, each accommodating four fuel assemblies, will be required to support, carry, and protect fuel assemblies while in transit to and from the reactor area.

9. FUEL RACK BASKET

Two fuel rack baskets will be required to transfer fuel between the sphere and the storage area. The baskets will accommodate 8 fuel racks and can be transferred through the 40-inch diameter discharge tube.

10. FUEL BASKET CARRIER

The fuel basket carrier is an underwater dolly for moving the fuel rack basket between the vertical discharge tube and the Fuel Building. It will be supported on tracks and moved by a cable system controlled from the Fuel Building.

11. CHANNEL STRIPPING MACHINE

This will be a remotely operated underwater machine used for removing the zirconium channels from the irradiated fuel bundles and for placing the used radioactive channels on new fuel bundles.

12. FUEL RACK CARRIER

The fuel rack ca[illegible]ier will be a trolley used to carry [illegible] racks to the reactor [illegible]vice hoist carrier. The carrier wi[illegible] [illegible]wered by a conveyor. Two carriers and drives are to be use[illegible] [illegible]o move the fuel racks.

13. VIEWING AIDS

A periscope will be used with the channel stripping machine to observe the underwater operation and to examine irradiated fuel bundles. Industrial television adapted for underwater use will be required for general underwater viewing assistance. Further description of these and other viewing aids are given in Section XV D-2.

14. CLEANING EQUIPMENT

An underwater "vacuum" cleaning machine will be provided at both the fuel handling canal inside the sphere and the decay storage pool in the fuel handling building to keep radioactive contamination from accumulating on the pool bottoms. Decontamination equipment for cleaning the irradiated fuel shipping cask is to be provided.

D. FACILITY REQUIREMENTS

Facilities will be required both inside and outside of the spherical enclosure to perform the fuel handling procedures in a safe and efficient manner. Various basins or pools will be necessary. Fourteen feet of water over irradiated fuel will be necessary to protect operators. The heights of the various crane equipment will be based on the minimum head room requirements for the material they will be handling.

The Fuel Building outside of the sphere will provide for receiving, preparing, inspecting, and storing new fuel and channels and for storing, stripping, casking and shipping spent fuel.

The following items describe the facilities:

1. BASIN

One basin will be provided in the sphere area as shown on Drawing 196-E-209. The fuel handling canal will connect the reactor well with the discharge tube and will be completely drained during reactor operation. The canal will have an average depth of 26 feet 8 inches and will hold 220,000 gallons of water when filled. The fuel rack carrier tracks will be on a ledge along the sides of the canal. The vessel head and other removable internals will be stored in the center of the canal during refueling.

2. DISCHARGE TUBE

A vertical tube through which the fuel rack basket will be lowered for removal from the sphere will be provided. A valve will be located at the bottom of this tube which with the fuel basket carrier will form a water lock to maintain the water level in the fuel handling canal. During reactor operation, this valve will be shut and a cover bolted to the top of the tube to maintain the integrity of the sphere.

3. FUEL BUILDING

The Fuel Building will be approximately 6200 square feet in area. It will be connected to the spherical enclosure by the horizontal transfer tube of rectangular cross-section. This transfer tube will terminate in the Fuel Building in a basin which will connect to the spent fuel storage pool. This basin will be 20 feet by 25½ feet by 42½ feet deep and will hold approximately 157,000 gallons of water. It will provide space for the transfer operations of fuel to and from the reactor. It will be separated from the spent fuel storage pool by a watertight barrier so that it may be drained for maintenance. The spent fuel storage pool will be 20 feet by 25 feet by 26 feet 8 inches deep and will contain approximately 100,000 gallons of water. The new fuel storage vault will be a part of the fuel storage building and will protect new fuel from fire, theft, or sabotage. The vault doors will open to the receiving and inspection area where the work of handling new fuel and fuel casks will take place. This area will be approximately 2200 square feet including space for a railroad flat car. In the end of the building, a decontamination area will be provided to decontaminate and survey the shipping casks before they leave the site. A truck driveway will be required outside the receiving and inspection area for the delivery of items arriving at the fuel storage building by motor shipment.

DRESDEN NUCLEAR POWER STATION

STEAM SUPPLY SYSTEM

SECTION IX

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STEAM SUPPLY SYSTEM

SECTION IX

The dual cycle boiling water reactor will produce primary steam directly, and secondary steam indirectly in the secondary steam generator. The primary steam generated in the reactor will be carried in a steam-water mixture from the reactor to the primary steam drum where the steam will be separated from the water for use in the turbine.

The reactor recirculating water will flow from the primary steam drum to the recirculating pumps and from there it will be discharged to the tube side of the secondary steam generators. The recirculating water continues on from the secondary steam generators to return to the reactor. Secondary steam will be produced in the secondary steam generator at a pressure lower than the primary steam for supply to the secondary admission of the turbine. To maintain relatively pure water in the recirculation loop, a reactor clean-up system will take a part of the recirculated water out of the circuit at the suction of the recirculating pumps and return the cleaned water to the primary steam drum.

A description of the shut-down and emergency cooling water systems will be included in this section also.

The following reference drawings are applicable to this section:

Plant Flow Diagram - Main Power Loop	193E816	Print 2
P&ID, Nuclear Steam Supply System*	7368E11	Print 39
Reactor Enclosure Arrangement - Scope	7368E61	Print 5
Drawings	7368E62	Print 6
	7368E65	Print 7
	7368E68	Print 8
	7368E71	Print 9
	7368E72	Print 10
	7368E74	Print 11
	7368E76	Print 12
	7368E78	Print 13
	7368E79	Print 14
	7368E81	Print 15

A. PRIMARY RECIRCULATING PIPING

The primary recirculating piping will be constructed of stainless steel per specification ASTM A-376 or A-358. Double valving will be used with a drain between in the suction lines of the recirculating pumps and in the outlet lines of the secondary steam generator. These valves will be constructed of stainless steel and have motor operators.

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* Included for information only

B. PRIMARY STEAM DRUM

A single primary steam drum will be provided to separate the steam generated in the reactor from the steam-water mixture. It will also provide an adequate water storage to assure a positive supply to the recirculating pumps and will be located high enough to maintain natural circulation in case the recirculating pumps trip. This drum will be 7 feet 11½ inches in diameter (I.D.) and 60 feet long.

There will be four 12-inch steam off-takes from the drum--a pair on each end to join into one of the two 18-inch primary steam lines to the turbine.

The main safety valves to be located on the primary steam drum will limit the pressure in the reactor vessel to code requirements if the reactor fails to scram after closure of the sphere isolation valves when operating at full rated load. These valves will discharge inside the sphere but will not be expected to operate except under the extreme emergency conditions mentioned above, as a set of low capacity pilot-operated safety valves located ahead of the sphere isolation valves will take care of the transients. These latter valves are described under Sec. 8-A-1-a.

1. CRITERIA

Design Pressure	1250 psia
Normal Operating Pressure	990 psia
Design Temperature	573.9 F (sat.)

The steam-water mixture from the reactor to the primary steam drum at rated load will be 25,695,000 pounds per hour, with a rated steam flow of 1,407,000 pounds per hour from the drum. The separating devices will be designed to take a 20 percent change in steam flow in 3 seconds from any load level between 10 and 100 percent and from 56 percent to 100 percent in 60 seconds without exceeding a moisture carryover of 0.1 percent. The separation factor will not be less than 1000 to 1 when the total solids are held to 1/2 ppm in the drum.

2. MATERIALS

The primary steam drum will be constructed of low alloy carbon steel per ASTM A-302, Grade B, and internally clad with 304 stainless (0.06 percent carbon maximum after fabrication). Drum internals will be stainless steel.

3. FEEDWATER CONTROL

A three-element feedwater regulator will be provided to maintain the proper water level in the primary drum. The water flow is to be maintained in balance with the steam flow with a level element to adjust for discrepancies in measurements and transient swell and shrinkage conditions. A low capacity by-pass valve actuated by the level element will be used during start-up of the plant. Feedwater will be supplied through the primary feedwater heaters by the primary feedwater pumps.

C. REACTOR RECIRCULATING PUMPS

Four reactor recirculating pumps will provide the necessary head to pump the required reactor recirculating water flow through the tube side of the secondary steam generator, reactor, and primary steam drum. No spare pump will be provided.

Each pump will be coupled to a secondary steam generator, and each pump secondary steam generator unit will form an independent loop from the pump suction header to the reactor vessel. Each loop will be designed and shielded in order to be isolated separately so that a unit can be out for maintenance while the other units continue to function.

1. TYPE

The pumps will be of the zero leakage type with a single speed induction motor drive close-coupled to the centrifugal pump. The pump motors will be sized to meet cold start-up conditions.

2. CRITERIA

Rated Capacity	16,500 GPM
Developed Head	103 feet
NPSH	45 feet
Design Temperature	542.8 F
Design Pressure	1250 psig

3. MATERIALS

In general, all parts of the pump and motor in contact with the reactor recirculating water will be 304 stainless steel. The bearings, also exposed, will be made of graphitar.

4. OPERATION

Normally the pumps will be started and stopped manually from a remote location. Recirculating flow will be held essentially constant, although there will be minor variations in flow due to variations in steam quality from the reactor.

D. SECONDARY STEAM GENERATORS

There will be four secondary steam generators, each consisting of a heat exchanger section and a steam separating section. Reactor water will be pumped through the tube side of the heat exchanger section. After passing through moisture separators and driers in the steam separating section the steam will flow through the secondary steam lines to be admitted to the turbine through the secondary control valves.

1. CRITERIA

Reactor recirculating flow at rated capacity	6,050,000 lb per hr
Rated Steam Flow (secondary)	297,000 lb per hr
Design pressure-tube and shell sides	1,250 psig
Operating pressure-tube side	1,050 psia
Operating pressure-shell side at zero load (Maximum)	1,050 psia
Operating pressure-full load	510 psia

2. MATERIALS

All parts of the secondary generators not exposed to reactor recirculating water will be constructed of low alloy carbon steel per ASTM A-302, or ASTM A-212-54T.

All parts exposed to the reactor recirculating water will be constructed either from or integrally clad with stainless steel.

3. STEAM SEPARATORS

The secondary steam separating devices will be designed so that moisture carryover will not exceed 0.1 percent over the operating load range. The separation factor will be not less than 1000 to 1 at the maximum design flow with the total solids held to 100 ppm in the secondary water. This gives a steam concentration of 0.1 ppm.

4. FEEDWATER CONTROL

Feedwater for the secondary steam generators will be supplied through the secondary feedwater heaters by the secondary feed pumps. In each branch line to the four secondary steam generators will be located a feedwater regulating valve. Each valve is to be positioned by a three element control.

E. REACTOR UNLOADING COOLING SYSTEM

The reactor unloading cooling system will be made to dissipate reactor decay heat for sustained periods of time after shutdown when normal heat sinks are not available. This system will be used during fuel loading and unloading periods and during reactor maintenance.

Initial cooling of the system can be accomplished best after a shutdown by reducing the system pressure and temperature by controlled steam flow to the main condenser through the turbine bypass valves. The rate of cooling will be limited by the maximum allowable rate of temperature decrease of major system components. After the system is cooled sufficiently, flow to the condenser will be shut off and the reactor decay heat will be removed by circulating cooling water through the tube side of the unloading heat exchangers.

The shutoff valves and pumps associated with the reactor unloading system will be designed for remote operation.

A schematic arrangement of the equipment is shown on P&ID Nuclear Steam Supply System Drawing #736E811. The bypass valves to the condenser are shown on the Plant Flow Diagram - Main Power Loop Drawing #193E816.

1. CRITERIA

   The capacity of this heat exchanger system will be approximately one percent of rated reactor power which corresponds to the estimated reactor decay heat rate approximately seven hours after shutdown. The capacity of this heat exchanger system will be (two heat exchangers operating in parallel) 17 x 10^6 BTU per hour. The shell side will be designed for 1250 psig.

2. MATERIALS

   The shell of the heat exchanger will be fabricated from carbon steel and the tube material will be copper nickel. Tubes will be welded into the tube sheets. Stainless steel piping and valves will be used up to and including the first shut-off valve on the reactor side. Carbon and low-carbon alloy steels will be used in balance of the system except in particular instances where design of equipment dictates otherwise.

3. PUMPS

   Water from the service water system will be circulated through the heat exchangers and two pumps will be provided to pump the reactor water through the shell side.

F. EMERGENCY SHUTDOWN COOLING SYSTEM

An emergency cooling system will be provided to dissipate reactor decay heat following a reactor scram and isolation of the primary steam supply from the main heat sink (condenser). Operation of the system will be initiated by closure of the sphere isolation valves or high reactor vessel pressure.

1. HEAT EXCHANGERS AND EMERGENCY COOLING WATER TANK

The emergency shutdown cooling system will consist of two heat exchangers both mounted with their tubes projecting into a single emergency cooling water storage tank located near the top of the sphere to permit proper drainage to the primary steam drum. Each exchanger will be connected seperately to the primary steam drum taking steam from the top of the drum and returning the condensate to the drum. Valves will be provided in the lines to permit isolation of the exchangers and vent lines will insure proper operation of the exchangers. Each heat exchanger will be sized to remove 3 percent of design reactor power.

The emergency cooling water tank will serve as the shell of both exchangers. It will be sized to provide the following:

1. Storage of 30,000 gallons of water above the tubes. When dissipating heat in accordance with reactor heat decay curve, this quantity will allow operating the exchangers for eight hours before refilling of the tank will be required.

2. Sufficient free surface to allow gravity separation of steam in the tank.

3. Sufficient free volume and surface area for steam separation to protect the tank in the event of the minor tube rupture.

The tank will be vented to the outside of the sphere and will be considered an integral part of the reactor enclosure (sphere). Therefore, it will be designed to withstand an external pressure equal to the design pressure of the reactor enclosure.

2. MATERIALS

The tubes will be constructed of stainless steel and the heads and tube sheets on steam side will be stainless clad carbon steel. Tubes will be welded into the tube sheets. The emergency cooling water storage tank will be constructed of carbon steel.

3. OPERATION

The steam lines will be normally open and the drain lines closed allowing the heat exchanger tubes to fill with water. When called upon to operate, gate type drain valves will be automatically opened allowing the condensate to drain from the exchangers to the primary steam drum. The system will function much like a conventional evaporator. Steam from the primary steam drum will condense in the tubes, causing heating and eventual evaporation of the water in the emergency cooling water storage tank. The steam from the tank will discharge through the vent to outside the sphere and the condensate will continue to drain to the primary steam drum.

G. REACTOR COOLANT CLEAN-UP SYSTEM

The reactor coolant clean-up system will be provided to prevent build up of undesirable corrosion-erosion products in the reactor primary system and to control water quality in the primary steam drum to minimize solids carryover to the steam turbine. This will be necessary to control system reactivity since contaminants in the water circulated through the reactor will be irradiated and become, in themselves, secondary sources of beta and gamma radiation.

1. DESCRIPTION OF SYSTEM

The reactor coolant clean-up system will consist of two separate duplicate loops each having a capacity of 100,000 pounds per hour of water. Recirculating water will be by-passed from the suction header of the recirculating pumps either to one (normal) or both loops depending upon the requirements, through a booster pump, a regenerative heat exchanger, a non-regenerative heat exchanger, and a demineralizer. The demineralized water will be fed back into the primary steam drum. The regenerative heat exchanger will use the recirculating water from the demineralizer for cooling and the non-regenerative heat exchanger will use water from the cooling water system for removal of heat.

2. DISPOSAL OF RESINS

Because of the radioactive nature of the particles trapped by the reactor clean-up demineralizer, the resins will not be regenerated but must be removed and replaced when the break-through point is reached by one of the demineralizers. Remote manual controls will be provided to sluice spent resins to the waste disposal system for storage and to charge the demineralizers with new resins.

DRESDEN NUCLEAR POWER STATION

TURBINE-GENERATOR

SECTION X

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TURBINE-GENERATOR

SECTION X

The turbine-generator unit will consist of a tandem-compound, dual-admission steam turbine, driving a 14,400 volt, 1800 rpm, separately-excited, hydrogen-cooled generator. The turbine will be rated 192,000 kw when operating at 2.5 in Hg exhaust pressure and one-half per cent make-up, and the generator will be rated 245,500 kva with 30 psig of hydrogen pressure and .85 power factor.

The following reference drawings are included:

Plant Flow Diagram Main Power Loop	193E816	Print 2
Main Steam and Condensate System P&ID*	736E810	Print 40
Turbine-Generator Outline	196E252	Print 41

A. TURBINE

The steam conditions for the turbine are as follows:

	Primary Steam	Secondary Steam Rated Load	Secondary Steam Zero Load
Pressure	965 psia	475 psia	990 psia
Temperature	541 F (Sat)	461 F (Sat)	544 F (Sat)

The basic turbine arrangement as shown on the turbine outline, 196E252, consists of:

1. Front Standard
2. High-pressure section
3. Intermediate pressure section
4. Double Flow low-pressure section

The turbine will be conservatively designed, incorporating low-velocity, low-energy drop stages to minimize erosion problems. The turbine will be designed to remove a maximum amount of the moisture from the stages and particular attention will be given to the elimination of pockets or crevices in which radioactive material might lodge. Every turbine stage will be self-drained by either internal or external means and all piping and drain lines will be sized for twice the calculated water removal flow. The turbine will be provided with moisture removal buckets at each extraction point and at the last stage of the HP and IP sections. Corrugated plate moisture separators will be provided in the cross-over between the IP and LP sections.

*Included for information only.

Steam seals will be used for shaft sealing. Turbine materials will be selected to operate under conditions of wet steam. Where concentrated erosion may be expected--shaft surfaces under packing and diaphragm sealing surfaces--erosion resistant materials will be used.

In the Turbine Building, shielding walls of concrete will protect the areas which will be accessible during normal operation from the radioactive equipment including the turbine and most of its auxiliaries.

1. STEAM PATH

a. Primary Steam

Steam from the primary steam drum will be supplied to the turbine through two 18-inch lines fabricated of ASTM A-155 or 335 ($2\frac{1}{4}$ Cr - 1 Mo) alloy steel. A sphere isolation valve will be located in each line. Their operation will be tied into the hydraulic oil system of the turbine. After the isolation valves, connections will take off from these lines to a header on which will be mounted eight bypass valves. They will be located at a higher elevation than the main steam lines to provide self-draining. These bypass valves will dump steam into the condenser through eight lines containing pressure reducing and desuperheating stations. The design of the bypass valves will incorporate provisions for the following:

1. Periodic testing
2. Leak detection
3. Fail-safe design in which valves will close upon loss of hydraulic oil pressure.

Conventional stop valves will be located in each primary steam line before entering the valve chest on the turbine. Four control valves will regulate reactor pressure by adjusting the steam flow to the first stage of the high-pressure turbine. Ahead of the sphere isolation valves, connections from each primary steam line will join into a common header on which will be mounted a set of low-capacity pilot-operated relief valves. These valves will be provided to handle any pressure transients or failure of the emergency heat exchanger following a scram. These valves will discharge into the condenser through the pressure reducing and desuperheating stations. When these valves operate, spray water will be admitted to the pressure reducing and desuperheating stations to desuperheat the steam. Manually actuated DC motor operated valves will be used in series with these relief valves to prevent the escape of gases after an incident.

b. Secondary Steam

The four 12-inch lines, one from each of the secondary steam generators, will join into a header from which two 18-inch carbon steel lines will supply secondary steam to the turbine. Conventional turbine stop valves will be located in these lines.

c. Turbine Steam

The primary steam will enter the first stage and the secondary steam will enter the secondary admission at the ninth stage of the high-pressure section of the turbine and will flow towards the front standard. The steam will enter the cross-under, which directs it to the intermediate pressure section, where it will flow toward the generator end. The steam from the intermediate section will then pass through the cross-over, to the center of the double flow low-pressure section and on to the condenser. Steam will be extracted from the turbine at five points to raise the feedwater temperature to 405 F in the feedwater heaters. The extracted steam will assist in removal of moisture formed in the turbine.

All of the cascaded heater drains will flow to the main condenser for deaeration.

2. GLAND SEALING SYSTEM

A complete gland steam seal system will be used both for start-up and for operation of the turbine. The sealing system will be essentially conventional. Leak-offs from the primary and secondary stop and control valves will be piped to the gland seal system.

a. Steam Supply

The seal system will be provided with steam from the secondary steam supply during start-up in order that condenser vacuum can be established and the condenser used as a heat sink. The gland seal regulators will maintain a constant pressure on the gland steam header by taking steam from the secondary steam header at low loads and dumping excess leak-off steam to the condenser at higher loads.

b. Gland Seal Condensers

Two full-sized gland seal condensers, each designed to maintain sufficient vacuum for removal of the steam-air mixture from the main turbine shaft seals and the valve leak-offs, will be provided. They will operate at approximately 10-inch water vacuum and the condensed steam will pass through loop seals to the condensate drip tank. Air will be removed by means of mechanical blowers, one on each condenser, which will deliver the air to the stack. The tube side of these condensers will be designed to take the main condensate flow after it passes through the air ejector inter and after condensers. An internal by-pass will be incorporated to allow only the necessary flow through the gland seal condenser.

3. LUBRICATION AND HYDRAULIC OIL SYSTEM

The turbine-generator lubricating oil system will consist of a tank, pumps, two full-capacity oil coolers, pressure switches and piping.

a. Oil Pumps

Oil for the hydraulic system and bearings normally will be supplied by a pump on the turbine shaft, located in the front standard. A full-capacity motor-driven auxiliary oil pump, located in the turbine oil tank, will supply the hydraulic and bearing oil requirements during start-up and whenever the unit is below normal speed. It will be started automatically on low hydraulic oil pressure. Also, there will be provided an AC motor-driven turning gear oil pump, sized to supply bearing oil requirements. It will start automatically on low bearing oil pressure. This latter pump will be backed up by a DC motor-driven pump that will be started automatically when the bearing oil pressure drops further or if AC power failure occurs.

b. Vapor Extractor

A vapor extractor located on top of the turbine oil tank will be provided to draw a small amount of air through the oil drain lines to remove any trace of hydrogen or moisture that might accumulate in the bearing pedestals or turbine oil tank itself. The extractor will discharge to the outside of the building.

c. Oil Cleaning

The bearings and other critical devices in the oil system will be protected from loose particles by passing the oil through the oil strainers on the suction side of the oil pumps and the combination orifice-and-strainers on the inlet line to each turbine and generator bearing. The turbine oil tank will be equipped with a pump and filter for continuously recirculating and filtering the oil when the unit is in service. The pump will take its suction near the bottom of the turbine oil tank and, after passing through the filter, the oil will be returned at the top of the tank. Piping will be arranged to prevent draining of the oil tank in case of an oil leak in this filtering system.

d. Oil Storage

A clean and a dirty oil storage tank, each having a capacity of 8,500 gallons, will be located in a separate room with the necessary piping and transfer pumps to pump the oil into and out of the turbine oil tank, and from tank to tank, in this room. The used oil may be filtered when in storage. The system will be arranged so that make-up will be added through the filtering system to the clean oil tank from which it can be transferred to the turbine oil tank. Storage and turbine oil tanks will have sloped bottoms for removal of collected water.

Shielding from radioactivity will make access possible to the oil pumps and turbine oil tank during operation.

4. CONTROL SYSTEM

The controls for both primary and secondary steam admission to the turbine will be an integral part of the overall control system of the plant. The turbine will have a load control device and speed governor on the secondary control system and an initial pressure regulator on the primary control and bypass valve control systems, with interconnecting links to correlate the action of the primary and secondary valves.

The pressure regulator will take its signal from the primary steam supply system. The set point of the pressure regulator will be variable from 1,000 psia down to 150 psia. The latter setting will be required for start-up conditions. Under normal operation, the pressure will be regulated by positioning the primary control valves, but the pressure will be regulated by operation of the bypass valves if the primary steam generation exceeds the requirements of the turbine, or if the turbine governor system overrides the control of the primary control valves. The latter will happen only when the secondary valves are closed.

Speed and load control will be accomplished by the governor system through the action of the secondary control valves and interaction of the primary control valves. The interconnection between the primary and secondary controls will be designed so that the load on the unit will be essentially constant for a given setting of the load control mechanism in case the ratio of primary to secondary steam changes. The interaction will be obtained by a ratio arm which will adjust the opening of the secondary control valves following a change in the position of the primary valves. Actually, the steady state division of primary to secondary steam will be determined by the void fraction in the reactor and not by the turbine control system. As implied above, the speed governor will override the pressure regulator in controlling the primary control valves, but not in controlling the bypass valves in the event of turbine overspeed. The turbine may be started and loaded at reduced pressure, in order to minimize the time required for start-up. The design will include provisions for starting on either primary or secondary steam.

5. VACUUM TRIPS

Two vacuum trip mechanisms will be provided. One mechanism will initiate reactor scram and trip the secondary control valves at about 25" Hg vacuum and trip the primary sphere isolation valves at 7" Hg vacuum. The other mechanism will initiate reactor scram at 25" Hg vacuum and will trip the turbine and secondary stop valves and primary control valve at about 20" Hg vacuum.

B. GENERATOR

The main generator will be a conventional 1,800 RPM hydrogen cooled machine. Power from the generator will be fed to the low side of the main power transformer through the isolated phase bus duct as described under Section XVI.

1. GENERATOR HYDROGEN SYSTEM

The generator will be cooled by a conventional hydrogen cooling system. The unit will be completely enclosed by a gas-tight shell or casing which contains the hydrogen cooling gases. The shell will be designed structurally to withstand the forces of an internal explosion. Baffles and gas passages will direct the forced flow of hydrogen over and through the stator, rotor and hydrogen coolers. This ventilating system will be completely self-contained with only the cooling water connections for the hydrogen coolers and the hydrogen control system located outside the casing.

a. Gas Coolers

The gas coolers will consist of banks of finned tube heat exchangers supplied with an external flow of cooling water (maximum inlet temperature 95 F) for heat removal. Generator temperature will be regulated by remotely adjusting from the control room the valve for control of the service water to the coolers.

b. Control and Instrumentation

The hydrogen control and carbon dioxide purging equipment will be located in the controlled access area directly under the generator. Instrumentation and alarm equipment will monitor the pressure, temperature, and purity. Gas pressure will be maintained inside the generator housing by means of a pressure regulator controlling the make-up from commercial hydrogen cylinders.

c. Oil Seals

Sealing of the generator casing along the rotor shaft will be accomplished by means of oil seals. A vacuum treating system will remove trapped gases from the oil. Normal and emergency seal oil pumps will assure a continuous supply of seal oil. Should both of these sources fail, oil will be supplied automatically from the bearing oil header.

2. EXCITATION

Excitation will be provided by one of two motor-driven exciters. Each exciter will be arranged to be regulated either manually or automatically by an amplidyne-generator voltage regulator.

DRESDEN NUCLEAR POWER STATION

CONDENSING SYSTEM

SECTION XI

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CONDENSING SYSTEM

SECTION XI

Description of the main condenser, the condensate pumps, the air ejector and the circulating water system are contained in this section.

The following reference drawings are included:

Main Steam and Condensate System P&ID*	7638E10	Print 40
Plant Flow Diagram	195E816	Print 2
General Site Plan	124F713	Print 1
Circulating Water Structures	124F730	Print 42
Plant Area Arrangement	124F714	Print 3

A. MAIN CONDENSER

The main condenser will be designed to serve four primary functions:

1. It will condense the steam exhausted from the turbine producing a vacuum at the turbine exhaust.

2. It will act as the primary heat sink for dissipating energy from the reactor when more primary steam is generated than can be used by the turbine.

3. It will deaerate the condensate and cascaded heater drains.

4. It will hold up the condensate in the hotwell sufficiently long to allow for decay of shortlived radioisotopes.

The main condenser will be a horizontal, single-pass, divided water box type. It will be located directly beneath the turbine exhaust and will be connected to the turbine by an expansion joint. The centerline of the condenser will be at right angles to the centerline of the turbine. The tubes will be protected against moisture erosion by means of impingement bars or baffles.

1. CRITERIA

Steam Flow to Condenser	1,524,490 lbs per hr
Heat Content of Steam	1,010 btu per lb
Heater Drains	1,030,000 lbs per hr
Heat Content of Drains	94 btu per lb
Absolute Pressure	2.5 in Hg
Inlet Circulating Water Temperature	75 F
Cleanliness Factor	70%
Maximum Velocity through Tubes	7 ft per sec

*Included for Information Only

The condenser will be capable of handling the normal steam flow from the turbine plus the heater drains as shown above, or the bypassed extraction steam. In order to serve as a heat sink for the reactor, it will be capable of handling 1,900,000 pounds per hour of bypass primary turbine steam. It will be designed to handle, under emergency conditions full bypass steam flow at about 300 F when desuperheating spray water is unavailable.

2. MATERIALS

Standard construction materials will be used. These will include cast iron or steel water boxes, carbon steel shell, tube support plates, and inner tube sheets, Muntz metal outer tube sheets, and phosphorized admiralty tubes. The deaeration trays and baffles will be stainless steel.

3. TUBE SHEETS

To prevent leakage of circulating water into the condenser, double tube sheets will be used. The space between the sheets will be filled with demineralized makeup water under sufficient static head to prevent circulating water leakage into the space between the tube sheets. Leaks at either tube sheet will be indicated by loss of sealing water.

4. HOTWELL

The storage type deaerating hotwell will have a capacity of 40,000 gallons and a compartmentalized condensate collection arrangement with individual conductivity meters in each to aid in locating leaks. Baffles in the hotwell compartments will provide hold-up time of the condensate for decay of the short-lived radioisotopes. Deaeration in the hotwell will provide condensate with an oxygen content not to exceed 0.01 cc per liter. Level controls will be provided to maintain the level of the condensate in the hotwell by admitting makeup water from the condensate storage tank to the condenser or allowing condensate from the primary condensate line after the condensate demineralizer to flow to the condensate storage tank.

B. AIR REMOVAL EQUIPMENT

Two twin-element, two-stage, steam-jet air ejector units, with inter and after condensers, will be provided. Each element will be capable of removing 40 cfm of oxygen and 12.5 cfm of air leakage on a free dry basis at 70 F with a condenser pressure of 2.5 in Hg. These units will be complete with all necessary integral steam piping, loop seals, traps and valves. Each unit will be located in a separate compartment. These compartments will be inaccessible when the equipment is in service. Only one will be required for normal operation. Should trouble develop, the other will be used while repairs are being made.

1. STEAM SUPPLY

One hundred psig steam will be supplied to the steam-jet air ejectors through a pressure reducing station which will receive steam from the secondary steam lines.

2. INTER AND AFTER CONDENSERS

Condensate will provide the cooling medium for the inter and after condensers. The tubes in these condensers will be made of stainless steel. Sufficient flow of condensate during periods of low flow will be assured by recirculating, from a point beyond the ejectors and the gland steam condenser, back to the condenser hotwell.

3. HOLD-UP TANKS

The air removal equipment will discharge the gases to a continuous hold-up tank which insures a minimum hold-up of three minutes. An emergency hold-up tank parallels the continuous hold-up tank. Remote manual valves will be provided to route non-condensible gases to the emergency hold-up tank for indefinite storage on an indication of high-level radioactivity from the instruments described under Section XV.

4. MECHANICAL VACUUM PUMP

A motor driven mechanical vacuum pump will be used for evacuating the steam spaces when starting up.

C. CONDENSATE PUMPS

Three one-half capacity, vertical, multi-stage, centrifugal, submerged suction, condensate pumps will be provided to pump the condensate from the condenser hotwell to the condensate system. These will be driven by solid shaft squirrel cage induction motors.

1. CRITERIA

Capacity	3100 gpm
Total Dynamic Hea	325 ft
Suction Pressure (Referred to normal hot-well level)	10 ft

MATERIALS

Casing - Inner	Cast Iron
Casing - Outer	Carbon Steel
Impeller and Wearing Rings	Bronze
Shaft Sleeves	11-14 Chrome-steel

D. CIRCULATING WATER PUMPS

Two one-half capacity, vertical, motor-operated circulating water pumps will be located in the intake structure as described under Circulating Water System, Item E-7. These pumps will be the submerged, vertical, propeller or mixed flow type with the motor mounted above the floor level.

1. CRITERIA

Capacity	90,000 gpm (approx.)
Dynamic Head	28.5 ft

2. MATERIALS

Casing	Cast Iron
Shaft, Shaft tubes	Carbon Steel
Impeller, Casing Wearing ring, Packing gland sleeves	Bronze
Packing Glands	Graphited Asbestos
Guide Bearings	Rubber in Bronze

E. CIRCULATING WATER SYSTEM

Cooling water for the condenser and the service water system will be drawn from the Kankakee River just up stream from its confluence with the Des Plaines River. This water will flow through the intake canal to the pump and intake structure. At this point, trash and debris will be removed and chlorine will be added. Circulating water and house service water pumps will deliver water to the Station. The circulating water will be returned to the Illinois River through the discharge head-works and the discharge canal.

1. INTAKE CANAL

The intake canal will be arranged as shown on Drawing 124F713, General Site Plan. Subsurface explorations indicate that canal will be in sandstone its entire length. The design section will be 12 feet wide at the bottom, with side slopes of 1:4 and a water depth of 10 feet with design flow. A log boom will be provided across the entrance to this canal to prevent the entrance of ice and floating debris. The canal will be provided with a single lane, graveled patrol road its entire length.

2. PUMP AND INTAKE STRUCTURE

The intake canal will terminate at the pump and intake structure. This structure will be divided as shown on Drawing 124F730 into three compartments, one for each of the two condenser circulating water pumps and one for the service water pumps. Means will be provided ahead of the bar racks to permit closing off the water at the entrance. The circulating pump compartments will be provided ahead of the bar racks to permit closing off the water at the entrance. The circulating pump compartments will be designed to assure optimum hydraulic conditions at the suction bell. Water for the service pump compartment will be taken from either of the circulating pump compartments through a gated opening immediately downstream from the traveling water screens. These manually operated gates will be large enough to allow design flow of service water into the service pump compartment from either circulating pump compartment in case the other is shut down. The service pump compartment will be a small weatherproof building containing the screen and screen wash pump controls, and diesel driven emergency fire pump. A removable housing will be located over the two circulating water pumps.

3. BAR RACK CLEANERS

The stationary bar racks located just after the stop log stops will be cleaned with a bar rack rake. This rake is to be mounted on rails and will move from rack to rack when in operation. The bar rack rake will be designed to grapple trash such as oil drums and large branches. The rake will dump this trash into a rubbish cart that can be hauled to a disposal area. Adequate clearance will be provided ahead of the bar racks for grappling debris with a clam-shell bucket, if necessary.

4. TRAVELING WATER SCREENS

Four automatically controlled traveling water screens will be located downstream from the bar rack. Two screens will serve each circulating water pump. A weatherproof enclosure for the traveling water screen housings will be provided by placing the screen operating floor level below that of the pumpdeck, forming a well. This well will be roofed, partially by extension of the concrete structure, the remainder by removable steel decking. The screens will be provided with protection against freezing.

5. CHLORINATORS

Chlorinators will treat the water supplied to the circulating water pumps and to the house service pumps to restrict algae growth.

6. SCREEN WASH PUMPS

High-pressure water for washing the trash off the traveling screens will be provided by means of two pumps taking their suction from the house service compartment. They will be started by the controls that operate the traveling screens.

These pumps also will serve as one source of supply to the fire system, so will be started automatically with a pressure reduction in this system.

7. CIRCULATING WATER PIPING

Each circulating water pump described in this section, Item D, will be equipped with a 66-inch motor-operated butterfly valve at the discharge nozzle. This valve will be electrically interlocked with the pump motor so that it opens when the motor starts and closes when the motor stops. Thus, it will serve as both a check valve and a shutoff valve. A rubber, spool-type expansion joint will be provided on the downstream side of each valve and the discharge piping will be anchored at the wall of the structure immediately downstream of the expansion joints. Two 66-inch O.D. steel pipes, suitably coated and wrapped, will carry the water from the screen and pump structure to the turbine building. A crossover between the two 66-inch pipes will be installed just outside the turbine building so that both sides of the condenser may be served by either circulating water pump.

The 96-inch O.D. steel discharge pipe, suitably coated and wrapped, will carry the water to the discharge headworks. It will be located to permit construction of an intake canal for future units without interference. The discharge headworks will be located at the end of the piping from the turbine building as shown on Drawing 124F714.

a. De-icing

This discharge headworks is to be arranged to permit dewatering of the discharge line and will permit throttling and control of the discharge if warmed water recirculation is required for de-icing at the screen and pump structure. De-icing will be accomplished by returning a portion of the warmed circulating water from the condenser discharge.

b. Back-wash Facilities

Provisions will be made for back-washing the condenser. Reversal of flow will be controlled by two motor-operated, four-way butterfly valves, one for each side of the divided condenser. No provision will be made for dewatering one side of the condenser while the other side is in operation because radioactivity will prohibit any maintenance work on the condenser while the plant is in operation.

8. DISCHARGE CANAL

The discharge canal will start at the discharge headworks and will be arranged as shown on Drawing 124F713. Sub-surface explorations indicate that this canal will be in sandstone and limestone. The design section will be 13 feet wide at the bottom, with the side slopes of 1:4 and the water depth of 8 feet at design flow. Where the canal enters the Illinois River, a transition section will be provided so that the discharge velocity will not exceed one foot per second. At this point, a log boom will be provided on the company's property to prevent trespass by persons in small boats. The canal will be provided with a single lane, graveled patrol road for its entire length.

DRESDEN NUCLEAR POWER STATION

CONDENSATE AND FEEDWATER SYSTEMS

SECTION XII

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CONDENSATE AND FEEDWATER SYSTEMS

SECTION XII

The circuits through which the condensed steam and drains from the main condenser return to the secondary steam generators and reactor are referred to as the condensate system and the feedwater system.

The following reference drawings are included:

P&ID Main Steam and Condensate*	7368E10	Print 40
Plant Flow Diagram Main Power Loop	193E816	Print 2

A. CONDENSATE SYSTEM

The Condensate System includes that part of the circuit from the condenser hotwell to the primary and secondary feed pumps.

The condensate pumps will take their suction from the condenser. These pumps will discharge the condensate through the steam jet air ejector condensers and the gland seal condensers to a single condensate line. This line will split into two smaller lines, one to feed the suction of the secondary feed pumps and the other to feed the condensate demineralizers which precede the suction of the primary feed pumps. The air ejector after-condenser drains and the gland seal condenser drains will flow to the condensate drip tank. The air ejector inter-condenser drains will return to the main condenser. To maintain a flow of condensate for condensing the steam in the air ejector and gland seal condensers during start-up of the turbine and low load periods, a recirculating line to the main condenser will be provided. The control valve in this line will be actuated by condensate flow, opening at a preset minimum. This valve will remain closed until the line is pressurized by starting of a condensate pump. This action will be necessary to avoid draining the make-up water out of the condensate storage tank into the condenser through the recirculating line.

Emergency suction lines with check valves will be installed from the condensate storage tank to each of the primary and secondary feed pump suction headers in order to safeguard the feed pumps on loss of condensate pumps. Automatic stand-by start of the condensate pumps will be provided for further protection. A pressure switch which will annunciate low pump suction pressure and initiate the start of the condensate pumps will be mounted in the primary feed pump suction header.

1. CONDENSATE PUMPS

The three condensate pumps, two of which are adequate to carry full plant capacity, are described in Section XI, Item C.

*Included for information only.

2. STEAM JET AIR EJECTORS

Two sets of steam jet air ejectors will be provided. The description of these appear under Air Removal Equipment, Section XI-B.

3. GLAND SEAL CONDENSERS

The two gland seal condensers are a part of the condensate system but serve the turbine so have been described under the Steam Sealing System, Section X, A-2-b. These will be located separately within the two Steam Jet Air Ejector compartments.

4. CONDENSATE DEMINERALIZER SYSTEM

In order to maintain high cleanliness of feedwater to the reactor, full-flow demineralizers will be provided in the primary stream ahead of the primary pumps. The condensate demineralizers will prevent the products of corrosion, erosion, and condenser leakage from entering the reactor. In order to keep the number and physical size of the demineralizers reasonable, design flow rates in the range of 50 to 75 gpm per square foot will be used.

This system will consist of three mixed bed demineralizers--one anion regenerating tank, one cation regenerating tank, two sluice pumps, and a resin storage tank. See Plant Diagram 193E816.

a. Capacity

Each demineralizer will be designed to handle one-half of the full load primary feedwater flow, thus making it possible to operate at full plant capacity when regenerating one demineralizer.

Means will be provided to bypass the condensate around the demineralizers to maintain sufficient flow of feedwater to the reactor in an emergency. In this case, the duty on the reactor clean-up demineralizers will be increased.

b. Regeneration

When the resin bed of a demineralizer unit reaches the break-through point, the spare unit will be cut in and the exhausted unit will be isolated from the stream. One of the two sluicing pumps will be started to transport the resins from the demineralizer tank into the anion regeneration tank where the anion and cation resins will be separated with compressed air. The lighter anion resins will be flushed out of the top of this tank into the anion regeneration tank. The spent resins in each tank will then be regenerated using caustic in the anion tank and acid in the cation tank. After this has been accomplished, both anion and cation resins will be transported to the single storage tank where they will await use in the next spent demineralizer. A spare batch of resins will thus be in the storage tank at all times except during regeneration. Any resin additions will be made in this tank.

Compressed air jets will be installed in the demineralizer tanks for the purpose of thoroughly mixing the regenerated resins after recharging.

Means will be provided to remove the resins from this system to the waste storage system.

Since the demineralizers must be shielded, means will be provided for full remote operation of the regenerating process. The valves involved will be either diaphragm motor operated or manually operated by means of reach-rods through the concrete shielding.

B. FEEDWATER SYSTEM

The two parallel circuits which begin at the suction of the feed pumps and continue to the reactor and secondary steam generators are referred to as the feedwater system.

The primary feed pumps will discharge the feedwater through a line to the tube side of drain cooler E61 which will lower the heater drain temperature and thus reduce the loss of heat in the condenser. From here the primary feedwater will pass consecutively through the tube side of heater E51, drain cooler E62, and heaters E52, E53, E54, and E55. The line out of the last primary heater will split into two lines each of which in turn again will split, providing four lines to feed into the four separate recirculating reactor inlet headers.

The secondary feedwater stream will pass through the tube side of the secondary feedwater heaters E41, E42, E43, E44, and E45. From here it will flow through a line which will split into four lines to feed the individual secondary steam generators.

The bleed steam and water from the five extraction points on the turbine will enter the five individual flash tanks. The steam from these will pass to an associated pair of primary and secondary feedwater heaters and the moisture will flow out of the bottom through a line to the associated drain cooler, either internal or external, located in the primary stream. The combined drains of both heaters will discharge to the flash tank associated with the next lower pressure heater. The drain piping will be arranged for cascading the drains to the condenser. Also, any or all of the heater drains can be by-passed directly to the condenser.

The total drains will be pumped from primary heater E51 and secondary heater E41 through drain cooler E61 and on to the main condenser to give the necessary spray action for deaeration in the condenser. Heater vents from each heater will be piped directly to the main condenser.

1. PRIMARY FEEDWATER PUMPS

Three primary feed pumps, two of which have sufficient capacity to supply the reactor at full plant capability, will develop the head required to pump the demineralized feedwater through drain coolers E61 and E62, the five primary feedwater heaters, and the header system to the reactor with sufficient operating margin.

Check valves in each pump discharge line located downstream from the recirculation line take-off, will be provided to prevent reverse flow through an idle pump. The operating conditions will be similar to those experienced by boiler feed pumps in conventional steam plants, except for the high purity of the water pumped and the requirement that the gland leakage be kept very low. The condensate demineralizers ahead of these pumps will remove enough of the radioactive material from the water so these pumps will not have to be shielded.

a. Criteria

Capacity	1650 GPM
Discharge Press	1400 psig
Suction Press	20 psig
Temperature	110 F
Nominal Speed	3600 RPM

b. Type

Conventional horizontal barrel-type, multi-stage centrifugal pumps will be provided. Breakdown bushing seals will be used. Each unit will have a self-contained lubrication system for the pump and motor.

c. Materials

Pump casing	5% Cr Steel
H.P. joints in outer casing overlaid	18-8 stainless
Impellers, Wearing rings, etc.	11-13% Cr Steel

d. Recirculation

In order to prevent overheating of the pumps when operating at low loads and during start-up, each primary feed pump is to be supplied with an automatic recirculation system. This system will have a breakdown orifice and an automatic flow actuated on-off valve in the line from the pump discharge to the condenser.

2. SECONDARY FEEDWATER PUMPS

Three secondary feed pumps, two of which have sufficient capacity to supply the secondary steam generators, will develop the head required to pump the deaerated feedwater through the five secondary feedwater heaters and the header system to the secondary steam generators with sufficient operating margin.

Check valves will be provided in each pump discharge. Due to the possible presence of radio-isotopic corrosion products in the condensate, these pumps will be separately shielded. Other than this possible activity, the water condition will be similar to a conventional plant.

a. Criteria

Capacity	1400 GPM
Discharge pressure at design capacity (full plant load)	775 psig (min)
Discharge pressure at shut-off (zero plant load)	1100 psig
Suction pressure	65 psig
Temperature	110 F
Nominal Speed	3600 RPM

b. Type

These will be horizontal barrel-type, multi-stage, centrifugal pumps with a steeply rising head characteristic to match the shut-off requirement contained in the criteria above. Each unit will have a self-contained lubrication system.

c. Materials

Pump Casing	5% Cr Steel
Impellers, Wearing rings, etc.	11-13% Cr Steel

d. Recirculation

The recirculation system provided for the secondary feedwater pumps is to be the same as the primary feedwater pumps.

3. EMERGENCY PRIMARY FEED PUMP

A low-capacity, vertical, multi-stage, motor-operated, emergency primary feed pump will be provided to take water directly from the condensate storage tank to the primary steam drum at full pressure bypassing all the intervening condensate and feed system equipment. The primary purpose of this pump is to provide feed water to the reactor when auxiliary power is only available from the diesel generator. It can be used to fill the reactor prior to a start-up to avoid the necessity of starting a primary feedwater pump.

4. FEEDWATER HEATERS

Two separate feedwater heaters for each of the five extraction points on the turbine will be provided making a total of ten, five of which are to be in the primary and five in the secondary stream. These heaters, with the associated drain coolers and drain pumps, will be arranged in groups occupying separate concrete shielded compartments as follows:

1. Primary heater E51 and secondary heater E41, drain cooler E61 and drain pumps.
2. Primary heaters E52 and E53, secondary heaters E42 and E43, and drain cooler E62.
3. Primary heaters E54 and E55 and secondary heaters E44 and E45.

The feedwater piping on these heaters also will be arranged so that these same groups can be removed from service to make necessary adjustments and repairs on an individual heater while the plant remains in operation at slightly reduced capacity. The valving on these heaters will be operated from a valve gallery running along the side of the heater bay.

a. Criteria

	Shell Side			Heater Drain Flows
	Press Range		Temp.	Design Load
	In Hg	psig	°F	Pounds per hour
Heater E41 & 51	30	30	274	1,044,553
E42 & 52	30	30	274	800,660
E43 & 53	30	75	320	638,070
E44 & 54	30	150	366	474,950
E45 & 55	30	350	436	246,584

Feedwater flow at rated plant capacity.

Primary	1,407,360 lbs. per hr
Secondary	1,200,620 lbs. per hr

Heater steam flows in per cent of full load values	120 per cent
Tube and channel design pressures	
Primary	1800 psig
Secondary	1200 psig
Overall height not to exceed	30 ft
Terminal difference (based on commercially clean tubes)	5 F
Drain (Heaters E43,44,45,53,54,55) minus Inlet temperature	15 F
Feedwater Pressure drop not to exceed (Heater E41 inlet to Heater E45 outlet, and Heater E51 inlet to Heater E55 outlet)	90 psi
Water velocity in tubes (maximum)	8 ft per sec

b. Materials

Tubes	
Heaters E41,42,51,52	70-30 Cu Ni
Heaters E43,44,45,53,54,55	Monel
Baffles (at steam and drain nozzles)	304 ss
Baffles (other)	carbon steel
Shells	carbon steel
Tube sheets	carbon steel

c. Type

These heaters will be mounted vertically with the channel up and will be of the "U" tube, surface, removable bundle type. All joints will be welded, including the tube-to-tube sheet connections. The lock type head will be used with a seal welded diaphragm or sealing ring.

The three highest pressure primary feedwater heaters, E53, E54 and E55, will have a drain cooling zone in addition to the condensing zone. The two lowest pressure primary feedwater heaters and all five secondary feedwater heaters will have only a condensing zone. External drain coolers will be furnished for the two lowest pressure primary feedwater heaters.

d. Heater Controls

Level in the feedwater heater shells will be controlled normally by means of regulating the drain flow out of the heater into the flash tank of the next lower pressure heater. During start-up and light load operation, heater drains will be bypassed to the main condenser through a bypass level control valve located in the bypass drain line.

Turbine extraction non-return valves will be located in each extraction line to prevent excessive turbine overspeed from the energy stored in the steam and water in the heaters. They will also prevent flooding of the turbine in case a feedwater heater becomes filled with water. The valve will be closed by an extraction relay dump valve activated by the overspeed emergency governor and by individual high level trips of the feedwater heaters. The signal which closes the non-return valve will also open an extraction bypass valve to the condenser. The diaphragm operated valve, restricting orifice and bypass line will be sized to pass an amount of extraction steam equal to one per cent of stage flow. This arrangement is important because the turbine will operate on saturated steam and extraction of moisture must be maintained. High level alarms will be provided to annunciate when the high level spills are in operation.

5. EXTERNAL DRAIN COOLERS

Two external drain coolers a.. included--one to cool the drains from heaters E42 and E52 and another to cool the drains from heaters E41 and E51.

a. Design Criteria

	Shell Side Press Range In Hg	Shell Side Press Range psig	Temp. °F	Maximum Design Flow Quantities pounds per hour
E61	30	30	274	1,044,533
E62	30	30	274	800,660

Drain minus Feedwater inlet temperature 15 F
Pressure drop (not to exceed) 3 psi

b. Materials

Tubes	70-30 Cu Ni
Shells	carbon steel

c. Type

They will be mounted vertically with the channel up and will be of the "U" tube, removable bundle type with all welded construction.

6. HEATER DRAIN PUMPS

Two vertical heater drain pumps, each designed to carry normal full load, will be provided for pumping the drains from heaters E41 and E51 through the drain cooler E61 to the condenser.

7. FEEDWATER CONTROL

a. Primary Feed

A three-element, steam-flow, water-flow, primary drum level, control system will be provided as described under Section IX-B-3.

A small bypass valve actuated by the level element will be provided to use during start-up of the plant.

b. Secondary Feed

Four three-element feedwater regulators will be required to control separately the feed to each secondary steam generator as described under Section IX-D-4.

DRESDEN NUCLEAR POWER STATION

MAKE-UP WATER SYSTEM

SECTION XIII

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MAKE-UP WATER SYSTEM

SECTION XIII

The make-up water system will consist of two fully automatic demineralizer units, each rated at 45 gpm, together with the required pre-treating equipment, storage tanks and pumps. All equipment included in this system, except tanks, will be located in the south auxiliary equipment bay on the ground level of the turbine building.

The following reference drawings are applicable to this section:

Plant Flow Diagram Services	124F701	Print 43
P&ID Main Steam & Condensate	7368E10	Print 40
Plant Flow Diagram	193E816	Print 2

A. MAKE-UP SUPPLY

The source of water for the demineralizers will be from the well water storage tank which in turn will be supplied from the deepwells described in Section XVIII-C-1. The well water, drawn from deep sandstone and dolomite strata, is expected to have a total mineral content in the range of 500-750 ppm. A typical analysis of well water of this area is as follows:

	ppm
Calcium	45
Magnesium	20
Sodium	167
Iron	0.6
Chloride	187
Sulphate	41
Silica	16
Total Hardness of $CaCO_3$	193
Alkalinity as $CaCO_3$	252
Residue	630
Temperature	55 F

B. MAKE-UP DEMINERALIZED WATER SYSTEM

The make-up demineralized water system is to be used to produce high purity water for replacing any loss of steam or condensate from the process and auxiliary systems. The treated water to be supplied by the demineralized water system will have a resistivity of not less than one megohm per cm and will contain not more than the indicated amount of the following elements:

	ppm
Fluorine	0.001
Chloride	0.01
Sodium	0.01
Silica	0.01

Untreated water is to be pumped from the well water storage tank, through the filters and cation exchangers to the degassifier. From here it is to be pumped through the anion exchangers and the mixed bed exchangers to the demineralized water storage tank.

1. MAKE-UP DEMINERALIZER FEED PUMPS

Two pumps will be provided to feed the well water from the well water storage tank to the demineralizers. Each pump will have sufficient capacity for the rated flow of the two demineralizer units plus backwash and will develop the head required to pump the water through the system to the degassifier.

2. FILTERS

Adequately sized pressure filters for removal of the materials causing turbidity are to be provided. The piping will be arranged so that filters can be used for either stream of demineralized water. A coagulent injection system will be provided upstream of the filters.

3. CATION EXCHANGERS

Two 45 gpm parallel arranged cation exchangers are to be provided. These will exchange the magnesium, calcium, and sodium ions for hydrogen ions in the well water influent.

4. DEGASSIFIER

One 90 gpm degassifier for removal of CO_2 is to be provided. A tank located below will collect the water. A regulating valve operated by the water level in this tank will control the degassifier influent flow rate. A vent line to the outside will be provided.

5. MAKE-UP DEMINERALIZER INTERMEDIATE PUMPS

Two pumps will be provided to discharge the water from the degassifier tank through the anion exchangers and the mixed bed exchangers to the demineralized water storage tanks. Each will have capacity sufficient to supply both streams.

6. ANION EXCHANGERS

Two 45 gpm parallel arranged anion exchangers which will remove all anions will be provided.

7. MIXED BED EXCHANGER

To reduce to a minimum the residual constituents in the treated water, two final stage mixed bed exchangers are to be provided. These each will have a rated capacity of 45 gpm.

8. REGENERATION

Conventional automatic regeneration equipment with the necessary automatically operated valves and pumps will be provided for the three stages of demineralization included in this process. The demineralizer system will be provided with a malfunction device for quick diagnosis of operating troubles.

C. DEMINERALIZED WATER STORAGE TANKS

The demineralized water storage tanks, each to be 200,000 gallons capacity, will be fabricated of aluminum to prevent corrosion. Potentially radioactive demineralized water from the water treatment system will be returned to one of the two tanks, and its primary use will be make-up for the main power loop. The other tank, containing only treated water from the make-up demineralizers, will feed any system requiring uncontaminated water.

D. MAKE-UP PUMPS

Two pumps, one for each tank, will be used to pump the water from the demineralized water storage tanks. The piping arrangement will be such that each pump can function as a spare for the other.

E. CONDENSATE STORAGE TANK

The 40,000 gallon aluminum storage tank located on the turbine operating floor will feed the make-up water through hot well level controlled regulating valves to the condenser. Excess water, as indicated by high hot well level, will flow through a level controlled regulating valve from the primary feed pump suction line to this tank.

F. OTHER USES OF MAKE-UP WATER

Demineralized water from the make-up system will also be fed to the following equipment:

1. Emergency Heat Exchanger Storage Tank
2. Cooling Water System Return Tank
3. Reactor Shield Cooler Surge Tank
4. Used Fuel Storage Pit
5. Fuel Unloading Tank
6. Space Heating Boilers

G. CONDENSATE DRIP SYSTEM

Heater shell relief valves, valve packing leak-offs, drains from the air ejector after condensers, and the gland seal condensers will be piped to a drip tank. Two pumps, only one required normally, will maintain the level in this tank by returning the water to the main power loop via the condensate storage tank.

DRESDEN NUCLEAR POWER STATION

WASTE TREATMENT AND DISPOSAL SYSTEM

SECTION XIV

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WASTE TREATMENT AND DISPOSAL SYSTEM

SECTION XIV

The Radioactive Waste System will be divided into two separate functional groups of equipment. All waste collection tankage and its auxiliary equipment located within or immediately adjacent to the Reactor Enclosure, Turbine Building, Fuel Building, Access Control Building, and Shop Facility will be included as a part of the main power plant. The waste treatment and disposal equipment will be treated as an independent system. This section presents the overall waste collection requirements and, for information purposes, preliminary requirements and design description of the radioactive waste disposal system, which includes the treatment and disposal of process water and other contaminated solution and the disposal of solids. The treatment and disposal of gaseous wastes is also covered in this section.

This section is supplemented by the following drawings:

Radioactive Waste Disposal System	Diagram 196E203	Print 44
Radioactive Waste Building	Diagram 124F728	Print 26

A. LIQUID WASTE DISPOSAL SYSTEM

1. FUNCTION

The radioactive waste disposal system must process all contaminated liquids produced in the plant and must perform the following major functions:

1. Remove radioisotope impurities.
2. Assure radioisotopic and chemical purity of the solutions before re-use in the process or release to the river.
3. Store in a safe manner the contaminated resins, filter materials, and concentrated salt solutions.

In order to fulfill the function of removal of radioisotopes and chemical impurities, high efficiency filters and demineralizers are to be provided. For solutions not compatible to this treatment, a waste concentrator is to be installed to produce distillate of satisfactory purity and to minimize the volume of stored radioactive salt solutions.

The assurance of obtaining treated water suitable for re-use or disposal to river is to be provided by tankage for batch control, sampling, and accountability of all liquids, with flexibility for treatment or lag storage of liquids not attaining satisfactory purity.

The safe storage of concentrated, contaminated solutions or slurries will be attained by use of underground storage tanks and vaults for permanent storage.

2. SOURCES OF RADIOACTIVE WASTES

a. Reactor System Drains

The reactor water solids will be made up of corrosion products from the materials of the reactor vessel, core, fuel rods, separators, pumps and heat exchangers, and traces of materials from the feed system. These solids become radioactive upon circulation through the core or when exposed to the neutron flux from the core. Any liquid leakages or drainage from the nuclear steam supply system will contain radioactive materials and must be processed through a waste disposal system. The steam supply system is to be arranged so that the primary drum, pumps, heat exchangers and piping can be drained and flushed during shutdown. This flushing solution must be processed through the waste disposal system. The reactor and the cooling and unloading system must be kept full of water unless all fuel is removed. Corrosion products in these systems must be removed by dilution or continuous recirculation through an ion exchanger bed.

b. Back-up Safety System

A special case of contamination of the steam supply system will result with the addition of sodium pentaborate to the reactor coolant. The sodium pentaborate in the reactor circulating system can be removed by draining the steam drum and recirculating system, diluting reactor water and draining effluents to the waste disposal system. The reactor clean-up demineralizers will be utilized for final clean-up of the primary system after the bulk of the sodium pentaborate has been diluted out of the system.

c. Secondary Steam Generator

Water treatment additives will be put into the low pressure side of the secondary steam generator and conventional water treatment methods will be followed. Blowdown from the secondary steam generator will be discharged to the waste disposal system for treatment or disposal to the river.

d. Sphere Compartments and Turbine Room Floor Drains

Provision is to be made to decontaminate the equipment compartment rooms, or cells, by flushing with demineralized water or other decontaminating fluids. Floor drainage will be processed in the same manner as reactor drainage with contaminants determined to establish disposal procedures.

Flow through this system to the waste disposal system is expected to be small and intermittent depending on the amount of cleaning and maintenance required and the degree of valve and equipment leakage.

e. Laboratory, Laundry and Equipment Maintenance Facilities

Equipment decontamination tanks will be located in the shop area and monitored to determine contaminant level. Decontaminating solutions will be handled in batches to the waste disposal system. Laboratory and laundry drainage will also be collected and routed to the waste disposal system.

f. Fuel Storage System

Spent fuel will be removed from the reactor and transported in water to the external storage basin through a valve closure at the wall of the sphere. Spent fuel liberates radioactive decay heat for an extended period of time requiring a circulating cooling system. The water in this basin will contain corrosion products from fuel elements and, in case of clad failure, highly radioactive oxide particles. Corrosion products from piping and equipment also will be present as well as dust from the atmosphere. Final removal of the sludge in the bottom of the basin will require filtering and demineralizing.

g. Contaminated Resins and Filter Materials

Remote operation for removal of resins and filter materials is required for the reactor cleanup and condensate demineralizer systems and the waste filter and waste demineralizer system. A hydraulic system for sluicing resins will be provided as shown in Diagram 196E203. The resins in the reactor cleanup system and waste disposal system will accumulate radioactive material and will not be regenerated. The resins are to be flushed directly to permanent waste resin storage as the need arises. The condensate demineralizer resins will remove corrosion products of relatively low activity from turbine and condenser plus traces of materials carried over from the reactor. These resins will be regenerated in automatic equipment. In case of fuel element ruptures, these resins may become highly radioactive, requiring disposal by flushing to the permanent waste resin storage.

h. Decontamination Solutions

Provisions will be made for the decontamination of the various pieces of equipment in the nuclear steam system in order that contact maintenance can be performed at times of needed repair. Equipment which may be decontaminated are the secondary steam generators, pumps, valves, the condenser, the turbine, and other major pieces in the system. Means will be provided to drain the decontaminating solutions to the waste disposal system for proper treatment.

3. GENERAL DESCRIPTION

The general flow and equipment provisions for the various waste source streams are described in the following pages:

a. Waste Receivers and Collectors

The waste streams are to be normally collected in receiver tanks located at the proximity of the sources. Such tanks will be the Reactor System Drain Tank, Sphere Floor Drain Tank, and others. From these tanks the waste is to be pumped to one of two Waste Collector Tanks located in the Waste Treatment Facility. These tanks will provide for batch sampling and monitoring for radioactivity and chemical content. On the basis of the nature and concentration of contaminants present, procedures for treatment and disposal are to be selected. Exceptions to the above are the continuous and intermittent blowdowns from the Secondary Steam Generators which are to be collected in independent receiver tanks for batch disposal.

b. Waste Treatment

Batches of waste which by analytical results are not suitable for process reuse but meet the permissible activity limits can be released directly to the river.

Batches with suspended solids and high in radioisotopic content may be pumped to the waste filter and demineralizer for clean-up. The effluent from the demineralizer will be received in one of the two waste hold-up tanks for batch sampling and monitoring to determine the extent of the clean-up. Disposition of the effluent either to the demineralized water storage tanks for reuse in the process or discharge to the river can be made dependent on effluent composition.

Batches containing radioisotopes of short half life may be stored in one of the two large waste storage tanks to permit activity decay before being bled to the river at controlled rates, or after treatment returned to the potentially contaminated demineralizer storage if of suitable purity.

Large volumes of waste water resulting from the drainage of the reactor canal after a refueling period or the drainage of the primary steam system due to high solid content or due to the presence of prohibitive amounts of sodium pentaborate can be temporarily stored in one of the two large liquid waste storage tanks and by means of pumps can be routed to the waste collector tanks for the required treatment as determined by sampling.

Batches of waste, due to their high acid, salt, or activity content, which are not compatible with the filter and demineralizer treatment, can be routed to the waste concentrator for evaporation. The steam will be condensed and will be routed to one of the two waste hold-up tanks for analysis and disposition. The concentrated waste slurry will be permanently stored in the waste concentrator tank.

c. Resin and Filter Cake Disposal

Resins in the reactor clean-up system and the waste disposal system demineralizer will accumulate radioactive material and cannot be regenerated. In addition, the filter cake from the waste disposal system filter will require disposal. These resins and filter cakes will be sluiced by an hydraulic system and will be flushed directly to a permanent waste resin storage tank. After the solid material has settled out, the transporting liquid may be pumped from this tank back to the waste collector tank in order that the total volume of the permanent storage tank will be utilized for the storage of resins and concentrated filter cake.

The condensate demineralizer resins, due to the low activity concentration, normally will be regenerated in automatic equipment. Facilities for sluicing these resins to the permanent resin storage tank will be provided also.

d. Equipment Decontamination Provisions

All major pieces of equipment which will require decontamination prior to repairs or replacement will be provided with piping connections for recirculation of decontaminating fluids through the equipment. This piping should terminate with blank flanges in a zone accessible to personnel and adjacent to the equipment. Piping connections to the waste system for the disposal of such solutions will be provided also.

e. Reactor Clean-up System Interconnection

Interconnections between the reactor clean-up system and the waste disposal system will allow the latter to be used to augment the former in the case of high contamination such as would result from a fuel element rupture or high concentration of suspended solids on start-up or load change.

In case of high water level in the primary steam drum during start-up and operation, excess water can be drained to the waste disposal system through the heat exchangers of the reactor clean-up system.

4. EQUIPMENT LAYOUT AND DESIGN

a. Criteria

1. The routine operation of the equipment will be conducted in a central operating room.

2. Sampling will be performed by means of remote samplers located in an area shielded from the equipment.

3. Equipment will be designed for ease of contact maintenance.

4. Where feasible, all piping will be sloped to eliminate solution trappage.

5. The equipment and structure will be ventilated to eliminate contamination of operating areas and environs.

b. Waste Collector Holdup Tanks

The waste collector and holdup tanks in the waste building will be provided with means of agitation, sampling, chemical additions, and solution transfer and will be instrumented for temperature and liquid level. Vertically mounted, submerged pumps will be provided. Cooling coils will be provided in those tanks receiving high temperature wastes or generating heat during the stored period.

c. Material of Construction

Cell receiver tankage and piping which will handle decontaminating solutions will require corrosion resistant construction. Batch neutralization of all solutions in the waste collector tanks will allow mild steel construction for equipment and piping beyond this point.

B. SOLID WASTE DISPOSAL

The sources of miscellaneous solids contaminated with radioactive material from the Dresden Plant will include laboratory wastes, contaminated clothing, paper wastes from the various controlled areas, and unsalvageable mechanical equipment and instrumentation. These wastes will be stored according to size and level of radioactive contamination.

The routine collection of paper, rags, and miscellaneous low level radioactive level wastes will be accumulated in a shelter adjacent to the Radioactive Waste Building until sufficient material has been received to form a bale or fill a large container. This quantity of waste then will be transferred to a waste disposal vault which consists of a 10 foot by 12 foot by 10 foot deep concrete basin located below grade. The basin will be provided with a removable concrete slab cover for placement of the waste in the vault. The method of disposal of unsalvageable mechanical equipment will be determined when the size of the equipment and level of the radiation are known.

C. GASEOUS WASTE

Ventilation air from the major process buildings is to be exhausted by means of suitable ductwork through the main stack. The air may become potentially contaminated by process leakage or general air-borne contamination from the controlled areas of the Reactor Enclosure, Turbine Building, Fuel Building, Mechanical Shop, and the laboratory part of the Access Control Building and may therefore require the air dilution provided by the stack to maintain the environs within permissible limits.

Other major sources of air to the main stack will be the air ejector and gland exhausters, the vents from the primary loop, and vessel vent systems from the waste collection and storage tankage.

The stack will be provided with suitable air samplers and monitors in order to determine the quantity of radioisotopes discharged to the environs.

Further discussion on the ventilation stack is included in Section XVII, Heating and Ventilation.

DRESDEN NUCLEAR POWER STATION

CONTROLS AND INSTRUMENTATION

SECTION XV

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4. FUEL ELEMENT RUPTURE DETECTION SYSTEM

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   b. Design Requirements
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5. REACTOR CLEAN-UP DEMINERALIZER SYSTEM

CONTROLS AND INSTRUMENTATION

SECTION XV

This section outlines the basic philosophy and criteria for the plant control systems, describes the plant instrumentation requirements for these control systems, and defines the instrument requirements for the area and health monitoring programs.

The following scope drawings are applicable to this section:

Instrumentation - Elementary Block Diagram	193E725	Print 45
Instrumentation - Radiation Type Reactor Schematic Monitoring	537D491	Print 46
Defective Fuel Element Location System	141F300	Print 47
Instrumentation - Control Room and Auxiliary Instrument Areas Arrangement	537D561	Print 48
Piping and Instrument Diagram Main Steam and Condensate	7368E10	Print 40
Piping and Instrument Diagram Nuclear Steam Supply	7368E11	Print 29

A. ELEMENTARY DESCRIPTION OF CONTROLS

1. PLANT CONTROL SYSTEM

The dual cycle boiling water reactor has, as an innate control, the phenomenon that formation of steam in the core reduces the amount of neutron moderator (water) and consequently the reactivity of the assembly. This gives rise to a negative power coefficient of reactivity providing an inherent safety feature. The dual cycle principle has a high degree of self-controlling response to load changes; changes in load triggering an automatic adjustment in reactor power independent of control rod movement. If additional load is requested of the system, more steam is removed from the secondary steam generators, lowering the temperature of the reactor incoming water thereby increasing reactivity by increasing the proportion of water (moderator) to steam present. This momentary condition accelerates the response to the new power level, but the reactivity contained in the voids must return to the pretransient value before stability is reached neglecting other reactivity effects. The inverse situation is created following a load decrease. In each of these transients, the change in reactor steaming rate is accommodated by pressure regulating devices which match the steam removal rate to the reactor steaming rate.

The basic controls of the Dresden Plant will consist of a conventional turbine speed governor that activates the turbine secondary admission control valves and a pressure regulating system that activates either the turbine primary admission control valves or the bypass relief valves. The first effect of an increased demand on the turbine (e.g., system frequency decrease or readjustment of the synchronizing device) will be to reposition the secondary admission control valves to permit a greater secondary steam flow. Pressure compensation will be applied to the secondary admission control to correct for secondary steam pressure variation with load. The increased demand on the secondary steam generators will cause an increase in both reactor power level and steaming rate. The pressure regulating system will accommodate the increased steaming rate by repositioning the primary admission control valves to permit greater primary steam flow. The primary admission control will be interconnected with the secondary admission control to maintain approximately constant turbine output by varying secondary steam flow in inverse proportion to primary steam flow. Thus, for rapid load changes, the increased (or decreased) energy will be supplied initially from secondary steam. As the reactor adjusts to the new conditions and changes the primary steam flow, a corresponding reduction in the initial change in secondary steam flow will occur. For slow load changes, the reactor will follow the change. A rate limiting device will be applied to the secondary admission control valves to limit the rate at which load may be increased after some maximum allowable instantaneous increase.

At rated conditions, it will be possible to vary the plant power from approximately 38% to 100% by this technique without the operation of control rods. For larger power transients, it will be necessary to move the control rods in the reactor core. This will result in a different amount of steam being held in the core in order to maintain criticality. Operation of the control rods will be necessary, from time to time, to compensate for poison transients and fuel depletion and during start-up and shutdown.

The plant control system will provide for manual start-up and automatic operation, and shutdown of plant equipment; it also will maintain steady-state operation at any power level within the operating range of the reactor and turbine-generator and will provide for load changes between power levels within the operating characteristics of the equipment.

2. PLANT SAFETY REQUIREMENTS

The plant safety system will protect against hazardous conditions arising within the plant that would impair its future usefulness or make it a hazard to either plant personnel or the environment. Safety devices similar to those in fossil-fired plants are to be applied to such equipment as the turbine-generator, feedwater heaters, and feed pumps in addition to safety systems unique to nuclear reactor systems.

There are three pertinent characteristics that are peculiar to nuclear reactors. First, it is possible to reach dangerously high reactor power levels making it necessary to measure neutron flux level or rate of change of neutron flux in order to prevent damage to the fuel, reactor vessel, and the remainder of the plant. Second, although the reactor may be shut down and the neutron flux may be substantially zero, heat continues to be generated at an ever decreasing rate as a result of the decay of radioactive fission products, so that it is necessary not only to scram the reactor when normal heat removal capacity is jeopardized but also to provide some heat removal capacity long after shutdown. Third, the hazards of releasing radioactive contamination to the environs are such that all reasonable measures must be taken to prevent such release above prescribed permissible concentration.

3. REACTOR SAFETY SYSTEM

The reactor safety system will protect equipment, plant, and personnel by scramming the reactor in the event of accident or dangerous maloperation. Control signals initiating scram will originate from a variety of control and detection devices. These signals will activate control circuitry to cause the reactor to be immediately scrammed and will initiate operation of whatever devices are necessary for safe plant shutdown.

The instrumentation system containing the scram sensors will be duplicated for greater reliability and will be arranged to reduce nuisance scrams to a minimum. The duplicate sensors will be divided between the two separate scram systems and a scram initiation function must be signaled in each system to scram the reactor. The scram circuit itself will be fail safe by making all devices in the safety circuit energized during normal plant operation. The de-energizing of any device or component will activate the appropriate device in the reactor scram system.

The following environmental or plant operating conditions will cause monitoring devices to initiate a scram signal.

a. High Neutron Flux and Reactor Period

The reactor neutron flux monitoring instrumentation will monitor the reactor neutron flux (or power level) and will scram the reactor if the power level or rate of rise of power level becomes excessive. These limitations are imposed to prevent the reactor from operating at a power level so high that the core cannot be safely cooled, and to avoid rates of rise which cannot be readily controlled.

b. High Reactor Pressure

Reactor vessel pressure sensing devices will scram the reactor upon excessive pressures within the reactor vessel. They will override normal operating transients but will scram the reactor to prevent excessive pressures that would cause operation of the primary relief valves.

c. Low Primary Steam Drum Level

A differentail pressure element operating on primary steam drum level variations will provide drum water level indication. This device will scram the reactor on low level before further loss of water would result in improper cooling of the reactor fuel elements.

d. Low Condenser Vacuum

The hydraulically operated turbine vacuum trip devices, operating on loss of condenser vacuum, sequentially will sound an alarm, close secondary control valves, scram the reactor, close the turbine stop and control valves and finally close the primary sphere isolation valves as the condenser loses its ability to condense steam.

e. Loss of Reactor Feedwater

Reactor scram will be initiated upon loss of all primary feedwater pumps by pressure switches connected to the pump discharge lines upstream of the pump check valves. Loss of discharge pressure at all pumps will effect a scram.

f. Primary Steam - Sphere Isolation Valve Closure

Closure of the isolation valves in the primary steam lines will scram the reactor by means of valve limit switches.

g. Loss of Auxiliary Power

Time delayed undervoltage relays will act to scram the reactor upon loss of auxiliary power from both of the main 4160 volt buses. Loss of these buses will result in a complete loss of station auxiliaries which renders the plant incapable of operating under load.

h. High Sphere Pressure

A pressure switch, operating from sphere pressure, will scram the reactor at any time that internal sphere pressure rises abnormally, indicating a rupture of a pressure vessel.

i. Manual Scram

There will be two manually operated scram devices in the control room. The normal manual scram device will instigate a reactor scram. The emergency manual scram device will scram the reactor and close all sphere isolation valves.

Upon actuation by one of the above scram signals, the reactor safety system will perform the following functions:

1. Scram reactor control rods to full poison position
2. Close turbine secondary admission control valves
3. Trip recirculation pumps after time delay
4. Close ventilation duct sphere penetrations (except on normal manual scram)
5. Initiate emergency cooling system (except on normal manual scram)

In addition, certain scram signals will initiate other safety operations. The following signals will close the primary sphere isolation valves and other necessary penetrations to insure complete sphere closure against the potential incident of release of dangerous radioactivity.

1. High sphere pressure scram
2. Low Primary steam drum level scram

4. PHILOSOPHY OF BLOCK DIAGRAM

The Instrumentation Elementary Block Diagram, 193E725, shows the relationship between the origin of an instrumentation signal and the various places where it is used.

This diagram indicates the instrumentation to be provided for components in the power producing loop; namely, the reactor, steam separators, secondary steam generators, turbine-generator, condenser, feedwater heaters, demineralizers, isolation valves, and critical pumps.

5. CENTRAL CONTROL ROOM

The central control room will be the nerve center of the plant. All information necessary to operate the plant will be presented qualitatively on the annunciators and backed up, where necessary, with quantitative measurements indicated or recorded on the instrument panel. From the central control room, the operator will have remote manual control of reactor control rods, pumps, valves, and the regulation of the plant load. He can also supervise the action of automatic controllers.

The auxiliary instrument area will house power supplies and amplifiers associated with indicators and recorders in the control room, and certain other instruments which will be necessary for long range plant operation.

Conventional power plant instrumentation will be used in all functions where applicable. Where radiation problems may occur, shielding and machinery arrangements are to be selected to minimize the use of special or non-standard control equipment. Where flow, pressure, or level are to be measured, local indicating transmitters will be installed outside of radiation shields to be accessible for maintenance or direct observation of the process variable. Receivers in the control room will operate recording, integrating or indicating instruments that are necessary for remote start-up and manual or automatic operation of all control room, operator-supervised equipment.

B. NUCLEAR STEAM SUPPLY CONTROL SYSTEM

(Included for reference is piping and instrument diagram, 7368E11.)

1. RECIRCULATING WATER AND STEAM SYSTEM

a. Reactor and Primary Steam Drum

The operating pressure of the reactor and primary steam drum is to be maintained constant by the turbine regulating system. (This system is described in Section X.)

The primary drum pressure will be recorded and indicated. The indicator will have an expanded range so that pressure changes of plus or minus 1 pound at an operating pressure of 1,000 pounds will be readable.

Primary drum level will be controlled by a three-element level control system. This system will measure flow of steam and feedwater. Feedwater flow will be regulated by a control valve in the feedwater line. The valve stem position will be transmitted to an indicator located in the main control room.

For start-up, a low capacity feedwater control valve will be provided. This is to be controlled directly by the drum level controller since at start-up loads, the normal steam flow and water flow instruments will not be effective in the control circuit. There will be auxiliary steam flow instruments to record and indicate low steam flow rates.

As a check on the level control system, there are to be separate and independent level indicators and level recorders. There is to be also an automatic-manual transfer switch in the main control room to permit remote manual regulation of the feedwater flow.

Low and high drum water level and low and high drum and reactor pressure will be annunciated.

b. Secondary Steam Generators

The secondary drum water levels are to be controlled by systems similar to that used for the primary drum, except that four regulating valves will be required. The steam flow from each of the four secondary steam drums will be added to give total secondary steam.

The secondary steam heat exchangers will have differential pressure indicators that will give the pressure drop of the recirculating water through them. High and low drum water levels are to be annunciated.

c. Recirculating Water

Differential pressure switches will measure the net positive suction head on the recirculation pumps. On low suction head, the switches will open to stop the pump motors. Each pump will have alarm and trip contacts for low flow rates, low flow rate of cooling water, and high temperatures in bearings and stator windings.

2. REACTOR RADIATION SAFETY SYSTEM

a. General

The reactor radiation safety system will monitor the reactor neutron flux and will scram the reactor if the power level (neutron flux) or rate of rise of power level is excessive. These limitations are imposed in order to prevent the reactor from operating at a power level so high that the core cannot be safely cooled, to prevent thermal stresses in fuel and vessel due to too rapid changes in power level, and to avoid rates of rise which cannot be readily controlled.

b. Design Description

The reactor radiation safety system will consist of twelve channels for monitoring. Each channel is to be composed of a primary detector for neutrons with associated amplifiers and controllers. Since the total dynamic range of operation of the reactor will extend from full power down to 10^{-10}, or less, of full power, the neutron monitors will cover this same range in three overlapping ranges; namely, the power level range, the pile period range, and the sub-critical and start-up range.

During steady state operation at or near full power level, reactor safety will be accomplished through six channels (1 through 6) of instrumentation operating into the scram circuit. (See drawing 537D491). Each channel is to consist of a neutron sensitive ionization chamber, amplifier, controller, and recorder. These channels are to monitor neutron flux from 10^{-2} to 1.5 times design power and scram the reactor if the flux exceeds a safe limit. These six channels are to be operated in two groups of three each. Each group is to be operated from a separate source of AC power. A trip of one channel in each group will be required to initiate a scram.

One channel (channel 12) will monitor from 10^{-1} to 1.5 times full power and will consist of an ionization chamber and a meter. No amplifier will be required. This channel will operate directly from a source of DC voltage. When the source of AC power to other instruments is interrupted, this channel will confirm that scram has been successfully accomplished, and that the flux remains at a safe level. This channel will not be in the scram circuit.

Three channels (7, 9, and 11) will monitor the neutron flux during start-up when the rate of rise must be limited. Each of these channels will consist of a gamma compensated ionization chamber, a log amplifier, a pile period trip, and a recorder. These channels are to be on range from 10^{-6} to 1.5 times full power. Operation of the pile period trip in the scram circuit above 10^{-1} times full power will be optional by manual bypass.

Two channels (8 and 10) will monitor neutron flux from source level (sub-critical) through the lower levels of start-up. Each channel will consist of a fission counter, pre-amplifier, linear amplifier, log counting rate meter, period amplifier and recorder. The fission counter may be moved away from the reactor core as the reactor increases power level by means of a motor positioner. These channels are expected to be sensitive to power levels as low as 10^{-10} of full power and remain in operation to approximately 10^{-4} of full power. These channels are not to be in the scram circuit.

3. CORE MONITOR SYSTEM

a. Core Flux Monitor

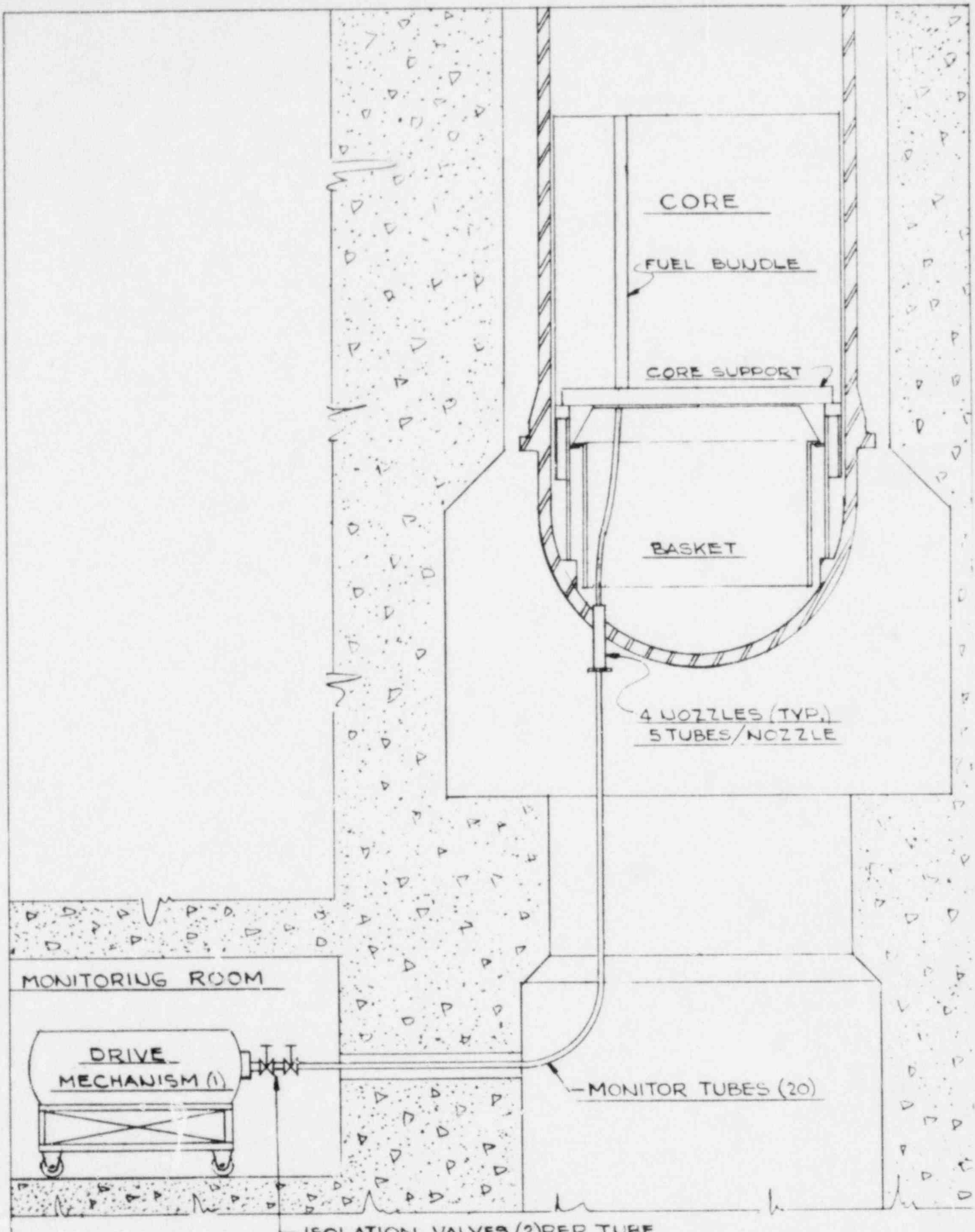
The purpose of the core flux monitor system is to determine the neutron flux distribution throughout the reactor in both radial and vertical planes, under steady state conditions. Flux is to be measured in about 20 fuel channels by inserting a copper wire specimen into the core, irradiating the specimen for a length of time, removing it and measuring the induced gamma radiation.

The wire will be fed from a pressurized drive system into a guide tube which extends from the access room through the vessel wall and up to the core base plate. The wire will be inserted through the guide tube into a tube which replaces one fuel element in special fuel channels. The following sketch shows the proposed equipment and layout of the flux monitoring mechanical arrangement.

The measuring systems will consist of a gamma scintillation detector, linear amplifier, spectrometer, countrate meter, and a recorder. The wire specimen, after removal from the vessel is to be moved across the detector and a plot of wire position versus activity is plotted on the recorder.

b. Core Flow Monitor

The flow system will provide measurement of the moderator coolant flow in 28 fuel channels. These channels are to be selected to provide flow data indicative of the various flow zones across the core pattern. The measured flows will be transmitted from the primary flow elements located within the reactor vessel to indicators located in the control room. The primary flow elements



FLUX MONITORING SYSTEM

POOR ORIGINAL

are Venturis which are to be located below the core base plate for the channels in which flows are to be measured. The individual Venturi throat pressures will be referenced to one common upstream pressure to provide differential pressures proportional to the square foot of the fuel channel flow rates. The upstream pressure will be developed in three piezometer rings located below, and spaced radially across, the core base plate. The differential pressures will be piped from the reactor vessel to high pressure flow transmitters located in an instrument room adjacent to and below the reactor. The flow transmitters will convert the developed differential pressures to electric flow signals which are to be transmitted to 28 individual indicators located in the control room.

4. FUEL ELEMENT RUPTURE DETECTION SYSTEM

a. General

If a fuel element becomes defective, fission products will be liberated into the common path. Fission gases which are liberated at the air ejector will be controlled to protect the environs. Excessive fission gases due to the faulty fuel may require that the reactor be shut down and the defective fuel removed.

The defective fuel element location system will monitor the fuel channels to determine the location of the defective fuel. This system is necessary to avoid discharging a whole reactor load of fuel to find the defective element.

b. Design Requirements

Reactor water will contain radioactive impurities due to contamination and corrosion and radioactive N^{16} and O^{19} generated within the reactor. Should a fuel element rupture, many radioactive fission products will be released to the water. The problem will be one of detecting and identifying fission products indicative of rupture in a background of other radioactivity.

The N^{16} and O^{19} have short half lives and decay in 5 to 10 minutes to a negligible level. The corrosion products and most of the fission products will be trapped in a cation resin bed. The principal fission products which pass through the cation resins will be the iodine isotopes; namely, 86 sec. I^{136}, 54 min. I^{134}, and 6.7 hr. I^{135}. The effluent of the cation unit will be monitored with a scintillation detector and gamma spectrometer biased to respond preferentially to the gamma energies characteristic of the iodines.

c. Design Description

Drawing 141F300 shows the monitor system in schematic form. Samples of water which can be identified uniquely with their respective channels are presented under continuous flow conditions to the iodine monitor. The samples are cooled, reduced in pressure, degassed, and filtered before entering the hold-up chamber where they are monitored.

The water flow will be metered in order to assure that the hold-up time is sufficient to allow for N^{16} and O^{19} decay. The samples are combined into manifolds to minimize the number of gamma spectrometers needed to survey the whole reactor.

The sample cooler rooms will contain most of the valving, filters, pressure reducers, and flow meters. The scanning rooms will be shielded from the heat exchanger rooms and from each other to minimize radiation background and interference.

The preamplifiers for the system are to be located in the scanning rooms. The spectrometers and recorders will be in the auxiliary instrument area outside the sphere. The water samples will flow continuously and are to be monitored intermittently on a 15 to 30 minute interval. A reading indication of a rupture will be annunciated in the control room.

In addition to the monitors for locating ruptures, an additional system will sample the non-condensible gases from the air ejector to give an early indication that a rupture has occurred. The fission gases, namely xenon and krypton, will be the principal ones detected in this bulk monitor.

5. CONTROL ROD POSITION INDICATION SYSTEM

a. General

The purpose of the control rod position indication system is to provide:

1. Control rod position data necessary to start up and control the reactor, and
2. Means to actuate the interlock and annunciator circuits at the "all-out", "all-in" and "decouple" positions of the rods.

The system will provide simultaneous indication of the positions of each of the control rods. Continuous position indicators are to be provided for each of the continuously adjustable rods, while pilot lights will indicate when any of the rods are at their "all-out", and "all-in" positions.

The continuous position indicators and fixed position pilot lights for each rod will be grouped together and arranged on the control room panel in a pattern simulating the relative locations of the rods in the core. The indicating mechanisms will operate at a positioning speed of 6 inches per second.

b. Continuous Position Indication Description

The control rod drive mechanism employed will not provide a mechanical coupling between the drive (inside the pressure container) and the continuous position indication system. The continuous indication system will consist of an electromagnetic position transmitter, amplifier, power supply and DC ammeter position indicator. The electromagnetic position transmitter will consist of a magnetic core piece which will be mechanically coupled to the rod drive mechanism and move "in" and "out" of an induction coil in relation to the position of the control rod. The magnetic core piece will be contained within the pressurized rod thimble and will be separated from the coil by a non-magnetic stainless steel thimble which is to be capable of withstanding reactor pressure. The coil will detect the length of the magnetic core piece which will be coupled into the coil field and provide a linear output signal of rod position. This signal will be amplified and will drive the indicator to denote the position of the rod in percentage of total travel from the all-out position. The accuracy of this system will be within plus or minus 3 per cent of full rod travel.

Detection of the control rod drive mechanism at the "all-out", "all-in" and "decouple" positions is also to be provided to control the operation of the electric drive motor. Sensitive relays, operating from the output signal of the continuous position amplifier, will control power relays which de-energize the electric drive motor when the limit positions of the drive mechanism are reached.

c. Fixed Position Indication Description

The detection and indication of the control rods at the "all-out", and "all-in" positions will be accomplished by electromagnetic detectors physically located on the exterior of the rod thimble at these positions.

6. REACTOR VESSEL AND COMPONENT MONITOR SYSTEM

Instruments will be provided to measure density of fluid in the reactor to give relative graphic records of boiling activity. One instrument is to be connected across the entire core, and a second and third across vertical sections above the core.

Position indicators will show movement of the reactor vessel. There are to be pressure indicators that will show whether or not there is a leak in the reactor head seal.

Thermocouples will measure outside reactor vessel skin temperatures, inside vessel temperatures, and temperature of the annular space between the shield and head in the upper section.

The flow of water to the reactor shield cooler is to be recorded. A level controller will admit any make-up water required to the surge tank on the suction side of the shield water circulating pumps. Low flow of shield water and indication of a seal leak are to be annunciated.

C. MAIN POWER LOOP

1. TURBINE AND MAIN STEAM CONTROL SYSTEM

Control and supervisory equipment for the turbine and generator essentially are to be standard but have been arranged for remote start-up and routine operation from the control room.

Control of the primary steam pressure and secondary steam flow is to be accomplished either manually or automatically through the hydraulic governing system of the turbine. Primary steam will be piped from the reactor to the high-pressure section of the turbine through primary control valves or to the condenser through oil operated bypass valves under the control of the primary pressure regulator. As these bypass valves operate, desuperheating water spray valves inject condensate into the primary steam bypassed around the turbine to the condenser. Operation of the pilot-operated safety relief valves will also cause spray water to be injected into the desuperheating section of the appropriate pressure reducers. High temperature of bypassed steam will operate an alarm in the control room. A backup pressure regulator is to be incorporated in the governing system to serve as a standby pressure regulating device to control primary steam pressure in the event of a failure of the normal pressure regulator.

Control of the settings of the pressure regulators, the speed governor, and of the load limiting devices will be accomplished remotely from the control room. Normal governor response as well as response to routine testing of all governor and stop valve components will be indicated by signal lights or position indicators. Routine valve testing will consist of exercising bypass valves, stop valves, and sphere isolation valves through their full travel.

For manual control of the shaft sealing system, remote bypassing of the steam seal regulator will be provided in the control room. This system will provide for shutoff of the secondary steam supply to the regulator and remote control of the inlet and outlet by-pass valves. The quantities of gases discharged from the shaft seal and the air ejector systems will be recorded in the control room.

2. CONDENSATE CONTROL SYSTEM

Due to the disassociation of water in the reactor, abnormal quantities of non-condensibles in the form of oxygen and hydrogen will be present in the steam and must be continuously removed for control of corrosion. The concentration of dissolved oxygen in the condensate leaving the condenser will be recorded to provide a guide to the performance of the gas removal system and the deaerating section of the condenser. Conductivity of this condensate is to be measured to indicate presence of condenser cooling water leakage. Measurement of pH of this condensate is to be provided.

Demineralized water make-up to the condenser or condensate rejection from the condensate pumps will be controlled automatically from condenser hotwell level. Either make-up or rejection may be operated manually from the remote manual-automatic selectors located in the control room where hotwell level and condensate flow are recorded.

Control room supervision of the condensate demineralizer will be by observation of the pressure drop across the demineralizers to indicate compaction of the resin and observation of conductivity of the effluent to indicate need for regeneration. Transfer of demineralizer beds and resin regeneration is to be controlled manually from a station adjacent to but shielded from the demineralizer.

Condensate, primary and secondary feed, and heater drip pump starting controls and indications of discharge pressure are to be located in the control room, as well as automatic standby start selectors. Primary and secondary feed pumps will be supplied with discharge flow metering equipment for control of recirculation at low pump flows. Individual feed pump flows and recirculation valve operation are to be indicated in the control room. Low feed pump suction pressure will start automatically the standby condensate pump and will initiate a low suction pressure alarm.

3. FEEDWATER HEATER CONTROL SYSTEM

Feedwater heater level control will assume two modes of operation; one at high loads when extraction pressure differentials are great enough to permit controlled cascade of heater condensate to lower pressure heaters; the other at lower loads when heater condensate level rises due to the inability of the condensate to cascade to the next lower stage heater. At this higher level, a second controller will operate a spill valve to divert heater condensate flow to the condenser. Action of these level control valves will be indicated in the control room.

Rupture of a tube or malfunction of a heater drair system may cause flooding of the steam side. Abnormally high heater level will be signalled by an alarm. A separate high level trip device will close an extraction non-return valve in the extraction steam line to prevent backflow to the turbine, and also will open a valve from the extraction line to the condenser to maintain the moisture removal function normally accomplished by that heater. Operation of this trip device also will initiate an alarm.

Extraction steam, feedwater, and heater drain temperatures at each primary and secondary heater are to be measured by thermocouples and recorded in the control room. Appropriate pressure indication will be provided on the feedwater influent line to each heater.

4. PROCESS RADIATION MONITOR SYSTEM

The process radiation monitor system will provide the information necessary to operate the plant within radiation limitations. Typical tasks are: to monitor the efficiency of filters in removing radioactive material; check "clean" water to assure that there are no contaminating leaks from process water; monitor process water to determine the identity and amount of corrosion contaminents. (For a complete listing of the process sampling system, see Section XX.)

Nominally "clean" water such as the cooling water for the unloading heat exchanger, the emergency heat exchanger, and the service water is to be monitored by ionization chambers for major break-trhough of contaminated water. Minor contamination will be detected by routine sample checking in the laboratory.

The effluent of the waste, clean-up, and condensate demineralizers are to be monitored for major break-through with ionization chambers.

Water which contains radioactive corrosion products will be monitored with a gamma spectrometer to aid in identifying the contaminents. This will include samples from the secondary steam generators.

The gases from the air ejector are to be monitored continuously with a gamma spectrometer to determine and record the relative concentration and radioactivity of the non-condensible gases sent to the stack. High activity level is to be annunciated in the control room.

The sensors are to be located at the point in the process which is being monitored. Amplifiers and preamplifiers will be located as necessary for operation. The functions most vital to plant operation will be indicated in the control room; the other shall be indicated and recorded in the auxiliary instrument area with annunciators in the control room.

There are to be 22 points in the process being monitored with ionization chambers. These ionization chambers will be appropriately grouped as to function and monitored intermittently. Each group of four to require on multiple switch, one amplifier, and one recorder.

Six sampling points requiring the sensitivity and selectivity of a gamma spectrometer will monitor process water on an intermittent basis. These points are all to be monitored with one gamma spectrometer with identification and annunciation for abnormal conditions.

D. MISCELLANEOUS CONTROL SYSTEMS

1. AREA AND HEALTH MONITORING SYSTEM

The area and health monitor system will provide radiation level and contamination measurements necessary to protect plant personnel and the public from radiation and contamination hazards.

The requirements of the system are:

1. Provide measurements and records of the general radiation levels existing within routinely occupied and controlled access areas.

2. Provide measurements of the localized radiation levels contributing to the general radiation level in the controlled access areas.

3. Provide individual personnel exposure measurements and records.

4. Provide plant environs radiation level measurement.

5. Provide public domain environs radiation level measurement including the atmosphere, terrain, and waterways.

a. Radiation Zone Monitoring

The general radiation levels existing throughout the plant and specifically those levels within the controlled access radiation zones are measured by fixed position gamma monitoring stations.

The complete system consists of 30 gamma sensitive ion chambers with built-in amplifiers, 30 logarithmic scale indicating alarm controllers, and 3 logarithmic scale multipoint radiation level recorders. The ion chambers are mounted in fixed positions in the various radiation zones, while the alarm controllers and recorders are located in the auxiliary instrument area in the turbine building.

The system provides continuous indication and alarm for each chamber while the radiation levels existing at the chambers are recorded on a time-cycled basis. High radiation levels are annunciated in the control room, and audible alarms are provided at locations where the transfer of irradiated fuel may cause high exposure to personnel. Typical locations which have local alarms are the unloading and fuel transfer positions at the top of the reactor and in the fuel handling building.

When personnel enter a radiation zone, the localized radiation levels which may exist within the zone are measured with portable radiation-monitoring instruments.

The portable instruments will be used to detect, measure the level and identify the type of radiation at specific work points. The portable radiation-monitoring equipment to be provided consists of:

1. Nine Low Range Beta-Gamma Monitors
2. Nine Medium Range Beta-Gamma Monitors
3. Two High Range Beta-Gamma Monitors
4. Two Alpha Monitors
5. Two Fast Neutron Monitors
6. Two Slow Neutron Monitors

Facilities for the maintenance and actual calibration of these instruments will not be supplied at the plant. Spot check sources will be provided for portable instruments where practical.

b. Personnel Radiation Exposure Monitoring

Individual exposure measurements will be made by the use of beta-gamma film badges for weekly dosage exposure records and by a pair of pocket ion chambers for daily exposure.

Slow neutron pocket chambers, fast neutron film badges, and beta-gamma film rings will be issued to personnel where conditions warrant their use. Facilities for the reading and servicing of these badges and rings will not be furnished on the plant.

c. Contamination Control Radiation Monitoring

Bench or shelf mounted alpha and beta probe type instruments are to be provided within the radiation zones to assist in control of contamination. Three alpha sensitive instruments and seven beta sensitive instruments will be provided. These are to be allocated to the various buildings and locations of the plant.

In the access control building, two beta-gamma (5 fold) hand and shoe counters will be provided for general personnel.

d. Environs Monitoring

In addition to the exhaust stack discharge monitoring system already described, ten semi-portable air samplers are to be provided to monitor ventilation duct and room air activities.

Three environs monitoring stations will be provided. Each station will be a building of approximately 50 square feet equipped with a gamma background counter, a large particle collector filter, and a moving strip air filter monitor. These stations are to be located on the periphery of the plant site. Other environs sampling, monitoring, and analytical requirements may be done by a competent nuclear instrument service organization.

2. REMOTE OPTICAL AND TELEVISION SYSTEM

The remote optical and television system provides visual means to assist in reactor unloading and loading operations, to assist in the transfer of fuel to and from the sphere, to inspect internal vessel components, to assist in the maintenance of vessel components, and to allow detailed inspection of irradiated fuel elements and fuel channels removed from the reactor.

Two closed-circuit industrial television systems will assist in fuel transfer operations through the discharge tube, and in performing internal reactor viewing.

One of the television systems will consist of a fixed position television camera located near the bottom of the fuel transfer discharge tube to "look" at the fuel basket when it is at the bottom of the transfer tube. A television monitor located near the fuel basket carrier will provide the crane operator with a picture of the crane hook and fuel basket bail to assist in the grappling operation.

The second television system will consist of a portable underwater television camera which can be placed within the reactor vessel after shutdown, and remotely (manually) positioned to observe the specific tasks being performed. A television monitor located on the loading platform at the top of the unit will provide the operator with a picture of the work being performed. This television system will be capable of being moved to the Fuel Building for use as the viewing aid for channel stripping as described in Section VIII-C-13.

Binoculars and a portable periscope are to be provided on the loading platform at the top of the reactor.

3. WASTE DISPOSAL SYSTEM

Instrumentation for the waste disposal system will be furnished on the individual vessels associated with the system. (The Radioactive Waste Disposal System is described in Section XIV.) In general, the instrumentation is to be located on panels adjacent to, but shielded from, the process vessels. Annunciation for alarm conditions will be provided in the control room.

A principal tool for observing the status of the radioactive waste disposal system is radiation-measuring ionization chambers. Six ion chambers are to be provided to determine radiation level of effluent from final stage process vessels. Ion chambers are to be located as follows:

	Number
1. Effluent from Waste Demineralizer Tank	1
2. Effluent from Waste Concentrator	1

Radiation level will be recorded in the auxiliary instrument area and local indication is to be made where required.

Liquid level measurements will be made and high level alarms or controllers are to be furnished on all tanks. Temperature will be measured and indicated locally. On vessels where the density of the waste solution may be expected to be greater than that of water, a specific gravity measurement will be made in addition to liquid level.

Flow of waste feed to the filter system will be controlled by means of flow recorder-controller and diaphragm control valves. Differential pressure across filters and demineralizers will be measured to determine equipment efficiency. Purity of effluent water from the waste disposal system will be determined by means of conductivity and pH measurements.

4. INSTRUMENT AIR SYSTEM

Three electric motor driven, non-lubricated compressors will be provided, with one to be a spare. Each compressor will deliver 250 SCFM at 100 psig. Each compressor is to be equipped with an intake silencer and filter. Inter and after coolers will be provided with provision for condensed moisture drainage. A system to supply cooling water to the inter and after coolers and compressor cylinder jackets will be provided. Throttling of the flow of water is to be controlled automatically by means of temperature regulator valves.

Three air receivers are to be provided and sized for a total reserve storage capacity of 10 minutes from 100 psig to 45 psig.

Automatic reactivating air drying equipment designed for a maximum dewpoint of minus 40 F is to be provided. Air from the drier will be passed through a suitable filter before entering the 100 psig instrument air supply header.

Suitable manifolding and bypass piping with manual block valves and automatic pressure regulating valves will be provided to permit the maximum flexibility in the operation and servicing of the air compressors.

Annunciators for motor overcurrent, low pressure of cooling water to the compressor after coolers and cylinder jackets, high temperature of jacket cooling water, high oil temperature, and low pressure in the instrument air supply header are to be provided. These alarms shall be located on the local air compressor instrument panel board. Low instrument air pressure alarm is to be annunciated in the control room.

The instrument air compressors are considered to be an essential service and will be kept in operation as long as electrical power is available. They are to be connected to the emergency electrical system.

Provision is to be made for auxiliary back-up of the instrument air supply compressors.

5. REACTOR CLEAN-UP DEMINERALIZER SYSTEM

The purity of water both to and from the clean-up demineralizer will be monitored by conductivity recorders. Pressure differential indicators across the demineralizers, flow indicators, and temperature indicators are to be provided. In addition, there are to be test thermocouples on inlets and outlets of the regenerative and non-regenerative heat exchangers. High differential pressure across the demineralizers, and low resistivity of the water outlet will be annunciated.

DRESDEN NUCLEAR POWER STATION

ELECTRICAL SYSTEM

SECTION XVI

INDEX

ELECTRICAL SYSTEM

SECTION XVI

The major electrical equipment and systems of this plant will consist of a generator, transformer, high voltage switchyard, auxiliary power system and associated services. The net electrical output of the plant will be 180,000 kw. Energy will be generated at 14.4 kv, and will be stepped up by means of a single three-phase main power transformer to the transmission voltage of 138 kv. This power is to be channeled through the high-voltage switchyard to the transmission lines feeding the Commonwealth Edison system.

Station auxiliary power normally will be provided in non-parallel dual feed from the auxiliary power transformers, (1) supplied directly from the generator leads and (2) from the 138 kv bus. Two 4160 volt and four 480 volt buses will distribute the power to the auxiliaries. Three independent power sources, including one of the normal station auxiliary sources (source 2) can supply power during shutdown or a post-incident period.

The following drawings are applicable to this section:

Electrical Single Line Diagram	124F740 Print 49
138 kv Switchyard - General Arrangement	124F743 Print 50
Single Line Diagram - 480V System	124F741 Print 51
Elementary Reactor Safety System	537D470 Print 52

A. GENERATOR AND CONNECTIONS

The 1800 rpm conventional hydrogen cooled generator will have a rating of 245,500 kva, at 0.85 power factor and 30 psig hydrogen pressure, and will have a voltage rating of 14.4 kv. Short circuit ratio under these conditions will be 0.64. The six bushing machine will feed directly into 10,000 ampere self-cooled isolated phase bus which will be directly connected to the main power transformer low voltage terminals. The generator neutral will be completed immediately external to the machine and grounded through a resistor loaded distribution transformer. Two sets of potential transformers, enclosed in a manner to maintain phase isolation, will supply metering, relaying, and control potentials. Housed within the same structure will be the generator lightning arresters and surge protection capacitors.

B. EXCITATION SYSTEM

Two motor driven exciters (one to serve as standby) will be provided for generator excitation. Each will be rated 500 kw at 375 volts and will be driven by a 4000 volt induction motor. Each exciter will be provided with the necessary equipment to connect either machine to the main generator through generator main field breakers. The motor-driven amplidyne-voltage regulator will be capable of being switched to either exciter. The auxiliary equipment associated with this system will be contained in conventional metal-clad excitation equipment cubicles. The exciters will be completely self-excited and stabilized over the entire operating range.

C. MAIN POWER TRANSFORMER

The conventional two winding, forced oil-to-air cooled, three-phase main power transformer will have a rating of 225,000 kva and a full load voltage ratio of 14.4 kv to 138 kv. The high voltage winding is to be wye connected and the low voltage winding delta connected. It will be provided with two 2.5 percent taps above and below the rated voltage. The transformer is to be de-energized before taps are changed. The high voltage winding of the transformer will operate with its neutral solidly grounded and will have a basic impulse insulation level of 550 kv. Appropriate lightning arresters will be provided for protection of the high voltage winding.

D. HIGH-VOLTAGE SWITCHYARD

The high-voltage switchyard will provide space for a main and transfer bus, five transmission line terminals, two bus sectionalizing positions in the main bus, two transformer connections, and a bus paralleling position. Installation for this unit will only include the main bus, four transmission line terminals, one bus sectionalizing breaker, two short sections of the transfer bus, and the two transformer connections.

The present design will utilize six 138 kv oil circuit breakers and provide space for four future breakers and associated equipment. Four of the initial six breakers will accommodate transmission lines 1205, 1206, 1904, and 1905. The fifth breaker will occupy a bus sectionalizing position between the 138 kv bus section 1-1 and 1-2. The sixth breaker will serve the main power transformer. No circuit breaker will be installed in the connection to the 138 kv auxiliary power transformer but a manual disconnect switch will provide no-load switching.

1. CIRCUIT BREAKERS AND DISCONNECT SWITCHES

All the 138 kv circuit breakers are to be rated 1200 amperes continuous, 36,000 amperes momentary, and 5,000,000 kva interrupting capability. The associated disconnect switches are also to be rated 1200 amperes continuous and have a compatible momentary capability. The disconnect switch in the tap to the 138 kv auxiliary transformer is rated 600 amperes continuous. The basic impulse insulation level of the above equipment will be at least 650 kv.

2. POTENTIAL DEVICES

Potential transformers are to be located on 138kv bus sections 1-1 and 1-2 for metering and relaying. Synchronization across the main power transformer circuit breaker will be accomplished by the main generator potential transformers, and the above mentioned potential transformers on the high-voltage switchyard bus. A bushing potential device on the generator side of the main power transformer circuit breaker will provide direct voltage indication for synchronization of the main generator.

E. STATION AUXILIARY POWER SYSTEM

The auxiliary power system will reliably supply the normal station auxiliary loads and will provide a high degree of availability of required power during shutdown or post-incident periods.

Four sources of auxiliary power will be available, as indicated below. The last two will provide back-up for the 138 kv transmission system source for shutdown or post-incident purposes.

1. Main generator
2. 138 kv transmission system
3. 34.5 kv sub-transmission system
4. Diesel generator

1. NORMAL STATION AUXILIARY POWER

Normal auxiliary power will be supplied from the two main auxiliary power transformers feeding the two 4160 volt buses in non-parallel operation. Each source will be capable of continuously supplying full station requirements. The loads will be divided among these buses as indicated below:

	Bus 1-1	Bus 1-2
Recirculating pump motors	2	2
Primary feed pump motors	2	1
Secondary feed pump motors	1	2
Circulating water pump motors	1	1
Condensate pump motors	1	2
Exciters	1	1
Load center transformers	1	1

At least one normal auxiliary power source, the 138 kv auxiliary power transformer (source 2) or the main generator auxiliary power transformer (source 1), will be necessary for continuous plant operation, as standby sources are of inadequate capacity. In the event of outage of either of the main auxiliary power transformers, automatic switching will transfer the dead bus to the remaining full capacity source. However, before such a transfer is effected the reactor recirculation pumps on that bus will be tripped out. This is necessary to prevent a spurious scram. Normal bus transfer, as on plant start-up, will be accomplished by a synchronized transfer.

2. SHUTDOWN OR POST-INCIDENT POWER

Power will be required for shutdown or post-incident purposes to operate station auxiliaries vital to the protection of equipment, plant and personnel. This power will be supplied from the 138 kv system via the 138 kv auxiliary power transformer, from the 34.5 kv sub-transmission system via the integral unit sub-station, or from the diesel driven generator.

All essential shutdown and post-incident loads are located on the 480 volt system and have ready access to all three independent sources of shutdown or post-incident power. Both double ended load centers will be connected to both 4160 volt buses, and one bus section of each load center will be connected to the diesel generator. The 480 volt load centers will be physically separated from each other, thus reducing the probability of a single incident rendering the auxiliary power system incapable of powering those essential loads.

F. STATION AUXILIARY POWER EQUIPMENT

1. 14.4 KV AUXILIARY POWER TRANSFORMER

The auxiliary power transformer to be fed from the main generator will be a three-phase, two winding, oil-immersed, air-cooled transformer. It will deliver power to the plant auxiliary system at 4160 volts in a dual feed arrangement to supply 4160 volt buses 1-1 and 1-2. Its self and forced air cooled ratings will be 10,000 and 12,500 kva respectively. Paralleling of the two main auxiliary power transformers occurs only during load transfer on start-up.

2. 138 KV AUXILIARY POWER TRANSFORMER

The auxiliary power transformer to be connected to the 138 kv transmission system will be a conventional oil-to-air cooled, three phase unit with self and forced-air cooled ratings of 10,000 and 12,500 kva respectively; the same as the 14.4 kv auxiliary power transformer. The basic impulse insulation level will be 500 kv with its grounded high voltage winding appropriately protected by lightning arresters. The transformer will deliver power to the plant auxiliary system through a dual feed arrangement to supply the 4160 volt buses 1-1 and 1-2, as indicated above.

3. 34.5 KV UNIT SUB-STATION

The 34.5 kv integral unit sub-station consists of oil-to-air self-cooled 2500 kva three-phase transformer integrally packaged with a 1200 amp 250,000 kva 4160 volt metal-clad switchgear feeder compartment. The circuit breaker will be interchangeable with other 4160 volt circuit breakers in the station. The unit will be connected to bus section 1-1 of the 4160 volt station auxiliary power system.

4. DIESEL GENERATOR

The diesel generator will be a complete integrated unit consisting of a diesel engine, 60-cycle a-c generator, a shaft-driven exciter, and the necessary field control and regulating equipment. It will be automatically started on failure of normal sources of auxiliary feed. The unit will be sized in accordance with vital shutdown and post-incident requirements.

5. 4160 VOLT SWITCHGEAR

Station auxiliary power is distributed by means of two metal-clad switchgear sections making up the two 4160 volt buses. Both sections are connected by means of bus ducts to the two main auxiliary power transformers. All incoming and feeder circuit breakers will be rated 1200 amp 250,000 kva and will be completely interchangeable with each other. Each bus section will contain appropriate metering and relaying instrument transformers and control devices.

6. 480 VOLT LOAD CENTERS

Two indoor double-ended 480 volt load centers will supply 480 volt station auxiliary power requirements. Each load center transformer will be pyranol filled with a self-cooled rating of 750 kva and will be throat-connected to its 480 volt switchgear section. Each switchgear section will be completely metal enclosed low voltage draw-out switchgear line-up containing an instrument compartment and required circuit breaker cubicles. The circuit breakers will be coordinated for selective tripping and so rated.

7. 480 VOLT CONTROL CENTERS

The 480 volt loads not directly switched by individual low voltage air circuit breakers will be supplied from control center equipment. This, in general, will include all motors up to 100 horsepower, lighting and miscellaneous plant services. These control centers will consist of packaged or grouped metal enclosed control and switching equipment. They shall consist of vertical sections joined together to form rigid, free-standing, completely dead front, enclosed control assemblies and contain appropriate motor starters and circuit switching functions.

G. SPECIAL ELECTRICAL SERVICES

Special services defined as those electrical systems provided for control, instrumentation, and special emergency power, are to be divided into two systems: an isolated a-c system and a station battery d-c system.

1. A-C REACTOR SAFETY AND INSTRUMENTATION SYSTEM

The function of this system will be to provide highly reliable 120 volt, 60 cycle, a-c power for the a-c reactor safety circuits. The important function of these safety circuits will be to protect the reactor, plant and personnel by scramming the reactor upon indication of trouble. All safety circuits and safety circuit equipment are to be provided in duplicate and are to be made fail-safe. To prevent nuisance scrams, each of the two separate safety and instrumentation systems will be supplied from its own isolated (electrically separate) a-c power source. These sources will be a-c motor generator sets equipped with flywheels to override momentary interruptions of driving power. In the event of outage of either of these sources, emergency operation may be achieved by switching directly to the 120 volt station power system.

2. STATION BATTERY D-C SYSTEM

The function of this system will be to provide highly reliable 125 and 250 volt d-c control, instrumentation, and special emergency power. Again, to accommodate reactor safety circuit functions, two separate and independent station batteries and d-c buses are to be provided. Essential loads are to be connected to both batteries through silicon rectifiers, thus achieving dual feed for these loads and still maintaining source isolation. Some of the emergency loads and circuits that will merit dual feed are:

1. Emergency seal oil pumps
2. Bearing oil pumps
3. Lighting circuits
4. Scram circuits
5. D-C motor operated valves

H. PROTECTIVE RELAYING

Modern relaying practices are to be utilized in the design of the plant protection system. The principle of overlapping protection zones is to be applied throughout with differential protection to be provided for all major transformers, the main generator, and the 138 kv bus. Sensitive ground protection and necessary back-up relaying for the generator, transformers, and the high voltage bus sectionalizing breaker will be provided in the relay pattern. Conventional carrier-current directional comparison type transmission line relaying with out-of-step blocking back-up relays, and instantaneous single-shot reclosing will be provided for all 138 kv transmission lines, and will be designed to operate successfully with Commonwealth Edison Company equipment at the remote terminal.

The generator will also be protected by loss of field relaying, negative sequence relaying and overcurrent with voltage restraint relaying. The generator neutral will be grounded through a resistance loaded distribution transformer which limits ground fault current and provides the means for the sensitive ground relaying.

The transformer differential zone around the main power transformer will be extended to include the generator. In this manner, back-up relaying will be provided for the generator as well as fast sensitive primary relaying for the main power transformer. Primary protection for both auxiliary power transformers will be by means of their own transformer differential relays.

In the 4160 volt auxiliary power system, all incoming lines and feeders will have phase and ground overcurrent relays. The transformer neutrals are to be resistance grounded to limit damage due to ground fault currents and yet provide fast effective ground relaying.

The 480 volt switchgear will be designed for selective tripping. Solid grounding of the load center transformers will provide for fast breaker tripping. Circuit breaker controlled loads will utilize available circuit breaker overcurrent protective devices for circuit and system protection rather than separate protective relays. Contactor controlled loads, such as loads fed from motor control centers, will utilize the thermal protection offered by contactor overload heaters and the fault overcurrent protection offered by molded case feeder breakers or fused switches.

I. GROUNDING

Grounding of the equipment structures for safety to personnel and a low impedance earth discharge path for lightning and surge protection will be provided.

Earth potential is to be established by providing a grounding network, or grid, of welded copper cables or ground rods below the permanent moisture level under the high voltage switchyard and turbine building. Additional lengths of buried cable will loop around the sphere and other auxiliary buildings. All conductors of the grounding system are to be sized to prevent melting during maximum fault conditions and are to be solidly interconnected.

Lightning arresters and station and incoming transmission line ground wires are all to be solidly connected to the grounding grid in the most direct manner possible. The main power transformer neutral is also to be directly connected to the grid.

Building steel, equipment frame work, switchgear, load center and motor control center ground buses are all to be solidly grounded to the grid. Cable tray runs each will carry a ground conductor to provide a low impedance ground return path.

Overhead ground wires will protect the incoming transmission lines, the high voltage switchyard and the transformer connections from direct lightning strokes. Rods atop the sphere are to be provided for lightning discharge protection. To insure a discharge path of lowest practical impedance, ground connections are to be made in the most direct manner.

J. MOTORS

All motors above 250 hp will be rated for 4,000 volts, 3 phase, 60 cycle, a-c operation. Motors from 3/4 hp to 250 hp will be rated for 440 volt, 3 phase, 60 cycle, a-c operation unless equipment design requirements justify a different supply voltage. Drip-proof motor enclosures are to be standard for all motors located in normally clean and dry locations. The selection between drip-proof, splash-proof, totally enclosed and weather protected enclosures for other areas will be determined upon the requirements of each location. Motors located out-doors are to be of the totally enclosed or of the weather protected type.

Class A insulation specially treated for power plant use is to be used for all motors of fram size 550 or larger located in areas with no appreciable heat radiation and in areas where ambient temperature during operation will not exceed 40 C. Class B insulation is to be used for all motors where the normal ambient temperature is to be from 40 C to 60 C and Class H insulation for motors operating in areas where the ambient is to be above 60 C or in the higher gamma radiation zone.

In cases where it will be possible for the ambient temperature to exceed the value specified for the operating conditions while the motor will not be running, the following limits are to be used: Class A insulated motors are to be limited to areas where the temperature cannot exceed 105 C and Class B insulated motors where temperatures will not exceed 130 C.

All motors to be located in areas where decontamination may be required will be specially treated to resist moisture absorption.

K. LIGHTING

The station lighting system will provide adequate lighting levels, commensurate with the visual criticality of the operations to be performed and personnel comfort and safety, with reasonable maintenance and efficiency. Each area will be considered separately before the appropriate lighting system selection is made. Incandescent, mercury vapor and fluorescent lights, alone or in combinations, are to be used to obtain illumination levels which follow closely the recommendations of the "Illuminating Engineering Society", and in particular, their committee on "Lighting of Central Station Properties".

The control room will be provided with a lighting system that will minimize contrasts or brightness differences, direct glare from light sources, and specular reflection in the glass faces of instruments.

Emergency lighting is to be provided for the control room to allow operators to carry on required tasks in the event of failure of regular lighting. In addition, emergency escape lighting is to be provided in all pertinent passageways, stairways, and exits for personnel movement during outage of normal lighting.

L. COMMUNICATIONS

The necessary provisions for installation of an Illinois Bell Telephone System are to be incorporated into the plant. This IBT phone system is to be used for major communication between various offices and portions of the plant requiring telephone communication off site. Necessary raceways and equipment are to be provided for the installation of the IBT leased lines for load dispatching and load indications.

Communications in the plant will be provided between all locations required to facilitate normal plant and start-up operations, refueling, and testing. This system will be supplemented with the interconnection of the 110 volt receptacle system throughout the turbine building and the sphere for the use of portable 110 volt carrier communication equipment.

Communication will be available (for maintenance or testing purposes) from the switchyard to adjacent locations in the Commonwealth Edison Company system over the carrier current equipment on the 138 kv transmission lines.

DRESDEN NUCLEAR POWER STATION

HEATING AND VENTILATION

SECTION XVII

INDEX

HEATING AND VENTILATION

SECTION XVII

This section outlines the basic philosophy and criteria for the heating and ventilating systems for the various process and service areas.

The following scope drawings are applicable to these criteria:

Turbine Building Flow Diagram - Heating and Ventilating
124F767 Print 53

Reactor Enclosure - Cooling and Ventilating Flow Diagram
537D495 Print 54

A. DESIGN REQUIREMENTS

1. PERSONNEL REQUIREMENTS

In general, the ventilating equipment will be designed to protect operating and maintenance personnel from, a) air-borne radioactive contaminants and, b) excessive thermal conditions. To meet the first requirement, the equipment will provide safe minimum face velocities across openings of cells which contain possible sources of radioactive aerosols and will insure air flow toward areas of greater activity, with final exhaust and dispersion to the atmosphere through a ventilation stack. For the second objective, cooling system capacities will be established to meet equipment heat loads and maintain safe effective temperatures on a time-weighted basis for the work rate involved.

2. EQUIPMENT REQUIREMENTS

Where structural and equipment operation considerations alone are of importance, air temperatures will be controlled 1) to prevent excessive stratification and hot spots and 2) within a range so as not to detrimentally affect performance and life of equipment and structures. Ventilation ducts will be designed to minimize condensate collection in duct runs.

3. DESIGN CONDITIONS

The following temperatures will be used as a design basis. As a further criterion for personnel work areas throughout the station, summer design conditions will be modified to produce a time-weighted effective temperature of 2° below the maximum permissible for the estimated work cycle. In most cases this will average 81 ET (°F effective temperature).

	Winter	Summer
Outside		
Dry bulb °F	-6	93
Wet bulb °F		76½
Reactor Enclosure		
General Areas °F	* 45 minimum	100
Nuclear Steam Supply System		
Habitable Rooms °F	70	85
Equipment Compartments °F	60	150
Turbine Building		
Areas with Extensive Electrical Cabling °F	* 45 minimum	104
General Areas °F	* 45 minimum	115
Areas Not Regularly Occupied °F	* 45 minimum	120
Controlled Areas Not Habitable during Operation °F	* 45 minimum	140
Air Conditioned Areas °F	72 ± 1	78 ± 1
Relative humidity %	40 ± 10%	40 ± 10%
Fuel Building °F	* 45 minimum	103
Access Control Building		
General Areas °F	72	100
Counting Room °F	72 ± 1	78 ± 1
Relative humidity %	40 ± 10%	40 ± 10%
Administration Building °F	72	78
Relative humidity %		50
Service Buildings		
Shop °F	60	103
Warehouse °F	* 45 minimum	110
Radioactive Waste Bldg. °F	* 45 minimum	105

*60 °F in areas occupied for periods exceeding one hour.

4. MATERIALS OF CONSTRUCTION

Heating and ventilating systems serving areas which contain possible sources of radioactive contamination will be constructed of such materials as to prevent formation of particulate products of corrosion and erosion. This requirement is necessary for the elimination of special filtration equipment for exhaust from these areas.

B. CENTRAL AIR HANDLING EQUIPMENT

1. CENTRAL SUPPLY EQUIPMENT

In the South Auxiliary Bay will be located the equipment for supplying ventilating air for the Turbine Building and Reactor Enclosure, each with an independent system. The screened and louvered inlet will be located to prevent recirculation of Ventilation Stack exhaust and insofar as possible, exhaust from other points. All supply air will be filtered through automatic cleanable or renewable media filters. Supply fans for systems required during periods of Reactor operation will be sized for 100% standby. Main volume dampers will be operated manually. During the heating season, supply air will be tempered as required by steam coils fed from the heating boiler. The tempering coils will be provided with a bypass and automatic damper for temperature regulation.

2. CENTRAL EXHAUST EQUIPMENT

Ventilating air from controlled areas will be discharged to the Ventilation Stack through exhaust fans in the North Auxiliary Bay. Independent exhaust systems will be provided for the Turbine Building and Reactor Enclosure with standby fans of 100% capacity included with equipment used during Reactor operation. Automatic changeover will be provided for spare fan start-up. In case of power failure, check dampers will function to prevent reverse flow.

The Ventilation Stack will be located just north of the northeast corner of the Turbine Building. It will be 300 feet high with a top diameter to provide a minimum of 1500 fpm release velocity. Provision will be made at the base for a drain with trap. An outside ladder will permit access to the top. The Stack will be marked and lighted to meet the requirements of the CAA. Stack exhaust will be monitored using a sampler of an isokinetic type, with an adequate sample routed to a collection device.

C. HEATING, VENTILATING AND AIR CONDITIONING SYSTEMS

1. REACTOR ENCLOSURE

Ventilating air from the Reactor Enclosure supply fans in the South Auxiliary Bay will be ducted along the south side of the Turbine Building, entering the Reactor Enclosure in the southwest quadrant for distribution to the general atmosphere of the Enclosure. Fin-type coil and fan units using well water will cool and recirculate air of the main operating area at a rate of approximately 24,000 cfm.

From the general atmosphere of the Enclosure, air will flow to the Nuclear Steam Supply System to meet its ventilating and infiltration requirements. All exhaust from the Nuclear Steam Supply System will be carried in a main exhaust duct penetrating the Reactor Enclosure in the northwest quadrant between grade and elevation 529' 6" and continuing to the Reactor Enclosure exhaust fans in the North Auxiliary Bay.

Both supply and exhaust ducts for the Reactor Enclosure will be provided with two quick-closing tight-seating valves in series which can be tripped to isolate the Enclosure. In both cases a by-pass around these valves will contain a single valve which can be opened during Reactor shutdown to permit increased airflow. Design airflow through supply and exhaust ducts, determined by Nuclear Steam Supply System requirements, will be approximately 4000 cfm maximum during Reactor operation and 12,000 cfm maximum during Reactor shutdown.

2. NUCLEAR STEAM SUPPLY SYSTEM

Equipment compartments will be cooled by air recirculation through fin-type coil and fan units, fed from manual balance valves by a river-water cooled demineralized water circuit. Similar units using well water will cool habitable rooms, including Flux Monitoring, Core Flow Monitoring, Nuclear Steam Instrumentation and Scanning. The latter rooms also will receive ventilating air through corridors or directly from the Reactor Enclosure general atmosphere to provide flow at control velocities into areas containing possible sources of air contaminants. An exhaust system will convey this air to the space surrounding the Reactor Vessel opposite the core for final collection and discharge to the main exhaust duct from the Nuclear Steam Supply System.

While equipment compartments will be sealed as far as practical during Reactor operation, the system will control crack infiltration into these compartments through maintenance of a sub-atmospheric pressure in the space surrounding the Reactor Vessel opposite the core. Design air flow during Reactor operation, including total infiltration and habitable room ventilation, will approximate 3000 cfm. In addition, approximately 1000 cfm exhaust capacity will be available for flushing equipment compartments shutdown under the unit system while the major part of the Nuclear Steam Supply System continues operating. Make-up air for the flushing operation will come directly from the Reactor Enclosure general atmosphere at safe control velocities through access openings.

During Reactor shutdown an exhaust system of approximately 4000 cfm capacity will be provided for flushing equipment compartments before entry. Exhaust points in the compartments will be located remotely from access openings, which will be sized to maintain safe air flow control velocities into compartments during flushing. An additional system will provide approximately 4000 cfm exhaust capacity at exposed shielding water surfaces above the Reactor during refueling. Total design air flow capacity available during Reactor shutdown will approximate 12,000 cfm.

Cooling units in equipment compartments not habitable will be designed to permit maintenance and replacement without requiring personnel entry into the compartment.

3. TURBINE BUILDING

The ventilation air for the Turbine Building will be provided from one of two Turbine Building Supply Fans located in the South Auxiliary Bay. The air will be ducted to the uncontrolled areas on the north, west and south sides of the Turbine Building, from which it will flow through controlled access corridors to the equipment rooms. Fresh air from the fans will be supplied directly to the operating floor of the Turbine Building. Exhaust air from the controlled areas will be drawn through ducts to the exhaust fans in the North Auxiliary Bay adjacent to the Ventilation Stack.

The system will assure air flow from uncontrolled to controlled areas by proper maintenance of static pressures at 300 fpm minimum face velocity through boundary openings. Within controlled areas air flow of at least 100 fpm face velocity will be maintained through openings into cells containing possible sources of radioactive contamination. Total design air flow will be approximately 65,000 cfm.

4. CONTROL ROOM

The Control Room and Auxiliary Instrument Room will be air conditioned by remote equipment located in the South Auxiliary Bay. Controls will maintain design temperatures within ± 10% RH.

5. FUEL BUILDING

The fuel building will be equipped with suspended steam unit heaters and the ventilating air will be tempered during the heating season by a supply unit. A cover will be provided over the fuel storage pit to prevent potential dissipation of gaseous fission products throughout the building from the stored irradiated fuel elements. Exhaust air from the building, including air from an exhaust system for the fuel storage pit will be discharged to the Ventilation Stack. The exhaust air will be removed from the north end of the building and ducted to the Ventilation Stack.

6. ACCESS CONTROL BUILDING

All areas of the building except the counting room will be heated and ventilated with supplementary perimeter heating. The counting room will be air conditioned by a remote unit capable of maintaining temperatures within ± 1°F and humidity within ± 10% RH. Supply air will be filtered by renewable paper or glass mat media filters. Air flow into the laboratory rooms will be maintained at an average face velocity of 100 fpm through louvered doors. Laboratory hood exhaust system capacity will be based on a 33% hood use factor. Average hood face velocities in the Hot Laboratory will be 150 fpm. Exhaust from Hot Laboratory hoods, Laundry Dryer and Initial Sorter will be carried to the ventilation stack through an exhaust system which will incorporate dual fans to provide 50% capacity in case of failure of one exhaust fan. Check dampers will prevent reverse flow from this system in event of power outage.

7. ADMINISTRATION BUILDING

The administration building will be comfort air conditioned by using mechanical refrigeration for summer cooling and perimeter heating as supplemental heating during the winter months.

8. SERVICE BUILDINGS

The shop will be heated in winter months by suspended steam unit-heaters located in the south end of the building. Air flow will be from uncontrolled areas to controlled shop areas to the decontamination area. A multi-service flexible duct exhaust system will be provided for cutting machine equipment in the controlled shop. An industrial vacuum system will be installed in controlled areas. Hood face velocities will be in accordance with ASHAE recommendations.

The warehouse and other service buildings will be heated with suspended steam unit heaters.

9. RADIOACTIVE WASTE BUILDING

The radioactive waste building will be ventilated by a single supply unit incorporating filters and heating coils, located in the control room. Steam coils will be provided in the pipeway and each tank cell for frost protection. The heated air from the control room will be exhausted through the pipeway to the tank cells by means of an exhaust fan. The fan will discharge through a ten foot high stack located on the roof of the control room. The equipment cell areas shall be maintained at approximately -0.20 inch static pressure to control contamination. Each tank will be provided with a self-draining vent.

D. REACTOR ENCLOSURE

It has been calculated that for the 'worst probable' accident, removal of heat at an initial rate of 30×10^6 btu/hr will be required to insure that the intial pressure will never exceed the 37 psig sphere test pressure. Furthermore, the equipment must be designed to provide a rate of heat removal sufficient to reduce the internal pressure to 5 psig within 24 hours. As the internal pressure is reduced, the rate of heat removal obtainable decreases, dropping to less than 15×10^6 btu/hr within 24 hours. These calculations allow for heat loss through reactor enclosure insulation, heat absorption by the concrete structure and reactor enclosure shell and the release of energy from fission-product decay.

The post-incident cooling system will consist of two independent systems each capable of removing 15×10^6 btu/hr from the reactor enclosure at the design temperature of 256°F. Each system will consist of a pump, pump suction strainers, a heat exchanger and a spray header. The two systems are to be arranged to operate independently.

The pumps will be located in a pit adjacent to the reactor enclosure and will take suction from sumps located in the lower compartments in the reactor enclosure. The system is to be primed with water which is released from the nuclear steam supply system as a result of the incident or with water from washdown by spray nozzles connected to the station fire system. Each suction sump will be provided with a grizzley to exclude coarse rubble from the system, and additional strainers or settling devices will be located on the suction side of each pump to assure non-plugging of the pumps or circulating system. The pumps, rated at 600 gpm, 120 ft TDH will be the vertical type designed with non-clogging features.

The heat exchangers will be the U-tube type with carbon steel shell and tubes and will be sized to cool 600 gpm each from the design temperature of 256°F to 206°F with 2000 gpm of river water at 95°F. The cooled water from the exchangers will be returned to the reactor enclosure and sprayed over the concrete of the nuclear steam supply system shielding through a series of 3/8 inch diameter holes in the spray headers located at elevation 540.

The system will be arranged for remote operation with the controls to be located in the central control room. A bleed line will be provided to the waste disposal system to aid in clean-up of the reactor enclosure after the internal pressure has been reduced to 5 psig.

DRESDEN NUCLEAR POWER STATION

AUXILIARY SERVICE FACILITIES

SECTION XVIII

INDEX

AUXILIARY SERVICE FACILITIES

SECTION XVIII

The purpose of this section is to present the design description of the auxiliary systems and facilities which service the major process facilities of the Dresden Plant.

The following reference drawings are applicable to this section:

Plant Flow Diagram - Services	124-F-701	Print 43
Plant Area Underground Piping	124-F-716	Print 55
General Site Plan	124-F-713	Print 1
Plant Area Arrangement	124-F-714	Print 3

A. COOLING WATER SYSTEM

The Cooling Water System will be designed to supply treated water for cooling those pieces of equipment in which deposition of scale cannot be tolerated. The cooling water will be demineralized water to which will be added an anionic inhibitor and is to be used in the following equipment.

- Service Air Compressor Jackets
- Service Air Compressor Coolers
- Instrument Air Compressor Jackets
- Hydrogen Seal Oil Cooler
- Primary Feed Pump Lube Oil Coolers
- Secondary Feed Pump Lube Oil Coolers
- Reactor Clean-up Demineralizer Non-regenerative Exchanger
- Reactor Recirculation Pump Motor Coolers
- Shield Cooling Exchanger

The system is sized for a normal duty of 12 million BTU per hour and a flow of 660 gpm. Provisions for monitoring the cooling water for radioactivity are to be made. A manually operated bypass control valve will regulate cooling water temperature by bypassing the heat exchangers on the cooling water side. This system will produce a cooling water temperature of 105F when the river water temperature is 95F.

The cooling water pump and its spare will take their suction from the return tank which is sized for a storage capacity of 10,000 gals, and will discharge through two full-capacity cooling water heat exchangers to supply the various auxiliary cooling loads. The water from these auxiliary loads will be discharged to the return tank. A level control on the return tank will regulate the make-up to allow for system losses. The treated water passing through heat exchangers will be cooled by river water from the service water system.

B. SERVICE WATER SYSTEM

The Service Water System is to be designed to furnish raw water for cooling purposes to those pieces of equipment in which some fouling of the heat transfer surfaces can be tolerated.

The two Service Water Pumps will be located at the intake structure, taking suction from the center well. This water will pass through the traveling screens and will be chlorinated before entering the pump section. The Service Water Pumps are rated at 7,500 gpm each to provide adequate cooling. House Service Water will be chlorinated separately.

From the intake structure, service water will be pumped through strainers into the Turbine Building and will be returned to the discharge canal. Service water will be used in the following exchangers:

Emergency Diesel Engine Cooler
Cooling Water Exchanger
Waste Collector Tank Coolers
Hydrogen Coolers
Turbine Lube Oil Cooler
Fuel Storage Pit Cooler Exchanger
Unloading Heat Exchanger
Reactor System Drain Tank Coolers
Post Incident Cooling Exchanger
Waste Concentrator Condenser

The Service Water is to be monitored for radioactivity where appropriate.

C. DOMESTIC WATER SYSTEM

The source of domestic water is to be two deep wells, with pumps, a well water storage tank, a domestic water service pump, a hypo-chlorinator, accumulator and distribution piping.

1. DEEP WELLS

Two deep wells are to supply domestic water, as well as water for make-up, bearing lubricating service and air conditioning. These wells are to be located 1500 feet apart, adjacent to and 200 feet west of the station access road. Drawing number 124-F-713, General Site Plant, shows the proposed locations for the wells. Each well will be capable of delivering 200 gpm on a continuous basis. These wells will take water from sandstone and dolomite. They will be drilled to a depth from which economical, demineralized treated water can be produced. Pumps are to be of the deep-well type with an electric driver. Each well casing will be adequately cemented. The pumps will be controlled from the Turbine

Building. Automatic actuation of pumps by a storage tank level control will also be provided. A one lane graveled road will connect the wells to the Station access road. There is to be adequate turn around space at each well.

2. DISTRIBUTION PIPING

A welded steel pipeline, suitably coated and wrapped, buried below the limit of frost penetration, and cathodically protected if required, will deliver water from both wells to the well water storage tank. This pipeline is to be located west of the Station access road, in line with the wells.

3. WELL WATER STORAGE TANK

Water from both wells will be delivered to the well water storage tank. This tank is to be located west of the Station roadways and north of the Station railroad. It will consist of a vertical cylindrical carbon steel tank of 200,000 gallons capacity. The bottom of this tank is to be on a foundation of select material, compacted and oil saturated. The level of the foundation will be above finished grade level to permit adequate drainage. Cathodic protection of the outside tank bottom and sides will be provided if required.

4. PUMP SYSTEM

Domestic water use has been estimated to be equal to 20 gpm continuous demand. Peak demand will be much larger than this. The two domestic water pumps will take suction from the well water storage tank. Water will pass from the pump through a flow proportioning hypo-chlorinator to the domestic water accumulator. This accumulator is to be located in the pump bay of the Turbine Building and will consist of an 8,400 gallon horizontal cylindrical carbon steel tank, 7 feet in diameter by 28 feet in length. Controls are to be arranged to keep this tank about two-thirds full of water at all times. Domestic water piping will run inside the buildings wherever possible. Outside piping is to be buried below the limit of frost penetration, suitably protected against corrosion by either galvanizing or coating and wrapping. All domestic water piping is to be sized to maintain pressure within a narrow range even at peak demand.

D. PLANT HEATING SYSTEM

Two oil-fired boilers will supply steam for space heating and auxiliary services. Each boiler is to be rated at 15,000 lbs. per hour at 150 psig. Normally, one boiler will be able to supply the plant's space heating and auxiliary steam requirements with the other as a stand-by.

The two boilers are to be located in the auxiliary bay at the north-east corner of the turbine building. Each unit is to be factory assembled, complete with forced draft fan, oil burners and registers, feedwater regulator, fuel oil pump and strainer, safety valves, blow down valves, automatic controls, instrument panel board, necessary piping and wiring.

A single stack will serve both boilers. This stack will be separate from the ventilation stack. The fuel storage tank is to be located outside the turbine building. It is sized to hold a month's supply of fuel oil.

Condensate returns from the heating system will be collected in a surge tank.

Three boiler feed pumps, rated at 60 gpm, are to be provided. A pump will serve each boiler, the third will serve as a common spare. Chemical injection equipment is to be provided. Make-up water will be drawn from the non-contaminated demineralized water storage tank.

E. SANITARY SEWER SYSTEM

The sanitary sewer system will collect and treat all human wastes. The system has been designed to treat a maximum flow of 8,000 gallons a day, which is equal to a population of 200 with a flow of 40 gallons per capita.

1. COLLECTION SYSTEM

Sanitary sewage will be collected by a system of gravity pipe sewers. Pipe with positive joints will be used to prevent infiltration, since this portion of the system will be beneath normal ground water table. Manholes are to be placed at the upper end of all lines, and at all changes in line or grade.

The gravity collection system will end at a low level manhole adjacent to the lift station. The lift station is to be located east of the station buildings and south of the intake canal. It will consist of a reinforced concrete dry pit covered with a small prefabricated metal building, arranged for easy access to the pit. Two pneumatic ejectors with cast iron pots of 50 gallon capacity will lift the sewage to the Imhoff tank through a force main.

The force main, 4 inches in diameter, will connect the lift station and the Imhoff tank. This line will be laid so that it will pass under the invert of future intake canals. Its route generally parallels the discharge canal to the Imhoff tank.

2. IMHOFF TREATMENT TANK

The Imhoff tank will be located north of the intake canal and east of the discharge canal, about 1,000 feet from the Station buildings. Its location has been coordinated with possible future development in this area. The Imhoff tank will be designed in accordance with the requirements and recommendations of the Illinois Sanitary Water Board and will treat a design flow of 8,000 gallons a day. Provision will be made to by-pass the tank, if necessary. The Imhoff tank will have bedrock as foundation; earth will be heaped around the tank for insulation. A $1\frac{1}{2}$-inch galvanized steel water line connected to the fire protection system will provide water service at the Imhoff tank. Where possible, this line is to be laid in the same trench as the force main. A small prefabricated metal building will be located near the Imhoff tank for storage of special tools and chemicals necessary for proper operation. The area containing the Imhoff tank and tool shed is to be enclosed with a seven-foot high chain link fence.

Effluent from the Imhoff tank will run the shortest distance possible by gravity in an outfall pipeline to the Illinois River, a distance of about 500 feet. The end of the outfall will terminate below normal river level.

The sanitary sewer system, as designed, meets the present requirements of the Illinois Sanitary Water Board. Space has been set aside near the Imhoff tank for additional stages of treatment if this should be necessary in the future.

F. ROADS AND WALKWAYS

1. ACCESS AND STATION ROADS

A system of two lane, paved roadways will serve the Station area and will provide access to the nearest public road. Single lane, graveled roads will serve areas outside the immediate Station area.

The access road will run from Goose Lake Road to the Station area and will consist of a two lane paved roadway with graveled shoulders. Grade is to be held above existing ground level to facilitate drainage. During the first stage of construction, a 6-inch thick base course will be placed on graded and compacted subgrade. During the second stage of construction, near completion of the job, the base course is to be reconditioned and a wearing surface of 2 inches of asphaltic concrete is to be placed.

Main Station roads are to be arranged as shown on the drawing number 124-F-714, Plant Area Arrangement, and are to be similar in cross section and construction sequence to the access road. Shoulder widths are varied to suit building arrangement.

Secondary Station roads will serve areas away from the Station that require access for routine maintenance and will consist of one-lane graveled roadways . The gravel wearing surface is to be placed over a graded and compacted sub-grade. Grade will be held above existing ground level wherever possible.

2. PARKING AREAS

Two parking areas are to be provided at the Station. Visitor and executive parking will be located south of the administration building, inside the security fencing. Employee parking will be located west of the Station access road and south of the security fence.

Visitor parking area will be paved to the standards of main Station roads. Concrete curbing is to be provided for wheel bumpers.

Employee parking area will be paved, using minimum thickness base and surface courses. This area will have a capacity of 100 cars. During the construction period, this area is to be used for construction parking. During the first stage of construction, a base course of 4-inch thickness will be placed on graded and compacted sub-grade. The second stage of construction, near the end of the construction period, will consist of reconditioning the base course and placing a one-inch thick wearing surface of asphaltic concrete on the base.

3. SITE DRAINAGE FACILITIES

Drainage facilities in the Station area will consist of shallow open ditches, culverts and a buried storm water drainage system. Drainage facilities elsewhere will consist of open ditches and culverts. The design storm will have a 25-year frequency.

Open ditches will be located on each side of main Station roads. Ditches are to be trapezoidal in cross section, with a maximum sideslope of 4:1, minimum bottom width of 3 feet, and a depth of 18 inches. Where possible, culverts are to be used to continue ditches and connect isolated drainage areas. Storm water inlets connected with buried piping will drain all other areas. Storm drains will discharge into the inlet canal.

4. WALKWAYS

Pedestrian walks are to be provided as required between buildings and between buildings and roadways. All walks will have a minimum width of three feet. Walks adjacent to buildings are to be constructed of Portland cement concrete. Other service walks are to be constructed of asphaltic concrete.

G. FIRE PROTECTION

The fire protection system will furnish river water at adequate pressure to all points throughout the plant area where water for fighting fires may be required. It is designed and will be constructed in accordance with the Standard Fire Protection Requirements of Commonwealth Edison Company. Pressure is to be maintained in the fire lines at all times by an electric driven jockey pump. The jockey pump will take suction from a small sump supplied from the well water storage tank.

Full flow of water will be provided by the screen wash pumps which also serve as motor driven fire pumps. There will be two screen wash pumps, each capable of washing all four screens. The piping will be designed so that either wash pump can be connected into the fire system and automatically started by low pressure in the fire system header. In normal service, the spare wash pump will be isolated from the screen wash system by a manually operated valve to insure the integrity of the fire system. The fire protection system will be backed up by a diesel driven fire pump sized for full flow.

Hydrants, hose house, hose racks, and manually operated fire extinquishers will be placed throughout the plant area in suitable places. Fog nozzles are to be provided for protection of all main power transformers. Separate pressurized carbon dioxide systems will be installed for controlling oil and electrical fires, and for purging the hydrogen from the generator. The carbon dioxide fire system is to be located in an auxiliary bay of the turbine building and the gas will be distributed to lube oil tanks, lube oil filters, and DC switchgear area, to be released automatically by a temperature rise above a safe point. Turbine oil lines adjacent to steam lines and DC switchgear will be similiarly protected if necessary.

H. RAILROAD FACILITIES

The station will be served by the Coal Branch of the Elgin, Joliet and Eastern Railway. Trackage is to be constructed from the serving railway to the Station where tracks enter the Turbine Building and the Fuel Building. An unloading siding for chlorine and fuel oil will also be provided. Additional temporary trackage may be laid during the construction period.

Trackage at the Station will be arranged so that the maximum degree of curve is 15° (Radius = 383.07 feet). The maximum degree of curve on trackage between the Station and the serving railway will be 8° (Radius = 716.78 feet). The turnout at the Station will have a number 8 frog, and the turnout at the serving railway will have a number 9 frog. Track grade is to be limited to one per cent, with a maximum rate of change of grade of 0.2 per cent per 100 feet.

Track is to be laid on compacted sub-grade 18 feet wide in both cut and fill sections. Ballast is to consist of crushed stone with a minimum depth of 12 inches beneath the ties. Ties are to be drilled and pressure treated with wood preservative. They are to be spaced 24 to a 39 foot rail. Tie plates are placed between the ties and the rails. Rails are to be ARA type B section, weighing 100 pounds per yard. All material is to be new, except that rails, joint bars, and tie plates may be approved relayer material.

Structures supporting the roadbed will be designed for Coopers E-65 loading.

I. FENCING

Minimum areas, consistent with station security, will be fenced. The fenced area is shown on Drawing 124F714, Plant Area Arrangement. Gates are to be provided where required.

The 138 KV switchyard and all electrical sub-stations are to be fenced and gated.

To prevent possible accidents due to personnel falling into the circulating water canal, a fence is to be located south of the intake canal, between the ends of the intake and discharge canals to the west of the discharge canal.

Existing property fences that will be disturbed during the construction period will be put back into satisfactory condition.

DRESDEN NUCLEAR POWER STATION

AUXILIARY SERVICE STRUCTURES

SECTION XIX

INDEX

AUXILIARY SERVICE STRUCTURES

SECTION XIX

The purpose of this section is to present the architectural and structural considerations and the functional and equipment requirements of the auxiliary service structures of the Dresden Plant.

The following drawings are reference drawings to this section:

Administration Building	124-F-724 Print 56
Access Control Building	124-F-725 Print 57
Shop and Warehouse	124-F-726 Print 58

A. ADMINISTRATION BUILDING

The Administration Building will be located south of the Turbine Generator Building and is to be bounded on the east by the Access Control Building. Plans and Elevations are shown on Drawing 124-F-724.

1. ARCHITECTURAL AND STRUCTURAL REQUIREMENTS

The foundations will be on rock and the structural floor slab will be one foot above finish grade. Overall dimensions of the building are to be approximately 62 feet by 118 feet by 14 feet high. The framing will be structural steel. Exterior walls are to be aluminum window curtain walls, reinforced concrete, and brick. The steel roof deck is to be covered with insulation and built-up roofing. Interior partitions will be metal lath and plaster on metal studs. Interior finishes are indicated in the schedule on the drawing.

2. FUNCTIONAL REQUIREMENTS

The Administration Building will provide office space for all of the plant management personnel and clerical staff, a meeting room, a heating and ventilation room, telephone exchange equipment, and toilet facilities.

B. ACCESS CONTROL BUILDING

Access control facilities and the laboratory will be housed in a single story structure as shown on Drawing 124-F-725.

1. ARCHITECTURAL AND STRUCTURAL REQUIREMENTS

This building will adjoin the Administration Building on the west and the Turbine structure on the north, forming common walls with these buildings. The architecture is similar to the Administration Building, with aluminum curtain walls, concrete slab floor, and steel framework. The interior finishes will be designated on the appropriate drawings.

2. FUNCTIONAL AND EQUIPMENT REQUIREMENTS OF ACCESS CONTROL SECTION

The Access Control Section of this building will provide space and facilities for the following services:

a. First Aid

A small dispensary room which will be used to treat minor injuries and illness and to conduct medical examinations shall be provided.

b. Laundry

Laundry facilities to process health protection clothing for approximately 50 men per day shall be provided including a dirty laundry sorting area, washer, dryer, clean laundry check table, storage bins, and mask cleaning station.

c. Locker Room

Locker room facilities to house approximately 85 male employees shall be provided including 100 full-length lockers, change area, lavatory, shower, and toilet facilities.

d. Personnel Check Area

An area to control personnel entrance and exit to and from all health regulated zones shall be provided and shall include a portable instrument storage and decontamination room, and a skin decontamination sink and shower.

e. Janitor's Closet

f. Meeting Room

A meeting room and lunch area shall be provided with facilities for 25 people.

g. Radiation Protection Records and Personnel Meter Laboratory

A personnel meter laboratory shall be provided with a fireproof storage area with file cabinets, and a work bench area.

h. Offices

An office for the Radiation Protection personnel shall be provided.

3. FUNCTIONAL REQUIREMENTS OF THE LABORATORY SECTION

The laboratory section of this building will provide space and facilities for the following services:

a. Process Laboratory Room

A laboratory to process radioactive samples shall be provided with the necessary laboratory hoods and benches for analytical work and the necessary sink and dryer hood for decontamination of sampling equipment.

b. Counting Room

A room to count the radioiostopic content of liquid and air samples shall be provided with 18 inch concrete shielding, air conditioning, and seven counting instruments and tables required for their mounting.

c. Cold Laboratory

A laboratory to process normal power plant samples shall be provided with two hoods, one cupboard unit, one sink, and bench area.

d. Instrument Repair Shop

An instrument shop to repair and calibrate the counting and laboratory instruments will have a bench, sink, work table, and cabinets.

e. Laboratory Ventilation Room

A room will be provided to contain heating and ventilating equipment, vacuum pump, and distilled water supply.

C. SHOPS

The building containing the shop will be one of a group of three adjoining buildings on the south side of the sphere. It is to be a one-story structure, bounded on the east by the warehouse and on the west by a railroad spur to the turbine building. A weatherproof extension at the north end will provide protected access for personnel and equipment to the shop from the sphere, turbine building and access control building. Architectural sections of the shop and warehouse are shown on Drawing 124F726.

1. ARCHITECTURAL AND STRUCTURAL REQUIREMENTS

The shop building will be constructed of structural steel framing, corrugated transite siding, and steel roof decking covered with insulation and built-up roofing. It is to be approximately 129 feet long, 38 feet wide and 30 feet high. The concrete floor is to be 6 inches above grade. One large rolling door will be provided at the end of the building and another one at the northwest corner.

Offices for shop foreman and warehouse foreman will be provided on the south end with a row of inoperable windows. The electrical shop, storeroom access wicket access to both uncontrolled and controlled shop, tool room, controlled instrument shop, store room, and welding room will separate the shop area from the warehouse area. The main bay is to be served by a 10-ton overhead bridge crane with an 18-foot hook lift. Partitions extending as close as possible to the roof and containing a slot through which the crane passes, will divide the bay into a contaminated equipment dismantling area, a controlled shop, and an uncontrolled shop. The crane will travel over the top of the partitions and will cover the entire length of the building. Adequate heating, ventilating, lighting and equipment decontamination facilities are to be provided. The upper portion of the west wall will have a row of inoperable windows.

2. FUNCTIONAL AND EQUIPMENT REQUIREMENTS

As mentioned under Item 1, the shop area is to be divided into the following three areas:

a. Equipment Decontamination and Disassembly Area

This area is to be provided for the cleaning of contaminated process equipment prior to repairs made in the adjoining regulated machine shop. Equipment is to be decontaminated to a level of 100 mr/hr at one foot or lower prior to entrance into the shop facility. To aid in decontamination of equipment, a shielded and hooded decontamination tank will be provided for the soaking and steam cleaning of equipment pieces and assemblies. In addition, a ventilated stainless steel sink for small tool and equipment decontamination, a disassembly area tray, and a regulated welding booth will be provided. A floor sump will be provided which will discharge into the waste disposal system.

b. Regulated Machine Shop

This area is to be provided for maintenance of the decontaminated process equipment. Machine tools to be provided include an engine lathe, radial drill, press drill, shaper, milling machine, shearing machine, work tables, bolt machine, arbor press, grinder, and power hacksaw.

c. Non-regulated Shops

This area will contain the necessary shop space and equipment to handle normal building maintenance and will consist of an electrical shop, a mechanical shop, a tool crib, and an office. Tools to be provided are a tool room lathe, drill press, grinder, sander, welding machine, pipe bender, pipe cutter, and pipe threader. Appropriate bench area is to be provided.

D. WAREHOUSE

The warehouse building will be a one-story structure located south of the sphere between the shop building and the fuel building. A row of small shops and offices are to be located along the west wall. Although most of these spaces are to be open to the main bay of the shop, the warehouse office, the tool crib and the bottled gas storage room open into the warehouse. A covered corridor will extend along the north side of the building to provide a passageway for personnel to and from the access control building.

The building will be constructed of structural steel framing, corrugated transite siding, and steel roof decking covered with insulation and built-up roofing. It is to be approximately 129 feet long, 60 feet wide and 30 feet high. The row of shops and offices will be about 16 feet wide; the remaining approximate 41 feet of width will be available for storage space and traffic aisles. The concrete floor is to be 6 inches above grade. A paint storage locker with concrete walls will be built into the southeast corner of the warehouse. No windows are to be provided, but a large rolling door at the south end will be used to receive equipment and material deliveries. Adequate lighting, heating and ventilating equipment and storage bins are to be provided.

E. GATEHOUSE

The gatehouse will be located on the west side of the entrance road and will control access of personnel and vehicles through the main entrance gate.

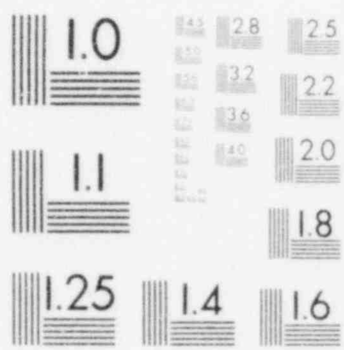
The structure is approximately 10 feet by 12 feet by 9 feet high. A personnel corridor will be provided for badge issuance. Walls are to be concrete up to the sill 3 feet 6 inches above finish floor, and glass above that level. The steel roof deck will be supported by pipe column and covered with insulation and built-up roofing.

F. BARGE DOCK

A barge dock will be provided on the Kankakee River just south of the mouth of the intake canal, which is to be about 1800 feet from the center of the sphere.

A steel sheet pile bulkhead 100 feet long will be driven and tied back to a continuous concrete anchorage. The bulkhead will be backfilled with granular fill taken from excavations on the site.

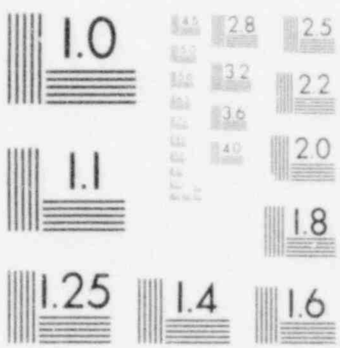
IMAGE EVALUATION
TEST TARGET (MT-3)



6"

MICROCOPY RESOLUTION TEST CHART

IMAGE EVALUATION
TEST TARGET (MT-3)



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MICROCOPY RESOLUTION TEST CHART

DRESDEN NUCLEAR POWER STATION

PROCESS SAMPLING SYSTEM

SECTION XX

INDEX

PROCESS SAMPLING SYSTEM

SECTION XX

The purpose of this section is to present the sampling requirements of the Dresden Plant and the basic criteria for the sampling equipment to be provided.

The following reference drawings are applicable to these criteria:

Piping and Instrument Diagram - Main Steam and Condensate	7368-E-10 Print 40
Piping and Instrument Diagram - Nuclear Steam Supply	7368-E-11 Print 39

A. PROCESS SAMPLING REQUIREMENTS

Equipment for the sampling of non-radioactive and radioactive process streams will be provided in order to supply information on process radiation levels, chemical compositions and other process variables necessary for satisfactory plant operation. This information will be used for the control of corrosion and radiation build-up, for the determination of cleaning and decontamination procedures, and for the control of the disposal of process and cleaning solution wastes. At critical process points, where current information is required for plant control, continuously monitoring instruments which measure radiation level, conductivity, pH, and dissolved oxygen, will be provided. Additional sampling equipment will be installed to provide batch and grab sampling of solutions for laboratory analyses to observe process trends, and to determine optimum disposal methods required for plant wastes. Wells in piping for temporary insertion of radiation monitoring instruments will be provided for certain process streams.

The following table lists plant sample requirements and the type of monitoring equipment required for various sampling points. The continuous monitors listed will either be recorded or annunciated in the central control room.

ITEM NO.	NO. OF SAMPLE PORTS	SAMPLE LOCATION	TYPE OF CONTINUOUS MONITOR*	RADIATION LEVEL INDICATED
1	2	Reactor to Steam Drum Riser	G	
2	1	Steam Drum to Turbine Line	RW, pHR, CR, G	
3	1	Recirculating Water	RR, pHR, CR, OR, G	100 MR-100 R
4	2	Line from Clean-up Demineralizer	RR, pHR, CR, G	1 MR- 1 R
5	4	Steam from Secondary Steam Generator	RW, pHR, CR, G	
6	4	Secondary Steam Generator Drum Water	pHR, CR, G	
7	4	Condensate-Hotwell	CR, G	
8	1	Condensate Demineralizer Influent	RR, pHR, OR	.01 MR-100 MR
9	1	Condensate Demineralizer Effluent Manifold	RR, pHR, CR, G	.01 MR-100 MR
10	3	Condensate Demineralizer Effluent	G	
11	1	Primary Feedwater Heater Effluent	G	
12	1	Secondary Feedwater Heater Effluent	G	
13	1	Turbine Extraction Line (A No. 1)	pHR, G	
14	4	Turbine Extraction Lines	G	
15	1	Condensate Storage Tank	CR, G	
16	5	Drains from Feedwater Heaters	G	
17	2	Demin. Water Storage Tanks	CR, G	
18	1	Effluent, Make-up Demineralizers	CR, G	
19	1	Influent, Make-up System	G	
20	1	Sanitary Water	G	
21	1	Circulating Water Influent	G	
22	1	Circulating Water Effluent	RR	**
23	2	Unloading Heat Exchanger Coolant Effluent	G	
24	1	Emergency Heat Exchanger Coolant	G	
25	2	Air Ejector Exhaust	RXR, HR, G	***
26	2	Gas Hold-up Tanks	RR, G	100 MR-100 R
27	1	Stack Gases	RXR, G	***
28	1	Gland Seal Exhaust	G	
29	2	Sphere Floor Drains Catch Tanks	G	
30	2	Reactor System Drains Catch Tanks	G	

ITEM NO.	NO. OF SAMPLE PORTS	SAMPLE LOCATION	TYPE OF CONTINUOUS MONITOR*	RADIATION LEVEL INDICATED
31	2	Secondary Steam Generator Blowdown Waste Tanks	G	
32	1	Decont. and Hot Shop Drains Catch Tank	G	
33	1	Hot Lab. Drains Catch Tank	G	
34	1	Laundry Drains Catch Tank	G	
35	2	Waste Hold-up Tanks	G	
36	1	Fuel Storage Basin Effluent	G	
37	1	Reactor Discharge Canal Water	G	
38	1	Waste Concentrate Tank	G	
39	2	Liquid Storage Tanks	G	
40	1	Service Water System Discharge	RR, G	**
41	1	Cooling Water System Leaving Sphere	RR, G	**
42	1	Clean-up Demineralizer Non-Regenerative Heat Exchanger Coolant	G	
43	4	Reactor Recirculating Pump Motor Coolers	G	
44	1	Proportional Sampler Effluent Canal	G	
45	1	Waste Demineralizer Effluent	RR, G	.01 MR-100 MR
46	1	Shield Cooling Heat Exchanger Coolant	G	
47	2	Reactor System Drain Tank Coolant	G	
48	1	Fuel Storage Pit Coolant	G	
49	1	Turbine Building Floor Drain Catch Tank	G	
50	2	Waste Collector Tank Coolant	G	
51	1	Reactor System Drain Tank Cooler Effluent	G	
52	1	Used Fuel Storage Pit Cooler Effluent	G	
53	1	Waste Collector Tank Cooler Effluent	G	
54	1	Cooling Water Exchanger Effluent	G	
55	1	Stack Gas Particulate Moving Filter Tape Monitor	RR	100 MR - 100 R
56	2	Resin Effluent from Cleanup Demineralizer	RW	

*R = Radiation level C = Conductivity O = Dissolved Oxygen pH = pH R after symbol = Recorder H = Hydrogen
RX = Radiation spectrometer G = Grab Sampling Point RW = Radiation well for insertion of temporary instrument (ion-chamber guide tubes)

** The radiation level indicated will be of the order of 6×10^{-5} micro curies per cc or 140 disintegrations per minute.

*** Gamma spectrometers provided.

B. DESIGN DESCRIPTION

The reference piping and instrumentation diagrams indicate the sampling locations and the type of cooling and analyzing equipment required. All sampling lines to the point of sampling will be of stainless steel tubing or other materials suitable for the particular corrosion conditions encountered. In general, where the stream to be sampled is at high temperature, a cooler will be provided. Where the stream to be sampled is at high pressure, an orifice or pressure reducing blowdown valve will be provided. All sample points, including those provided with continuous monitors, will have suitable valving and sample take-off piping to permit the obtaining of grab samples. All sample points will be provided with drainage facilities. The samplers on radioactive gas streams and on potentially high radiation streams will have ventilation provisions to contain airborne contamination. Adequate shielding will likewise be required for the sample equipment on the high radiation streams. Suitable portable sample containers will be provided to allow for the safe transfer of the sample from the various ports to the laboratory.

DRESDEN NUCLEAR POWER STATION

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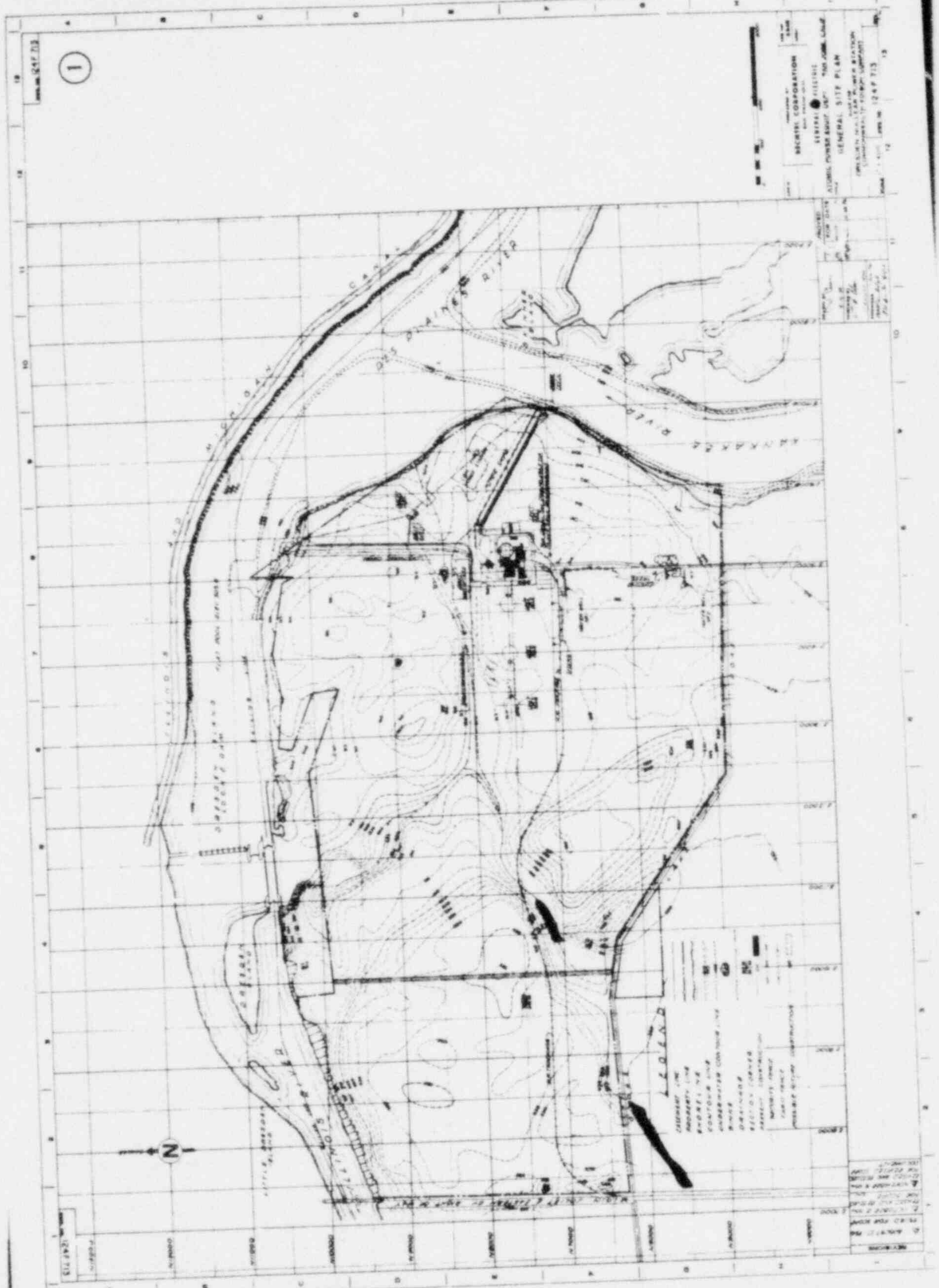

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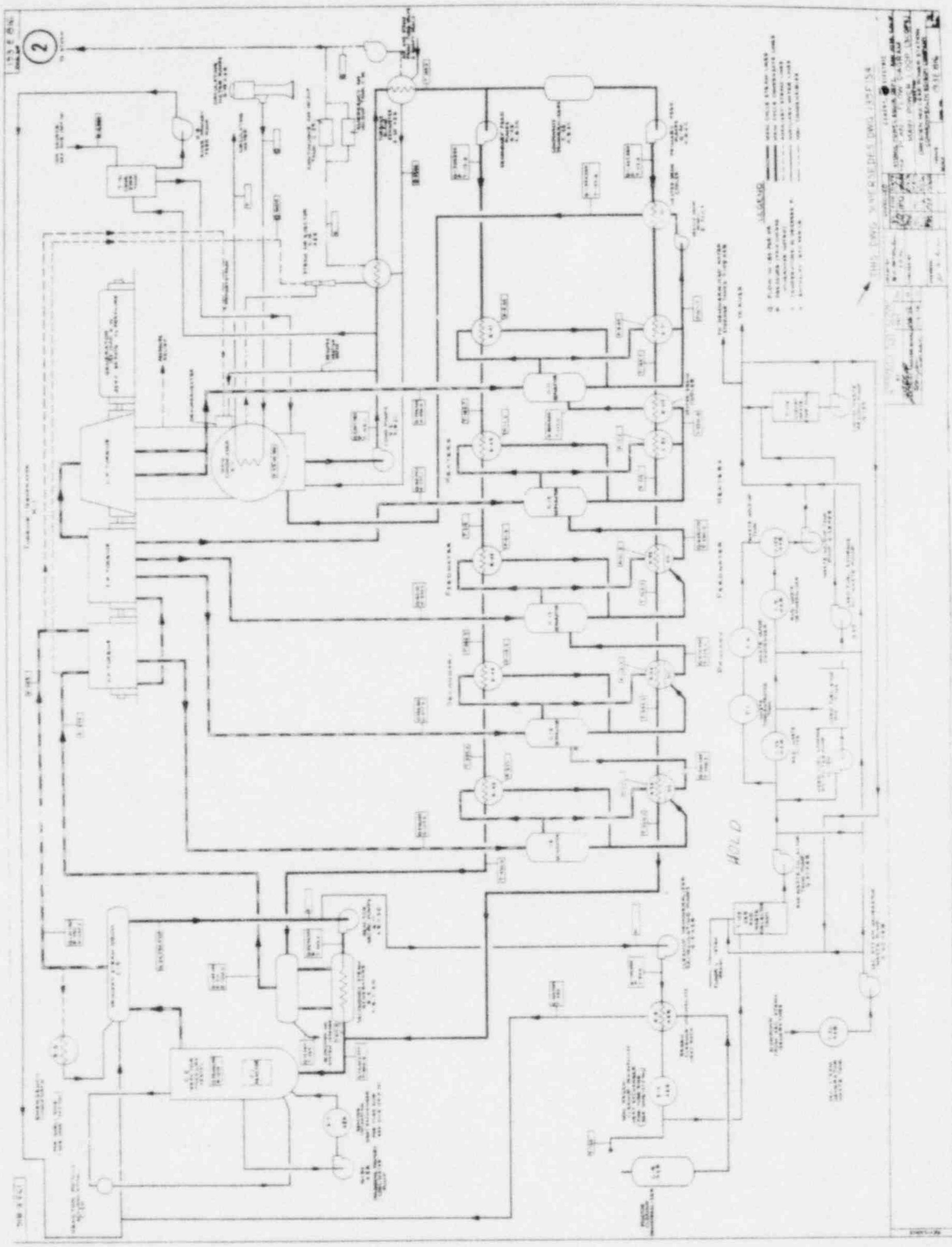

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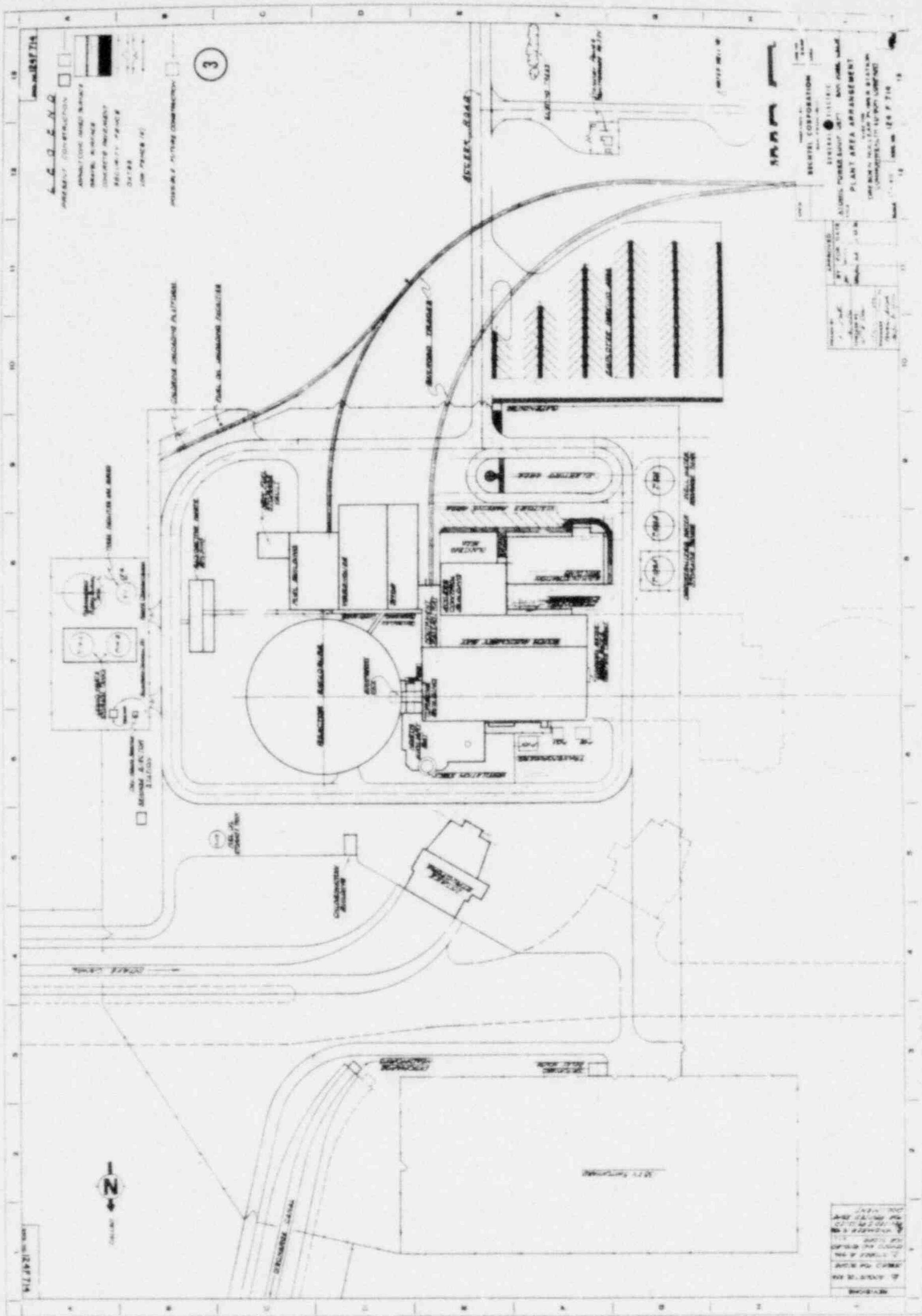

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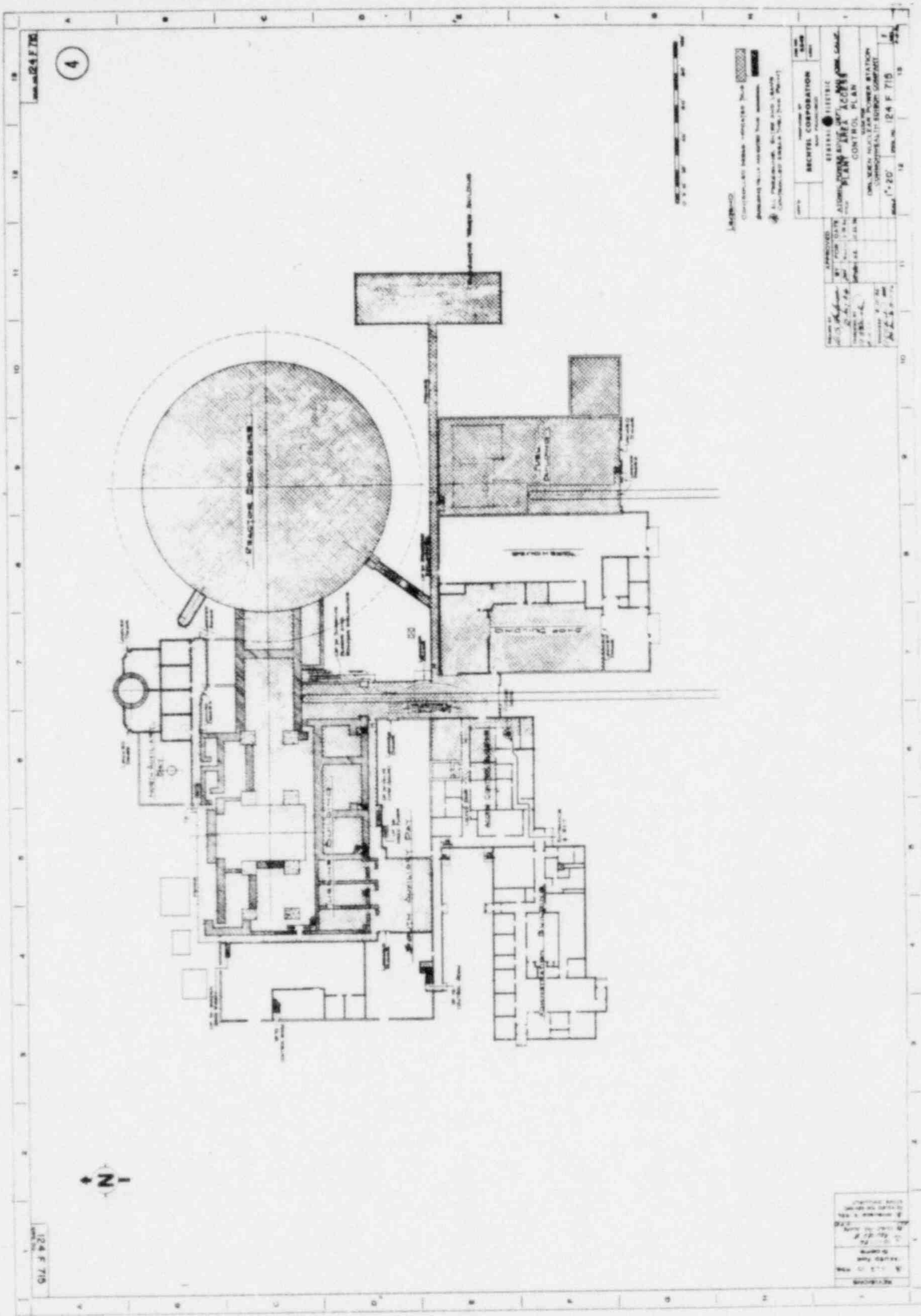
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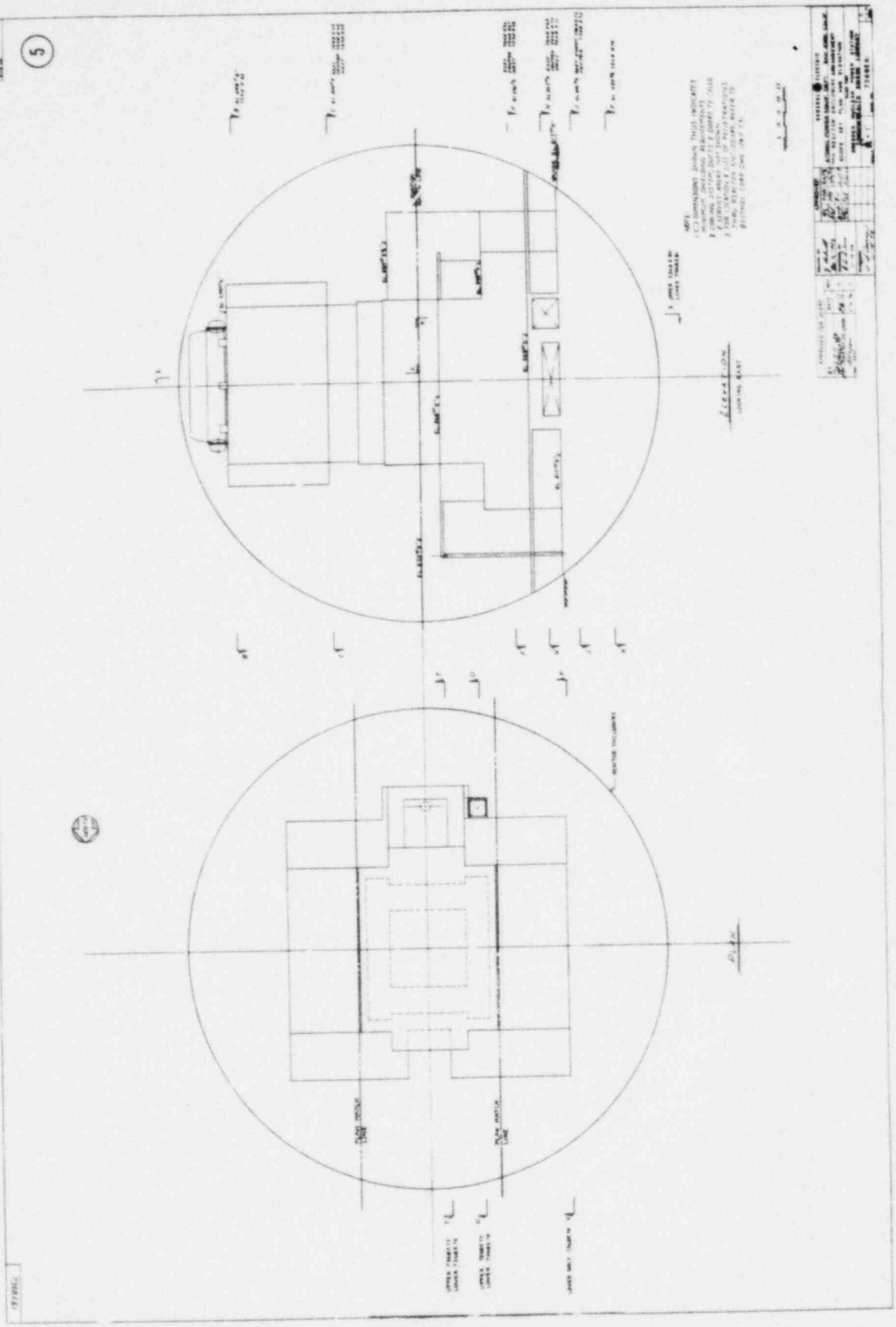
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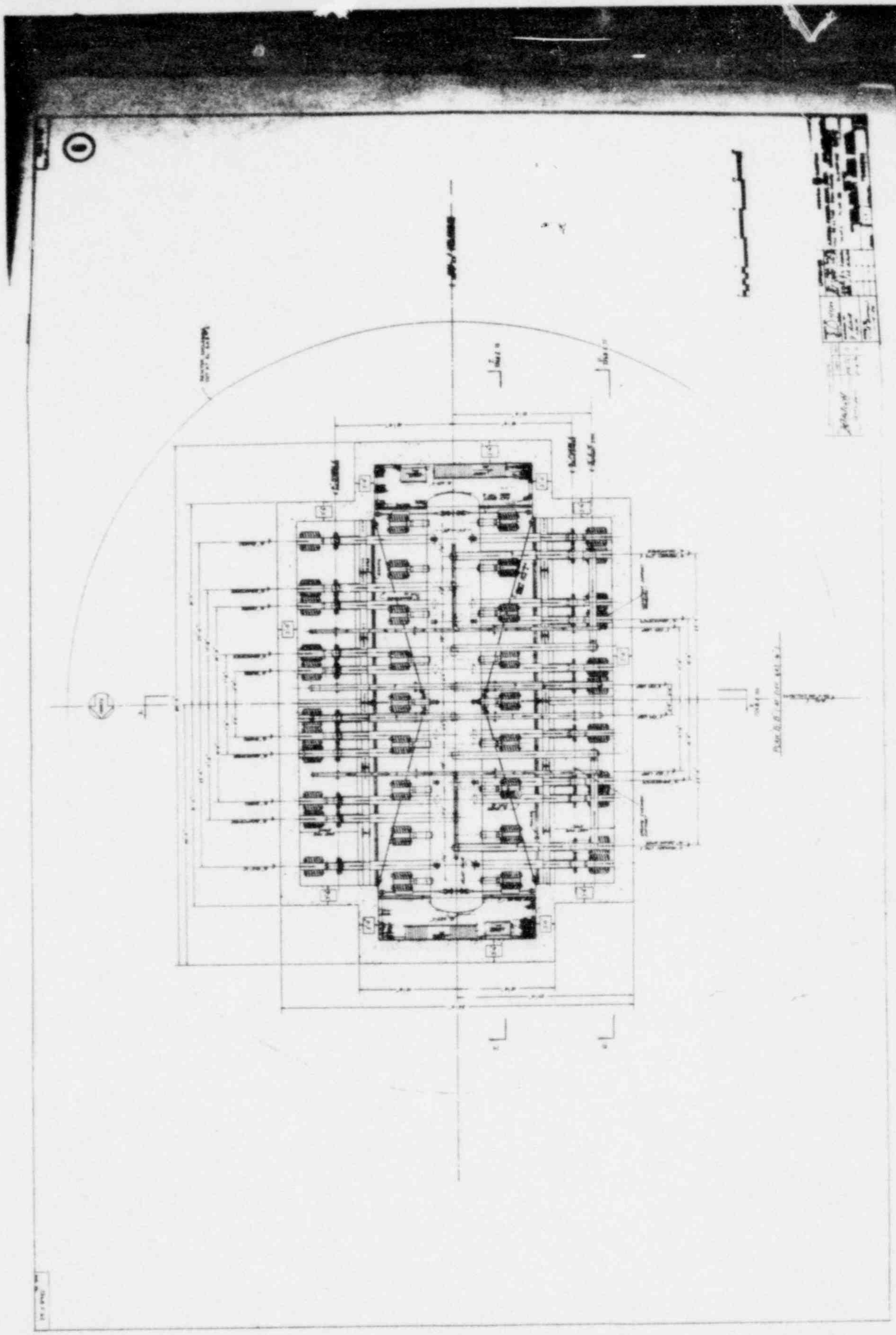
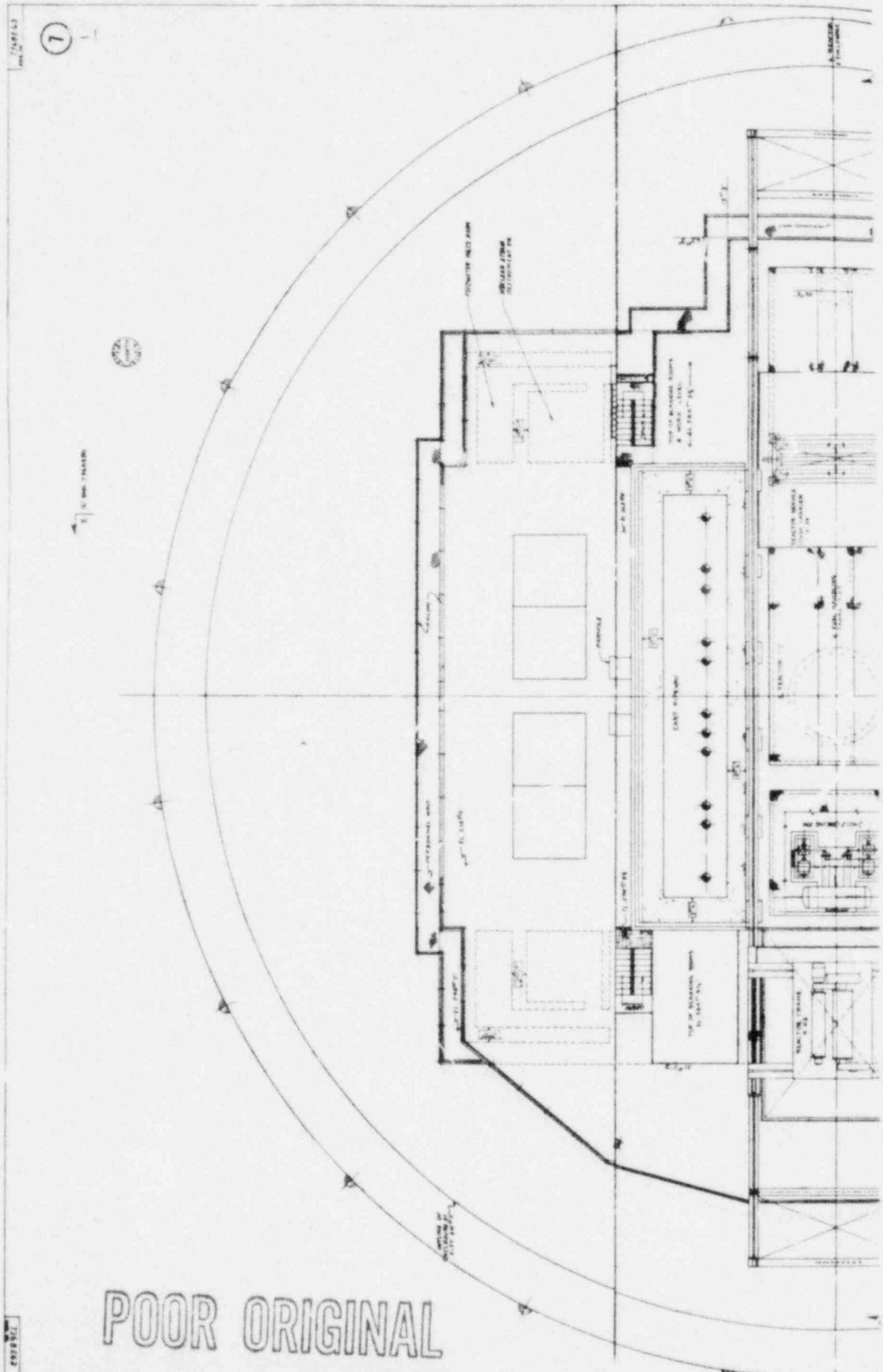
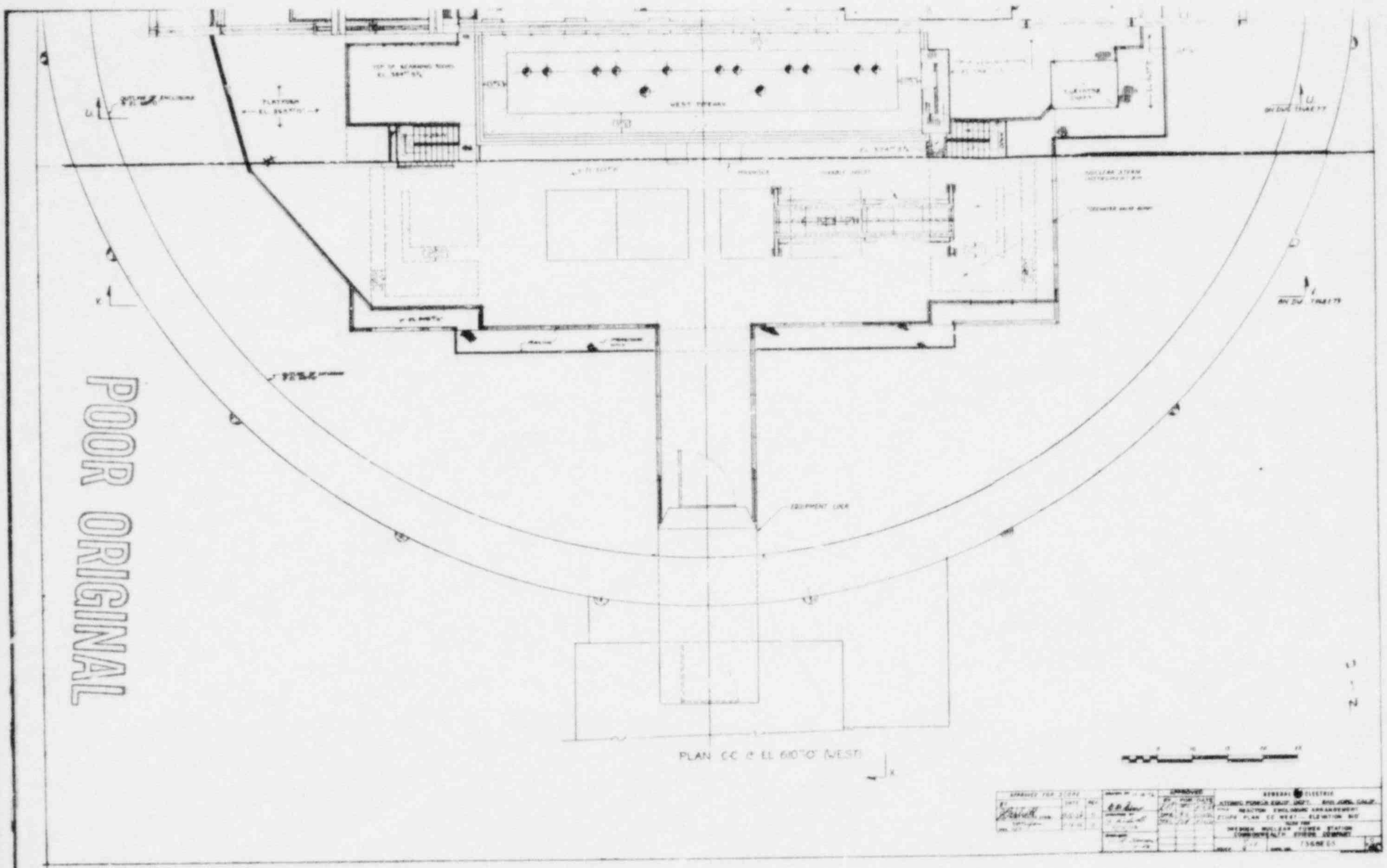
ELEVATION







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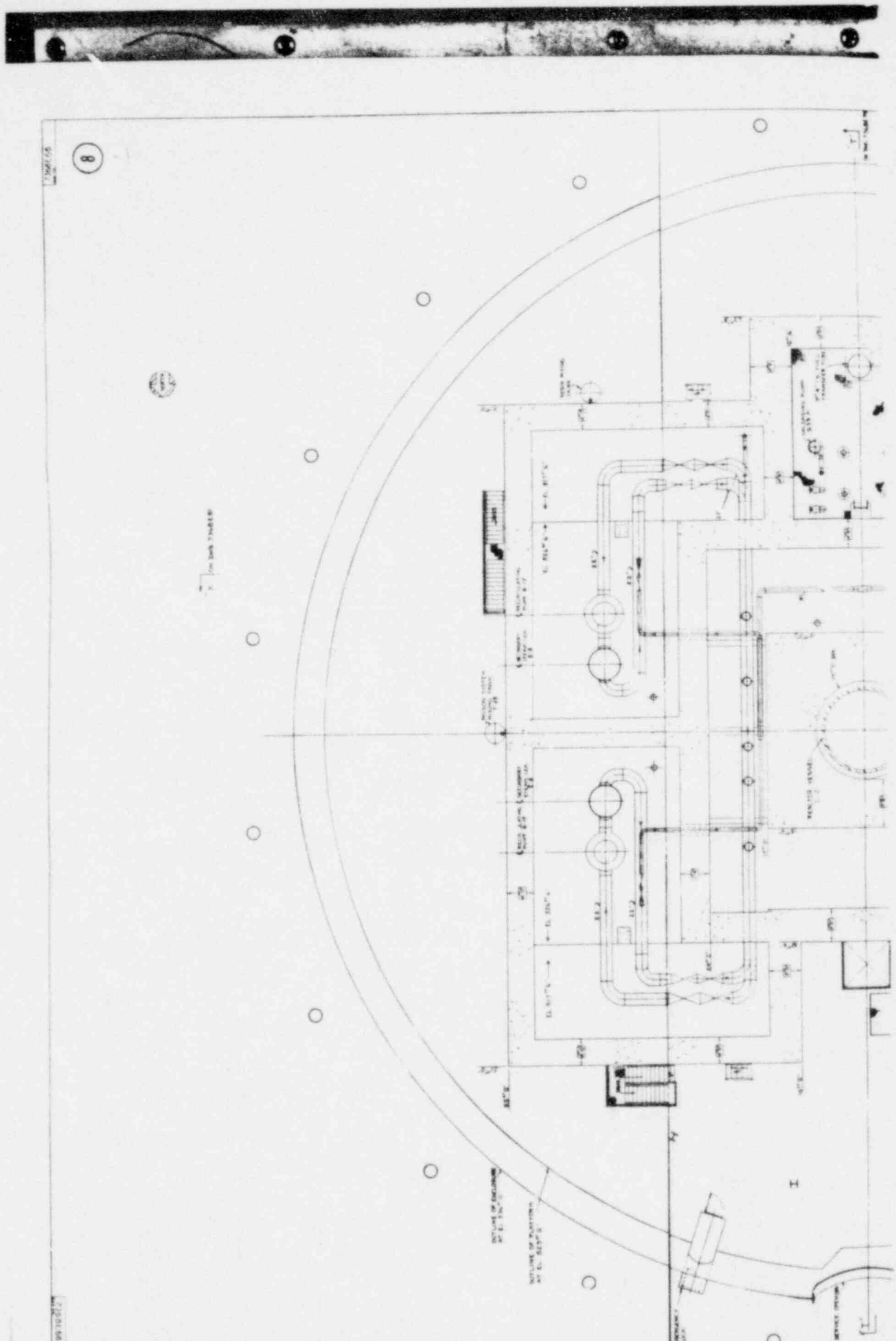

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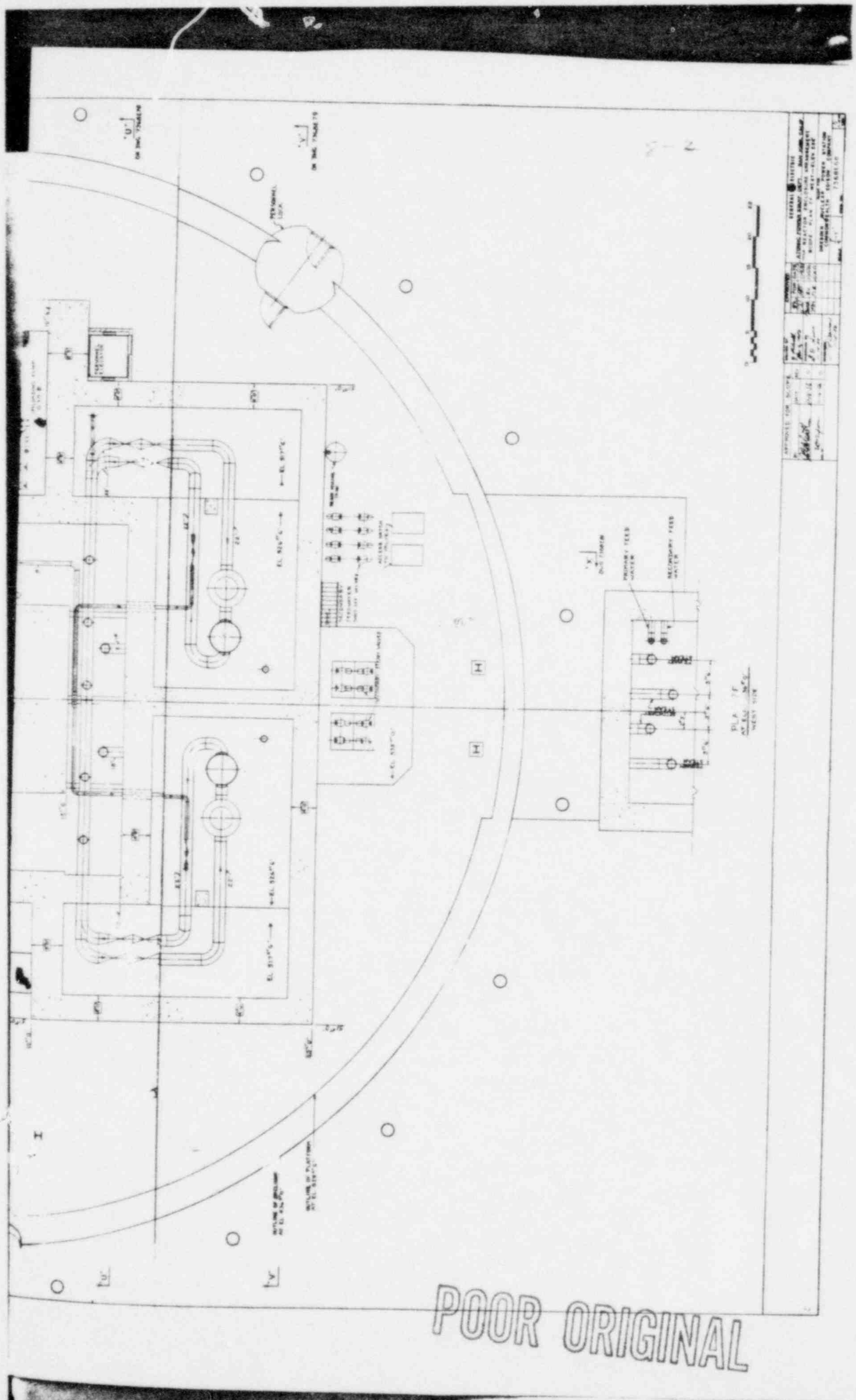
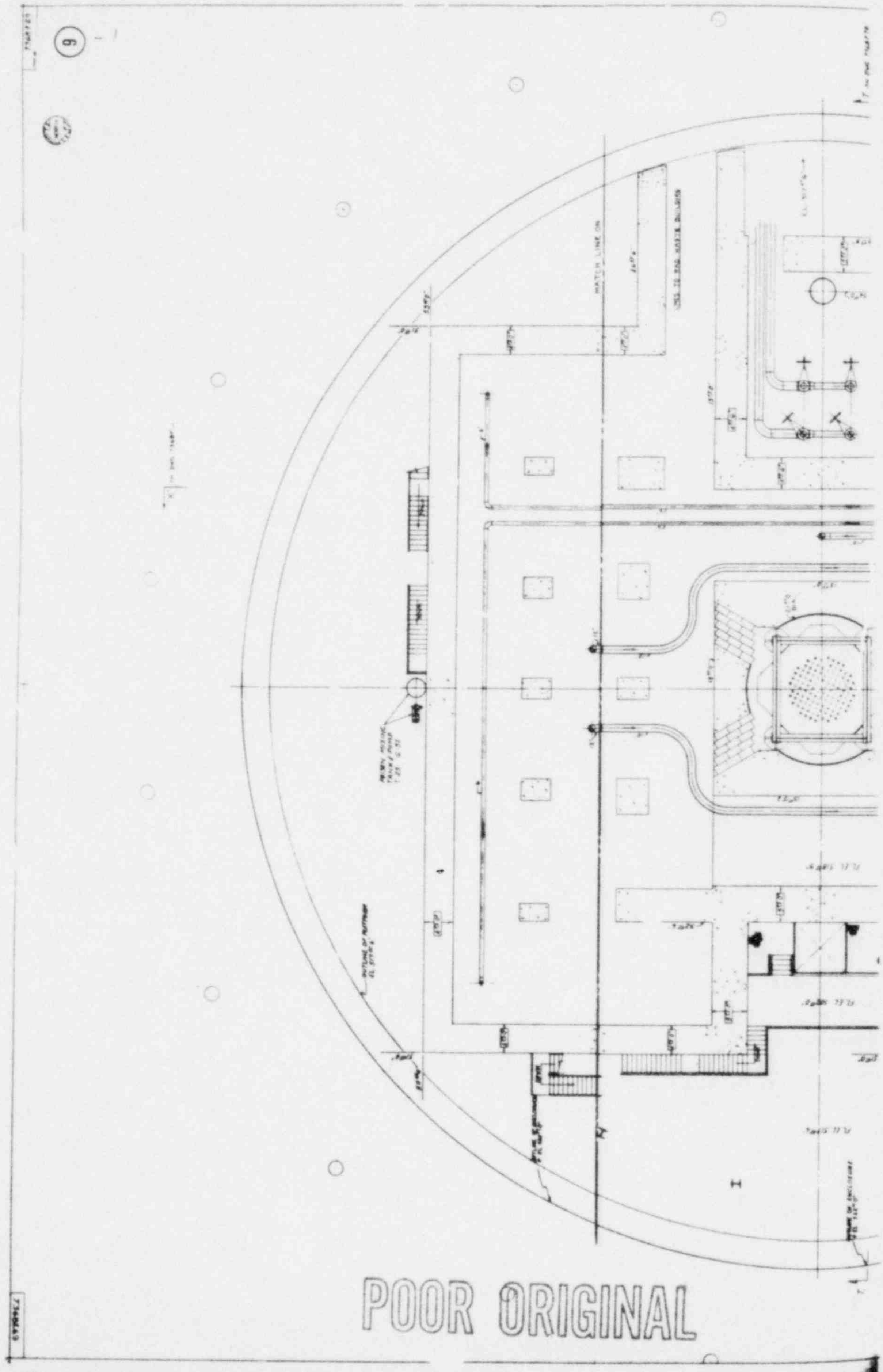
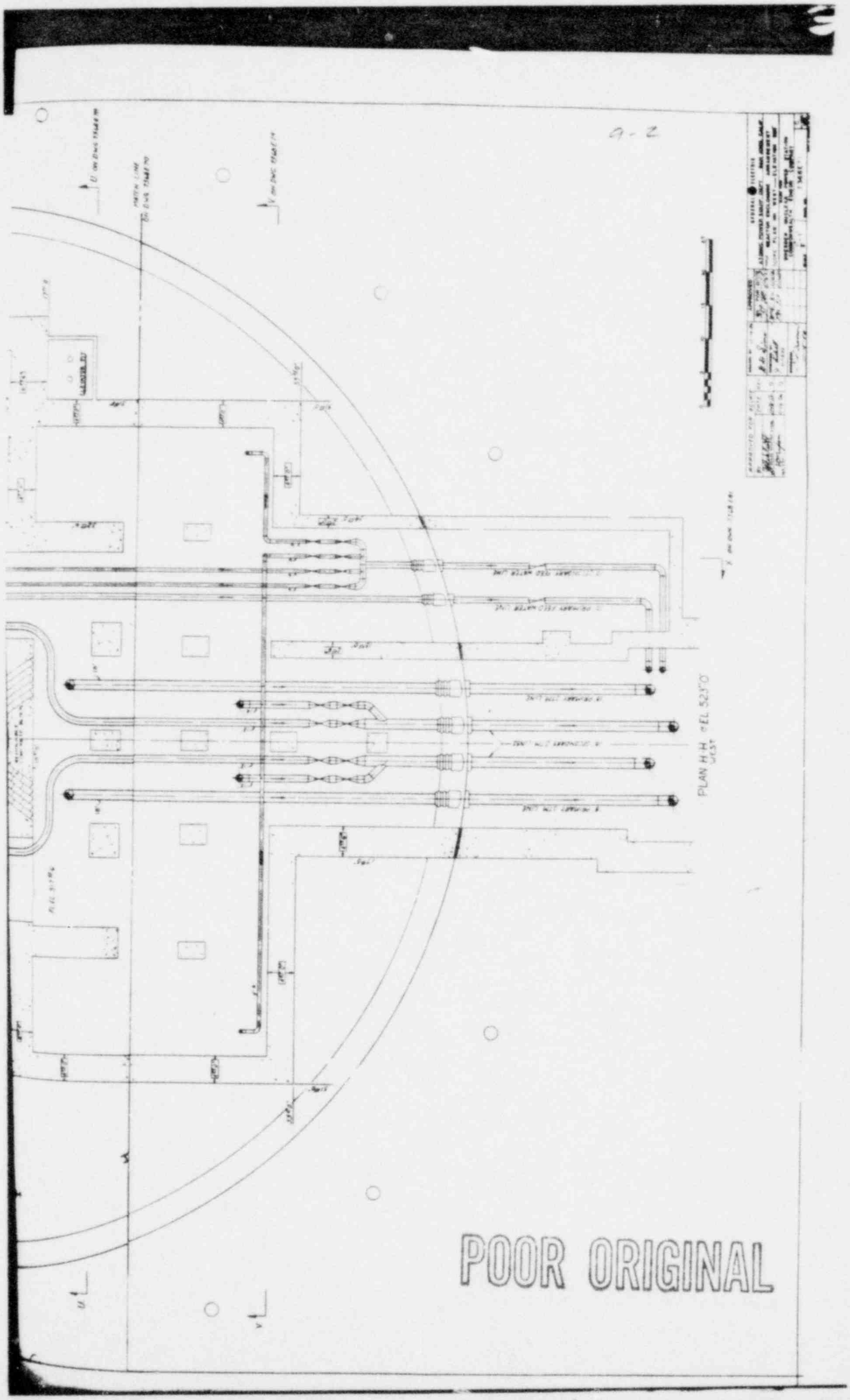

PRIMARY FEED WATER
SECONDARY FEED WATER





POOR ORIGINAL

7368E72

(10)

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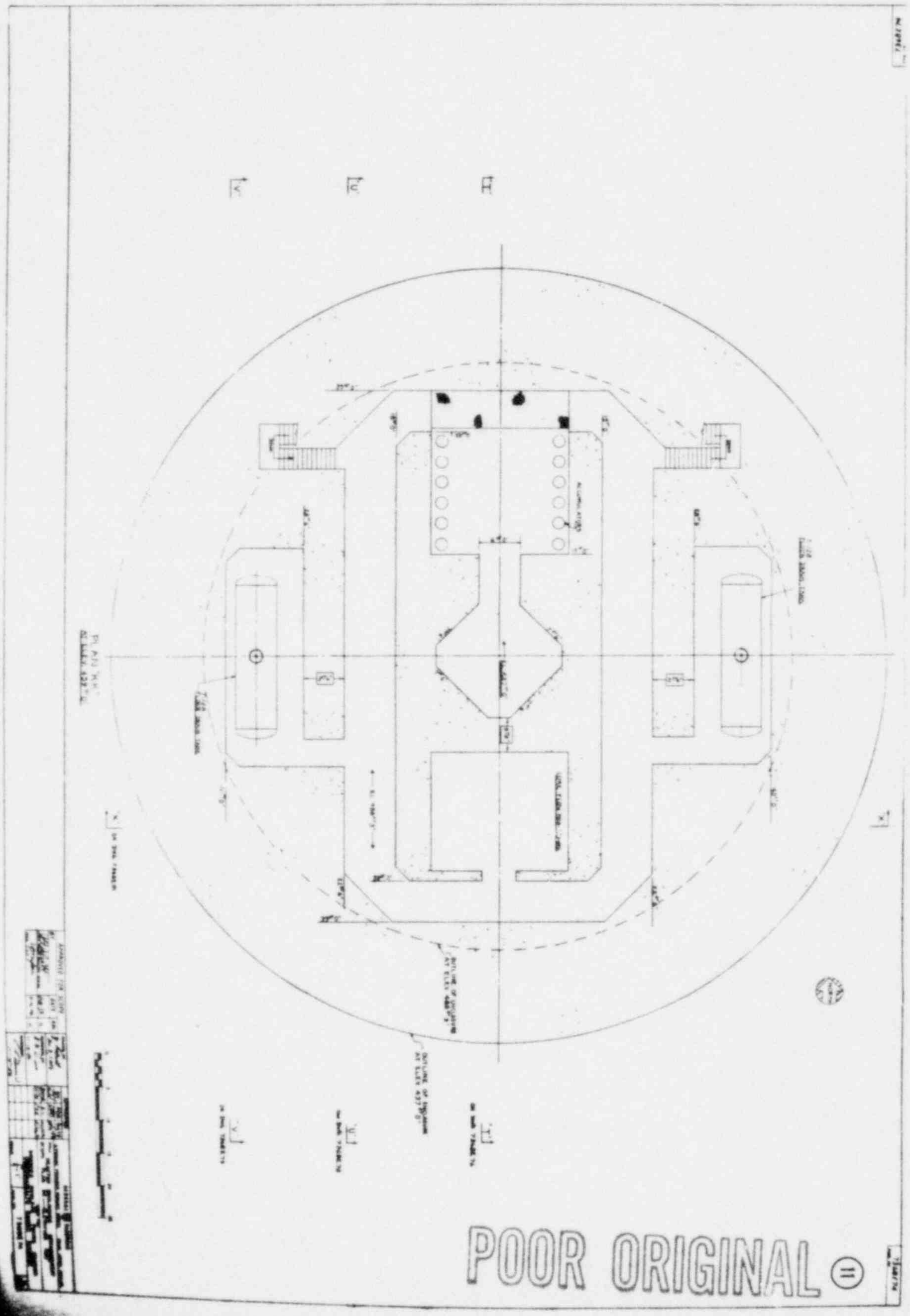
to copy

PE	DRAWN BY	APPROVED			
REV.	J. Kikell	BY	FOR	DATE	GENERAL ELECTRIC
0	CHECKED BY		RPD		ATOMIC POWER EQUIP. DEPT. SAN JOSE, CALIF.
0	D.D. Sims 11-15-56	SMR	RY		TITLE REACTOR ENCLOSURE ARRANGEMENT SCOPE-PLAN JJ EAST & WEST—ELEV. 512'
	ENGINEER C. A. Lemon 11-15-56	MWE	PSE		MADE FOR DRESDEN NUCLEAR POWER STATION COMMONWEALTH EDISON COMPANY
					SCALE $\frac{1}{4}" = 1'$ DWG. NO. 7368E72 REV. 0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7368E75
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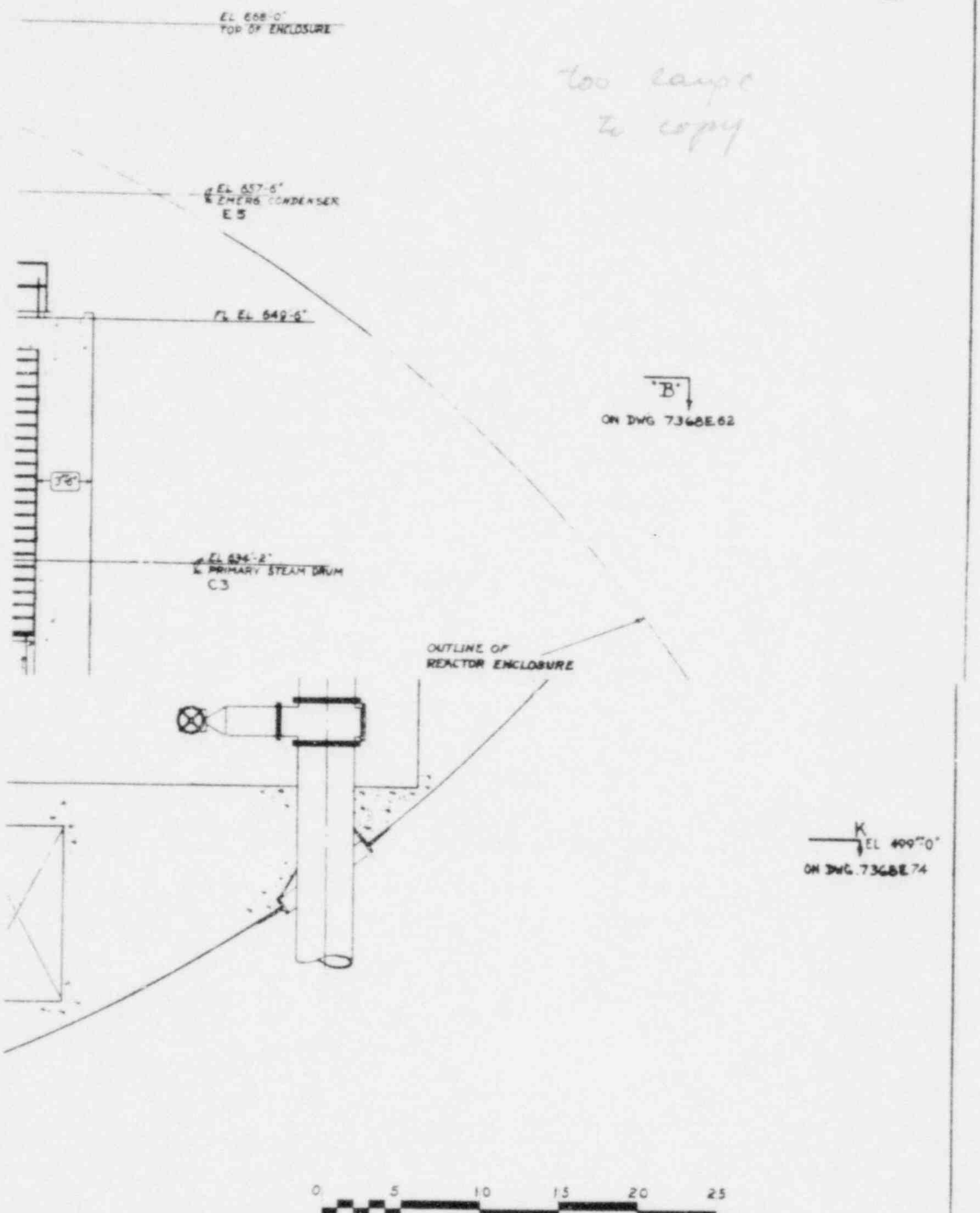


APPROVED FOR SCOPE		
BY	DATE	REV
[signature]	11-16-56	0
[signature]	11-16-56	0

DRAWN BY: [signature] 11/15/56
CHECKED BY: G. Rickell 11/15/56
ENGINEER: C. A. Duncan 11-15-56

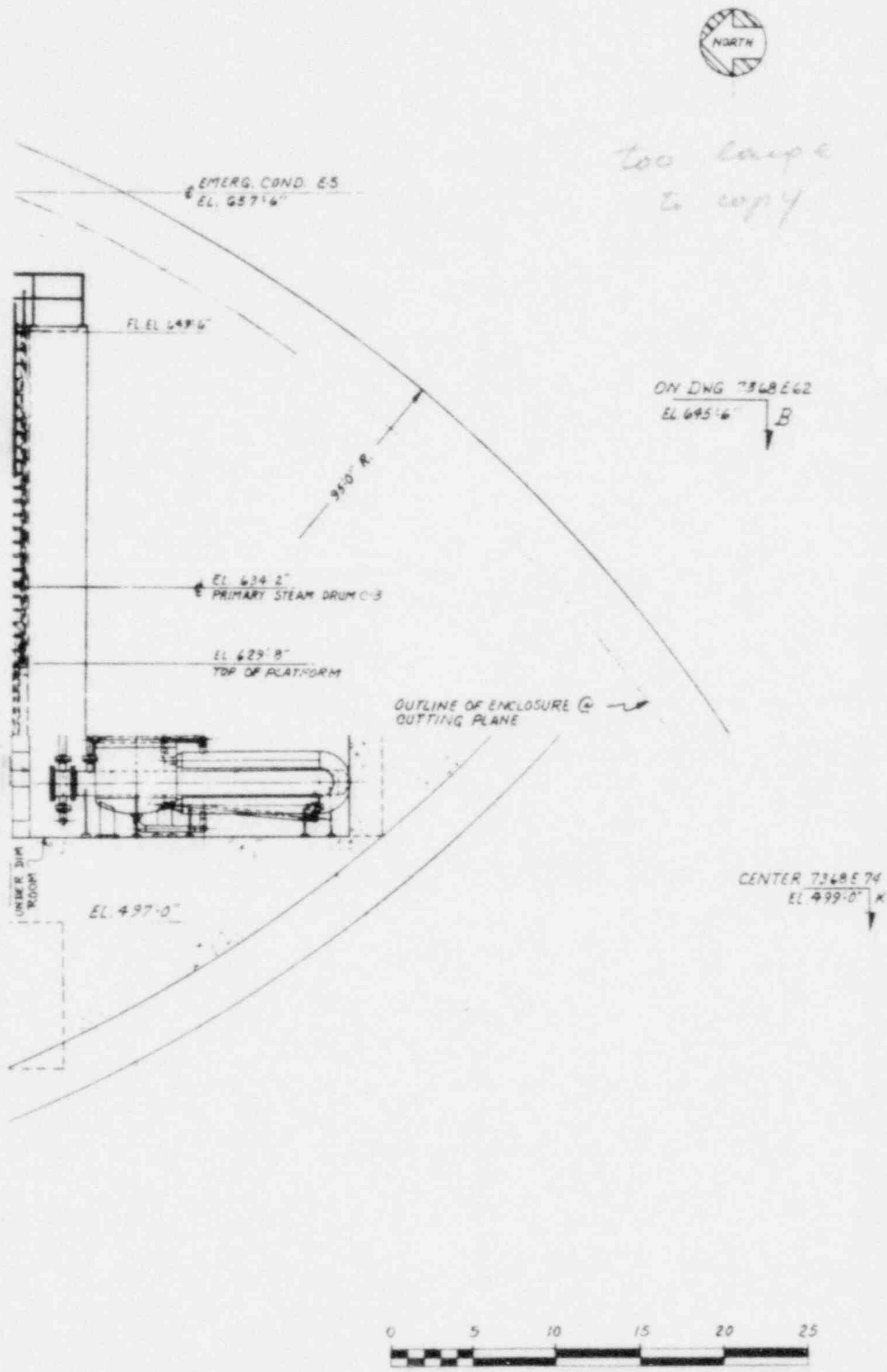
APPROVED: BY / FOR / DATE

GENERAL ELECTRIC
ATOMIC POWER EQUIP. DEPT. SAN JOSE, CALIF.
TITLE REACTOR ENCLOSURE ARRANGEMENT
SCOPE - ELEVATION YY LOWER
MADE FOR
DRESDEN NUCLEAR POWER STATION
COMMONWEALTH EDISON COMPANY
SCALE 1/8" = 1'
DWG. NO. 7368E76

POOR ORIGINAL

7368E77
DWG. NO.

(13)



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APPROVED FOR SCOPE		
BY	DATE	REV.
MGR. POWER REACTOR ENGRG.	11-16-56	0
MGR. C.E.P.	11-16-56	1

DRAWN BY 11-10-56 R. D. Simms
CHECKED BY J. Kidwell 11/15/56
ENGINEER 11-15-56

APPROVED		
BY	FOR	DATE

GENERAL ELECTRIC
ATOMIC POWER EQUIP. DEPT. SAN JOSE, CALIF.
TITLE REACTOR ENCLOSURE ARRANGEMENT
SCOPE - ELEVATION UU LOWER
MADE FOR
DRESDEN NUCLEAR POWER STATION
COMMONWEALTH EDISON COMPANY
SCALE 1/4" = 1'
DWG. NO. 7368E78
REV. 0 11-16-56

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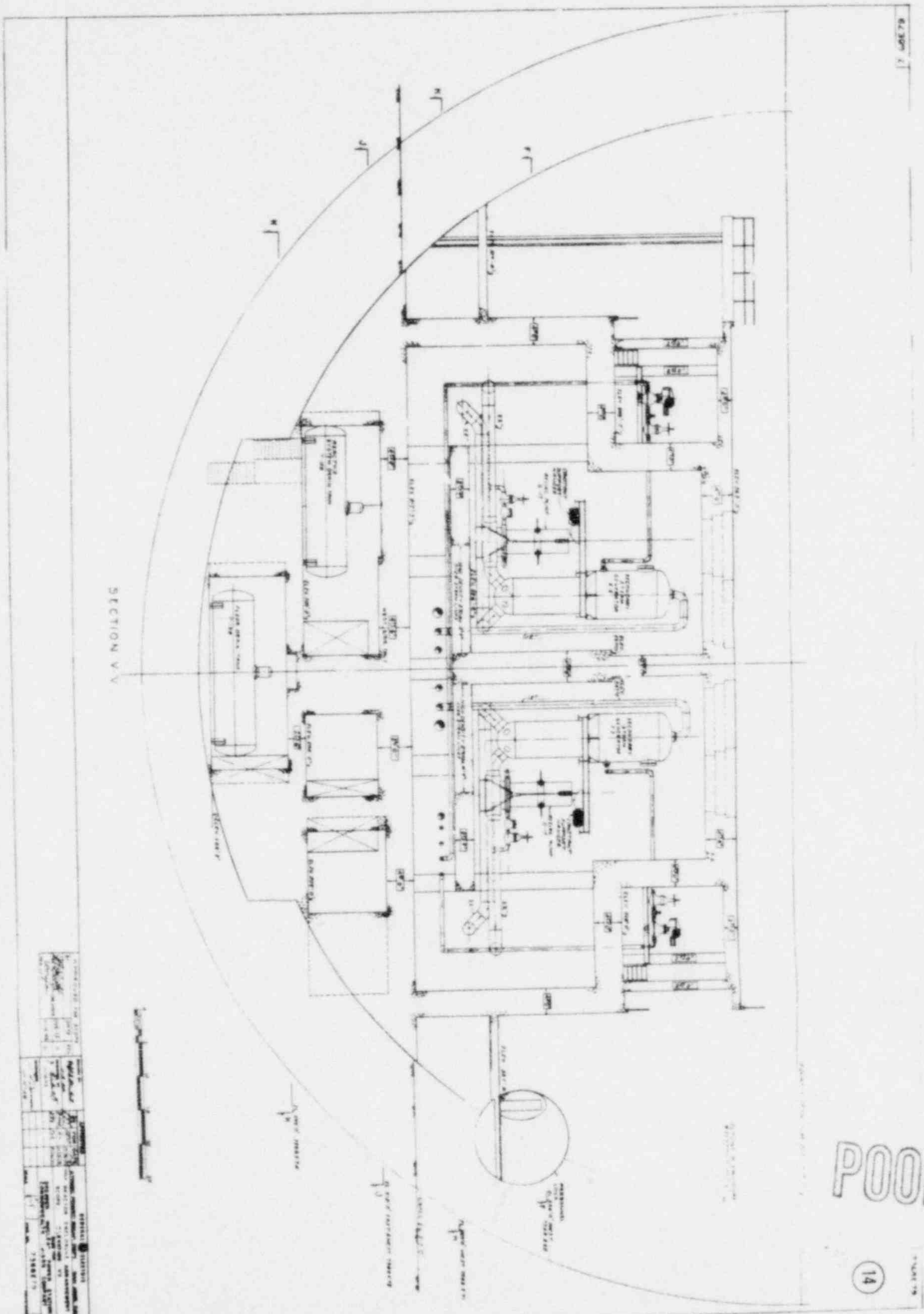

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DWG NO

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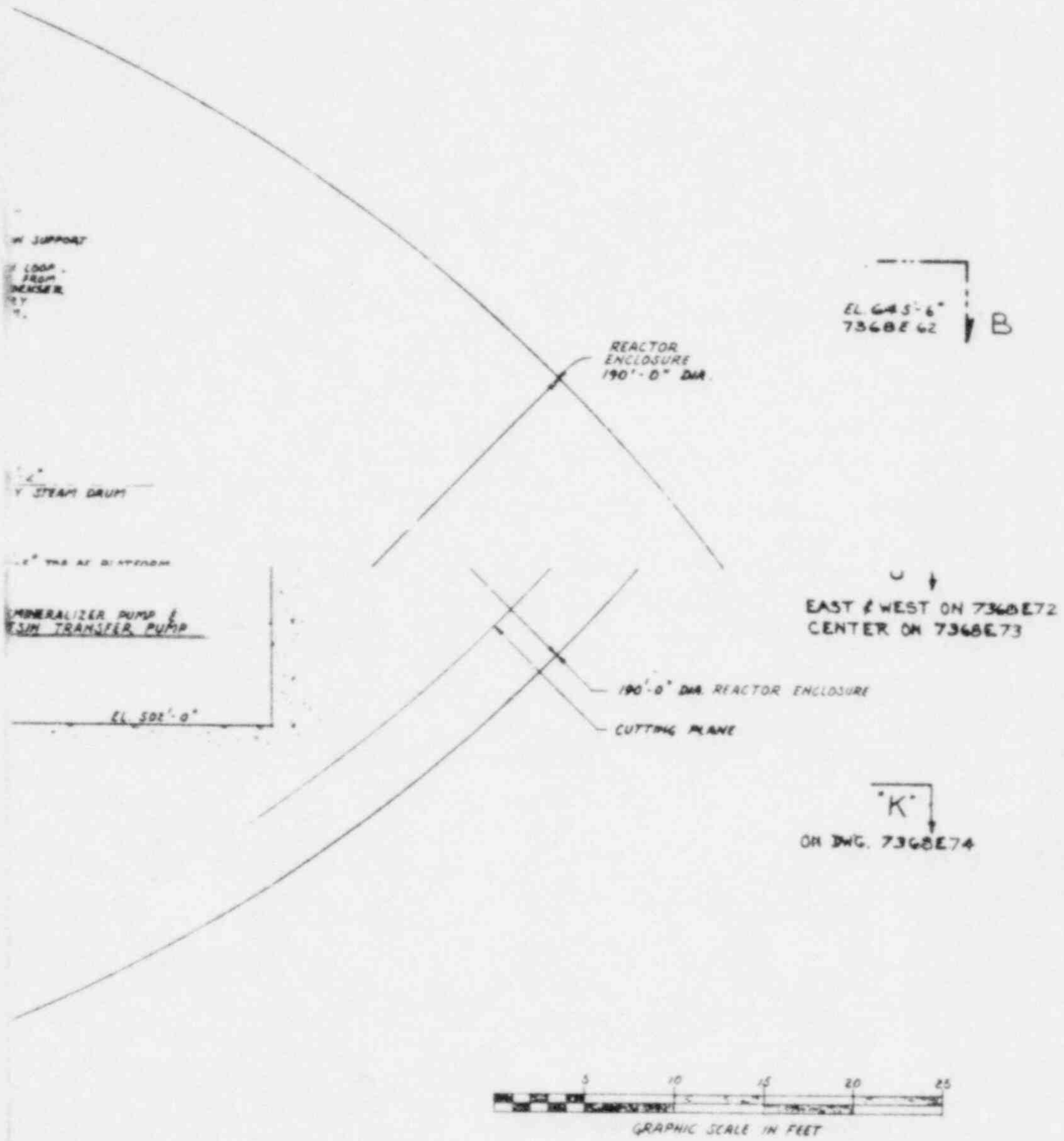

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BY	DATE	REV.
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GENERAL ELECTRIC
ATOMIC POWER EQUIP. DEPT. SAN JOSE, CALIF.
TITLE REACTOR ENCLOSURE ARRANGEMENT
SCOPE - ELEVATION XX LOWER
DRESDEN NUCLEAR POWER STATION
COMMONWEALTH EDISON COMPANY
SCALE 1/4" = 1'
DWG. NO. 7368E81

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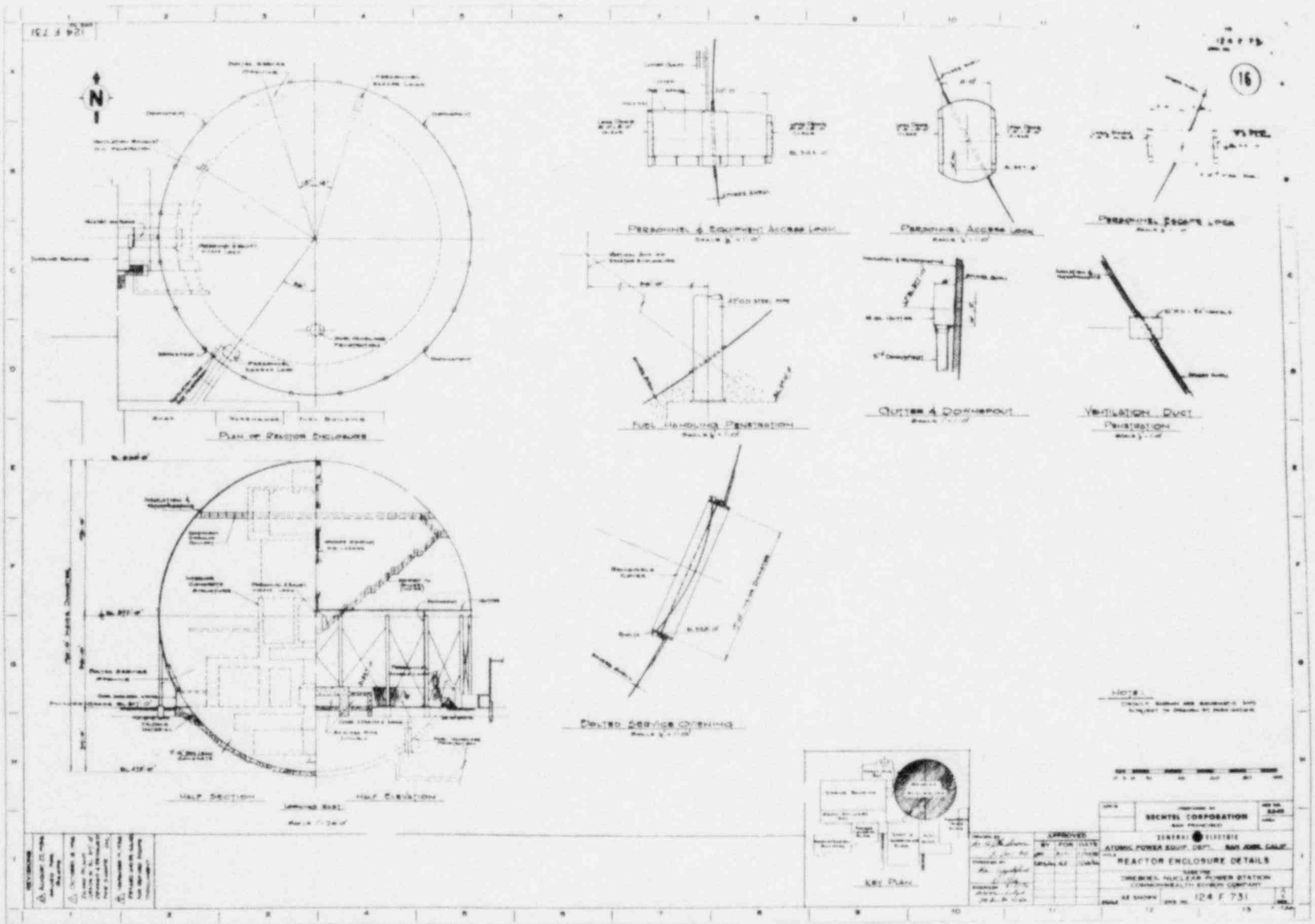

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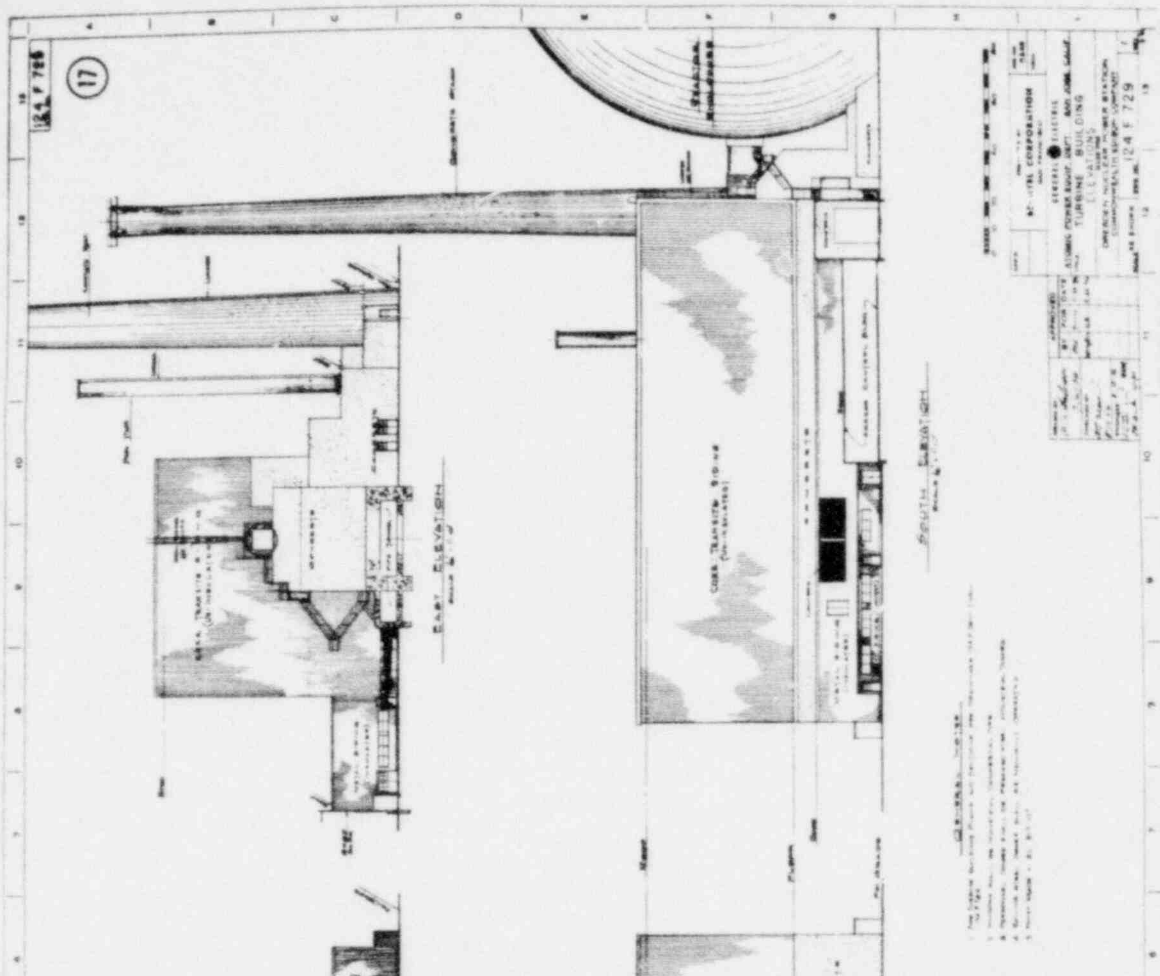
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NORTH ELEVATION
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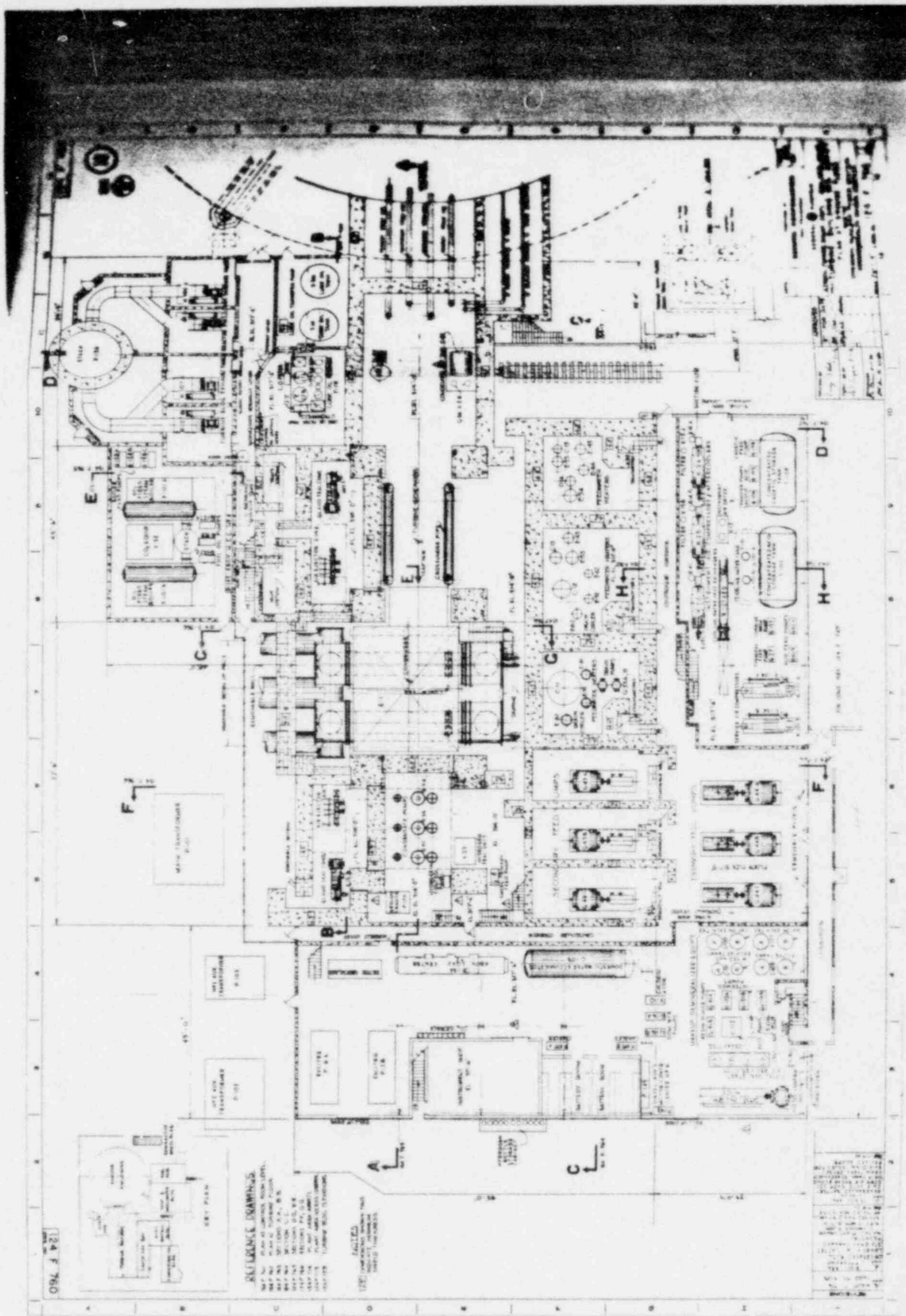

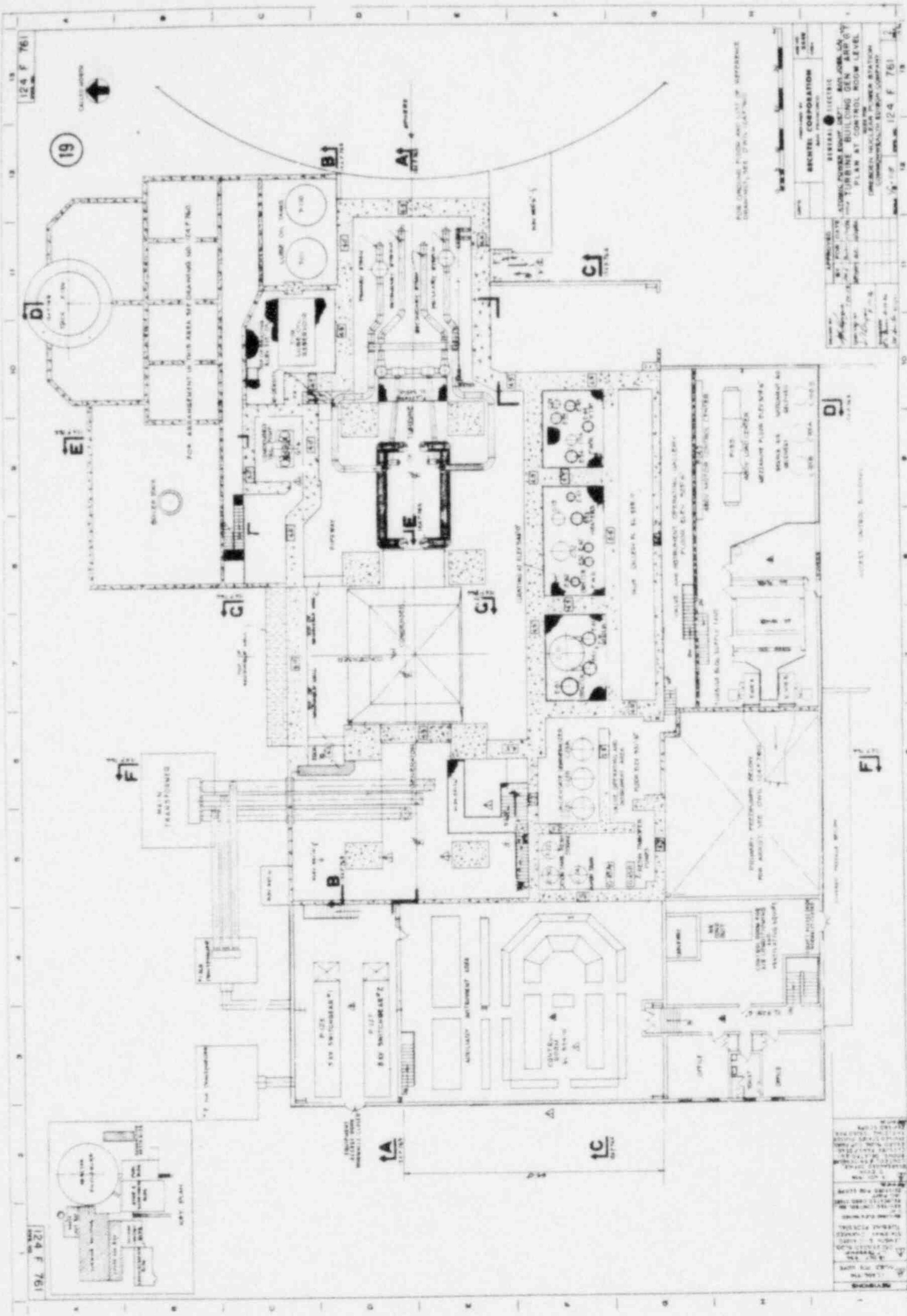

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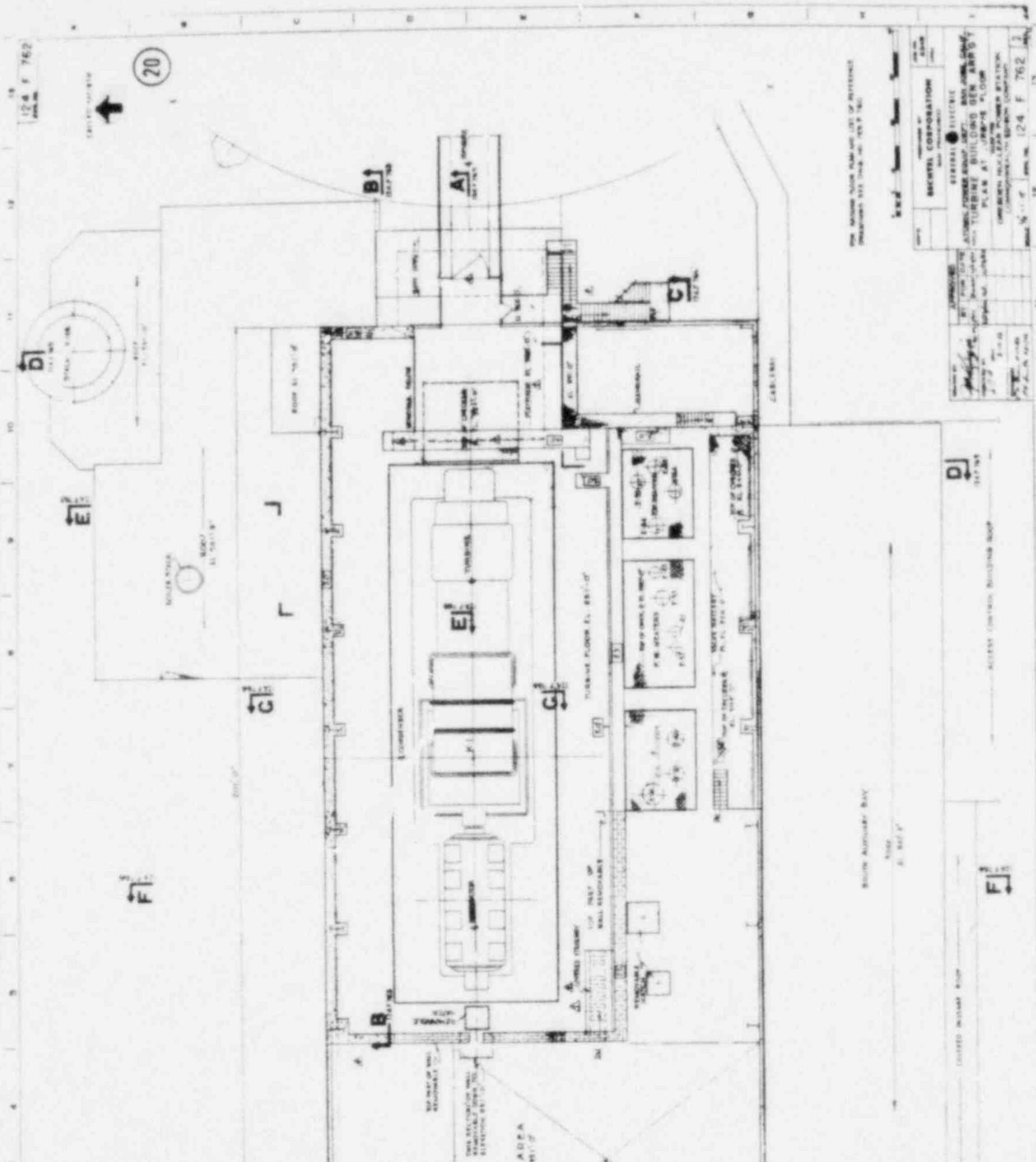

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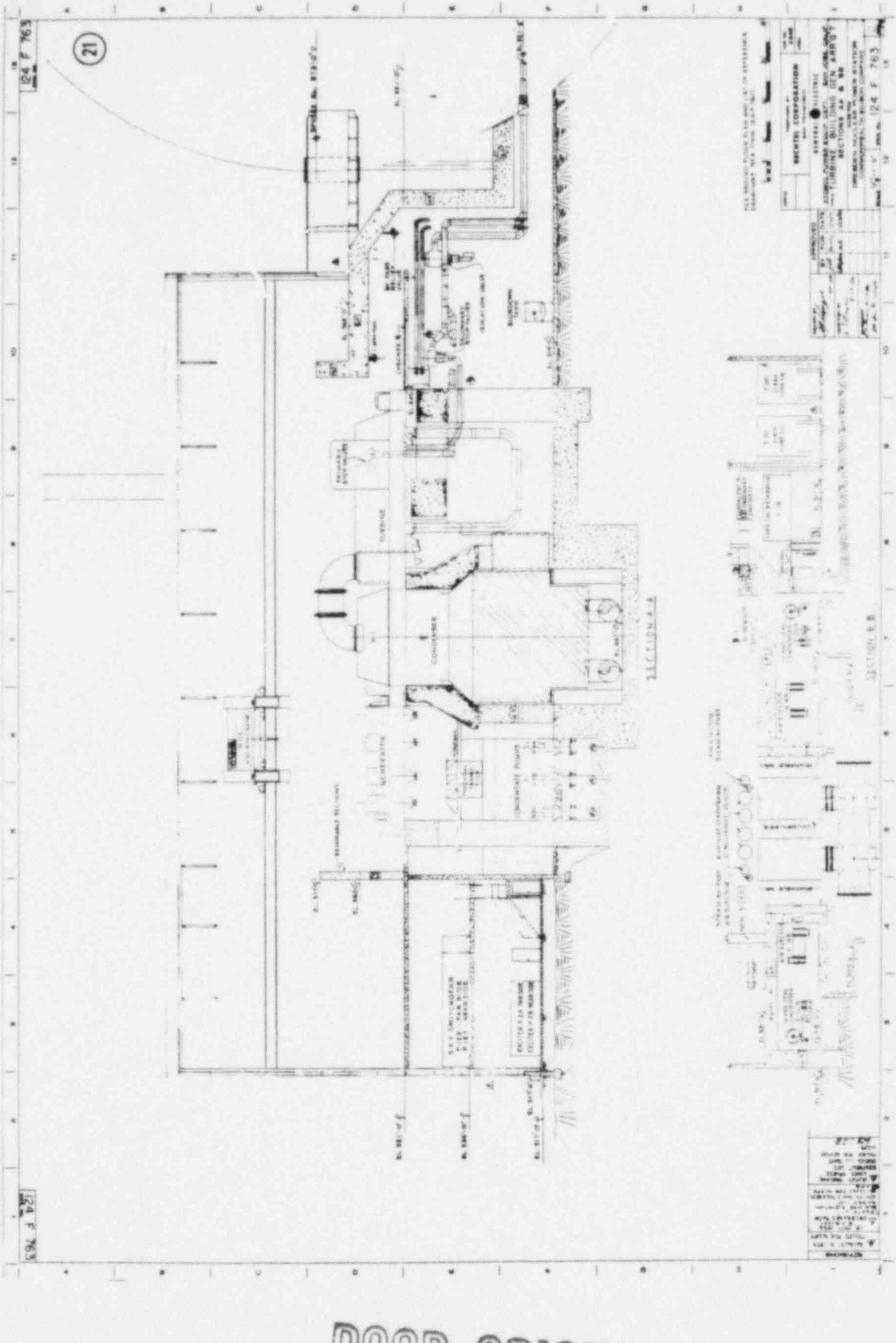

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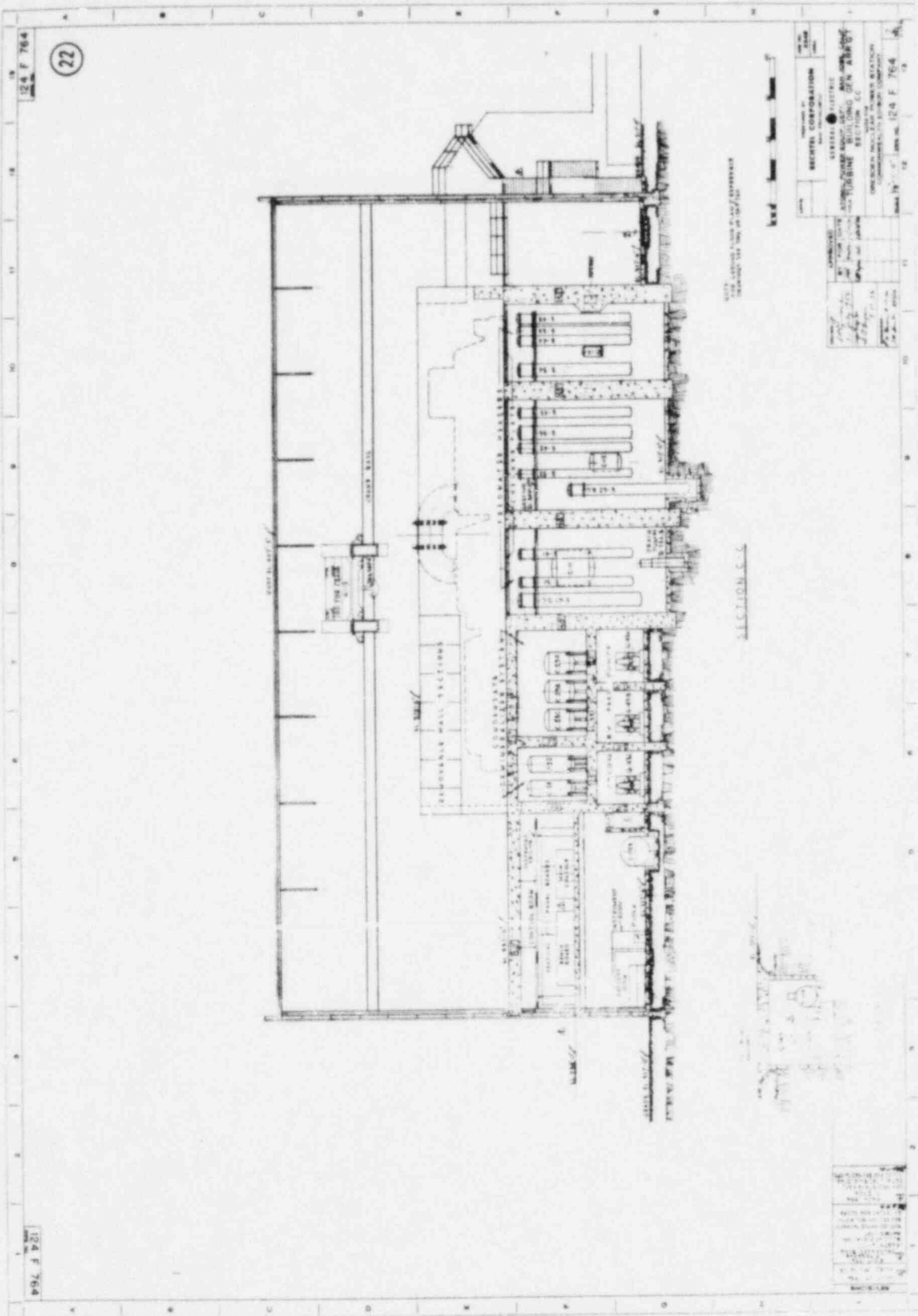

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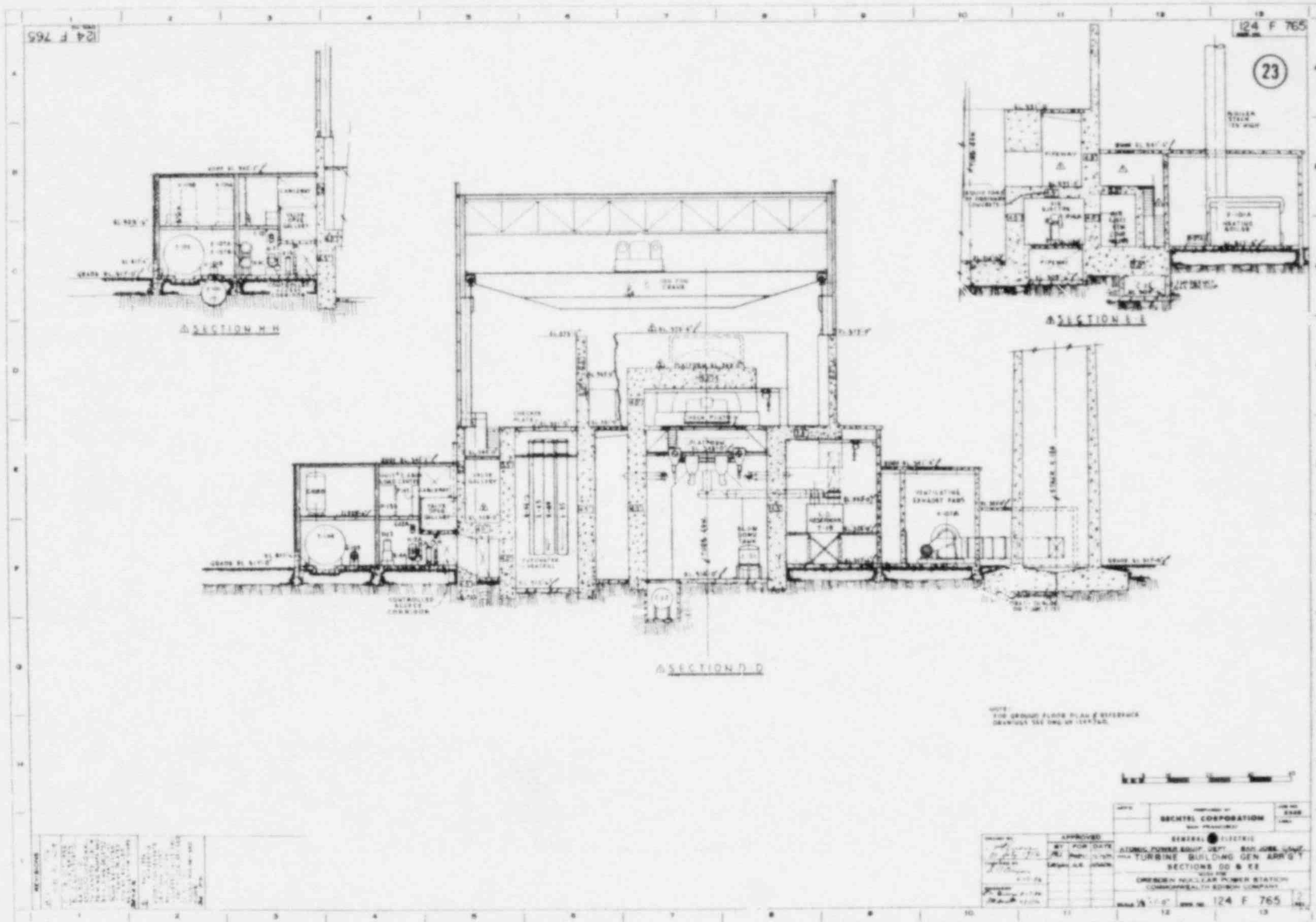

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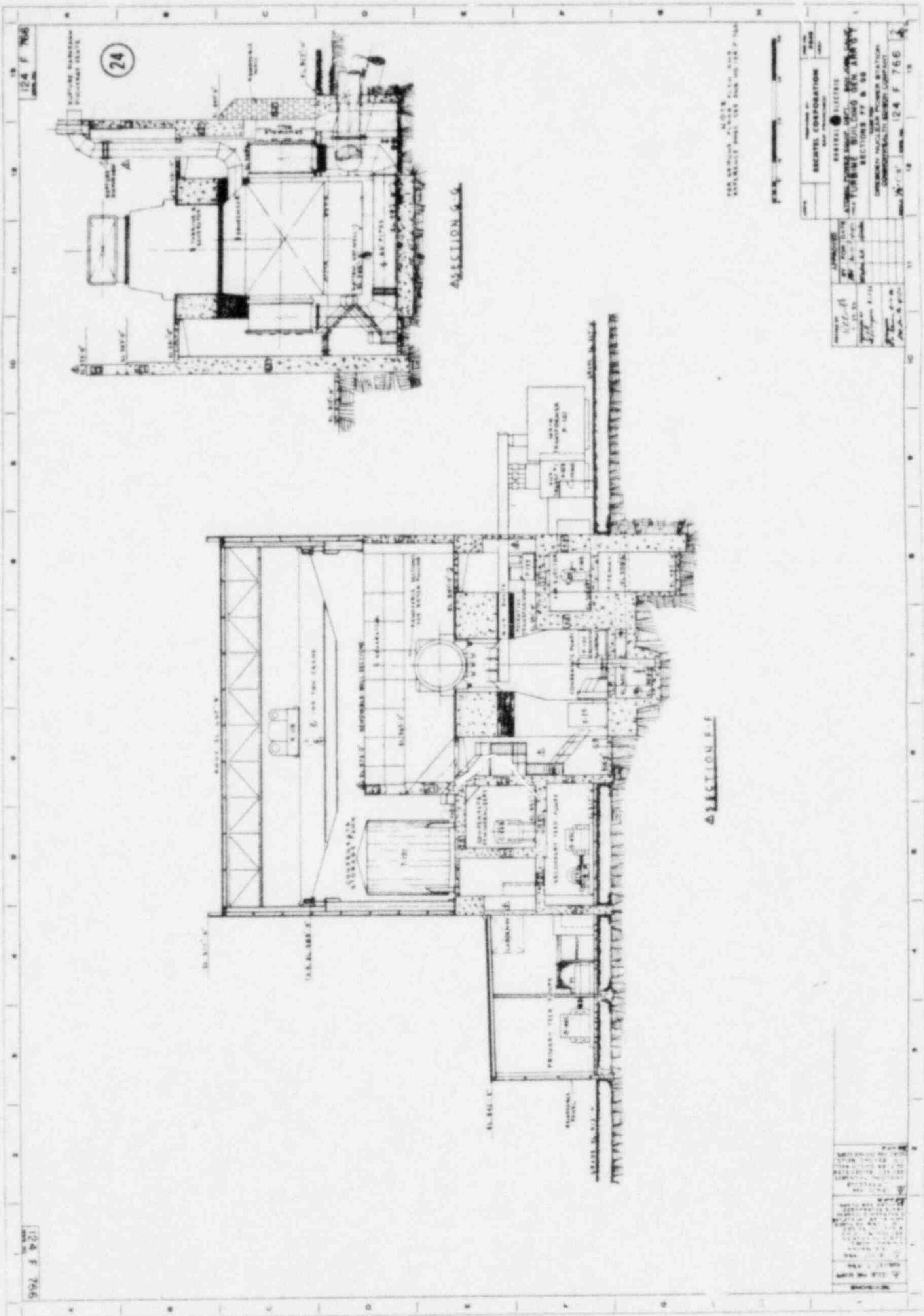

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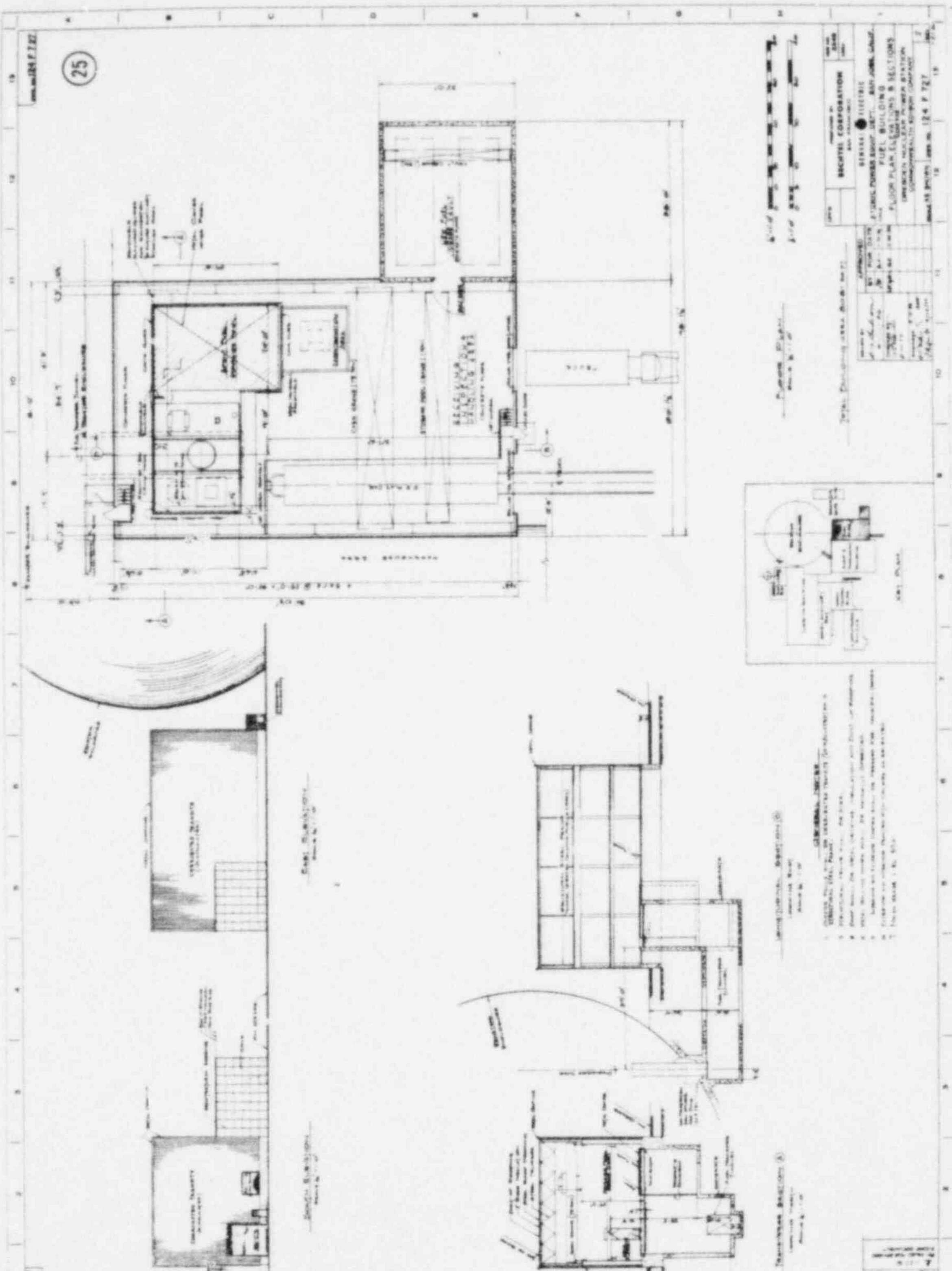

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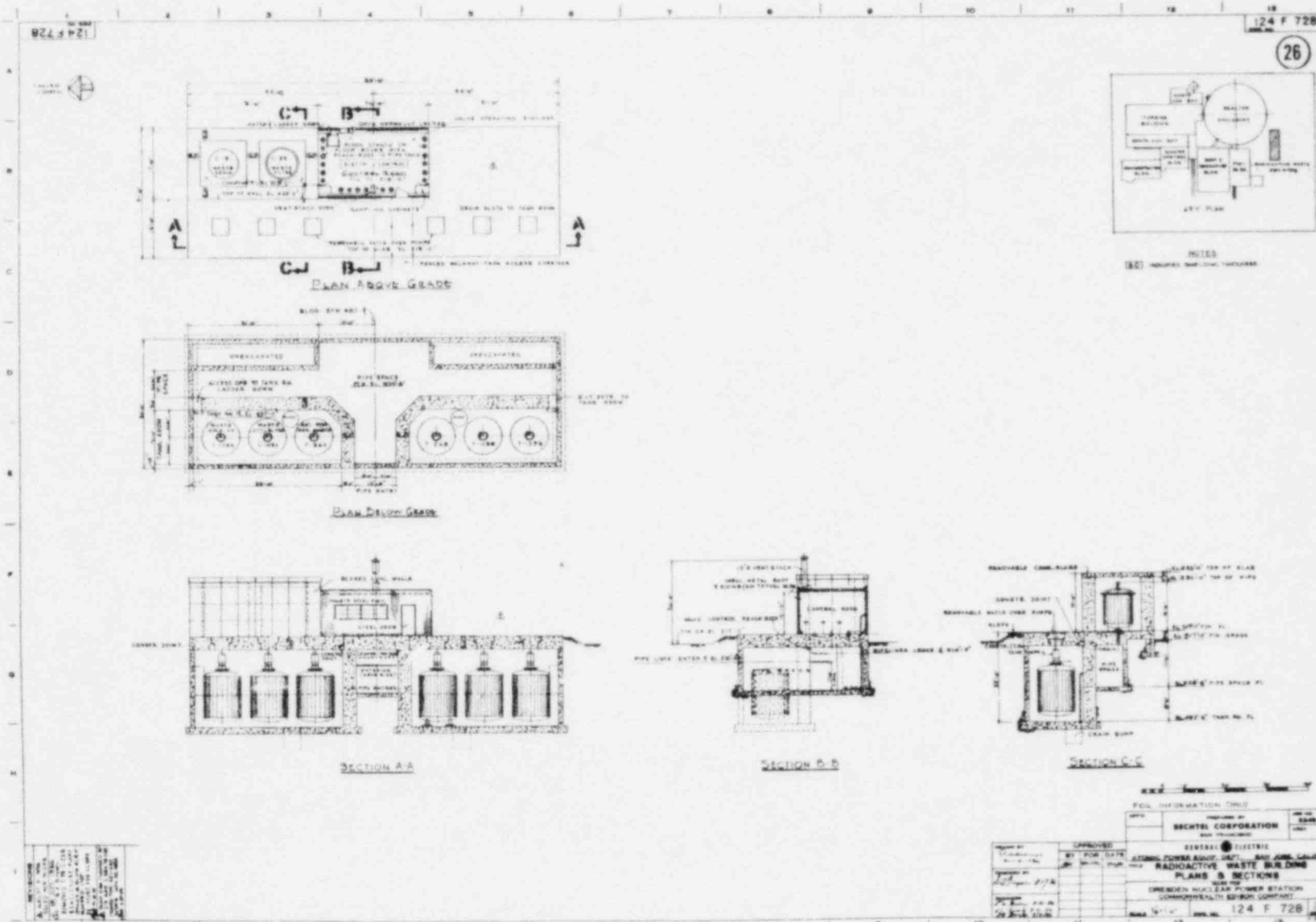

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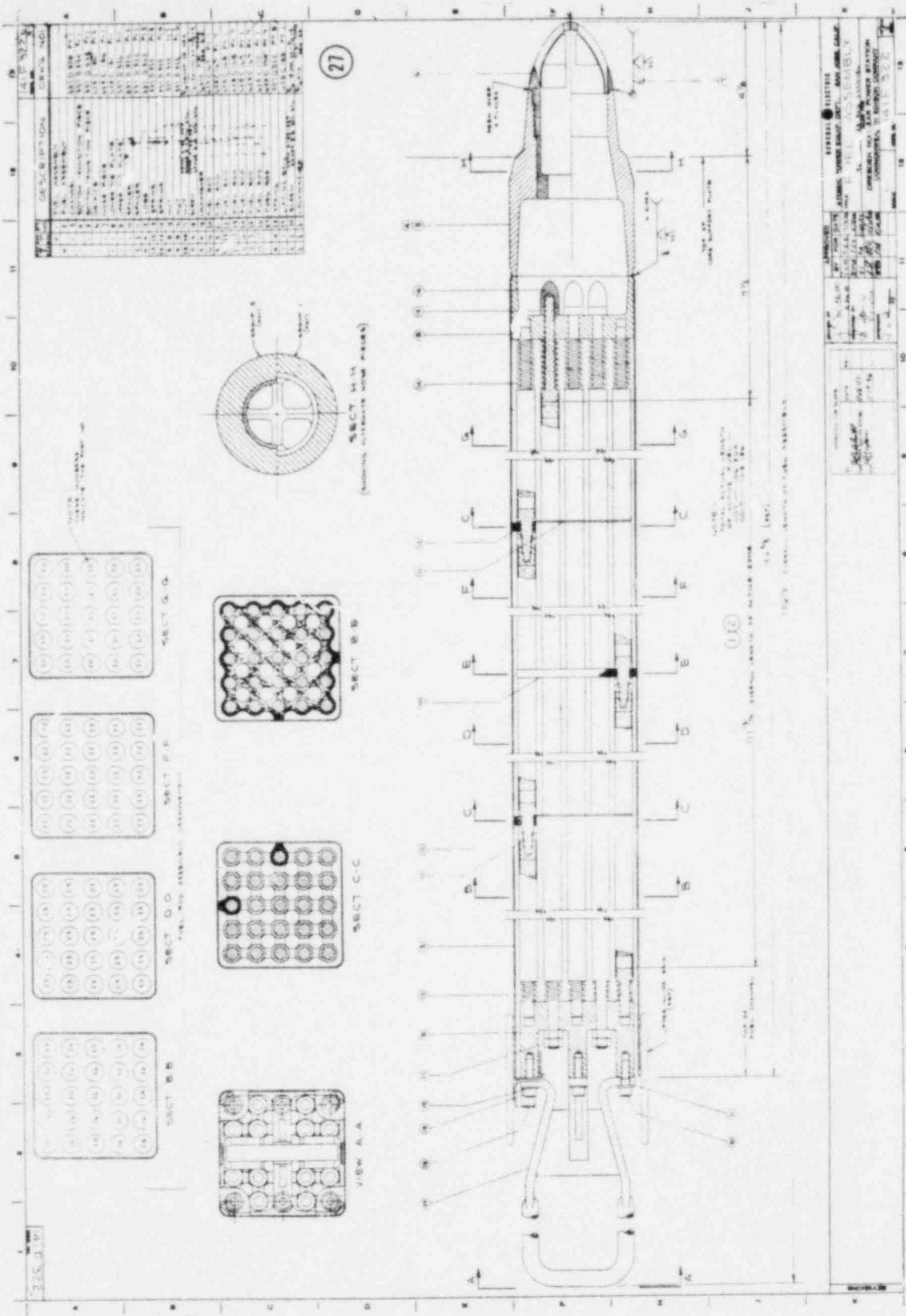

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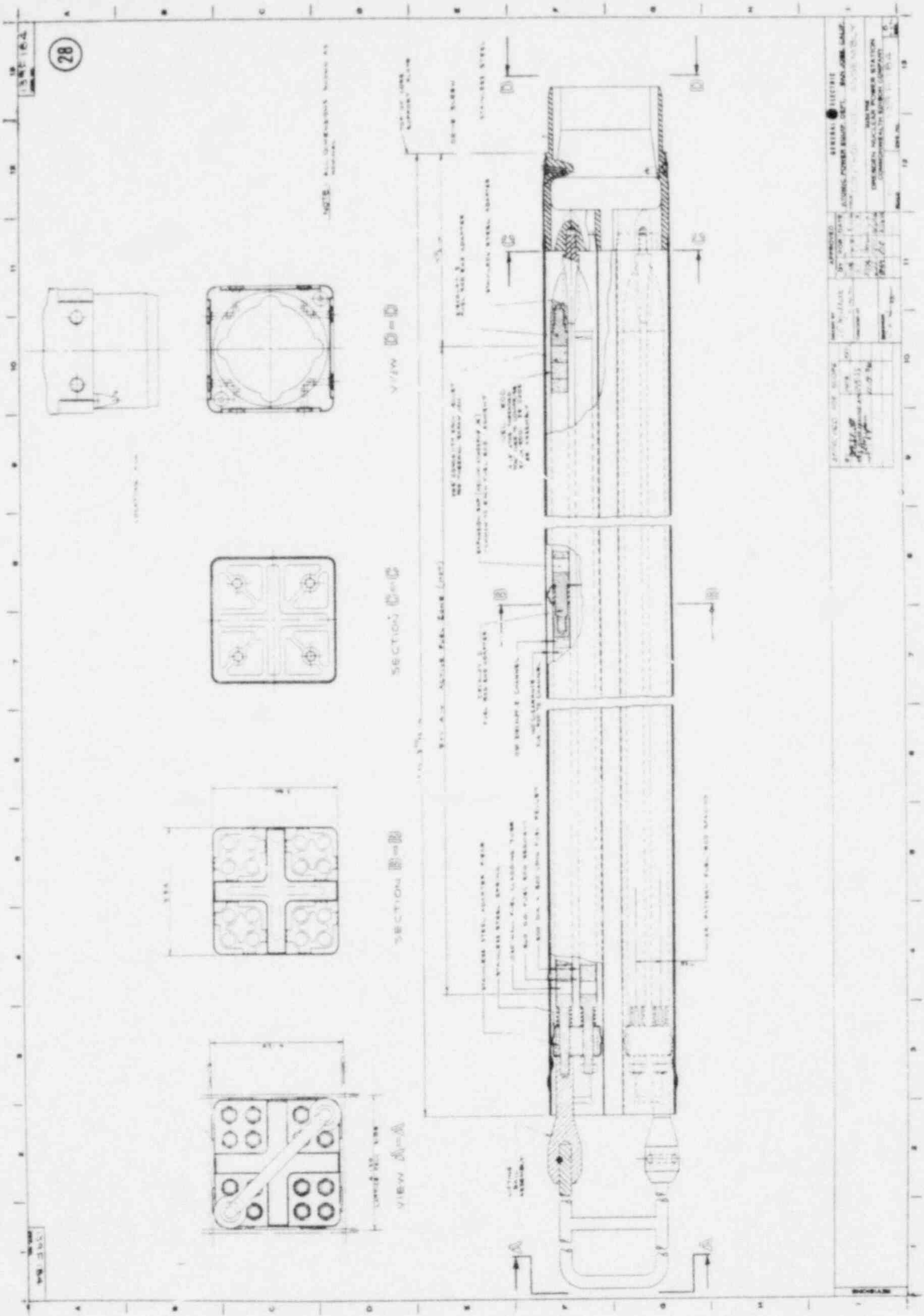

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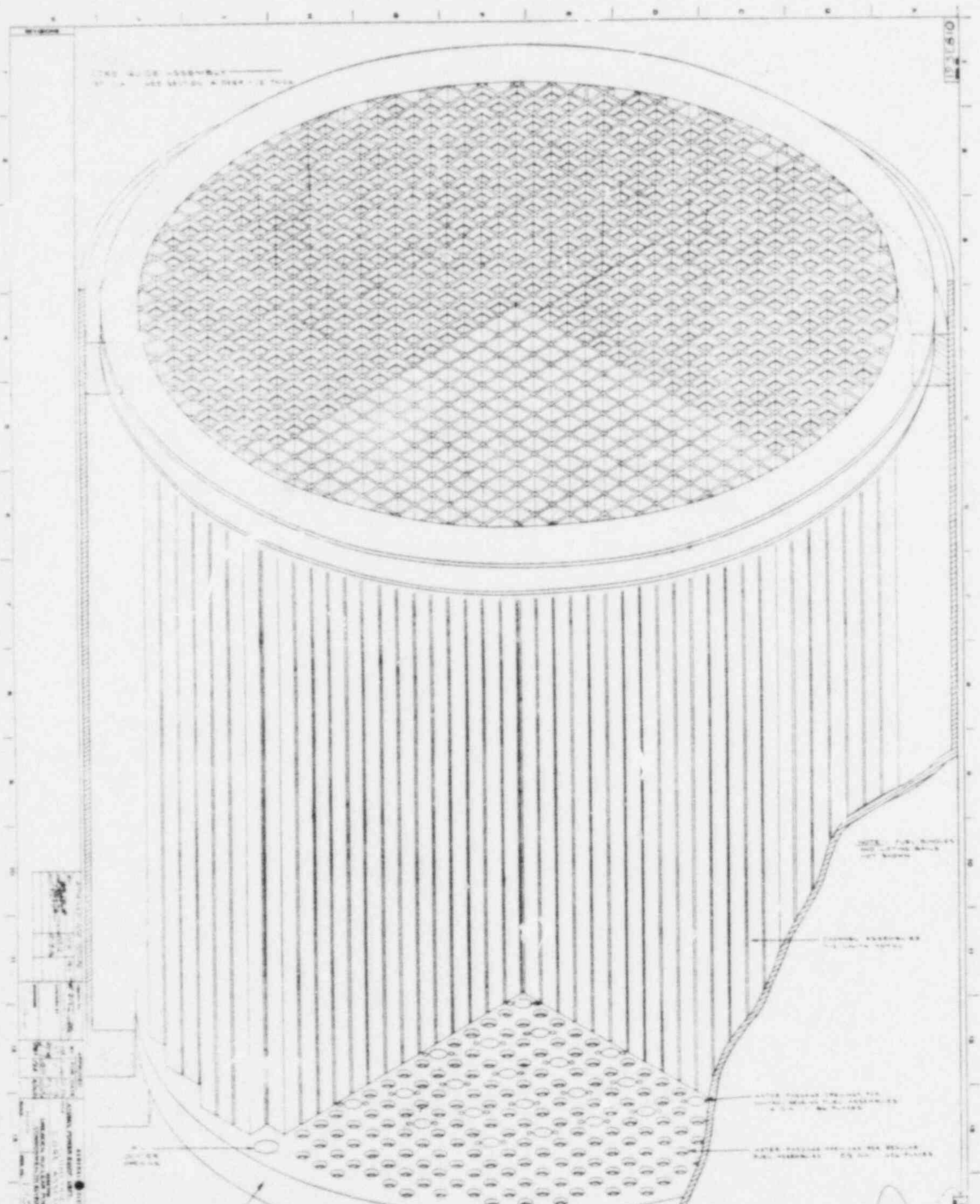
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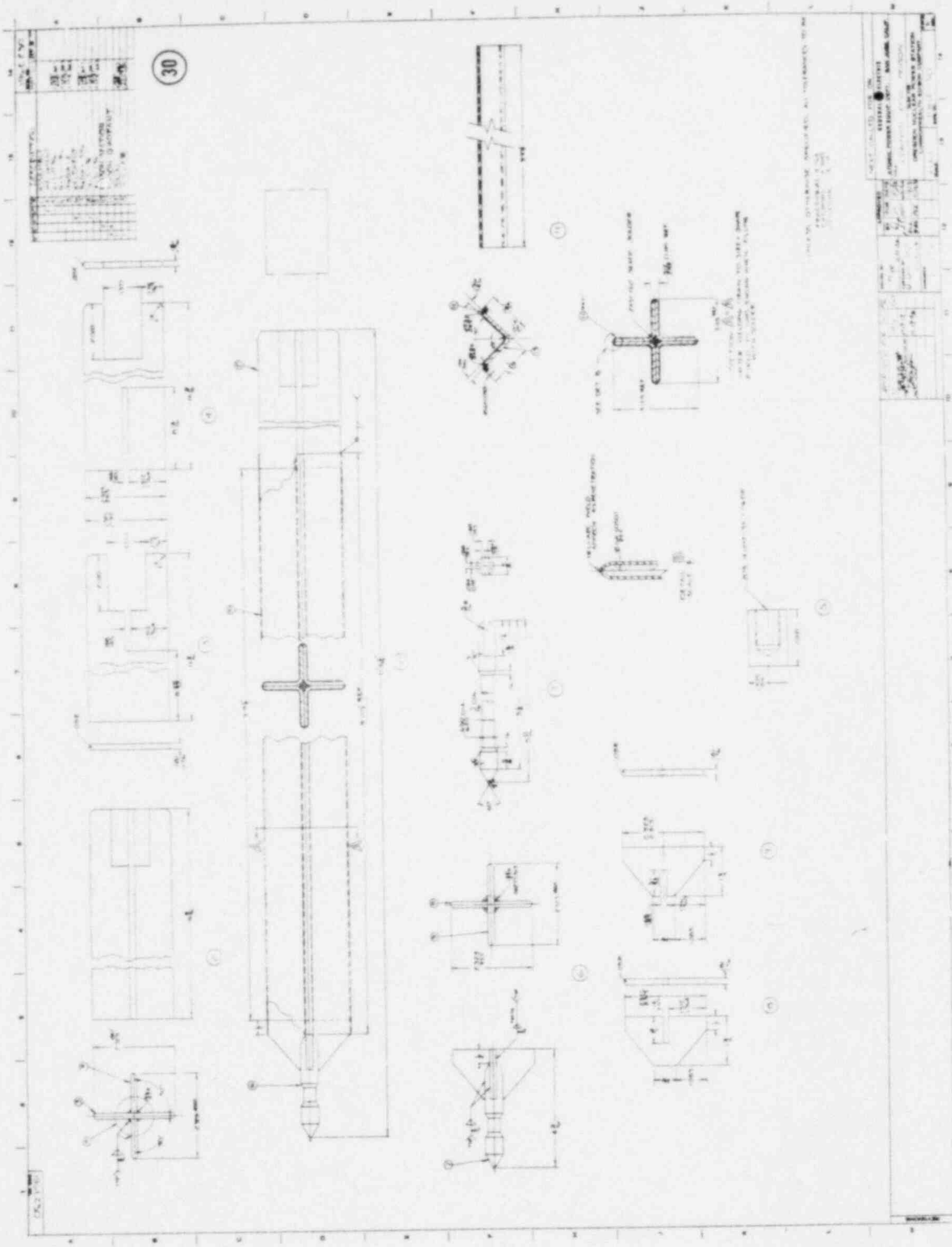
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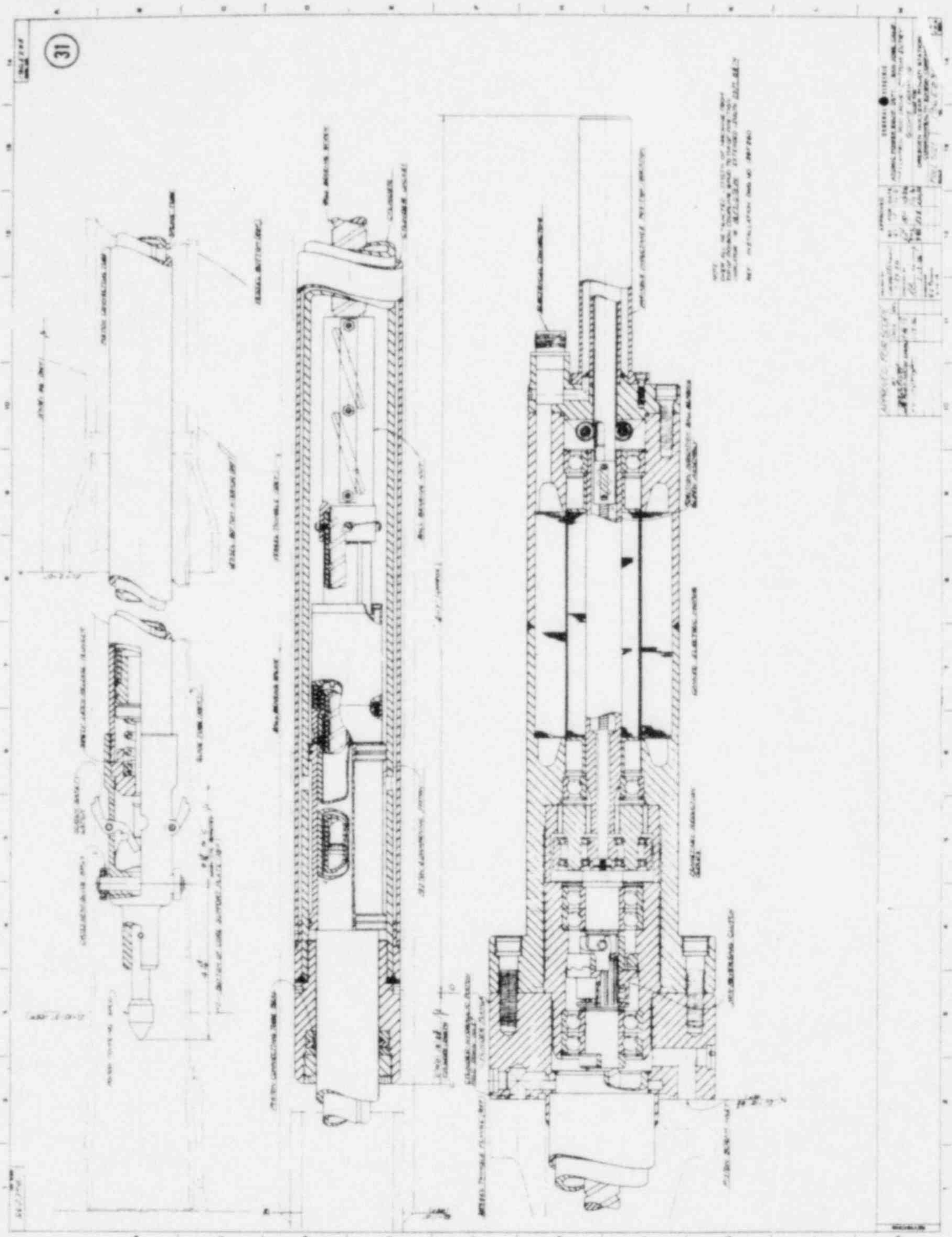

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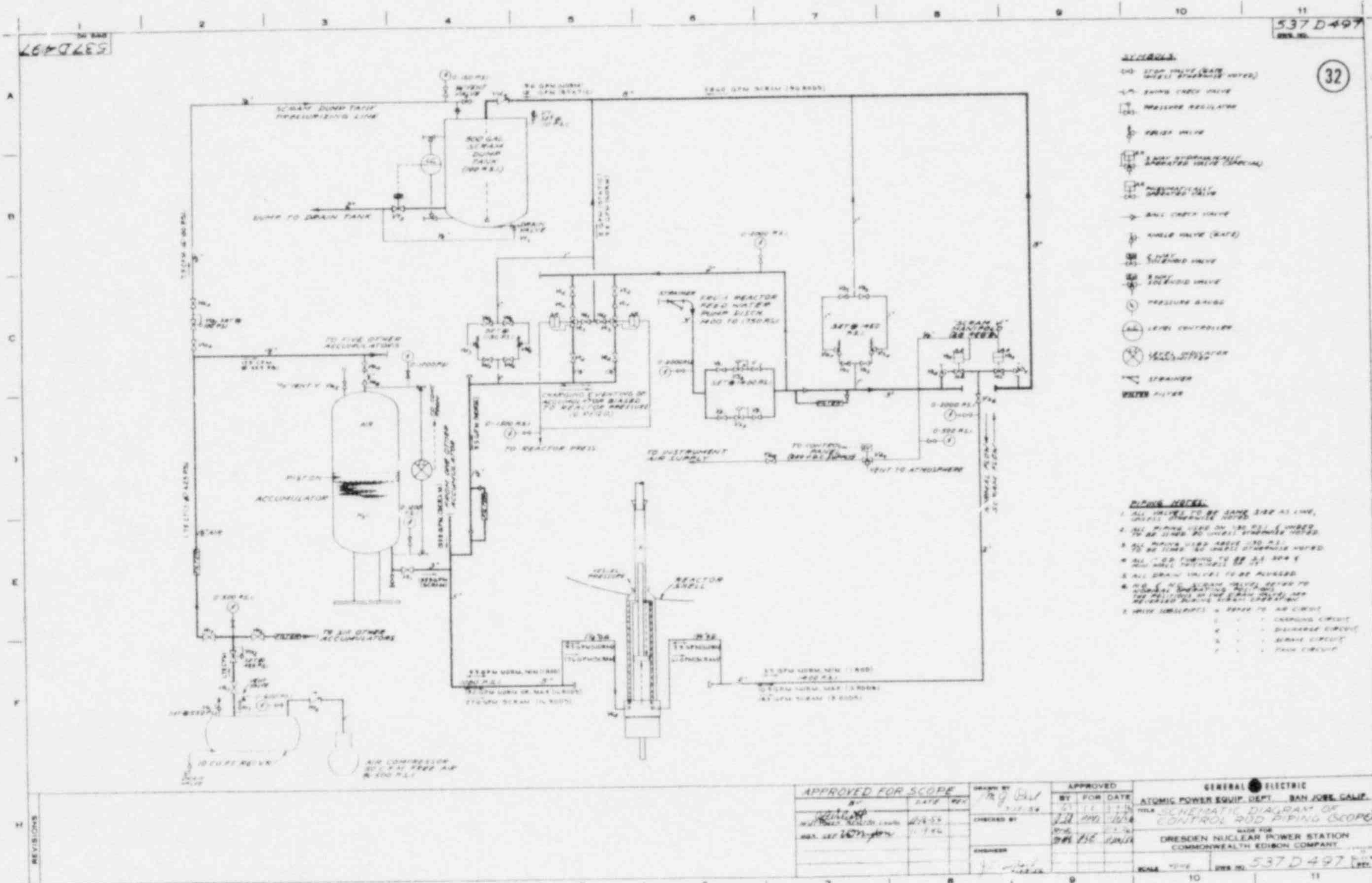

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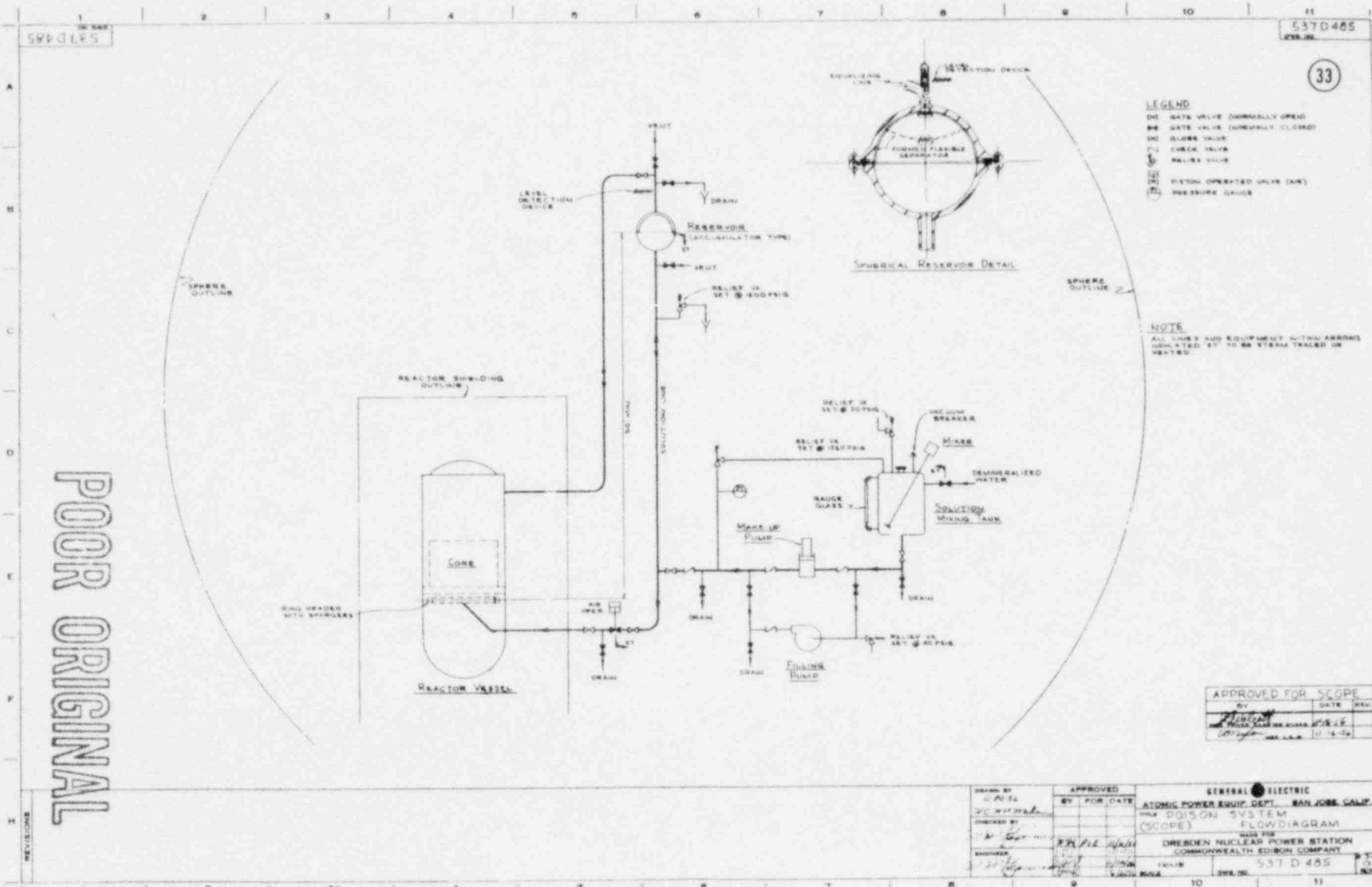

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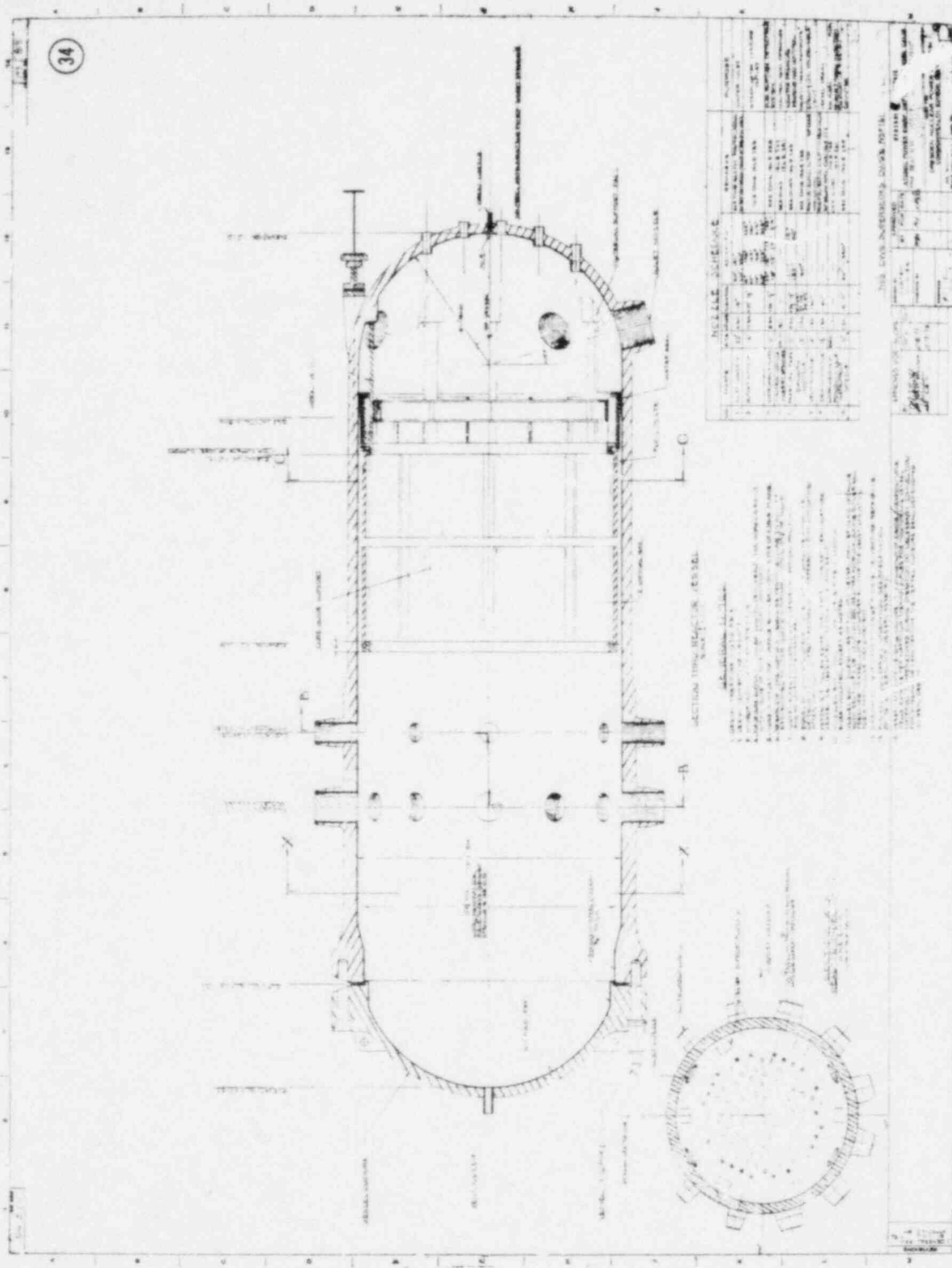

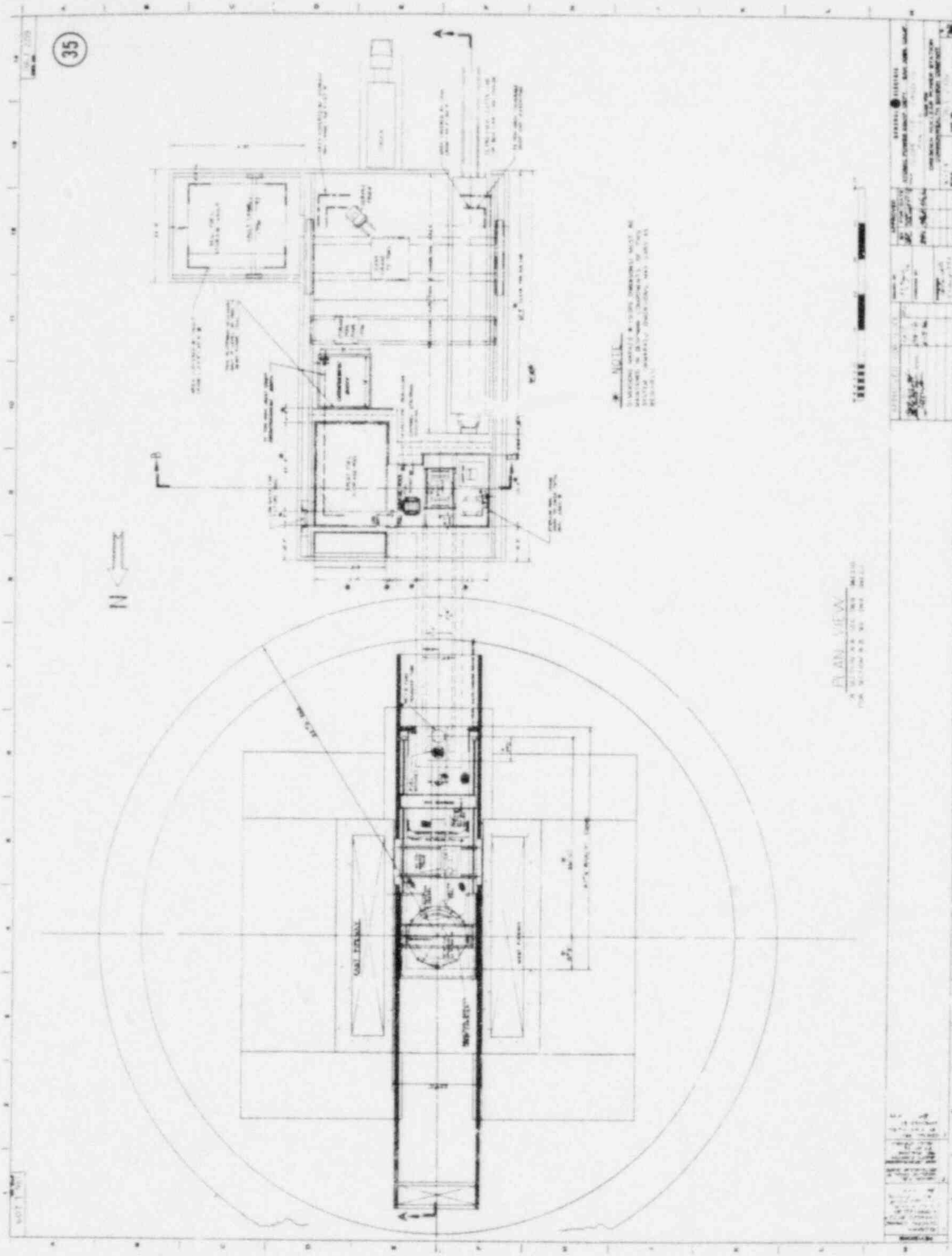
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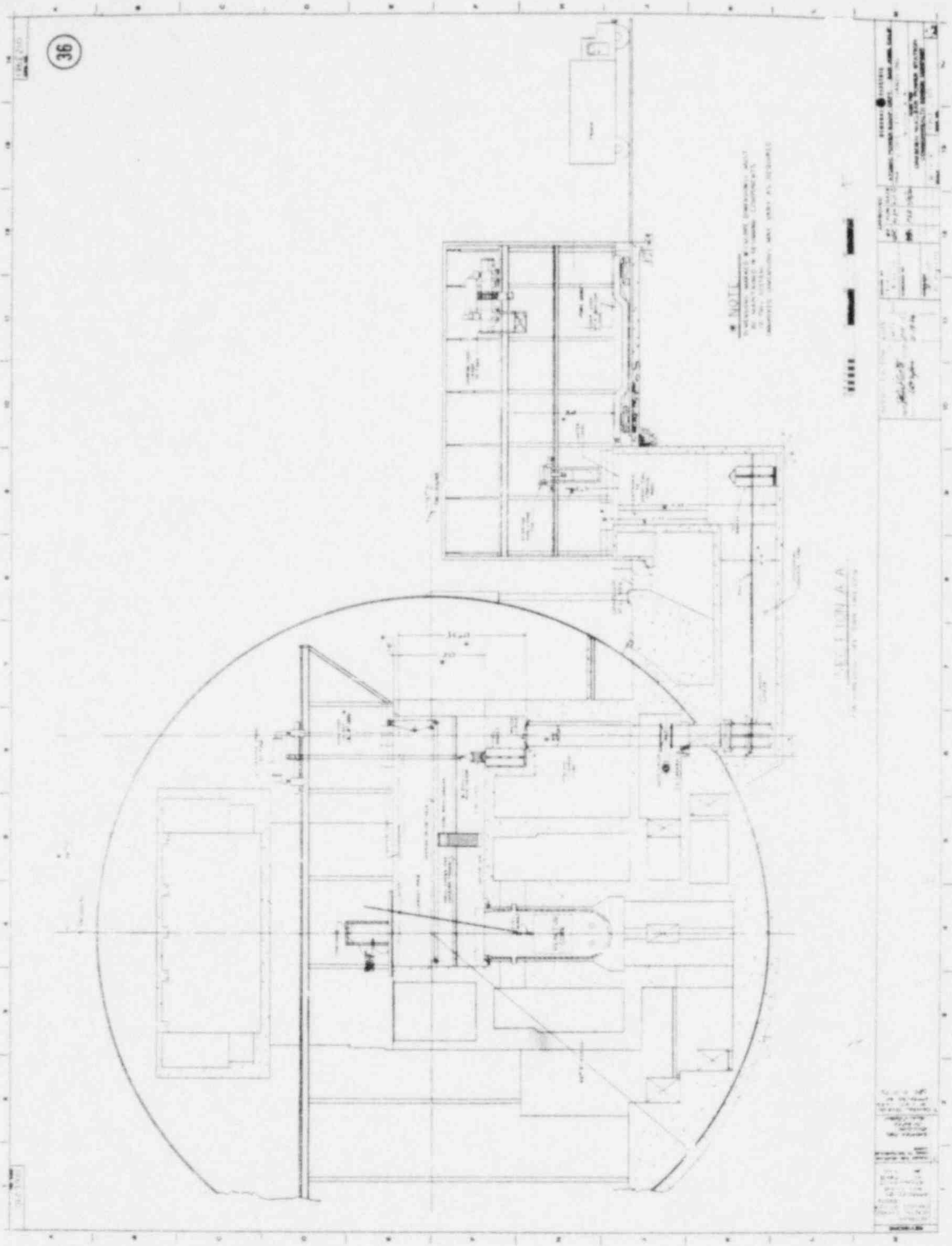
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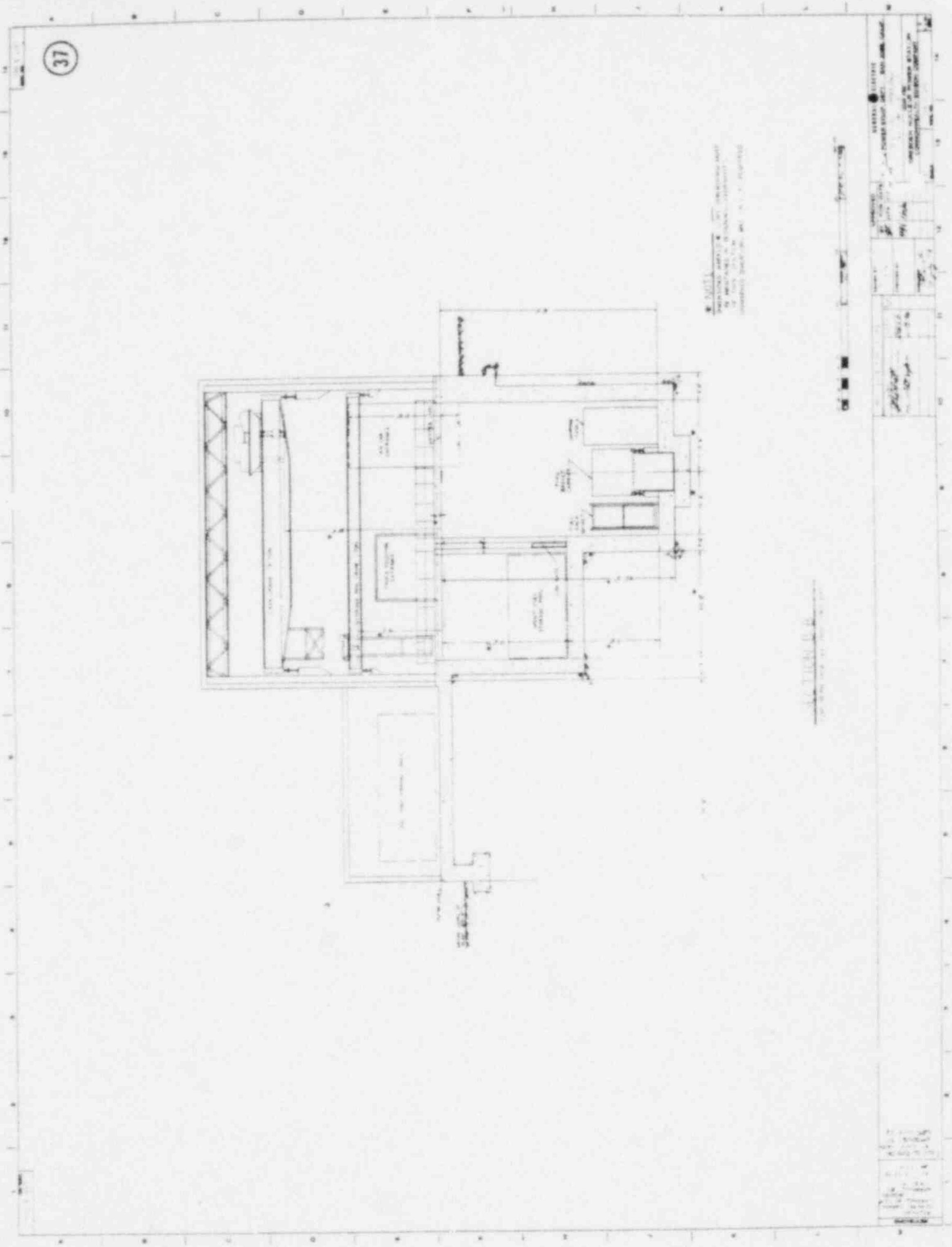

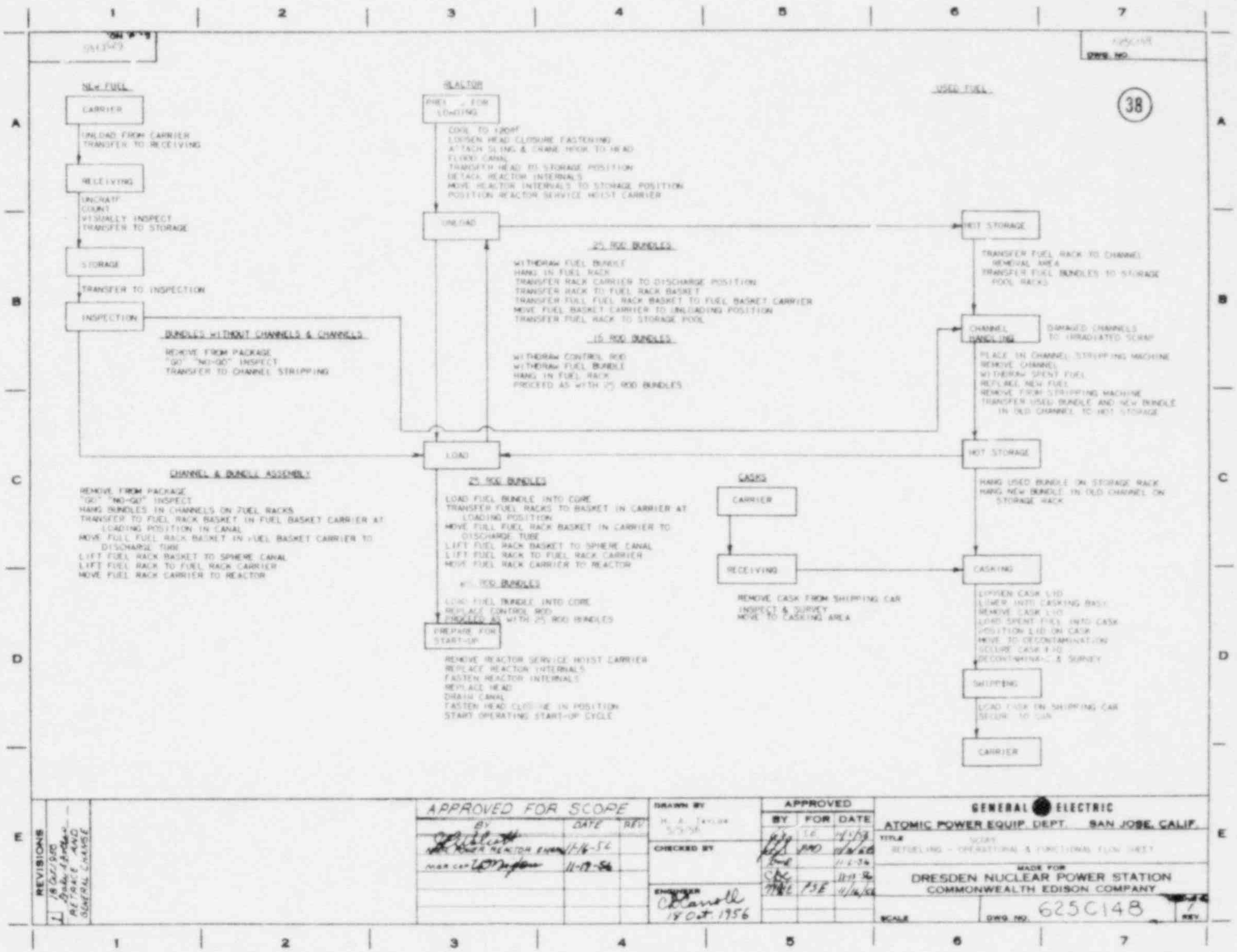

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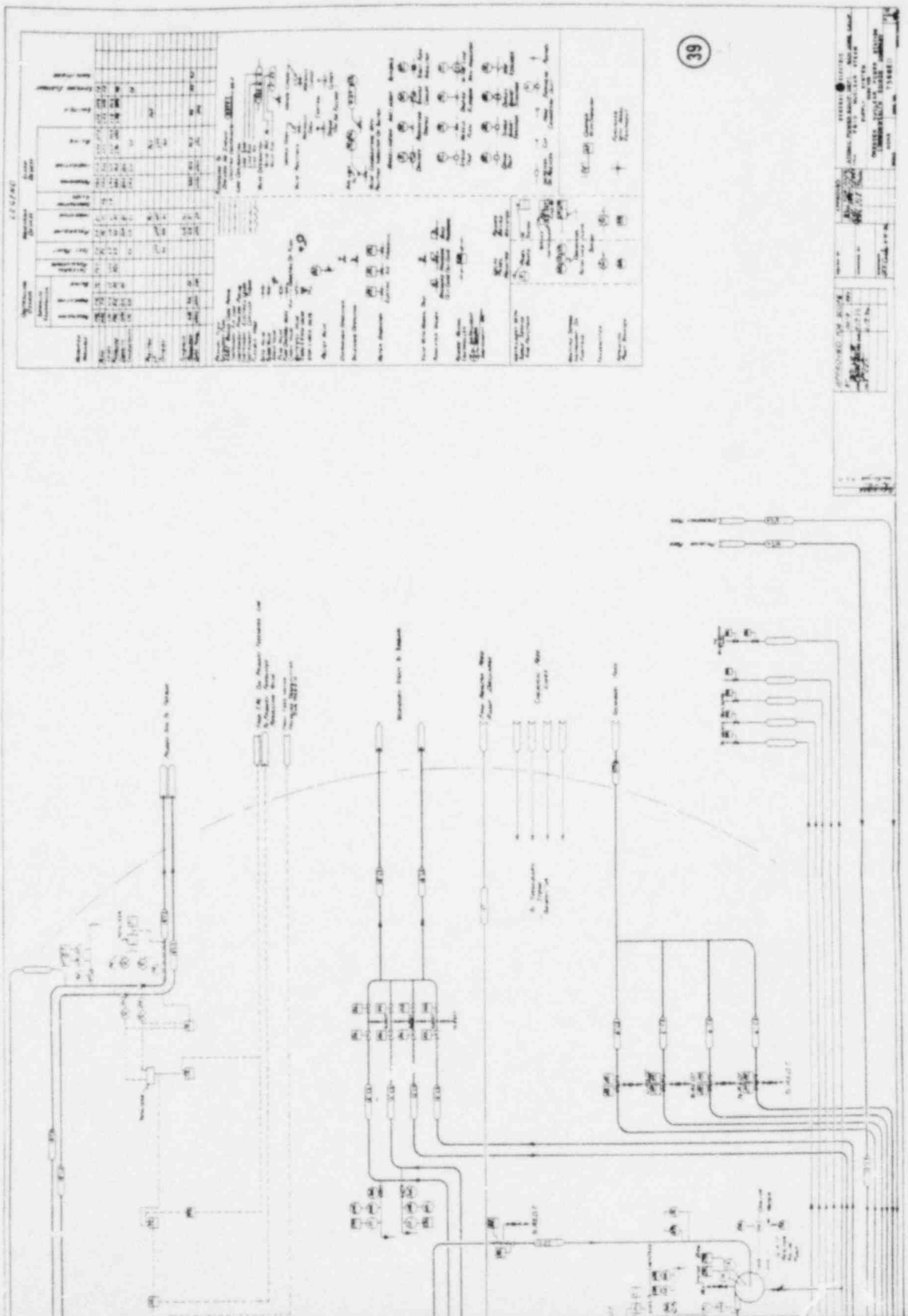

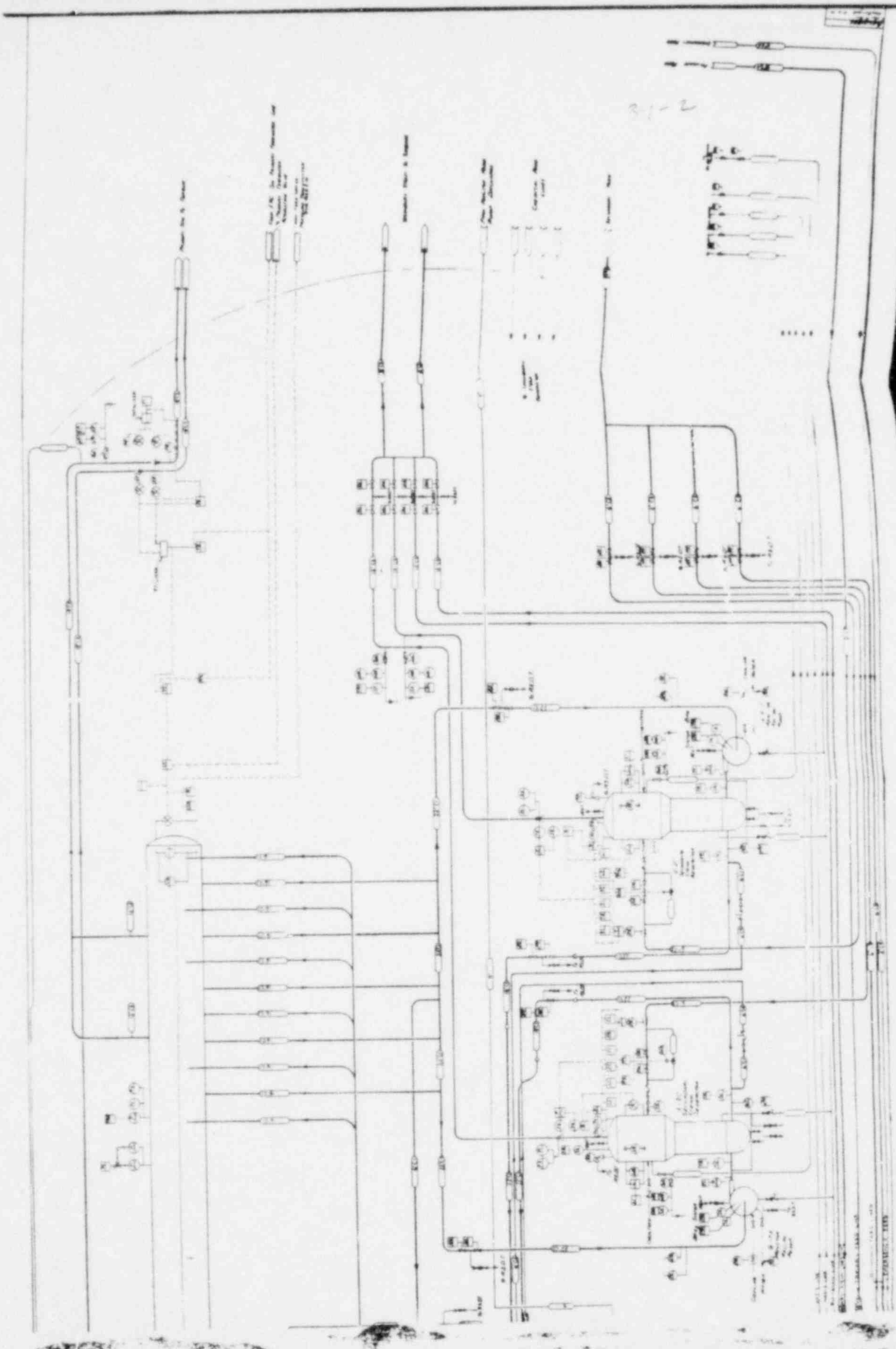

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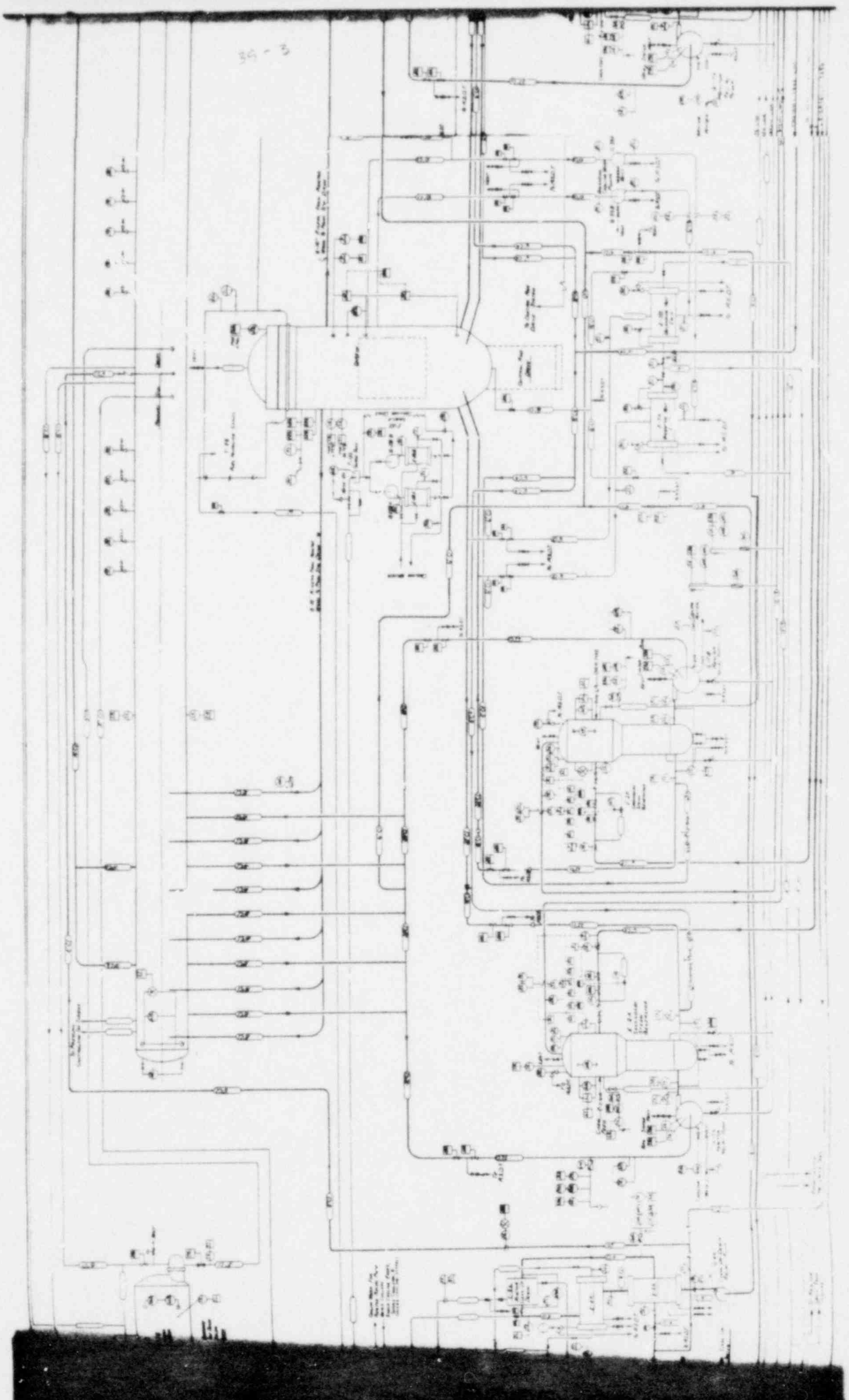
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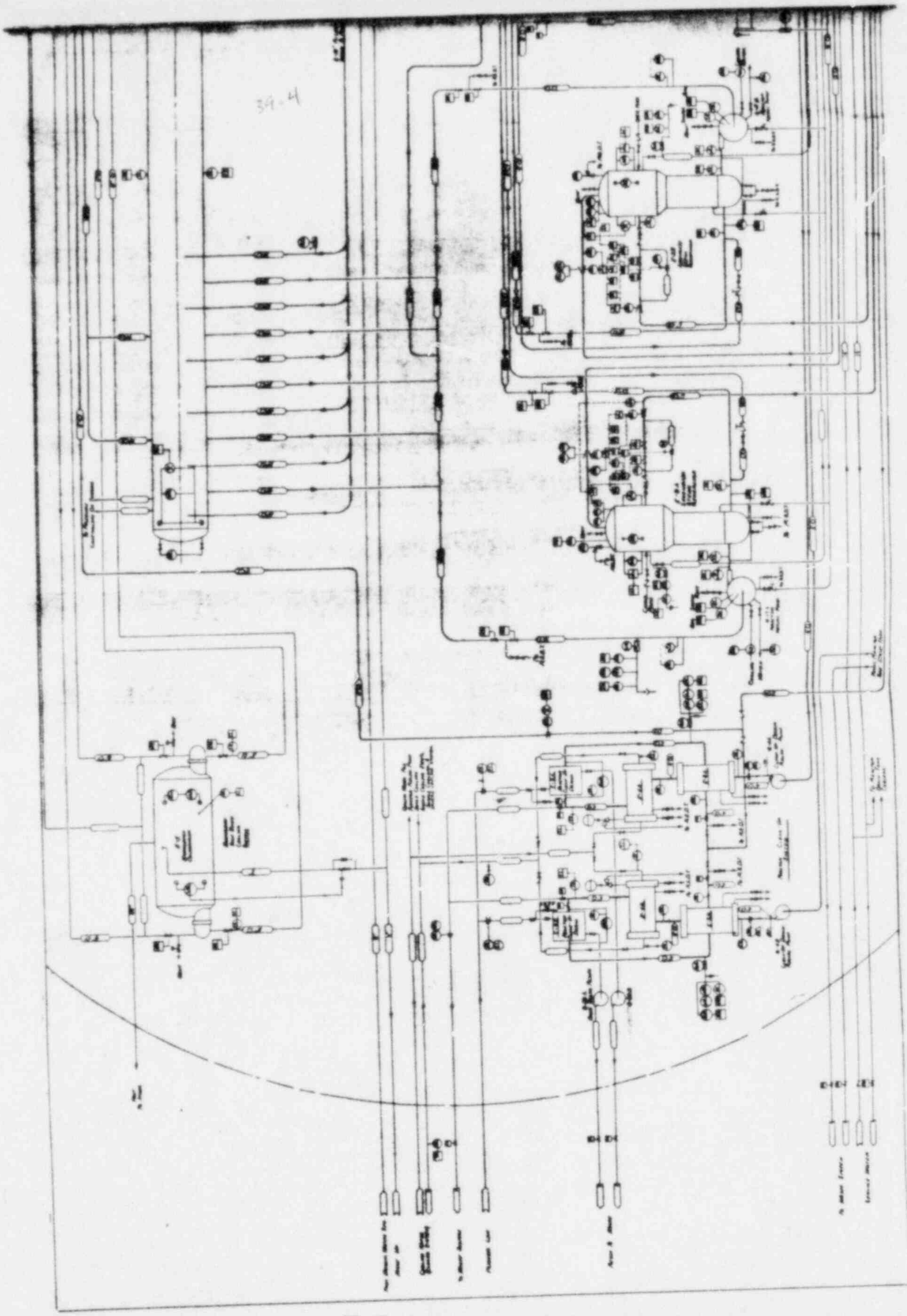
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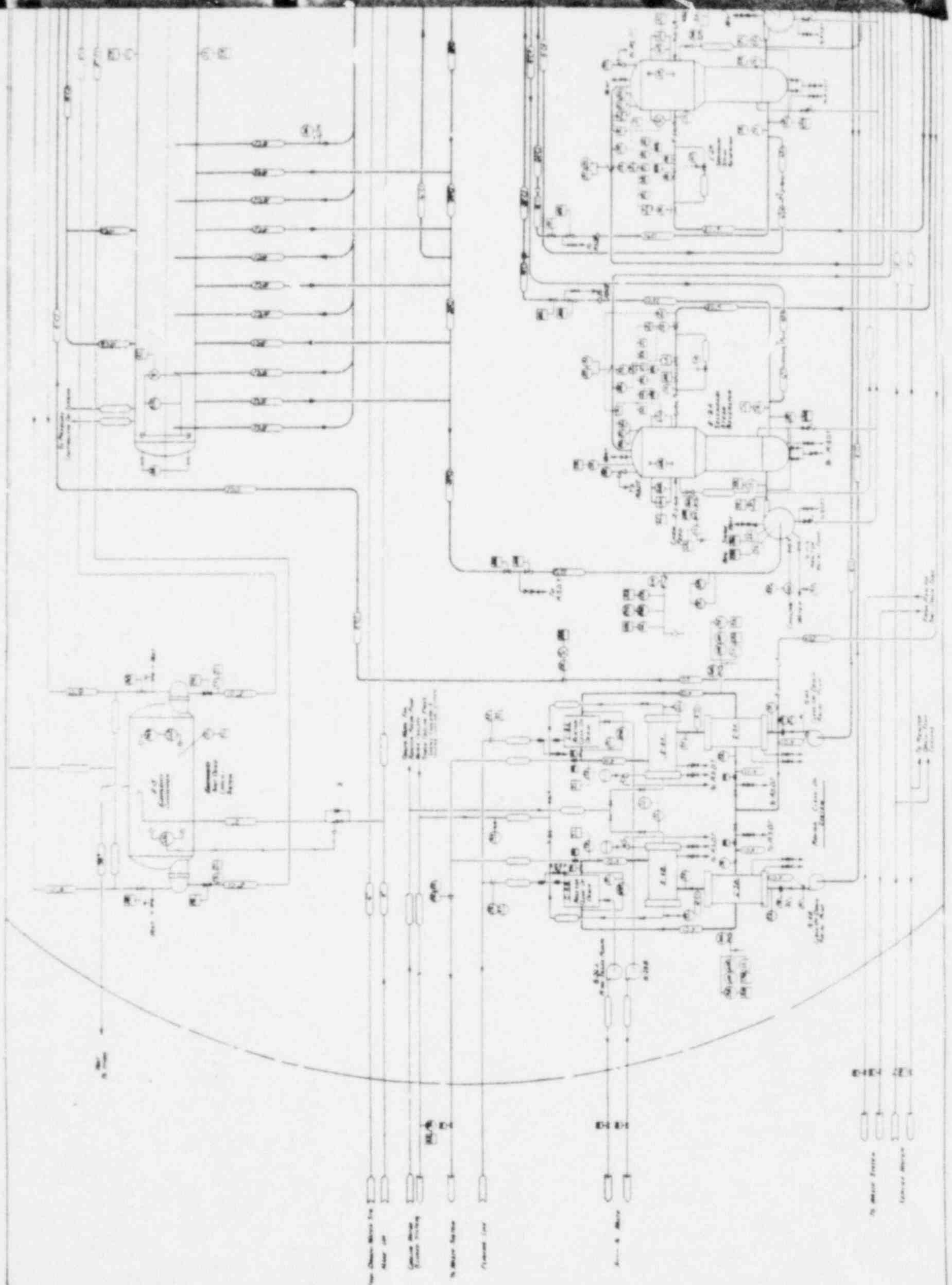

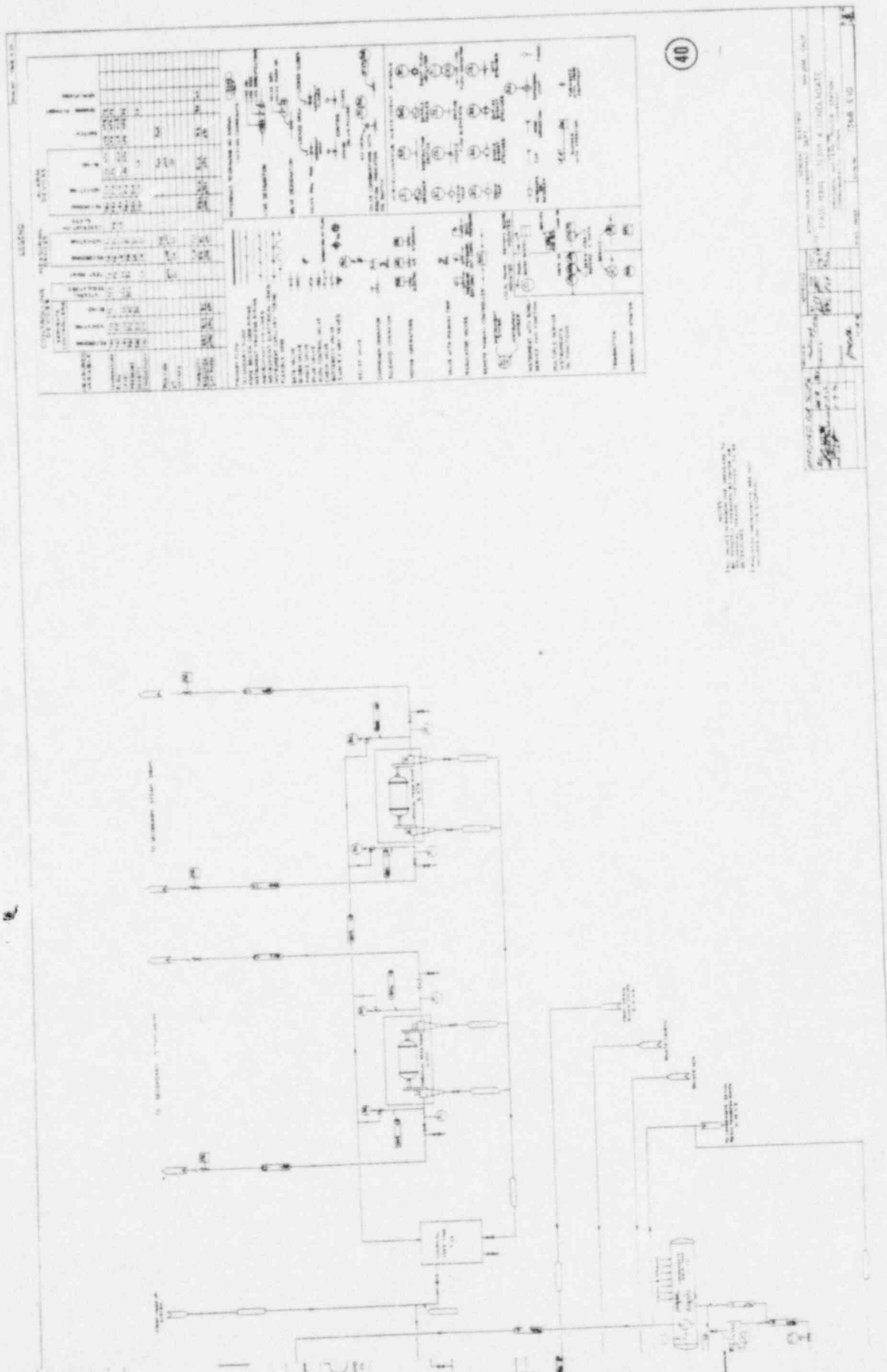

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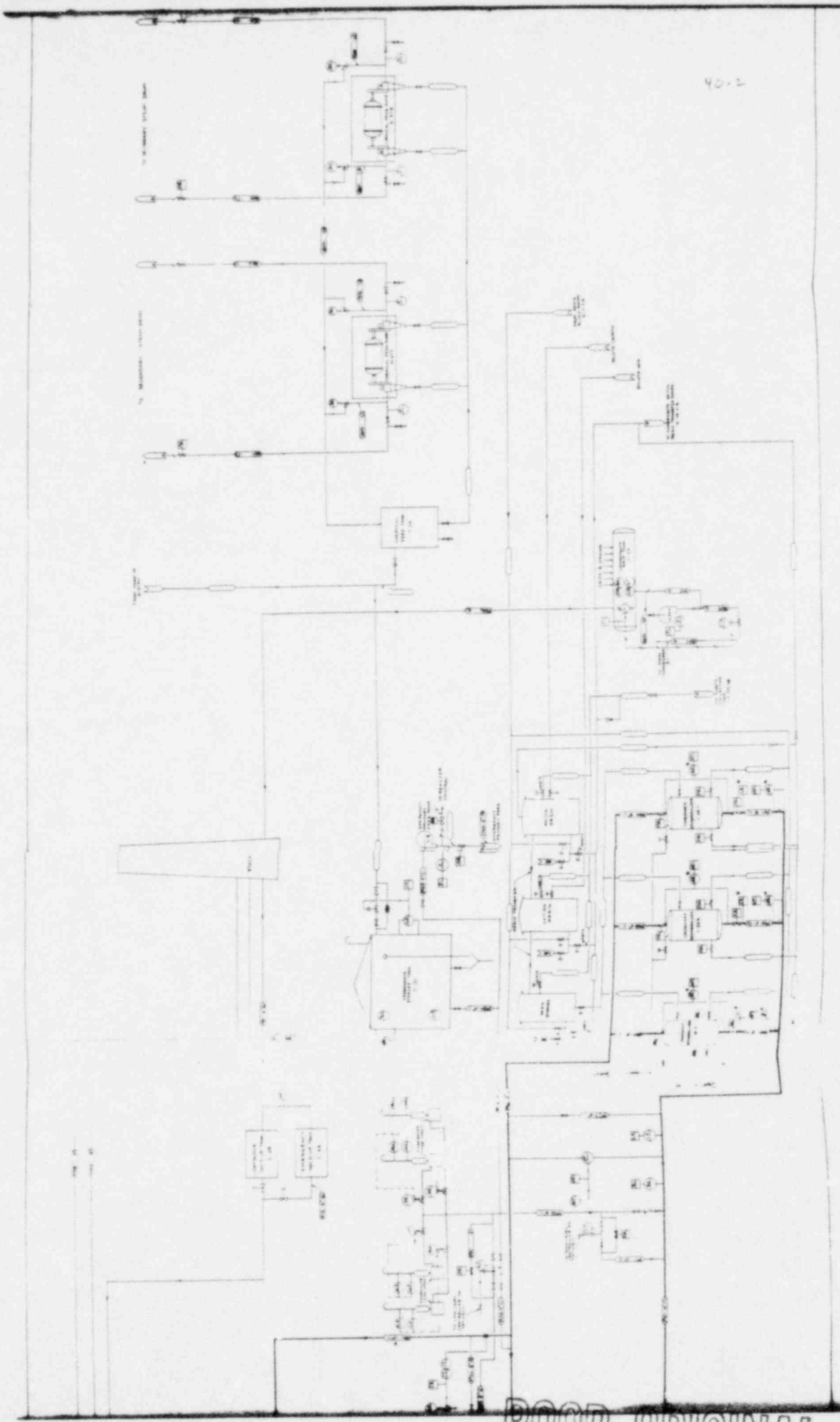

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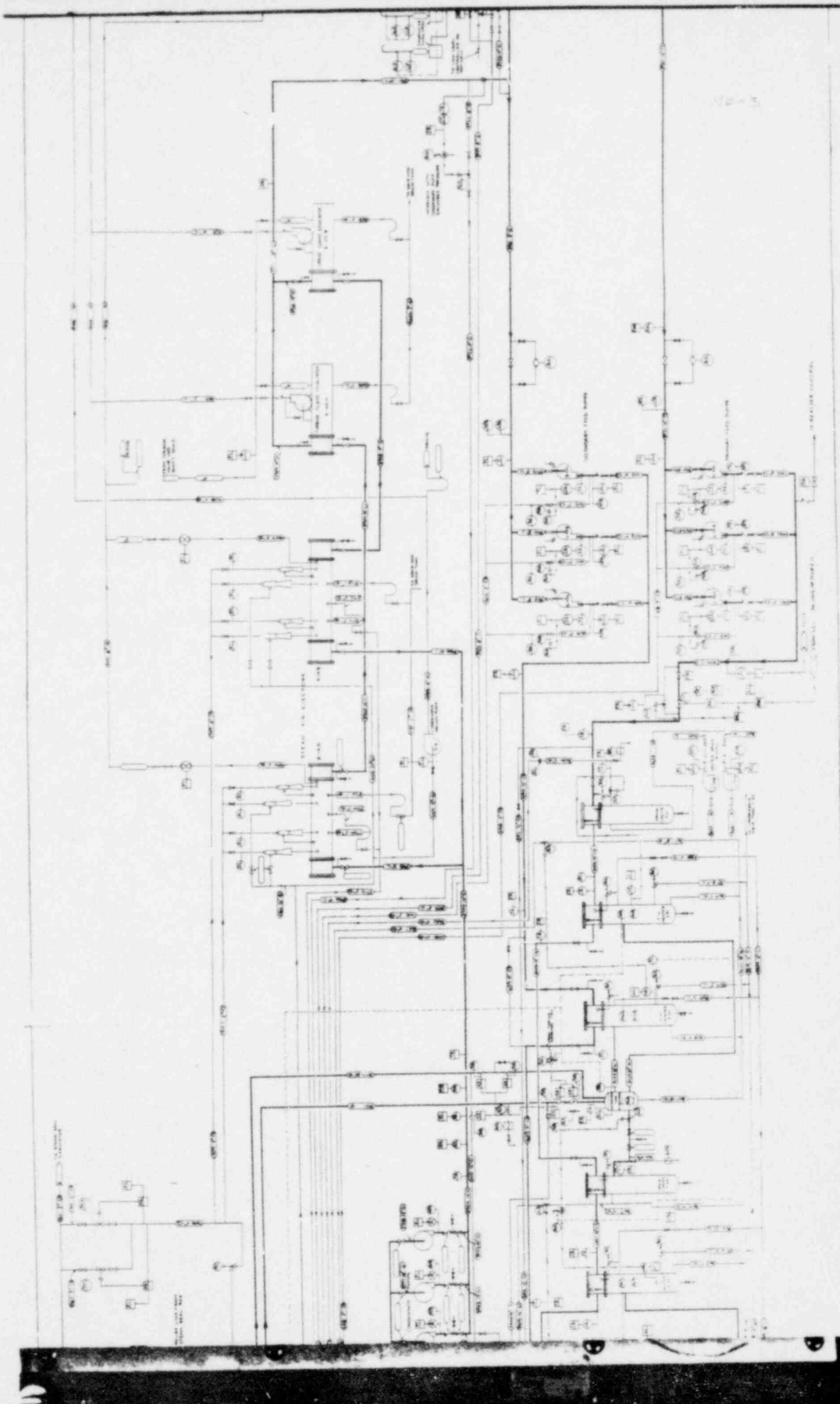

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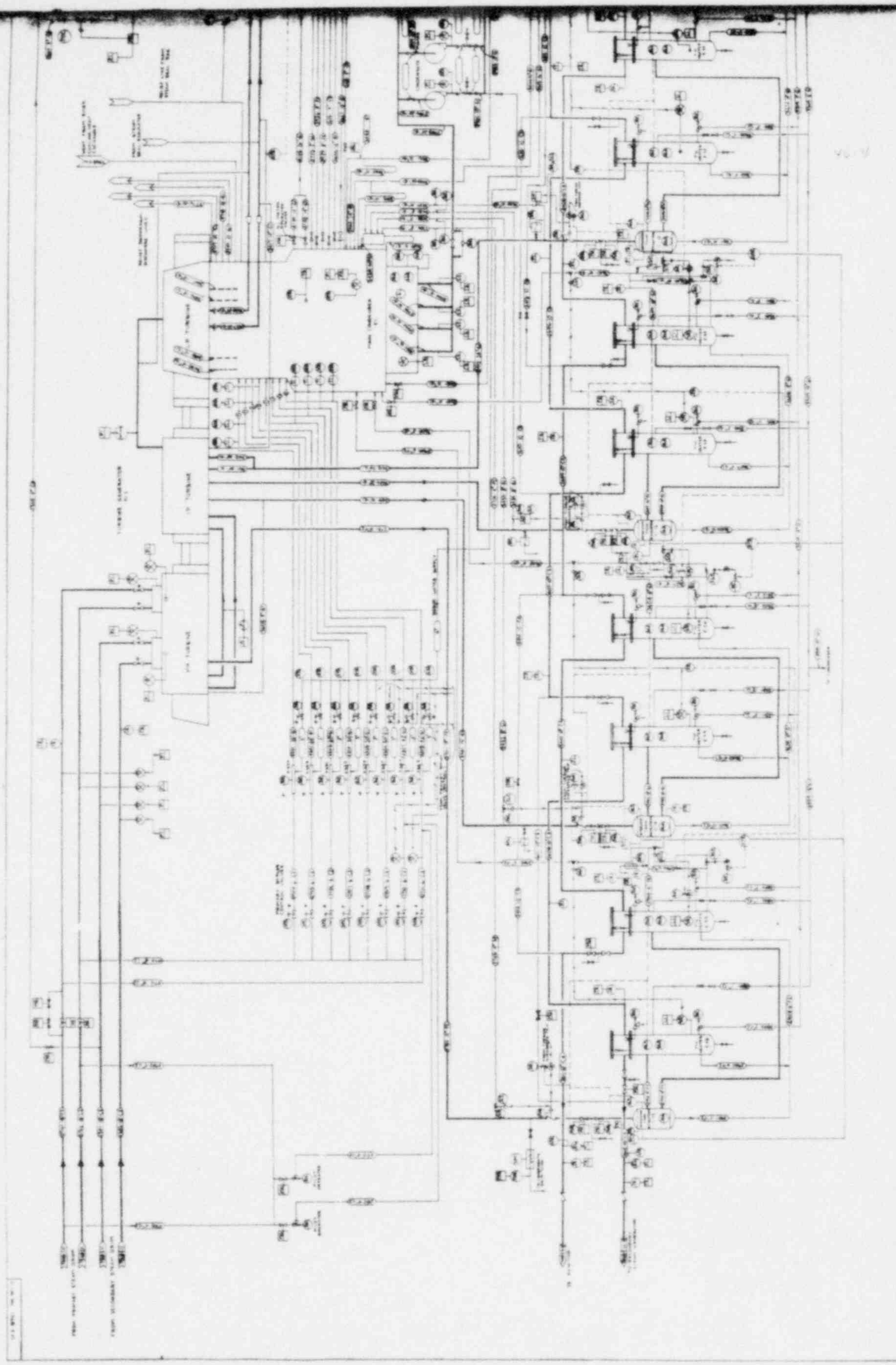

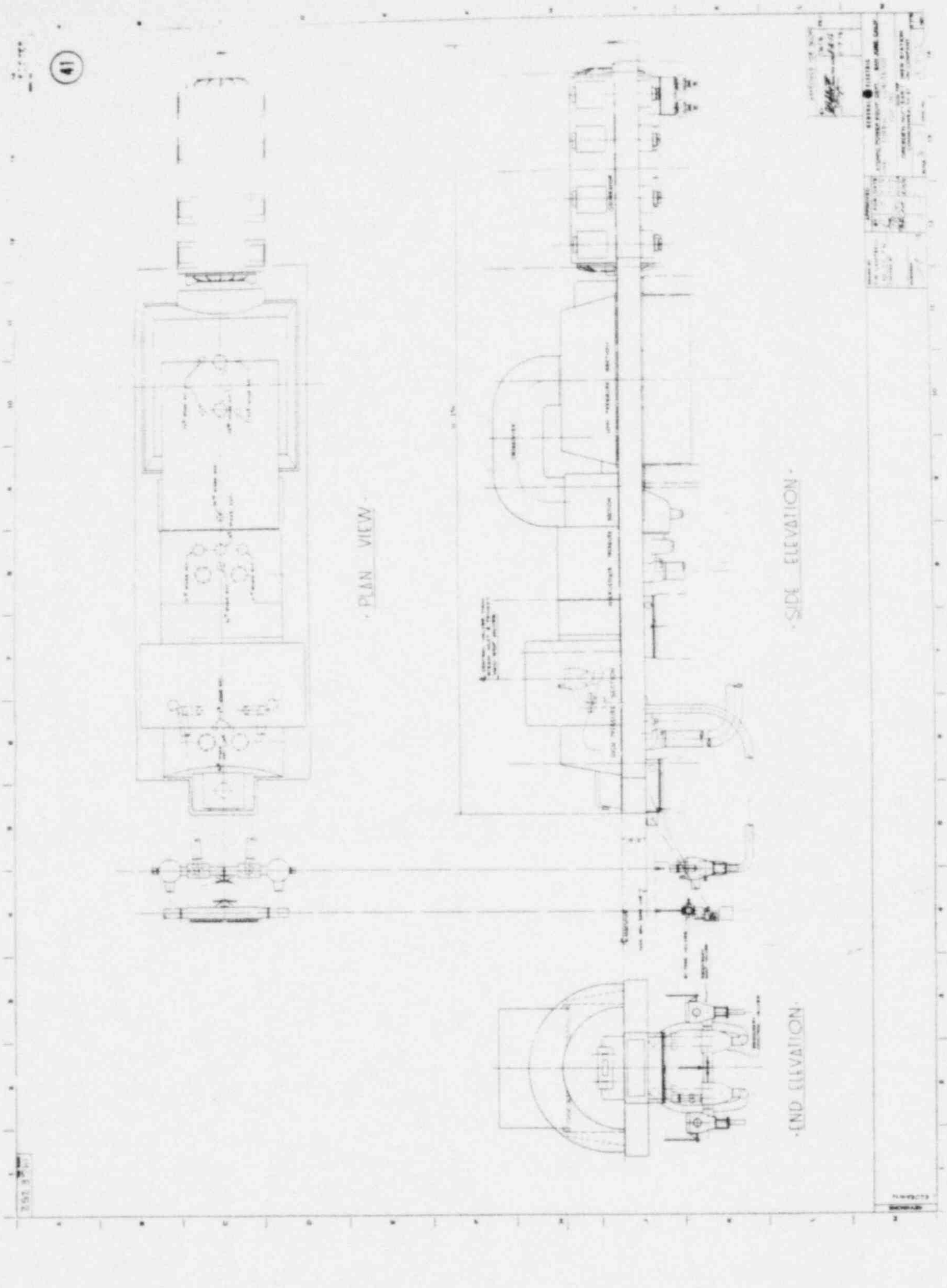

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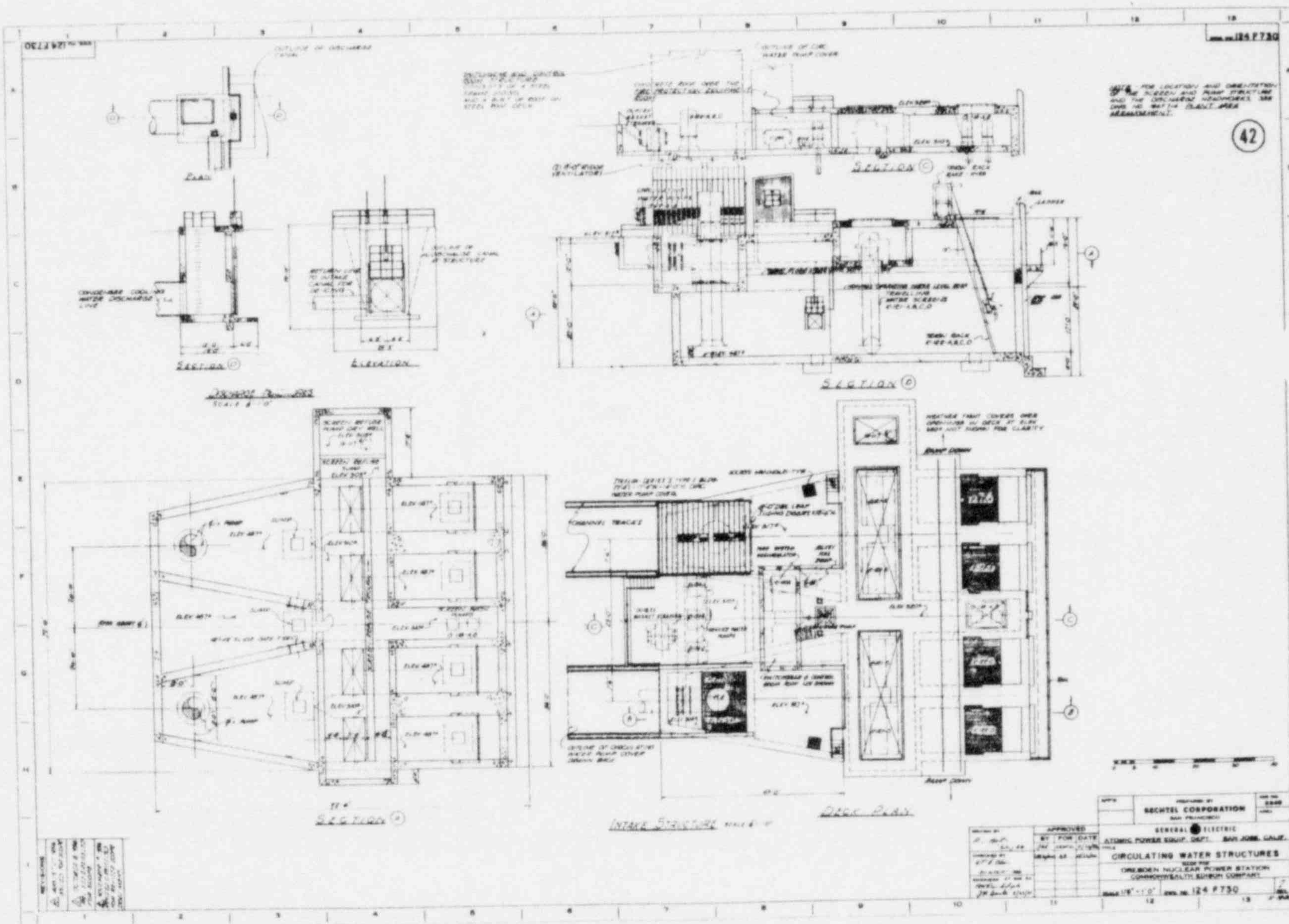

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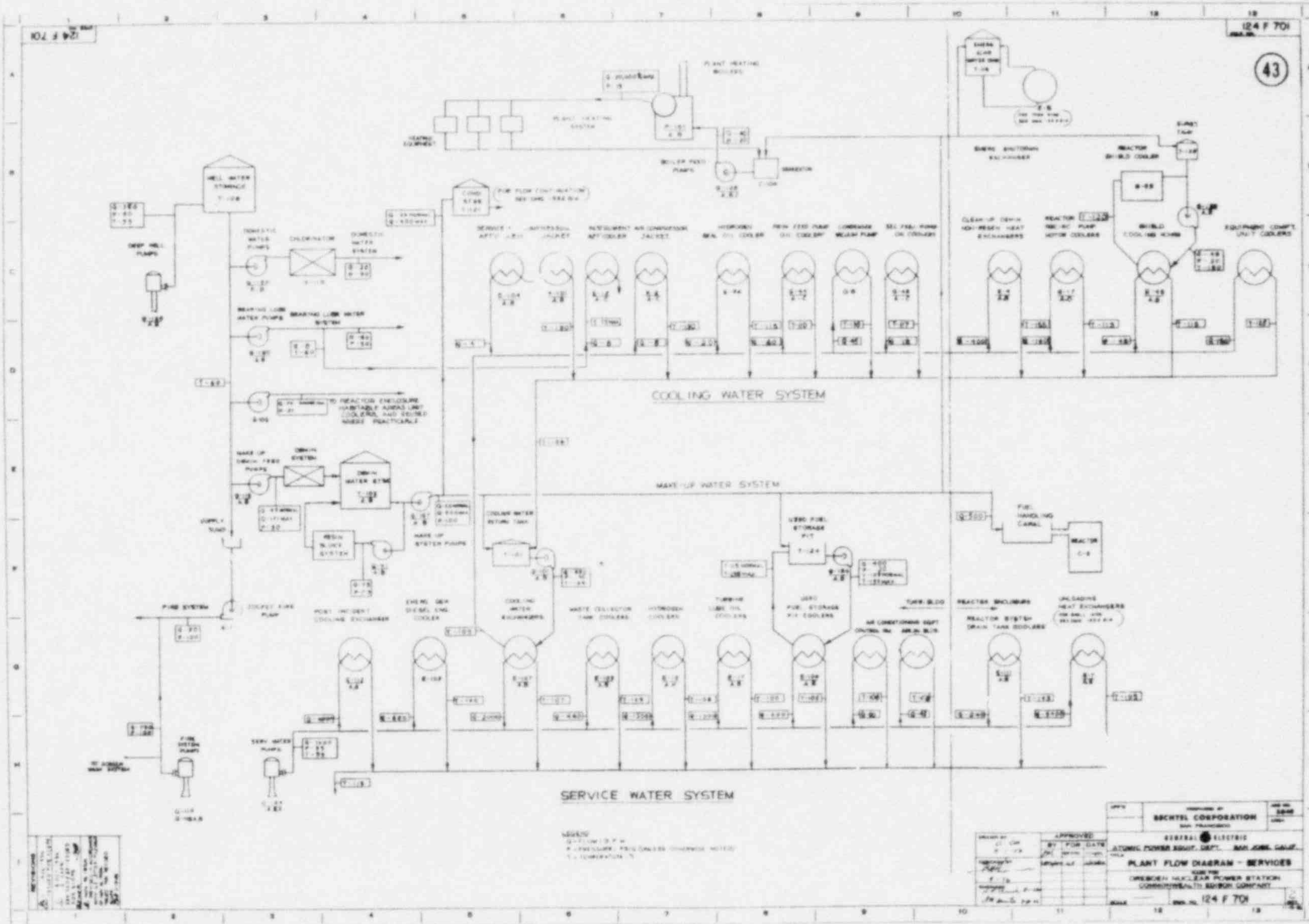

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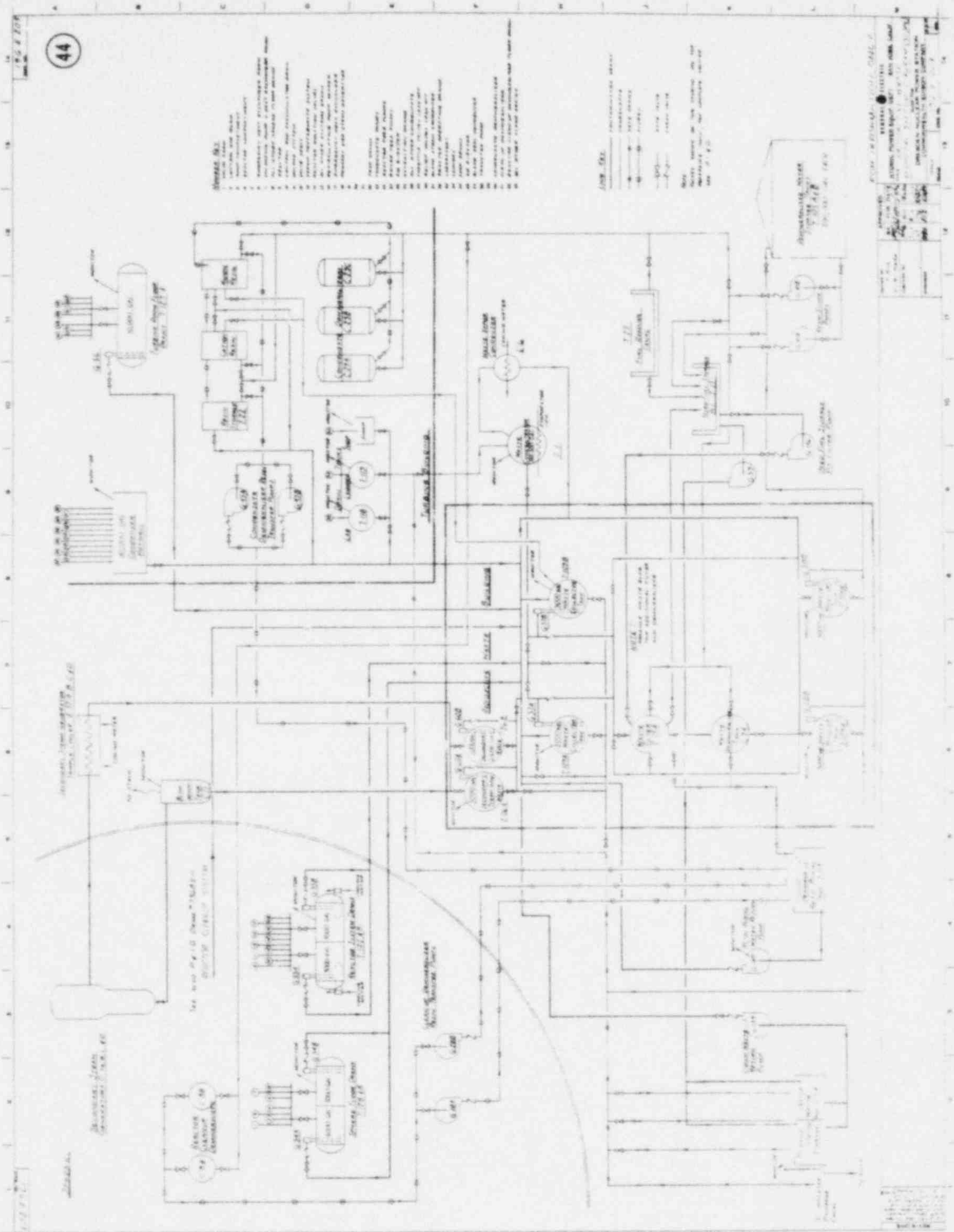

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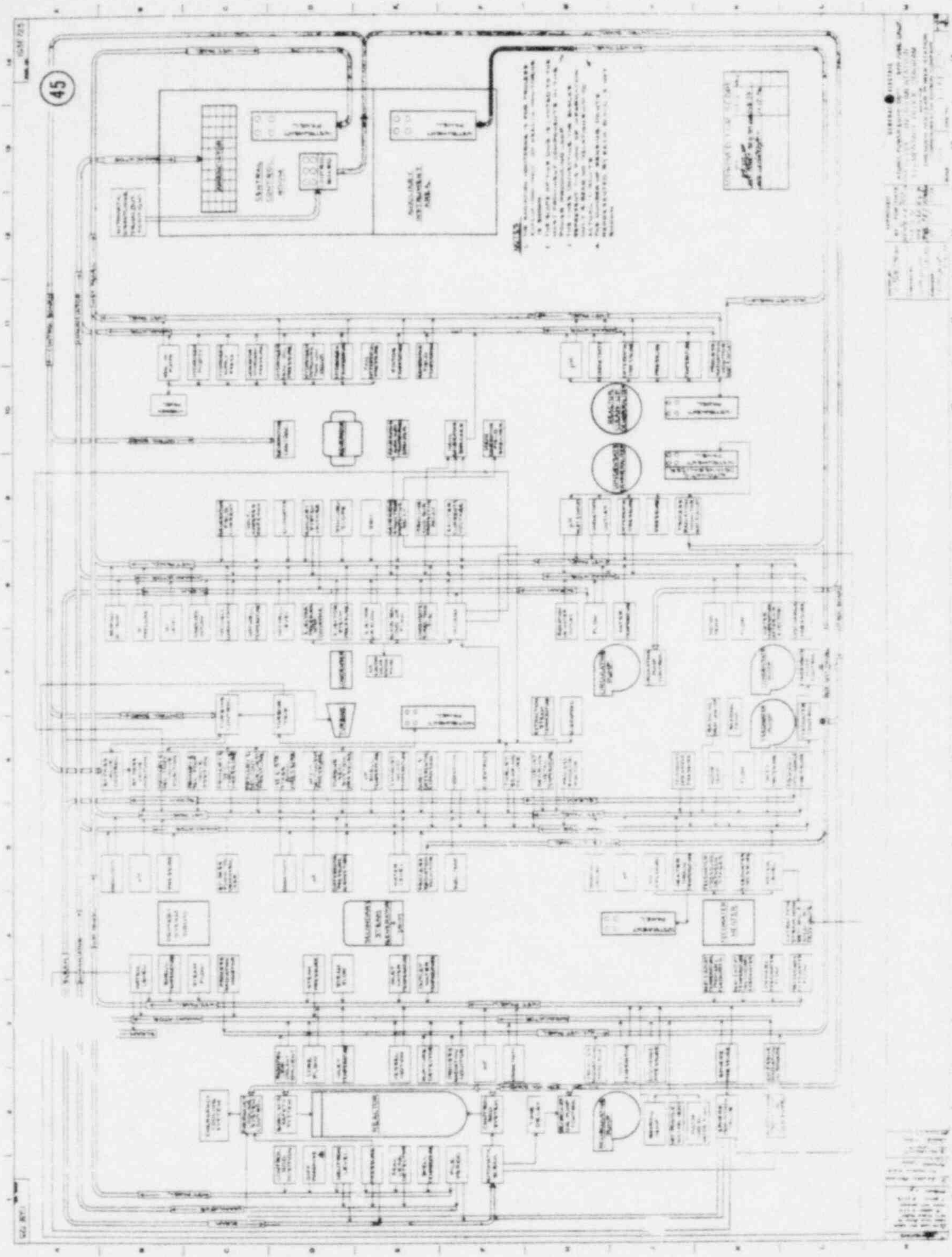

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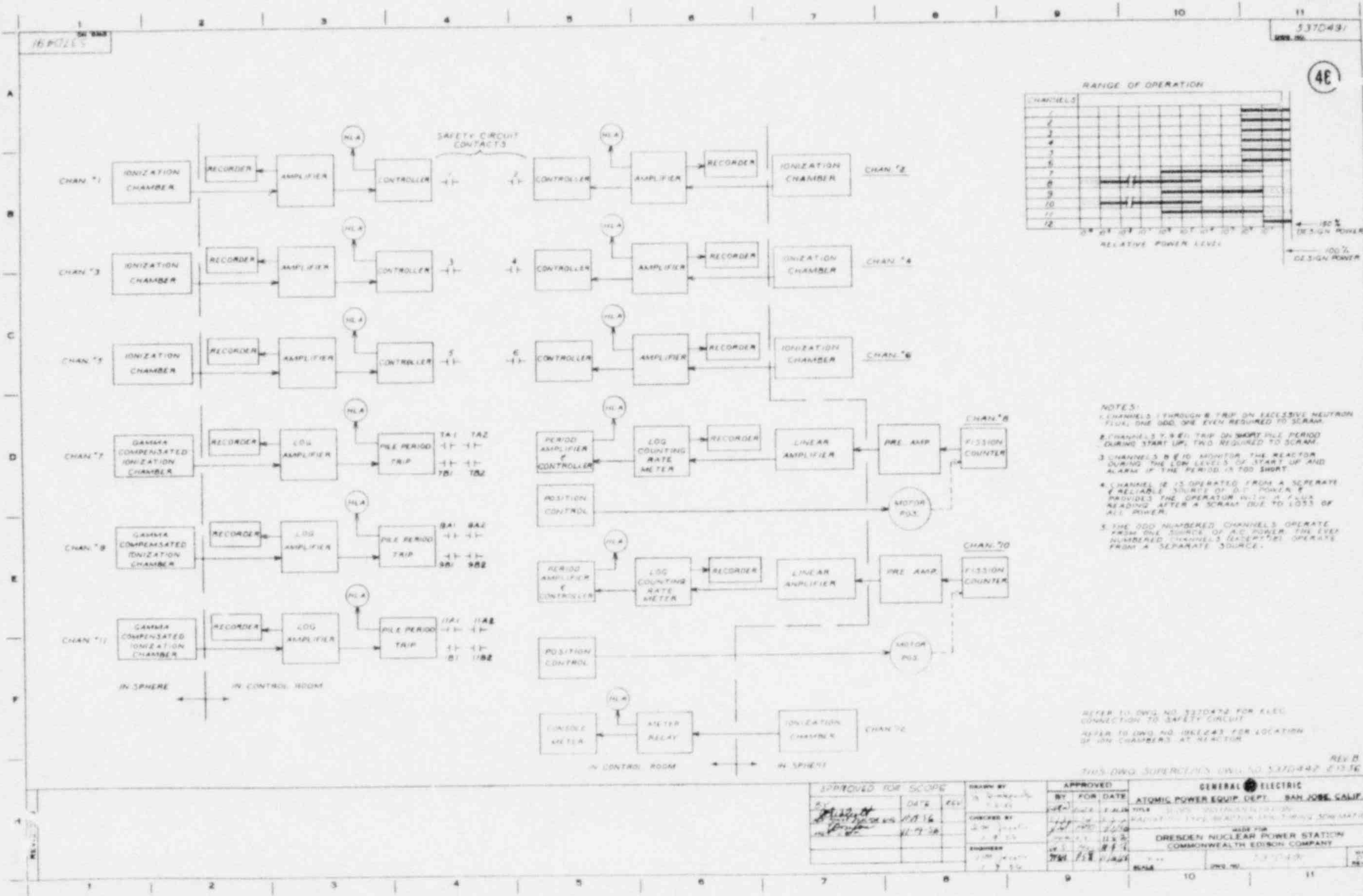

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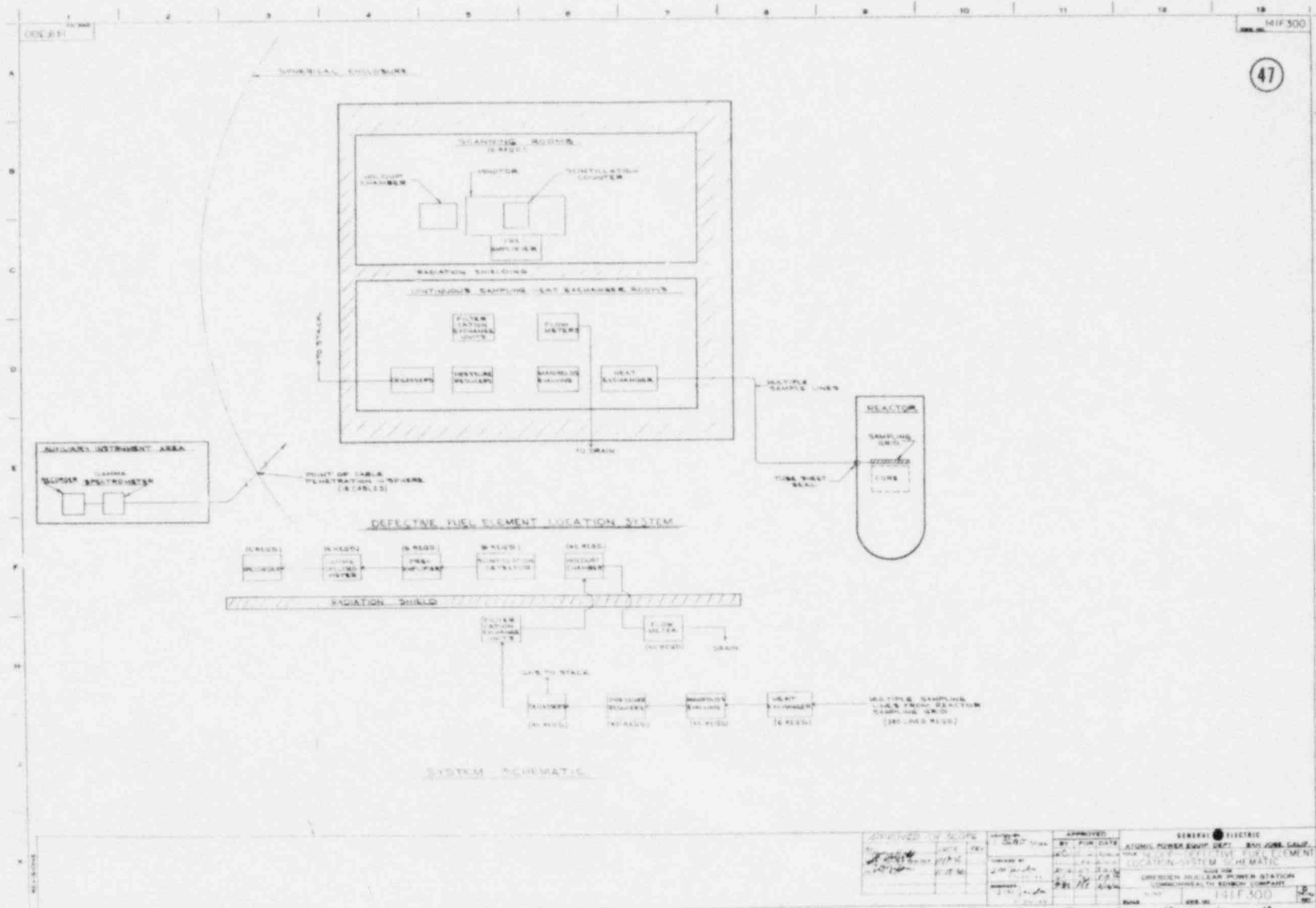

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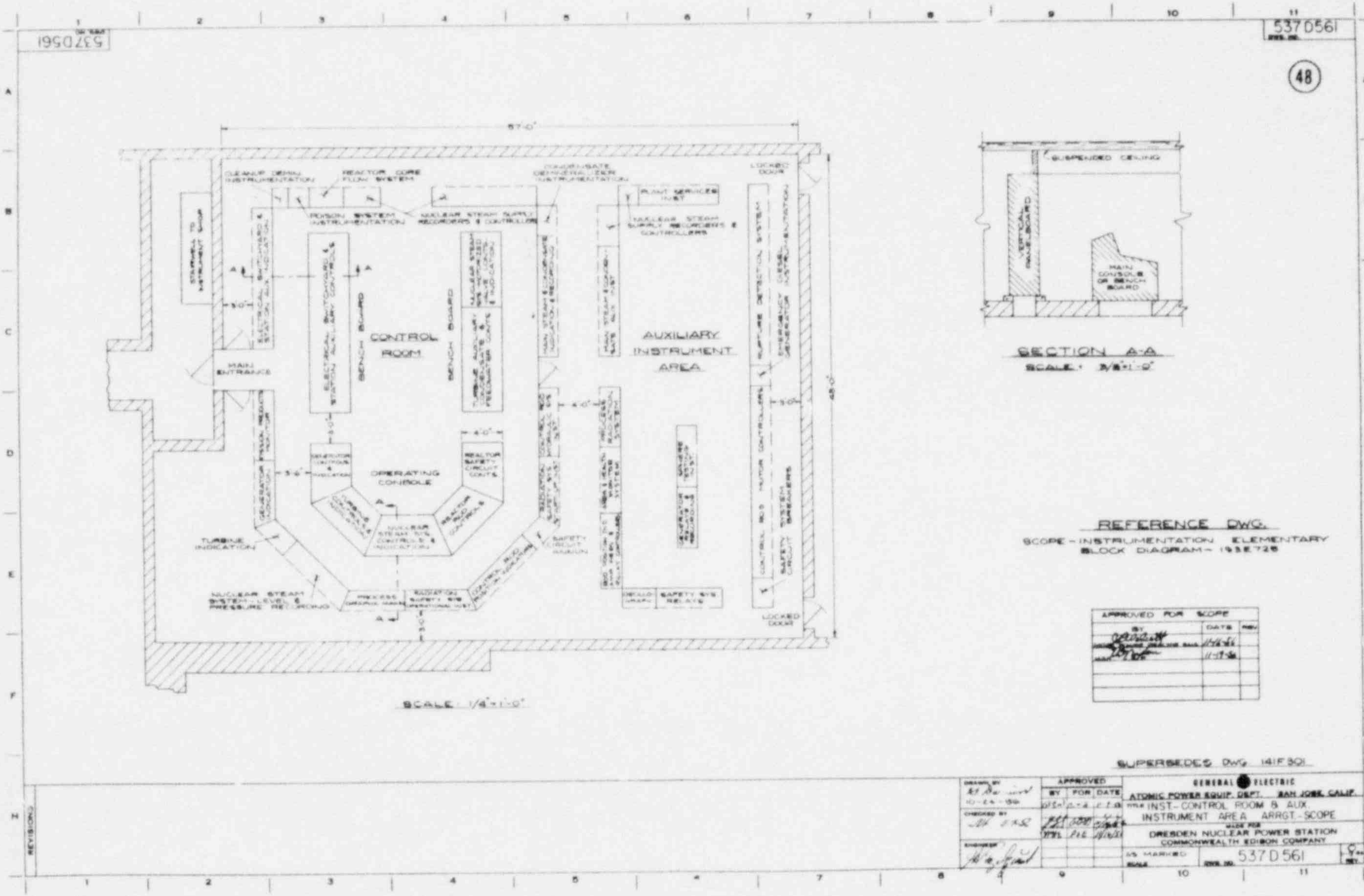

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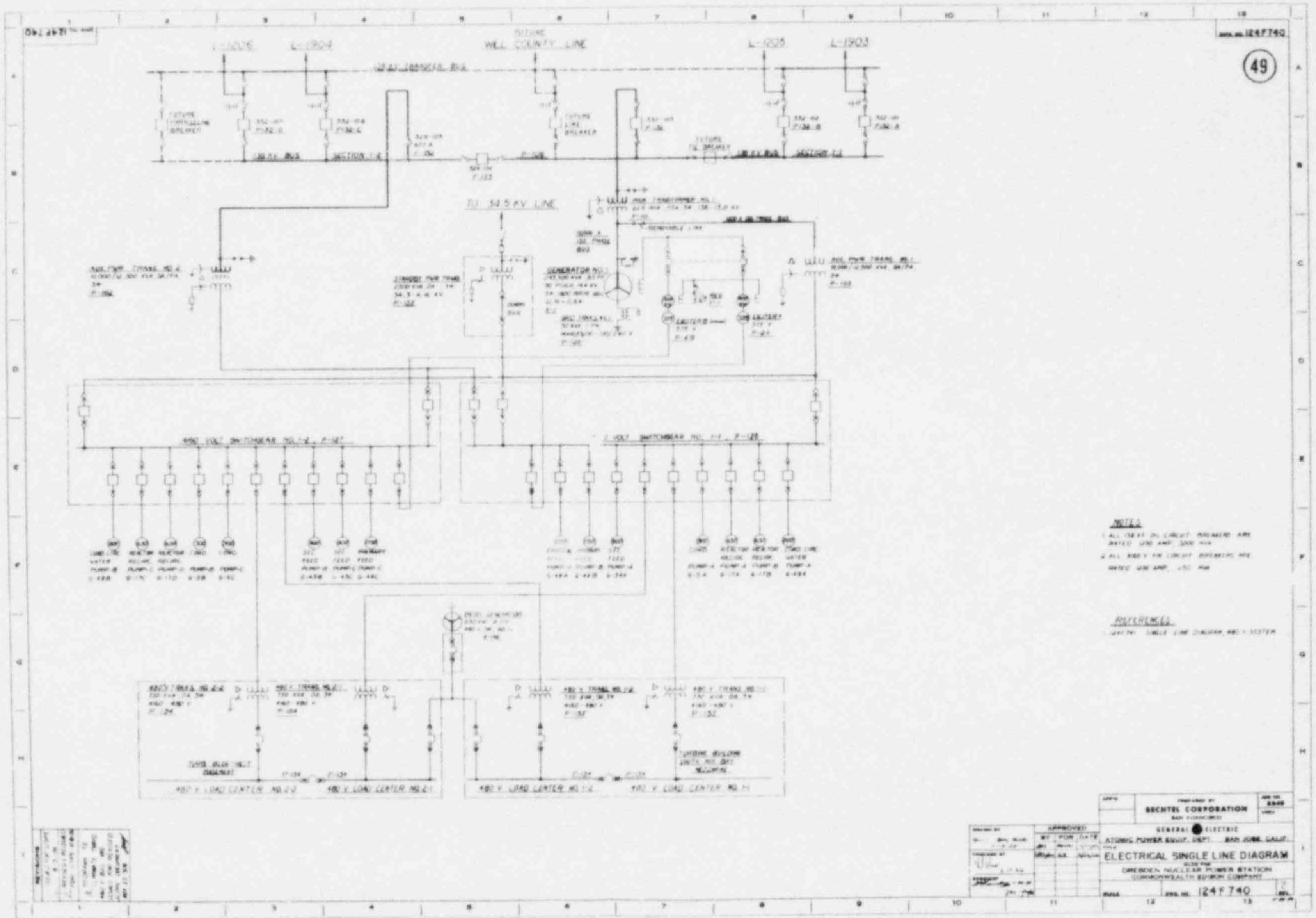

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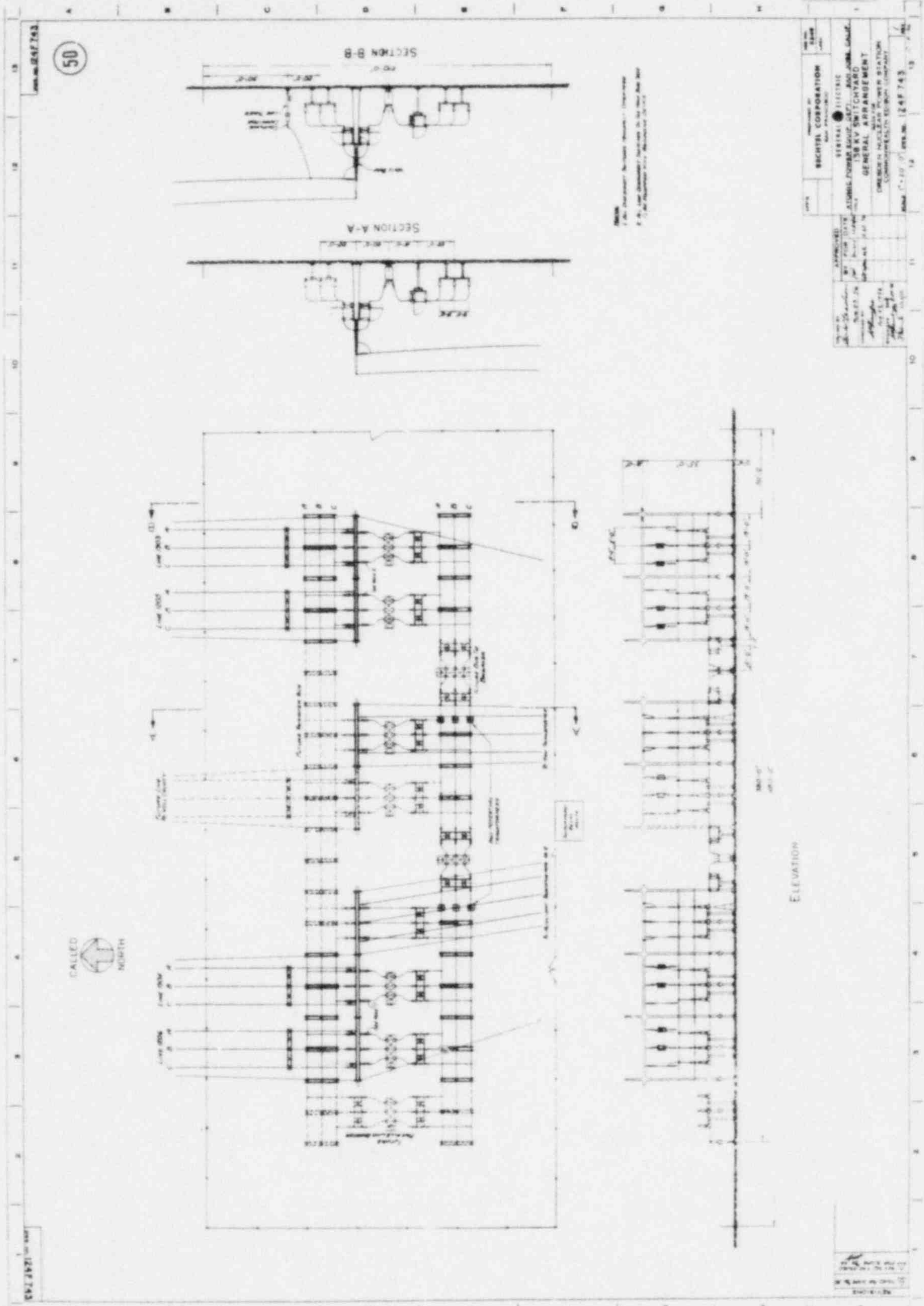

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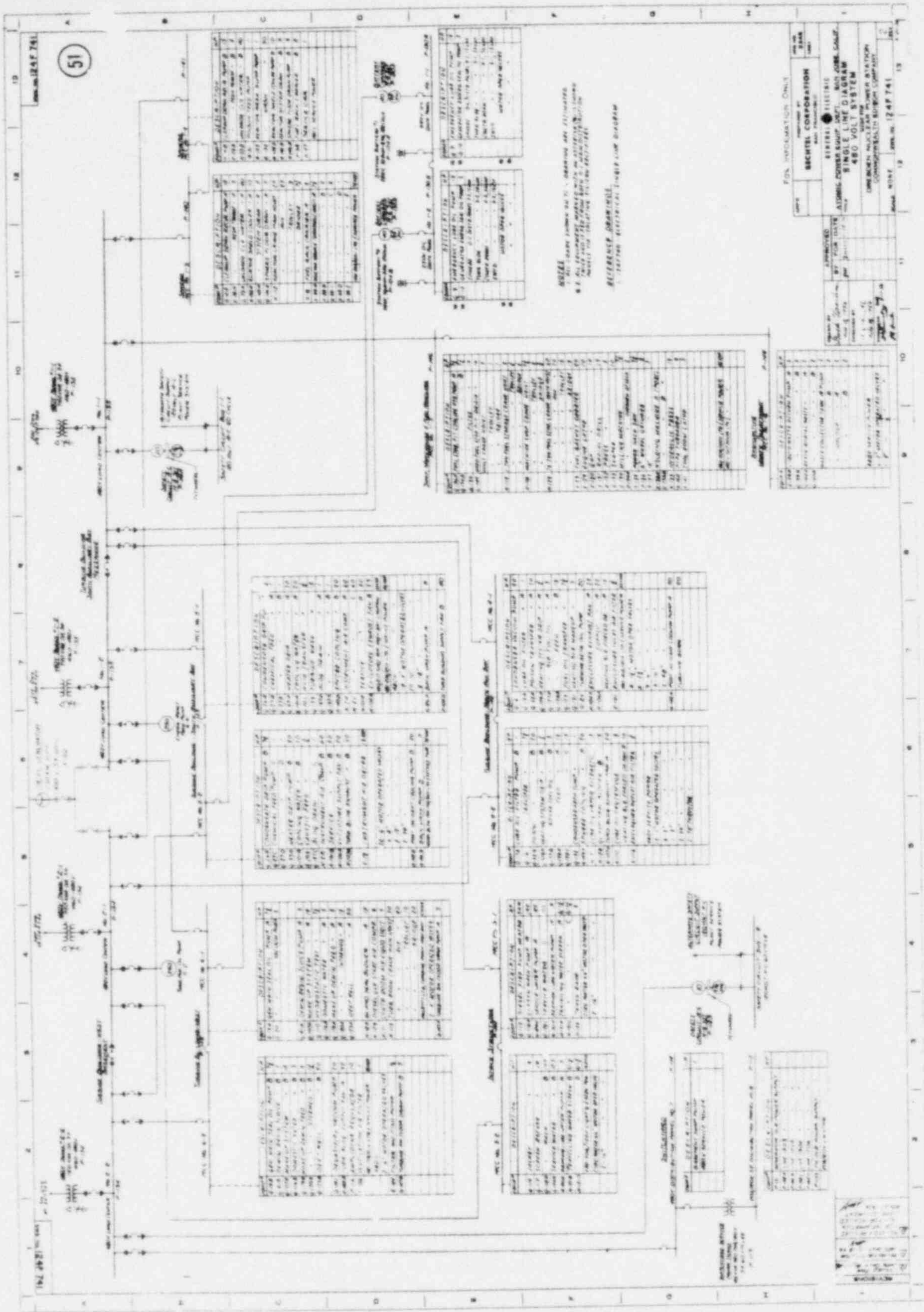

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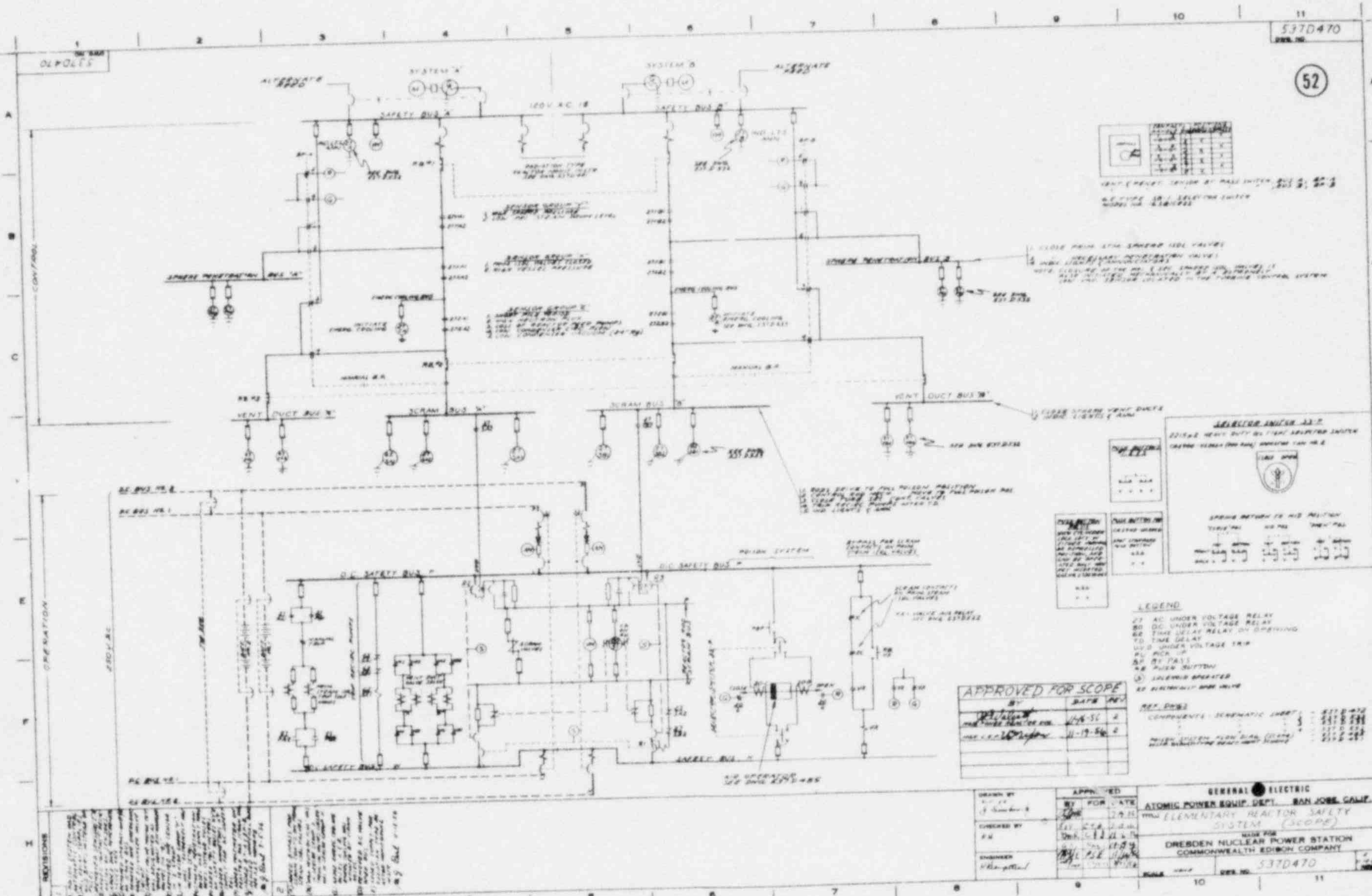
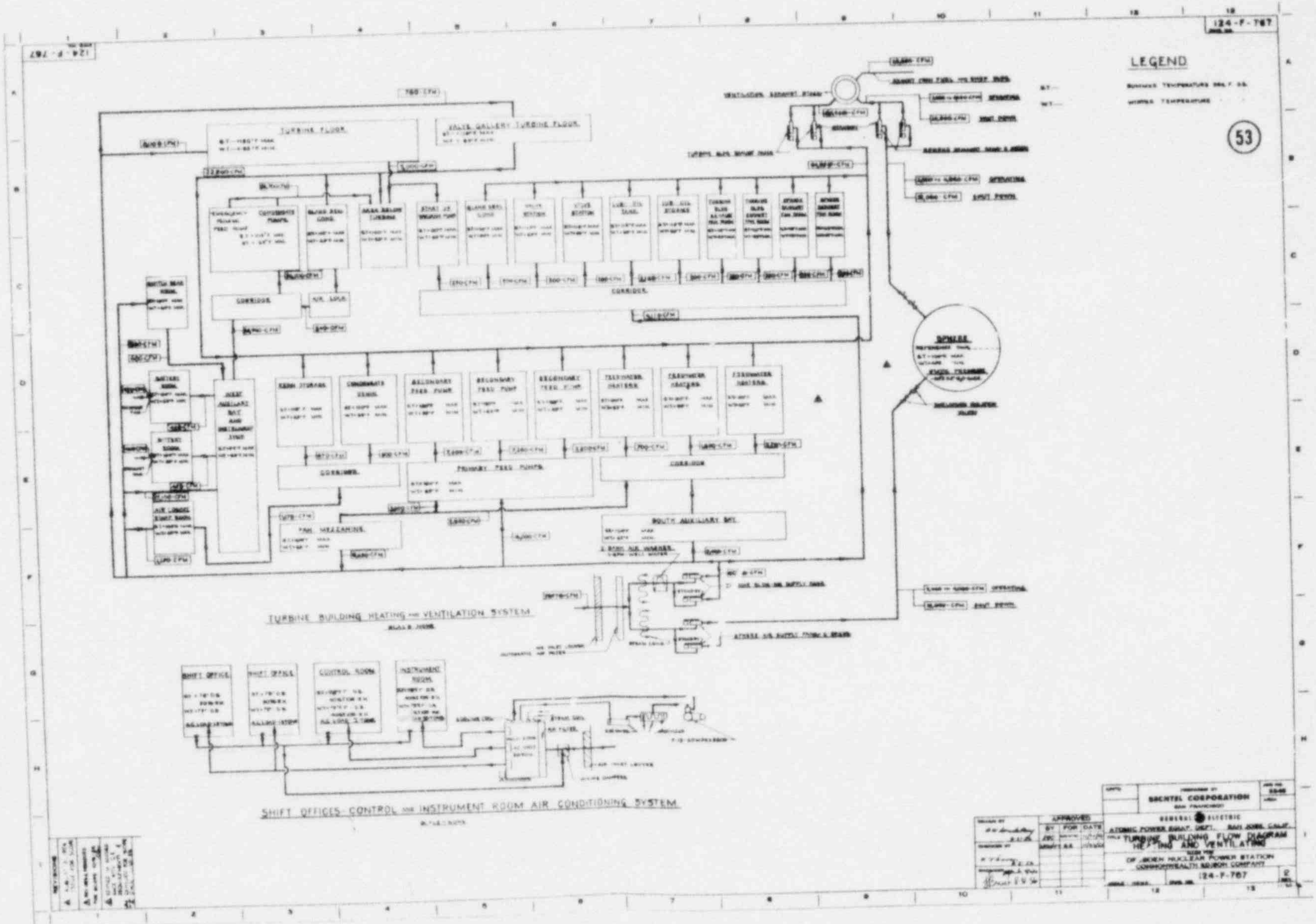

537D470
52
SYSTEM "A"
SYSTEM "B"
SAFETY BUS "A"
SAFETY BUS "B"
120V AC. 18
SCRAM BUS "A"
SCRAM BUS "B"
VENT DUCT BUS "A"
VENT DUCT BUS "B"
D.C. SAFETY BUS
POISON SYSTEM
CONTROL
OPERATION
250 V AC
LEGEND
SELECTOR SWITCH
APPROVED FOR SCOPE
BY
DATE
REV
GENERAL ELECTRIC
ATOMIC POWER EQUIP. DEPT. SAN JOSE, CALIF.
ELEMENTARY REACTOR SAFETY SYSTEM (SCOPE)
DRESDEN NUCLEAR POWER STATION
COMMONWEALTH EDISON COMPANY
DRAWN BY
CHECKED BY
ENGINEER
APPROVED
FOR
DATE
REVISIONS



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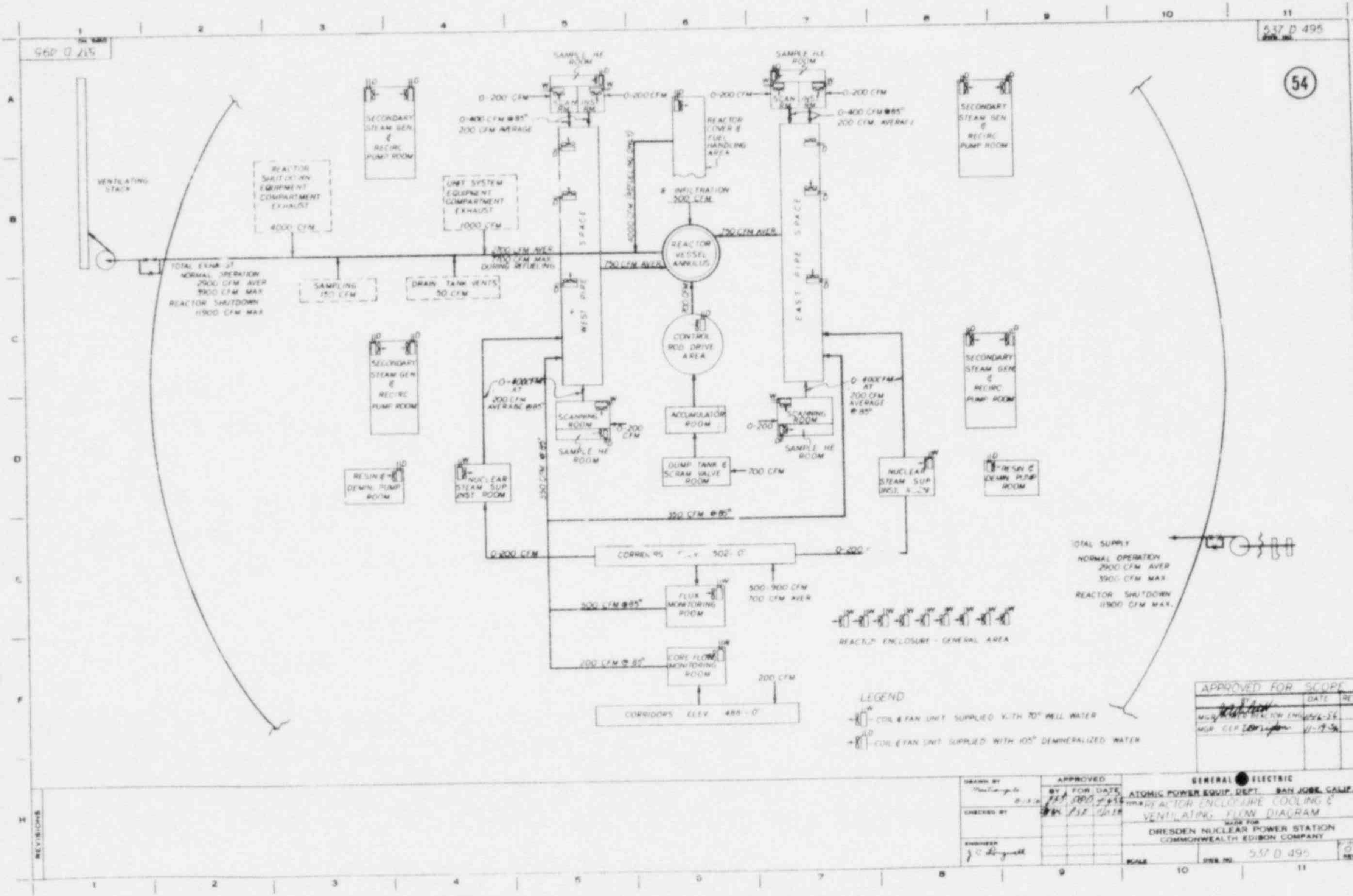

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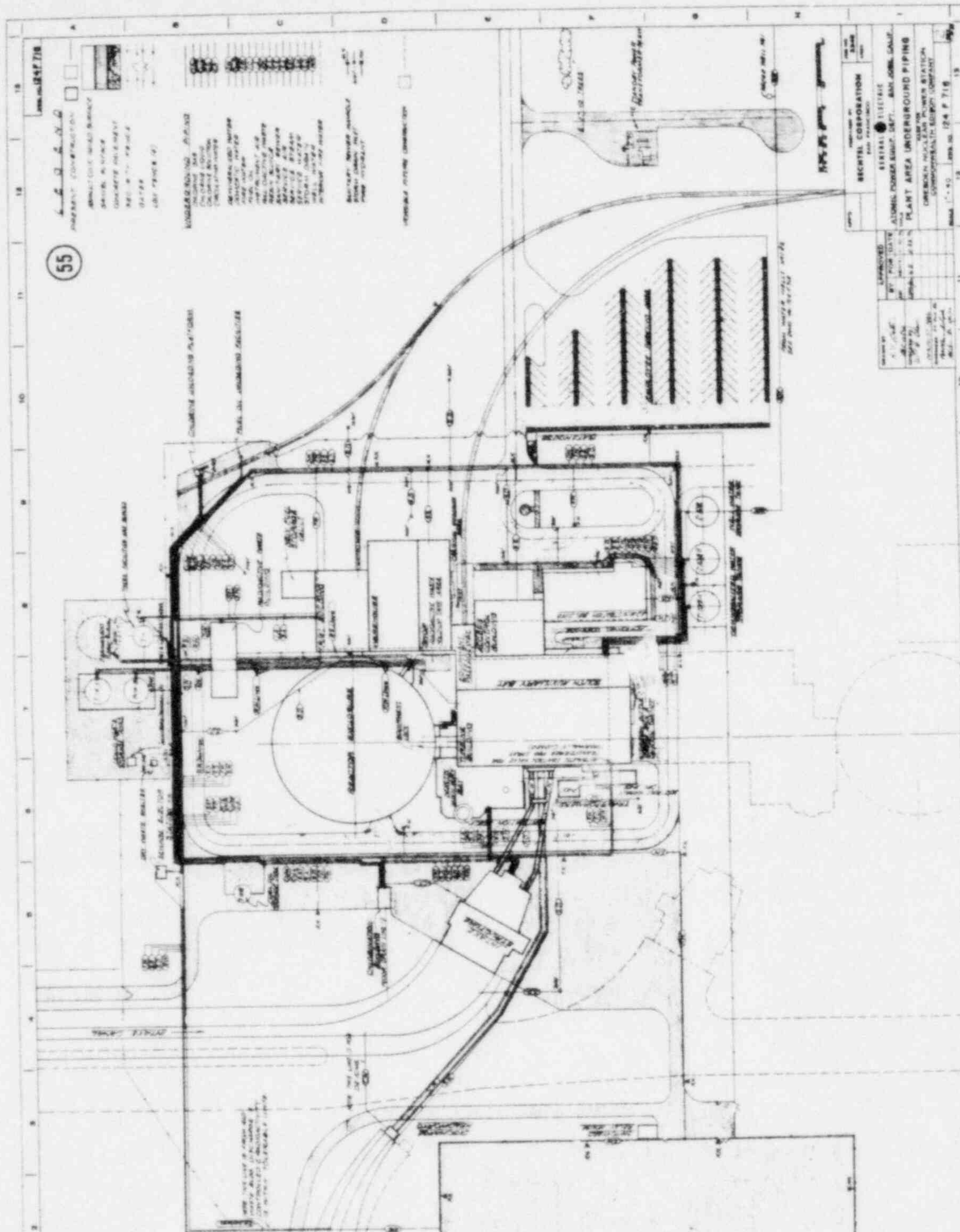

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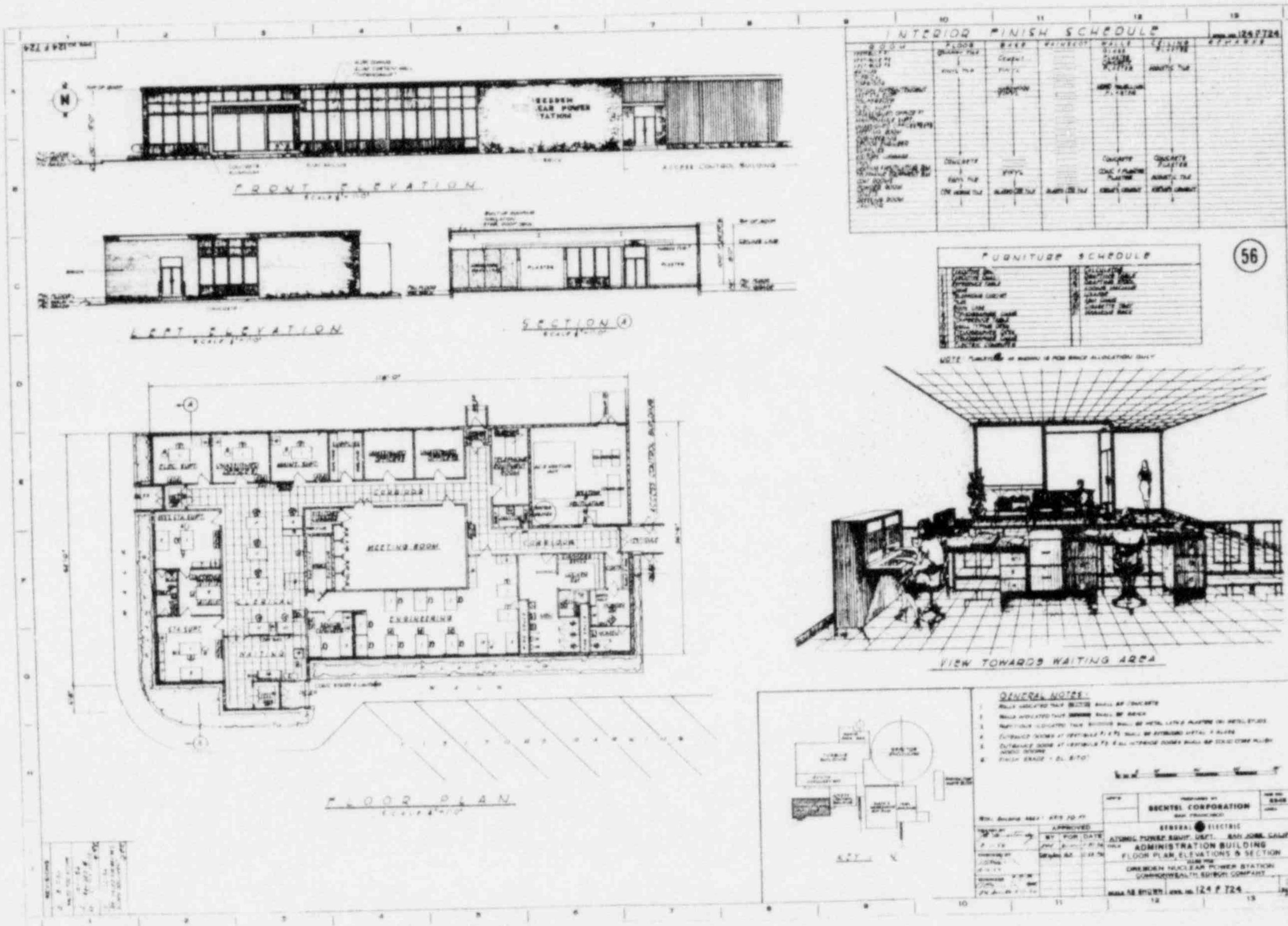
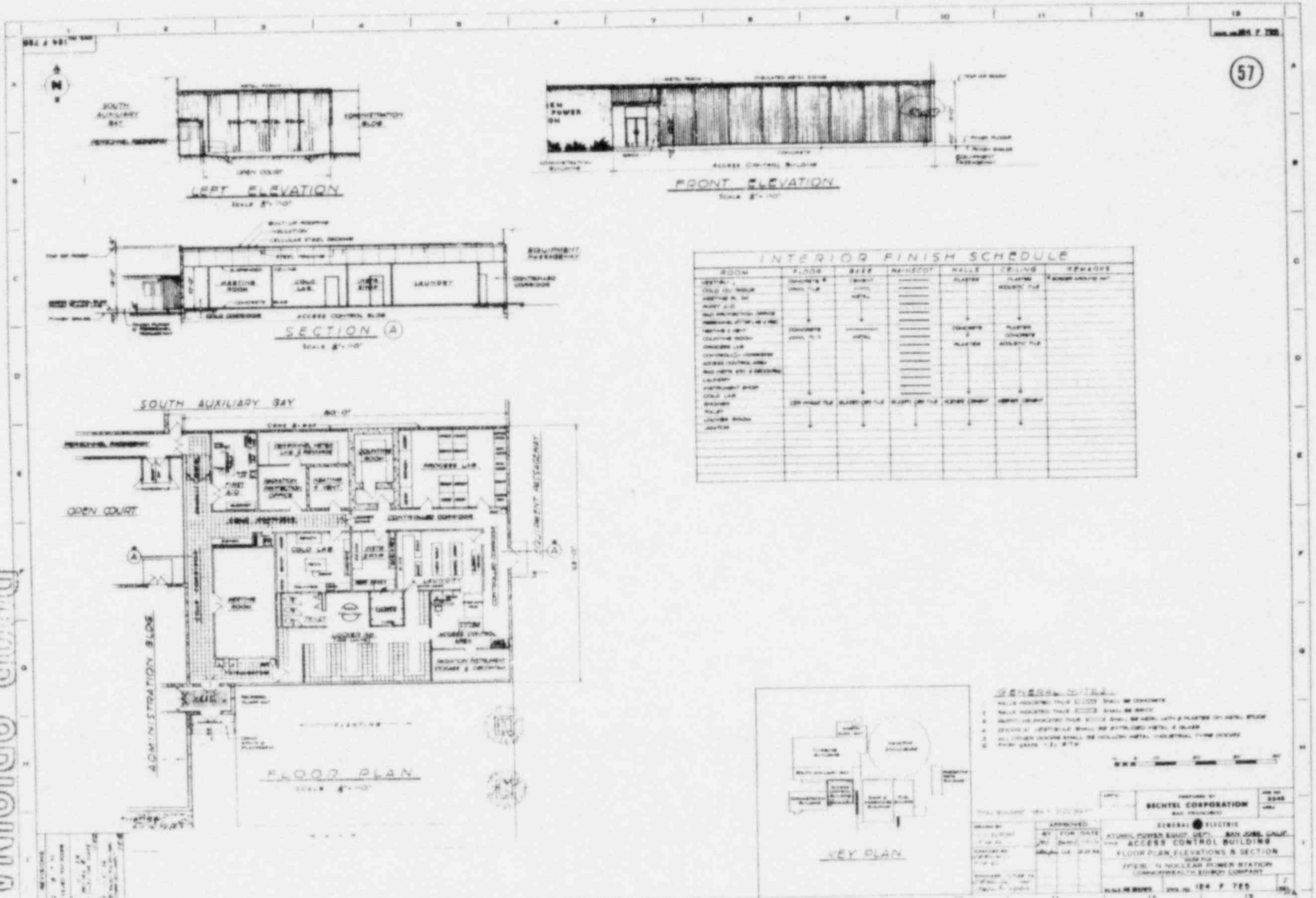
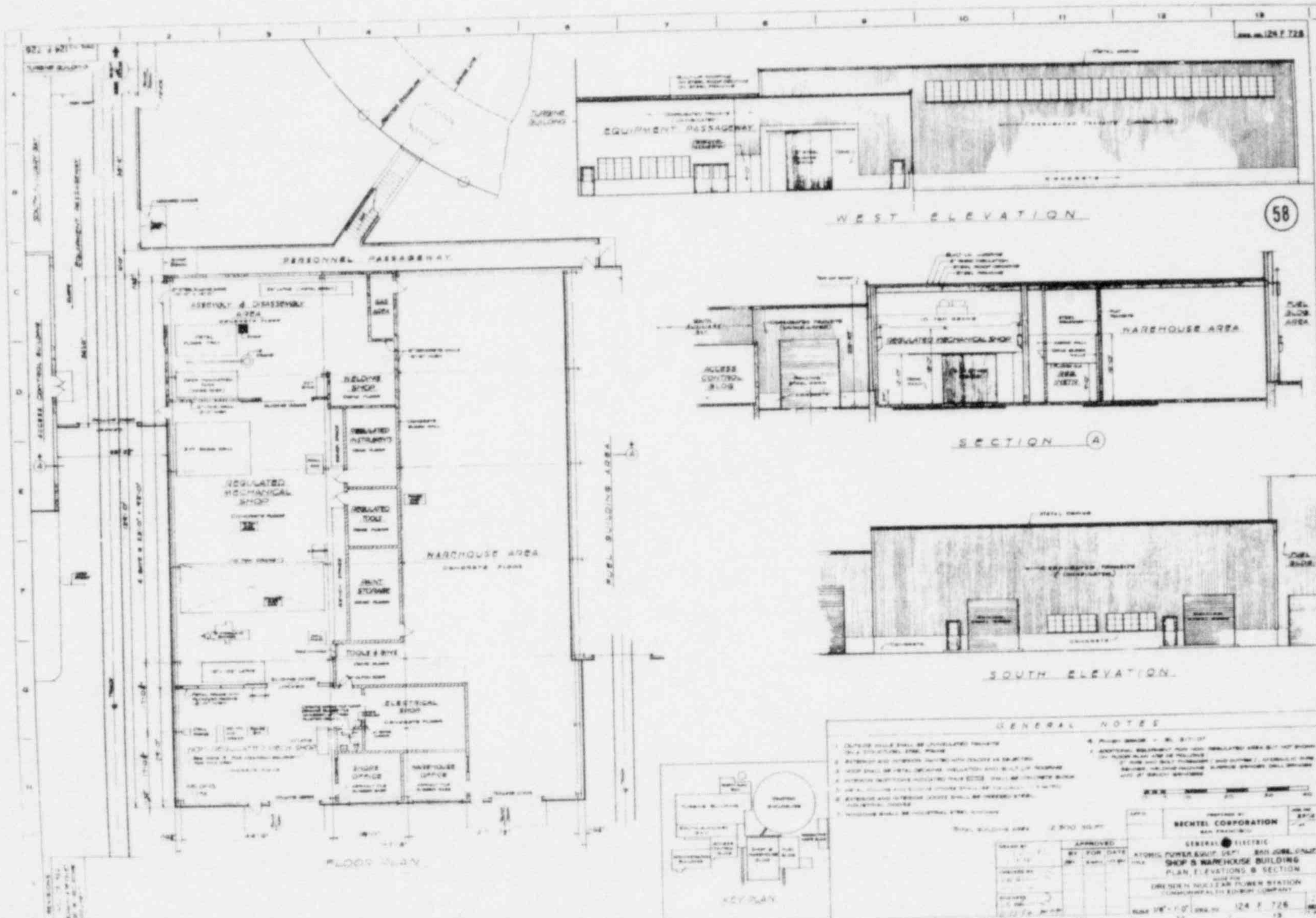

INTERIOR FINISH SCHEDULE
FURNITURE SCHEDULE
56
FRONT ELEVATION
LEFT ELEVATION
SECTION A
FLOOR PLAN
MEETING ROOM
ENGINEERING
WAITING
CORRIDOR
ACCESS CONTROL BUILDING
VIEW TOWARDS WAITING AREA
GENERAL NOTES:
BECHTEL CORPORATION
GENERAL ELECTRIC
ATOMIC POWER EQUIP. DEPT. SAN JOSE, CALIF.
ADMINISTRATION BUILDING
FLOOR PLAN, ELEVATIONS & SECTION
DRESDEN NUCLEAR POWER STATION
COMMONWEALTH EDISON COMPANY
124 F 724


57
LEFT ELEVATION
FRONT ELEVATION
ACCESS CONTROL BUILDING
SECTION A
SOUTH AUXILIARY BAY
OPEN COURT
ADMINISTRATION BLDG
FLOOR PLAN
INTERIOR FINISH SCHEDULE
ROOM
FLOOR
BASE
WAINSCOT
WALLS
CEILING
REMARKS
GENERAL NOTES
KEY PLAN
BECHTEL CORPORATION
SAN FRANCISCO
GENERAL ELECTRIC
ACCESS CONTROL BUILDING
FLOOR PLAN, ELEVATIONS & SECTION
124 F 725



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