This document was too large to scan as a single document. It has been divided into smaller sections.

Section 4 of 5

Document Information			
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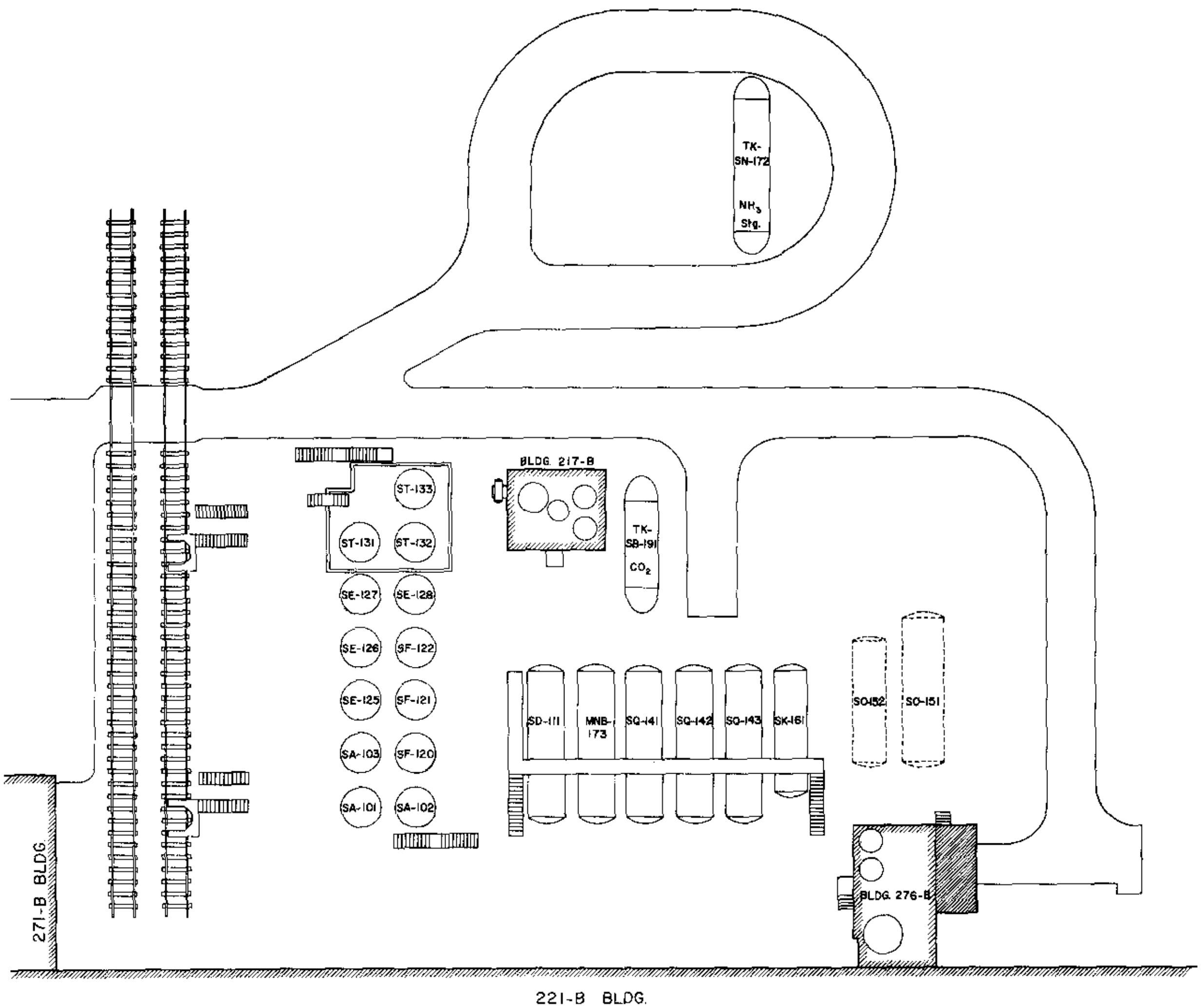

FIGURE IX-11

Chemical Tank Farm, 211-B

8. Utilities

8.1 Steam

The 200 East Area Power House, 284-E, supplies high pressure 225 psig (450 F) steam to B-Plant through an 8-inch overhead line which enters the B-Plant area at the SE corner. High pressure steam to the process stack area (219-B), 222-B Building, and the 224-B Building is supplied by branches from this line. The line continues around the west end of B-Plant and enters 221-B in the vicinity of Cell 37 on the electrical gallery level. The main steam cut-off valve is located in the electrical gallery at this point. Two PRV stations in the pipe gallery, one near Cell 29 and one near Cell 15, reduce the high pressure steam to medium pressure, 100 psig steam. Low pressure steam used in the building heating system and in process vessel heating coils and jackets is provided by further reducing the medium pressure steam with additional PRV's. Separate PRV's are used to reduce medium pressure steam to 29 psig for the concentrators in Cell 5 and Cell 23. Medium pressure steam for the 271-B Building and the 211-B Tank Farm is supplied through an 8-inch line which leaves the pipe gallery in the vicinity of Cell 20. A simplified schematic of the steam trunk lines is shown in Figure IX-12.

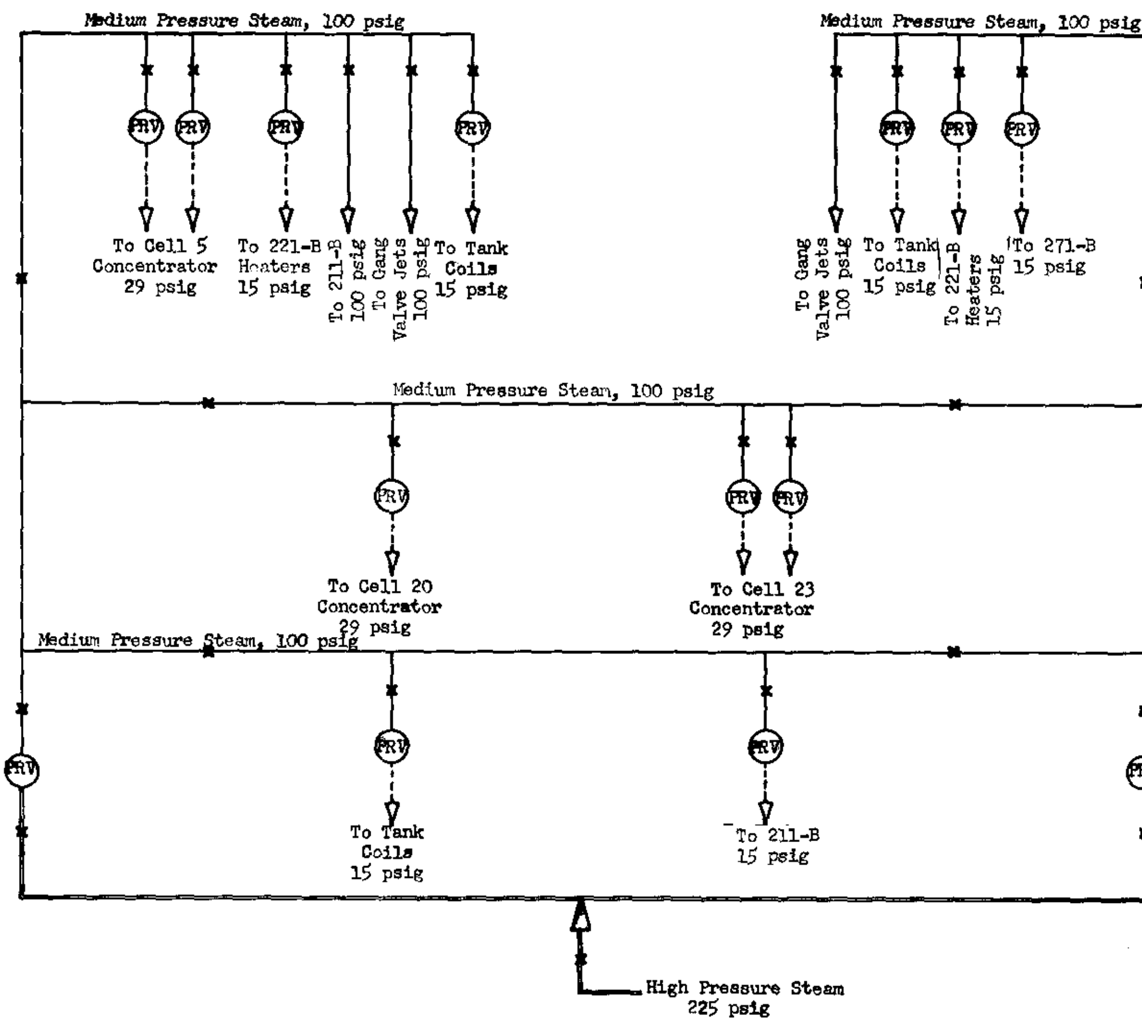

FIGURE IX-12

Schematic of Steam Trunk Lines in 221-B

8.2 Compressed Air Systems

8.2.1 Process Air

Compressed process air for the B-Plant area is supplied from the compressor room in the basement of the 271-B Building. Equipment consists of one Worthington 782 cfm, two-stage duplex compressor and two 335 cfm single-stage Pennsylvania compressors. The compressors are arranged to start automatically as certain prescribed drops occur in header pressure; thus the system will be maintained around 95 psig over a wide range of demand. The air for the compressors is filtered before being compressed. The compressed air is routed through an aftercooler and then into two large air receivers located outside of the 271-B Building.

8.2.2 Instrument Air

Instrument air for the B-Plant area is supplied by a 300 cfm, 100 psig compressor located in the electrical gallery in the 221-B Building. The compressor is equipped with polytetrafluorethylene rings for oil-free operation. Supply air is filtered before being compressed. Interconnections exist between the process and instrument air systems; however, these are used only in an emergency.

8.2.3 Breathing Air

Four Mine Safety Appliance (MSA) clean air blowers with water separators are installed in an enclosure on the south side of the 221-B Building. Two of these blowers, operated by 3 HP Continental Electric motors, deliver 38 cfm of breathing air. The remaining two blowers are each driven by a 5 HP Louis Allis motor and have a combined capacity of 120 cfm. The total flow delivered by the four blowers can supply breathing air to a total of 32 mask outlets. The compressors were manually operated at the time this was written but may be converted to an automatic system through the use of existing line pressure switches. Breathing air is supplied to air manifold stations located in the canyon, the railroad tunnel, the pipe gallery, the operating gallery, and to the 211-B Chemical Tank Farm.

8.3 Raw Water

Raw or untreated water which is used for cooling water and for cell sprays is supplied to B-Plant from the 200 East Reservoir (282-E) through a 12-inch line entering the building on the east end, and a 10-inch line entering the building on the west end. The two lines are joined together in the operating gallery to form a loop system. Emergency raw water is provided from two wells located near the west entrance to the B-Plant enclosure. The diesel-driven pumps with which the wells are equipped are capable of supplying 550 gpm of emergency cooling water. The emergency water supply is connected to the 10-inch raw water supply line with appropriate hand and check valves.

8.4 Sanitary Water

Sanitary (filtered) water is used in B-Plant for safety showers, drinking and toilet facilities, feed to the 217-B water demineralizer, and as emergency water in wall niches in the 221-B canyon. Lines to the wall niches in the canyon are equipped with backflow preventers as a protection against contaminating the sanitary water. Sanitary water is supplied to the B-Plant area from the 200 East Area filter plant (283-E) through an 8-inch line which enters the building near the north-west corner.

8.5 Process Water

Water used in B-Plant processes is prepared from the 200 East Area filtered water supply. As received, this water contains relatively large quantities of dissolved ionic impurities. Before being used in the process, the ionic impurities must be reduced. Purification is achieved by means of a two-state ion exchange water demineralization unit. The unit has a capacity of 50 gpm and is regenerated every 8 to 10 days or 240,000 gallons. Regeneration of the units takes about two hours. Impurities present in filtered and process water are shown in Table IX-6. A more complete description of the demineralizer may be found in Chapter VI.

The location and layout of water mains which supply the B-Plant area are shown in Figure IX-6.

8.6 Electrical Power Distribution

Electrical power is furnished to B-Plant facilities by two normal power incoming lines, E8-L53 and E8-L58, and one emergency line, E8-L66. These lines feed 2300 volt switchgear equipment in the 221-B Building electrical gallery. From the 2300 volt switchgears, power is fed to 2300 V/440 V transformers and to 2300 V/110-220 V transformers for power and lighting, respectively. These transformers are located on the north and adjacent to the 221-B Building. The 440 V power from the transformers is distributed to cubicles in the electrical gallery where switchgear equipment and distribution circuits for individual pieces of equipment are located. The lower voltage transformers feed lighting circuits and various small loads. If either one of the normal power incoming lines fail, its load can be switched at the 440 volt level to the other normal line.

A limited amount of emergency power is available to B-Plant in the event both normal electric power supplies fail. At the time this chapter was written only the regulated voltage circuit for instruments and the canyon door latch circuit switched automatically to the emergency line E8-L66 when normal power failed. An emergency air compressor, a limited number of ventilation air supply fans, and some emergency lighting circuits will be added to the emergency power supply as power is made available. Emergency power for the 200 East Area is provided by a steam turbine-generator set located in the 284-E power house. Some battery-powered emergency lights, sparsely placed throughout the building, come on automatically in the event of a power failure.

TABLE IX-6
IMPURITIES IN FILTERED AND PROCESS WATER

Constituent	Filtered Water	Process Water Specifications
Total Hardness (as $CaCO_3$)	55-80 ppm	2 ppm
Calcium	20-40	0.2
Magnesium	4-5.5	0.01
Strontium	0.13*	0.01
Sodium	--	0.1
Chloride (as NaCl)	1-5	0.6
Sulfates (as Na_2SO_4)	14-30	1.5
Dissolved Solids	85-110**	4.5***
Silica (as SiO_2)	3-7.5	7.5
pH	7.6-8.1	5-8

* Raw Water Concentration
** Includes Silicates
*** Excluding Silicates

C. WASTE STORAGE TANK FARMS

The complex of waste storage tanks at Hanford include 149 tanks ranging in capacity from 50,000 to 1,000,000 gallons. These tanks are grouped in twelve tank farms located in the 200 East and 200 West Areas up to ten miles apart. Some general information about these tanks is tabulated in Table IX-7.

TABLE IX-7
WASTE STORAGE TANKS AT HANFORD

Farm	Tanks per Farm	Capacity per Tank, Gallons	Capacity per Farm, Gallons	Year Constructed	Type
A	6	1,000,000	6,000,000	1954-55	Boiling
AX	4	1,000,000	4,000,000	1963-64	Boiling
B	16	54,500 (4) 530,000 (12)	6,578,000	1943-44	Non-Boiling
BX	12	530,000	6,360,000	1946-47	Non-Boiling
BY	12	758,000	9,096,000	1948-49	Non-Boiling
C	16	54,500 (4) 530,000 (12)	6,578,000	1943-44	Non-Boiling
S	12	758,000	0,096,000	1950-51	Non-Boiling
SX	15	1,000,000	15,000,000	1953-54	Boiling
T	16	54,500 (4) 530,000 (12)	6,578,000	1943-44	Non-Boiling
TX	18	758,000	13,644,000	1947-48	Non-Boiling
TY	6	758,000	4,548,000	1951-52	Non-Boiling
U	16	54,500 (4) 530,000 (12)	6,578,000	1943-44	Non-Boiling

1. Non-Boiling Tank Farms

1.1 General Description of Non-Boiling Tank Farms

The tanks in the nine non-boiling tank farms are of three sizes, 54,500 gallons; 530,000 gallons; and 758,000 gallons as indicated in Table IX-7. The 530,000-gallon and the 758,000-gallon tanks are arranged in three, four, or six tank cascades. That is, the tanks are arranged in such a manner that when the first tank in a cascade is filled it overflows to the second tank and so on. Through the years as various programs have been instigated, many of the overflows between tanks in the various cascades have been removed, modified, or blanked off. In 1952 as part of the Uranium Recovery Program, sluice pits, diversion boxes, and transfer lines were installed in the tank farms. Section D of this chapter will discuss the transfer facilities in greater detail.

1.2 Layout of the Non-Boiling Tank Farms

Plot plans of the non-boiling tank farms are shown in Figures IX-13 through IX-19.

1.3 Construction of Non-Boiling Waste Tanks

The non-boiling waste tanks are constructed of reinforced concrete with a mild steel liner on the bottom and side walls. The tanks are placed with the top of the dome about seven feet below the surface of the ground. The earth serves both as shielding and as a sink for dissipation of the heat from radioactive decay. A number of the tanks are equipped with air-cooled reflux condensers. Dry wells located within the tank farms are used to monitor the soil for radioactivity thus serving as a leak detection system.

1.3.1 530,000-Gallon Waste Tank

The 530,000-gallon waste tanks, located in the B, BX, C, T, and U tank farms, are the oldest or first generation waste storage tanks. The tanks are of the type shown in Figure IX-20. They are 75 feet in diameter and store liquid to a depth of 16 feet.

1.3.2 758,000-Gallon Waste Tanks

The 758,000-gallon waste storage tanks, located in the BY, TX, TY and S tank farms, are second generation waste storage tanks. The tanks are similar to the 530,000-gallon tanks in that they are 75 feet in diameter; however, they are designed to hold wastes to a level of 22 feet.

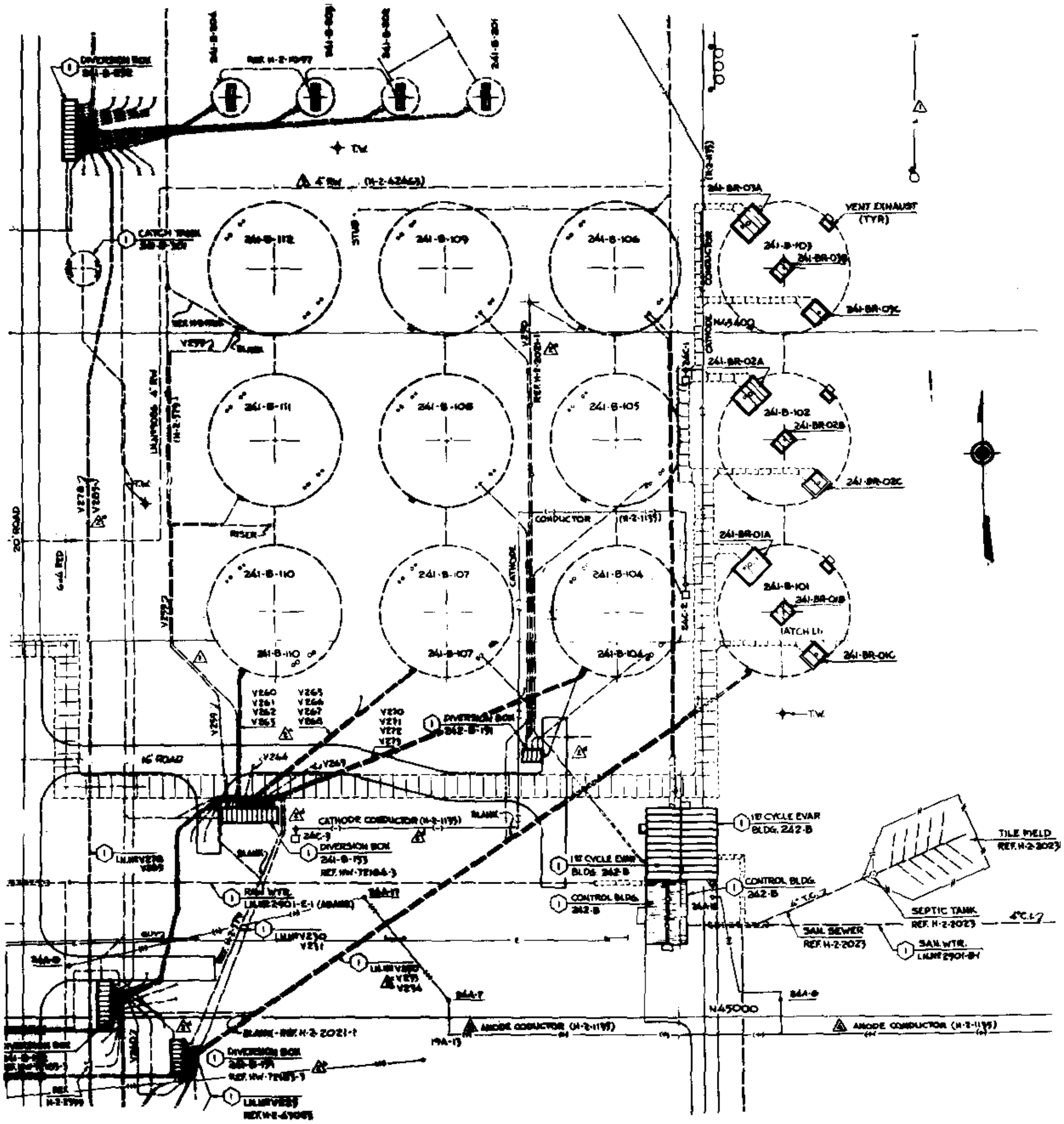

FIGURE IX-13

Layout of B Tank Farm
(Based on H-2-44501)

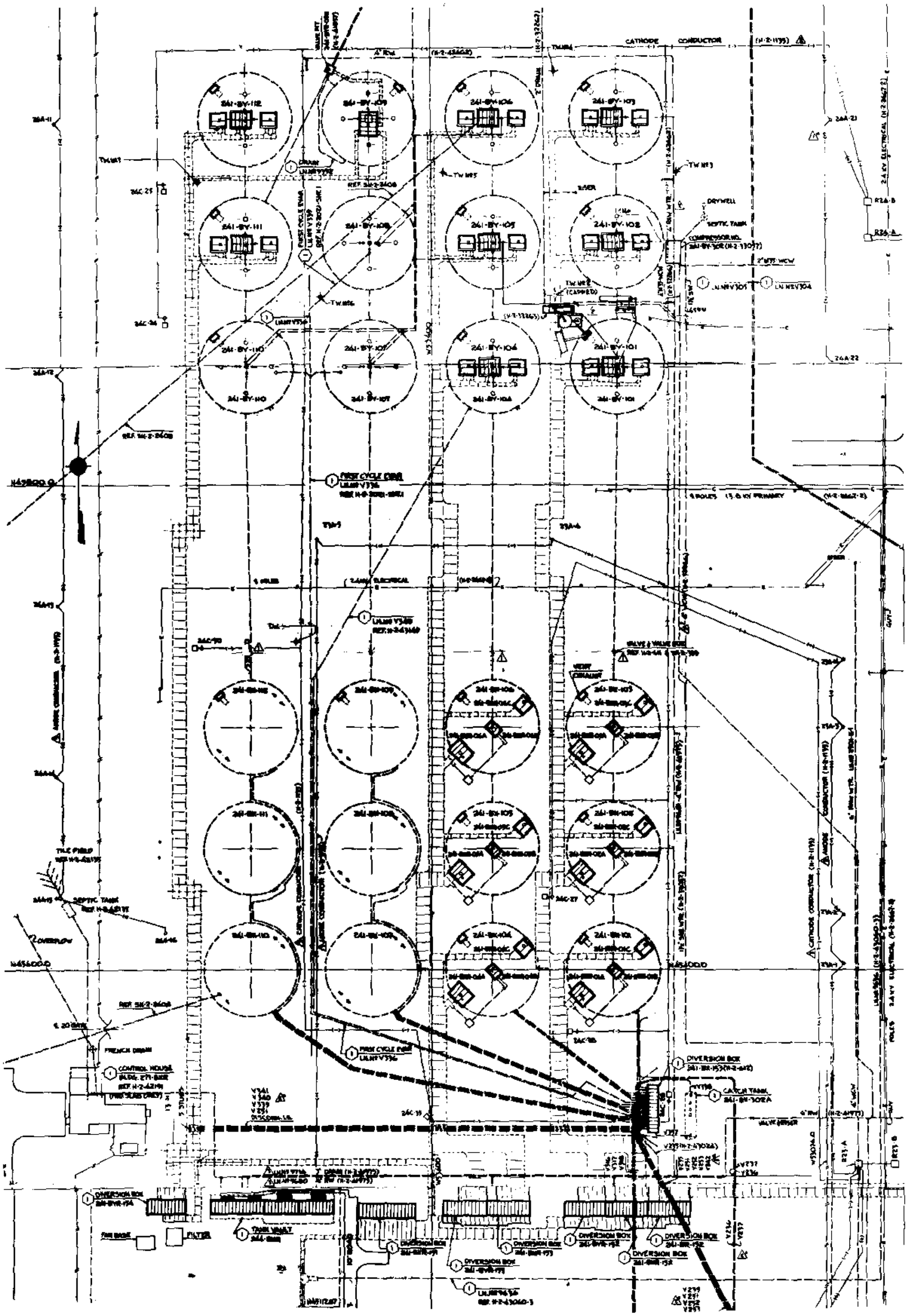

FIGURE IX-14

Layout of BX and BY Tank Farms
(Based on H-2-44501)

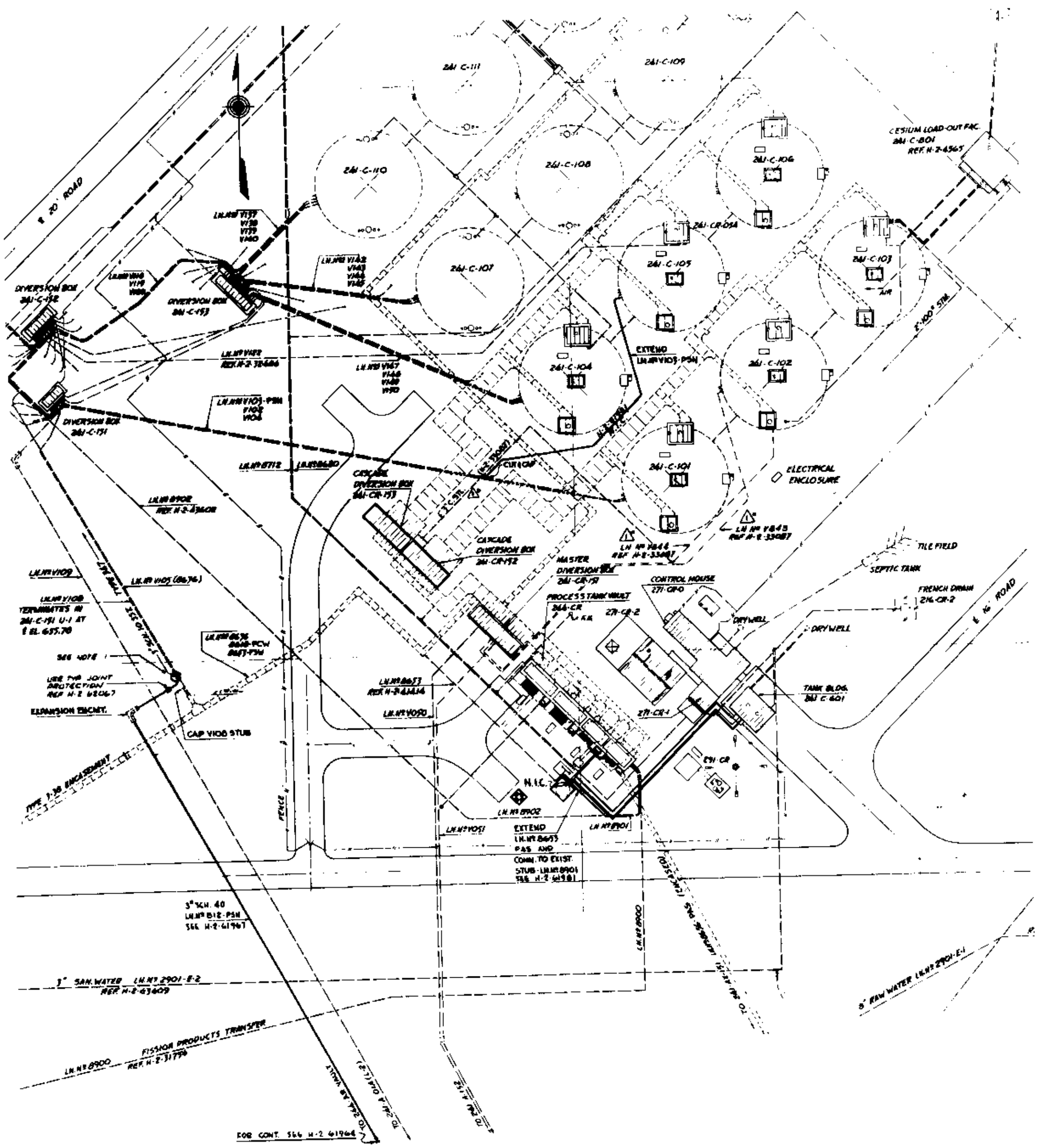

FIGURE IX-15

Layout of C Tank Farm
(Based on H-2-61962)

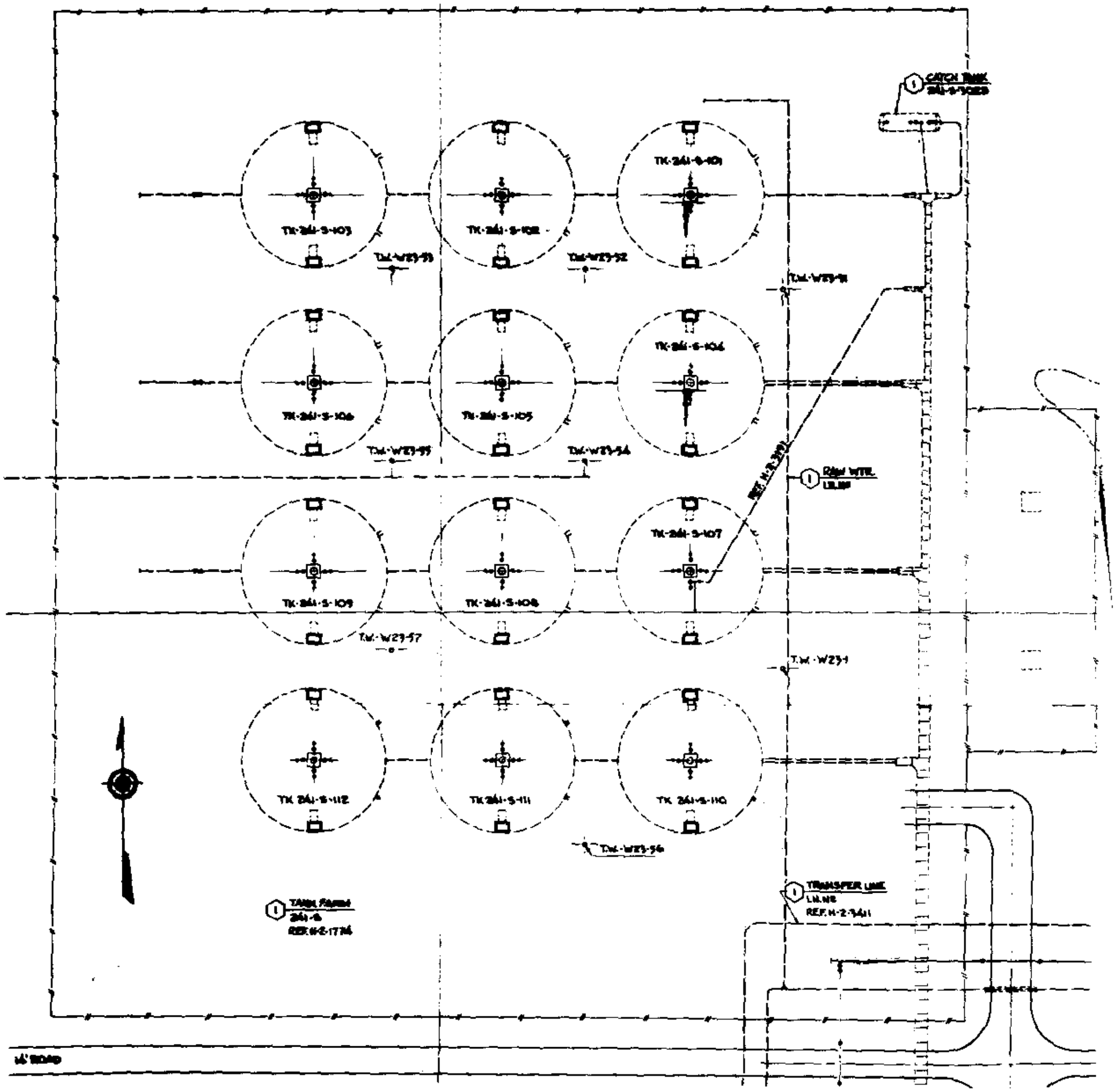

FIGURE IX-16

Layout of S Tank Farm
(Based on H-2-44511)

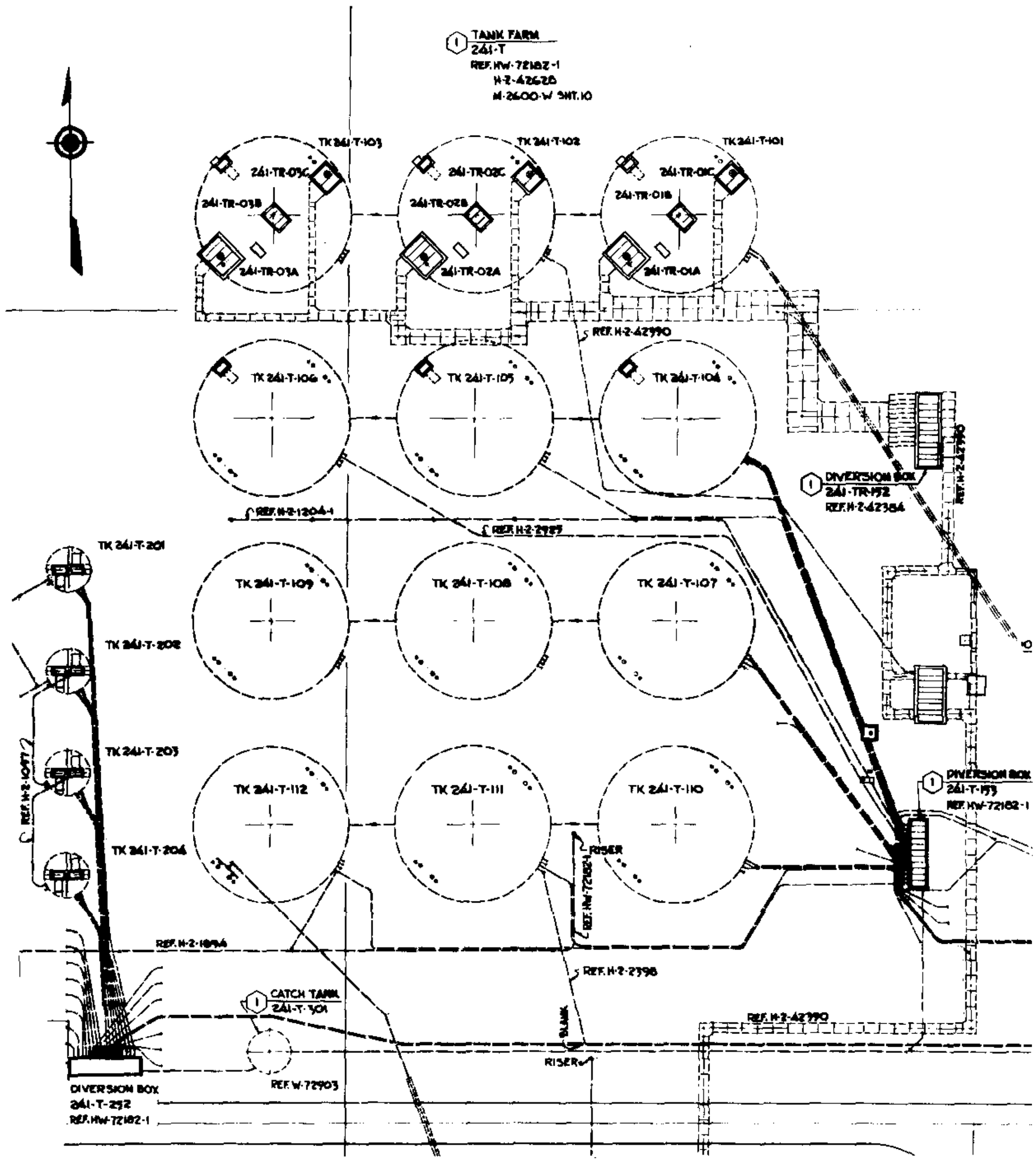

FIGURE IX-17

Layout of T Tank Farm
(Based on H-2-44511)

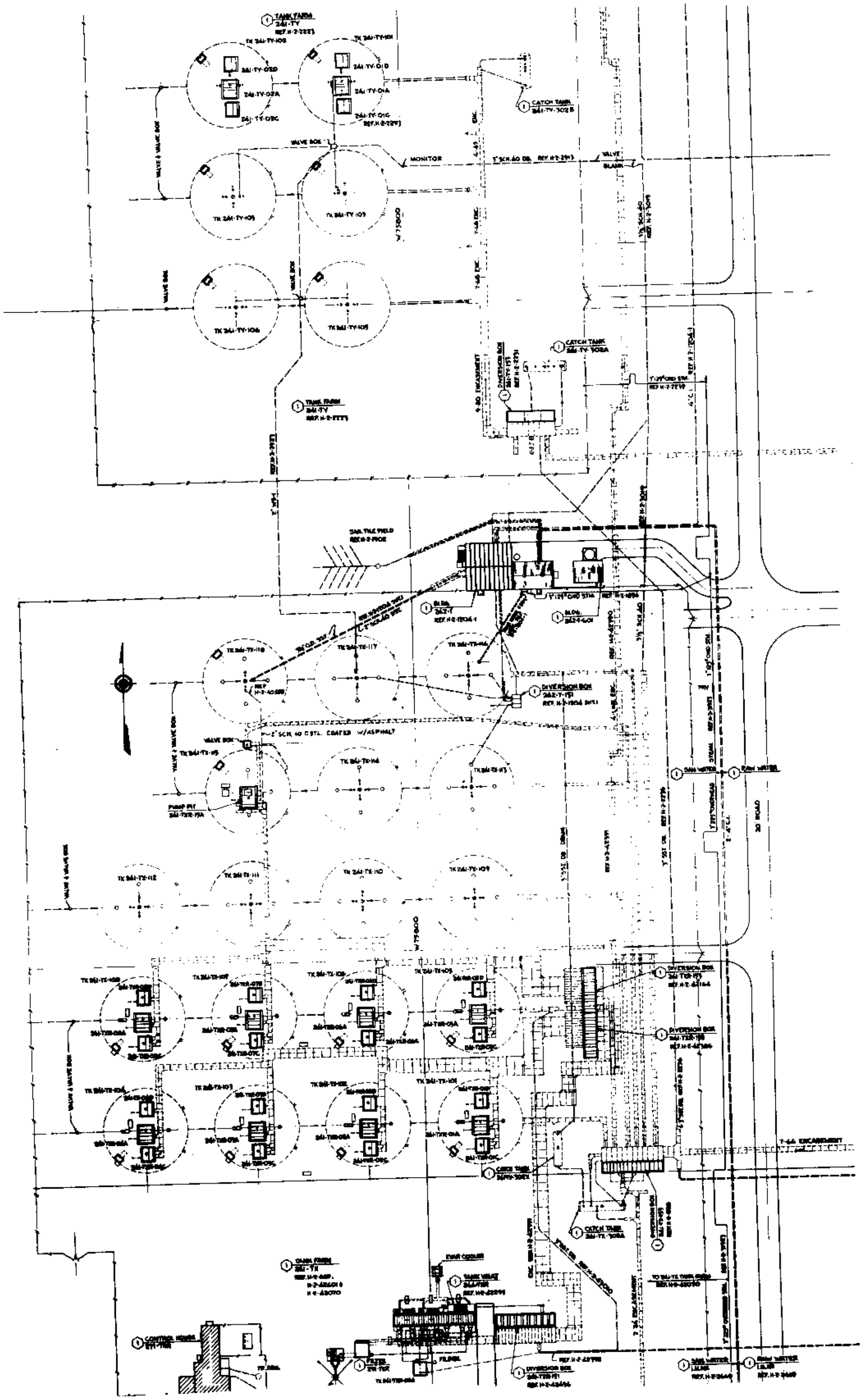

FIGURE IX-18

Layout of TX and TY Tank Farms
(Based on H-2-44511)

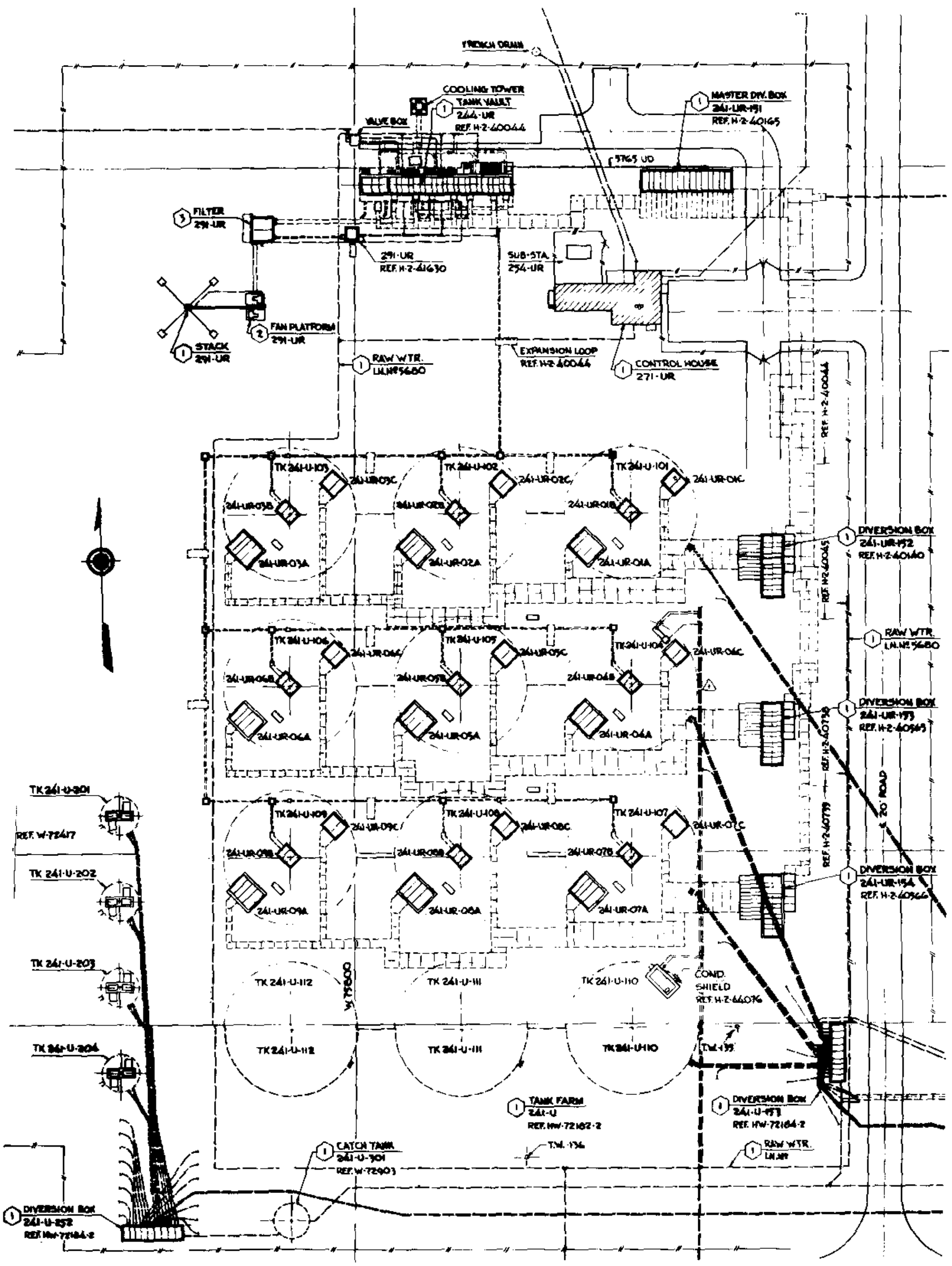

FIGURE IX-19

Layout of U Tank Farm
(Based on H-2-44511)

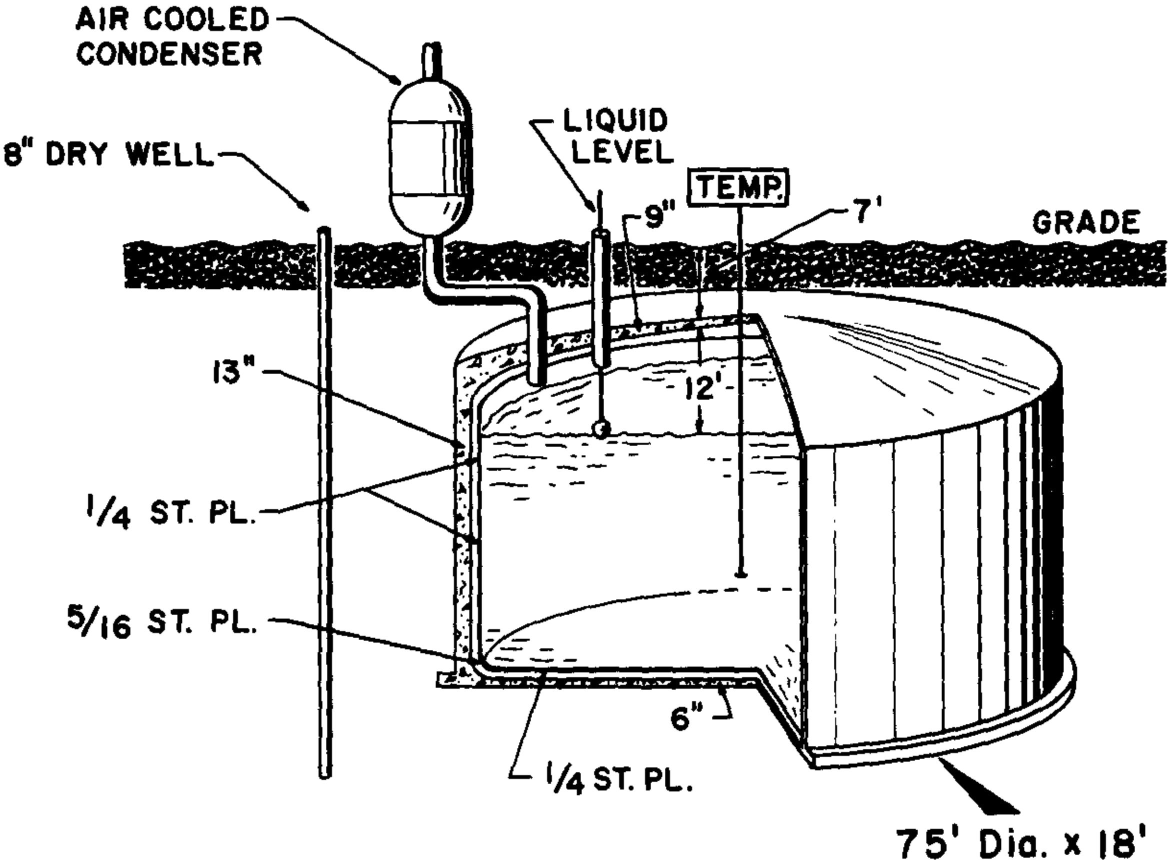

FIGURE IX-20

Storage Tank for Non-Boiling Waste

1.3.3 54,500-Gallon Waste Tanks

Four smaller tanks are located in each of the B, C, T, and U tank farms. These tanks are 20 feet in diameter and are filled to a depth of 24 feet. The tanks were originally designed to hold a highly radioactive cake from a scavenging-precipitation process on Bismuth Phosphate wastes. However, the tanks were never used for this purpose. Instead, general high-level non-boiling waste solutions are stored in them.

2. Boiling Tank Farms

2.1 General Description of the Boiling Tank Farms

There are three boiling waste tank farms - A, AX, and SX, containing 6, 4, and 15 waste storage tanks, respectively. The SX tank farm was the first tank farm designed specifically to handle boiling waste solutions. The A tank farm was built to handle Purex plant wastes and incorporated a number of new features developed during the operation of the SX tank farm. The AX tank farm, the latest one built, also handles Purex wastes and includes improvements not found in the A farm. These additional features are discussed in the following sections. As with non-boiling tanks, the waste tanks are constructed of reinforced concrete with carbon steel liners on the bottom and side walls. The tanks have a diameter of 75 feet and a height of 44 feet 4 inches from the top of the dome to the bottom of the tank. The working height of the tank, that is the height to which solutions can be stored, is 32.5 feet. The nominal capacity of the tank is one million gallons. The boiling waste tanks are designed to permit self-concentration of the wastes. The vapors are routed through headers to condensers which are vented to the atmosphere through filters. Condensate is either discarded to ground or returned to the waste tank. The contents of the waste tanks are agitated by means of air-lift circulators. Leak detection in the boiling waste tank farms is provided by a system of dry wells or drainage grids. A sketch of a boiling waste tank is shown in Figure IX-21.

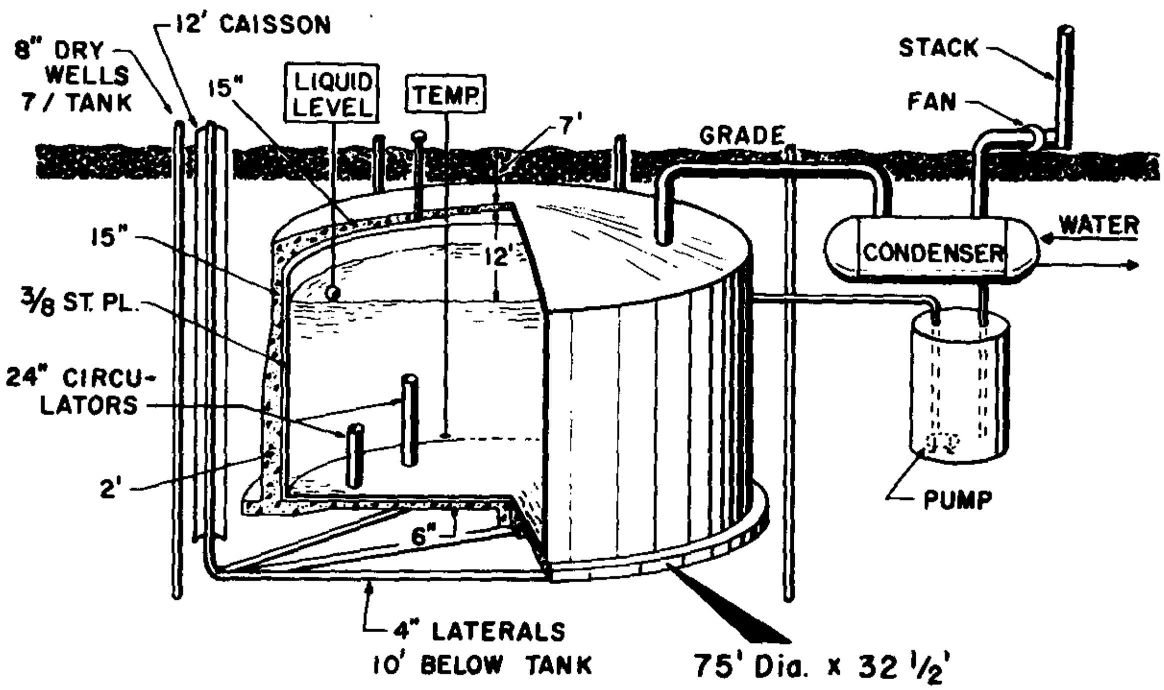

FIGURE IX-21

Storage Tank for Boiling Waste

2.2 241-A and AX Tank Farms

Because of their close proximity to one another, the A and AX tank farms have many common facilities such as the air supply, vent headers and condensers, normal and emergency electrical supply, and a number of miscellaneous services and buildings. The layout of the A and AX tank farms is shown in Figure IX-22. Common facilities include the following:

Process Air - used for the air-lift circulators is supplied by three 50-horsepower, vertical, single cylinder, piston-type units built by the Joy Manufacturing Company. Each compressor has a nominal capacity of 360 cfm with a discharge pressure of 40 psig. The compressors are located in the compressor building, 241-A-701.

Instrument Air - is supplied by two 25 cfm, 35 psig compressors.

Electrical Power - for the A and AX tank farms is supplied from a 300 KVA 2400/480 volt three-phase transformer. Emergency power for the air compressors and other auxiliary equipment is supplied by a 125 KVA diesel-driven generator located in the compressor building. A 35 KVA gasoline-driven generator supplies emergency power to the control building and the emergency cooling water system. Both emergency electrical systems start and switch automatically in the event of a primary power failure.

Vent Header and Condensers - All of the tanks in the A and AX tank farms are connected to a common vent header, sometimes referred to as the vacuum header. Water seals are used to isolate non-boiling tanks from the vent system. Air and water vapor from the waste tanks are routed through the vent system to three surface and two contact condensers located in the condenser building - 241-A-401. Individual condensers can be isolated from the vent system by means of water seals.

The water seals to the contact condensers will automatically blow and activate these condensers when the differential pressure exceeds 30 and 34 inches of water. Other water seals will blow by-passing the condensers should the differential pressure exceed 66 inches of water. Non-condensible gases pass from the condensers, through a deentrainment vessel and are exhausted through filters to the atmosphere. Three exhaust blowers, two in operation and one on stand-by, of 600 cfm keep the vent system under a vacuum. Cooling water for the condensers is supplied by gravity flow from the 201 tank just east of the 202-A (Purex) building. The 750,000-gallon 201 tank is automatically kept filled with used cooling water from 202-A. Condensed vapors are collected in the 14,000-gallon 417 tank. The condensate can either be pumped back to a waste tank, or allowed to overflow to the A-24 crib.

Miscellaneous Service Buildings - Service buildings located in the A and AX tank farm area include a Change House (2707-EB), and a Control House (2711).

A comparison between the A and the AX tank farm is given in Table IX-8, and pertinent features of each tank farm are discussed in the following sections.

TABLE IX-8

A AND AX TANK FARM COMPARISON

	AX Tank Farm	A Tank Farm
Number of tanks	4	6
Maximum volume of concentrated waste that can be stored per tank (gal.)	1,000,000 at 1.8 SpG	840,000 at 1.37 SpG
Vapor Pressure Allowed	2.24 psi	2.25 psi
Tank Dome Live Load	40 psi plus a 50 T concentrated load	28-ton concentrated load
Earth Cover	6.5 to 7.5 ft	7 ft
Number of Air-lift Circulators	22	4
Leak Detection	Internal	External
Vapor Handling Facilities	--- Common	---
Number of Risers in Tank Dome	54	13
Temperature Elements	59	9

2.2.1 A Tank Farm

A cross-section of a waste storage tank in the 241-A tank farm is shown in Figure IX-23. Each tank is equipped with four air-operated circulators, except tank 101-A, which has 5. The lower end of the circulators are positioned 18 inches from the bottom of the tank. Two circulators are designed for agitation of liquid greater than 19 feet from the bottom. The circulators can "turn over" liquid at up to 4000 gpm with maximum air flow at 10 cfm. Instrumentation on the A farm tanks include electrode type liquid level measurement, weight factor

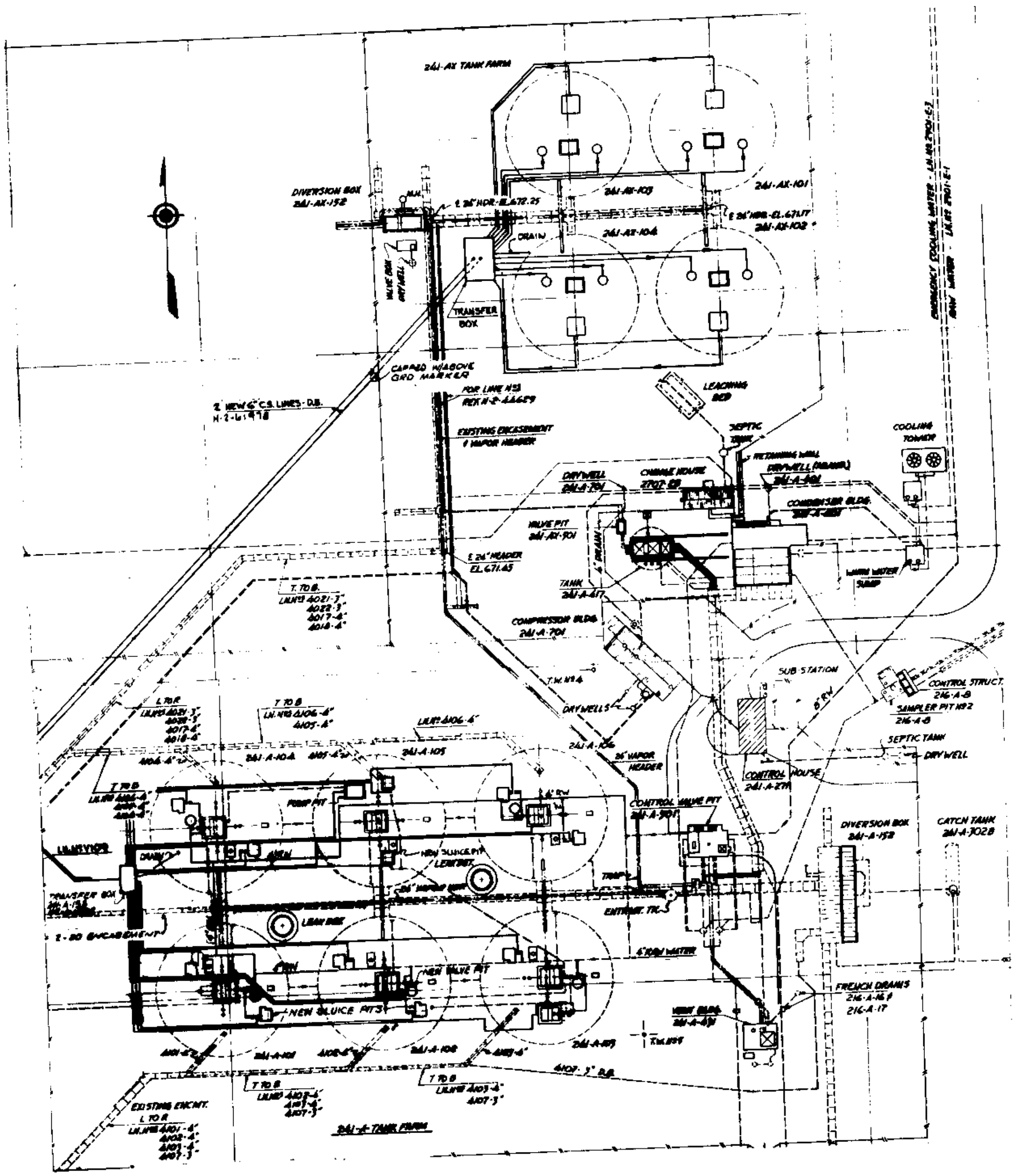

FIGURE IX-22

Layout of A and AX Tank Farms
(Based on H-2-61963 and H-2-61964)

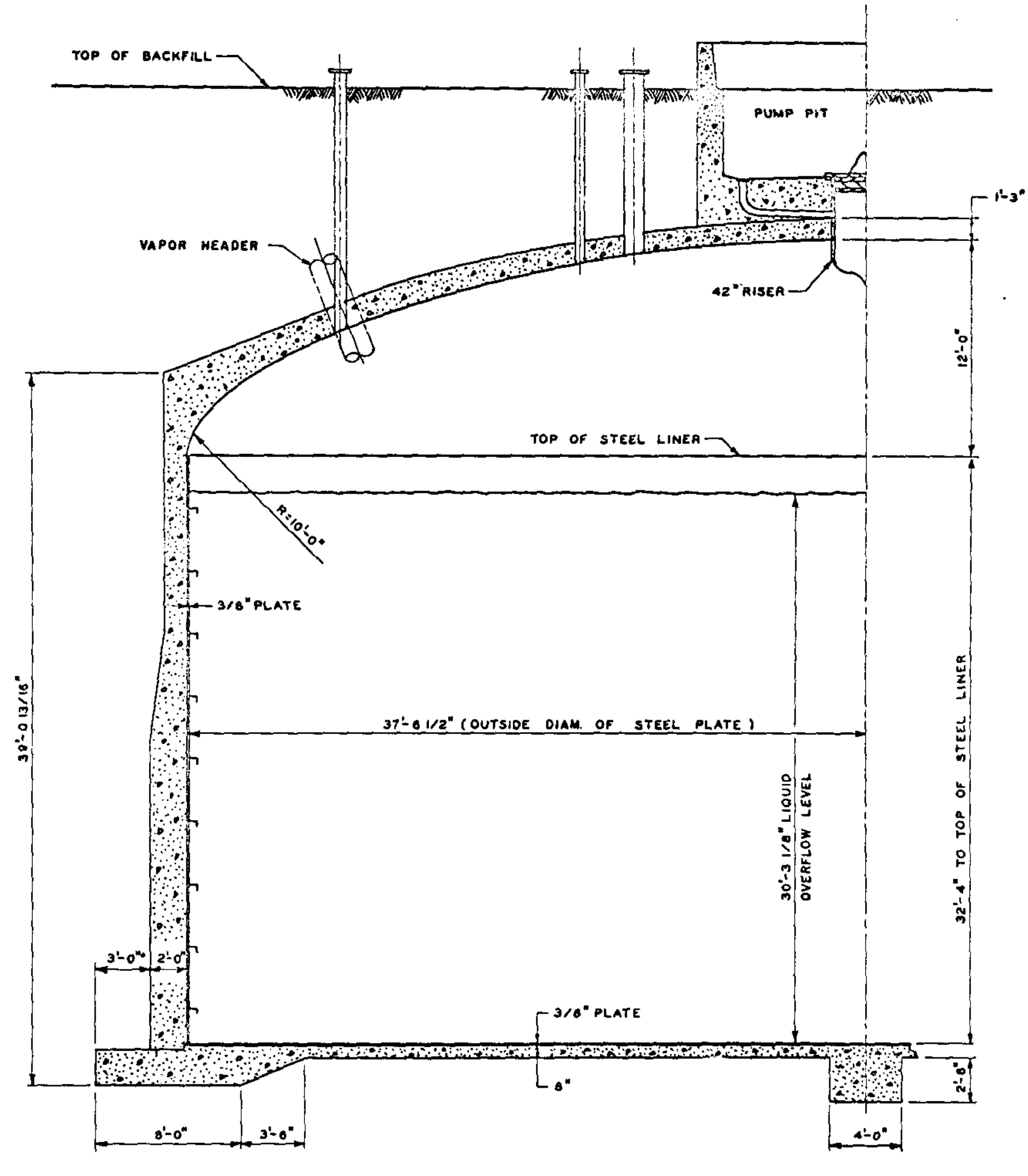

FIGURE IX-23

Cross Section of A Farm Waste Storage Tank bubbler tubes, pressure-vacuum instruments, and approximately 9 temperature measuring elements. For leak detection, a system of 44 vertical dry wells plus three laterals under each tank has been installed to permit taking radiation detection probe readings. The three laterals utilize air pressure to force a probe through the horizontal distance.

2.2.2 AX Tank Farm

The waste storage tanks in the 241-AX Tank Farm are basically similar to those in the 241-A Tank Farm. A composite cross-section of an AX Farm tank is shown in Figure IX-24. There are 22 air-lift circulators in the AX Farm tanks, 17 being 22 feet long, and 5 being 17 feet long. The taller circulators require a tank volume of 800,000 gallons to operate, and the shorter ones require a volume of about 600,000 gallons. All of the circulators are located 30 inches from the bottom of the tank. Normally, each circulator requires about 5 cfm of air.

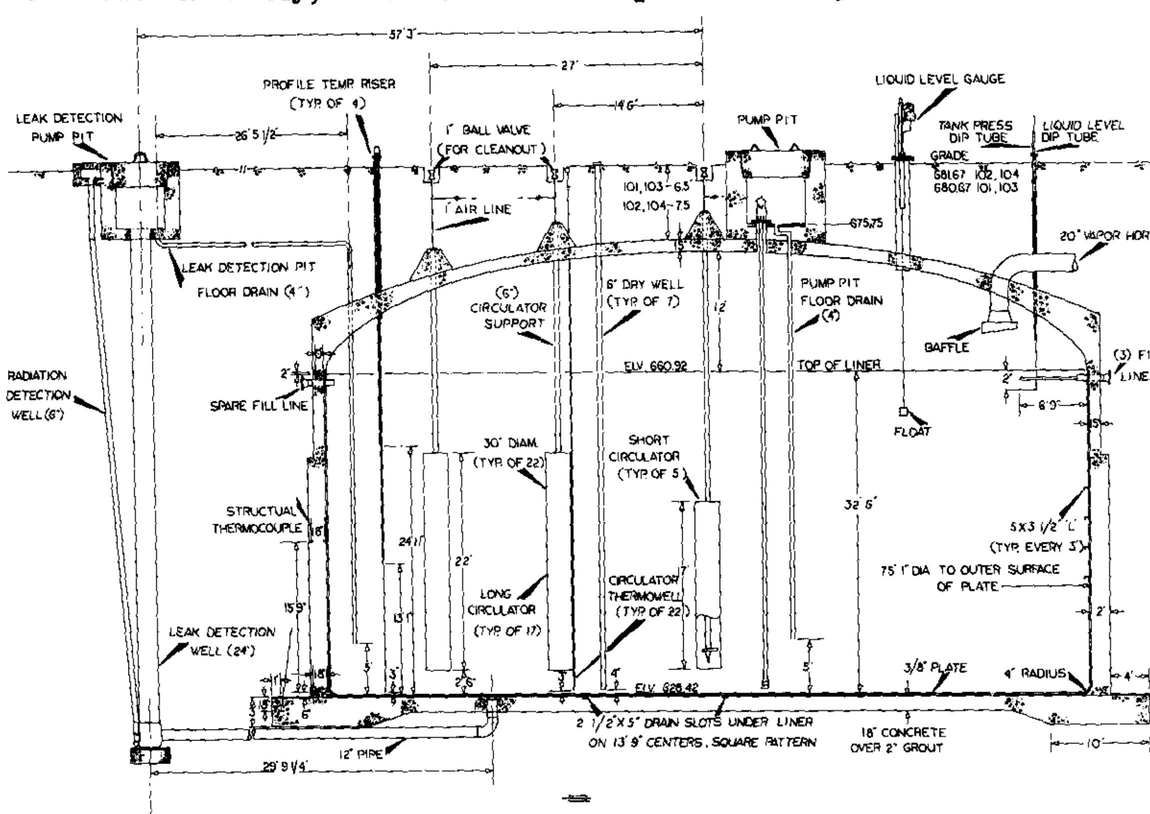

FIGURE IX-24

Cross Section of AX Farm Waste Storage Tank

A total of 59 iron-constantan thermocouples is installed in each of the AX Farm waste storage tanks. Each of the air-lift circulators has a temperature element below it that extends to within three inches of the tank bottom, and is used to help determine malfunction of a circulator. Twenty-one thermocouples are installed within each storage tank's concrete structure. Twelve thermocouples are in thermowells within the storage tanks and are used to measure temperature gradients in the stored waste at four different locations. The remaining thermocouples are located at various places in the tank to record sensitive areas.

Other instrumentation on the AX storage tanks include float-actuated liquid level measuring devices, air-purged dip tubes to sense tank pressure and liquid level in excess of 30.5 feet, sludge level meters, and radiation probes. Each storage tank in the AX Farm has its own internal leak detection system. This consists of a network of drain slots in the concrete base immediately below the carbon steel tank liner. The drain network is connected to a leak detection well from which any leakage can be pumped.

2.3 241-SX Tank Farm

The 241-SX Tank Farm consists of fifteen, 75-foot diameter tanks arranged in five cascades of three tanks each. The layout of the 241-SX Tank Farm is shown in Figure IX-25. The original design provided for four 12-inch risers, four 4-inch risers and one 42-inch riser on each tank; however, modifications to the tank farms have made it necessary to use some of these risers for other purposes. Waste can be routed directly to each tank in the tank farm, or the filling can be done by cascading. Vapor generated by the heat of radioactive waste in the SX Tank Farm is condensed in water-cooled condensers located in the 401 Condenser Building adjacent to tank 106-SX. Vapors from each tank are carried via headers to tank 106-SX where some condensation takes place and entrained liquids drop out. From tank 106-SX, the vapors are routed to the condensers, and uncondensible gases are then exhausted to the atmosphere.

Emergency cooling water for the condensers is provided by two, 150,000-gallon water storage tanks located near the 401 condenser house. Condensate may be routed to a crib, or it may be returned to tank 106-SX or to any of the other tanks.

A special air-purge tank cooler has been installed on tank 108-SX making it necessary to remove that tank from the tank farm vent system. The special equipment consists of a 7000 cfm exhauster, a heater to keep the temperature of the exiting air above the dew point, and a bank of high efficiency filters to remove particulate matter. The air is exhausted to atmosphere through a 15-foot stack in the tank farm.

Air-lift circulators were developed to overcome the bumping phenomenon first observed in tank 101-SX. Tanks 101-SX and 104-SX each contain one air-lift circulator. Tanks 107 through 115 each contain four circulators. Two of the circulators are designed to discharge at the 10-foot level and two discharge at the 15-foot level.

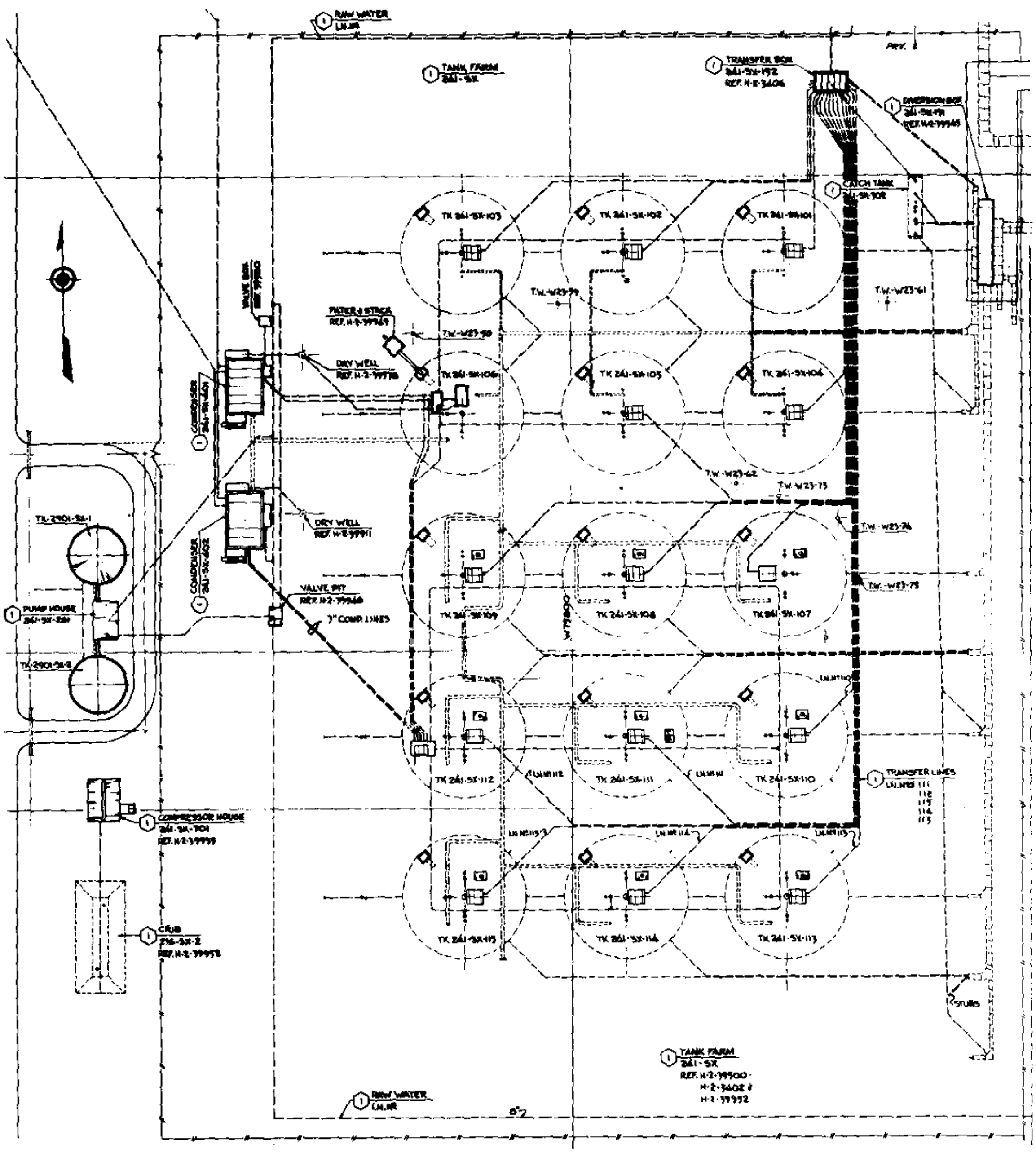

FIGURE IX-25

Layout of SX Tank Farm
(Based on H-2-44511)

Process air for the air-lift circulators is supplied by two, forty-horse-power Fuller rotary type compressors located in the compressor house. Instrument air is supplied by two five-horsepower De Vilbiss piston type compressors also located in the compressor house. The compressors are alternated in service, and are so arranged that the standby unit will start should the operating unit stop.

Each tank 107 through 115 has an instrument shack located adjacent to it. The instrument shacks contain instruments for specific gravity, differential pressure between the inside and outside of the air-lift circulators, air flow to the circulators, temperature measurements, and static pressure.

D. WASTE TRANSFER FACILITIES

1. General Description of Waste Transfer Facilities

In 1952, a network of underground lines and transfer stations was installed to connect many of the underground tanks with the building used to recover uranium from the stored wastes from the bismuth phosphate process. These lines are constructed of stainless steel tubing about three inches in diameter and are contained in concrete trenches. Multiple lines interconnect the older tank farms in each area with a pumping station, and the two pumping stations are interconnected by multiple inter-area transfer lines.

Facilities for transferring wastes between tanks, and for routing wastes to the desired tanks were included in the design of the A and AX Tank Farms. A facility for the accumulation and dissolution of stored sludge waste has been built adjacent to the A and AX Tank Farm. This facility is called the 244-AR Vault.

2. 244-AR Vault

The 244-AR Vault is designed to accumulate and acidify stored sludge waste sluiced from the waste storage tanks in the A and AX Tank Farms. The AR Vault also includes a lag storage tank for current Purex acid waste (PAW and ZAW) enroute to B-Plant for processing and a lag storage tank for neutralized high-level waste (NHW) enroute from B-Plant to the A or AX Tank Farm.

2.1 Layout of 244-AR Vault Area

The layout of the 244-AR Vault Area is shown in Figure IX-26. Facilities included in the AR Vault area include the vault canyon or process area, service building, filter building (291-AR), change house, air compressor, emergency electrical generator, two chemical storage tanks, vessel vent stack (291-AR-B), ventilation stack (291-AR Stack), and sluicing and routing system.

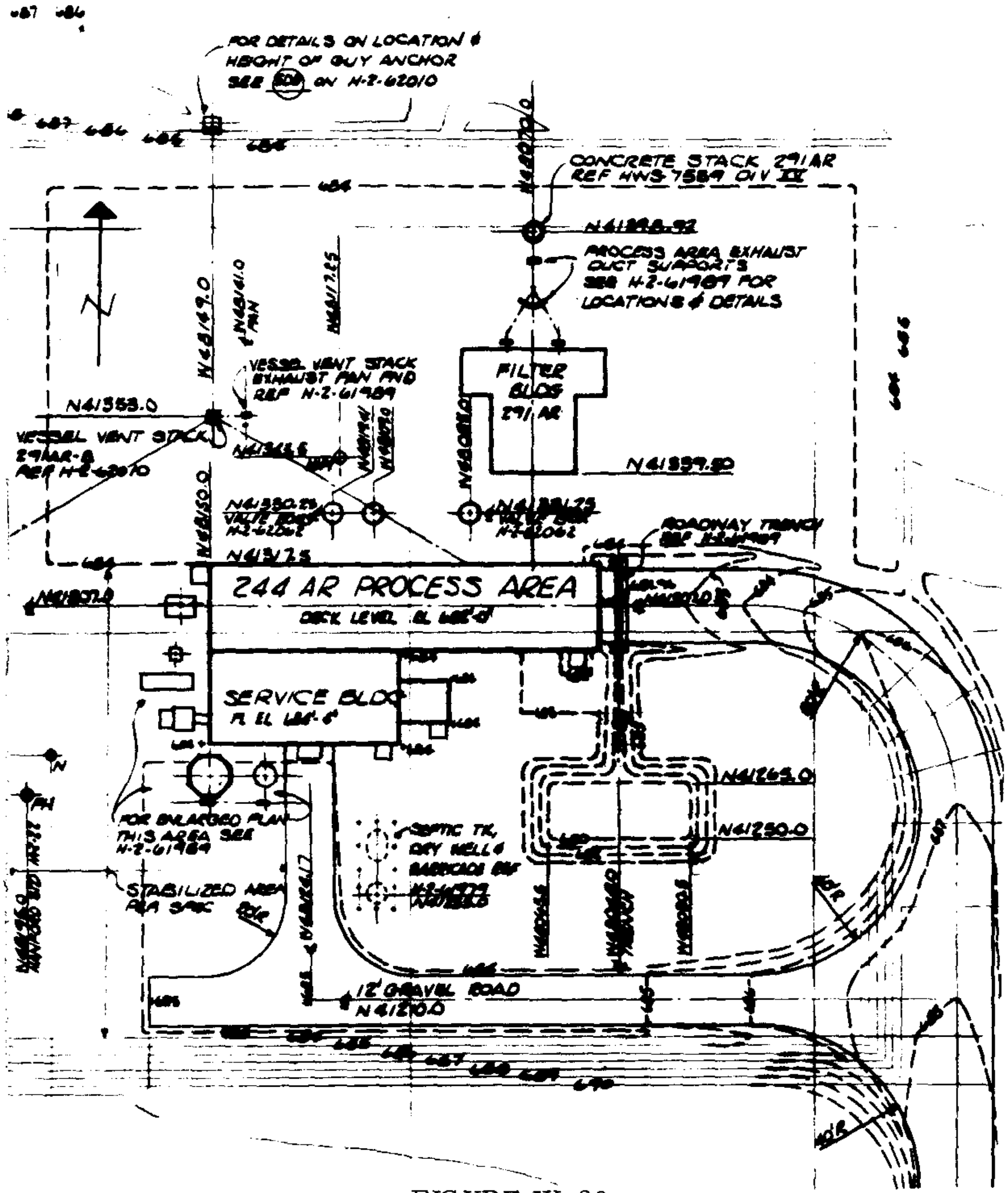

FIGURE IX-26

Layout of 244-AR Vault Area
(Based on H-2-61988)

2.2 Description of 244-AR Vault Buildings

The 244-AR Vault process area consists of a reinforced concrete structure approximately 97 feet long and 21 feet wide. The process area is divided into three cells plus a failed equipment storage area all located below grade level. Two of the cells are 21 feet square and 32 feet 9 inches deep. The 50,000-gallon PAW Transfer Tank (TK-001) is located in one of these cells, and the 50,000-gallon Slurry Accumulator Tank (TK-002) is located in the other. The third cell is 32 feet long, 12 feet wide and 21 feet deep. The 5000-gallon Neutralized High Level Waste Tank (TK-003), and the 5000-gallon Sludge Acidification Tank (TK-004) are located in this cell. The process cells are covered by interlocking concrete cover blocks 5 feet thick. The cover blocks over the equipment storage area are two feet thick.

The area above the cells is enclosed by a reinforced concrete building approximately 36 feet in height above the cover blocks. A remotely operated crane with four 1-ton hoists and one 20-ton hoist operates along rails located 30 feet above the deck. The crane is operated from a control room located midway along and 7 feet south of the canyon building. The reinforced walls of the crane control room provide additional shielding to the crane operator when the cell cover blocks are removed. A periscope and a closed circuit television system in the crane control room provide for remote viewing of operations within the vault process area. The floor plan of the AR Vault is shown in Figure IX-27, and an elevation view is shown in Figure IX-28.

2.3 244-AR Vault Equipment and Facilities

2.3.1 Tanks

Four process tanks, two chemical storage tanks, and an aqueous make-up tank are included in the AR Vault. The function, volume, and major pieces of equipment installed on the tanks are shown in Table IX-9.

2.3.2 Ventilation

Ventilation air for the service area and the crane control room is supplied by a 5700 cfm fan located on the roof of the service area. The air is filtered, water washed, heated and distributed through ducts to the control room, rest room, sample room and crane control room. The air is exhausted to atmosphere from the service area through two 1700 cfm exhaust fans. From the rest room air is exhausted through an 1100 cfm ventilating fan, and from the chemical make-up tank it is exhausted through a 200 cfm exhaust fan. The crane control room is vented to the atmosphere through a dampered port. The sample room is vented through a dampered opening into the canyon. The damper is controlled so the air flow is always into the canyon.

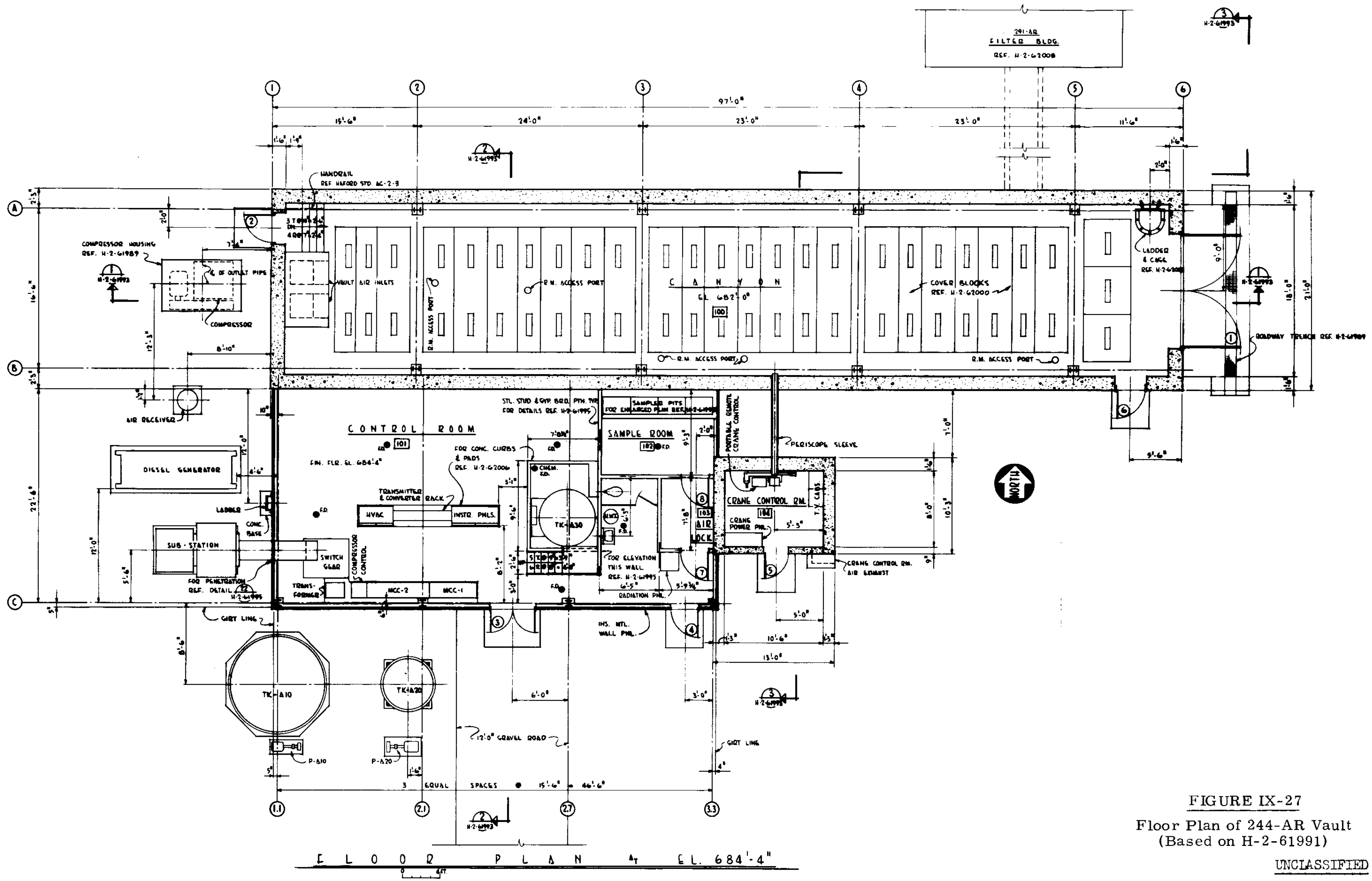

FIGURE IX-27

Floor Plan of 244-AR Vault
(Based on H-2-61991)

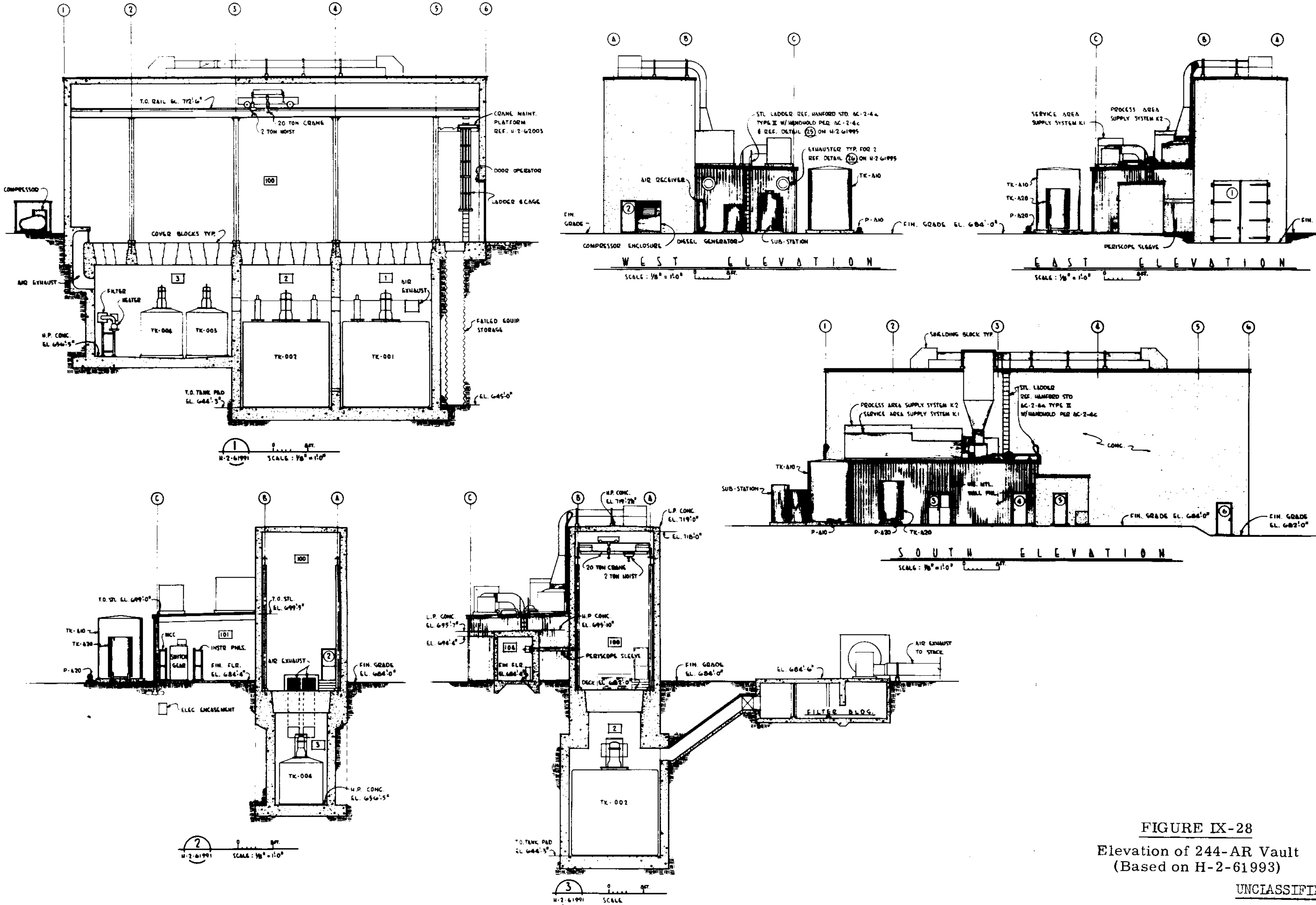

FIGURE IX-28
Elevation of 244-AR Vault
(Based on H-2-61993)

TABLE IX-9

TANKS IN THE 244-AR VAULT

Tank	Function	Volume, gallons	Equipment
001	PAW Storage	50,000	Pump, agitator
002	Slurry Receiving	50,000	Pump, sluice pump, agitator
003	FP Waste Storage	5,000	Agitator
004	Acidification Tank	5,000	Agitator, Radiation Mon. dry well
A10	Nitric Acid Storage	8,000	Pump
A20	Caustic Storage	1,300	Pump
A30	Aqueous Make-up	800	Agitator

Ventilation air for the canyon and process cells is supplied by a 21,500 cfm supply fan which is also located on the roof of the service building. The filtered, water-washed, and heated air is delivered to the canyon at two places through the roof of the building. The air passes through the canyon and into the process cells through two ducts located at the west end of the building. The air sweeps through all three cells and is exhausted from Cell 1 through an underground duct to the filter building. The filter building provides for filtering the air through two banks of high efficiency filters before exhausting the air to atmosphere through a 61-foot high concrete stack. Two 24,300 cfm exhaust fans are used, one in operation and one on standby. The No. 2 fan is connected to the emergency electrical supply and will automatically start should there be a failure of the normal electric power.

2.3.3 Vessel Vent

The four process vessels, TKS-001, 002, 003, and 004, in the AR Vault are vented by means of a vessel vent header. The off-gases are heated well above the dew point and filtered through two stages of high efficiency filters. The heater and filter are located in Cell 3 of the Vault Canyon. The filtered gases are discharged to atmosphere through a 150-foot vessel vent stack. The vessel vent exhaust fan is rated to deliver 525 cfm at 12 inches of water vacuum.

2.3.4 Pumps

In general the pumps used for process solutions in the AR Vault are single stage vertical centrifugal pumps. Except for a brief description of the Sluice Pump and the Waste Recovery Pump, detailed information about the pumps is included in Chapter X and will not be discussed here.

The Sluice Pump, located in tank 002, is designed to pump the recirculating sluicing solution under high pressure to the sluicing nozzles located in the underground storage tanks. The pump is specified to deliver a solution with a specific gravity of 1.5, a viscosity of 1.02 cps., and a temperature of 176 F at 600 gpm with a 390-foot head.

The Waste Recovery Pump is used to pump the sludge slurry from the underground storage tanks to the Slurry Receiving Tank in the AR Vault. The pump is a single stage suction, vertical centrifugal pump with radial discharge from the impeller. The pump is specified to pump a slurry containing 1 pound per gallon solids having a specific gravity of 2.2 and a maximum dimension of 1.0 inch. The slurry has a specific gravity of 1.6, a viscosity of 0.83 cps at a temperature of 220 F. The normal capacity of the pump is specified to be 660 gpm with a head of 116 feet.

2.3.5 Utilities

Utilities available to the 244-AR Vault include the following:

Water - Filtered untreated water for cooling is supplied from the 200-E raw water supply system through an 8-inch supply line. Sanitary water from the area supply is delivered to the AR Vault through a 6-inch supply line. Emergency cooling water is available from the sanitary water supply by means of an intertie between the sanitary and raw water supply through a back-flow preventer.

Steam - from the 200 E power house is received at 225 psig and reduced to 100 psig for use in jets and the vessel vent off-gas heater. Low pressure, 20 psig, steam is used in the tank coils and in the building heating and ventilation systems.

Electricity - is supplied through a 750 KVA 13,800 volt primary and 480 and 277 volt secondary transformer. Emergency electrical power is supplied from a 90 KVA diesel generator located adjacent to the Vault. The emergency power is sufficient to operate one canyon ventilation exhaust fan and the vessel vent exhaust fan.

Compressed Air - Information on the air compressor that supplies the process and instrument air for the AR Vault was not available when this chapter was written.

2.4 Sluicing Facilities

Facilities for sluice mining sludge from the underground waste storage tanks have been installed in the A Tank Farm. At the time this manual was written sluicing facilities for the AX Tank Farm were in the design stage and are not included here. However, the sluicing equipment in the AX Tank Farm will be similar to that in the A Tank Farm. Facilities needed to sluice mine the underground storage tanks are as follows: 1) a sluice pump and waste recovery pump. (Pumps are discussed in Section D. 2.3.4. and in Chapter X.); 2) pump pits, sluice pits, and diversion boxes all are discussed in Section D. 3.; and 3) sluicing nozzles. The sluicing nozzles are discussed in detail in the references and are described only briefly here. The sluicing nozzles are suspended approximately 31 feet below the support flange into the storage tank. The nozzles may be rotated 360 degrees in the horizontal plane and 110 degrees in the vertical plane. The nozzle has a 1-inch opening and is designed to impinge 75 percent of the stream within a 12-inch diameter circle at a distance of 50 feet at a minimum tip pressure of 100 pounds per square inch. The sluicer is equipped with an electrical driven oscillating cam designed to swing the nozzle through a horizontal arc variable from 5 to 120 degrees at a frequency of 1 cycle per minute.

In A Tank Farm the Waste Recovery Pump is located in the pump pit near the center of the tank. The Waste Recovery Pump is used to pump the slurried sludge loosened by the sluicers from the storage tank, through the 153-A Diversion Box to TK-002 in the AR Vault. Those transfer lines used to transport slurries from the underground tanks to the AR Vault, and sluicing solution back to the tanks are all 6-inch, schedule 40 direct buried carbon steel pipe.

3. A and AX Transfer Facilities

Transfer of solutions into, out of, and within the A and AX Tank Farms is accomplished by means of stainless steel lines contained in concrete trenches or directly buried carbon steel pipe. The lines terminate at risers from the underground tanks, pump pits or sluice pits above the tanks, diversion boxes or diverter stations located in or near the tank farms.

3.1 Pump Pits

Each waste storage tank in the A Tank Farm has a pump pit 12 feet long, 11 feet wide, by 7.5 feet deep with 2.5-foot thick block covers. The pump pits are centered on top of the underground storage tanks. The 42-inch flanged pump riser from the tank and two discharge nozzles are located in the pump pit. One discharge nozzle is connected to the 4-inch carbon steel inter-tank transfer line V-032 and the other discharge nozzle is for the 6-inch carbon steel line to the 152-A Diversion Box. This latter line is the line through which the sludge slurry will be pumped when the tank is sluice mined. A three-inch drain in the bottom of the pit empties to the tank below. Spray nozzles and nozzles to route water to the pump from an adjacent valve pit are also located in the pump pit. See Figure IX-23 for the location of the pump pit in relation to the rest of the tank.

The pump pits in the AX Tank Farm are 7.5 feet long by 6 feet wide by 7.5 feet deep with 2.5-foot thick cover blocks. The center line of the pump pit is located 7 feet 3 inches from the center of the tank and contains two 12-inch risers for pump mounts. A 4-inch pump pit floor drain extends to within 5 feet of the bottom of the tank. Each pump pit contains two discharge nozzles, one a spare and the other connected to the 3-inch carbon steel pump-out header line 4026. The location of the pump pits can be seen in Figure IX-24.

3.2 Sluice Pits

Each tank in the A Tank Farm has two sluice pits in addition to the pump pit. Sluice pits in the AX Tank Farm were not constructed at the time this manual was written. The sluice pits are 6 feet long, 6 feet wide, by 8-1/2 feet deep and are covered by a two-foot thick cover block. Each pit contains a 12-inch flanged riser for the Sluicer, a 4-inch nozzle for sluicing solution, four spray nozzles, and a floor drain back to the waste tank. The sluice pits are located 28 feet from the center of the tank and on four of the tanks are oriented on a NW-SE axis. The reader is referred to Figure IX-29 and the appropriate reference drawings for the proper location of the sluice pits. The sluice pits in the A Tank Farm receive their sluicing solution from the AR Vault via Diversion Box 153-A.

3.3 Diverter Stations

A diverter station operates similar to a switch board in that highly radioactive waste solutions can be routed to a selected underground waste storage tank, the AR Vault, or the CR Vault. This is accomplished by means of diverter tanks within the diverter station. Transfer lines leading into the stations terminate in the diverter tanks. The waste solution overflows the diverter tank through a movable spout into a funnel on a transfer line leaving the station. A routing change is made by moving the spout to the proper funnel. Positioning the spout is done with a shaft that extends through the cover block to a handle located above the station. Illustrations of diverter stations are shown in Figures IX-30 and XII-16. Since diverter tanks rely on gravity flow, the flows are unidirectional and are limited to less than 150 gallons per minute.

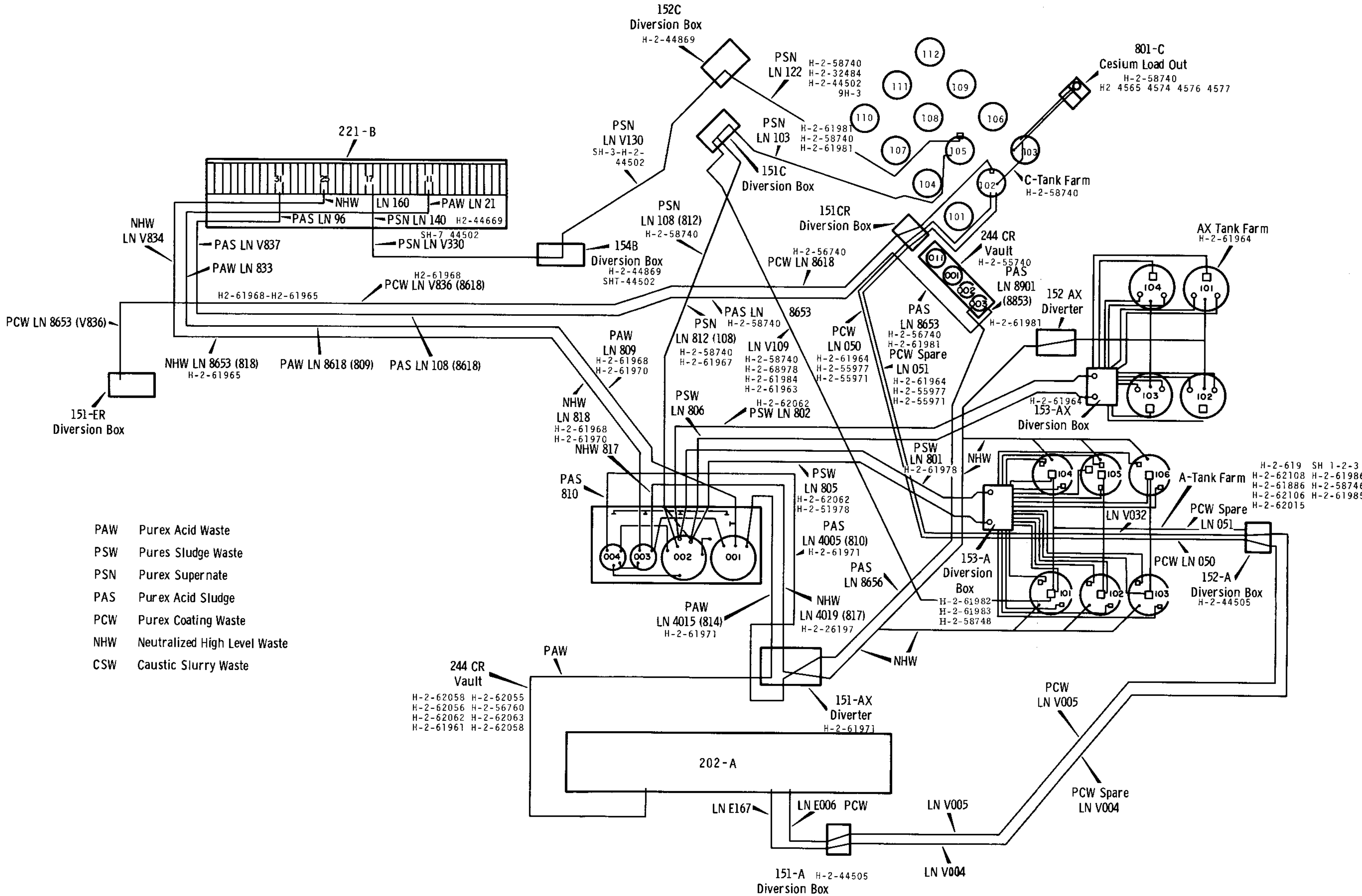

FIGURE IX-29

Transfer Lines Associated with 244-AR Vault

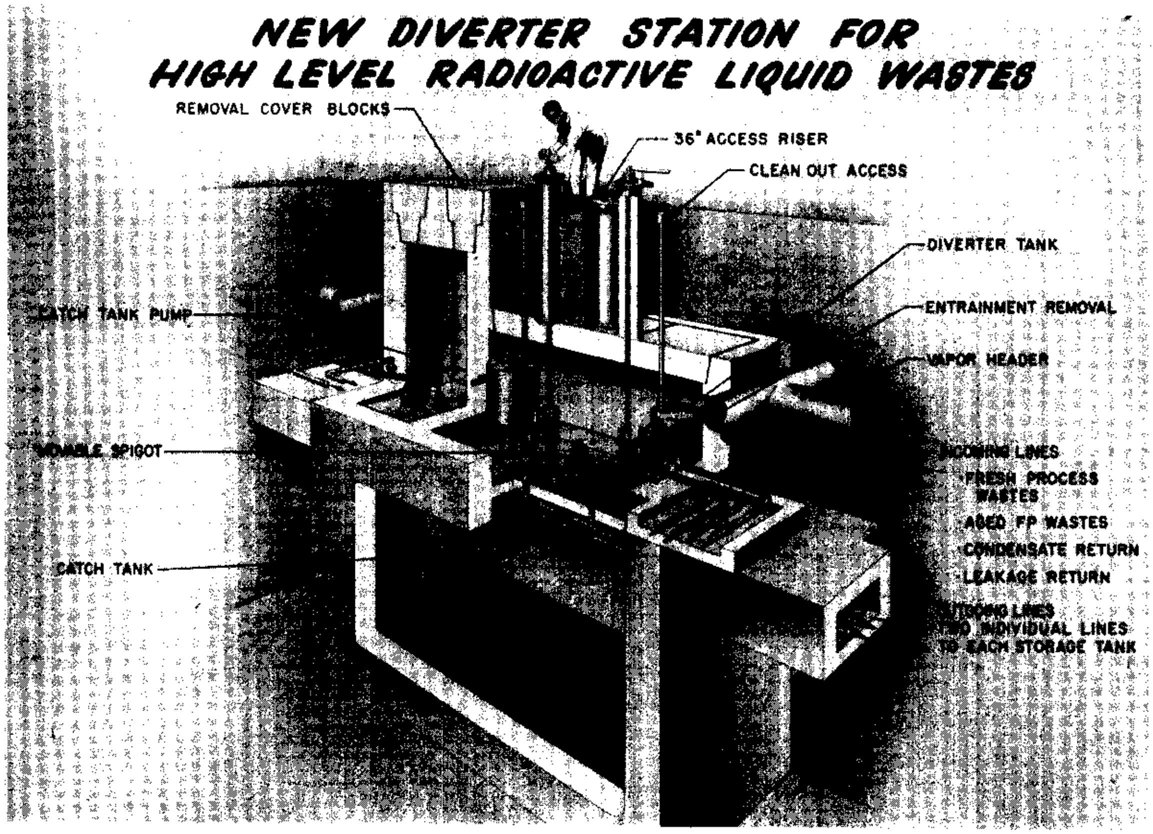

FIGURE IX-30

Diverter Station

There are two diverter stations associated with the waste transfer facilities in the A and AX Tank Farms. Diverter station 151-AX is 41 feet 4 inches long, 10 feet wide, and 24 feet 10 inches high. The station contains four diverter tanks, C, D, E and F, located in individual cells. An 11,000-gallon stainless steel lined catch tank is located below the diverter tanks. Drainage into the catch tank can be pumped or jetted to diverter tank E or F.

Various high level wastes from the Purex plant are routed to the diverter tanks in the 151-AX station as indicated in Figuve IX-31. Depending on the disposition of the waste, it may be routed to an underground storage tank in the A farm, to Tank 003 in the 244-CR Vault, to Tank 001 in the 244-AR Vault, or to one of the two diverter tanks in Diverter Station 241-AX-152.

Diverter Station 152-AX contains two diverter tanks, A and B, located in a common cell. The dimensions of the station are 25 feet 2 inches

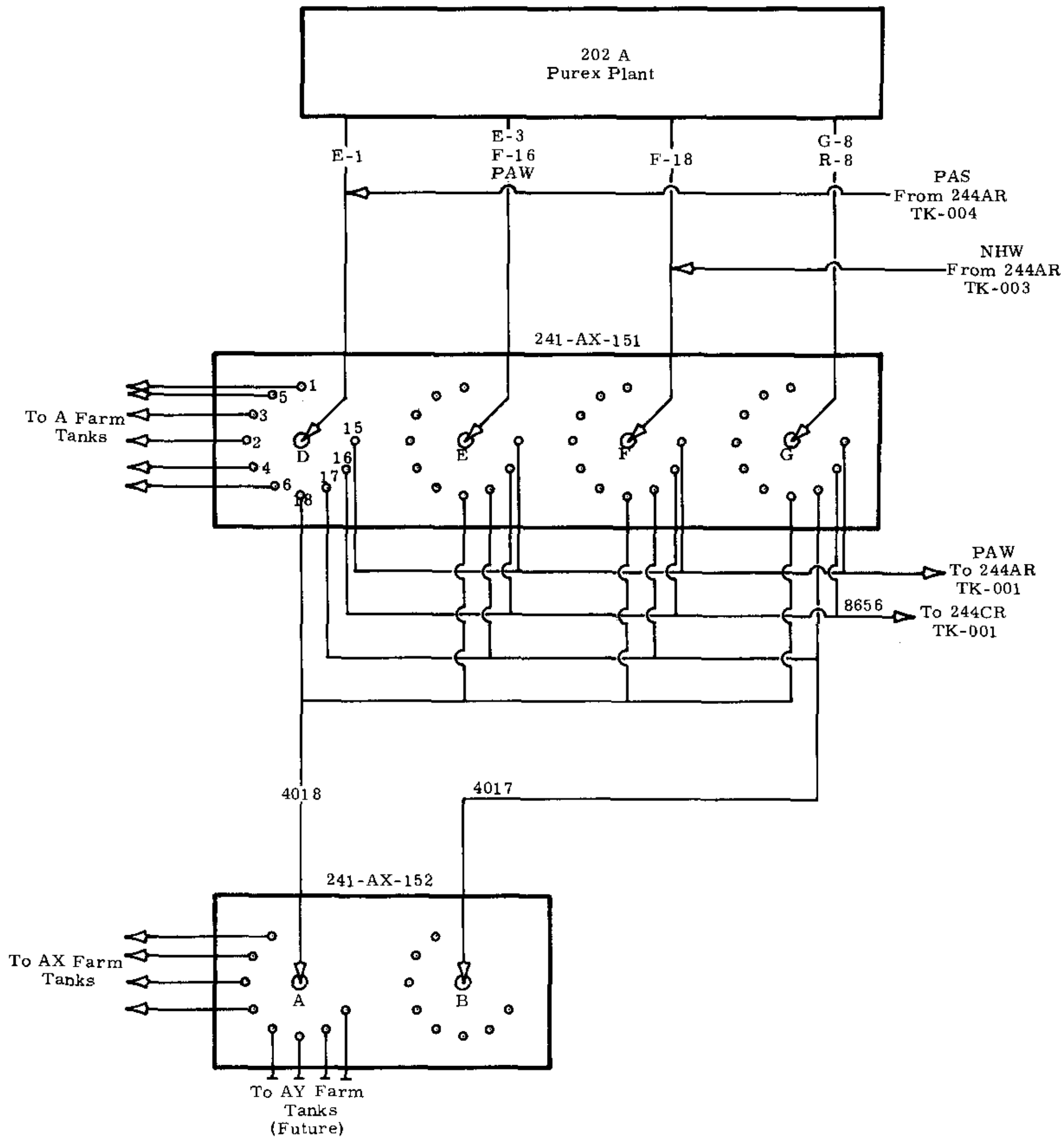

FIGURE IX-31

Simplified Diverter Station Transfer Routes

long, 9 feet wide, and 29 feet 2 inches high. There is also an 11,000-gallon stainless steel lined catch tank located beneath the two diverter tanks in this station. The diverter tanks in the 152-AX station are used to route solutions to the existing tanks in the AX Tank Farm. Stubbed lines exist for four future underground waste storage tanks in the proposed AY Tank Farm. The catch tank in the 152-AX station may be pumped or jetted to diverter tanks D or G in the 151-AX station.

3.4 Diversion Boxes

Diversion boxes are essentially piping "patch boards" which are used to minimize duplication of piping and allow the changing of line routings without the use of valves. Diversion boxes are used when the line must be under pressure while diverter stations are used for gravity flow only. The diversion boxes are concrete pits with the pipes passing through the concrete and terminating in remote connector nozzles inside. Two diversion boxes, 151-A located on the south side of the Purex plant, and 152-A located at the east end of the A Tank Farm were originally used to route all high-level wastes to the various tanks in the A Tank Farm. Now, however, the majority of the high-level waste is handled by the diverter stations discussed in Section D. 3.3 above and the 151-A and 152-A diversion boxes are used to route coating wastes from the Purex plant to the C Tank Farm.

Two new diversion boxes have been built as part of the sludge removal facilities in the A and AX Tank Farms. These two new boxes are the 153-A and the 153-AX Diversion Boxes. The new boxes route the high pressure solution used for sluice mining sludge from the 244-AR Vault to the desired sluice pit on the tank, and route the sludge slurry pumped from the tank to the 244-AR Vault. These routings are shown in Figure IX-29.

An illustration of a diversion box is shown in Figure IX-32 and in Chapter XII, Figure XII-14.

4. Other Waste Transfer Facilities

Other waste transfer facilities which are or may be used in the Waste Management Program are briefly described below. More detailed information may be found in appropriate prints and references.

4.1 244-CR Vault

The 244-CR Vault located in the C Tank Farm contains two 40,000-gallon tanks (001-CR and 011-CR) and two 15,000-gallon tanks (002-CR and 003-CR). The two 15,000-gallon tanks have cooling coils, but the two 40,000-gallon tanks do not. All of the tanks are equipped with agitators, pumps, samplers, and appropriate instrumentation. Tank 003-CR is used as a lag storage tank for acidified sludge waste (PAS) between the AR Vault and B-Plant. The 002-CR tank is used to store miscellaneous special fission product fractions. The two larger tanks, 001-CR and 011-CR, are used to collect and transfer a variety of waste solutions in an out of the C Tank Farm.

4.2 244-BXR, 244-TXR, 244-UR Vaults

There are three other vaults similar in construction to the 244-CR Vault. These are 244-BXR, 244-TXR, and 244-UR Vaults. However, the 244-TXR and 244-UR Vaults do not contain a 011 Tank. At the time this manual was written these vaults were not being used.

4.3 241-WR Diversion Station

The 241-WR Diversion Station is another vault-like structure located adjacent to the 221-U Building. This vault contains nine 50,000-gallon tanks. At the time this section of the manual was being written the 241-WR Vault was not being used.

4.4 Inter-Area Transfer Lines

A 6-line buried pipe encasement connects Diversion Box 154-UX, adjacent to the 221-U Building in 200 West Area with Diversion Box 151-ER southwest of B-Plant in 200 East Area. The 151-ER and the 154-UX Diversion Boxes are each connected to other diversion boxes in their respective areas. Virtually all of the waste storage tanks in all of the tank farms may be connected together through diversion boxes and the inter- and intra-area transfer lines.

4.5 Other Diversion Boxes

Practically all of the lines used to transfer high level waste within or between facilities in the chemical separations complex originate or terminate in Diversion Boxes. The Diversion Boxes serve as "Patch Boards" by which the various facilities may be interconnected. Very likely, all of the many diversion boxes in the 200 Areas will be used in the Waste Management Program at one time or another.

Four diversion boxes, not previously mentioned in other sections of this chapter, have a special use and are listed below.

151-CR - Used to route coating wastes into and out of C Tank Farm.

151-C - Used to route PSN and PSS from the AR Vault and from the pump pit on 101-A Tank to the 105-C Tank.

152-C - Used to route PSN from 105-C to B-Plant.

154-B - B-Plant Diversion Box. PSN from 105-C passes through 154-B enroute to B-Plant as well as 152-C. Non-boiling high-level salt waste from the waste concentrator in Cell 24 is routed to the ITS units in the BY Tank Farm via 154-B.

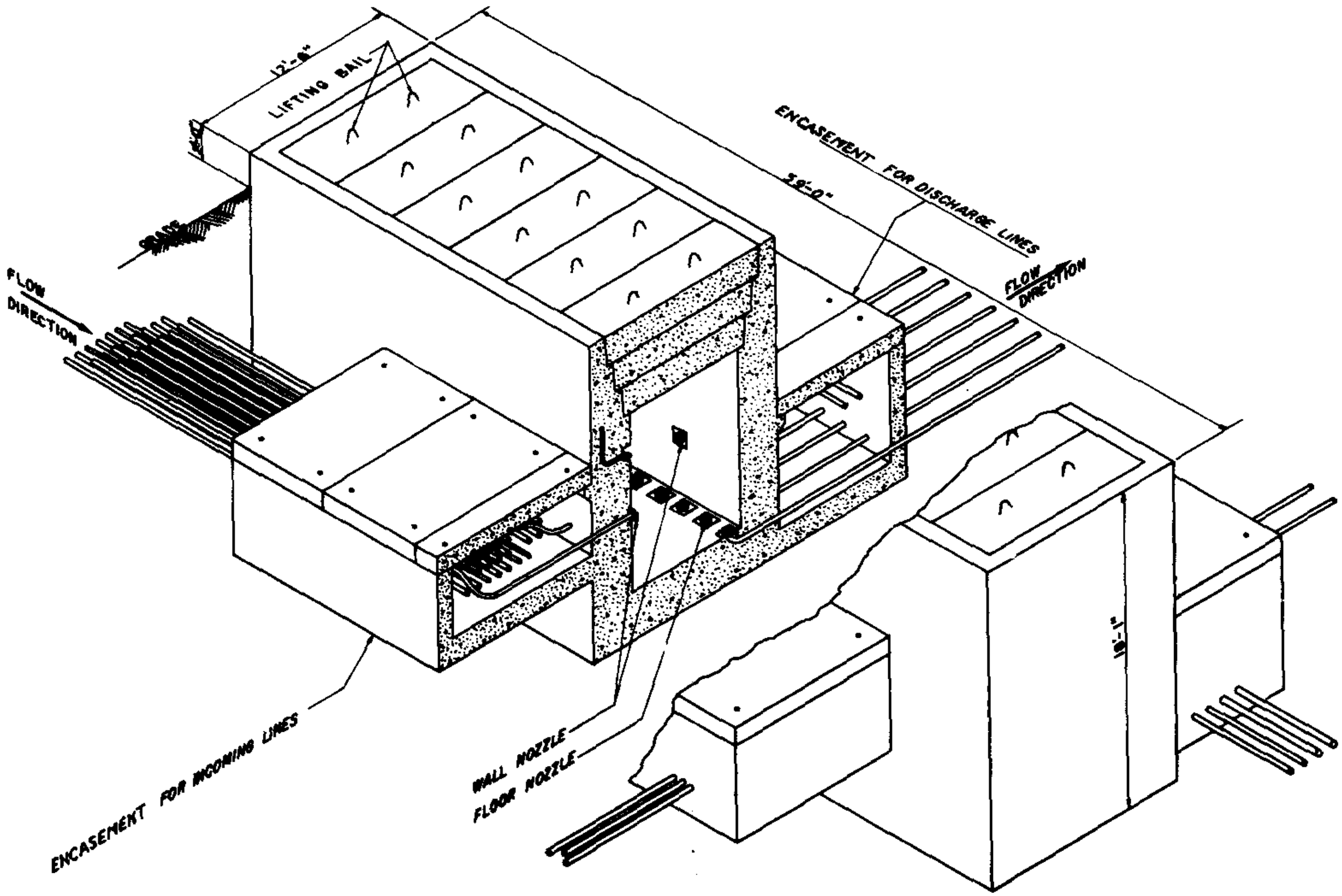

FIGURE IX-32

Diversion Box

DRAWING INDEX

A drawing index for the entire Waste Management complex would include a number of indexes for separate facilities and projects. A complete index would be quite long; therefore, the index included in this section of the Waste Management Technical Manual includes only a list of the other indexes, a list of the Engineering Flow Diagrams, and a few other pertinent, often-used drawings. The reader should refer to the other drawing lists to find additional information.

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PART V, *Continued*

PLANT AND EQUIPMENT

CHAPTER X

PROCESSING EQUIPMENT

By

R. A. Kyle

PART V: PLANT AND EQUIPMENT, Continued

CHAPTER X

PROCESSING EQUIPMENT

Page

LIST OF TABLES AND FIGURES

CHAPTER X

PROCESSING EQUIPMENT

A. INTRODUCTION

The Waste Management facilities involve the operation of a wide variety of process equipment such as tanks, concentrators, condensers, centrifuges, pulse columns, an ion exchange column, an adsorber, and a scrubber. Some of the equipment is new, but a large portion has been relocated from the Uranium Recovery Plant (221-U), T-Plant (221-T), and within B-Plant (221-B) itself.

1. Equipment Notations

The following notations are used in identifying the process equipment:

A - Agitator
E - Heat Transfer Equipment
F - Filter
G - Centrifuge
J - Jet
P - Pump
PA - Pump Agitator
T - Tower
TK - Tank

The process equipment is referenced to a particular cell by an assigned piece number. For example, TK-13-1 denotes Tank (TK), Cell 13 (13), and piece 1 (1). Accordingly, the equipment in the AR and CR Vaults is identified by an AR or CR.

2. Process Equipment Classification

The term "vessel" designates all non-mechanical equipment pieces containing a liquid or gaseous stream. In the Waste Management facilities the following three types of vessels are used:

1) Class I vessels are made of stainless steel and are designed to contain radioactive materials. They are designed for remote maintenance and handling.

2) Class II vessels are also made of stainless steel but are not intended for radioactive materials. They are designed for contact maintenance.

3) Class III vessels are those which are fabricated from materials other than stainless steel and are not designed to contain radioactive materials. They are designed for contact maintenance.

2.1 Class I Vessels

Class I vessels are essentially of all-welded stainless steel construction with carbon steel used only for necessary external attachments. The carbon steel attachments are protected with a coating of Amercoat* and are not in contact with process solutions. Double butt welds are used for pressure-holding seams where possible. The quality of the welds is controlled by radiographic testing or by other specialized techniques depending on the location of the weld.

Special construction features which allow installation or removal of the equipment with a crane are necessary for remote maintenance of the equipment. Thus, the equipment piece must be provided with remote connector nozzles for lines up to 4 inches in diameter and with remote flanges for larger size lines. The equipment must be provided with lifting bails so placed that when suspenced it will be balanced and will hang essentially in its installed position. Dowels and aligning holes or trunnions and trunnion guides are provided to position the equipment in its designated location. The equipment is fabricated to unusually close tolerances in order that replacement equipment or parts may be readily installed.

2.2 Class II Vessels

Class II vessels, like Class I vessels, are of all-welded stainless steel construction with carbon steel used only for supports and attachments not in contact with a process solution. Examples of Class II vessels are the AMU tanks, the head tanks and weigh tanks in the operating gallery, and certain chemical storage tanks in the 211-B Chemical Tank Farm. As the vessels do not contain radioactive solutions it is possible to perform contact maintenance on them and the design tolerances are less stringent than with Class I vessels.

For the design and fabrication of Class II vessels as pressure vessels, the general requirements of the A.S.M.E. Boiler Construction Code were followed. Basic design pressures were taken to be an internal pressure of 15 psig or 110 percent of the operating pressure, whichever is greater, and an external pressure of 5 psig.

For the design and construction of Class II atmospheric tanks, the general requirements of the American Petroleum Institute Standard 12C were followed. Designs were for the maximum internal pressure imposed by a liquid of 1.8 specific gravity with loads due to wind pressure and earthquake forces also considered.

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* Trade name of Amercoat Corporation

2.3 Class III Vessels

Specifications for Class III vessels are similar to Class II vessels except the Class III vessels are constructed of materials other than stainless steel. Examples of Class III vessels are the ammonia storage tank, the carbon dioxide storage tank, the caustic storage tanks, and the diluent storage tanks.

B. CANYON AND VAULT TANKS

1. Canyon Tanks

Most of the process tanks in the B-Plant canyon have been relocated from the Uranium Recovery Plant, T-Plant, or other cells in B-Plant. All tanks, except the deep cell tank in Cell 10, are either cylindrical or oval shaped with vertical sides. The 10,000-gallon waste collection tank in Cell 10 is rectangular in shape and has no top. All tanks are equipped with cooling coils except TK-29-4 which is inside TK-29-2. In addition, many of the tanks have water jackets; however, none of these are connected. Table X-1 is a list of the tanks and pertinent data applicable to the tank.

2. Vault Tanks

Four tanks in the 244-AR Vault and tank 003 in the 244-CR Vault are also used in the Waste Management Program. All of these tanks are Class I vessels. Pertinent data pertaining to the tanks in the vaults are listed in Table X-1.

C. SOLVENT EXTRACTION EQUIPMENT

The solvent extraction system, located in Cells 26, 27, 28, 29, and 30, is composed of four pulse columns and associated pumps, tanks, and pulsers. There is a pulse column in every cell but 26. The function of the pulse columns permits the separation of strontium and rare earths from the bulk salts and other fission products.

1. Columns

A pulse column is a type of solvent extraction contactor containing a series of horizontal, perforated plates. In a pulse column an up-and-down pulsing motion is superimposed on the net countercurrent flow of the liquid phases through the column.

The upward and downward pulsing movement of the column contents through the plate perforations provides agitation resulting in intimate mixing of the two countercurrently flowing phases. The pulsing also provides the means for countercurrent flow of the aqueous and organic phases through the columns. Experience indicates that the specific gravity

TABLE X-1
CANYON AND VAULT TANKS

Tank No.	Name	Dimensions (feet)	Capacity(1) (gal)	No. of Agitators(2)	No.of Pumps(2)	No.of Jets(2)	Coil Area (sq. ft.)	Design Duty(3) (Btu/hr)	Coil Range(1) (gal.) From	To
TK-5-1	Strontium Concentrate Receiver	3-1/4x7x4	400	1	0	3	240	480,000 cool	65	416
TK-6-1	Strontium Storage	8ø x 14	4100	1	0	1	420	840,000 cool	227*	1649
TK-6-2	Strontium Storage	8ø x 14	4100	1	0	2	420	840,000 cool	238*	1698
TK-7-1	Strontium Storage	8ø x 14	4100	1	0	2	157	314,000 cool	494	4051
TK-7-2	Strontium Storage	8ø x 14	4100	1	0	2	157	314,000 cool	500*	4000
TK-8-1	Strontium Storage	8ø x 14	4100	1	0	1	157	314,000 cool	499	4022
TK-8-2	Strontium Storage	8ø x 14	4100	1	0	1	157	314,000 cool	516	4026
TK-9-1	Waste Receiver	8ø x 14	4100	1	0	1	157	314,000 cool	432	4035
TK-9-2	Supernatant Storage	8ø x 14	4100	1	0	1	157	314,000 cool	505	4065
TK-10-1	Waste Collection	18x11x7	8000	0	0	1	908	1,816,000 cool	700	7200
TK-11-1	Slurry Tank	4-1/2øx7	650	1	0	2	78	156,000 cool	122	662
TK-11-2	Decant and Metathesis	9ø x 9	3400	1	0	3	300	600,000 cool	100*	1500
TK-12-1	Supernatant Receiver	9ø x 9	3400	1	0	1	118	236,000 cool	551	2964
TK-13-1	Centrifuge Supernatant Receiver	9ø x 9	3400	1	1	4	30	60,000 cool	318	3532
TK-14-1	Undesignated	4-1/2x7	595	1	0	2	78	156,000 cool	98	687
TK-14-2	Cesium Storage	9 x 9	3180			1	118	236,000 cool	491	2939
TK-16-1	Undesignated	6-1/2øx14	2585	1	0	3	70	140,000 cool	305	2007
TK-17-1	Cesium Storage	8ø x 14	3950	1	0	1	228	456,000 cool	173	1476
TK-17-2	Cesium Supernatant Receiver	8ø x 14	4000	1	1	1	100	197,000 cool	110*	950*
TK-18-1	IXW Receiver	9-1/2øx12	1480	1	1	1	52	104,000 cool	100*	507
TK-18-3	IXF Pump Tank	4-1/2øx7	590	1	1	1	40	80,000 cool	25*	324
TK-19-1	IXP Receiver Tank	10x16x14	11,260	2	1	0	160	320,000 cool	600*	2670
TK-20-1	IXP Concentrate Receiver	3-1/4øx7x4	396	1	0	2	240	480,000 cool	62	412
TK-21-1	Cesium Eluent Storage	10x16x14	11,260	2	2	0	160	320,000 cool	500*	2520
TK-22-1	Condensate Receiver	3-1/4x7x4	375	1	1	0	240	2,160,000 heat 480,000 cool	68	417
TK-23-1	Non-boiling Waste Concentrate	3-1/4x7x4	634	1	1	1	128	256,000 cool	53	502
TK-24-1	Low-Level Waste Receiver	10x16x14	11,090	2	1	0	290	580,000 cool	500*	7092
TK-25-1	Cerium Waste Receiver	8ø x 14	3900	1	1	2	435	870,000 cool	150*	2045
TK-25-2	High-Level Waste Receiver	8ø x 14	3900	1	1	2	435	870,000 cool	150*	2096
TK-26-1	Organic Contactor	9ø x 9	3146	1	1	3	68	136,000 cool	302	3358
TK-26-2	1CP Contactor	5x7x12-1/2	2110	1	1	3	48	96,000 cool	150*	610*
TK-26-3	1CW Receiver	5x7x12-1/2	2095	1	1	2	48	96,000 cool	125*	569
TK-27-2	1CP Receiver	5-1/2øx12	1600	1	0	1	52	104,000 cool	60*	460*
TK-27-3	1CW Contactor	7ø x 14	3030	1	1	3	200	400,000 cool	200*	2074
TK-27-4	1CF Pump Tank	2-3/4x5x3-1/2	224	1	1	1	55	110,000 cool	30*	205

TABLE X-1, continued

Tank No.	Name	Dimensions (feet)	Capacity[1] (gal)	No. of Agitators[2]	No. of Pumps[2]	No. of Jets[2]	Coil Area (sq. ft.)	Design Duty[3] (Btu/hr)	Coil Range[1] (gal.) From	To
TK-28-2	1BP Receiver	5-1/2∅ x 12	1584	1	1	1	52	104,000 cool	64	561
TK-28-3	1AX Make-up	7∅ x 14	3012	1	1	3	200	400,000 cool	189	1934
TK-28-4	1BF Pump Tank	2-3/4x5x3-1/2	228	1	1	1	55	495,000 heat 110,000 cool	30*	202
TK-29-2	1AF Make-up	9-1/2x5x14	3294	1	0	3	200	400,000 cool	237	1636
TK-29-3	1AF Pump Tank	9-1/2x5x14	3319	1	1	2	200	400,000 cool	240	1651
TK-29-4	1SF Pump Tank	1-2/3x8-2/3	66	0	1	0	-	- -	-	-
TK-30-2	1AW Receiver	9-1/2x5x14	3300	1	0	3	200	400,000 cool	140*	1500*
TK-30-3	1AX Pump Tank	9-1/2x5x14	3300	1	1	0	200	1,800,000 heat 400,000 cool	209	1634
TK-31-1	PAS Metathesis Tank	5-1/2∅x9	1200	1	0	2	52	468,000 heat 104,000 cool	61	533
TK-31-2	Dissolved Cake Storage	4-1/2∅ x 7	572	1	0	1	40	80,000 cool	111	405
TK-31-3	PAS Precipitator Tank	6-1/2∅x13	2561	1	0	2	115	1,030,000 heat 230,000 cool	1370	2636
TK-32-1	Waste Receiver	9-1/2∅ x 9	3175	1	0	3	115	230,000 cool	852	3011
TK-33-1	Treated PAS Storage	10x16x14	11,246	2	0	1	160	320,000 cool	562	2555
AR-001	PAW Storage	20∅x19-3/4	36,000	1	1	1	1324	2,650,000 cool	1750	31,500
AR-003	Neutralized High-Level Waste Storage	9-1/2∅x9	4000	1	0	2	219	438,000 cool	460	3570
AR-004	Sludge Waste Acidification	9-1/2∅x9	4000	1	0	2	219	438,000 cool	460	3570
CR-003	PAS Storage	14∅ x 12	15,000	1	1	0	586	1,172,000 cool	877	5224

Footnotes:

1 The working capacities and coil ranges were obtained from calibration data. Those marked with an asterisk were estimated.

2 The number of agitators, pumps, and jets on each tank, as well as the coil area, were obtained from Engineering Flow Diagrams.

3 The design cooling duty was computed using the following assumptions:

(a) $U = 40 \frac{\text{Btu}}{\text{hr.sq.ft.}^{\circ}\text{F}}$

(b) Cooling water inlet temp. = 70 F; outlet temp. = 90 F

(c) Bulk solution temp. = 130 F; therefore average ΔT = 50 F

For heating, the following assumptions are made:

(a) $U = 150 \frac{\text{Btu}}{\text{hr.sq.ft.}^{\circ}\text{F}}$

(b) Average ΔT = 60 F

difference between the two phases is usually not sufficient to cause a significant countercurrent flow through the small holes in the perforated plates. Consequently, the net flow of the light phase up and the heavy phase down the column is caused almost entirely by the actions of the pulse generator and the stream pumps.

1.1 Column Dimensions and Capacities

The 1A and the 1B Columns are identical. Both have an over-all height of 18.5 feet with a 4 ft by 5 ft by 2 ft high bottom disengaging section. The column proper is 20 inches in diameter. The plate section is 14.5 feet high. The dimensions of the top disengaging section are 4 ft by 4 ft by 2 ft high.

The disengaging sections on the 1S and the 1C Columns have the same dimensions as the 1A and the 1B Columns. However, the 20-inch diameter plate section of the 1S Column is only 10.5 feet in height. The plate section of the 1C Column is 14.5 feet in height, but has an inside diameter of 15.25 inches. Table X-2 lists the pertinent data for the pulse columns. Simplified sketches of the columns are shown in Figures X-1 through X-4.

TABLE X-2
PULSE COLUMNS

Column	Overall Height Feet	Column I. D. Inch	Plate Section Height Feet	Plate Holes Dia. Inch	Hole Centers Inch	Perforations Nozzle Direction	Louver Plate (e)	Column Volume Gal.	Volumn(f) Top Dis. Section Gal.	Volume Plate Contact Section Gal.	Volume Bottom Dis. Section Gal.	Dispersed Phase	Cont. Phase
T-30-1 1A	18.5	20	14.0(a)	0.1875	3/8 Tri.	Down	Yes	731	218	263	250	Aq.	Org.
T-29-1 1S	14.5	20	10.0 (b)	0.125	3/8 Tri.	Up	Yes	603	156	195	252	Aq.	Org.
T-28-1 1B	18.5	20	14.0 (c)	0.125	3/8 Tri.	Down	Yes	731	218	263	250	Aq.	Org.
T-27-1 1C	18.5	15.25	14.33(d)	0.125	3/8 Tri.	Up	No	600	185	158	257	Org.	Aq.

(a) Two 6.5' sections at 2" plate spacing.

(b) Two 4.5' sections at 2" plate spacing.

(c) Two 6.5' sections at 2" plate spacing.

(d) One 10.33' section at 4" plate spacing.
One 4.0' section at 2" plate spacing.

(e) The louver plate is 6" below the upper section and 6" above the lower section.

(f) To overflow nozzle.

Pilot plant studies indicate that satisfactory operation can be obtained for throughput rates of up to 2300 gallons per hour (total of both phases) in the 1A Column; 1200 gallons per hour in the 1S and 1B Columns; and 1700 gallons per hour in the 1C Column. However, the throughput rates vary with the stream being processed and are usually at least a factor of two under the above rates.

NOZZLE	SERVICE
A-	TEMPERATURE & INTERFACE CONTROL
B-	TEMPERATURE
C-	IAF AQUEOUS FEED
D-	SPARE
E-	VESSEL VENT
F-	PULSE LEG
G-	DIFF. PRESSURE & SPECIFIC GRAVITY
H-	CHEMICAL ADDITION
J-	IAX ORGANIC FEED
K-	IAW AQUEOUS WASTE
L-	ISF ORGANIC OUT
M-	COLUMN EMPTY-OUT
N-	IAS AQUEOUS SCRUB

REFERENCES: DRAWING H-2-61003
TABLE X-1
PULSE LEAKAGE TO TK-30-3

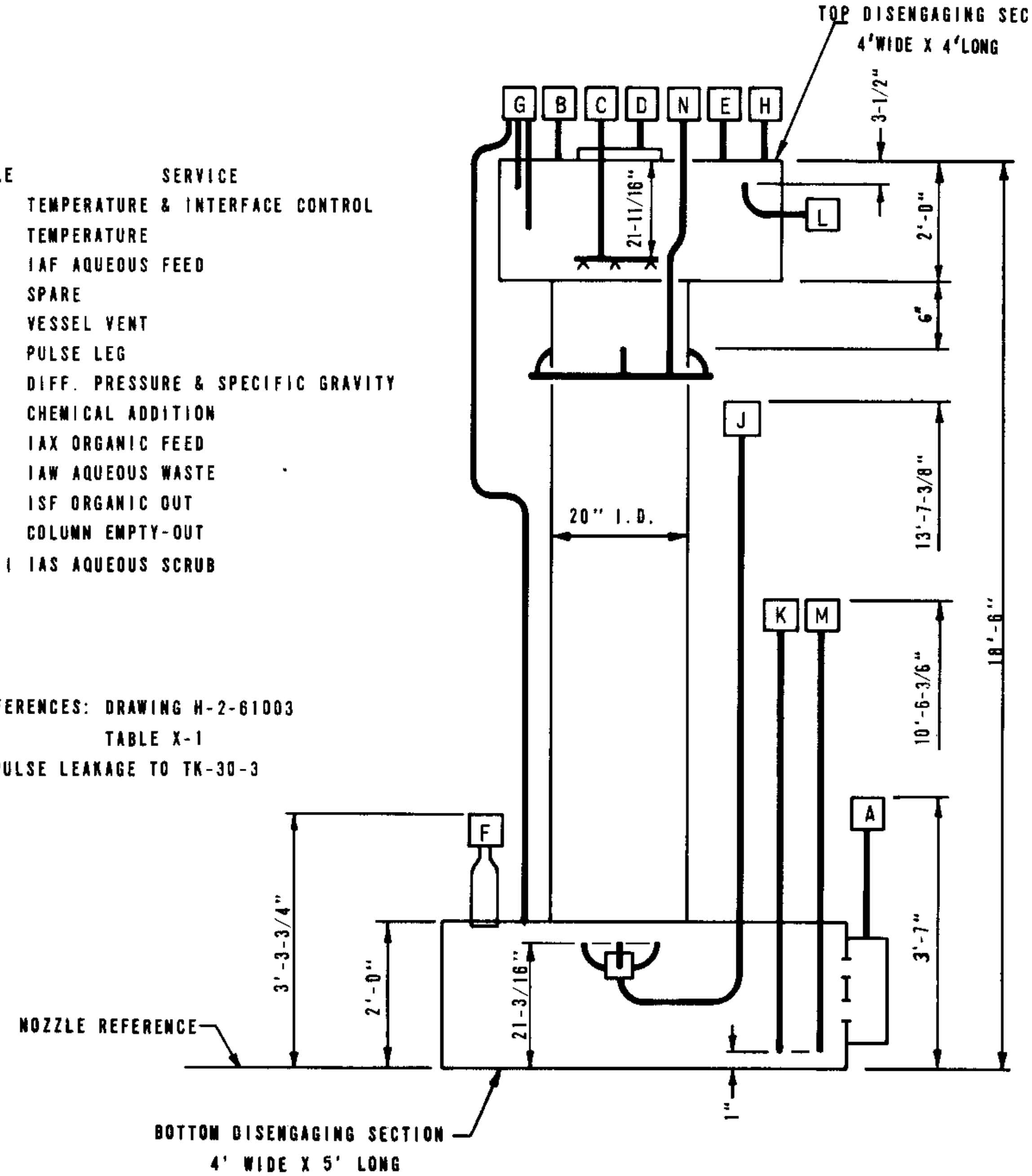


FIGURE X-1

T-30-1, 1A Column

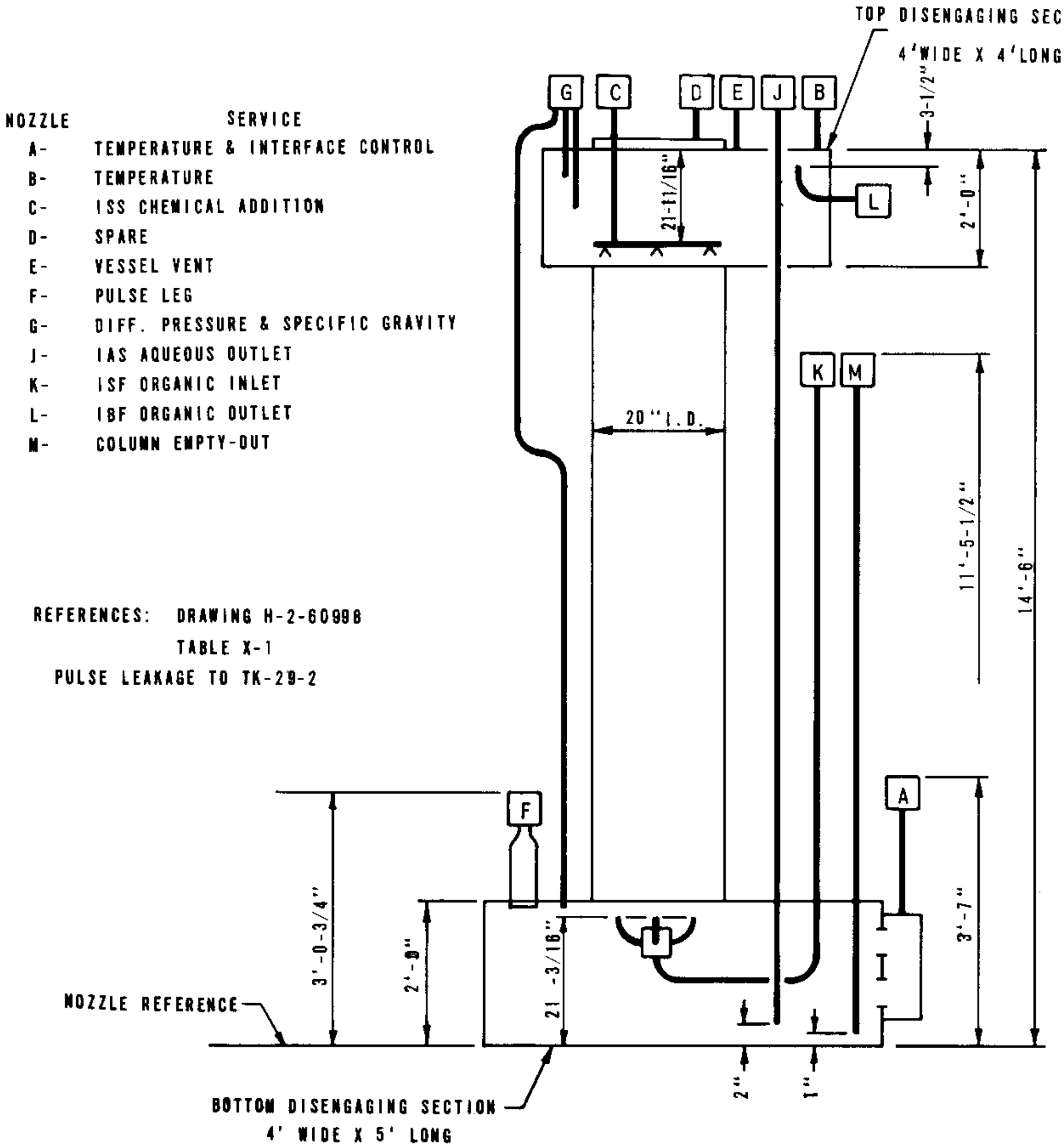


FIGURE X-2

T-29-1, IS Column

NOZZLE	SERVICE
A-	TEMPERATURE & INTERFACE CONTROL
B-	TEMPERATURE
C-	IBX CHEMICAL ADDITION
D-	SPARE
E-	VESSEL VENT
F-	PULSE LEG
G-	DIFF. PRESSURE & SPECIFIC GRAVITY
H-	SPARE
J-	IBF ORGANIC FEED
K-	IBP AQUEOUS PRODUCT
L-	IBW ORGANIC OUTLET
M-	COLUMN EMPTY-OUT
N-	SPARE

REFERENCES: DRAWING H-2-61003
TABLE X-1
PULSE LEAKAGE TO TK-28-2

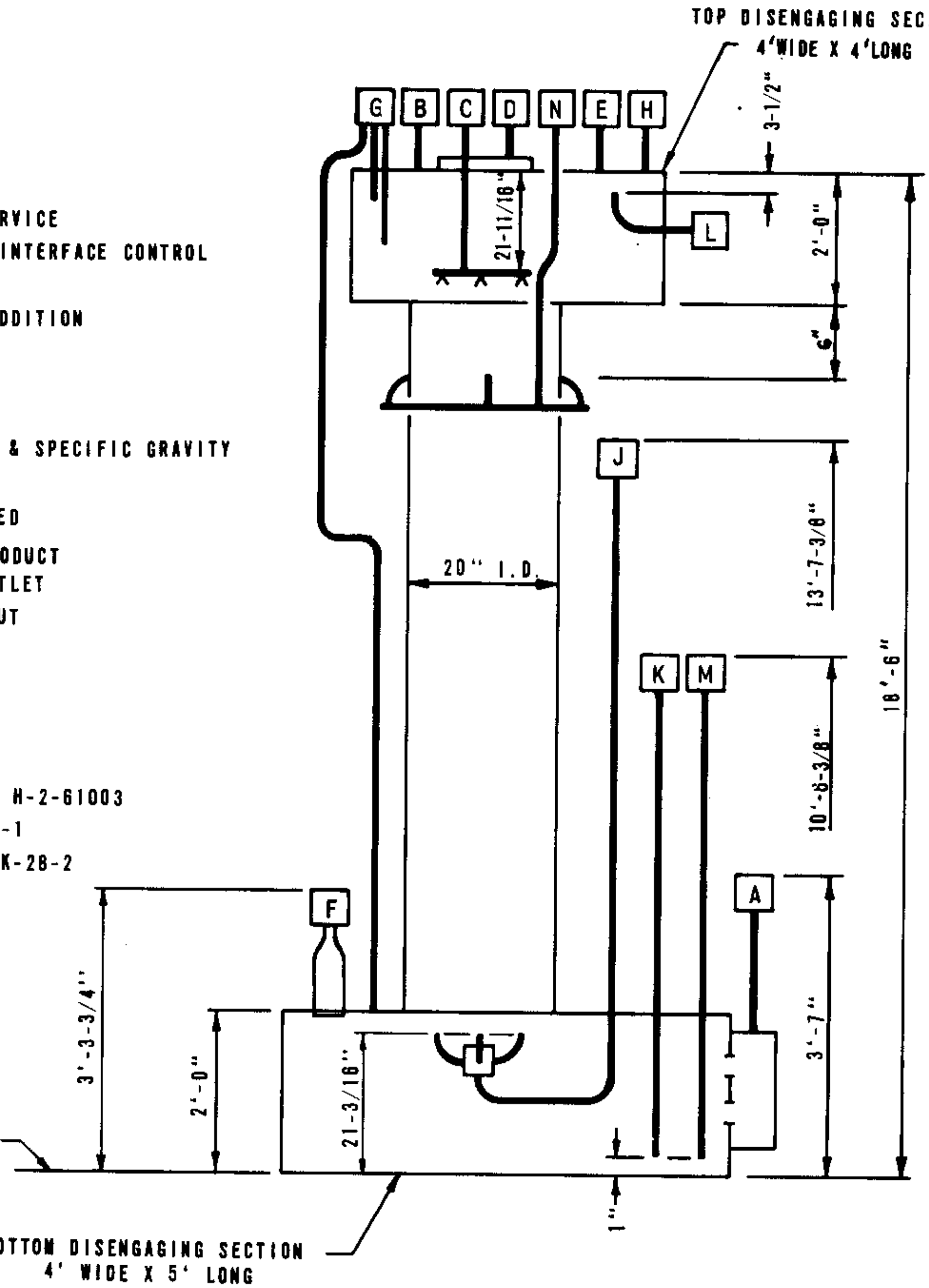


FIGURE X-3

T-28-1, 1B Column

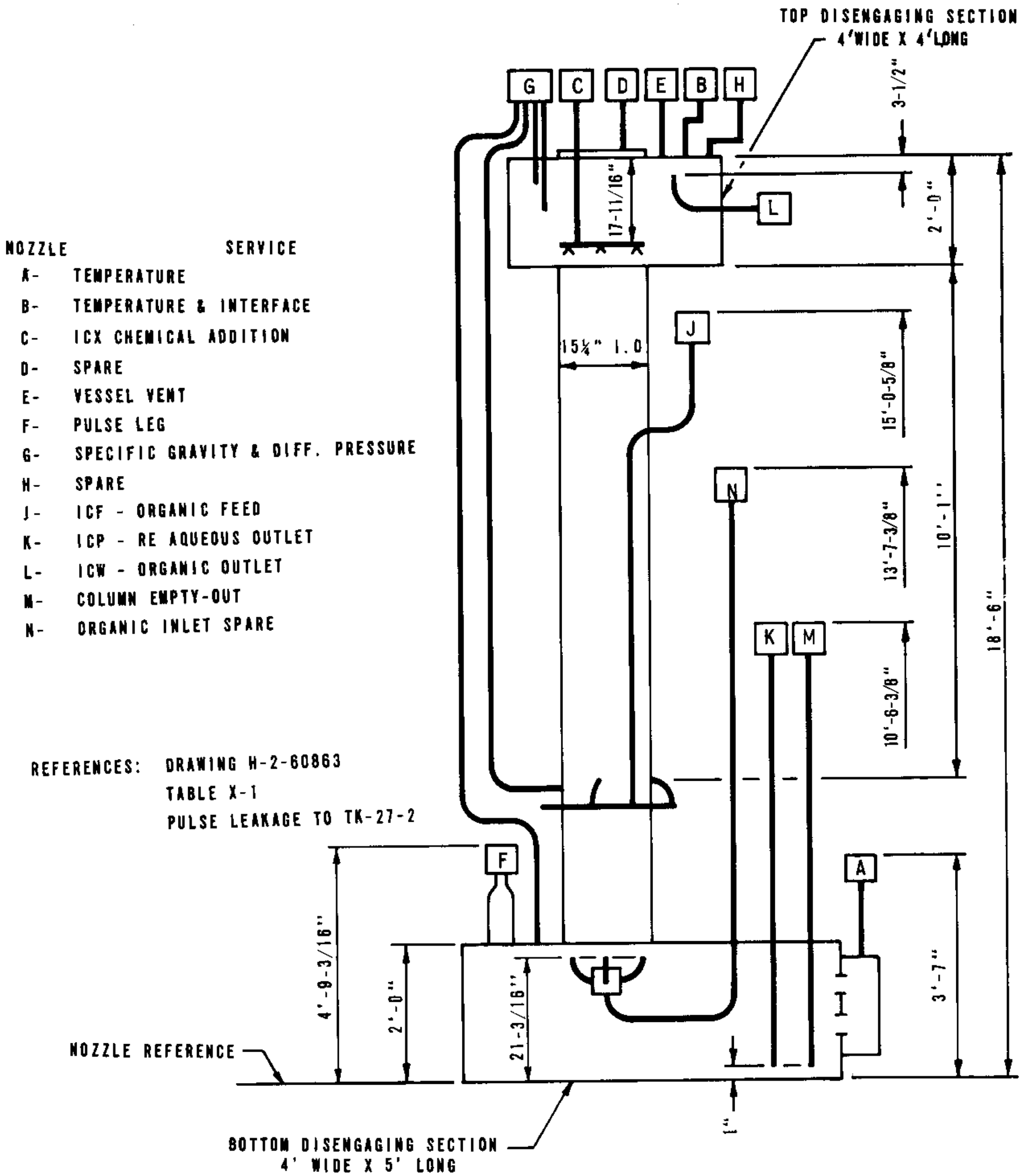


FIGURE X-4

T-27-1, 1C Column

1.2 Sieve Plates

The countercurrent flow sections of the four pulse columns are fitted with horizontal stainless steel sieve plates. The plates in the 1S, 1B, and 1C Columns have 1/8-inch diameter holes spaced 3/8-inch apart, center to center, in an equilateral triangular arrangement. The free perforated area of the plate is about 10 percent. The holes in the 1A Column plates are 0.1875 inch in diameter and are spaced in the same array. The free perforated area of the 1A Column plate is about 22 percent. The holes are formed in such a way they act as nozzles which point downward in the 1A and 1B Columns and upward in the 1S and 1C Columns.

All plates are spaced 2 inches apart except for the upper section of the 1C Column which has a four-inch plate spacing.

1.3 Louver Plates

Each of the columns except the 1C Column is equipped with a louver plate located midway up the column six inches above the bottom section of plates and six inches below the upper section of plates. The purpose of the louver plates is to impart a swirling motion to the column contents and to break up channeling. Vertical baffles are placed in front of the louvers to provide additional agitation.

1.4 Cartridge Construction

The stainless steel sieve and louver plates are assembled in a cartridge which can be inserted in the column as a unit. In the 1A, 1S, and 1B Columns, the plates are supported by thirteen, 3/4-inch tie rods connected at the top and bottom of the cartridge to support "spiders". Sections of 3/4-inch schedule 40 pipe slipped over the rods are used to hold the plates apart. For the 1C Column the plates are supported by nine, 1/2-inch diameter tie rods with 1/2-inch schedule 40 pipe used for spacers.

1.5 Distributors

The influent stream distributors are designed to provide reasonably uniform phase distribution across the column cross-section area without unnecessary complexity of design. Each column has a four-nozzle organic distributor located 21-3/16 inches above the bottom of the lower disengaging section which is 3-7/8 inches below the bottom sieve plate. The aqueous distributor in each column is located 7-1/4 inches above the top sieve plate. This aqueous distributor is attached to and is part of the remotable cartridge. In addition to these two distributors, the

1A and 1B Columns have a second aqueous distributor located 30 inches below the top of the upper disengaging section which would place it 1-1/16 inches below the top sieve plate. This distributor consists of eight nozzles equally spaced around the column and directed radially towards the center of the column. The 1C Column has an additional organic distributor 77 inches above the bottom of the lower disengaging section which would place it 55-3/16 inches above the lower organic distributor. The design of the intermediate 1C Column distributor is similar to the lower aqueous distributors on the 1A and 1B Columns.

2. Pulse Generators

The aqueous and organic liquid phases in the pulse columns are forced alternately upwards and downwards through the perforated plates in the columns to cause intimate mixing of the phases and, hence, good extraction. The pulsing of the liquid contents of the columns is done by means of reciprocating piston devices called pulse generators. A diagram of the pulse generators is shown in Figure X-5.

The pulse is generated by means of a 16-inch diameter piston. The amplitude of the pulse is preset at two inches in the 1A, 1S, and 1B Columns, and one inch in the 1C Column. However, the frequency of the pulse may be varied from 25 to 90 cycles per minute during column operation. The pulse is transmitted hydraulically to the liquid contents of the solvent extraction column through a pulse leg at the bottom of the column.

2.1 Piston and Cylinder Assembly

The 16-inch piston operates in a cylinder 27 inches long and flanged at the lower end to a reducer which adapts the cylinder to the 8-inch diameter pulse leg. The cylinder head contains a bushing of Graphitar 41 centered concentrically with the bore of the cylinder. The bushing, with a nominal bore of three inches, provides a 0.004 inch diametrical clearance with the piston rod and restricts leakage of vapor and mist from the cylinder. A two-inch overflow line in the cylinder wall just above the piston allows solutions which leak past the piston to flow by gravity to a tank containing a solution of the same phase as is present at the bottom of the column. A 3/32-inch weep hole originally present in each piston has been plugged to reduce the pulse leakage rates to less than 0.2 gpm.

2.2 Pulse Leg

The pulse is transmitted from the pulse generator to the lower disengaging section of the solvent extraction column through an eight-inch diameter pulse leg approximately six feet long. The pulse leg

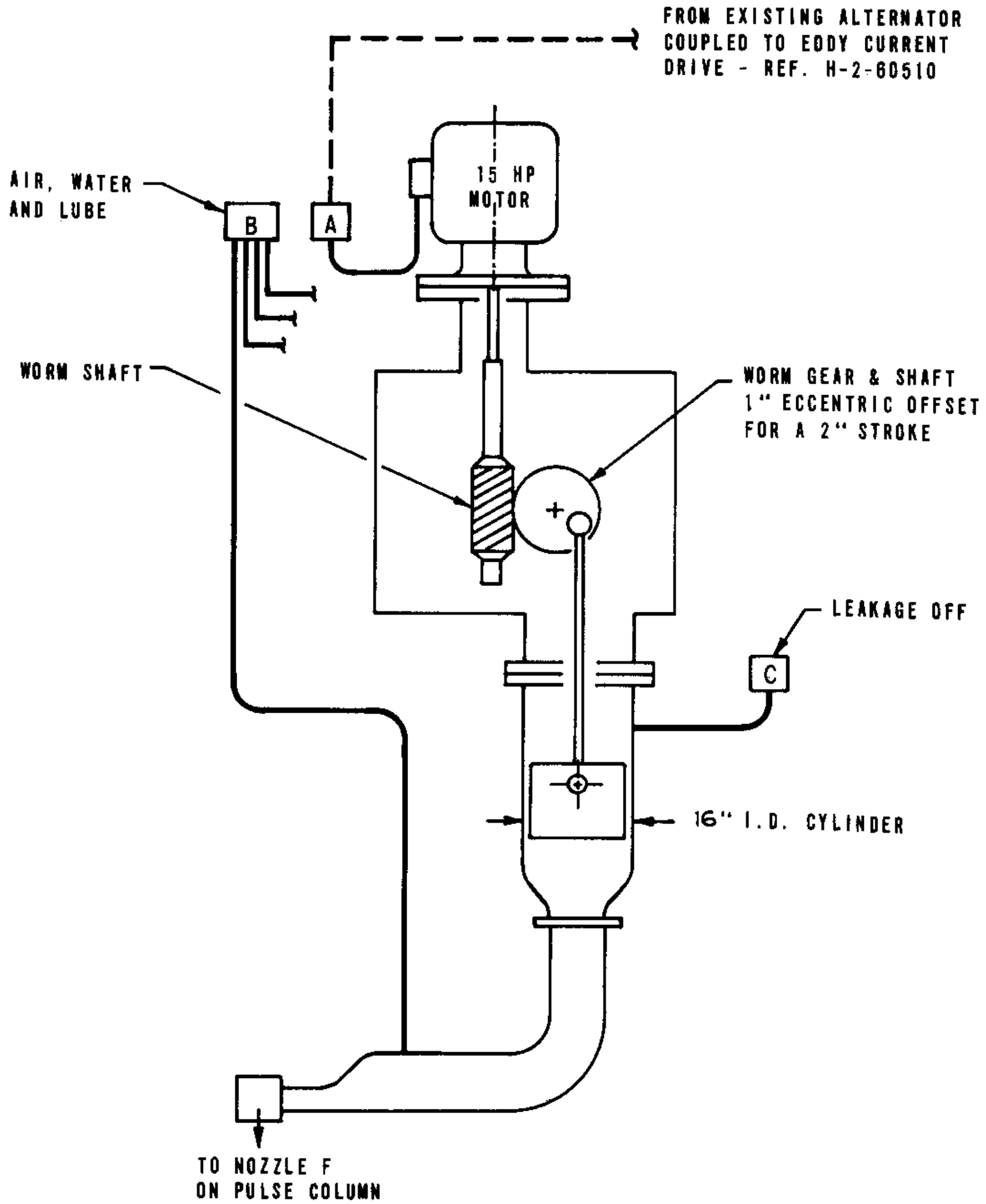


FIGURE X-5

PULSE GENERATOR
PS-27, PS-28, PS-29, PS-30

is equipped with an air or water purge. The air purge is used when the column is shut down to prevent excessive leakage of liquid past the piston. However, before operating the pulse generator the pulse leg must be filled with liquid to provide proper lubrication for the piston. The pulse leg is filled with organic phase for the 1A Column, and with an aqueous phase in the 1S, 1B, and the 1C Columns.

2.3 Motion Box

The motion box reduces the speed of the variable speed electric motor, and converts the rotary motion of the motor to reciprocating motion. The variable speed electric motor is a vertically mounted, 15-horsepower, 440-volt, 3-phase, totally enclosed-fan cooled, 55 C-rise, induction motor having Class B insulation and constant torque loading the motor operates over a speed range of approximately 1800 to 497 rpm from a variable-frequency motor-generator set power supply. The power supply is described in 2.4 below.

The driving motor is directly connected to a worm shaft by means of a spline joint. The worm threads engage a 20-inch diameter worm gear which provides a reduction ratio of 18-1/2 to 1. The worm gear is keyed to a 4-1/4-inch worm gear shaft. The worm gear shaft is provided with an overhanging stub, 3 inches in diameter, which is eccentric to the shaft.

A slide block is fixed to the eccentric shaft of the worm gear by means of lock nuts. The slide block supports a cast iron yoke which is free to move vertically up and down, but is otherwise fixed in position on guide rods. Thus, eccentric movement of the worm gear shaft is transmitted into vertical reciprocating motion. The piston rod is attached to the yoke through the top of the box by means of yoke arms and tie rods. Connections through the top of the box this way reduces the chance of oil leakage through seals.
All moving parts in the motion box are lubricated by oil directed through nozzles to the gear set and moving parts. The motion box contains 20 gallons of oil which is recirculated by means of a gear pump driven from the worm gear shaft. Oil is changed at regular intervals by introducing fresh oil through a remote connector. An overflow line in the motion box allows the waste oil to be flushed to a waste oil container mounted on the side of the unit.

2.4 Electric Power Supply

The electric power supply delivers variable frequency power to the variable speed induction motor that drives the pulse generator. The variable frequency alternating current is generated by means of a General Electric Company Type AT1-924, 9.0/2.75-IVA, 1800/497-rpm, alternator. The alternator is driven by an Easton, Yale, and Towne type GCA, 15-hp, 1755-rpm, 220/440-volt, 3-phase induction motor, connected through an eddy current coupling adjustable speed drive. The eddy current coupling is an Easton, Yale, and Towne Company model MO-100001-0905 capable of speed variations from 1680 to 100-rpm. The dc current used to excite the field of the alternator is provided by General Electric Company Type B-254, 3-Kw, 1750-rpm, 125-volt, generators directly connected to a standard induction motor. The five alternators (one for each pulser plus a spare) along with the other power supply equipment, are located in the electrical gallery adjacent to Cells 28, 29, and 30.

D. CENTRIFUGES

1. General Description

Cells 12, 13, and 32 each have a centrifuge and a supernatant receiver. The principal components of a centrifuge include: a) a solid cylindrical bowl; b) a vertical spindle from which the bowl is axially suspended; c) an electric motor directly connected to the spindle; and d) an outer cylindrical case which encloses the rotating bown. These components are mounted on a raised concrete foundation so that the bowl effluent will drain by gravity through an opening near the bottom of the outer cylinder to the supernatant receiver. The entire assembly is designed for remote operation and maintenance. All parts in contact with process solutions or fumes are stainless steel. A sketch of a centrifuge is shown in Figure X-6.

2. Centrifuge Bowl

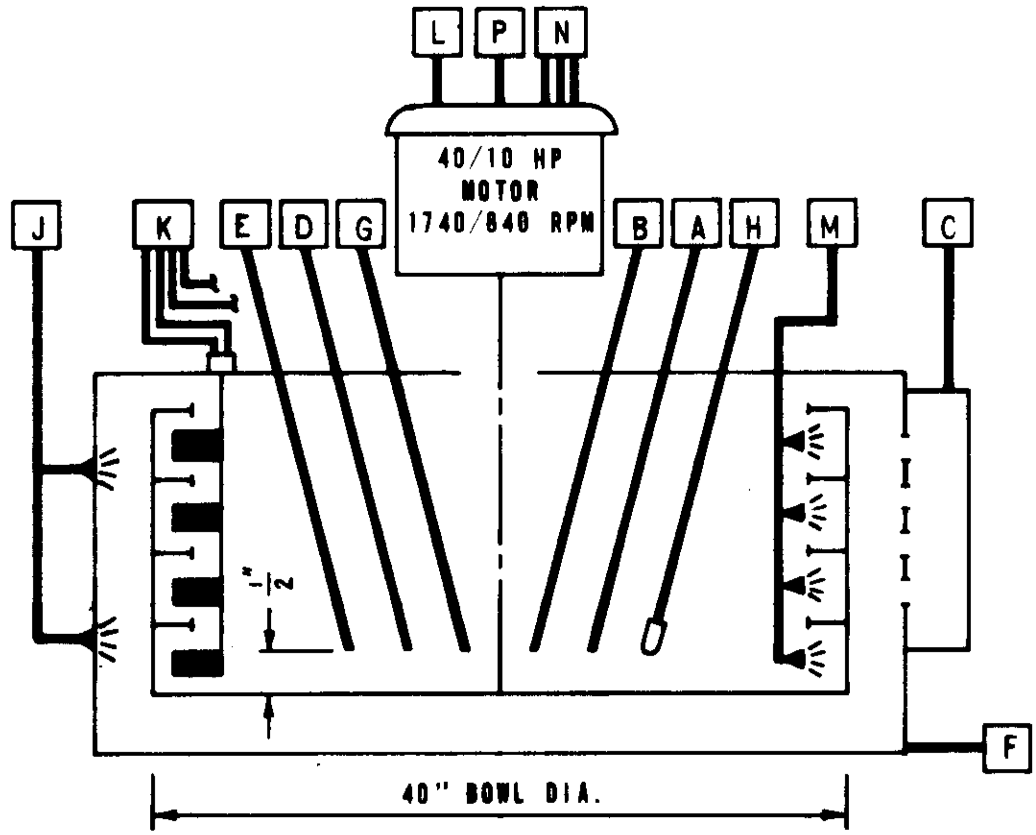
The bowl of the centrifuge is solid and measures 40 inches in diameter and 24 inches in height. The capacity of the bowl when not spinning is 120 gallons; however, during operation the maximum hold-up is 60 gallons. The hold-up may be reduced by adjusting hydraulically-operated skimmers with which each centrifuge is equipped. Three horizontal baffle plates with weep holes are equally spaced around the inside of the bowl. The bowls and the cases are equipped with sprays supplied by 230-foot head pumps from scale tanks located in the operating gallery.

3. Electrical Features and Instrumentation

A 440-volt, 40-hp electric motor rotates the bowl at 1740 rpm or 870 rpm with a corresponding centrifugal force of 1720 G's (1720 times the force of gravity) and 430 G's. It is possible to obtain other centrifuge speeds by intermittent operation of the drive motor.

A centrifuge is slowed or braked by applying a direct current to the motor windings after the ac power has been removed.

Each centrifuge is equipped with a tachometer, a weight factor manometer, a vibration meter, and a temperature element in the bottom of the bowl.



NOZZLE	SERVICE
A-	CHEMICAL ADDITION
B-	PROCESS INLET
C-	BLANK
D-	PROCESS INLET
E-	SOLUTION OUT
F-	GRAVITY OUTLET TO RECEIVER
G-	LIQUID LEVEL
H-	TEMPERATURE
J-	CASE SPRAY OR CHEMICAL ADDITION
K-	HYDRAULIC CONTROL
L-	POWER TO MOTOR
M-	BOWL SPRAY
N-	LUBE
P-	SPEED INDICATOR

FIGURE X-6

CENTRIFUGE

G-32-2, G-13-2, G-12-2
Reference Drawing H-2-61009

E. ION EXCHANGE COLUMN

The ion exchange column, T-18-2, is a Class I vessel 6 feet in diameter and 15 feet high. For down-flow operation, solutions enter the column at the top through a cage three feet in diameter made of 80 mesh stainless steel screen attached to the inside top of the column. The screen cage covers the outlets to nozzles B, C, F, and H. Solutions are collected near the bottom of the column in a 10-arm "spider" 64 inches in diameter. The arms of the spider are covered with a 50-mesh stainless steel screen. The lower 13 feet of the column are filled with an ion exchange medium which is added to the column as a slurry through a nozzle which by-passes the top screen. The ion exchange media may be removed by jetting it through a drain line located below the bottom collection spider. Instrumentation on the ion exchange column includes an ion exchange medium level indicator, top and bottom pressure indicators, and a temperature indicator. Figure X-7 is a schematic sketch of the ion exchange column.

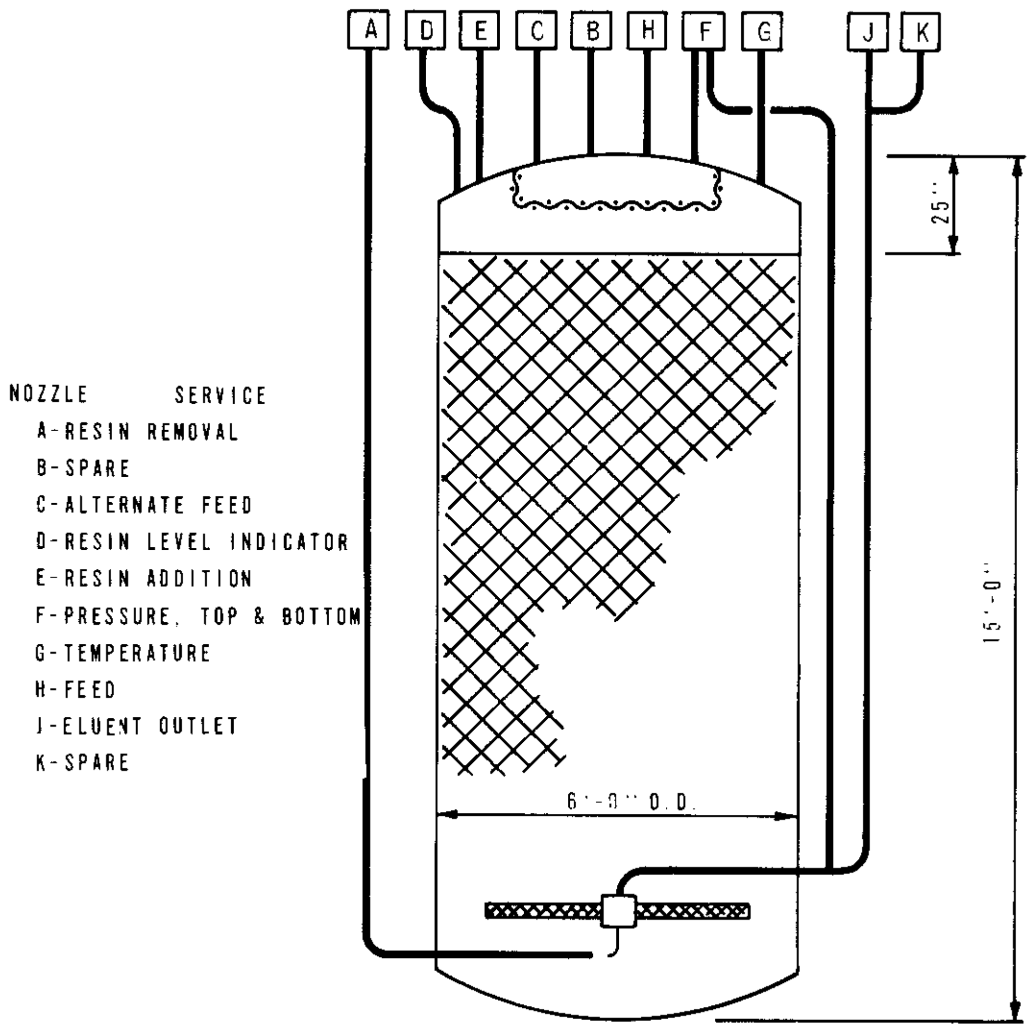


FIGURE X-7

Ion Exchange Column
Based on H-2-60840

F. CONCENTRATORS AND CONDENSERS

Concentrators are located in Cells 5, 20, and 23. The concentrators are of the vertical-tube, thermal-recirculation, steam-heated variety. The concentrators in Cell 5 and Cell 20 are used to concentrate strontium and cesium product solutions, respectively. The Cell 5 concentrator may also be used to concentrate rare earth solutions if required. Both of these concentrators have been modified from equipment in the Uranium Recovery Plant. The Cell 23 concentrator is of the Purex type. It is used to concentrate liquid wastes with the condensate going to an underground crib, and the concentrated bottoms to an In-Tank Solidification unit via non-boiling waste storage. Pertinent data for the concentrators are listed in Table X-3.

No.	Name	Capacity	Duty BTU/Hr.	Area ft^2	Bundle Description
E-5-2	SR Concentrator	300 Gal.	4,500,000	896	307 Vert. Tubes 1" x 12 BWG x 14'2-7/8"
E-20-2	CS Concentrator	300 Gal.	9,000,000	896	307 Vert. Tubes 1" x 12 BWG x 14'2-7/8"
E-23-3	Waste Concentrator	3,000 Gal.	30,000,000	1,850	West-687 Vert. Tubes 1-1/4" x 12 BWG x 10'
					East-630 Vert. Tubes 1" x 12 BWG x 10'
E-5-3	SR Condenser	----	4,500,000	895	342 Hor. Tubes 1" x 12 BWG x 10'
E-20-3	CS Condenser	----	9,000,000	895	342 Hor. Tubes 1" x 12 BWG x 10'
E-23-4	Waste Condenser	----	30,000,000	1,340	568 Hor. Tubes 1" x 12 BWG x 9'
E-22-3	Vessel Vent Heater	----	200,000	190	91 Hor. Tubes 1" x 12 BWG x 8'
E-22-4	Vessel Vent Condenser	----	2,000,000	895	342 Hor. Tubes 1" x 12 BWG x 10'
E-22-7	Scrubber Vent Heater	----	50,000	40	51 Hor. Tubes 1" x 12 BWG x 3'

TABLE X-3

CONCENTRATORS AND CONDENSERS

1. Product Concentrators

The product concentrators each have one tube bundle containing 307 one-inch No. 12 B.W.G. tubes 14 feet 2-3/4 inches long. The outside surface area of the tubes is 1197 square feet. The concentrators are operated with process solution on the tube side and steam on the shell side. The over-all dimensions of the tube bundle section are 25-1/2 inches in diameter and 15 feet high.

Below the tube bundle is an enlarged section 54 inches in diameter and 12 inches high. Above the tube bundle is the vapor section 54 inches in diameter and 37-1/16 inches high. A reverse-dished impingement plate which deflects the percolated liquid is located in the vapor shell. The impingement plate effects a separation of liquid and vapor. The vapor section and the bottom section are connected with an eight-inch downcomer which allows recirculation of the concentrated liquid.

Directly above the vapor section is a deentrainment section 54 inches in diameter and 32-3/16 inches high containing a mist separator and spray nozzles. The mist separator, consisting of "Z" barrles, removes the entrained droplets of liquid from the vapors and returns the liquid to the deentrainment section through a seal pot. The seal pot prevents vapors from by-passing the impingement plate and traveling directly to the mist separator.

Semicircular baffles, acting as tube supports, are located in the steam chest of each evaporator. The baffles prevent channeling of steam through the tube bundles. Expansion joints in both the evaporator shells and downcomers minimize strain due to large temperature changes. A schematic sketch of the concentrator in Cell 5 is shown in Figure X-8 and a sketch of the concentrator in Cell 20 is shown in Figure X-9.

2. Waste Concentrator

The large waste concentrator in Cell 23 has two remotable stainless steel tube bundles located in 55-inch diameter cylinders 14 feet 5 inches high. The two tube bundles are of different design with the west bundle having a surface area of 1850 square feet and the east bundle having a surface area of 1290 square feet. The west bundle has 687 tubes, 1-1/4 inches O.D., No. 12 B.W.G., 10 feet long. The east bundle contains 630 tubes, 1-inch O.D., No. 12 B.W.G, 10 feet long.

A 30-inch diameter draft tower sits between the tube bundles which allows liquid to circulate down the draft tower and back into the bottom of the tube bundle sections. The shells containing the tube bundles are connected to the draft tower by 21-inch diameter pipes at the bottom and by 4-feet 7-inch by 6-foot rectangular ducts on top.

The stripping and deentrainment section is 60 inches in diameter by 7 feet 1-1/8 inches high. It rests on the ducts that join the side cylinders to the top of the draft tube. The vessel contains four sets of spray nozzles located 9 inches, 31 inches, 58 inches and 73 inches below the top of the vessel. Above and below the second set of spray nozzles are two entrainment separator pads. These pads are 6 inches thick and are made of 0.006-inch diameter stainless steel wire. The upper pad has a density of 14 lbs/ft^3 and the lower pad has a density of 6 lbs/ft^3. A 16-inch flanged nozzle at the top of the deentrainment section is the vapor outlet leading to the condenser.

An overflow column for the concentrated solution is located next to the draft tower. This column, which has a diameter of 18 inches, contains the weight factor and specific gravity dip tubes. An elevation sketch of the concentrator is shown in Figure X-10 and a plan view of the concentrator is shown in Figure X-11.

3. Condensers

The horizontal, multi-pass, water-tube condensers located in Cells 5 and 20, have been modified and relocated from 221-U Building. Each condenser has 342 tubes, 10 feet long. The surface area of the tubes is 895 square feet, and there are 9 tube passes. Seven segmental baffles spaced throughout the length of each condenser distribute the vapor flow through the shell. An expansion joint is provided in the condenser shell to relieve stresses caused by shell temperature changes. Condenser 20-3 is equipped with four water spray nozzles. A sketch of the condenser in Cell 5 is shown in Figure X-12 and a sketch of the condenser in Cell 20 is shown in Figure X-13. Table X-3 lists pertinent data on the condensers.

The condenser on the Waste Evaporator in Cell 23 is also a horizontal, multiple-pass, water-tube type containing 568 tubes 9 feet long. The surface area of the tubes is 1340 square feet. Four segmental baffles serve to channel the vapor flow through the condenser. The cooling water makes six passes through the condenser. The design duty of the condenser is 30 million Btu/hr. Figure X-14 is a sketch of the condenser, and Table X-3 contains pertinent data on the condenser.

G. AMMONIUM CARBONATE ABSORBER

The ammonium carbonate absorber, T-21-2, is used to adsorb ammonia and carbon dioxide gas in water to make a solution of ammonium carbonate and ammonium hydroxide. The absorber which sits on top of TK-21-1 has an over-all height of 6 feet 6 inches, and an outside diameter of 22 inches. A five-foot section of the column is packed with 3/4-inch porcelain Intalox* saddles. Liquid is pumped from TK-21-1 to the top of the tower where it is allowed to trickle down through the packing back into the tank through a sieve plate on the bottom. Gases not absorbed by the recirculated liquid exit the top of the tower and enter the No. 2 vessel vent system in Cell 22. A sketch of the ammonium carbonate absorber is shown in Figure X-15.

* Trade name of U.S. Stoneware Company

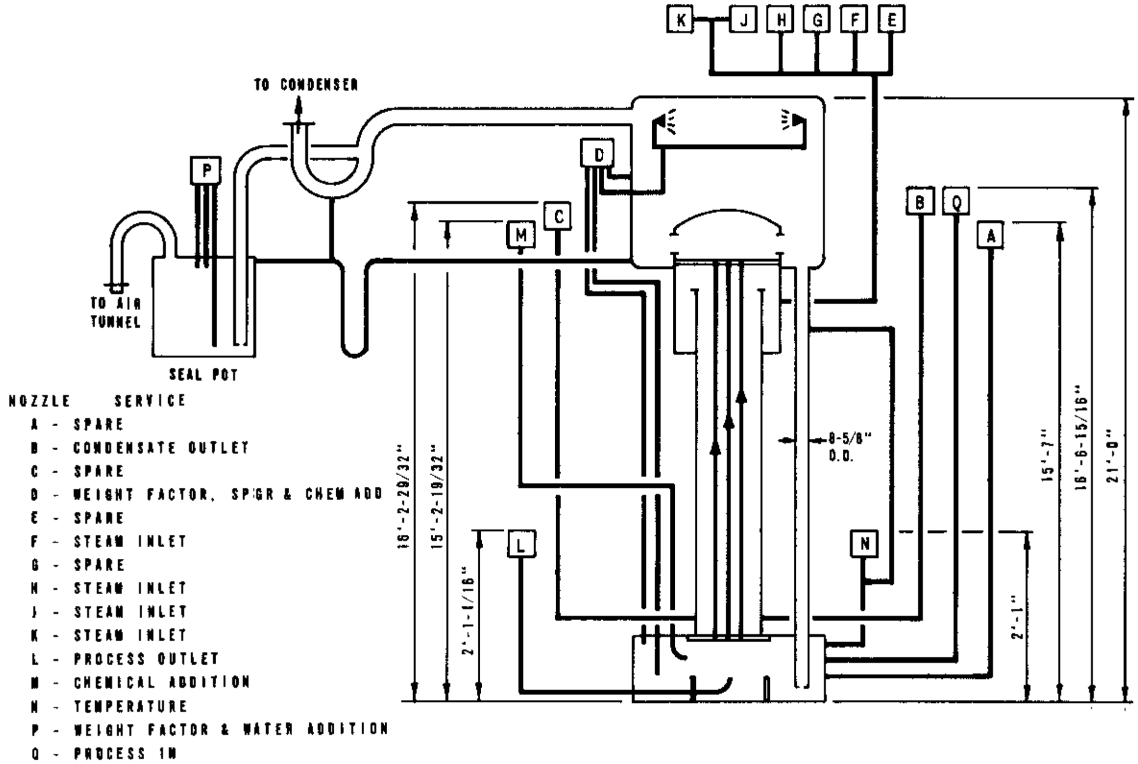


FIGURE X-8

E-5-2 Concentrator
Based on H-2-60942

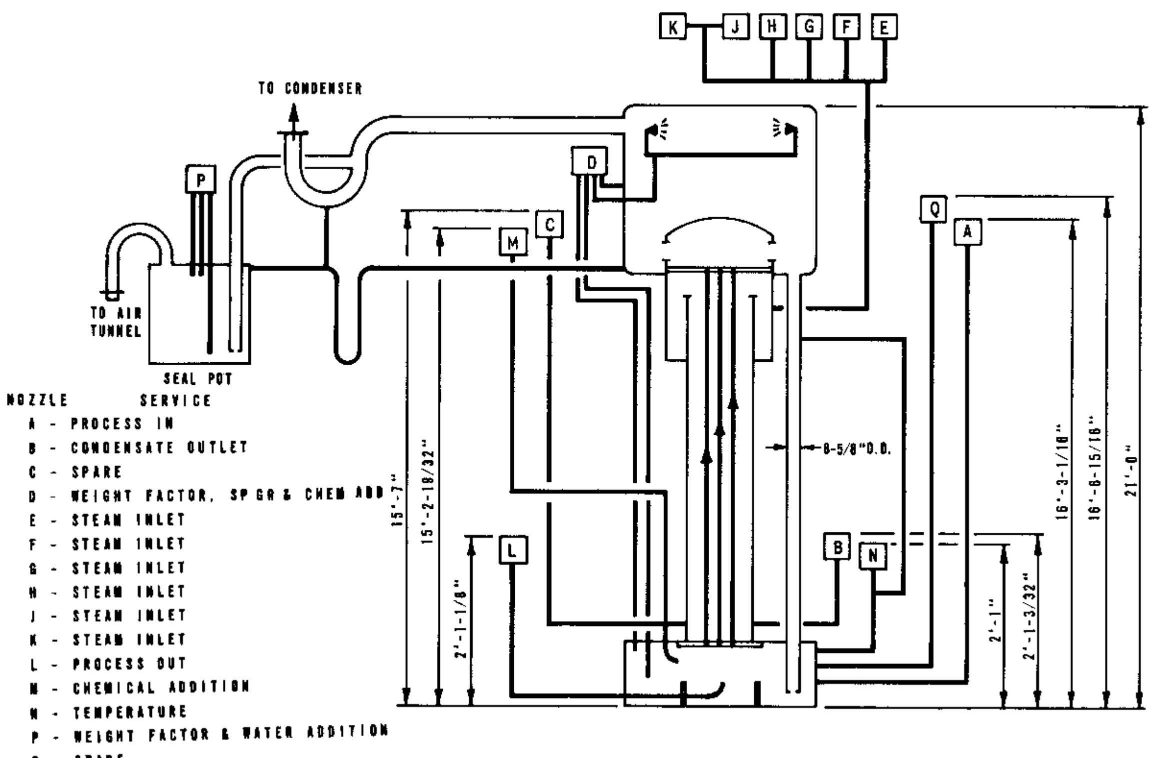
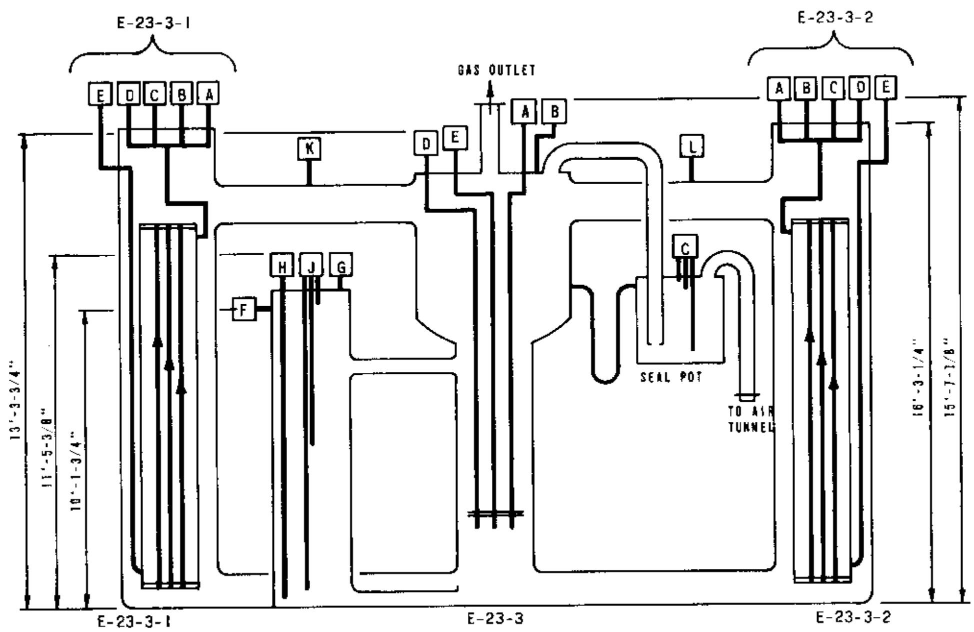


FIGURE X-9

E-20-2 Concentrator
Based on H-2-60945



REFERENCE DRAWING H-2-58043 | REFERENCE DRAWING H-2-60851 | REFERENCE DRAWING H-2-58043

E-23-3-1

NOZZLE	SERVICE
A-	STEAM INLET
B-	STEAM INLET
C-	STEAM INLET
D-	STEAM INLET
E-	CONDENSATE OUTLET

E-23-3

NOZZLE	SERVICE
A-	PROCESS IN
B-	CHEMICAL ADDITION
C-	WEIGHT FACTOR & WATER ADDITION
D-	LIQUID RETURN
E-	SPARE
F-	PROCESS OVERFLOW
G-	SPARE
H-	PROCESS OUT
J-	WEIGHT FACTOR & SPECIFIC GRAVITY
K-	TEMPERATURE
L-	SPARE

E-23-3-2

NOZZLE	SERVICE
A-	STEAM INLET
B-	STEAM INLET
C-	STEAM INLET
D-	STEAM INLET
E-	CONDENSATE OUTLET

FIGURE X-10

E-23-3 Concentrator

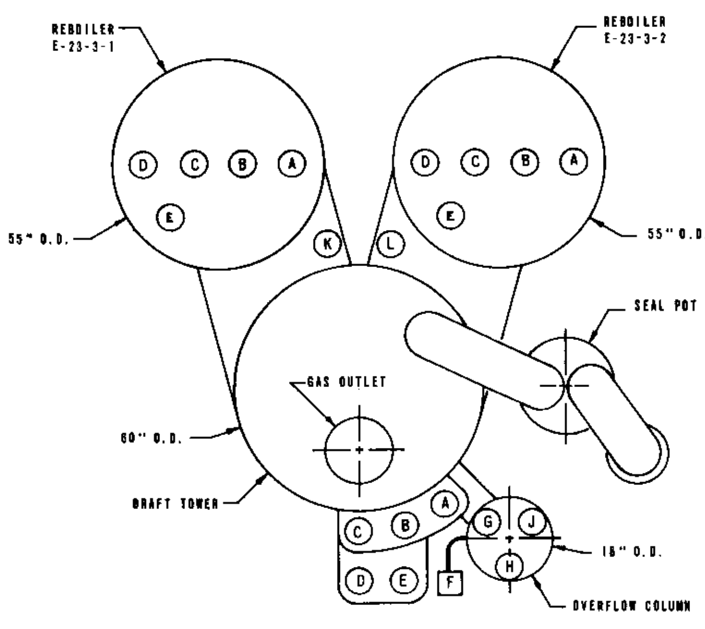
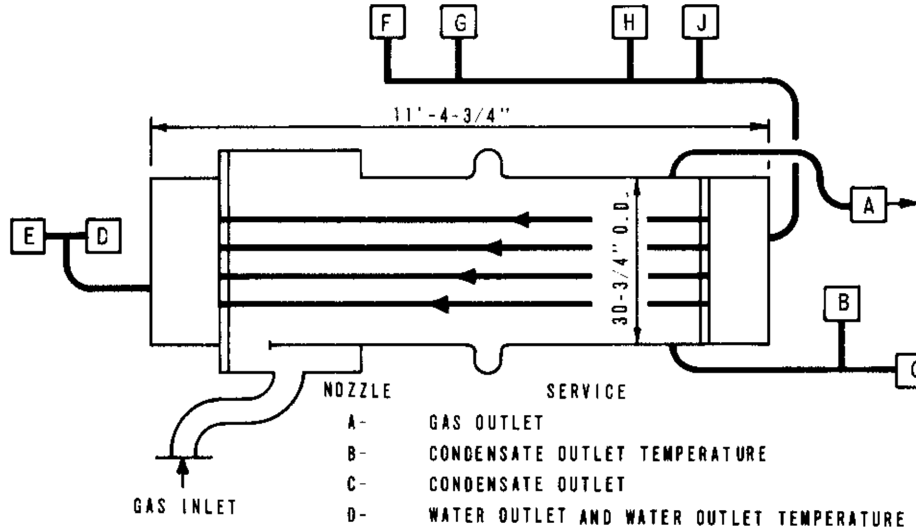


FIGURE X-11

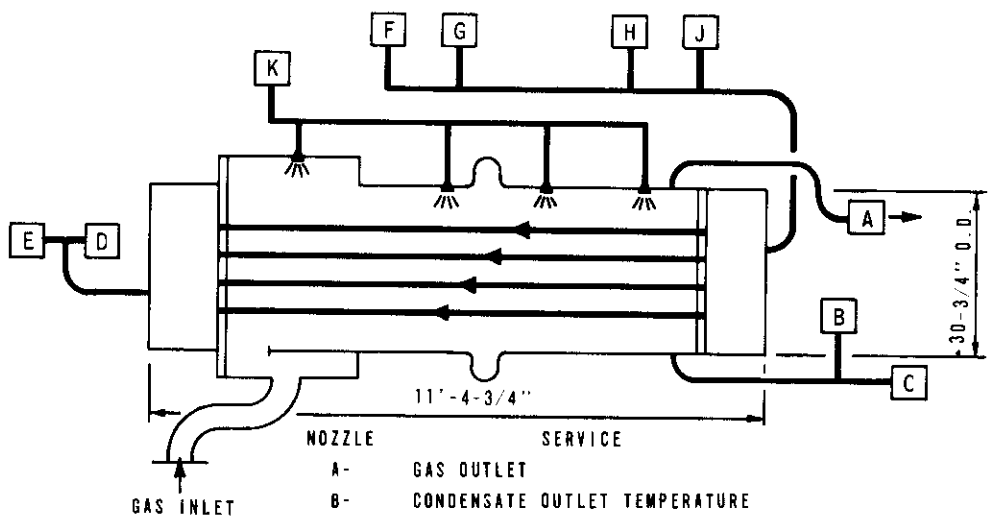
E-23-3 Concentrator - Plan View



NOZZLE	SERVICE
A-	GAS OUTLET
B-	CONDENSATE OUTLET TEMPERATURE
C-	CONDENSATE OUTLET
D-	WATER OUTLET AND WATER OUTLET TEMPERATURE
E-	SPARE
F-	SPARE
G-	WATER INLET
H-	WATER INLET
J-	WATER INLET

FIGURE X-12

E-5-3 Condenser
Based on H-2-60948



NOZZLE	SERVICE
A-	GAS OUTLET
B-	CONDENSATE OUTLET TEMPERATURE
C-	CONDENSATE OUTLET
D-	WATER OUTLET TEMPERATURE
E-	WATER OUTLET
F-	WATER INLET
G-	WATER INLET
H-	WATER INLET
J-	WATER INLET
K-	SPRAY WATER INLET

FIGURE X-13

E-20-3 Condenser
Based on H-2-60948

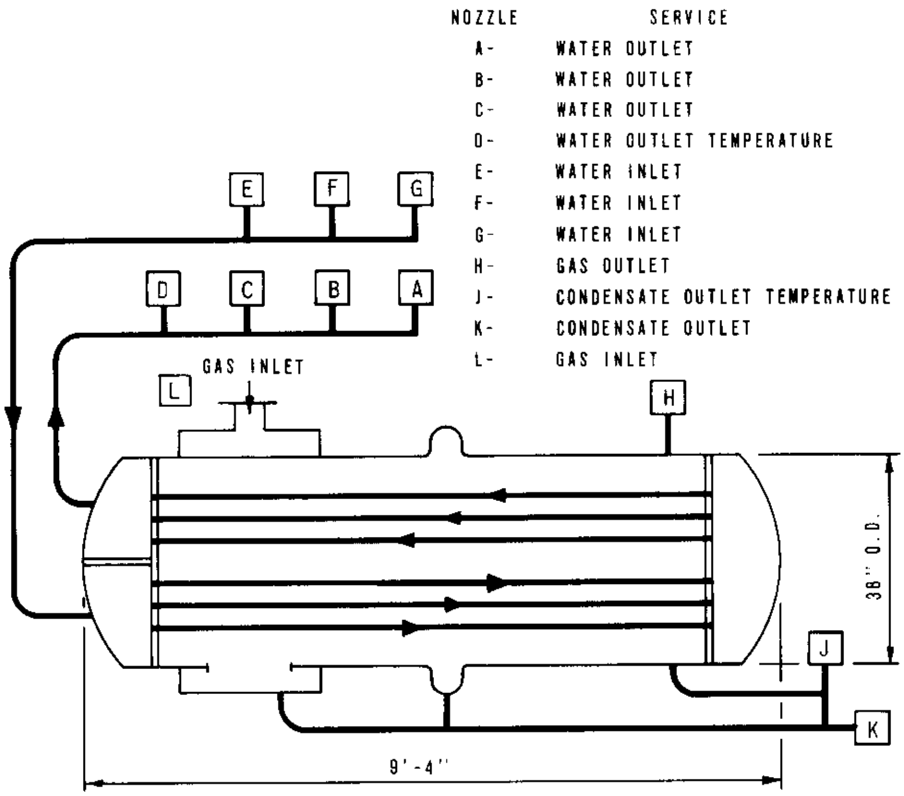


FIGURE X-14

E-23-4 Condenser
Based on H-2-60854

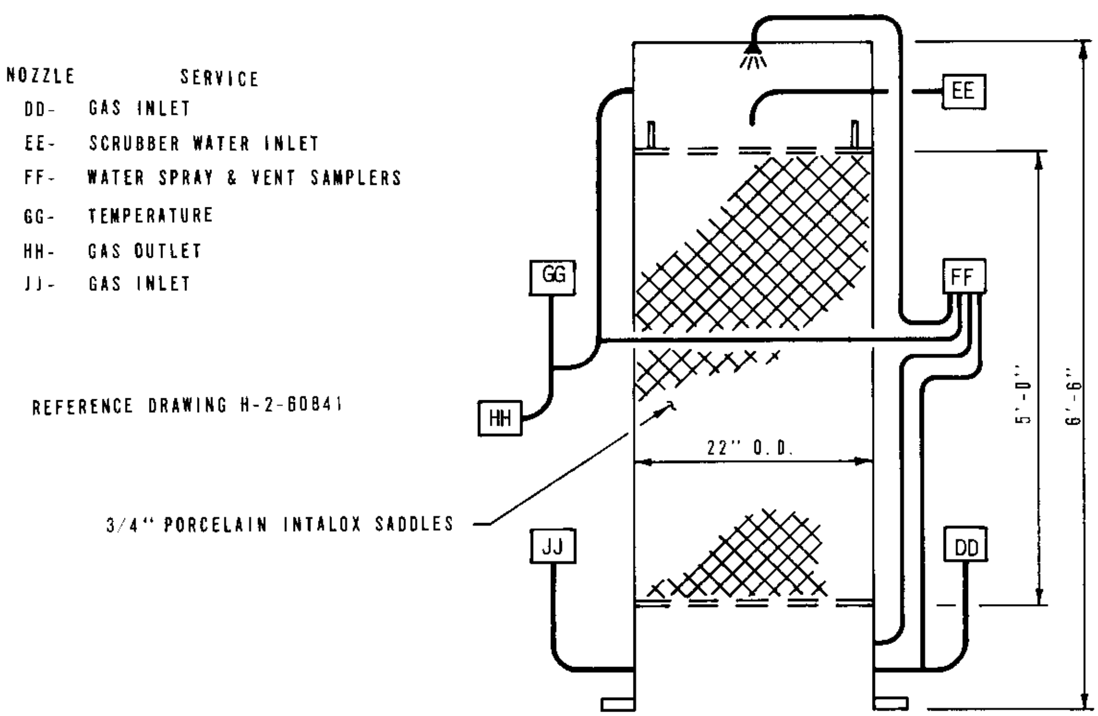


FIGURE X-15

T-21-2 Ammonia Carbonate Absorber
Based on H-2-60841

H. VESSEL VENT SYSTEMS

1. Vessel Vent System No. 1 (Normal)

1.1 Vent Gas Heater

The vent gas heater, E-22-3, is 9 feet, 7-1/2 inches long and has an outside diameter of 18 inches. Heat is supplied by 100 psig steam delivered to 91 tubes, 8 feet long. Three segmented baffles distribute the vapor flow through the shell. Figure X-16 is a sketch of the vent gas heater.

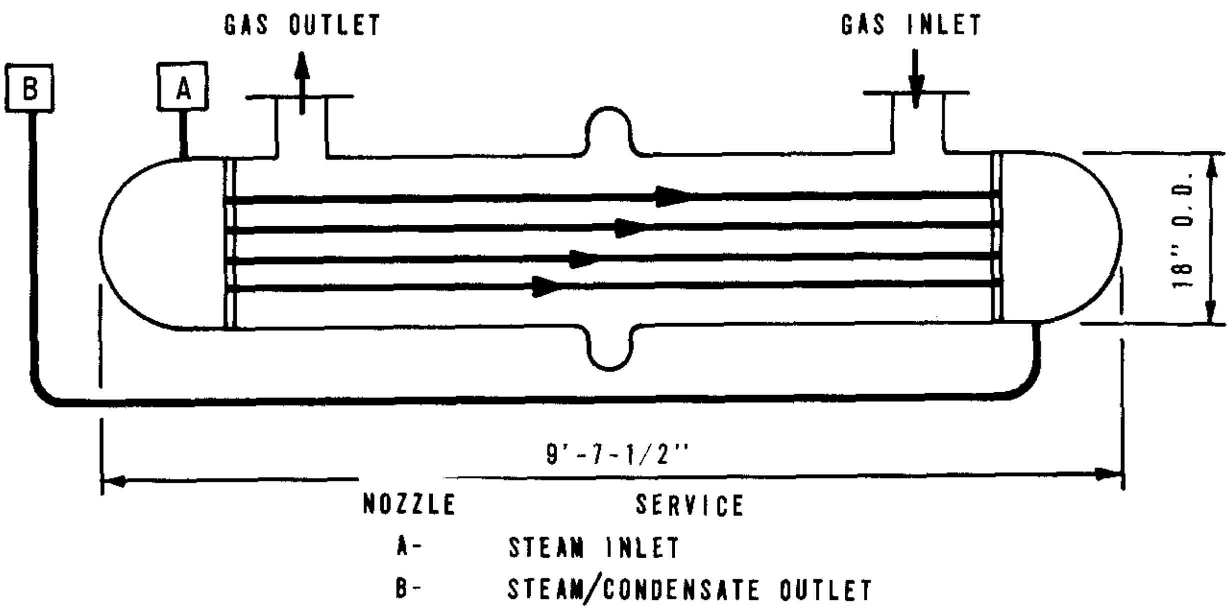


FIGURE X-16

E-22-3 Vent Gas Heater
Based on H-2-60843

1.2 Filter

Filter, E-22-5, consists of two banks of two CWS high efficiency fiberglass filters stacked on top of each other. Each filter is 24 inches square and 11-3/4 inches deep. The second bank of filters is located six inches downstream from the first bank.

1.3 Condenser

Condenser, E-22-4, has been relocated from 221-U Building and is nearly identical to the condensers in Cells 5 and 20. The condenser contains 342 tubes arranged for 9 tube passes. There are seven segmented baffles distributed through the length of the condenser. An expansion joint in the condenser shell is provided to relieve stresses caused by shell temperature changes. Condenser is shown in Figure X-17, and pertinent data are given in Table X-3.

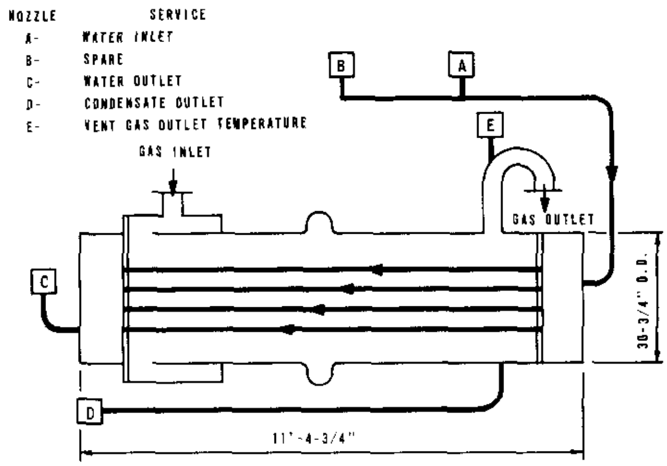


FIGURE X-17

E-22-4 Condenser .
Based on H-2-60968

2. Vessel Vent System No. 2 (Ammonia)

2.1 Ammonia Scrubber

The ammonia scrubber tower, T-22-2, which sits on top of TK-22-1, is 16 feet, 8 inches high and has an outside diameter of 26 inches. A large vapor to liquid contact area is provided by 3/4-inch Intalox* porcelain saddles. The packing is 13 feet, 9 inches high and starts one foot above the bottom of the tower. Liquid enters the top of the tower (through one spray nozzle), trickles down through the packing, and drains into TK-22-1 through a dip leg. A York style moisture entrainment separator or demister, located 11 inches above the packing in the center of the tower, is 4-5/8 inches in diameter and 4 inches in height. Figure X-18 is a sketch of the scrubber tower.

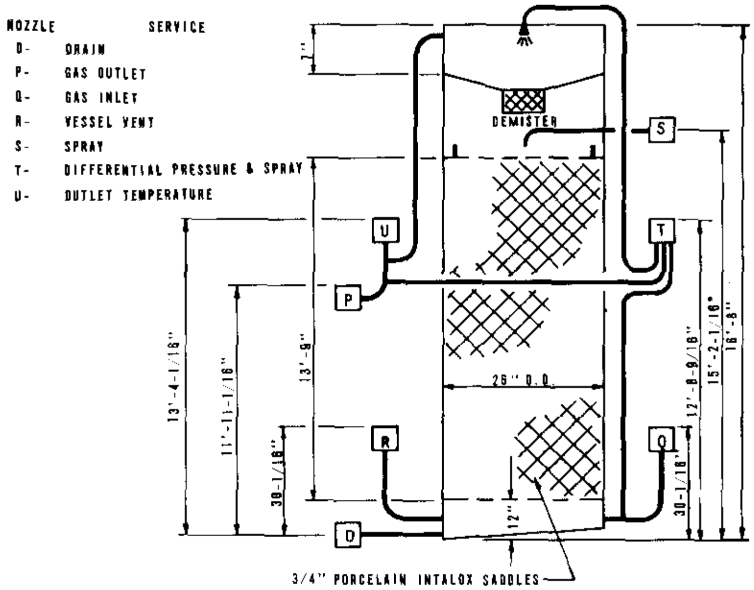


FIGURE X-18

T-22-2 Ammonia Scrubber Tower
Based on H-2-60842

* Trade name of U.S. Stoneware Company

2.2 Vent Gas Heater

The vent gas heater, E-22-7, is 56 inches long and has an outside diameter of 12-3/4 inches. Steam at 100 psig is supplied to 51 tubes, 3 feet in length. There are two baffle plates in the heater. Figure X-19 is a sketch of the heater and Table X-3 contains pertinent data.

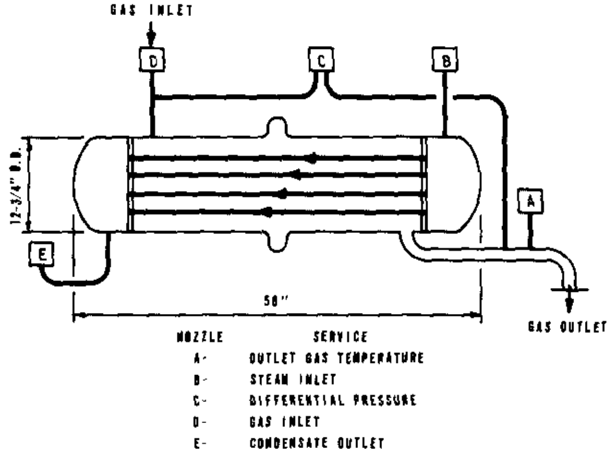


FIGURE X-19

E-22-7 Heater
Based on H-2-60845

2.3 Filters

A sketch of the fiberglass prefilter, F-22-6, is shown in Figure X-20. Filters F-22-8-1 and F-22-8-2 each consist of two CWS high efficiency fiberglass filters in series. Each CWS filter is 24 inches square and 11-3/4 inches deep. Filter, F-22-9, is located in a pit on the south side of the 221-Building adjacent to Cell 22. The F-22-9 filter is identical to F-22-8. Additional discussion of the vessel vent systems is given in Chapter IX, Section B 6.

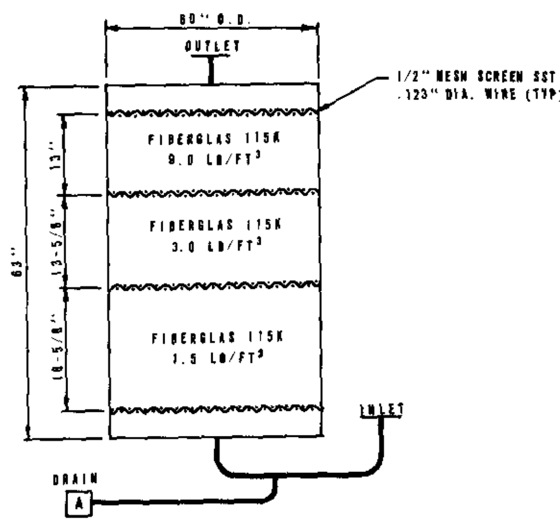


FIGURE X-20

Fiberglass Prefilter

I. AUXILIARY EQUIPMENT

The following section on auxiliary equipment deals primarily with the mixing and transfer of solutions in the process.

1. Pumps

The majority of pumps used in the Waste Management Facilities have been relocated from 221-U Building. Those pumps which are new have been built to U-Plant design. Pumps located within the process tanks are supported and fixed on the top of the vessel by means of a mounting flange resting on a nozzle flange. A vertical column, containing the pump stages as an integral part, extends downward the desired distance. The number of stages in the pump is determined by the desired head and capacity required. Solutions enter the pump axially at the lower end of the column and pass vertically upward from stage to stage through the column. The pumped solution is discharged radially through a side arm at the top of the column section just above the mounting flange. The drive shaft extends concentrically through the column and is guided by sleeve bearings lubricated by the pumped solution. The drive shaft is directly coupled to the shaft of the electric pump motor mounted above the mounting flange. The weight of the shaft and the thrust developed during operation are absorbed by the motor bearings. A throttle bushing is provided at the point where the drive shaft emerges from the column section. Leakage past the throttle bushing is returned to the vessel. Table X-4 is a summary of the pumps.

TABLE X-4

PUMP SUMMARY

Pump EPN	Capacity gpm	Head ft	Motor hp	Service	Dimensions (feet)	Pump Heel (gal)
244-AR-P-001	100	355	20	PAW Storage	20∅ x 20	400*
244-AR-P-002-1	600	390	150	Slurry Receiver	20∅ x 20	14,000*
244-AR-P-002-2	50	38	2	Slurry Receiver	20∅ x 20	1,200*
244-CR-P-003	50	100	5	PAS Storage	14∅ x 12	584
P-13-1	50	50	2	Centrifuge Supernatant Receiver	9∅ x 9	55*
P-17-2	50	80	2	Cesium Supernatant Receiver	8∅ x 12	347
P-18-1	50	90	3	IXW Receiver	9-1/2∅x12	45*
PA-18-3	50	90	3	IXF Pump Tank	4-1/2∅x7	25.3
P-19-1	15	110	2	1CP Receiver Tank	10x16x14	787
P-21-1-1	50	80	2	Cesium Eluent Storage	10x16x14	818.6
P-21-1-2	15	70	3	Cesium Eluent Storage	10x16x14	818.6
P-22-1	15	70	2	Condensate Receiver	3-1/4x7x4	22.8
P-23-1	10	25	2	Non-boiling Waste Receiver	3-1/4x7x4	43
P-24-1	45	90	2	Low-Level Waste Receiver	10x16x14	1,244
P-25-1	50	120	5	Cerium Waste Receiver	8∅ x 14	137.7
P-25-2	50	120	5	High-Level Waste Receiver	8∅ x 14	122.3
P-26-1	75	45	3	Organic Contactor	9∅ x 9	1,830
P-26-2	75	117	5	1CP Contactor	5x7x12-1/2	28
P-26-3	75	117	5	1CP Receiver	5x7x12-1/2	31
P-27-3	100	70	5	1CW Contactor	7∅ x 14	1,300
P-27-4	5	72	4	1CF Pump Tank	2-3/4x5x3-1/2	126
P-28-2	10	90	5	1BP Receiver	5-1/2∅x12	82.3
P-28-3	100	70	5	1AX Makeup	7∅ x 14	1,621.1
PA-28-4	8	72	4	1BF Pump Tank	2-3/4x5x3-1/2	11.8
P-29-3	5	110	6	1AF Pump Tank	9-1/2x5x14	90*
P-30-3	10	110	6	1AX Pump Tank	9-1/2x5x14	92.1

*Estimated Heel

1.1 Pump Agitators

In several B-Plant tanks, limited space has necessitate modifying existing pumps into pump agitators. The modification consists of drilling three holes in the bowl of the bottom pump stage. A portion of the solution entering the first stage is forced through the holes back into the tank, and a portion passes on to the upper pump stages. Through the use of a diaphragm operated valve on the pump discharge line a pump agitator may be used for two modes of operation: 1) with the pump discharge valve closed, solution will recirculate back to the tank agitating the contents of the tank; 2) with the pump discharge valve open solution will be pumped and agitated simultaneously. It should be pointed out that pump agitators cannot be used for batch contactors because it cannot pump without also agitating the solution.

2. Agitators

Many of the agitators used at B-Plant have been modified and relocated from U-Plant, T-Plant, and within B-Plant. Several different types of agitators are in service. These are summarized in Table X-5.

All of the agitators are of stainless steel construction. The agitator shaft is connected through a flexible coupling to the output shaft of a speed reducer which is directly connected to the shaft of an electric motor. The agitator shaft is fabricated in two sections; the upper portion carries both thrust and radial bearing loads, while the lower portion carries the agitator blades. The two sections are joined together with a rigid, flange-type coupling. The upper section is sealed by a kerosene-lubricated Durametallic seal at the upper end of a cylindrical torque tube welded in the mounting flange. The torque tube also contains a grease-lubricated guide bearing near its lower end to provide shaft support near the point of load application. Contact of process solutions with the guide bearing is prevented by means of positive air pressure introduced to the torque tube. Kerosene drippings from the Durametallic seal and air escape through the clearance between the agitator shaft and the lower end of the torque tube.

3. Transfer Jets

Transfer jets are used for transferring many solutions. The rated water syphoning capacity ranges from 3 to 75 gallons per minute with somewhat smaller jets used in samplers. Solutions transferred by steam jet are diluted 2 to 3 percent. Although steam is usually used for the motive fluid, both water and air may be used. Solutions at temperatures greater than about 145 F can not be jetted because suction of the solution is great enough to cause the solution to vaporize. However, submerged jets are capable of jetting solutions up to about 175 F. When the solution to be jetted vaporizes, the jet is said to be "gassed".

TABLE X-5

AGITATOR SUMMARY

Agitator EPN	Motor hp	Motor rpm	Shaft rpm	Type	Impeller Dia., In.	Impeller No. Blades	Minimum Volume to Agitate (gal)	Vessel Service	Dimensions (feet)
244-AR-A-001	50	1800	45	turb	48	14	1200*	PAW Storage	20ø x 19-3/4
244-AR-A-002	60	1800	45	turb	48	14	1200*	Slurry Receiver	20ø x 19-3/4
244-AR-A-003	15	1150	68	turb	20	8	140*	Neutralized High Level Waste Storage	9-1/2ø x 9
244-AR-A-004	15	1150	68	turb	20	8	140*	Sludge Waste Acidification	9-1/2ø x 9
244-CR-A-003	10	1750	82	turb	33	70(3)	2019	PAS Storage	14ø x 12
A-5-1	2	1150	1150	prop	8	3	140*	Strontium Concentrate Receiver	3-1/4x7x4
A-6-1	7.5	1750	186	turb	17	8	494.4	Strontium Storage	8ø x 14
A-6-2	7.5	1750	186	turb	17	8	508	Strontium Storage	8ø x 14
A-7-1	5	1150	150	turb	18	4	316	Strontium Storage	8ø x 14
A-7-2	7.5	1750	186	turb	17	8	320	Strontium Storage	8ø x 14
A-8-1	5	1150	100	turb	18	4	324	Strontium Storage	8ø x 14
A-8-2	5	1150	100	turb	18	4	333	Strontium Storage	8ø x 14
A-9-1	5	1150	100	turb	18	4	329	Waste Receiver	8ø x 14
A-9-2	5	1150	100	turb	18	4	320	Supernatant Storage	8ø x 14
A-11-1	5	1150	100	turb	14	4	69	Slurry Tank	4-1/2ø x 7
A-11-2	15	1150	68	turb	36	8	368	Decant and Metathesis	9ø x 9
A-12-1	15	1150	68	turb	24	4	437	Supernatant Receiver	9ø x 9
A-13-1	5	1750	150	turb	20	8	753.6	Centrifuge Supernatant Receiver	9ø x 9
A-14-1	5	1150	100	turb	14	4	98.4	Undesignated	4-1/2ø x 7
A-14-2	15	1150	68	turb	24	4	490.8	Cesium Storage	9ø x 9
A-16-1	5	1150	100	turb	14	4	348.6	Undesignated	6-1/2ø x 14
A-17-1	7.5	1750	186	turb	17	8	423	Cesium Storage	8ø x 14
A-17-2	5	1750	150	turb	17	8	347	Cesium Supernatant Receiver	8ø x 14
A-18-1	5	1150	100	prop	9	3	176.2	1XW Receiver	9-1/2ø x 12
PA-18-3	3	--	-	pump	--	-	25.3	1XF Pump Tank	4-1/2ø x 7
A-19-1-1	7.5	1750	186	turb	17	8	1170.4	1CP Receiver Tank	10x16x14
A-19-1-2	7.5	1750	186	turb	17	8	1170.4	1CP Receiver Tank	10x16x14

UNCLASSIFIED

TABLE X-5, Continued

Agitator EPN	Motor Shaft hp	Motor Shaft rpm	rpm	Type	Impeller Dia., In.	Impeller No. Blades	Minimum Volume to Agitate (gal)	Vessel Service	Dimensions (feet)
A-20-1	2	1150	1150	prop	8	3	134.9	1XP Concentrate Receiver	3-1/4x7x4
A-21-1-1	7.5	1750	186	turb	17	8	1169.3	Cesium Eluent Storage	10x16x14
A-21-1-2	7.5	1750	186	turb	17	8	1169.3	Cesium Eluent Storage	10x16x14
PA-22-1	2	--	-	pump	--	-	22.8	Condensate Receiver	3-1/4x7x4
PA-23-1	2	--	-	pump	--	-	33	Non-Boiling Waste Concentrate	3-1/4x7x4
A-24-1-1	7.5	1750	186	turb	17	8	1244	Low-Level Waste Receiver	10x16x14
A-24-1-2	7.5	1750	186	turb	17	8	1244	Low-Level Waste Receiver	10x16x14
A-25-1	7.5	1750	186	turb	17	8	408.5	Cerium Waste Receiver	8Ø x 14
A-25-2	7.5	1750	186	turb	17	8	399	High-Level Waste Receiver	8Ø x 14
A-26-1	5	1150	1150	prop	9	3	1043	Organic Contactor	9Ø x 9
A-26-2	5	1150	1150	prop	9	3	280	1CP Contactor	5x7x12-1/2
A-26-3	5	1150	1150	prop	9	3	280	1CW Receiver	5x7x12-1/2
A-27-2	5	1150	1150	prop	9	3	225	1CP Receiver	5-1/2Øx12
A-27-3	5	1150	1150	prop	9	3	530	1CW Contactor	7Ø x 14
PA-27-4	5	--	-	pump	--	-	12.6	1CF Pump Tank	2-3/4x5x3-1/2
A-28-2	5	1150	1150	prop	9	3	208.8	1BP Receiver	5-1/2Øx12
A-28-3	5	1150	1150	prop	9	3	547.1	1AX Makeup	7Ø x 14
PA-28-4	2	--	-	pump	--	-	11.8	1BF Pump Tank	2-3/4x5x3-1/2
A-29-2	7.5	1750	186	turb	17	8	377	1AF Makeup	9-1/2x5x14
A-29-3	7.5	1750	186	turb	17	8	385.6	1AF Pump Tank	9-1/2x5x14
A-30-2	7.5	1750	186	turb	17	8	390*	1AW Receiver	9-1/2x5x14
A-30-3	7.5	1750	186	turb	17	8	355.3	1AX Pump Tank	9-1/2x5x14
A-31-1	2	1150	1150	prop	8	3	212.3	PAS Metathesis Tank	5-1/2Øx9
A-31-2	5	1150	100	turb	18	4	154.9	Dissolved Cake Storage	4-1/2Øx7
A-31-3	5	1750	150	turb	20	8	308.2	PAS Precipitator Tank	6-1/2Øx14
A-32-1	5	1150	150	turb	24	8	752	Waste Receiver	9-1/2Øx9
A-33-1-1	7.5	1750	186	turb	17	8	1308.8	Treated PAS Storage	10x10x14
A-33-1-2	7.5	1750	186	turb	17	8	1308.8	Treated PAS Storage	10x10x14

*Estimated volume

4. Gang Valves

Gang valves are used to operate the steam jets in the B-Plant. A gang valve consists of four spring-closed, globe-type valves with all working parts constructed of bronze. The four valves control steam, air, shut-off, and vent. The use of the gang valves prevent back flow of radioactive solutions into the partial vacuum created by condensation of steam in un-purged lines. The following four positions of a gang valve are used:

Position 1. Normal Closed Position

Valve to operating gallery closed, valve to jet is open, steam and air valves are closed.

Position 2. Air Venting of Jet or Sparger

Gallery valve closed, jet and air valve open, steam valve closed.

Position 3. Steam Being Supplied to Jet or Sparger

Gallery valve closed, jet and steam valve open, air valve closed.

Position 4. Jet Vented to Operating Gallery - Maintenance Position

Gallery and jet valves open, steam and air valves closed.

PART V, Continued

PLANT AND EQUIPMENT

CHAPTER XI

PACKAGING EQUIPMENT

PART V, Continued

PLANT AND EQUIPMENT

CHAPTER XII

REMOTE OPERATION AND MAINTENANCE

By

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HANFORD ENGINEERING SERVICES

WASTE MANAGEMENT TECHNICAL MANUAL

CHAPTER XII

REMOTE OPERATION AND MAINTENANCE

CHAPTER XII

REMOTE OPERATION AND MAINTENANCE

The high radiation levels prevailing in much of the Waste Management Facilities necessitate interposition of massive shielding between personnel and processing areas. Routine operation and maintenance are carried out in many cases with no access to the process equipment. Instrument control, discussed in Chapter XIII, is extensively used. Methods of remote sampling of process streams for laboratory checks on instrument control, are discussed in Chapter XIV. The methods and equipment used in performing remote operation and maintenance (except process-control instrumentation and sampling) are the subject of this chapter.

A. PRINCIPLES OF REMOTE OPERATION AND MAINTENANCE

The Waste Management process equipment has been designed, insofar as possible, to provide trouble-free service with a minimum of maintenance and attention. However, during the design of this equipment, it was recognized that each item would have a finite life and would require service or replacement at the end of life. For this reason and to provide flexibility to accomodate future design changes, most of the equipment has been designed so that it may be installed or removed remotely.

To avoid exposing personnel to excessive radiation, the equipment is located in heavy-walled concrete "vaults" or "cells", often underground. These vaults are covered with massive concrete cover blocks. The cover blocks have stepped interlocking edges so that an emerging "radioactive ray" originating within the vault must pass through a certain minimum thickness of shielding. When it is necessary to perform work in a vault, the cover blocks may be removed with a crane.

All remote maintenance is accomplished from above using cranes. The cranes not only lift equipment but handle the tools used in remote maintenance. One of the unique features of the Waste Management Facilities is that all equipment is assembled and disassembled vertically. Consequently, the equipment is counter-balanced so that when suspended from a crane hook, it will assume the correct attitude for vertical assembly.

When a cell or vault is first constructed, the actual or "As-Built" dimensions of all fixed-location (embedded in concrete) points are recorded. Such location points include mounting pads, trunnions, dowels, and remote connector nozzles. The "As-Built" dimensions of each item subsequently installed (dunnages, vessels, pumps, jumpers,

A. PRINCIPLES OF REMOTE OPERATION AND MAINTENANCE (Continued)

et cetera) are similarly recorded. In this manner, all equipment may be prefabricated in the 277 mock-up building which is radioactively "cold", then set into the "hot" cell without exposing personnel to radiation.

Radioactive process fluids naturally "contaminate" all surfaces which they contact; therefore, it is necessary to design and construct equipment that may be contacted by these fluids so it can be removed and decontaminated. To this end, crevices, porous materials, and pockets which will contain liquid pools must be avoided. Process lines are self-draining without low points to trap solutions. Process solutions, if spilled, may contaminate equipment which cannot be decontaminated. Leakage must be minimized if not avoided entirely. All joints are, therefore, located above the static liquid level and are gasketed. Valves are avoided wherever possible and where used are incorporated in jumpers in order to be serviceable should leakage occur. Deep-well type pumps are used where steam jet syphons cannot perform the function satisfactorily. Vessels and potentially radioactively contaminated areas are maintained at a slight vacuum so that all air leakage will be directed into the most contaminated area. The vacuum is maintained by blowers that draw the air from the contaminated area through particulate filters to minimize atmospheric contamination.

Many remotely operated components have been standardized, such as: remote connectors, dowels, studs, nuts, and steam syphons.

B. CRANES

In the Waste Management Facilities, all remote operations are carried out from above using cranes. Bridge cranes are the work horses of the canyon building and mobile cranes are used to service the tank farms, diversion boxes, and vault buildings. The cranes which serve the Waste Management Facilities are described in the following.

1. 221-B Building (B Plant) Canyon Cranes

The "B" Plant Canyon has been provided with two electrically-operated overhead bridge cranes, sharing the same rails. The main crane is used for most remote maintenance operations since the operator is shielded from radiation. The auxiliary crane is used for other tasks where the radiation levels are low. Crane maintenance platforms located at each end of the building provide access to the cranes for servicing.

B. CRANES (Continued)

1.1 Main Crane (CVI 65106 and H-2-33671)

The main crane is located west of the auxiliary crane on their common rails which extend the length of the canyon. The main crane is illustrated in the building cutaway, Figure XII-1. Figure XII-2 is a photograph showing the main crane and the east crane maintenance platform. The crane operator is protected from radiation both by the shielded cab and the parapet wall behind which it travels. The crane cab is air conditioned.

The main trolley runs atop the bridge and carries a 75-ton hoist and a 10-ton hoist. The 10-ton hoist is fitted with an electrically-operated rotary hook. Beneath each of the two bridge girders is a monorail and trolley. Each trolley carries a 1-ton and a 1/2-ton hoist from which hang auxiliary hooks, grabbers, or impact wrenches having 2 or 3-inch sockets. The bridge, the three trolleys, the six hoists, the rotary hook, and the two impact wrenches are controlled from the crane cab.

The area below the crane is illuminated by twenty flood-lights on the bridge, four 1,000 watt lamps beneath the trolley, and two 1,000 watt periscope spotlights. The crane operator views the operation through two periscopes or through a closed-circuit television system.

1.1.1 Capabilities

Drawing H-2-44966 shows the crane lifting capabilities. The speeds of the bridge, trolley, 75-ton hoist, and 10-ton hoist are controlled by a drum controller which affords six speeds in either direction (plus a stop position). The maximum speeds are: Bridge travel - 160 FPM, trolley travel - 25 FPM, 75-ton hoist lift - 5 FPM, and 10-ton hoist lift - 35 FPM. It is possible to block the higher speeds so they cannot be used. The trolleys of the monorail hoists travel at 25 FPM and the hoists lift at 21 FPM (both single speed).

1.1.2 Shielding

The crane cab is shielded from direct gamma radiation by the concrete parapet behind which it runs. Protection against scattered radiation is afforded by the steel shielding of the cab which is 4-1/2 inches thick on the top and upper part of the sides, 3 inches thick on the lower part of the sides, and 1-1/2 inches thick on the bottom. The cab is

B. CRANES (Continued)

entered through steel doors 3 inches thick. Steel is used in this structure rather than lead because of the danger that lead might eventually sag and crevices open up through the shield. The periscopes are brought in through a labyrinth on the front wall of the cab. The objective lens systems of the periscopes are exposed to moderately severe gamma bombardment while the crane is moving contaminated equipment. As a result, the lens elements gradually become discolored; but transparency may be restored by heat treatment. Ventilating air is supplied through a shielded duct from a blower mounted on top.

1.1.3 Crane Optical Aids

Because the crane cab in the Canyon Building is separated from the canyon by a 5-foot thick concrete parapet, the operator cannot directly watch the operation of the crane and recourse must be made to optical aids.

Two large periscopes, one on either side of the crane bridge permit the operator to view the crane hooks, impact wrenches and cell equipment with clarity. Although the field of vision is rather limited (to gain magnification) scanning may be obtained at the operator's discretion by electric motors which "telescope" the periscope across the canyon, and rotate it on its axis. The eyepieces are automatically synchronized with the viewing direction of the objective ends of the periscopes so that the operator is always looking in the true direction.

Large negative lenses have been installed on the outboard side of each periscope objective so that when the objective is rotated in this direction, a tremendously increased field of view is obtained. This allows the operator, in one glance, to get a general view of the canyon, to see whether or not all cover blocks are in place, and to see if anyone is on the deck.

A television camera also is installed under the crane bridge. The viewing angle of this instrument is varied by electric motors under the operator's control which rotate the camera on both the horizontal and vertical axes. The "picture" picked up by the camera is transmitted by wire to the crane cab where it appears on the screen of a television monitor. Although the television lacks the definition of the periscope, it has a broad field of view, is not as tiring to the eye, permits quicker scanning of the situation, and affords an additional view from a different angle. Portable, closed-circuit

B. CRANES (Continued)

television systems may be used with the crane when necessary to gain additional viewpoints. The portable television equipment requires "Kluge" setups and is used only when absolutely necessary.

1.1.4 Electrical Services

The crane is supplied with 440 volt, three-phase, 60 cycle power via conductors and collector shoes mounted on the crane. Similar conductors and collectors supply power to the trolley. The monorail trolleys are supplied by festooned cables. The rotary hook and the impact wrenches and/or grabbers are supplied through reel-type cord retractors. A telephone in the cab is connected to the building PAX system. Cab air-conditioning is provided for operator comfort.

1.1.5 Rotary Crane Hook (H-2-44970)

The 10-ton rotary hook was designed to allow the crane greater versatility. A 115 volt DC gear motor drives the hook through a slip clutch set at 60 ft.lb. maximum torque. The load is transmitted from the 10-ton hook to the block by a tapered roller bearing.

1.2 Auxiliary Crane (CVI 76513)

The auxiliary crane operates on the west side of the main crane. The crane operator, having little radiation shielding and no optical aids, views his work directly. The auxiliary crane is therefore used only for work in low level radiation zones.

The main trolley runs atop the bridge and carries a 10-ton hoist. Six-speed drum controllers like those on the main crane are also used to control the bridge, trolley, and hoist movements. The maximum design speeds are: Bridge - 300 FPM, Trolley - 25 FPM, and Hoist - 35 FPM. The lift is 70 feet. The monorail hoists located beneath the two bridge girders are identical with those on the main crane except that the right trolley carries only one cable reel (for supplying power and control to an impact wrench).

Lighting is provided by four 1,000 watt floodlights beneath the trolley and a 400 watt searchlight.

B. CRANES (Continued)

1.3 Crane Maintenance Platforms (H-2-2762 and H-2-33125)

Two mobile crane maintenance platforms are provided to service the cranes. Each is mounted on a short section of rails at the end of the canyon and is propelled by driving the wheels through a handcrank mechanism. Access to each platform is provided by a fixed ladder mounted on the canyon end walls. A fixed, caged ladder hangs from the west end platform allowing access at any position along the rails. The east platform is of split-level design, which allows maintenance of the crane on the upper level and of the impact wrenches on the lower. The east platform has a swing-down ladder which may be lowered from the platform by a manually-operated winch.

2. 244 AR Building Canyon Cranes (H-2-62046)

A 20-ton bridge crane spans the 244 AR Building and runs the length of the canyon. Four "I" beams are suspended beneath the bridge girders, two under each girder, providing runways for four 1-ton monorail hoists. Two of the auxiliary hoists carry impact wrenches as shown in Figure XII-3. The cranes are all controlled from the crane control room from which the operator may observe the crane movements through three closed-circuit television systems and a periscope. In event of failure, a manually-operated system is provided to retrieve the bridge to the east end of the canyon where maintenance may be performed by personnel on the crane maintenance platform. The operating characteristics of the cranes are shown in the following Table.

TABLE XII-1

Hoist*	No. Hoists	Capacity (Tons)	Trolley Speed (FPM)	Hoist Speed (FPM)	Maximum Hook Height (Above Canyon Floor, 682) (Ft.)	Lift (Ft.)
Main	1	20	20/10/3	15/7.5/3	30	50
Auxiliary	4	1	30	31/10	26-1/2	59

* Bridge travel speed 10/20/40 FPM.

2.1 Observation System

A monocular periscope from the crane control room penetrates the south wall of the canyon, 9 feet 4 inches from the floor, enabling the operator to view the canyon area. The objective

B. CRANES (Continued)

lens can scan through a solid angle of 180°. The eyepiece provides magnifications of 2X and 10X and is adjustable in elevation to ensure operator comfort. Each of the three closed-circuit television systems has a 17-inch monitor located within the control room; is shielded from ambient radiation; is contained in a corrosion-resistant housing that may be decontaminated and has remotely-controlled pan, tilt, and zoom mechanisms (pans through 350°, tilts through 90°, and zooms from a focal length of 25 mm to 150 mm). One camera is mounted on the crane, one may be mounted upon any of sixteen wall brackets provided, and the other may be mounted on any of the remaining fifteen wall brackets.

The canyon area is provided with high-intensity lighting along the walls. A ten-foot diameter area of the vault is lighted to an intensity of 100 foot candles by mercury-vapor floodlights on the crane. The lights are controlled from Crane Control Room.

2.2 Crane Maintenance Platform (H-2-62003 and H-2-62004)

In order to service the crane and its associated equipment, a crane maintenance platform is provided at the east end of the canyon. The platform moves along a short section of rail powered by an electric drive motor. The drive motor may be controlled either from the platform or the canyon floor. In order to reach the platform, personnel must climb one of two open ladders to an intermediate platform on the north wall, then up a caged ladder, then onto the crane maintenance platform.

3. Mobile Gantry Crane (CVI 2973)

The gantry crane is used in the Waste Management Facilities for installing and removing pumps, sluicing nozzles, and other equipment; and for making jumper changes in the diversion boxes and vaults.

3.1 Description

The gantry crane is a self-propelled railway crane equipped with two electric hoists (10-ton and 1-ton capacities), and is designed to span diversion boxes and pump, heel, and sluice pits. The crane may be towed from one location to another by lowering rubber-tired wheels which lift the crane from its rails. Crane rails are provided at the 244 CR Vault and the 241-ER-151 diversion box. Figure XII-4 is a photograph of the gantry crane.

B. CRANES (Continued)

3.2 Superstructure

The superstructure of the gantry crane is a steel frame, supported on side members equipped with railway wheels, to position the hoist monorail directly over the working area. The monorail is an 18 inch "I" beam, 26 feet 7 inches long, positioned transversely 12 feet 9 inches above the crane rails. One end of the monorail overhangs the railway 8 feet and the other end overhangs 4 feet 7 inches. The side members allow a transverse clearance of 12 feet 8 inches. The center-to-center distance between the 70 pound rails is 14 feet. The gantry crane is also equipped with pneumatic rubber-tired auxiliary wheels which are raised and lowered by 10-ton capacity Porta-Power (No. R-159) hydraulic rams. One pair of wheels is fitted with a towing bar and steering links which permit a minimum turning radius of 19 feet.

3.3 Hooks and Hoists

The crane is equipped with two Yale and Towne Company hoists of 10-ton and 1-ton capacities. Pertinent data concerning the hoists is tabulated below.

TABLE XII-2

Hoist Data

Model	XE-1DC30M12	PC-1C38M15
Maximum Clerance Hook Face to Top of Rails	7 Ft.	9 Ft. 10 Inches
Total Lift	30 Ft.	38 Ft.
Hoist Speeds	12 and 4 Ft./Min.	15 and 7.5 Ft./Min.
Trolley Speeds	15 and 5 Ft./Min.	15 and 5 Ft./Min.

3.4 Electrical Services

The required 480 volt, 3-phase electrical supply is brought to the crane through a No. 4, four-conductor cable which is carried on an Appleton cable reel (No. GW-46) mounted at one corner of the superstructure. The crane is self-propelled on the rails at speeds of 40 and 3 Ft./Min. through a gear and shaft system by means of two separate motors mounted on the superstructure.

B. CRANES (Continued)

A portable pushbutton control panel is provided for operating the crane. The control leads are of sufficient length to allow the operator to be at least 30 feet from either side of the crane. A 200 foot cable is also available to decrease operator proximity.

3.5 Lighting

The crane work area is lighted by six, 750 watt, 110 volt floodlights (Westinghouse type AH-16, Style No. 891 572), which are mounted on the crane superstructure in two banks of three lights each.

3.6 Optical System

A system of mirrors may be employed to assist the crane operator in carrying out remote operation. Binoculars are employed by the operators to aid in viewing the equipment through the mirrors. The portable television system may be used, if necessary, to view operations.

3.7 Rotary Hook (H-2-33551)

The gantry cranes are equipped with an electrically-operated, 10-ton rotary hook. The hook may be rotated either clockwise or counter-clockwise at 2-1/4 RPM. Hook rotation may be started and stopped by engaging or disengaging a magnetic clutch. The control station has two pushbuttons and one selector switch to control the hook. One pushbutton runs the motor "forward", one "reverse" and the selector "locks" or "unlocks" the clutch.

3.8 Operation

The crane and hoists may be operated from any point within 200 feet of the crane through the use of the portable control panel.

Jumper changes and the removal and installation of equipment are observed with the mirror-type viewing system.

The 10-ton capacity hoist is used for handling cover blocks and equipment, while the 1-ton hoist is used with an impact wrench for loosening and tightening remote connectors and equipment hold-down nuts.

B. CRANES (Continued)

4. Boom Cranes

Two boom cranes are assigned permanently to serve the Waste Management Facilities and two are available on a work order basis from "On-Site" services. All are standard industrial models with extendable booms.

4.1 20-Ton Lorain Crane

A Lorain, Series 40, Model MC-414, 20-ton, wheel-mounted, self-propelled crane is assigned to the Waste Management Facilities. Boom sections are available to vary the boom length from 30 feet to 70 feet. This crane is shown performing work in a diversion box in Figure XII-5. The H.O. (Hanford Operations) number of this crane is 17T-10797.

4.2 45-Ton American Crane

An American Model 599T, wheel-mounted, self-propelled, 45-ton crane is available from J. A. Jones Construction Company on work order basis. Boom sections are available to extend the 40 foot (minimum) boom to 110 feet. Its H.O. Number is 17T-19959.

4.3 60-Ton Manitowoc Crane

A 60-ton, wheel-mounted, self-propelled, Model 2900, Manitowoc crane is available on a work order basis from ITT/FSS Road Maintenance Section. Boom sections are available to extend the 40 foot (minimum) boom to 110 feet. Its H.O. Number is 17T-19960.

4.4 100-Ton Manitowoc Crane

A Manitowoc, Model 3900, 3-1/2 yard, 100-ton, track-mounted crane is assigned to the 200 Areas (Isochem, Inc.), and is normally used for construction. Boom sections are available to extend its 50 foot (minimum) boom to 140 feet. Its H.O. Number is 17-10666.

C. REMOTE CONNECTORS

The remote connector is a device for connecting process pipes, auxiliary lines, instrument lines, or electrical lines in areas where radiation levels or radioactive contaminates prohibit human access. The stationary portions of the connectors (always the lower portions) are usually mounted on the cell wall or upon the

C. REMOTE CONNECTORS (Continued)

process vessels. The movable portions (the "uppers") are normally attached to jumpers or to equipment subject to periodic removal. This equipment is arranged and balanced so that, when it is dangled from a crane hook, the "uppers" are properly oriented to engage simultaneously with their assigned "lowers" as the equipment is lowered vertically. The connectors are so designed that once they have been engaged, the equipment will remain in position after release from the crane. The connectors are secured by tightening the nuts with the remote impact wrench.

There are three basic types of connectors - the pipe connector, the electrical connector, and the wedge connector.

1. Pipe Connectors

Pipe connectors are used to connect pipes and multi-passage conduits, and to insert and seal thermocouple wells. Two types of pipe connectors are employed in the Waste Management Facilities, the "Hanford connector" which has a 3-inch hexagonal operating nut and employs flat mating surfaces, and the "Purex connector" which has a 2-inch hexagonal operating nut and spherical mating surfaces. In all other respects the two types are similar but they are not interchangeable. In pipe connectors, the "lowers" are known as "nozzles" while the "uppers" include everything else and are generally called "the connector". Figure XII-6 illustrates the two types of connectors.

Both types of connectors are available in two styles, horizontal or vertical; the connector skirt determines the style. The function of the connector skirt is to locate the connector upon the nozzle and hold it in position until the nut is tightened. In Figure XII-6, the Hanford connector is shown with a horizontal skirt and the Purex connector with a vertical skirt. The horizontal skirts are so shaped that they engage the nozzles and hang cantilevered from them. The vertical skirts are shaped like an inverted funnel in order to locate upon nozzles with vertical axes.

The nut is jacked away from the mating surfaces by tightening the pivoted, operating screw. The nut carries three latches which catch behind the nozzle flange and draw the mating surfaces together upon the gasket. The latches pass through openings in the yoke; and the geometry of these openings, the connector block, and the latches is such that, upon making the connection, the yoke forces the latches in behind the flange and, when breaking the connection, the connector block forces the latches out to clear the flange. Located directly behind the nozzle

C. REMOTE CONNECTORS (Continued)

flange is a "kickplate" which may be a separate or an integral part of the equipment upon which the nozzle is mounted. When loosening the connector, the last few turns of the screw brings the latches against the kickplate forcing the mating surfaces apart, thus overcoming any tendency of the gasket to stick.

1.1 Hanford Connectors (H-2-32700)

Hanford connectors are available in one size only. A variety of blocks and nozzles are available for single 1, 2, and 3-inch pipe connectors, 4-port instrument connections, coaxial recirculation line connections, thermometer well connections, and blank plugs. All connector blocks and nozzles are made of type 304-L stainless steel. Gaskets are spiral wound metal with a filler. Metals available are stainless steel and titanium; fillers are blue African asbestos, teflon, and linear polyethylene.

1.2 Purex Connectors (H-2-32410, H-2-32420, H-2-32430, H-2-32440)

There are four sizes of Purex connectors, 1, 2, 3, and 4-inch IPS. A multitude of connector blocks and nozzles are available for same size, reducing and increasing pipe connections, three-port instrument connection, recirculation connections, thermometer installation, and blank plugs. The connector nozzles are centrifugally cast stainless steel, the spherical mating surface of one type is faced with Stellite #6. The gaskets are teflon or teflon-impregnated asbestos.

2. Electrical Connectors

Electrical connectors are used to connect power, instrumentation, and communication conductors. Two types are employed - the "Hanford connector" which is simply a modification of the Hanford pipe connector and the "Purex connector" which employs the same size operating nut as the Purex pipe connector. Unlike the pipe connectors, the electrical connectors are all "vertical" connectors; that is, the "Nozzles" have vertical axes. Electrical connections are formed between silver-plated bronze contacts held under pressure by a spring. The springs are deformed as the operating screw is tightened.

2.1 Hanford Electrical Connector (H-2-32710)

The Hanford electrical connector, illustrated in Figure XII-7, is essentially the same as the Hanford pipe connector but with six electrical contacts made to accept No. 6 Awg conductors.

C. REMOTE CONNECTORS (Continued)

2.2 Purex Electrical Connector (H-2-32400 and H-2-32401)

The Purex electrical connector is illustrated in Figure XII-7. The physical configuration bears little resemblance to the Purex pipe connector except in principle; three latches draw the "upper" down to the "lower" as the nut is tightened. When released, the latches are cammed out to clear the striker flange. They are guided in behind the flange as the screw is tightened. The connector halves are guided together by dowel pins. The several standardized contact arrangements available for the Purex connectors are seven contacts for No. 6 wire, thirteen for No. 6, twenty for No. 14, and thirty-three for No. 16. Also available are arrangements for magnetic shielded and coaxial connections.

3. Wedge Connectors (H-2-33444 and H-2-62081)

Several wedge connectors are utilized in the Waste Management Facilities. The Wedge Connector was developed to satisfy the need to remotely couple lines larger than 4 inch IPS. A typical wedge connector is illustrated in Figure XII-8. The saddle is attached to the most permanent equipment and the wedge is attached to the more mobile equipment. The gasket is lowered by the crane onto the saddle's sealing surface; the wedge and the attached equipment are then lowered into the saddle where they will remain at rest until the nuts are tightened. Wedge connectors are designed to connect pipes with horizontal axes. The smaller wedge connectors utilize a spiral-wound stainless steel-asbestos gasket while the larger sizes require a more compressible gasket such as a tubular metallic "O" ring. Contact surfaces of the wedge connector should be re-lubricated with a suitable lubricant prior to each assembly.

D. SPECIAL TOOLS

Since a crane hook is not sufficiently versatile to perform all maintenance tasks, special tools are used in conjunction with it. Yokes are used to handle equipment which cannot be suspended from one point for structural, envelope, or clearance reasons. Such yokes are generally stored on racks within reach of the crane. Since few yokes are used to handle more than one equipment, let it suffice to say that each yoke is a "special" designed to fit only its intended equipment. Impact wrenches and grabbers are the more universal tools used with the crane to perform maintenance. A common electrical circuit serves all "hook-mounted" tooling. The electrical connectors of the grabber, impact wrench, or any other tool are the same so they will mate with the crane connector.

D. SPECIAL TOOLS (Continued)

1. Impact Wrench (H-2-31103 and H-2-32324)

Electrically-driven reversible impact wrenches are employed to rotate the remote nuts and connector-operating screws. A bail on the impact wrench is designed so that when suspended on a crane hook, the wrench may be balanced with the socket axis either horizontal or vertical. The wrench attitude may be changed by resting the wrench on the floor and sliding the crane hook along the bail to the opposite suspension point. The electric motor drives an Ingersol Rand impact wrench head through a gear train. When transmitting low torques, the rotary hammer is engaged with the anvil lugs and the torque is transmitted directly through with no relative motion; but when the torque exceeds a preset value, the hammer and spring are repeatedly cocked and released each time delivering a sharp impact to the anvil lugs, thence to the nut via the socket. The impact wrench is prevented from rotating by a reaction bar alongside the socket. There are two types of impact wrenches - one has a 2-inch hexagonal socket and delivers approximately 500 ft.lb. of torque to the nut and is pictured in Figure XII-9. The other has a 3-inch hexagonal socket (for special occasions, it may be fitted with a 2-inch socket) and delivers a torque of about 600 ft.lb. It should be noted that the impact wrench torque is preset to one value and cannot be varied while in use. Impact wrenches may be seen suspended from the small crane hooks in Figure XII-2.

2. Grabber (CVI 74629)

The grabber is a clam-shell bucket device for handling small pieces of equipment that cannot be picked up with the crane hooks. The tool is powered by a reversible fractional-horsepower electric motor that rotates a threaded shaft which in turn opens or closes the bucket jaws. The lips of the jaws are used to grasp loose nuts and other small items. Pipes may be gripped in semicircular notches cut in the sides of the bucket jaws. A single pair of semicircular jaws are attached to one side of the bucket for handling vertical pipe. A grabber is illustrated in Figure XII-10.

3. Flushing Wand (H-2-33094)

The flushing wand is a device used for ridding apparatus of gross contamination prior to removal. The wand is a weighted (approximately 500 pounds) pipe with a remote connector nozzle at one end, a spray nozzle at the other, and lifting bails located to allow the crane operator several choices of wand

D. SPECIAL TOOLS (Continued)

attitude. In Figure XII-11 the wand is illustrated in a horizontal attitude spraying downward (the angle is 23° below the horizontal). Yoke D-63066-F is used with the crane hook to support the wand horizontally.

A flat, sharply-defined spray pattern with uniform distribution, minimum atomization, and maximum impact is characteristic of the spray nozzle which directs 25 gpm (water at 100 psi) against the apparatus being flushed. The nozzle forms a flat spray with a 40° spread. Since the wand is stainless steel, it may be used with most decontaminating solutions and may itself be decontaminated if necessary.

4. Jumper Cutter (CVI-12484 HWS-6335)

The jumper cutter is 50-ton alligator shear and is pictured in Figure XII-12. The primary function of the jumper cutter is to cut up contaminated jumpers prior to scrapping them; in this manner the volume of the scrap is reduced and burial is more efficient. Costly items such as remote connectors, valves, and instruments may be severed from the bulky jumpers, decontaminated individually, and reused. At times the jumper cutter is used in the cells to sever tangled jumpers and other equipment.

The jumper cutter is capable of cutting a 4 inch schedule 40S pipe and a structural 4 inch, 9.2 lbs./ft. tee simultaneously. The jaws, which open to 12 inches, are actuated by a four-bar toggle linkage which is powered by a ball screw driven by a 7-1/2 horsepower electric motor. The knives are 14 inches long with edges serrated to retain the victim material during cutting. The knives are fastened in the jaws by 2-inch remote nuts. Two fixed bails permit suspending the jumper cutter from a 10-ton crane hook with the jaws either horizontal or vertical.

The jumper cutter is powered by a 440 volt, 3-phase, electric motor supplied through the standard (impact wrench grabber) connector. The circuitry is such that only the "forward" momentary-contact pushbutton controls the cutter. Holding the button in the depressed position causes the jaws to cycle from open, to closed, to open again which takes about 45 seconds. A fifteen-second time delay following each cycle allows the operator to release the button before another cycle is begun. The cutter will continue to cycle as long as the button is depressed. If the button is released at any time during the cycle, the cutter will stop immediately; the jaws will open when the button is again depressed, regardless of the point in the cycle at which they were stopped.

D. SPECIAL TOOLS (Continued)

5. Extension Hooks (H-2-57884)

Extension hooks are used to extend the reach of the crane and to permit hooking small bails. The hooks are for use with 10-ton crane hooks; lengths are 2 feet and 5 feet. The hook section is 1-1/4 inches deep by 1 inch wide (7-ton maximum based on a safety factor of 4 on ultimate tensile strength) with a throat of 1-1/4 inches.

E. PORTABLE CLOSED-CIRCUIT TELEVISION SYSTEM

A portable closed-circuit television system is available from Redox on a loan basis. This system may be used to view operations or apparatus from vantage points other than those afforded by the fixed optical aids. The television camera unit is a commercial unit (General Electric Model 4TE9B3) designed to withstand severe environmental conditions. The basic camera pictured in Figure XII-13 is approximately 5-1/2 inches in diameter and 11-3/4 inches long. The camera will accept any "C" mount lens and compensates automatically for light level variations. Several television monitors may be used with the camera, usually, however, a 12 inch (General Electric Model 4TH25B1) or a 14 inch (4TH26F3) is used.

Since this is a commercial system, neither radiation shielding nor remote aiming devices are provided; these items must be designed in accordance with the situation and provided by the user. Purex has a shielded enclosure with a bail which is rotated by a television antenna rotor to permit pan control. The camera is aimed downward at a mirror which "looks" horizontally; no tilt control is provided but the camera may be raised or lowered with the crane auxiliary hook. This enclosure is available on loan to the Waste Management Facilities.

F. DIVERSION BOXES

Diversion boxes are essentially piping "patch boards". Their function is to minimize duplication of piping and to allow the changing of line routings without the use of valves. The diversion boxes are concrete pits with pipes passing through the concrete and terminating in remote connector nozzles inside (see Figure XII-14). The nozzles are arranged so that all desired connections may be obtained with several jumper configurations. Mobile cranes are used to service the diversion boxes. One type of diversion box, known as a transfer box, which connects one common pipe to each of several others, one at a time, uses only one jumper and has the several nozzles arranged in a circle about the common nozzle as shown in Figure XII-15. All diversion box lines are capable of passing fluids under pressure;

F. DIVERSION BOXES (Continued)

this feature distinguishes diversion boxes from diverter stations which can only accomodate gravity flows. Leakage occurring within the diversion box is collected in a basin until there is sufficient quantity to return it to the processing operation.

Although one of the functions of diversion boxes is to eliminate valves, in some instances it has been necessary to utilize valves. Where valves are used, they are located in the jumpers so they may be removed from the diversion box remotely and either discarded and replaced or serviced. The valve stem extensions project upward through the concrete cover blocks and radiation shielding is provided around the penetration.

G. DIVERTER STATIONS

Diverter stations are similar to diversion boxes except that gravity flow is necessary. A typical diverter station is shown in Figure XII-16. Fluid flows into the diverter tank; when the fluid level reaches the height of the exit piping, it flows out through a short jumper and falls into the spout funnel. From the spout, the liquid flows out into the selected floor funnel. Selection of the floor funnel is accomplished manually. The spout is raised out of the funnel it is presently in, rotated until it is above the desired funnel, and lowered. The floor drain allows all leakage to collect in a sump from which it may be returned to the process operation.

H. REMOVAL AND REPAIR OF RADIOACTIVELY CONTAMINATED EQUIPMENT

Occasionally it is necessary to repair, replace, or maintain contaminated equipment located within a cell or vault. Wherever possible, the equipment is flushed or rinsed with decontamination solutions while still in location. On rare occasions, it is possible to perform the required "contact maintenance" after rinsing without removing the equipment, but usually it is necessary to remove the equipment for maintenance.

Often, due to the length of time an item would be out of service for decontamination and repair, the item, even though it can be repaired, must be replaced with new equipment. The nature of the equipment and the contaminant dictate the disposition of each particular piece of equipment. Employing chemical and physical decontamination methods, the radiation level of many items may be reduced sufficiently to permit the required maintenance. The remaining items must either be scrapped or, when the contaminating isotope(s) are relatively short-lived, allowed to "cool-off".

H. REMOVAL AND REPAIR OF RADIOACTIVELY CONTAMINATED EQUIPMENT (Continued)

Items to be scrapped are placed on an old, contaminated railroad flat car, often separated from the engine by several empty cars, and removed via the Hanford Railroad to a desert burial tunnel where it is abandoned - flat car and all. Equipment which is to "cool-off" is removed to a designated area where it will not be a hazard to personnel while the radioactive isotopes decay. At the end of the cooling-off period, maintenance may be performed and the equipment returned to service when needed.

Equipment which is to be chemically or physically decontaminated is sent via railroad to a decontamination facility, often the 221-T Building, where the required decontamination and repair may be performed.

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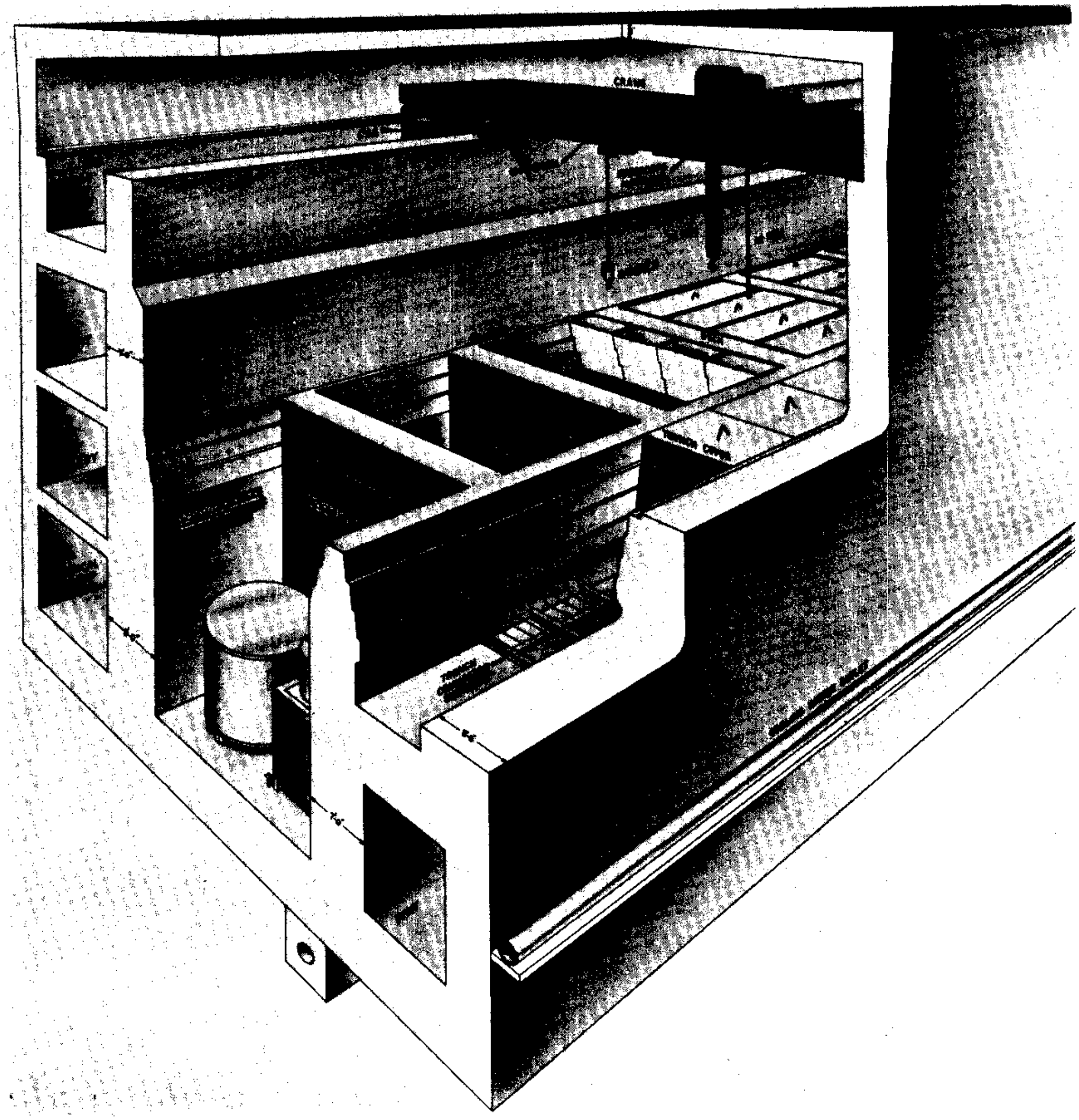

FIGURE XII-1

221-B Canyon Building
Sectional View

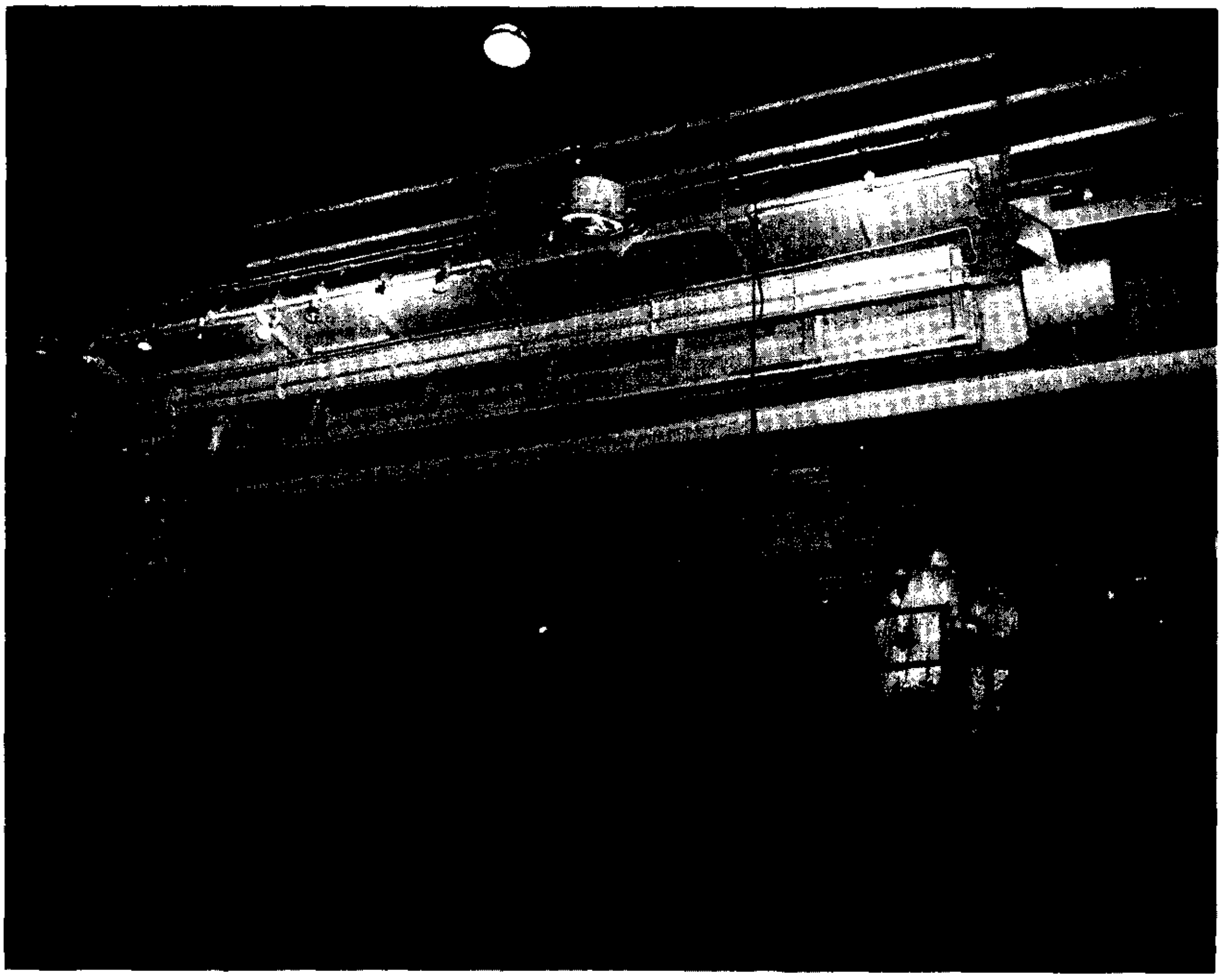

FIGURE XII-2

Main Crane and East Crane Maintenance Platform
221-B Building

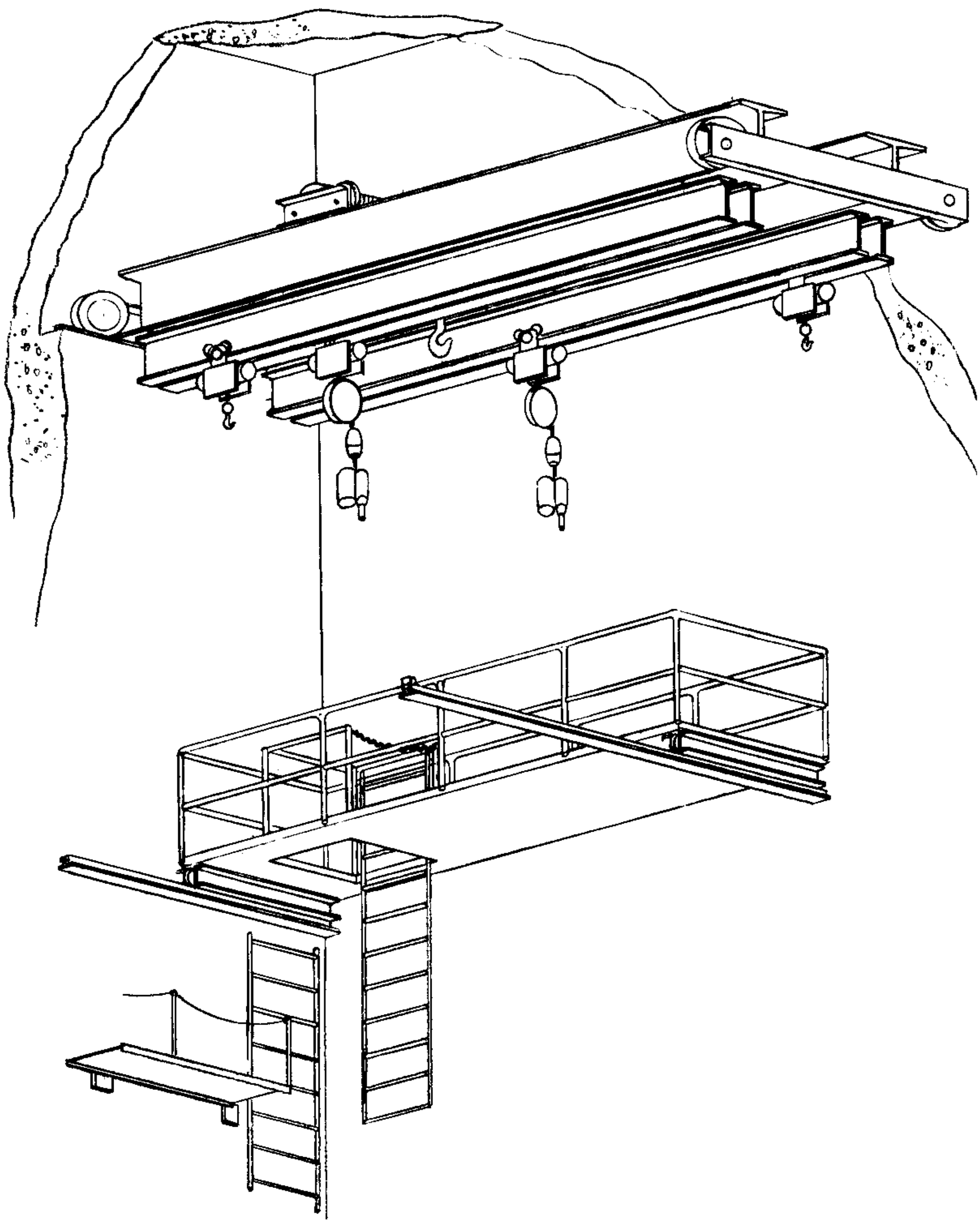

FIGURE XII-3

244 AR Crane and Crane Maintenance Platform

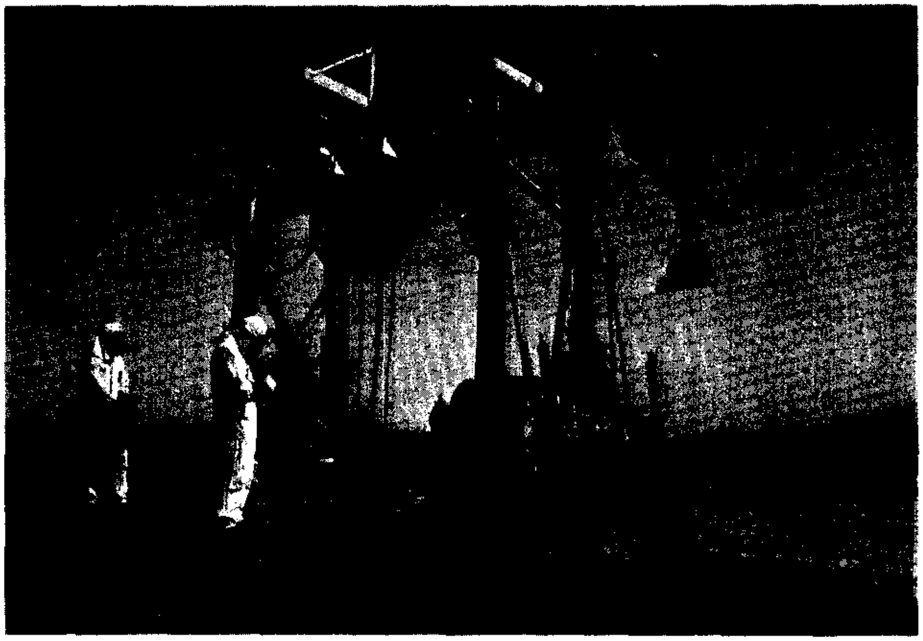

FIGURE XII-4

Gantry Crane

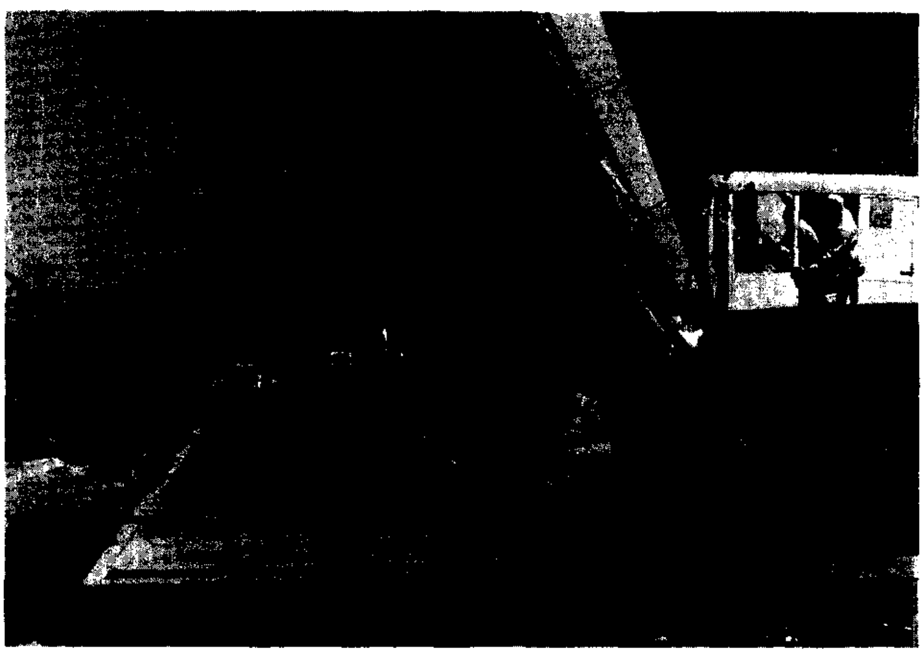

FIGURE XII-5

20 Ton Lorain
Performing Work in Diversion Box

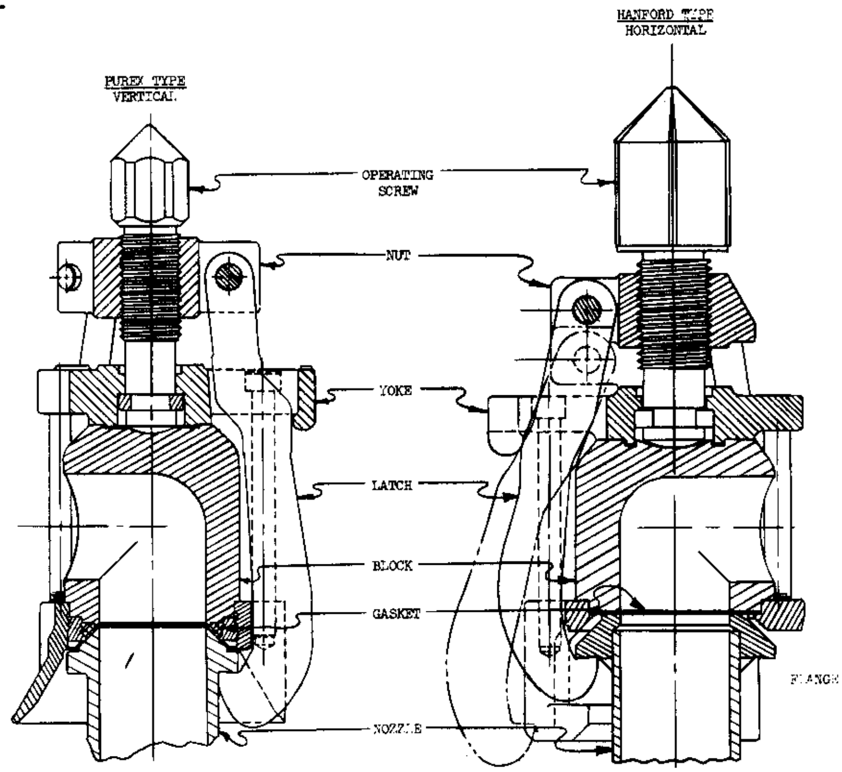

FIGURE XII-6

Pipe Connector

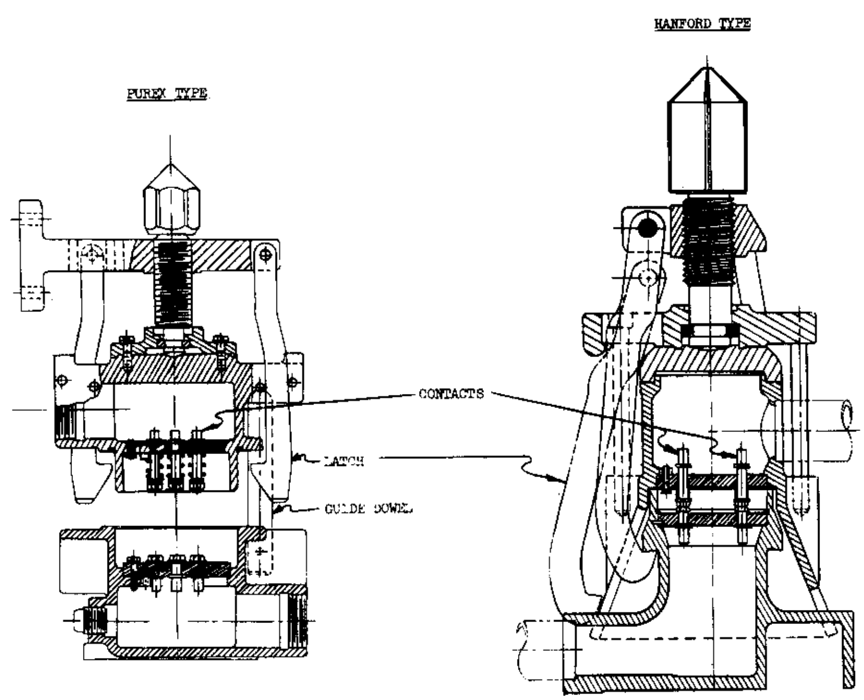

FIGURE XII-7

Electrical Connectors

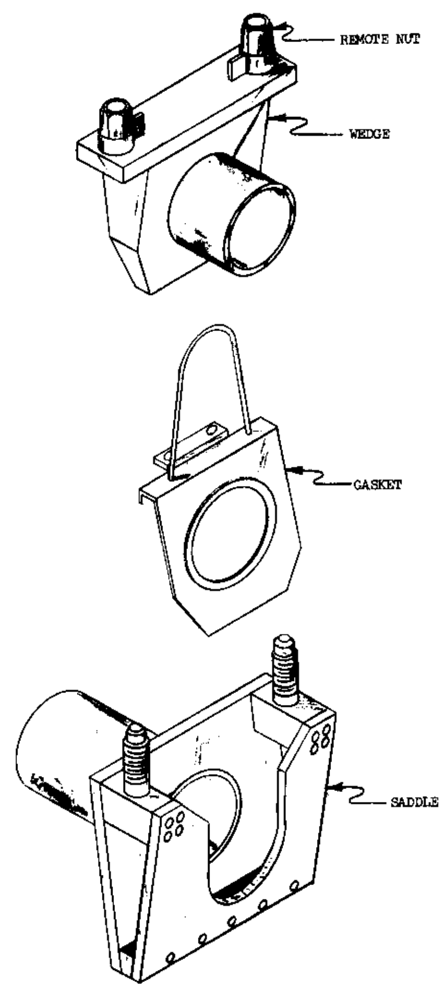

FIGURE XII-8
Wedge Connector

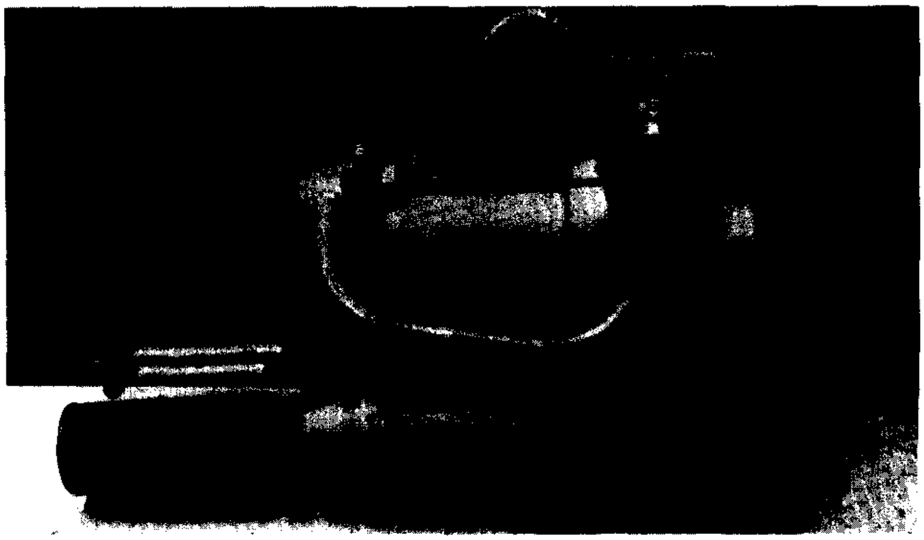

FIGURE XII-9

Impact Wrench
(2 inch Socket)

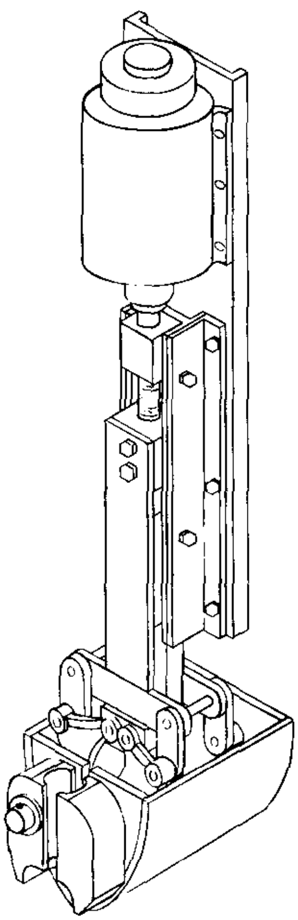

FIGURE XII-10

Grabber

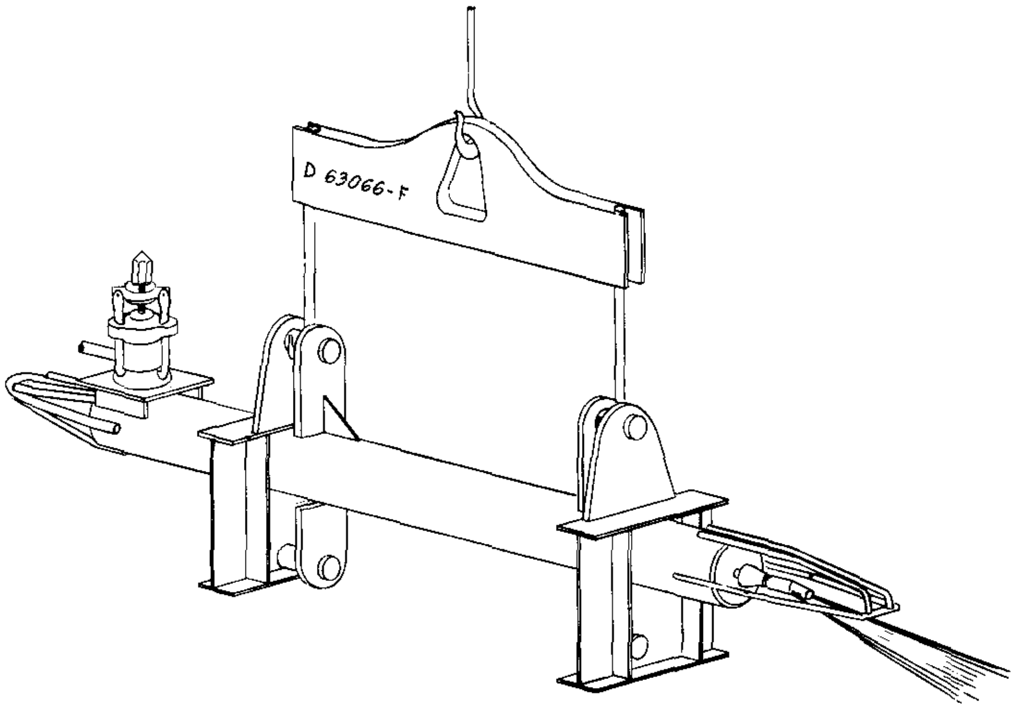

FIGURE XII-11

Flushing Wand

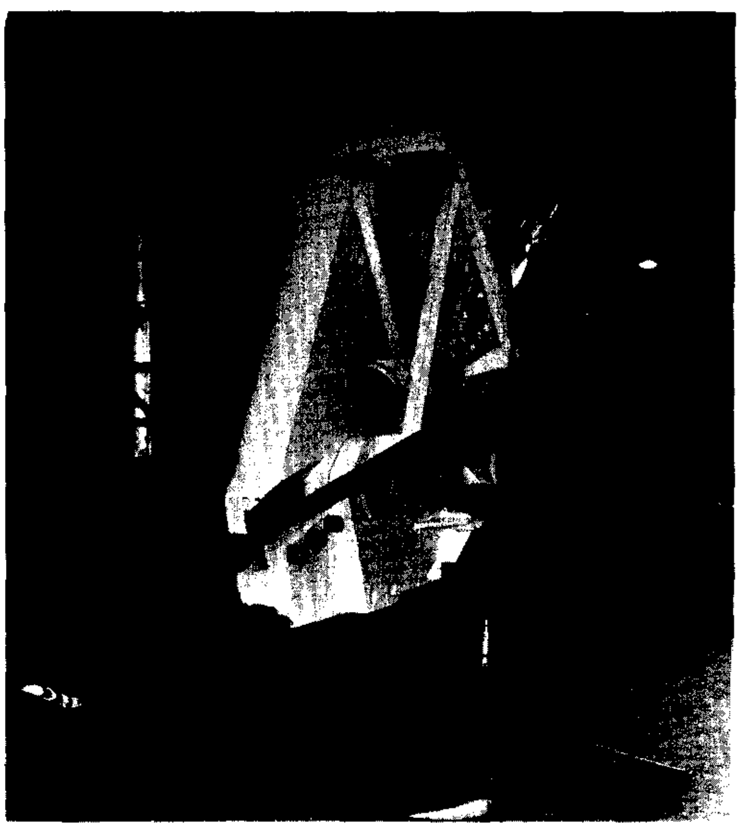

FIGURE XII-12

Jumper Cutter

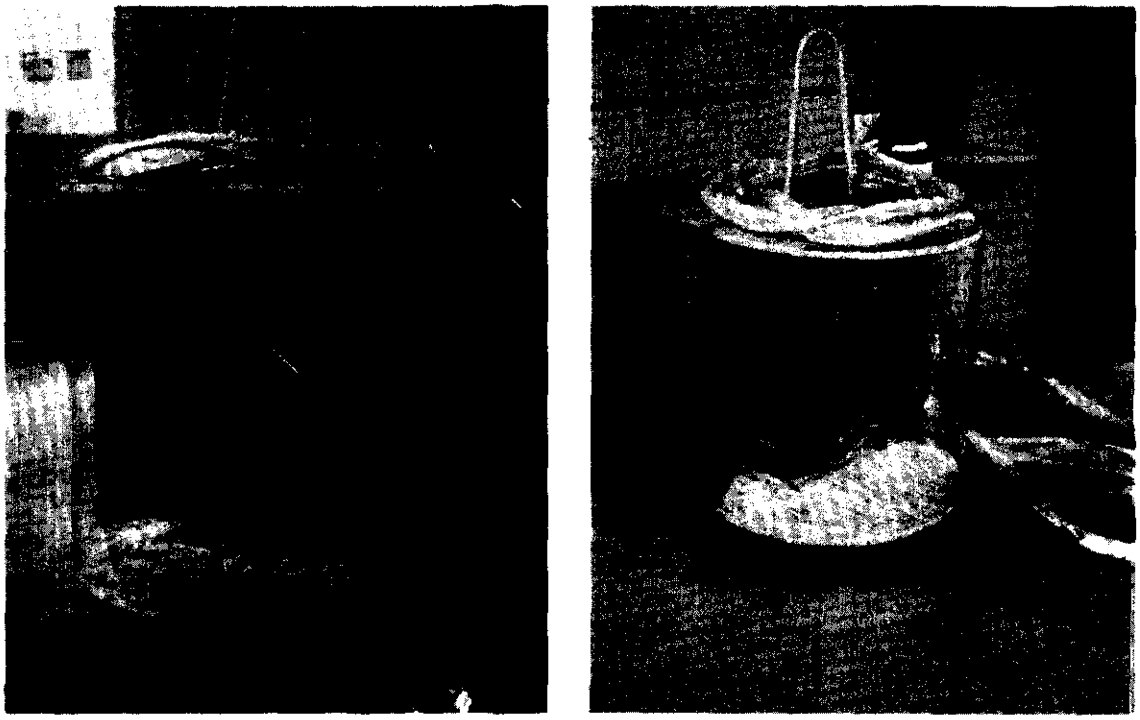

FIGURE XII-13
Portable Television Camera

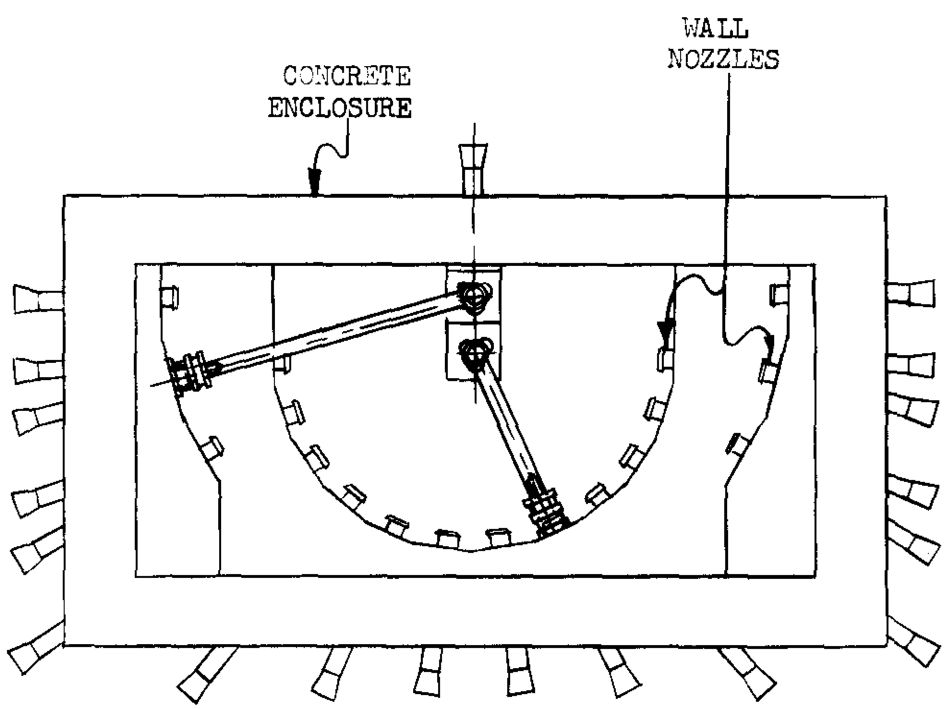

FIGURE XII-15
Plan View of Transfer Box

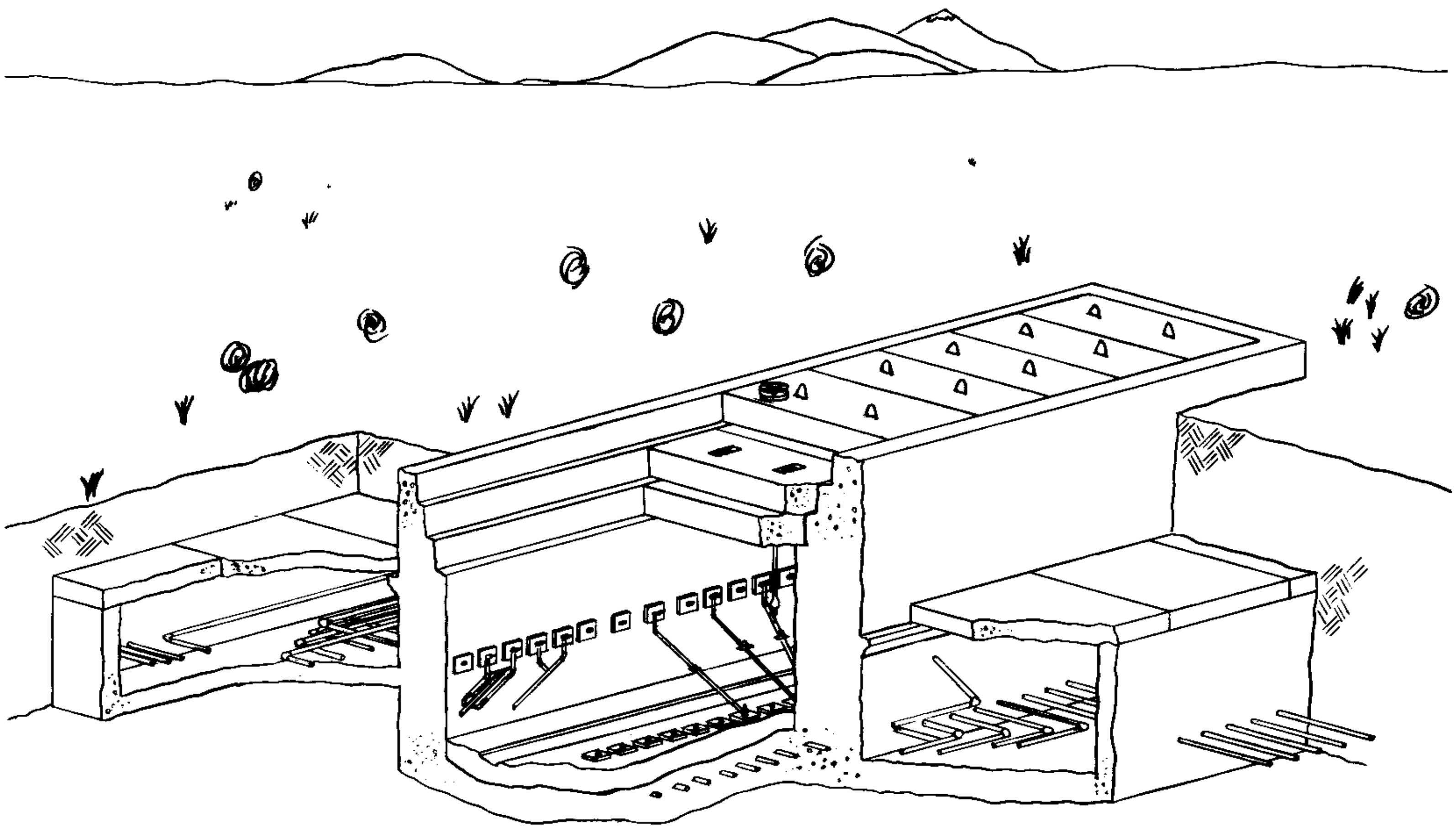

FIGURE XII-14

Diversion Box
(241-A-151)

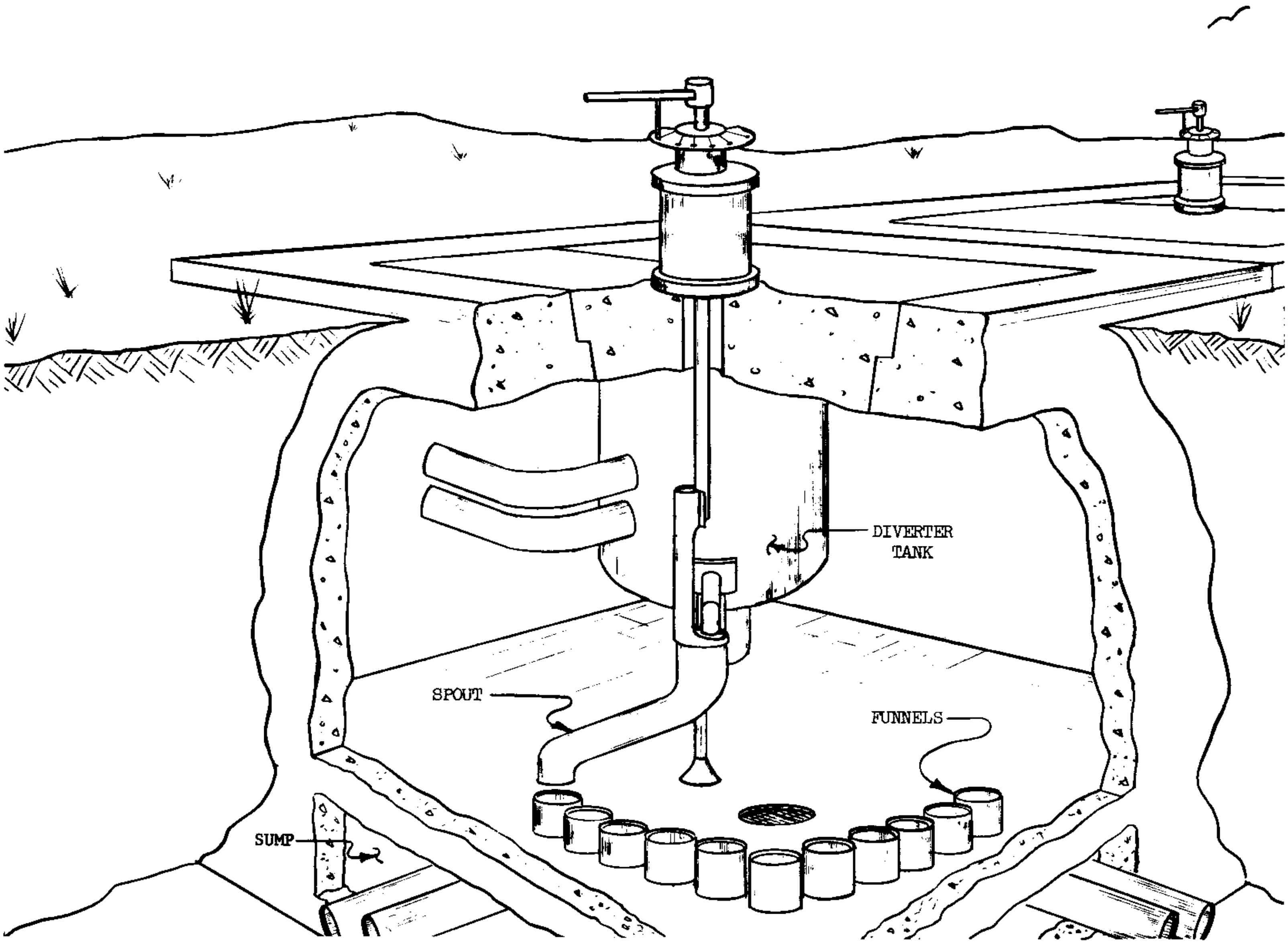

FIGURE XII-16

Diverter Station

PART VI

PROCESS CONTROL

CHAPTER XIII

INSTRUMENTATION

By

R. J. Merriman

HANFORD ENGINEERING SERVICES

WASTE MANAGEMENT TECHNICAL MANUAL

CHAPTER XIII

INSTRUMENTATION

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CHAPTER XIII

INSTRUMENTATION

A. INTRODUCTION

Continuous processing employed in the Waste Management Program requires that automatic instrumentation measure and control a majority of the process variables encountered. These variables include flow, pressure, liquid level, weight factor, specific gravity, liquid-liquid interface position, speed, vibration, sound, pH, temperature and radiation.

Generally an instrument measuring and control system consists of several component elements integrated to function as a system. The integrated component elements are the primary element which "senses" the process variable; an element that receives the signal from the primary element, conditions or modifies this signal, and transmits the modified signal to a receiver element where it is indicated or recorded; the controlling element which automatically transmits varying signals to the final control element to keep the process variable at the desired operating condition; and the alarm element to warn the process operator of an abnormal condition.

The purpose of this chapter is to discuss in detail the various instruments used in the Waste Management Program to measure and control the many processes.

B. FLOW MEASUREMENT AND CONTROL

The following types of flow measuring and/or control systems are used in the Waste Management Program: (1) electronic transmitting rotameter, (2) pneumatic transmitting rotameter, (3) indicating rotameter, (4) magnetic flowmeter, (5) orifice meter, and (6) displacement meter. The choice of the system depends upon the solution to be measured, whether it is radioactive or non-radioactive, acid or caustic, aqueous or organic, contains solids or not; upon the accuracy of the measurement desired; and upon the flow rates and the range of flow likely to be encountered.

1. Rotameters

Rotameters make use of a constant differential head across a restriction of variable area to measure the flow rate of a fluid. The general flow equation is:

$Q = CA\sqrt{2gH}$ where Q = flow rate, C = flow coefficient of discharge, A = area (variable), H = head difference across the annular restriction (constant), and g = acceleration due to gravity.

B.1. Rotameters (Continued)

The stream being measured passes upward through a vertical, truncated conical metering tube having the maximum diameter at the top. A float inside the tube adjusts its vertical position as required by the flow rate, and in so doing changes the annular area between the tube and the maximum diameter of the float.

Rotameters are usually designed for a flow rangeability of 10 to 1, but up to about 20 to 1 can be obtained. Rotameters have given satisfactory operation in flow ranges from a minimum of 6 to 60 ml/min to a maximum of 10 to 100 gal/min. Rotameters are generally not recommended for ranges below 0.1 to 1.0 gal/min. For smaller flows, the magnetic flowmeter should be considered.

Volumetric flow rates are affected by the density and viscosity of the fluid being measured. A density correction can be applied if the viscosity is less than about 3.0 centipoise for flows up to 2 gal/min., and less than about 20.0 centipoise for flows from 2 to 20 gal/min.

$$F = \sqrt{\frac{(P_{f2} - P_{w2})\ (P_{w1})}{(P_{f1} - P_{w1})\ (P_{w2})}}$$

F = Correction Factor
(Multiply original calibration by factor to obtain new flow rate)

P_{f1} = Density of original float

P_{f2} = Density of new float

P_{w1} = Density of original solution

P_{w2} = Density of new solution

The pressure drop across the rotameter is nominally 30 inches of water but can vary from about 0.1 inch to 50 inches depending upon size and service.

1.1 Electronic Transmitting Rotameters

A typical flow measurement and control system for use in a remotely operated separations facility is shown schematically in Figure XIII-1. The process solution line contains an electronic rotameter-transmitter and an air-operated control valve. An electrical conduit or jumper carries the signal wires from the rotameter through

B.1.1 Electronic Transmitting Rotameters (Continued)

the shielding wall to the amplifier-converter, located in a non-radioactive zone. It converts the electronic signal to a 3-15 psig air signal and is sent to a recorder-controller located on the instrument panelboard. The recorder-controller, in turn, sends a 3-15 psig air signal back through the shielding wall to operate the control valve.

1.1.1 Transmitters

A rotameter transmitter, especially designed for use in measuring the flow of a radioactive stream, is shown in Figure XIII-2. A float with an attached soft iron armature covered with a stainless steel tube assumes a vertical position in the tapered metering tube for a given flow rate. The transmitting coil, attached below the metering tube, forms an impedance bridge with a similar pair of inductance coils in the amplifier-converter. The float armature movement causes an impedance change that is detected by the amplifier-converter.

The stainless steel metering tube and coil housing are joined together by flanges and sealed with a Teflon "O" ring. The fluid enters at the bottom of the coil housing and passes through and around the coil housing (for flows greater than 0.25 gal/min), converges beneath the float, and then passes through the metering tube which is approximately 50 millimeters (mm) in active length. The tube has an enlarged section above the active length to allow purging of foreign matter which may cause the float to stick. The lower float stop is approximately 10 percent up the metering tube from the true zero so that the float portion will allow back flushing of the tube. All parts in contact with process solution are type 347 and 304L stainless steel or Teflon.

1.1.2 Amplifier-Converters

The amplifier-converter has a pair of induction coils and a soft iron armature (not stainless steel clad) similar to the rotameter. The armature is driven by a reversible motor controlled by the amplifier. Linkage attached to the upper part of the armature connects to a pneumatic transmitter to produce a 3-15 psig air signal proportional to flow.

The rotameter coils and the amplifier-converter are connected to form two parallel circuits. The outer leads are connected via a step-down transformer to a source of alternating current and the center lead of each coil is connected to the amplifier. The amplifier controls the rotation of the reversible servomotor. When the transmitter and receiver armatures are in corresponding positions in the coils, the impedance in each of the two circuits is equal, and no current flows through the center lead. However, as soon as the transmitter armature moves due to a change in flow rate, the impedance of the transmitter coils varies and causes a small current to flow in the center lead. The magnitude and phase relationship of this current is detected by the amplifier and energizes the reversing winding of the motor. The other winding (reference) of the

B.1.1.2 Amplifier-Converters (Continued)

motor is energized from a steady source of alternating current supplied through a capacitor to provide proper phase relationship. Depending on the direction of the error signal, the amplifier output current is always leading or lagging the current in the line winding by 90°, thus causing the servomotor to rotate in one direction or the other. Rotation of the servomotor is transmitted through a reduction gear and friction drive assembly to move the amplifier armature until it is again in a position corresponding to the transmitter armature. When this occurs, the error signal and amplifier output diminish to zero, the servomotor stops rotating, and the system is balanced.

The upper end of the armature in the amplifier-converter is connected through linkages to a pneumatic transmitter. The transmitter converts the mechanical input signal to a proportional 3-15 psig air signal, which is connected to a recorder-controller.

1.1.3 Recorder-Controllers

A miniature pneumatic recorder-controller is used for most flow measurements. It has a 3-15 psig bellows that receives the air signal from the amplifier-converter and, through linkages, operates a recording pen on a 4-inch, 0-100 percent, linear strip chart. A controller is usually attached to the recorder and a switching device is provided to allow transfer from "manual" to "automatic" control and vice versa without upsetting the flow control.

See Section B.6 for more information on the recorder and the various controller functions and see Section B.5 for information on control valves.

1.2 Pneumatic Transmitting Rotameters

The pneumatic transmitting rotameter is used only to measure the flow rate of certain "non-radioactive" process streams. A common control system consists of a pneumatic transmitting rotameter, a recorder-controller, and an air-operated control valve located in the process line. A 3-15 psig signal from the transmitter is received by the recorder-controller located on the instrument panelboard. The recorder-controller, in turn, sends a 3-15 psig air signal back through the shielding wall to operate the control valve.

A cascade control system consisting of pneumatic transmitting rotameters, master and slave recorder-controllers, ratio set point instrument, cascade subpanel and control valves, is shown schematically in Figure XIII-3. The function of the system is to maintain the flow rates of two streams according to a predetermined ratio.

The operation of the system is as follows: The set point of the master flow recorder controller (FRC) must be set for the desired operating conditions. Its 3-15 psig air control signal is directed to the control valve (DOV) located in the 1BX H_2O stream permitting flow through the pneumatic transmitting rotameter (FT) to the 1BX column. The flow transmitter's 3-15 psig output signal is transmitted to the master controller (see Figure XIII-4) and the ratio set point unit (SP).

B.1.2 Pneumatic Transmitting Rotameters (Continued)

The ratio unit contains a ratio relay which receives the linear input signal and produces an output signal that is a preset ratio of the input; a large dial for selecting and indicating the desired ratio; and a transfer station that consists of a transfer valve and a manual regulator. During normal operation, the transfer valve is placed in the "ratio set" position which permits the ratio relay to generate the output signal. When the transfer valve is placed in the "manual set" position, the manual regulator can be adjusted to generate the output signal.

The ratio set point output signal is transmitted to the slave flow recorder-controller (FRC) set point capsule, see Figure XIII-4, via the controller sub-panel described in Section B.6.3.4. The set point of the slave FRC is then adjusted automatically or manually by the ratio set point unit to maintain the proper flow ratio between the 1BX H_2O and 1BX chemical addition streams. The master flow recorder-controller transfer switch is described in Section B.6.3.4.

1.2.1 Transmitters

There are two general types of pneumatic transmitting rotameters. The first contains a glass metering tube which is fluted to guide the float and armature. The fluid enters horizontally at the bottom of the glass tube and leaves horizontally at the top. A stainless steel extension housing for the float armature is mounted on top of the glass tube with a magnetically-coupled pneumatic flow transmitter mounted around the extension housing. An armature is attached to the upper part of the float consisting of a stainless steel tube containing two cylindrical permanent magnets in the upper portion placed so that the north-seeking poles are adjacent. An additional pair of magnets is mounted around the outside of the stainless steel tube with their south-seeking poles adjacent to the north-seeking poles of the magnets inside the armatures. One manufacturer uses only one magnet on the armature and one on the follower. Thus, as the armature moves, the external magnets follow and, through a mechanical linkage system, operate a pneumatic transmitter to produce an air signal proportional to float position. The glass tube is usually calibrated in percent of maximum flow and the transmitter indicator reads in percent. The pneumatic 3-15 psig output signal is received by a panel-mounted recorder, recorder-controller or indicator.

The second type consists of a stainless steel metering tube with the fluid entering and leaving the bottom and top vertically. It is called a straight-through flow meter and is very compact. The transmitter is attached at about the middle of the metering tube. The operation is the same as described in the foregoing.

B.1.2.2 Recorders and Recorder-Controllers

A miniature pneumatic recorder-controller is used for most flow measurements. It has a 3-15 psig bellows that receives the air signal from the transmitter and, through linkages, operates a recording pen on a 4-inch, 0-100 percent, linear strip chart. A controller is usually attached to the recorder and a switching device is provided to allow transfer from "manual" to "automatic" control and vice versa without upsetting the flow control.

See Section B-6 for more information on the recorder and the various controller functions and Section B-5 for information on control valves.

1.3 Indicating Rotameters

1.3.1 Purge Rotameters for Dip Tubes

A small compact indicating rotameter, approximately six inches long, is used to measure the air flow to a dip tube for measuring weight factor, specific gravity, et cetera. It consists of a glass or plastic tapered metering tube and a ball float. The tube is calibrated in standard cubic feet per hour (SCFH) at 10 psig and 70 F. The range is usually 0.1 to 1.0 SCFH, 0.2 to 2.0 SCFH or 0.25-2.5 SCFH. A needle valve at the base of the metering tube is used for setting the desired flow rate. Accuracy is $\pm$ 3 percent of maximum flow.

1.3.2 Rotameters for Air, Water, and Chemical Flow

An indicating rotameter is located directly in the fluid to be measured and the flow rate is indicated by the float position opposite a calibration on the side of the glass tube or on a metal scale positioned vertically along the glass tube. The tubes are usually 130 mm or 250 mm in length and the calibration is usually in percent of maximum, but the calibration may be in actual flow units, gal/min, SCFM, et cetera, or in millimeters of float travel. If it is in mm float travel, a calibration curve would have to be provided. The body is usually stainless steel for chemical flow and brass or steel for water and air flow.

2. Magnetic Flowmeters

The "magnetic" flowmeter operates on the principle of Faraday's law of electro-magnetic induction - the voltage induced across any conductor as it moves at right angles through a magnetic field is proportional to the velocity of the conductor. The "magnetic" flowmeter is a modified form of an alternating current generator.

Figure XIII-5 illustrates the basic operating principle. Consider à segment of the moving fluid as a conductor of length "d", which is equal to meter pipe diameter. As the fluid conductor section moves

B.2. Magnetic Flowmeters (Continued)

transversely at velocity "V" through a uniform magnetic field "B", the voltage "E" induced across this section in the plane of the meter electrodes is proportional to the rate of fluid flow.

The "magnetic" flowmeter measures volumetric flow rate and is not affected by density, viscosity and fluid pressure. As long as the conductivity of the flowing fluid is above a certain minimum value, depending on meter size and cable length, changes in conductivity do not affect the flow measurement. The nominal minimum value of 80 micromhos per centimeter will be satisfactory for all meters. Some can go as low as 20 micromhos per centimeter. At 80 micromhos, the cable length between meter and amplifier can be up to 800 feet.

The "magnetic" flowmeter requires no "straightening" devices and may be connected directly at piping elbows and valves, or to a reducer from a larger or smaller diameter pipeline. The flowmeter has to be completely filled with the solution to be measured for accurate flow measurements. If the electrodes were covered with liquid but the upper portion of the pipe were filled with gas, the flow indicated would be the same as a completely filled pipe. The pressure drop through the meter is equivalent to an equal length of straight pipe of the same diameter.

The meter can measure flow in either direction by simply reversing the signal leads at the receiver or, if it is desired, the zero flow point could be elevated to 50% and flow measured in both directions. By adjustments at the receiver, a flow range change can be made over a 3,000 to 1 range.

The flowmeters are manufactured in the following sizes and are capable of operating over the range shown. Larger sizes can also be obtained.

Size	Flow Range - Gal/Min
1/10"	0 - 0.034 to 0 - 1.08
3/16"	0 - 0.137 to 0 - 4.1
1/2"	0 - 0.66 to 0 - 20.0
1"	0 - 2.9 to 0 - 80.0
2"	0 - 11.0 to 0 - 400.0

A typical flow system is very similar to an electronic rotameter system except that it uses a "magnetic" flowmeter instead of a rotameter. It consists of a process line incorporating the flowmeter and an air-operated control valve. An electrical conduit carries the signal and power via special cable through the shielding wall to an amplifier-converter located in a non-radioactive zone. It converts the electronic signal to a 3-15 psig air signal and is sent to a recorder-controller located on the instrument panelboard. The recorder-controller, in turn, sends 3-15 psig air signal back through the shielding wall to operate the control valve.

B.2.1 Flowmeter Transmitters

2.1.1 Special Radioactive-Service Flowmeter

A specially designed Fischer and Porter "magnetic" flowmeter is used to measure the flow of very radioactive streams that would cause a plugging problem if a "canyon type" rotameter were used.

The meter consists of a straight pipe section, approximately 10 to 20 inches in length, of "Inconel" coated with a liner of vitreous enamel 0.003 inches thick with two platinum electrodes fused into the liner. The liner provides the electrical insulation to prevent short-circuiting of the generated voltage. This liner should not be exposed to "caustic" or fluoride solutions. The meter is provided with either a butt weld fitting for welding directly into a process line, or with a standard 150 pound, type 316, stainless steel flange.

Two magnet coils, 180 degrees apart around the pipe, are wired in series and are fabricated of wire coated with a polyester film that has a very good resistance to gamma radiation. The signal wire and the wire for 120 volt, 60 Hz current to the magnet coils are insulated with linear polyethylene and go to a waterproof "Kovar" seal (an assembly of electrodes through a ceramic disc). From the "Kovar" seal, the signal and power cables are run together in a special shielded cable with linear polyethylene insulation. The coil, electrodes and a portion of the metering tube are covered with a 6-inch, Schedule 40, 304L stainless steel pipe to provide an acid-proof meter. The meter is potted with silicone rubber to fill all voids.

The reference calibration components that are normally in the meter were removed and placed in a box installed in an accessible location next to the amplifier-converter because these components could be damaged by radiation. However, it must be remembered that the calibration components are correct with only one meter and must be changed whenever the meter is changed.

See Figure XIII-6 for a schematic wiring diagram.

2.1.2 Standard Service Flowmeters

The "magnetic" flowmeter as obtained from the manufacturer is a standard line instrument and is very similar to the "special" described in foregoing Section except: (1) it cannot stand very high gamma exposure (10^6R as compared to 10^9R for the special meter, (2) the coil housing is not as resistant to chemical corrosion, and (3) it is not as rugged structurally. Since it is a production line instrument, the cost is about half of the special meter. Therefore, this type should be used wherever practical.

B.2.2 Amplifier-Converters

The amplifier-converter is an a-c, self-balancing potentiometer. The flow signal as developed across the meter electrodes is transmitted to the amplifier by a balanced line and is series-coupled through the dual secondary windings of a balancing transformer on the servomotor panel. A reference balancing signal is derived from a current transformer located in the calibration component block. The reference balancing signal goes through a servo-driven balancing network before being applied to the balancing transformer primary winding in phase opposition to the flow signal. The magnet coils and the reference calibration components are connected in series, and consequently are excited by the same current. Therefore, the amplitudes of the signal and reference voltage will increase or decrease proportionally with variations of line voltage. Since it is the ratio of signal to reference voltage which establishes the measurement criterion, no loss of accuracy will be experienced with a ± 10 percent variation of the line voltage or frequency.

The resultant error signal produced by the comparison of the flow and reference signals at the balancing transformer is amplified and applied to the control winding of a split-phase motor. The servomotor responds to the error signal by driving the balancing network slidewire potentiometer to a position which causes the signal output to be equal and opposite to that of the incoming flow signal. Thus, the servomotor is positioned by proportional feed back. The motor is mechanically joined to an indicating pointer to show the flow rate.

The motor is also connected through linkages to a pneumatic transmitter. The transmitter converts the mechanical input signal to a proportional 3-15 psig air signal, which is sent to a recorder-controller.

The output signal from the magnetic flowmeter electrodes is approximately 0.3 millivolts per ft/sec of fluid velocity. The flow range can be adjusted by two dials on the amplifier, from 0-1 ft/sec to 0-31 ft/sec. One dial increases the range by 10 ft/sec while the other dial is a ten-turn potentiometer which allows the velocity to be set to two decimal places. A full zero adjust allows the scale to be expanded from 1-31 ft/sec to any value from 1 to 62 ft/sec full scale. This also allows bi-directional flow to be measured by adjusting the zero to 50 percent for no flow.

2.3 Recorder-Controllers

A miniature pneumatic recorder-controller is used for most flow measurements. It has a 3-15 psig bellows that receives the air signal from the amplifier-converter and through linkages operates a recording pen on a 4-inch, 0-100 percent, linear strip chart. A controller is usually attached to the recorder, and a switching device is provided to allow transfer from "manual" to "automatic" control and vice versa without upsetting the flow control.

B.2.3 Recorder-Controllers (Continued)

See Section B.6 for more information on the recorder and the various controller functions and Section B.5 for control valves.

Sometimes the amplifier-converter is just an amplifier with recording provisions but may also have control functions. Such a recorder would have a 24-hour, 12-inch diameter, circular chart with a 4-5/8 inch calibrated length, 0-100 percent linear. If it has control functions, they would be the same as those described in Section B.6.

3. Orifice Meters

Orifice meters operate on the principle of a constant area flow restriction with variable head (pressure) loss. The relationship of flow rate and head loss is expressed in general form by the equation:

$Q = CA\sqrt{2gH}$ where Q = flow rate, C = flow coefficient of discharge, A = area (constant), H = head difference across the restriction (variable) and g = acceleration due to gravity. The difference in hydrostatic head created by the orifice is impressed across an instrument such as a manometer or a differential pressure transmitter.

The orifice system has a useful minimum to maximum flow range of about 3 to 1. The measurement of flow ratio beyond the range of a particular installation can be accomplished by either changing the size of the orifice or allowing a greater pressure drop across the orifice.

The orifice system is used primarily on air, steam, and water flow where all of the instruments including the orifice can be located in an accessible zone for maintenance.

Since air and steam are compressible fluids, the upstream orifice pressure should be fairly constant, otherwise a correction would have to be applied to the flow reading based on the known upstream pressure.

A typical orifice flow measuring system consists of: (1) an orifice plate mounted in a special flange on the process line, (2) high and low pressure taps at the flange, (3) valves in each line and by-pass valve between the two taps, (4) a differential pressure transmitter across the two taps below the valves, (5) a 3 - 15 psig air output signal from the transmitter to a recorder-controller located on a panelboard, and (6) a 3 - 15 psig signal from the controller to a control valve located in the process line. See Figure XIII-7.

B.3.1 Orifice Plates

The device used to produce the variable head is usually a sharp-edge orifice made from a 1/8-inch thick plate. This orifice is usually mounted in a special orifice flange that has pressure taps located one inch upstream and downstream from the face of the orifice. If the pressure taps are not located at the orifice, they are located at 2-1/2 pipe diameters upstream and 8 pipe diameters downstream, and it is called a pipe tap installation.

The thickness of the orifice plate should not exceed d/8, D/50, or (D-d)/8, where d is orifice diameter and D is pipe diameter. If thicker plate is used, the outlet face of the orifice should be beveled so that a straightedge laid across the bevel will form an angle not less than 45° to the axis of the pipe. The upstream edge should be square and as sharp as possible. Any rounding should not exceed 0.025 percent of the orifice diameter. The orifice plate should be centered in the pipe so that its eccentricity is less than 3 percent of the pipe diameter.

Valves, pipe fittings, sharp bends, et cetera, set up swirls, eddy currents, or other irregular velocity distributions in the pipe and may cause substantial errors in flow measurement. These effects are dissipated after the fluid flows through a considerable length of straight pipe. The length of straight pipe required on the downstream side of a valve or fitting is a function of type of fitting and the ratio of orifice diameter d to pipe diameter D. The orifice should have five pipe diameters of straight pipe after a 90° elbow at a d/D of 0.1 and should have twenty pipe diameters at a d/D of 0.8. After a valve there should be fifteen pipe diameters of straight pipe with a d/D of 0.1 and fifty pipe diameters at d/D of 0.8.

3.2 Transmitters

Transmitters from several manufacturers are used throughout the Waste Management Program such as Fischer & Porter, Foxboro, Republic, et cetera. They all work on the force balance principle – the resultant force caused by a differential pressure applied to a lever is balanced by an air pressure which amplifies the pressure to a proportional 3-15 psig air signal. See Figure XIII-8. This type transmitter is also used for weight factor, specific gravity, interface and pressure measurement.

3.2.1 Linear Transmitters

The transmitter is connected across the high and low pressure taps at the orifice. These pressures are applied to opposite sides of a measuring diaphragm and the resulting differential pressure exerts a force on a lever. This lever transmits the force, which is exactly proportional to the differential pressure on the diaphragm, through a range adjustment fulcrum to move the lever towards or away from the flapper nozzle of an air relay. The air output pressure of the relay is transmitted to a recorder or indicator and to a feedback bellows. The force exerted by the feedback bellows is exactly proportional to the force applied to the force lever

B.3.2.1 Linear Transmitters (Continued)

(proportional to differential pressure). In operation, the movement of the force lever is continuously adjusting the flapper-nozzle to maintain a balance of forces.

The 3-15 psig output signal is proportional and linear in relation to the differential pressure across the orifice. Since the flow through an orifice is a function of the square root of the pressure drop, the output signal must be transmitted to a square root indicating or recording instrument. If the output signal is transmitted to an instrument with linear or uniform scale, a calibration curve must be provided.

3.2.2 Square Root Extractor

Square root extraction is frequently necessary to linearize flow measurements from differential pressure signals developed by a differential pressure type flow transmitter. The resulting linearized signals are proportional to the flow.

The Moore square root extractor, shown in Figure XIII-9, employs a geometric relationship as the operating principle — the cosine of an included angle is compared with the change in the angle. This relationship holds true for small angular displacements. Referring to Figure XIII-9, the signal whose square root is to be computed is the input pressure A. The value of T is the square root of A. That is:

$T = K\sqrt{A}$, where K is a constant. The device works on a motion-balance principle. Increasing input signal A moves the floating link to the left to restrict the pilot nozzle. The restricted nozzle increases the output pressure and moves the output feedback bellows upward until balance is restored. Since the length of the floating link is fixed, $\cos \theta$ equals $1 - X/L$. A plot of output displacement, $Y = \theta L$ (for small values of θ, in radians) versus input displacement X shows the relationship to be virtually an exact square root.

3.3 Recorder-Controllers and Indicators

The 3-15 psig air signal from the differential pressure transmitter is received by either a recorder or a pressure indicator located on the instrument panelboard. If the signal comes from a linear transmitter, the recorder chart and indicator scale is usually calibrated 0-100 or 0-10 square root so that they express percentage of maximum flow directly. If the chart or scale is 0-10, it would have to be multiplied by 10 to get actual percentage. If the signal is from a square root extractor, the chart or scale would be 0-100 percent linear and would express the flow directly as percentage of maximum flow.

B.3.3 Recorder-Controllers and Indicators (Continued)

A miniature recorder-controller is used for most flow measurements. It has 3-15 psig bellows that receives the air signal from the transmitter and through linkages operates a recording pen on a 4-inch strip chart. A controller is usually attached to the recorder and a switching device is provided to allow transfer from "manual" to "automatic" control and vice-versa without upsetting the flow control.

See Section B.6 for more information on the recorder and the various controller functions and Section B.5 for control valves.

A pressure gauge, calibrated 0-100 percent or 0-100 square root for 3-15 psig, may be used if only indication is required.

4. Displacement Meters

Inexpensive displacement meters are used to measure the volume of water transferred where rate measurement or control is not necessary.

The meter contains a nutating piston which is activated by the passage of a fixed volume of liquid. The nutation of the piston, through a gear train, actuates a counter and registers total flow. Usually a six digit counter is used and resets to zero only after a full register.

5. Valves

Control valves are used to regulate the flow of process solutions, air, water and steam at a given rate by "throttling" or full line flow by "on-off" operation.

The valve has a plug or trim that is raised or lowered within a seat ring to change the amount of flow area thus regulating the flow. There are three general types of plugs used: (1) a linear (parabolic) plug produces a constant change in flow rate for a unit change in valve plug travel providing the pressure drop across the valve remains constant. This type of plug is used in those cases where the pressure drop in the system is largely concentrated across the valve. (2) An equal percentage (ratio or logarithmic) plug produces an equal percentage in flow rate for a unit change in valve plug travel (above 2 percent) providing the pressure drop across the valve remains constant. At any position of the plug, when the travel is changed 10 percent, the flow changes approximately 50 percent. This plug is used in those cases where only a small fraction of the pressure drop is dissipated by the valve. At low flow rates, however, it is possible for practically all of the pressure drop to be concentrated at the valve if necessary. (3) Quick opening or "on-off" valves are usually the same size as the line. Some throttling can be done with this type plug but full flow is obtained at 25 percent of valve travel. See Figure XIII-10 for curves of valve characteristics.

B.5. Valves (Continued)

Control valves have a rangeability of approximately 50:1 based on the ratio of the maximum flow coefficient to the minimum flow coefficient, which is determined by the clearance between the valve plug and its seat. If this clearance becomes large, the rangeability will drop off. The flow coefficient (C_V) is the flow rate in gal/min of water at one psi drop across the valve. A flow range of 50:1 may seem to be an unnecessary requirement; however, it is necessary for a system where a decrease in flow greatly increases the pressure drop or the energy that must be absorbed by the valve. For example, assume the maximum flow is 10 gal/min at 9 psi pressure drop and the minimum flow is 0.5 gal/min at 49 psi pressure drop.

Since: $$C_v = \frac{\text{gal/min}}{\sqrt{\Delta P}}$$

Then: $$\frac{C_v \text{ Max}}{C_v \text{ Min}} = \frac{\frac{10}{\sqrt{9}}}{\frac{0.5}{\sqrt{49}}} = 46.7:1$$

A valve rangeability of 50:1 would just handle the above flow condition even though the actual flow ratio is only 20:1.

The general flow formulas are:

Liquid: $$\text{Flow rate in gal/min} = C_V \sqrt{\frac{\Delta P}{G}}$$

Gas: $$Q = 1360\, C_v \sqrt{\frac{\Delta P}{(460 + {}^{\circ}F)G}} \sqrt{\frac{P_1 + P_2}{2}}$$

Steam: $$W = 2.1\, C_V \sqrt{\Delta P} \sqrt{P_1 + P_2}$$

Where C_V = the flow coefficient of valve defined as the flow rate in gal/min of water at 1 psi drop across the valve.

P_1 = Inlet pressure in psia

P_2 = Outlet pressure in psia

$\Delta P = (P_1 - P_2)$ pressure drop, psi

B.5. Valves (Continued)

Q = SCFH at 14.7 psia and 60 F

G = Specific Gravity

W = Pounds per hour saturated steam

The following plug sizes are available in both linear and equal percentage types. The listed C_V is based on Hammel Dahl data but other manufacturer types are approximately the same.

Nominal Plug Size Inches	C_V For Fully Open Position
1/4	1.6
3/8	2.5
1/2	4.0
3/4	6.3
1	12.0
1-1/4	18.0
1-1/2	28.0
2	48.0
2-1/2	72.0
3	100.0
4	160.0
6	360.0

For very small flows a "spline" type plug is used and consists of a 1/4-inch diameter rod with a groove of various tapers depending on size. This rod moves within a seat ring hole which must be a lap fit to give 50:1 rangeability. If the clearance is 0.001-0.002 inches, the rangeability is only 25:1. The splines come in sizes 1 through 15 but from a practical standpoint it is not recommended to use a spline smaller than No. 7.

Spline No.	C_V For Fully Open Position
1	0.63
2	0.40
3	0.25
4	0.16
5	0.10
6	0.063
7	0.040

Splines 1 through 5 come only as equal percentage and splines 6 through 15 come only as linear.

B.5.1 Diaphragm-Operated Valves

5.1.1 Radioactive Service

Diaphragm, air-operated control valves, especially designed for use in a radioactive area are shown in Figure XIII-11 and 12, and are the Hammel Dahl type and the Kieley-Mueller type which are similar in construction. The body is designed to allow complete drainage when the plug is off the seat ring and the valve is installed in a jumper to allow the liquid to return by gravity to a vessel. The valve has a single seat plug for tight shut-off with provision for easy removal of both the plug and seat. A welded, leaf-type stainless steel bellows is attached to the plug stem and is installed to permit the process solution to contact only the outside of the bellows, thus providing a washing action to prevent the bellows from fouling. Open construction between the auxiliary Teflon stem seal above the bellows seal and the diaphragm chamber allows the process solution to drain to the floor instead of backing up into a non-radioactive zone through the air line, if both seals should fail. The design of the Hammel Dahl diaphragm chamber allows the valve action to be changed from air-to-open to air-to-close by repositioning the spring adjustment nuts and moving the air connection from one side of the diaphragm to the other. The Kieley-Mueller valve is designed so that the diaphragm chamber must be removed and inverted in order to change the operation of the valve from normally closed to normally open. Most valves are the normally closed type, that is, on an air signal failure the valve will close. The diaphragm is fabricated of "Buna N" rubber with "nylon" inserts. This diaphragm can withstand a total gamma exposure of about 1×10^9R before failure. The life of the diaphragm can be improved somewhat by placing a lead shield around the chamber. If a valve is required to handle a much larger total exposure, the type described in Section B.5.2 should be used. Some of the other valves use neoprene with nylon inserts for the diaphragm and can withstand a total gamma exposure of about 1×10^8R before failure.

5.1.2 Non-Radioactive Service

Manufacturer's standard diaphragm-operated valves supplied by such companies as Fischer Governor, Foxboro, Honeywell, Keiley-Mueller, etc. are used to regulate the flow of non-radioactive streams. They are single- and double-seated valves designed for only one type of action, either air-to-open or air-to-close. The plug stem has a standard packing gland instead of a bellows seal — the packing is usually Teflon.

5.2 Piston-Operated Valves

An especially designed valve for very high gamma fields has been fabricated by the Fischer Governor Company and consists of a piston actuator instead of the diaphragm actuator. The piston actuator is

B.5.2 Piston-Operated Valves (Continued)

made without the use of plastics or organic materials and is capable of withstanding a very high gamma exposure in the magnitude of 1×10^{11} to 1×10^{12}R.

The valve body is of the angle type with the inlet vertical and the discharge horizontal. Two plug stem seals are provided: (1) the primary seal is a stainless steel convolution type bellows with the process solution on the outside of the bellows to provide a washing action, and (2) an auxiliary Teflon packing seal. The piston uses iron seal rings. An operating pressure greater than 40 psig is required for full-range operation of the piston. Since the controller output is a 3-15 psig air signal, an air relay must be installed to convert this signal to 9-45 psig.

5.3 Ball Valves

Ball valves are used in certain streams when positive shut-off is required. It consists of a stainless steel ball that rotates within an upstream and downstream Teflon seal ring. If used with high radioactive solutions, the seals are fabricated of linear polyethylene. The opening through the ball is equivalent to full line size and a ninety degree turn of the ball opens or closes the valve. It is normally used for on-off service and operated: (1) manually, (2) by an air-operated piston connected to the ball shaft, or (3) an electric motor connected to the ball shaft. If electric operated, micro switches operated by cams on the ball shaft are provided to limit the shaft rotation to ninety degrees each time the switch is energized. At times the switches get out of synchronization and then it is not known if the valve is open or closed. The ball valve can also be used for throttling service by the use of a "positioner" attached to the ball shaft which rotates the shaft proportionally for a 3-15 psig signal applied to the positioner. The positioner requires an air supply greater than 60 psig.

5.4 Solenoid Valves

Solenoid valves are installed in air signal lines to certain diaphragm or piston-operated control valves so that the valve can be opened or closed by an electrical signal from an alarm switch or relay. The alarm switch is operated by pressure, temperature, weight factor, flow, liquid level, power failure, etc.

A solenoid valve is a combination of two basic functional units, a solenoid (electro-magnet) with its plunger or core, and a valve containing a plug which is opened or closed by the magnetic plunger being drawn into the solenoid when the coil is energized. Most of the solenoids in service are three-way valves, that is, one port is connected to the diaphragm of an air-operated valve, the second port is connected to the

B.5.4 Solenoid Valves (Continued)

air supply, and the third port is a vent to remove air from the valve diaphragm when the air supply port of the solenoid valve is closed, thereby returning the control valve to its initial position. Two-way and four-way solenoid valves are also commonly used.

Solenoids must be installed with the direction of air flow through the valve as indicated by the arrows on the body. The process pressure must be on the top of the seat to assist in closing the valve when the plunger falls upon de-energizing the coil.

5.5 Pilot-Actuated Pressure Reducing Valves

A pressure reducing valve is used to reduce the pressure of air, water, steam, or any other process fluid to a fixed pressure lower than the supply pressure.

A pilot-actuated pressure reducing valve consists of a diaphragm-actuated main valve and a pilot valve to control the main valve by regulating the diaphragm pressure. The small pilot valve has a spring-loaded diaphragm. The spring tension can be adjusted by a screw. The pilot diaphragm is pressurized from the downstream (regulated) side of the main valve.

The pilot valve is normally open and is located in a small pilot line between the upstream (supply) pressure of the main valve and the top of the main valve diaphragm. The other side of this diaphragm is open to the downstream pressure. As supply pressure passes through the pilot, the main valve diaphragm is depressed, thus opening the main valve and allowing the process fluid to flow. When the desired downstream pressure is reached, the pilot valve closes the pilot line. A small bleed in the main valve diaphragm permits the pressure on both sides to equalize, restoring the main valve to its normal closed position. As fluid is drawn from the regulated pressure, the valve will open and modulate the flow to maintain a constant pressure. A pressure drop of at least 20 psi across the main valve is required to assure proper operation.

5.6 Safety Relief Valves

The basic function of the safety relief valve is protection of personnel, plant, and process equipment. In order to perform this function, the valve is designed to open automatically at a pre-determined set pressure, sized to provide full pressure relief of system, and to close tightly after operation.

. The safety relief valves used are direct, spring-loaded pop type. The main parts of the valve are the valve body and trim, loading spring, and disc. The disc is the moving part of valve against which the spring load is applied. The spring tension can be adjusted by a screw.

B.5.6 Safety Relief Valves (Continued)

When the force per unit area on the valve disc overcomes the load set-up in the spring, the valve will pop open. The pop action of the valve is caused when the air, steam, or gas media is first liberated, resulting in a powerful expansion force. This force, added to the dynamic force of the media flowing from the valve orifice, is utilized to give definite pop valve action. The set pressure of the valve should not be greater than ten percent above the maximum allowable working pressure of the system.

6. Receiving and Controlling Instruments

6.1 Indicators

If the indicator is part of the transmitter, it is described in that Section. If an indicator is used on the panelboard, it is a 0-15 psig pressure gauge calibrated 0-100 percent for 3-15 psig. It is either the normal, round, bourdon-type gauge or a drum-type gauge consisting of a 3-15 psig bellows and a drum dial indicator mounted on a metal frame. The dial, calibrated 0-100 percent, revolves in response to the pressure signal until the approximate value on the dial coincides with a stationary index on the window through which the drum revolves.

6.2 Recorders

The recorder described herein is the standard miniature pneumatic strip chart recorder. All other recorders are described under the various operating systems. Fischer & Porter and Foxboro recorders are used extensively. Bristol and Taylor recorders are similar. The Foxboro instrument has a chart that rolls down and, if a controller, the control set pointer and valve pressure indicators are along the top. The Fischer & Porter instrument has a chart that rolls from right to left and, if a controller, the control set pointer and valve indicators are on the right side of the case. These recorders come with one, two or three pens but generally are two-pen recorders. Each recording pen is operated through linkages from a 3-15 psig bellows receiver. A 4-inch chart is operated by an electric motor and the chart speed is either 3/4 inch or 3/8 inch per hour.

6.3 Control Functions

The controller is attached to the rear of the recorder and has a control set pointer, valve pressure indicator and a "manual" to "automatic" transfer switch within the recorder case - all adjustable from the front of the recorder.

B.6.3 Control Functions (Continued)

In the "manual" position, the control pointer is set at the desired air pressure to the valve and the process control function assumes some reading for this valve setting. In the "automatic" position, the control pointer is set to the desired value of the process control function and the controller adjusts the valve output pressure to maintain this setting. The controller has one or more of three modes of operation, that is, proportional band, reset, or derivative. See Figure XIII-4.

Some controllers (slave) are reset by another controller (master) and require a cascade sub-panel or ratio unit (see Section B.6.3.4) through which a signal resets the control point of the slave controller by means of a 3-15 psig bellows attached to the set point.

6.3.1 Proportional Band

The proportional band setting determines the amount of process pen movement from the control set point, expressed as percent of chart, necessary to change the controller output pressure from 3-15 psig. This is usually adjustable from 0-200 or 0-500 percent.

Example: Assume a proportional band setting of 10 percent and the control pointer set at 50 percent controlling the flow of a system. The controller output will be 15 psig if the flow pen falls to 45 percent, and the output will be 3 psig if the flow pen goes to 55 percent. Whenever the controller set pointer and process pen coincide, the output is 9 psig regardless of percent of chart reading. The process pen can stabilize at any point within the proportional band setting, and not necessarily at the control point. The smaller the proportional band setting the closer the process pen will stabilize to the control set point. On any given application, however, the proportional band can be reduced only to a certain point below which the controller will cycle.

6.3.2 Reset

The reset function is proportional to the deviation of the process reading from the set point and is continuous only as long as any deviation exists. The reset function can be installed only in a controller that has the proportional band function. The reset rate is usually expressed in minutes and is the time it takes for the controller output pressure to stabilize after one upset. It is usually adjustable, 0.01 – 10 or 0.1 to 50 minutes. If the reset setting is too fast, the controller output will change faster than the process variable and cycling will result – the action will become more like an on-off type controller. If it is too slow, the controller will not recover fast enough and will behave like a straight proportional controller. If the process is oscillating, it may take several hours for the controller to stabilize at a 10 minute reset setting.

B.6.3.3 Rate or Derivative

A rate or derivative function is proportional to the rate of change of the setpoint and the process variable. Such control equipment can be installed only on controllers that have proportional band functions or proportional band and reset functions. It provides fast stabilization of the process after a load change. This function is usually used whenever there is a long dead time or transfer lag in a process system. It is expressed in minutes and is usually adjustable for 0.01 — 10 or 0.1 — 50 minutes.

6.3.4 Transfer Station and Cascade Sub-Panel

The transfer station is mounted on the interface of the recorder-controller air connection manifold. The station consists of a three-position transfer valve, manually adjustable pneumatic pressure regulator, and a pressure indicator. The pressure regulator is furnished when local set point is required and omitted for remote set point use. When the recorder-controller is used with remote set point, an external cascade sub-panel having a transfer valve and pressure regulator for local set point is usually used.

The shaft of the transfer valve and regulator extend through the case of the instrument and are accessible from the front of instrument. The transfer valve permits selection of "automatic" or "manual" operating mode. The intermediate "seal" position is used when switching the controller from "automatic" to "manual" or vice versa. The "manual" position of the transfer valve directs the output of the pressure regulator to the final control element and simultaneously isolates the controller output. When in the "seal" position, the controller signal is isolated and the final control element pressure is sealed in. This final control element pressure is indicated on the transfer station pressure indicator. When transferring from "automatic" to "manual", this sealed-in pressure is used to adjust the pressure regulator output, as indicated by the recorder-controller recording pen, to the same value as the final control element pressure. When transferring from "manual" to "automatic" the sealed-in pressure is used to adjust the pressure regulator output set pointer to the exact value indicated by the recording pen. In the "automatic" position, the controller output is connected to the final control element. The pressure regulator output then becomes the set point pressure and is disconnected from the final control element.

The cascade sub-panel is located beneath the "slave" controller and consists of a three-way, two-position air switch, pressure indicator and a pressure regulator. The switch positions are called: (1) "Local Set" or "Manual", and (2) "Remote Set", "Pneumatic Set", or "Auto". In position No. 1 the pressure regulator adjusts the set point of the "slave" controller. In position No. 2 the signal from the "master" controller adjusts the set point of the "slave" controller.

B.6.3.5 Ratio Unit

In order to maintain the flow rates of two streams according to a predetermined ratio, a flow system consisting of the following is used. A flow recorder-controller (master) controlling the stream sends a signal proportional to the flow through a ratio unit to the set point of the second flow recorder-controller (slave).

The ratio unit is a controller with fixed setting except for the proportional band adjustment. This proportional band adjustment moves along a dial calibrated 0.3 to 3.0 for linear flows, or 0.6 to 1.7 for square root functions, from an orifice transmitter. Thus, ratios may be established from 0.3 to 1 through 3 to 1 by setting the ratio lever to the desired value. This is a set point air signal adjustment and not a flow rate ratio; for a true flow ratio the flow calibration of the recorders must be taken into consideration. The 3-15 psig signal from the flow transmitter is multiplied by the ratio setting factor and this new signal goes to the set point of the slave controller. Thus, the ratio is based on the slave to master reading.

The ratio unit also has a transfer switch as described in Section B.6.3.4 combined in one unit. The selector switch has two positions called: (1) "Ratio Set", where the "master" signal goes through the ratio unit and then to the "slave" set point, and (2) "Manual Set", where the signal from the unit PRV goes to the "slave" set point. Example: Consider a "master" flow range of 0 - 10 gal/min for a 3-15 psig air signal. The flow reading is 50 percent at 5 gal/min with an air signal of 9 psig. The ratio unit is set at 0.6 so the signal to the "slave" set point is (9-3)(0.6)=3.6+3=6.6 psig. The "slave" flow range is 0 - 5 gal/min for 3 - 15 psig, so the control set point of the "slave" is 30 percent or 1.5 gal/min. This is a flow ratio of 1.5 to 5.

6.3.6 Reverse Acting Pneumatic Relay

In pneumatic valve control systems it is desirable at times to operate several valves with one pneumatic signal and to operate valves in the event of failure of the air supply (which in some instances will close and in other instances will open). This sometimes requires the reversal of air pressure from an increasing signal to a decreasing signal.

The reverse acting pneumatic relay will receive an increasing (3 to 15 psig) input and transmit a decreasing output (15 to 3 psig). It has three air ports; one port receives the 3 to 15 psig input, the second port receives a 20 psig air supply, and the third port is for the 15 to 3 psig output. There is a 1 psig change in the output for each psig change in the input.

The relay also functions as an air volume amplifier, receiving a small volume of air and transmitting a large volume of air for valve control. A screw adjustment is provided which permits setting the 15 psig output with a 3 psig input.

B.6.4 Manual Controllers

Manual controllers are used to provide 3-15 psig pressure to air-operated control valves. The controller is an adjustable pressure regulating valve with a vertical dial to indicate the output pressure. The dial is calibrated 3-15 psig or 0-100 percent.

6.5 Integrators

6.5.1 Indicators

The flow indicator integrator consists of a 3-15 psig bellows that receives the pneumatic output signal from a flow transmitter and converts this pneumatic input to a mechanical lever position representing the signal level. The output lever is in turn linked to the input mechanism of an integrator and to an indicator arm to provide a visual flow rate indication on the vertical scale of the instrument. The integrator is a mechanical device employing a synchronous motor to provide the source of timed power to operate a feeler mechanism. The feeler detects the rise of an integrator cam as it is positioned by the receiver bellows. The integrator shows the cumulative total flow on a six-digit counter.

6.5.2 Indicator-Controller

The flow indicator-controller integrator consists of two separate units mounted one above the other on the instrument panel. One unit is that described above in Section B.6.5.1 with one exception - the integrator is equipped with a cam (sometimes referred to as a star wheel) and a microswitch to provide electrical pulses which are used to actuate the second unit, an electronic pre-determining type counter.

The electronic counter is a six-digit unit consisting of an electro-magnetically operated set of geared digit wheels. When the coil of the magnet is energized, the armature and ratchet advance the units digit wheel by one-half step. When the coil is de-energized, the return spring advances the wheel a second half-step, thus completing the registration of one count. The count is transferred to the next higher digit wheel by lock teeth and transfer pinions. The counter is capable of indicating totalized flow and is equipped with a pre-determining counter. The set of pre-determining wheels operate a single-pole, double-throw switch by means of a trip mechanism. The pre-determining wheels can be preset for any desired value by raising the preset cover on the front of unit. When in operation, the pre-determining counter counts from zero up to the preset number or desired value at which point the switch trips and the pre-determining wheels return to zero. The switch is automatically restored to its untripped position when the counter is reset either manually or electrically. The unit speed is 10 counts per second.

B.6.6 Alarms

The majority of the visual and audible alarms in the Waste Management Program are activated electrically by pressure-actuated switches connected directly to an air-purged dip tube system, directly to process lines, or to the output signal from a pneumatic transmitter. The variables monitored are flow, pressure, weight factor, liquid-level and temperature.

6.6.1 Visual Alarm Units

The visual alarm unit consists of two lamps, plug-in relay, flasher and electrical circuitry interconnected with the remote pressure switch contacts. The components are installed within a metal enclosure the front of which is transparent plastic. Lettering engraved in the plastic shows the condition of the variable monitored. Should an abnormal condition exist, the equipment or process monitored is identified.

6.6.2 Audible Alarms

The audible alarm used is a horn. It is usually electrically paralleled with a number of visual alarm units.

6.6.3 Pressure Switches

The sensing element of pressure-actuated switches is a bourdon tube or diaphragm linked mechanically to a single pole double throw (SPDT) snap-acting switch. When the pressure overcomes the setting of the load spring, the switch contacts are activated to open or close an electrical circuit.

When an abnormal condition exists in the monitored system, the visual alarm is activated and begins flashing and the audible alarm is activated. The audible alarm may be silenced by pressing the "acknowledge" pushbutton. The alarm lights then change from flashing to steady-on.

C. WEIGHT FACTOR, SPECIFIC GRAVITY, PRESSURE AND LIQUID LEVEL MEASUREMENT AND CONTROL

1. Purge Dip Tube Systems

An air-purged dip tube system is used for the measurement of weight factor, specific gravity and pressure of process vessels in the Waste Management Program. The system utilizes a controlled stream of air through an open-ended tube to counterbalance the pressure or hydrostatic head of another fluid into which it is flowing. The back pressure in the line is measured by a sensing device such as a manometer, gauge or differential pressure transmitter. See Figure XIII-13.

C.1. Purge Dip Tube Systems (Continued)

The air purged system produces a reading that is proportional to liquid height and specific gravity which is called the weight factor; thus liquid level, in inches of water, equals the weight factor reading, in inches of water, divided by specific gravity. Specific gravity measurements are made across a fixed liquid height and equal the differential pressure, in inches of water, divided by the actual inches of vertical distance between the high and low pressure dip tubes. A reading of 20 inches of water divided by a 10 inch dip tube spacing gives a specific gravity reading of 2.0. There must be liquid covering both dip tubes or the specific gravity reading will be a weight factor reading. Differential pressure measurements, such as static pressures on columns, is identical to a weight factor installation.

1.1 Weight Factor

The sensing element consists of two 1/2-inch stainless steel pipes; one extends to a point 1/2-inch (approximately) from the tank bottom and is known as the high pressure dip tube, and the other, known as the low pressure dip tube, senses at the extreme top of the tank. A stream of air flows through each pipe, controlled by a purge rotameter (see Section B.1.3.1), at approximately one cubic foot per hour. A differential pressure transmitter, see Section B.3.2.1, is connected across the high and low pressure dip tubes. It transmits a 3 - 15 psig air signal to a receiving instrument such as a gauge, manometer or recorder-controller, see Section B.3.3. If the receiving instrument is a weight factor recorder-controller, its 3 - 15 psig air output signal is directed to either a control valve or to a slave flow recorder-controller to control the flow into or out of the vessel and thus maintain a constant weight factor. A special weight factor control system is shown schematically in Figure XIII-14 and described in Section I.4.

Weight factor alarm switches, see Section B.6.6.3, are connected either across the weight factor dip tubes or to the output of the weight factor transmitter. They are used to provide visual and audible alarms at high and low values and also to automatically shut down pumps, agitators, flows, etc. to prevent overflowing a vessel or damage to equipment.

1.2 Specific Gravity

The sensing element consists of two 1/2-inch stainless steel pipes, the high pressure tube is commonly the same as that used for the high pressure weight factor tube, and the low pressure dip tube is usually ten inches higher in elevation than the high pressure dip tube. The low pressure dip tube elevation above the high pressure dip tube can be less or greater than the ten inches indicated above, provided it is normally covered with the process solution. A stream of air flows through

C.1.2 Specific Gravity (Continued)

each pipe and is controlled by a purge rotameter, see Section B.1.3.1, at approximately one cubic foot per hour. A differential pressure transmitter, see Section B.3.2.1, is connected across the high and low pressure dip tubes. It transmits a 3 - 15 psig air signal to a receiving instrument such as a gauge, manometer or recorder-controller, see Section B.3.3. The transmitter is equipped with an additional adjustment that allows the zero reading to be suppressed in order to give greater accuracy and readability.

Example: If the specific gravity range of a solution in a vessel will normally be from 0.7 to 1.2, the zero of the transmitter can be suppressed so that 0 percent represents 0.7 and 100 percent represents 1.2 specific gravity. With a 10-inch dip tube spacing the transmitter would then have a range of 7 to 12 inches to produce a 3 to 15 psig output signal.

If the receiving instrument is a specific gravity recorder-controller, its 3 - 15 psig air output signal is directed to either a control valve or to a slave flow recorder-controller to control flows into a vessel and thus maintain a constant specific gravity.

1.3 Differential Pressure

Differential pressure is measured across an extraction column and is called static pressure. The sensing element consists of two 1/2-inch stainless steel pipes; the high pressure tube senses at a point near the bottom of the column and the other at a point two inches below the organic overflow line. The installation is exactly the same as the weight factor installation and the static pressure reading is in inches of water. See Figure XIII-15.

Differential pressure is also measured across various gas flow restrictions such as filters, towers, etc. to indicate plugging of the equipment. The sensing element is two 1/2-inch stainless steel pipes; one at the high pressure side of the restriction and the other at the low pressure side. A differential pressure transmitter, see Section B.3.3, is connected to the sensing elements. The transmitter's 3 - 15 psig output signal is received either by an indicator, recorder, or a recorder-controller. In some cases, a transmitter is not used and the differential pressure sensing elements are connected directly to a manometer or a differential gauge.

2. Pressure Gauges

2.1 Bourdon Tube Type

Standard bourdon tube-type dial gauges are used for visual pressure indication of process steam, air, and water in vessels and pipe lines. Combination pressure-vacuum gauges are used on the steam jet systems and spargers. These gauges indicate the steam pressure to the jet and also show

C.2.1 Bourdon Tube Type (Continued)

a vacuum in the line in the event of steam condensation after the jet is turned off. A vacuum is undesirable since radioactive solutions might be drawn to the operating gallery.

The bourdon tube is a curved (essentially circular in form) tube of elliptical cross section with one end sealed. Pressure applied to the open end tends to straighten the tube; conversely, vacuum causes the tube to curl up. The movement of the closed, free end of the bourdon tube is transmitted through a mechanical linkage which, in the conventional pressure gauge, is multiplied by a rack and pinion system to activate a pointer. The gauges are calibrated in pounds per square inch (psi) or inches of water.

2.2 Manometers

A manometer is an instrument for measuring the pressure exerted by a gas, vapor or liquid. The simplest form consists of a U-shaped glass tube partially filled with liquid and with provision for measuring the height of the liquid. When both ends of the tube are open to atmosphere, or when they are both under the same pressure (greater or less than atmospheric), the liquid is at the same height in each leg of the tube. When one leg of the tube is connected to a source of pressure, the liquid in that leg is forced downward and the liquid in the other leg rises until the difference in height corresponds exactly to the pressure applied. By measuring this difference in height of the liquid, the applied pressure can be determined. The measurement can be expressed in units of length, such as inches or millimeters, making sure the liquid used in the manometer is specified, or a scale can be provided so that the reading can be in pounds per square inch (psi) or any other units desired. Because the U-tube manometer has one leg at atmospheric pressure, the measurements show gauge pressure rather than absolute pressure. The measurement is actually differential pressure — the difference between the pressure applied to the two legs of the manometer.

Vacuum pressure is measured in the same way as positive pressure. One leg of the manometer tube is connected to the source of vacuum and the other leg open to the atmosphere.

The two types of manometers used in the Waste Management Program are the well type and the inclined type.

C.2.2.1 Well Type Manometer

The fact that the reading of a manometer does not depend on the diameter of the manometer tube, and that the two legs do not have to be the same diameter makes possible the well type or single-tube manometer.

The well type manometer is essentially a U-tube manometer that has one leg of much greater cross sectional area than the other. In effect, the difference in level of the liquid in the well and the small tube is still being measured. However, the well is 200 or more times greater in area than the tube, and accordingly, the liquid in the tube changes its level 200 or more times as much as the liquid in the well. The change in the well liquid height is very minor and is corrected by the graduations on the scale. Thus, measurements are obtained by reading the change in level in the small tube. The well type manometer is used for weight factor and liquid level measurements which are usually read in inches of water.

2.2.2 Inclined Tube Manometers

The ventilation system of the canyon is so designed that the cells are maintained at a slight vacuum with respect to the operating gallery or deck level to prevent any radioactive gases from seeping into the operating gallery. The vacuum is measured by an inclined tube manometer having a range of 0-1 inch.

An inclined tube manometer is similar to the well type manometer except the small tube is inclined instead of vertical. Since vertical height controls the range of the manometer, the indicating liquid of an inclined manometer must travel a greater length in the tube to reach a given difference in vertical height. Therefore, the inclined manometer scale divisions are much farther apart and can be read much more easily and accurately.

3. Resin Column Pressure and Differential Pressure Measurement

The following instruments are used to measure and/or control the pressure in the resin column and the differential pressure across the resin bed: (1) pressure transducers, (2) signal converters, (3) differential pressure amplifier, (4) alarm, and (5) recorder. See Figure XIII-16.

3.1 Pressure Transducers

The diaphragm-type pressure transducer operates on the magnetic reluctance principle. The transducer is shown in simplified form in Figure XIII-17. A diaphragm of magnetically permeable stainless steel is clamped between two blocks and deflects when pressure is applied at

C.3.1 Pressure Transducers (Continued)

the pressure port. An "E" core and coil assembly is embedded in each block (with a small gap between the diaphragm and the "E" core) in a symmetrical arrangement, both coils having the same inductance when the diaphragm in the undeflected position. Diaphragm deflection increases the gap in the magnetic flux path of one core, and decreases it in the other. The magnetic reluctance varies with the gap so that the effect of the diaphragm motion is a change in inductance of the two coils, one increasing and the other decreasing. The two coils, L_1 and L_2, form two arms of a bridge circuit located in a carrier-demodulator unit described in the following section.

3.2 Carrier-Demodulation Converters

The solid-state carrier-demodulator instrument provides excitation to the bridge circuitry within the unit, including excitation of the two coils of the pressure transducer, which form two arms of the bridge. An amplifier and demodulator convert the bridge output to a 0 - 10 volt d-c signal.

3.2.1 Converters

The two signal converters in operation on the resin column convert the 0 - 10 volt d-c output signal from the carrier-demodulator to a d-c voltage compatible with other instruments of the system. Each converter utilizes six silicon transistors. Four transistors are connected as a stable dual-differential amplifier, and the remaining two transistors provide power amplification and a constant current output. One side of the differential amplifier is driven by the input signal through appropriate dividers; the other side is driven by feedback from the output stage.

The output stage provides a constant current source. It is also possible to obtain voltage outputs through internal loads in the output stage. The instrument is provided with potentiometer-type "zero" and "gain" adjustments.

3.3 Differential Pressure Amplifier

The function of the differential pressure amplifier is to provide an output signal proportional to the difference of two input signals. The signal converters, conditioning the two pressure transducer signals, provide the input to the differential pressure amplifier. The operation of the differential pressure amplifier is identical to that of the absolute pressure converters.

3.4 Alarms

The two alarms for the resin column monitor the absolute pressure in the area above the resin bed, and the differential pressure across the resin bed.

C.3.4 Alarms (Continued)

The alarms are electronic trip devices whose function is to actuate visual and audible alarms on high pressure/low differential pressure. Their action is similar to that of a relay and are used to sense a voltage level. When that voltage level exceeds the adjustable trip level, the single-pole, double-throw (SPDT) relay contacts in the device will switch.

The electronic trip receives a milliamp input signal from the converters, Section C.3.2.1. The device consists of a high gain, three-transistor amplifier and power supplies. The output of this amplifier is at approximately +12 volts until the input voltage exceeds that of the reference voltage, at which time the high gain causes the output to switch to zero volts. The reference voltage is set by a precision potentiometer powered by a zener diode reference supply.

3.5 Recorder

A miniature electronic two-pen recorder is used for recording absolute pressure and differential pressure measurements in the resin column system. The recorder is a self-balancing potentiometric instrument with built-in reference d-c power supply, servo-amplifier, and balancing motor components. The power supply, which furnishes power to the recorder-amplifier circuits and the balancing motor, and the servo-amplifier circuits are on printed circuit cards. Each servo-amplifier (two required) compares the process variable voltage with a local voltage generated by a slidewire circuit and, by means of an emitter-coupled difference amplifier, functions to produce sufficient voltage amplification to drive a two-phase balancing motor in a compensating direction. The balancing motor serves two major functions: (1) mechanically positions the slidewire to a condition of electrical null, and (2) mechanically positions the process indicator and recording pen. The recorder 4-inch strip chart and indicator scale is calibrated 0-100 linear. The strip chart speed is 7/8-inch per hour.

4. Conductivity Type Liquid Level Instruments

This type of system is used at the Tank Farm sluice pits for monitoring high water levels and liquid level in the underground waste storage tanks. See Figure XIII-18. The instruments of the system consist of the following:

(1) Level sensing electrodes and electrode holder.
(2) Indicating meter, and in some cases,
(3) Alarm light and horn.

4.1 Sluice Pit Probe

The sensing electrodes are two solid stainless steel rods with Teflon insulation over their entire length except at the extreme

C.4.1 Sluice Pit Probe (Continued)

tips. The upper end of the rods are threaded to fit a pressure-tight electrode holder with electrode plugs. The electrode plugs provide electrical termination points for the system control wiring.

The sensing electrodes, supported within the electrode holder, are installed vertically in the sluice pits at a pre-determined elevation for level monitoring. When the conductive liquid in the sluice pit rises to the level of the sensing electrodes, an electronic relay is energized which may activate a visual and audible alarm on the Instrument Control Panel.

4.2 Underground Waste Tank Probe and Indicating Meters

The probes used to measure the level in the underground waste tanks are of two types.

The first consists of an electric, rubber-insulated cord which can be lowered through a nozzle into the tank by a small winch. The cord is connected to a stainless steel electrode at the lower end which makes contact with the solution in the tank. The cord is marked with metal markers, one foot apart, starting with zero at the winch when the electrode is touching the bottom of the tank.

The second type is similar except that the winch is insulated from the tank and a stainless steel measuring tape is used in place of the electric cord to indicate the depth of solution. An ohmmeter is connected across the cord or winch and the tank metal. A charge in resistance indicates that the probe has contacted the liquid in the tank. The cord or tape markings then indicate the liquid level.

4.3 Alarms

The alarm light is one point or drop in a ten-unit annunciator. When the level sensing unit and electronic relay detect a high level in the sluice pit, the alarm light in the annunciator will begin to flash and a horn will be audible, indicating the abnormal condition. An acknowledge button which is part of the annunciator system silences the horn and changes the alarm light from flashing to steady-on. The alarm light will remain steady-on until the abnormal condition is corrected.

D. Interface Measurement

Two methods are utilized to obtain interface measurements between organic and aqueous phases in the solvent extraction tanks and columns: (1) An electronic float type system, and (2) the purged dip tube system. The electronic float system is used on the pulsed columns, because variation of pulse frequency would cause pressure variations in a purged dip tube system.

D.1 Electronic Float-Type System

A typical interface measurement and control system for use in a remotely-operated separations facility is shown schematically in Figure XIII-15. The vessel or column contains an electronic-float type transmitter assembly immersed in the process solution. The transmitter assembly also houses a resistance-type temperature bulb for measuring solution temperature. An electrical conduit or jumper carries the signal wires from the transmitter and the temperature bulb through the shielding wall to their respective amplifier-converters, located in a non-radioactive zone. For additional information on the temperature amplifier-converter see Section F.1.2.

The converter output is a 3 - 15 psig air signal and is received by a recorder-controller, which in turn sends a 3 - 15 psig air signal to a control valve to maintain the interface level constant.

1.1 Electronic Transmitter

The electronic transmitter utilized for interface measurement is a special instrument designed for applications in radioactive zones and is shown in Figure XIII-19. The transmitter consists of two separated chambers; the lower chamber contains the measuring float and is immersed directly in the process solution. The upper chamber contains the transmitting inductance coils. The float in the lower chamber is attached to a small-diameter, thin-walled, stainless steel tube that extends up through a larger stainless steel tube in the upper chamber. The larger diameter tube extends through the transmitting inductance coils. Contained within the small diameter tube, at its upper end, is a soft iron armature which is held in place by crimping the tube. The float assembly (float, connecting tube and armature) produces a linear motion in the vertical plane with changing interface levels. The float assembly must be weighted so that it will sink through the organic phase and float in the heavier aqueous phase. The float is calibrated so that it will float about 1/4 inch from the top of the float in an air-water interface and sink 1/4 inch from the bottom of the float in a 0.92 specific gravity organic-water interface. The transmitter inductance coils and similar inductance coils in the amplifier-converter are interconnected to form an inductance bridge.

1.2 Amplifier-Converter

The amplifier-converter for interface measurement is identical to that described in Section B.1.1.2.

1.3 Recorder-Controller - See Section B.6

2. Ultrasonic Detection (Resin Column)

A system utilizing ultrasonic techniques for measuring resin level in an ion exchange column is shown schematically in Figure XIII-20. The system consists of four basic components: (1) Transducer, (2) Scope, (3) Power Supply, and (4) Time Analog Unit.

D.2.1 Transducer

The transducer is a Branson Instruments, Inc. stainless steel clad probe. It is placed in the upper part of the resin tank, above the resin level but below the liquid level. A transmitted pulse will be reflected from the resin surface and return to generate an echo pulse in the transducer. The voltage analog of the time between transmitted pulse, plus an adjustable delay, and the echo pulse is received by the scope, and presents a visual indication on the cathode ray tube.

2.2 Scope

The function of the scope is to provide a pulse to the transducer, amplify the echo, and provide noise-free signals of the main bang and echos to the time analog converter. The scope also presents a visual display of the transmitted pulse (main bang) and the echo pulse. Some of the controls on the scope unit do not affect the time analog unit because the pulse height is not changed, but merely serves to control the visual display.

2.3 Time Analog Unit

The time analog unit converts the time between the gate and echo into a proportional voltage. This voltage is scaled with the material calibration dial on the unit and biased with the recorder zero dial. The gate can be delayed with respect to the main bang by the gate delay dial. If set too close to the main bang, adjustment of the damping or reject controls can cause faulty gating. The display of gating given on the scope is useful in correcting malfunction. The recorder zero of the time analog unit is not related to pulse time information but is used to generate a reference or bias for a recorder-output voltage.

3. Purged Dip Tube System

The purged dip tube system used for interface measurements is similar to that used for specific gravity measurements, see Section C.1.2, except the dip tube spacing for interface is usually greater.

This type of system cannot be used for bottom interface measurements on a pulse column due to the pressure variations created by the pulser.

4. Capacitance Probe

The liquid level of the waste cask is determined by the use of an electrical capitance measurement. The level system consists of a capacitance probe, a pulse height to d-c converter, and a liquid level indicator.

This method for the conversion of capacitance to a pulse height or amplitude has been developed at Hanford. In essence, the method involves measuring the charge stored on an unknown capacitance by shunting the capacitor with one winding of a pulse transformer and measuring the output of the secondary

D.4 Capacitance Probe (Continued)

winding. This process is repeated by alternately charging and shunting the capacitor. The resulting output is a series of pulses whose amplitude is proportional to the unknown capacitance. The pulses are conditioned to develop a d-c voltage which is indicated on a voltmeter calibrated in liquid level units. A functional diagram is shown in Figure 21.

Measurement of the capacitance of the probe at the end of a long cable of high characteristic capacitance is accomplished as follows:

A pulse transformer is connected in series with one electrode of the capacitance probe C_x (see in Figure 21). The capacitor and cable are charged through resistor R_1 by power source E_0, the cable is shorted periodically by the electronic switch S_1, and the charge on the unknown capacitor C_x discharges through the pulse transformer T-1. A voltage proportional to the unknown capacitance is induced in the transformer secondary. A pulse height to d-c converter is then utilized to develop an analog d-c voltage for the level read-out.

All components of the capacitance measuring probe use radiation-resistant materials.

E. RADIATION MONITOR SYSTEMS

The Waste Management Program has two generalized applications for radiation monitoring instrumentation, (1) process control monitoring, and (2) environmental monitoring.

Process control monitoring is provided for measuring the radiation intensity of process streams and process vessels. This radiation information indicates: (1) the activity of the solutions inside a vessel, (2) permits the operator to "see" the solution enter and leave the vessel, and (3) indicates the effectiveness of the separation steps.

Environmental monitoring/health monitoring is provided throughout the building work areas for personnel protection. The radiation levels are continuously monitored by indicating and recording instruments. Should high radiation levels be detected, the system will activate audible and visual warning devices.

1. Geiger-Mueller Type

Two Geiger-Mueller type radiation detection systems are used to monitor the radiation level of the steam condensate to crib 216-B-55, and the process condensate to crib 216-B-12. Each Geiger-Mueller detector is mounted within a 3-inch diameter pipe well which is closed at the bottom end and is provided with a removable pipe cap at the upper end. One side of the pipe well at the upper end is slotted to accommodate the detector cables. The wells are approximately 4'-6" in length and are installed in their respective system condensate tanks.

E.1 Geiger-Mueller Type (Continued)

Each monitoring system consists of the following instruments: (1) a Geiger-Mueller counter tube, (2) a d-c power supply, (3) an amplifier-discriminator, (4) a count rate meter, and (5) a two-pen recorder which is used to record the radiation level of the two systems.

1.1 Geiger-Mueller Counter Tube

The Geiger-Mueller detector is a gas-filled, halogen quenched, beta-gamma counter tube which produces a large, easily counted, pulse for each ionizing event that enters and triggers the tube. Within the cylindrical metal tube, a fine wire anode is stretched along its axis. When a high voltage (500 to 2,000 volts) is impressed across the wire and the grounded metal tube wall, the radiation energies entering the counter tube will initiate the ionizing process and produce output pulses.

1.2 Power Supply

The high voltage d-c power supply for the system is rated 0 - 2100 volts at 30 milliamperes. The high voltage is developed by a voltage doubler circuit using a switched secondary high-voltage transformer, high-voltage silicon rectifier stacks, and oil-filled filter capacitors. The output of this supply is regulated by series pass tubes. The tubes are in turn controlled by a solid-state feedback amplifier with greater than 130 decibels of d-c gain. The variable voltage divider sampling string, which is switched to change output voltage, consists of stable low-temperature coefficient wirewound resistors. Output of the supply is available at both the front and rear panel through coaxial type connectors. Output polarity is controlled by a front panel switch to provide either positive or negative grounded operation. A zero-center panel meter monitors the output voltage. Calibration accuracy of the power supply unit is ±0.25 percent or 100 millivolts (whichever is greater) with vernier at zero. Load regulation is 0.001 percent or 5 millivolts (whichever is greater) for a full-load change.

1.3 Amplifier-Discriminator

The function of the linear amplifier and discriminator is to accept pulses from the Geiger-Mueller counter tube and to provide amplification and amplitude discrimination of these pulses. The unit has three integrated controls that are accessible from the front of the unit: (1) course gain/fixed sensitivity, (2) fine gain, and (3) discrimination. The output pulses of the amplifier are delivered directly to the discriminator section and must have an amplitude exceeding the level for which sensitivity is set in the discriminator. Any pulse above the discrimination level triggers the discriminator to produce an output pulse with a fixed amplitude and duration. This pulse is then received by the count rate meter. The d-c power required for operation of the amplifier-discriminator is available at each of the four plug-in module positions in the instrument cabinet.

E.1.4 Count Rate Meter

The count rate meter receives the positive output pulses from the discriminator, converts these pulses to a direct current proportional to the average count rate in counts per minute (CPM). This current, amplified, operates a 3-inch meter and records potentiometric outputs. This instrument offers the choice of linear or logarithmic presentation of the count rate. When the function switch is in the linear mode, a range switch selects one of eight full scale ranges from 500 to 1,000,000 CPM. With the function switch in the logarithmic mode, a three decade presentation between 10^3 and 10^6 CPM is obtained. The front panel controls and their functions are as follows:

1. Background Control - Single-turn potentiometer that allows the zero level of the front panel meter to be set above background which is below the region of interest.

2. Function Control - Two-position rotary switch to select the linear or logarithmic operating modes.

3. Volume Control - On-off switch and volume control adjusts the audio output for the built-in aural monitoring system.

4. Response Control - Six-position rotary switch which will function only in the linear mode. Switch selects one of five integrating time constants marked in seconds. The sixth position on the rotary switch is marked "Cal". When in this position, the count rate meter input is disconnected while the meter response is checked against an internal 3600 CPM signal. This "Cal" position will function in both linear and logarithmic modes.

5. Range Control - Eight-position rotary switch selects one of eight full-scale ranges marked in CPM. Range control switch functions in linear mode of operation only.

6. Potentiometer Expansion Control - Ten-turn precision potentiometer provides ten-times expansion of the count rate meter recorder outputs. The output toggle switch at the rear of unit must be in the 10 mv or 100 mv range to utilize this control.

7. Zero Adjustment Control - Single-turn potentiometer adjustable from the front of unit with a small screwdriver which sets the front panel meter or recorder to zero.

1.5 Radiation Recorder

The instrument is an electronic, self-balancing, potentiometer type strip chart recorder with two recording pens. The 4-inch strip chart and indicator scale are calibrated 0-100 linear. The strip chart is operated at 3/4 inches per hour by a synchronous motor. The 0-100 millivolt signal from the count rate meter is received by the recorder input conversion module. The input conversion module conditions the count rate meter signal and, through retransmitting circuitry, sends a 0-10 volt

E.1.5 Radiation Recorder (Continued)

d-c signal to the servo amplifier assembly. The components of the servo amplifier assembly consist of an operational amplifier and other circuit components to amplify the difference between the input signal and a d-c feedback voltage. The operational amplifier also provides power to drive a torque motor clockwise or counter-clockwise.

The torque motor has a permanent magnet field stator and a one coil armature for bi-directional rotation of its output shaft. Also attached to the output shaft is a potentiometer which provides a servo system feedback voltage variation of 10 volts d-c. The torque motor drives the recording pen through linkages.

When the input signal to the operational amplifier increases, a momentary difference occurs in the ratio of input signal to the feedback voltage. This error signal is amplified by the operational amplifier to rotate the torque motor and the attached potentiometer clockwise. The increased feedback voltage is also applied to a summing junction. Upscale motor rotation (clockwise) will bring the motor into a position that restores the balance between the feedback voltage and the input signal.

2. Gamma Spectrometer System

The gamma spectrometer system is used to measure cesium 137 breakthrough on the ion-exchange column effluent line. Similar systems monitor additional process streams, such as 1AP, 1CP, etc.

Each isotope has a gamma spectrum, and usually one or more descriptive peaks that can be used to identify the radioactive substances carried in a process stream.

2. Gamma Spectrometer System (Continued)

By calibrating the spectrometer spread in pulse height, 0 - 1 Mev for example, a scan can be made to show what isotopes are present. Then by utilizing the pulse height analyzer in the system, a given peak can be selected and monitored continuously. The gamma-ray energy peak of 0.667 Mev is used for cesium 137; with the pulse height set to monitor between 0.647 and 0.687 Mev.

The gamma spectrometer system consists of the following components:

1. Monitor probe encasement assembly.
2. Detector assembly.
3. High-voltage power supply.
4. Linear amplifier.
5. Pulse height analyzer.
6. Baseline sweep.
7. Count rate meter.
8. Recorder.
9. Nuclear instrument modular bin.

2.1 Monitor Probe Encasement Assembly

The monitor probe encasement assembly (see Figure XIII-22) is a collimating column that penetrates the concrete wall separating the radioactive process cell and a non-radioactive zone. It consists of a 3-inch, schedule 40S, stainless steel pipe approximately 9'6" long, extending from the non-radioactive zone into the radioactive zone at an angle of 20 degrees from the horizontal. The pipe end that pentrates the radioactive zone is sealed by a 1/4-inch thick steel plate welded to the pipe, and is as close as possible to the process line being monitored. A hinged door at the other end of the pipe is shielded with lead and has provisions for the routing of the radiation detector electrical cable. Within the 3-inch pipe is a 2-1/2 inch, Schedule 40, carbon steel pipe whose length depends on the number of

E.2.1 Monitor Probe Encasement Assembly (Continued)

lead shields or plugs required in the length of 3-inch pipe. Each lead shield has a hole through its length on the centerline to form a collimating column. The lead shield closest to the stream to be monitored has the smaller diameter hole and, in each plug thereafter, the hole size increases a fractional amount. The detector assembly described in the following Section is inserted between the shielding door and the final plug.

2.2 Detector Assembly

The detector assembly consists of scintillation crystal, photomultiplier tube, and preamplifier. The approximately dimensions of the assembly are 3 inches in diameter by 10-1/2 inches long.

An americium doped sodium iodide (thallium-activated) crystal is used for gamma ray detection of cesium 137. It is approximately 1-3/4 inches in diameter by 2 inches thick. The photomultiplier tube is an 11 stage, head-on, flat-surface type with an S-11 response.

The preamplifier accepts the output signal from the crystal and photomultiplier combination and transforms the signal into a pulse that can be amplified. It has a 3-12 adjustable gain control.

2.3 High-Voltage Power Supply

The high-voltage power supply for the system is a regulated d-c source delivering from 1 to 2,012 volts at up to 10 milliamperes. It is possible to select any voltage over the range of 1 to 2,012 volts by three, step switches and a unit volts vernier potentiometer. Output regulation is 0.0025 percent of voltage setting or 2 millivolts (whichever is greater) at any setting for a 100 percent load change or a 10 percent a-c line voltage variation. Calibration accuracy of the power supply is less than 0.25 percent from 250-2,012 volts.

2.4 Linear Amplifier

The double RC clipped linear amplifier accepts the input pulses from the preamplifier (Section E.2.2), shapes these pulses, and increases their amplitude. The instrument is equipped with "course" and "fine" gain controls, adjustable 20 to 1,000. This linear amplifier furnishes power to the preamplifier.

2.5 Pulse Height Analyzer

The pulse height analyzer accepts input pulses from the linear amplifier. The instrument trigger circuit performs two important functions: (1) it establishes a pulse amplitude threshold level, permitting discrimination against noise pulses, and (2) it produces output pulses of fixed amplitude and width for reliable operation of the count rate meter, Section E-2.7. The pulse height analyzer controls are accessible from the front

E.2.5 Pulse Height Analyzer (Continued)

of unit and consist of an "E" discriminator (a 10-turn precision potentiometer) that may be varied continuously over a range of 300 millivolts to 10 volts; a "ΔE" discriminator (a 10-turn precision potentiometer) continuously variable over a range of 0-10 volts; an integral-differential toggle switch which selects the pulse height analysis mode; and a baseline sweep control to permit a choice of either front panel baseline control or remote baseline control.

2.6 Baseline Sweep

The baseline sweep instrument in the gamma spectrometer system permits a recorder plot of all or part of an energy spectrum by continuously sweeping the window (the acceptance region whose edges are defined by the upper and lower trigger levels) of the pulse height analyzer through the region of interest.

The controls for the instrument are accessible from the front and consist of the following:

1. Upper limit control - potentiometer to select upper or starting voltage across a 0-10 volt baseline.

2. Lower limit control - potentiometer to select lower or ending voltage across a 0-10 volt baseline.

3. Sweep time control - four-position selector switch to select sweep times of 2, 5, 10 or 20 minutes over the full 10-volt sweep range.

4. Recycle-manual control - two-position switch to select automatic recycle or manual operation.

5. Start control - pushbutton to initiate sweep operation.

When the upper and lower limit voltages and the sweep time are selected, the instrument will continuously drive the threshold setting of the pulse height analyzer, to which it is electrically connected, from the upper to lower setting. In the automatic recycling mode, the sweep voltage, upon reaching the lower level setting, will return to the starting value. After a pause the sweep cycle will be repeated. The range of the sweep is from 0 to 10 volts which matches the dynamic range of the pulse height analyzer. With the sweep limits set for the full ten-volt range, the sweep time will be as selected by the sweep time control. The length of the sweep period is reduced proportionately as the range of the sweep is reduced. The meter located at the front of instrument reads sweep position at all times.

E.2.7 Count Rate Meter

The linear count rate meter integrates the input pulses from the pulse height analyzer, Section E.2.5, and shows the integrated count rate in terms of counts per second (CPS) on the 2-1/2 inch meter of the instrument. It has thirteen linear ranges with full-scale values from 10 to 100,000 CPS. The instrument has the following controls:

1. Signal selector control - four-position selector switch which selects polarity of the signal to be counted. It also selects one of two calibration frequencies.

2. Time constant control - selects desired integration time constant of 0.5, 2, 10 and 40 seconds.

3. Range switches - primary range switch selects 10, 100, 1,000 and 10,000 CPS full-scale reading. The secondary range switch selects the multiplier factor to which the meter scale is multiplied.

4. Zero suppression control - 10-turn precision potentiometer can provide zero suppression up to 100 percent of full scale.

5. Recorder output control - the output voltage level to the recorder may be adjusted over a range of plus 20 millivolts.

2.8 Recorder

The recorder is a null-balance, servo-operated potentiometric strip chart recorder with the following basic functions: (1) display, (2) feedback generating, (3) error-detecting, and (4) amplifying.

The voltage to be measured is connected to the recorder in opposition to an internally generated feedback voltage. The difference between the voltage to be measured and the feedback voltage is applied as the input to the amplifier. The amplifier output drives the servomotor which, in turn, drives a potentiometer which changes the internally generated voltage until the difference voltage is very small. The servomotor then stops and the pen records the value of voltage measured. Very little current is drawn from the voltage source because it is balanced by the internal feedback voltage. In addition to these basic functions, the recorder requires damping. With a sudden change in the input signal, the error voltage may be sufficient to run the servomotor at full speed. But when the error voltage reaches zero, the servomotor inertia prevents a sudden reduction to zero speed. Without damping, the recorder would overshoot the proper balance point and go into steady oscillation, first overshooting on one side of the balance point and then the other. The damping system develops a voltage proportional to the speed and feeds it into the amplifier so that the servomotor torque generator stops exactly when the feedback voltage equals the voltage to be measured.

E.2.8 Recorder (Continued)

The recorder reference power supply is a highly accurate d-c voltage source. The unit consists of a voltage-regulator circuit with a temperature-compensated zener diode reference element. The accuracy of the recorder is ± 0.25 percent full scale or ± 5 microvolts - whichever is greater. The chart speed for spectra analysis can be selected from one of seven basic speeds: 1, 6, or 10 inches per hour and 1, 6, 10, or 30 inches per minutes and, by the installation of change gears, the 1-inch per hour and 1-inch per minute speeds can be doubled and quadrupled. Normal chart speed is 1 inch per hour; but, when a scan is run the chart speed is 1 inch per minute. The response time for full-scale pen travel is 5.0 seconds.

2.9 Nuclear Instrument Modular Bin

The instrument modular bin provides power and mounting space for the instruments described in Sections E.2.4, 2.5, 2.6 and 2.7. The bin conforms to the adopted standards of the Atomic Energy Commission Committee on Nuclear Instrument Modules as described in Report TID-20893(Rev.).

3. Ionization Chambers

There are two types of ionization chambers used: (1) process type and (2) environmental/health monitoring type. The principle of operation is the same for both types.

The ionization chamber is simply a cylindrical container housing an insulated center "collector electrode" or anode, and a concentric "high-voltage electrode" near the outer shell. The container is filled with a gas, such as dry air or argon, at atmospheric pressure. When gamma rays enter the container, some of their energy is expended in ionizing the gas. These ions are attracted to the electrode of opposite charge and cause a minute electric current to flow from one electrode to the other through a sensitive external readout circuit.

3.1 Process Type Chambers

Process type ionization chambers for monitoring in-cell process vessels are 5-inch diameter, 27-inch long steel cylinders, filled with argon gas. The chambers are located in a 6-inch steel pipe embedded in the concrete cell wall. A "window" covered with a steel plate is provided in the concrete opposite each chamber so that the chamber "sees" predominately only the vessel which it is intended to monitor.

The ionization chamber is connected electrically to a picoammeter, described in Section E.3.3, which provides the chamber with regulated power as well as the circuitry for measuring the chamber output currents.

3.2 Environmental/Health Monitoring Chambers

The environmental type ionization chambers are 5-inch diameter, 19-inch long, paper-reinforced, phenolic cylinders, filled with dry air. A description of the chamber is as follows: Refer to Figure XIII-23.

E.3.2 Environmental/Health Monitoring Chambers (Continued)

The chamber anode consists of a polystyrene tube with a conductive spray paint coating over its entire surface except for a 1/2-inch insulation barrier at the open end. The anode structure is attached to the head plate with epoxy cement. Since the head plate is at ground potential, it provides isolation between the anode current path and the cathode polarizing potential and, therefore, acts as an anode guard ring.

A 1/4-inch female pipe thread opening is provided in the center of the head plate for insertion of a low-level radioactive source to obtain a minimum chamber output current for certain radiation monitoring system requirements. The insertion or removal of this source does not affect the chamber seal due to the sealed anode structure. Since the source can be inserted in the center of the chamber volume, providing 4π geometry, a minimum source intensity can be used to provide any given background current.

The cathode consists of a conductive spray coating on the inside of the cylindrical shell. As in the case of the anode structure, a 3/8-inch insulating barrier is provided at the open end to prevent the polarizing voltage shorting to ground. Because the shell is constructed of an insulating material, there is no shock hazard when the assembled chamber is placed in an active circuit.

A simulated high radiation level monitoring system check circuit is incorporated in the chamber. The circuit provides a means for checking all the cables and connections to the ion chamber for proper makeup and to determine that the system will function in a high radiation level. The check circuit is actuated by placing a permanent magnet on the outside surface of the chamber near a magnetically-actuated reed switch. The most effective position of the external magnet is marked on the outside of the chamber by a painted yellow rectangle. Any magnet that will produce a magnetic field strength of 80 gauss at a point 1/2 inch inside the chamber surface will actuate the reed switch.

The chamber has a gamma sensitivity of 3.33×10^{-10} amperes per Roentgen per hour and has less than 10 percent loss of saturation in a field of 1,000 R/hr when operated at a polarizing voltage of 250 volts d-c.

The environmental ionization chamber is connected electrically to a picoammeter, described in Section E.3.3, which provides the chamber with regulated power as well as the circuitry for measuring the chamber currents.

3.3 Picoammeters

Picoammeters are used to measure small electric currents generated in the ionization chambers described in Sections E.3.1 and E.3.2. The current produced by a chamber is proportional to the radiation intensity. Picoammeters discussed below are the Keithley Model 410 and Model 410-C.

E.3.3 Picoammeters (Continued)

The Keithley Model 410 is a line-operated, vacuum-tube, electrometer designed for measuring small currents. The total range is from 1 x 10^{-3} to 3 x 10^{-13} amperes. This range is divided into twenty overlapping full-scale current ranges in amperes as follows:

10 x 10^{-4}	10 x 10^{-9}
3 x 10^{-4}	3 x 10^{-9}
10 x 10^{-5}	10 x 10^{-10}
3 x 10^{-5}	3 x 10^{-10}
10 x 10^{-6}	10 x 10^{-11}
3 x 10^{-6}	3 x 10^{-11}
10 x 10^{-7}	10 x 10^{-12}
3 x 10^{-7}	3 x 10^{-12}
10 x 10^{-8}	10 x 10^{-13}
3 x 10^{-8}	3 x 10^{-13}

The above ranges are selected and read from the front panel. The major panel controls are the range switch (amperes full scale) and the zero adjust knob. Minor controls are the zero check, used to short circuit the input to permit setting the zero point; meter polarity switch for providing up-scale readings for current flows in either direction; and an on-off power switch. An illuminated meter, calibrated 0 to 10 and 0 to 3 is located on the panel.

An output of up to 5 volts and 5 ma is provided from a connector located on the back of the chassis for driving recorders. Most ionization chambers require an extremely well regulated polarizing voltage. A connection on the back of the chassis provides a +216 d-c voltage suitable for this purpose.

The Keithley Model 410 C is identical to the Model 410, except that the panel meter is provided with contacts which can be set to close at any predetermined pointer deflection. The delicate meter contacts operated a relay within the chassis, and the relay contacts (SPDT) are available for external switching functions through a connector on the back of the chassis.

3.4 Recorders

3.4.1 Process Cell Radiation Recorder

The process cell radiation recorder is a Leeds & Northrup "micromax" potentiometric-type, multipoint recorder.

It is approximately twenty-four years old, but this four-point recorder has been reconditioned to record the radiation intensity in the process cells as detected by the ionization chambers described in Section E.3.1.

3.4.2 Environmental Radiation Recorder

The instrument is a potentiometric type, multipoint recorder utilizing an automatic null-balance measuring system. The essential parts of the system

E.3.4.2 Environmental Radiation Recorder (Continued)

are: (1) the null-balance measuring circuit, (2) the null detector-amplifier, (3) the balancing motor and linkage, and (4) the display system.

The measuring circuit consists of an adjustable, calibrated emf connected to oppose the emf being measured. If the two voltages are not equal, an "error" or unbalance current flows and is detected by the input circuit of the amplifier.

After amplification, the error signal is applied to a reversible balancing motor which adjusts the calibrated emf through a mechanical linkage. The system is sensitive to the direction of error current so that the motor always adjusts the calibrated emf in the proper direction to reduce the magnitude of the error current. The motor continues to drive until the error current is so small that the amplified signal will no longer produce motor rotation, but this occurs when the error is substantially zero and the calibrated emf differs by only a negligible amount from the emf being measured. A null or balance condition then exists. While adjusting the calibrated emf, the motor also drives the display system.

The recorder measuring circuit is supplied by a-c power, rectified and regulated by a zener diode circuit.

Additional pertinent information is noted below:

Strip Chart	9-7/8 inches width. Calibrated 0-100 linear.
Indicator Scale	9-7/8 inches length. Calibrated 0-100 linear.
Chart Speed	2 inches per hour.
Number of Points	Most recorders have 8 points.
Printing Speed	3 seconds per point.
Response Time	1 second full scale.
Accuracy	± 0.3 percent of scale span.

F. TEMPERATURE MEASUREMENT AND CONTROL

The following types of temperature measuring and/or control systems are used in the Waste Management Program.

1. Resistance thermometers
2. Filled-system thermometers
3. Filled-system temperature indicating alarm switches
4. Thermocouples.

Resistance type thermometers are used predominately for temperature measurements, usually to monitor the process vessel liquids.

1. Resistance Thermometer Systems

A resistance temperature measuring system comprises a resistance-type primary element, an amplifier-converter, and a pneumatic recorder. Sometimes the pneumatic recorder is equipped with a controller to perform control functions. Other systems consist of the primary element and an electronic recorder only.

1.1 Resistance Element

The resistance thermometer depends upon the inherent characteristic of metals to change in electrical resistance when they undergo a change in temperature. The sensitive element of the thermometer is a nickel or platinum wire wound on an insulating spool and housed in a metal sheath. Nickel wire is used for low temperature ranges (32-248F) and platinum wire is used for high temperature ranges (32-1000F). The sheathed element is approximately 3/8 inch in diameter and is inserted in a well which is immersed in the media whose temperature is to be measured. The temperature-sensitive nickel or platinum wire forms one arm of a Wheatstone bridge circuit. The other three arms of the bridge, located within a resistance to pneumatic converter or recorder instrument, contain resistances which have an extremely low temperature coefficient of resistance.

An extensive test program was performed at Hanford prior to the Waste Management Program to determine the service life of resistance-type temperature elements in a high radiation environment. Temperature elements, as received from several manufacturers, were subjected to an accumulated gamma radiation exposure of 8×10^9 Roentgens (R). The results of the test indicated that a Leeds & Northrup (L&N) temperature element, type 8181, nickel thermohm with rubber-insulated wire encased within a metallic lead jacket would function indefinitely. The other elements failed after a gamma exposure of 1×10^9 R due to radiolytic decomposition of water vapor which leaked into the element due to an inadequate waterproof seal around the electrical wires at the element.

The L&N type 8181, nickel thermohm with a resistance of 100 ohms at 68F has a response time of 20 seconds and a limit of error of $\pm$ 0.5 F in the temperature range 32 to 248F, and is used to measure the temperature of process vessel liquids. For higher temperature measurements a platinum thermohm, 25 ohms at 32F, is used. The response time of the platinum element is approximately 15 seconds and has a limit of error of $\pm$ 1.5F in the range of 32 to 248F and $\pm$ 3F in the range 248 to 1000F.

Standard conversion tables for Leeds & Northrup nickel and platinum thermohms are shown in Tables XIII-1, XIII-2, XIII-3 and XIII-4, on the following pages 1350, 1350(a) and 1350(b).

TABLE XIII-1

NICKEL THERMOHMS
Degrees Fahrenheit

Deg. F	Ohms	Deg. F	Ohms	Deg. F	Ohms	Deg. F	Ohms	Deg. F	Ohms	Deg. F	Ohms	Deg. F	Ohms
		0	87.696	50	96.708	100	106.34	150	116.64	200	127.64	250	139.39
		1	87.872	51	96.896	101	106.54	151	116.85	201	127.87	251	139.63
		2	88.047	52	97.085	102	106.74	152	117.06	202	128.10	252	139.87
		3	88.223	53	97.273	103	106.94	153	117.28	203	128.32	253	140.12
		4	88.399	54	97.462	104	107.13	154	117.49	204	128.55	254	140.36
		5	88.574	55	97.650	105	107.33	155	117.70	205	128.78	255	140.60
		6	88.750	56	97.839	106	107.53	156	117.91	206	129.01	256	140.85
		7	88.926	57	98.027	107	107.73	157	118.12	207	129.23	257	141.09
		8	89.101	58	98.216	108	107.93	158	118.34	208	129.46	258	141.33
		9	89.277	59	98.404	109	108.13	159	118.56	209	129.69	259	141.57
-40	80.890	10	89.453	60	98.592	110	108.34	160	118.78	210	129.92	260	141.82
39	81.057	11	89.628	61	98.781	111	108.54	161	119.00	211	130.15		
38	81.224	12	89.804	62	98.969	112	108.74	162	119.21	212	130.37		
37	81.392	13	89.980	63	99.158	113	108.94	163	119.43	213	130.60		
36	81.559	14	90.155	64	99.346	114	109.14	164	119.65	214	130.84		
-35	81.726	15	90.335	65	99.535	115	109.34	165	119.86	215	131.07		
34	81.894	16	90.514	66	99.723	116	109.55	166	120.08	216	131.30		
33	82.061	17	90.694	67	99.911	117	109.75	167	120.30	217	131.54		
32	82.228	18	90.873	68	100.10	118	109.95	168	120.52	218	131.77		
31	82.396	19	91.053	69	100.29	119	110.15	169	120.73	219	132.01		
-30	82.563	20	91.232	70	100.48	120	110.35	170	120.95	220	132.24		
29	82.730	21	91.412	71	100.67	121	110.55	171	121.17	221	132.48		
28	82.898	22	91.591	72	100.87	122	110.76	172	121.38	222	132.71		
27	83.065	23	91.771	73	101.06	123	110.97	173	121.60	223	132.95		
26	83.232	24	91.950	74	101.25	124	111.18	174	121.82	224	133.18		
-25	83.400	25	92.130	75	101.44	125	111.39	175	122.04	225	133.41		
24	83.567	26	92.309	76	101.63	126	111.60	176	122.25	226	133.65		
23	83.734	27	92.489	77	101.83	127	111.81	177	122.47	227	133.88		
22	83.902	28	92.668	78	102.02	128	112.02	178	122.69	228	134.12		
21	84.074	29	92.848	79	102.21	129	112.23	179	122.92	229	134.35		
-20	84.246	30	93.027	80	102.40	130	112.44	180	123.14	230	134.59		
19	84.418	31	93.207	81	102.60	131	112.64	181	123.36	231	134.83		
18	84.589	32	93.386	82	102.79	132	112.85	182	123.59	232	135.07		
17	84.761	33	93.571	83	102.98	133	113.06	183	123.81	233	135.31		
16	84.933	34	93.755	84	103.17	134	113.27	184	124.03	234	135.55		
-15	85.104	35	93.940	85	103.36	135	113.48	185	124.26	235	135.79		
14	85.276	36	94.124	86	103.56	136	113.69	186	124.48	236	136.03		
13	85.448	37	94.309	87	103.76	137	113.90	187	124.70	237	136.27		
12	85.620	38	94.493	88	103.96	138	114.11	188	124.93	238	136.51		
11	85.791	39	94.678	89	104.16	139	114.32	189	125.15	239	136.75		
-10	85.963	40	94.863	90	104.36	140	114.52	190	125.37	240	136.98		
9	86.135	41	95.047	91	104.55	141	114.73	191	125.60	241	137.22		
8	86.306	42	95.232	92	104.75	142	114.94	192	125.82	242	137.46		
7	86.478	43	95.416	93	104.95	143	115.15	193	126.04	243	137.70		
6	86.650	44	95.601	94	105.15	144	115.37	194	126.27	244	137.94		
-5	86.822	45	95.785	95	105.35	145	115.58	195	126.50	245	138.18		
4	86.993	46	95.970	96	105.55	146	115.79	196	126.73	246	138.42		
3	87.169	47	96.154	97	105.75	147	116.00	197	126.96	247	138.66		
2	87.345	48	96.339	98	105.94	148	116.21	198	127.18	248	138.90		
-1	87.520	49	96.524	99	106.14	149	116.43	199	127.41	249	139.15		
0	87.696	50	96.708	100	106.34	150	116.64	200	127.64	250	139.39		

TABLE XIII-2

25 OHM PLATINUM THERMOHMS
Degrees Fahrenheit

Deg. F	Ohms	Deg. F	Ohms	Deg. F	Ohms	Deg. F	Ohms
		0	23.236	350	42.149	700	59.947
		10	23.792	360	42.672	710	60.439
-330	4.123	20	24.347	370	43.195	720	60.930
320	4.734	30	24.901	380	43.717	730	61.420
310	5.344	40	25.455	390	44.238	740	61.910
-300	5.950	50	26.007	400	44.758	750	62.398
290	6.553	60	26.558	410	45.277	760	62.885
280	7.154	70	27.108	420	45.796	770	63.372
270	7.752	80	27.658	430	46.314	780	63.859
260	8.348	90	28.206	440	46.830	790	64.343
-250	8.941	100	28.753	450	47.346	800	64.827
240	9.533	110	29.299	460	47.862	810	65.310
230	10.122	120	29.846	470	48.376	820	65.793
220	10.709	130	30.391	480	48.889	830	66.274
210	11.295	140	30.935	490	49.401	840	66.754
-200	11.878	150	31.479	500	49.913	850	67.233
190	12.459	160	32.020	510	50.423	860	67.712
180	13.039	170	32.561	520	50.932	870	68.189
170	13.618	180	33.101	530	51.440	880	68.666
160	14.194	190	33.641	540	51.948	890	69.142
-150	14.769	200	34.179	550	52.454	900	69.617
140	15.343	210	34.716	560	52.960	910	70.092
130	15.915	220	35.253	570	53.465	920	70.564
120	16.485	230	35.790	580	53.970	930	71.036
110	17.054	240	36.325	590	54.473	940	71.507
-100	17.623	250	36.858	600	54.975	950	71.978
90	18.189	260	37.391	610	55.476	960	72.447
80	18.754	270	37.924	620	55.977	970	72.916
70	19.319	280	38.455	630	56.476	980	73.383
60	19.882	290	38.985	640	56.974	990	73.850
- 50	20.443	300	39.515	650	57.471	1000	74.316
40	21.004	310	40.043	660	57.968		
30	21.564	320	40.571	670	58.464		
20	22.123	330	41.098	680	58.959		
- 10	22.680	340	41.625	690	59.453		
0	23.236	350	42.149	700	59.947		

TABLE XIII-3
NICKEL THERMOHM
Degrees Centigrade

Deg. C	Ohms	Deg. C	Ohms	Deg. C	Ohms	Deg. C	Ohms
		0	93.386	50	110.76	100	130.37
		1	93.718	51	111.14	101	130.79
		2	94.050	52	111.51	102	131.21
		3	94.382	53	111.89	103	131.63
		4	94.714	54	112.27	104	132.05
		5	95.047	55	112.64	105	132.48
		6	95.379	56	113.02	106	132.90
		7	95.711	57	113.39	107	133.32
		8	96.043	58	113.77	108	133.74
		9	96.375	59	114.15	109	134.16
-40	80.890	10	96.708	60	114.52	110	134.59
39	81.191	11	97.047	61	114.90	111	135.02
38	81.492	12	97.386	62	115.28	112	135.45
37	81.793	13	97.725	63	115.66	113	135.88
36	82.094	14	98.064	64	116.04	114	136.31
-35	82.396	15	98.404	65	116.43	115	136.75
34	82.697	16	98.743	66	116.81	116	137.18
33	82.998	17	99.082	67	117.19	117	137.61
32	83.299	18	99.421	68	117.57	118	138.04
31	83.600	19	99.760	69	117.95	119	138.47
-30	83.902	20	100.10	70	118.34	120	138.90
29	84.211	21	100.45	71	118.73	121	139.34
28	84.520	22	100.79	72	119.12	122	139.78
27	84.829	23	101.14	73	119.51	123	140.21
26	85.138	24	101.49	74	119.90	124	140.65
-25	85.448	25	101.83	75	120.30	125	141.09
24	85.757	26	102.18	76	120.69	126	141.53
23	86.066	27	102.52	77	121.08	127	141.96
22	86.375	28	102.87	78	121.47	128	142.40
21	86.684	29	103.22	79	121.86	129	142.84
-20	86.993	30	103.56	80	122.25	130	143.27
19	87.309	31	103.92	81	122.65	131	143.72
18	87.625	32	104.28	82	123.05	132	144.17
17	87.941	33	104.63	83	123.45	133	144.62
16	88.257	34	104.99	84	123.85	134	145.07
-15	88.574	35	105.35	85	124.26	135	145.52
14	88.890	36	105.71	86	124.66	136	145.97
13	89.206	37	106.06	87	125.06	137	146.42
12	89.522	38	106.42	88	125.46	138	146.87
11	89.838	39	106.78	89	125.86	139	147.32
-10	90.155	40	107.13	90	126.27	140	147.77
9	90.478	41	107.49	91	126.68		
8	90.801	42	107.85	92	127.09		
7	91.124	43	108.22	93	127.50		
6	91.447	44	108.58	94	127.91		
-5	91.771	45	108.94	95	128.32		
4	92.094	46	109.30	96	128.73		
3	92.417	47	109.67	97	129.14		
2	92.740	48	110.03	98	129.55		
-1	93.063	49	110.39	99	129.96		
0	93.386	50	110.76	100	130.37		

TABLE XIII-4
25-OHM PLATINUM THERMOHM
Degrees Centigrade

Deg. C	Ohms	Deg. C	Ohms	Deg. C	Ohms	Deg. C	Ohms
-200	4.245	0	25.012	200	44.342	400	62.496
195	4.795	5	25.510	205	44.810	405	62.934
190	5.344	10	26.007	210	45.277	410	63.372
185	5.889	15	26.503	215	45.745	415	63.810
180	6.432	20	26.998	220	46.211	420	64.246
-175	6.973	25	27.493	225	46.676	425	64.682
170	7.513	30	27.987	230	47.140	430	65.117
165	8.050	35	28.480	235	47.605	435	65.551
160	8.585	40	28.972	240	48.068	440	65.985
155	9.119	45	29.465	245	48.530	445	66.418
-150	9.651	50	29.956	250	48.991	450	66.850
145	10.181	55	30.446	255	49.452	455	67.281
140	10.709	60	30.935	260	49.913	460	67.712
135	11.237	65	31.424	265	50.372	465	68.142
130	11.762	70	31.912	270	50.830	470	68.571
-125	12.285	75	32.399	275	51.288	475	68.999
120	12.807	80	32.885	280	51.746	480	69.427
115	13.329	85	33.372	285	52.202	485	69.855
110	13.849	90	33.857	290	52.657	490	70.281
105	14.367	95	34.341	295	53.112	495	70.706
-100	14.884	100	34.824	300	53.567	500	71.130
95	15.400	105	35.307	305	54.020	505	71.554
90	15.915	110	35.790	310	54.473	510	71.978
85	16.428	115	36.271	315	54.924	515	72.400
80	16.940	120	36.751	320	55.375	520	72.822
- 75	17.452	125	37.231	325	55.826	525	73.243
70	17.962	130	37.711	330	56.276	530	73.663
65	18.471	135	38.189	335	56.725	535	74.083
60	18.980	140	38.667	340	57.173	540	74.502
55	19.488	145	39.144	345	57.621		
- 50	19.994	150	39.621	350	58.068		
45	20.499	155	40.096	355	58.514		
40	21.004	160	40.571	360	58.959		
35	21.508	165	41.045	365	59.403		
30	22.011	170	41.519	370	59.848		
- 25	22.513	175	41.991	375	60.291		
20	23.014	180	42.463	380	60.733		
15	23.515	185	42.934	385	61.175		
10	24.016	190	43.404	390	61.616		
- 5	24.514	195	43.874	395	62.057		
0	25.012	200	44.342	400	62.496		

F.1.2 Amplifier-Converter

The resistance thermometer leads are usually connected to a resistance to pneumatic converter consisting of a d-c power supply, Wheatstone bridge, amplifier and a current to air pressure transducer. The final output from the converter is a 3-15 psig air signal, proportional to the measured temperature, and is received by a pneumatic recorder or recorder-controller.

1.3 Recorder-Controller

The recorder for temperature measurement is usually a single-pen recorder, but there are some two-pen recorders in use. The recorder 4-inch strip charts and indicator scales are calibrated for several ranges (0-100 C, 0-150 C). The strip chart is operated by a synchronous motor at speeds of 3/4 inch or 1 inch per hour. Each recorder pen is operated through linkages by a 3-15 psig receiver bellows.

Some recorders are equipped with controller functions. See Section B.6.3 for description.

1.3.1 Electronic Recorder

The recorder for temperature measurement is a four-pen recorder. The recorder 7-1/8 inch strip chart and indicator scale are calibrated for a range of 0-100 C. The strip chart is operated by a synchronous motor at a speed of 1 inch per hour. The recorder is complete with a Wheatstone bridge excited by a zener regulated d-c power supply, a slide-wire contact, photoelectric chopper, amplifier and a two-phase balancing motor.

When the resistance of the sensitive element in one arm of a Wheatstone bridge changes, the bridge is unbalanced and an error signal is developed between the slide-wire contact and the sensitive element inputs to the amplifier. The error signal is converted to an a-c voltage by a photoelectric chopper and amplified. The amplifier output drives a two-phase balancing motor whose direction of rotation depends on the polarity of the error signal. The balancing motor moves the contact on the slide-wire until the bridge is rebalanced and no error signal exists. The recorder pen and slide-wire contact are positioned simultaneously to indicate the temperature.

1.3.2 Existing Leeds & Northrup Recorder

This instrument (approximately twenty-four years old) is a multipoint strip chart recorder with a single recording pen. The recorder is capable of recording the temperature of four, independent, temperature-sensitive elements through an automatic selector switch. The multipoint instrument makes use of the Wheatstone bridge method to determine the resistance change of the temperature-sensitive elements utilizing a galvanometer balancing unit.

F.1.3.2 Existing Leeds & Northrup Recorder (Continued)

The galvanometer deflection is determined by the balancing unit, which in turn rotates the slide-wire until the bridge circuit is rebalanced. The recording pen is moved across a calibrated temperature scale by means of a mechanical linkage.

1.4 Alarm Switch

The alarm switch is a pressure-actuated switch whose primary function is to trigger visual and audible alarm devices. The pressure-sensitive element is a Bourdon tube or a diaphragm which is mechanically linked to the switch contacts. When the pressure sensed by the sensitive element overcomes the setting of the load spring, a SPDT snap-action switch is activated to open or close an electrical circuit. The temperature alarm switches in the Waste Management Program are usually connected to the pneumatic output signal from a transmitter or a controller, and have a pressure range of 0-15 psig.

2. Filled-System Thermometers

The filled-system thermometer is used for temperature measurement of process streams and vessels where a record is not required. The system consists of a sensitive measuring element or bulb containing a gas or fluid which changes in physical characteristics (either volumetric or pressure) with temperature. This change is communicated to a Bourdon tube, located within the case of a dial indicator, through a capillary tube. The Bourdon tube responds to the signal from the sensitive measuring element to provide motion in relation to the temperature which is transmitted by mechanical linkages to a dial indicator pointer to provide temperature indication.

Some filled-system thermometers, in addition to providing temperature indication, are equipped to perform an alarm function. They have one or more SPDT electrical snap-action switches to provide high/low limit adjustable trip points. The trip points may be adjusted from the front of the dial indicator to open or close an electrical circuit at a pre-determined temperature limit.

3. Thermocouple Systems

A temperature measuring system using a thermocouple for the primary element usually consists of the element and an electronic multipoint recorder. Thermocouples are used in the tank farm installations and other systems where temperatures exceed the limits of a resistance type element.

3.1 Element

The thermocouple temperature sensing element is based on the thermoelectric effect of dissimilar metallic junctions. The heat liberated or absorbed by the junctions results in a change of the thermal electromotive force.

F.3.1 Element (Continued)

The majority of the thermocouple elements are of the iron-constantan type and have a usual temperature range of (-)300 to 1400 F. The upper temperature limit is dependent upon the size of the thermocouple wire. Two other common thermocouple types are chromel-alumel, temperature range (-)300 to 2300 F; and copper-constantan, temperature range (-)300 to 700 F.

The thermocouple measuring junction is usually formed by twisting together and welding the ends of the two dissimilar conductors. The junctions are formed to provide the required spacing between the wires to permit easy insertion of ceramic insulators. Protecting tubes of stainless steel are used for most of the thermocouple installations to prevent contamination of the thermocouple and provide mechanical protection and support. Thermocouples with magnesium oxide insulation and encased within a stainless steel sheath are used in high gamma radiation fields. The protecting tube must be immersed in the process stream to a sufficient depth to minimize heat transfer along the length of tube. A thermocouple connection head or a quick-disconnect plug and jack are used to provide a positive connection between the thermocouple and the thermocouple extension wire.

The response time of thermocouples is from 0.1 to 10 seconds and is dependent upon the time constant of the protecting tube. The limits of error for thermocouples, as recommended by the Instrument Society of America (ISA), are given in Table XIII-3.

TABLE XIII-3

LIMITS OF ERROR FOR THERMOCOUPLES

Type	Temp. Range °F	Limits of Error Standard	Limits of Error Special
Copper-Constantan	-300 to -75	--	± 1%
	-150 to -75	± 2%	± 1%
	-75 to +200	± 1-1/2 F	± 3/4 F
	200 to 700	± 3/4%	± 3/8%
Iron-Constantan	0 to 530	± 4 F	± 2 F
	530 to 1400	± 3/4%	± 3/8%
Chromel-Alumel	0 to 530	± 4 F	--
	530 to 2300	± 3/4%	--

The millivolt signal generated by the thermocouple is received by a multipoint potentiometric recorder as described in the following Section.

3.2 Recorder

The instrument employed for recording thermocouple temperature measurements is a multipoint recorder with an automatically-balanced d-c potentiometer measuring circuit. The measuring circuit current is supplied from an a-c line, F.3.2 Recorder (Continued)

rectified and regulated by a zener-diode circuit. Any unbalance of the measuring circuit is amplified, and a reversing motor is utilized to restore the balance.

The instrument is equipped with an automatic reference junction compensator and five individually adjustable, dual, SPDT, alarm contacts. The recorder is capable of recording the temperature of sixteen independent thermocouple elements through an automatic selector switch at a speed of two seconds per point. The recorder strip chart has a calibrated width of 9-7/8 inches, and a speed of 3/4 inch per hour. The recorder accuracy is $\pm$ 0.3 percent full span.

G. pH MEASUREMENT

The pH measurement system employs special electrodes that develop an emf proportional to the hydrogen-ion concentration in the solution into which they are immersed. By definition:

$$pH = \log \frac{1}{\text{hydrogen-ion concentration in moles/liter}}$$

The hydrogen-ion concentration of a solution is determined electrometrically by measuring the difference in potential between an electrode which has a fixed voltage (calomel reference electrode) and an electrode in which the voltage varies with the solution pH (glass electrode). The pH system consists of the sampling air jet, a flow chamber with pH electrodes, a pH analyzer, and an electronic recorder. Refer to Figure XIII-24.

1. pH Electrodes

The glass electrode consists of a glass tube closed at the bottom by a membrane of special pH sensitive glass. In contact with the inner wall of the glass membrane is a constant pH solution in which is immersed an internal metallic element. When the glass electrode is immersed in the sample solution, a surface potential is developed on the pH sensitive membrane of the electrode which is proportional to the active hydrogen-ion concentration of the sample. The potential developed by the glass electrode is compared with the constant-potential calomel reference electrode. The calomel electrode is contained within a glass tube and consists of mercury and mercurous chloride in contact with saturated potassium chloride as an electrolyte. The electrolyte is permitted to flow slowly through a porous palladium junction sealed in the immersion end of the electrode, and into the sample solution. This flow of the electrolyte from the electrode to the sample solution completes the electrical circuit of the pH measurement system. The glass and reference electrodes can tolerate a total gamma exposure of 5×10^8 Roentgen; at this point they will break due to pressure build-up by radiolysis.

G.1 pH Electrodes (Continued)

The thermocompensator is a well-type platinum resistance-temperature detector that is tip sensitive and has a response time of less than three seconds. When immersed in the sample solution, the thermocompensator corrects automatically the pH amplifier circuit for the effects of temperature variations in the sample solution. The three pH elements described above are placed side by side in a Hanford-designed, in-line flow chamber and connected by shielded cable to the pH analyzer.

2. pH Analyzer

The analyzer is an electroanalytical instrument equipped with an amplifier circuit board, two power supply circuit boards, and a potentiometric and current output board; all furnished as plug-in units. A special multi-conductor electrical cable connects the analyzer with the electrodes. The analyzer measures the electrochemical properties of the process streams for the degree of acidity or alkalinity, and indicates on a panel meter the H-ion concentration in pH units. Also, the analyzer provides an output signal that drives a special potentiometric recorder.

3. Recorder

The recorder is a null-balance, servo-operated potentiometric recorder, having two independent measuring circuits and pens and a common strip chart.

The potentiometer circuit is the conventional slide-wire type, but has continuous standardization by means of a highly accurate silicon (zener) diode reference. The unknown input voltage is balanced against a known voltage from the voltage reference. Balance is achieved when the two opposing voltages are equal and no current flows in the balancing circuit.

A slide-wire equipped with a moving contact is used to vary the known voltage. The unbalanced or error signal is amplified sufficiently to drive the servo motor (rebalancing motor). Because the motor is mechanically linked to the slide-wire contact as well as the pen, the position of the contact is proportional to the measured variable.

The recorder range is 0-14 pH units. It has zero and span adjustment knobs accessible from the front of instrument. The normal span is 2 pH, and by using the zero adjustment it can be adjusted from 0-2 pH to 10-12 pH.

The recorder has an accuracy of $\pm$ 1/4 percent of full scale and a response time of four seconds full scale. Recorder strip chart calibrated width is 10-3/4 inches and the chart speed is 2 inches per hour.

4. Buffer and Rinse Tanks

In order to calibrate the pH system periodically, each station has its own small capacity buffer and rinse tanks. To transfer buffer solution to the flow chamber, the three-position selector switch (SS) must be manually turned

G.4 Buffer and Rinse Tanks (Continued)

to position 3. This will energize the time-delay relay coil K-TDR and the canyon and operating gallery buffer solenoid valves. When the transfer of buffer solution is completed, the selector switch is returned to the "off" or No. 2 position which de-energizes the time delay relay coil; de-energizes the buffer solenoid valve in the operating gallery; the buffer solenoid valve in the canyon area will remain energized until the K-TDR contacts are timed out (5-180 second delay on de-energization of relay coil). To rinse the flow chamber with demineralized water, the selector switch must be placed in the No. 1 position, which will energize solenoid valve EV-Water in the canyon area.

H. MISCELLANEOUS INSTRUMENTATION

1. Cell Microphones

All process tanks are equipped with contact microphones. The operator may ascertain, to some degree, conditions within a tank by listening to loud speakers connected to these microphones. Thus, it is possible to determine the proper operation of agitators and pumps and to determine whether jets are gassing or pumping liquids.

The amplifiers are located in the operating gallery opposite the panelboards. Some amplifiers handle more than one microphone and the required switches are located on the panelboard. Loudspeakers, one for each amplifier, are located at the top of the panelboard. The sound volume is controlled by gain controls located on the amplifier and on the panelboard.

2. Tachometers

All centrifuges are equipped with electric tachometers to indicate the speed of rotation. The tachometer consists of: (1) a small a-c generator mounted on the centrifuge shaft with voltage output proportional to speed, and (2) a panel-mounted indicator with control functions.

An automatic control attached to the centrifuge tachometers prevents inadvertent reversal of the centrifuge in case of prolonged "plugging". When a centrifuge is plugged, the power phases to the motor are reversed so that the motor torque is applied in the reverse direction. This causes the speed to decrease rapidly, but if the plug control is held in too long the centrifuge will reverse its direction of rotation resulting in serious damage to the centrifuge. To forestall that possiblity, a panel-mounted indicator with a locking coil d-c meter-relay device is used. It has an adjustable control-action pointer, load relays (with d-c power supply), and rectification components to make it compatible with the tachometer a-c generator. In operation, the pointer is set at approximately zero RPM. Should the speed of the centrifuge motor, during "plugging", decrease to near zero RPM, the control-action is initiated and the motor is shut down. The indicating meter is a dual-range unit calibrated in revolutions per minute (RPM). The outer scale range is 0-2000 RPM

H.2. Tachometers (Continued)

and the inner scale range is 0-1000 RPM. The indicating accuracy is ± 2 percent full scale. A two-position, electrical selector switch is mounted near the panel-mounted indicator to select the proper indicator scale range.

3. Ammeters

Indicating ammeters are used to provide a visual indication at the instrument panel of the current drawn by electric motors used to drive pumps, agitators, and centrifuges. The ammeters assist in the detection of abnormal operating conditions manifested by changing current demand. The a-c ammeters used are the iron-vane, repulsion type. It consists of two vanes or iron pieces placed within a coil. One of the vanes is stationary and the other is movable and mounted on a shaft with an attached pointer. When the alternating current passes through the coil the vanes become magnetized and a force or torque is created which repels the vanes. This causes the movable vane to rotate and move the pointer shaft. The ammeter size is approximately 3-1/2 inches square and has a graduated scale calibrated in amperes. The ammeter accuracy is ± 2.0 percent of full scale reading.

4. Selector Switches

4.1 Electric Switches

An electric selector switch is a manually-operated pilot device used to control (usually by actuating a remote magnetic device) and to indicate the condition of one or more electrical circuits. It is fundamentally a contact "making" and "breaking" device with one or more sets of movable and stationary contacts depending upon the number of selector switch positions required and the number of electrical circuits to be controlled.

The contact arrangements are referred to as normally open (N.O.) or normally closed (N.C.). A normally open position is one where the stationary and movable contacts are separated prior to actuation. When the actuator control shaft is positioned, the contacts join and close a circuit. Normally closed refers to the condition where the movable and stationary contacts are touching prior to actuation. When the actuator control shaft is positioned, the contacts separate, breaking the circuit. Cams attached to the actuator control shaft are used to make or break electrical circuits for each selector switch position.

There are two types of selector switch contacts— momentary and maintained. Momentary contacts return to their original position as soon as the actuator is released. Maintained contacts remain in the position in which they are actuated.

H.4.2 Air Switches

An air switch is basically a plug-type selector valve with a minimum of three ports. Most switches are of the two-position, three-port type and are used to open and close a diaphragm-operated valve.

The inlet port is connected to an air supply header, the outlet port is connected to the controlled device, and a vent port is open to the atmosphere. The switch selector handle, attached to the valve plug, controls flow direction by positioning passes within the valve plug over the inlet and outlet ports. The nameplate provided shows the internal function of the switch. Some of the nameplate legends used are: "On-Off", "Automatic-Manual", and "Load-Unload". When the selector handle is placed in the "On" position, the inlet and outlet ports are connected and the vent port is closed. When the handle is in the "Off" position, the outlet and vent ports are connected and the inlet port is closed.

Air switches are also available as two-position, four-port; three-position, four-port; and four-position, five-port. They are used in control systems where more than one device is to be controlled from a single air switch.

I. SPECIAL CONTROL SYSTEMS

1. Concentrator Safety Interlocks

Concentrators E-5-2, E-20-2, and E-23-3 located in Building 221-B process cells 5, 20, and 23 respectively, are equipped with safety devices and electrical interlocks designed to shut down the steam flow to the concentrator tube bundles whenever one or more of the following occur:

1. High steam pressure to tube bundles
2. Low pressure in the tube bundles (for air pressurization)
3. Low weight factor in concentrator, and
4. High temperature in concentrator

The safety devices eliminate the possibility of an explosion, when red oil is formed in the concentrator, by limiting the solution temperature and the pressure in the concentrator.

A typical tube bundle control system is shown in Figure XIII-25 and the tube bundle safety interlocks are on Figure XIII-26.

The concentrators E-5-2 and E-20-2 are each equipped with one tube bundle system but the concentrator E-23-3 has a two-tube bundle system.

The operation of a one-tube bundle system is as follows: System start-up is initiated by depressing PB-1 which energizes relay K-1, solenoid valve EV-STM (operating steam valve DOV-1) and solenoid valve EV-COND (opening condensate valve DOV-3) to permit steam flow to tube bundle. At the same time, solenoid valve EV-AIR is de-energized (closing air valve DOV-2). PB-1 must be held depressed until pressure switch PS-2 (Lo) contact closes to place system in the automatic mode.

I.1 Concentrator Safety Interlocks (Continued)

Automatic shutdown of the system will occur in the event any of the following conditions occur.

1. High pressure steam to the tube bundles - The monitoring pressure switch, PS-1 (Hi), dual contacts will open, deactivating the system and activating a visual and audible annunciation system, PA-1 (Hi).

2. Low pressure in the tube bundles - The monitoring pressure switch, PS-2 (Lo), dual contacts will open, deactivating the system and activating a visual and audible annunciator system, PA-2 (Lo). This also admits air to the tube bundle to prevent any solution leaking from bundle to condensate header.

3. Low weight factor in concentrator - The monitoring pressure switch WFAS-2 (Lo), contact will open, deactivating the system.

4. High temperature in concentrator - The monitoring pressure switch, TAS-1 (Hi), dual contacts will open, deactivating the system and activating a visual and audible annunciator system, TA-1 (Hi).

When any one of the above shutdown conditions occur, the following takes place to deactivate the tube bundle system. Relay K-1 is de-energized, solenoid valve EV-STM is de-energized closing steam valve DOV-1, solenoid valve EV-COND is de-energized closing steam condensate valve DOV-3, solenoid valve EV-AIR is energized opening air valve DOV-2, thus pressurizing the tube bundle with air.

To add raw water to concentrator tube bundle, it will be necessary to hold pushbutton PB-1 in until pressure to tube bundle is approximately 10 psig which will energize solenoid valve EV-COND opening steam condensate valve DOV-3, and open raw water header block valve upstream from raw water pressure reducing valve PRV-3.

To restart the steam flow to tube bundle, pushbutton PB-1 must be depressed momentarily until pressure to tube bundle is approximately 10 psig.

2. Ammonia, Carbon Dioxide, and Nitrogen System

The control system used for the addition of ammonia or carbon dioxide to tank TK-21-1 is shown schematically in Figure XIII-27.

The measuring components are identical for both systems and consist of a flow orifice FE-1, differential pressure transmitter FT-1, and a flow indicating integrator controller FIQC-1.

I.2 Ammonia, Carbon Dioxide, and Nitrogen System (Continued)

The operation of the ammonia or carbon dioxide addition system is as follows:

The desired quantity to be added must be preset on the predetermining counter which is one unit of the FIQC instrument (see Section B.6.5.2). Manual switch MS-1 must be in the operating position. The system is then started by momentarily depressing pushbutton PB-1 to close the flow alarm switch FAS-1, which seals in the control circuit. Relay K-1 and time delay relay TDR are then energized permitting DOV-1 to be positioned via manual controller MC-1, solenoid valve EV-3 is energized opening DOV-3. When the desired flow quantity, preset on the pre-determining counter, has been added to the system, the SPDT switch in the counter opens automatically and will cause the following to take place.

Relay K-1 is de-energized, flow alarm FA-1 will indicate a visual and audible alarm condition, EV-1 is de-energized closing DOV-1, time delay relay coil TDR is de-energized but its contact will remain closed for a preset timed period (three minute maximum delay before opening) which will energize the solenoid valve EV-3 allowing a nitrogen purge of the system. After the timed nitrogen purge, all relays and valves in the system will automatically return to their normal condition.

3. Vent Systems

The instrument controls for vent systems No. 1 and No. 2 serving Cell 22, Building 221-B, are shown schematically in Figure XIII-28 and Figure XIII-29 respectively. The controls for both systems are identical except for the additional pressure switch PS-22-4-2 in vent system No. 1.

The operation of vent system No. 1 is as follows:

The set point of differential pressure recorder controller DPRC-22-4 must be set for the desired operating conditions to maintain the correct differential pressure between the process cell and the air tunnel. The system start-up is initiated by placing selector switch SS-22-4 in the automatic position. This de-energizes solenoid valve EV-22-4-1, permitting diaphragm-operated valve DOV-22-4-1 to open and respond to the DPRC-22-4 control signals. The opening of DOV-22-4-1 allows the 100 psig steam supply to motivate the variable jet J-22-4. The jet is then varied or throttled automatically via DPRC-22-4 and DOV-22-4-1 to maintain the correct differential pressure between the process cell and the air tunnel. If the steam supply pressure to the jet is lost or drops to a low value, pressure switch PS-22-4-1 contacts will close at its preset trip setting

I.3 Vent Systems (Continued)

energizing EV-22-4-1 and closing DOV-22-4-1, energizing EV-22-4-2 to permit DPRC-22-4 to automatically control DOV-22-4-2 in the 100 psig air supply line. At this time jet J-22-4 is motivated by air and is varied automatically via DPRC-22-4 and DOV-22-4-2. Should the steam supply pressure return to normal, the system jet J-22-4 will again be motivated by steam automatically. When selector switch SS-22-4 is placed in position 3 (the air position), jet J-22-4 is motivated by air. The pressure switch PS-22-4-2 is used as a permissive switch for the vent system of Cell 5, Building 221-B. Cell 5 vent instrument controls are inoperative until Cell 22 jet J-22-4 is operating. At this time PS-22-4-2 contacts close permitting the Cell 5 vent system to function. The cell 22 vent system may be shut down by placing selector switch SS-22-4 in the "off" position.

4. Weight Factor Control System - Cell 18

The weight factor control system for tank TK-18-3 is shown schematically in Figure XIII-14 and operates as follows:

The setpoint of the weight factor recorder controller WFRC-18-3 must be set for the desired operating conditions. During normal operation, solenoid valve EV-18-3-2 is de-energized and the control signal from WFRC-18-3 is as shown in Figure XIII-14. When in this operating mode, it is possible to transfer automatically the process solutions from tanks TK-13-1, TK-17-2 or TK-21-1 (located in cells 13, 17 and 21 respectively) after first depressing the appropriate pushbutton at the pushbutton station. Each pushbutton depressed will open the contacts of the preceding pushbutton operated; therefore, it is not possible to transfer the process solution from two or more vessels at the same time. To shut down the process solution transfer operation, the "All Systems Off" pushbutton must be depressed.

The chemical addition line to tank TK-18-3 is made up of three streams manifolded together. To add ammonium carbonate from one stream, it is necessary for solenoid valve EV-18-3-2 to remain de-energized, solenoid valve EV-18-3-5 must be energized via PB-18-3-5 to allow the WFRC-18-3 to control automatically DOV-18-3-3. The two remaining streams in the weight factor system utilize a cascade control system to control automatically their flow rate according to a predetermined ratio. The cascade control instruments include the weight factor recorder controller WFRC-18-3, flow recorder controller FRC-18-3-3, flow recorder controller FRC-18-3-1, FRC-18-3-3 cascade subpanel, and the setpoint or ratio instrument SP-18-3.

To activate the cascade control system, solenoid valve EV-18-3-2 must be energized via PB-18-3-2 at the pushbutton station. The WFRC-18-3 (master controller) control signal is then directed to the setpoint capsule in FRC-18-3-3 (slave controller - see Figure XIII-14) via the FRC-18-3-3 cascade subpanel. Refer to Section B.6.3.4 for description of the cascade subpanel. The output signal of the flow transmitter FT-18-3-2, measuring the demineralized water stream, is received by FRC-18-3-3 and the setpoint or ratio instrument SP-18-3.

I.4 Weight Factor Control System - Cell 18 (Continued)

The function of the FRC-18-3-3 "slave" controller is to record and control automatically the demineralized water flow rate which is dependent upon the "master" controller WFRC-18-3. The SP-18-3 instrument contains a ratio relay which receives the linear input signal and produces an output signal that is a preset ratio of the input signal, a large dial for selecting and indicating the desired ratio, and a transfer station consisting of a transfer valve and a manual regulator. During normal operating conditions the transfer valve control knob is placed in the "ratio set" position which permits the ratio relay to generate the output signal. When the transfer valve is placed in the "manual set" position, the manual regulator can be adjusted to generate the output signal. The output signal of the SP-18-3 is directed to the setpoint capsule of FRC-18-3-1. The setpoint of FRC-18-3-1 is then adjusted automatically or manually by the SP-18-3 instrument to maintain the proper flow ratio in the chemical addition line (from chemical make-up tank TK-18-3C) and the demineralized water line.

5. Pulser Drive Equipment

Piston-type pulsers are installed in Cells 27, 28, 29, and 30 for columns T-27-1, T-28-1, T-29-1, and T-30-1. The following is a brief description of the electrical power and control equipment installed to drive these pulsers at variable speeds. See Figure XIII-30 for schematic diagram.

Five complete and separate drive units are installed, one for each pulser and one standby unit. The standby drive may be used to power any one of the pulser motors in the event of failure or during maintenance of a normal drive. The control system is arranged so that not more than one pulser can be driven from the standby drive at any particular time.

Each individual drive consists of a 15 HP, 440 volt, a-c motor connected to a 9 KW alternator through a eddy-current coupling (electrically-controlled clutch) so that the speed and frequency of the alternator may be varied. A feedback voltage from a tachometer generator on the output side of the clutch maintains the speed constant for any control setting.

Two motor generator sets are provided to furnish field excitation for the alternators. Each consists of a 7-1/2 HP motor driving two, 2 KW, 120 volt, d-c generators. One motor generator set is capable of supplying the field current for four alternators. The 15 HP drive motors cannot be started until either one of the two motor-generator sets are running. The second motor generator is provided as a spare unit, but it is necessary to manually switch the d-c output to the exciter bus.

Each of the four 15 HP pulser-drive, induction motors can be fed from its normal alternator supply or from the standby alternator. The change-over is affected by a selector switch on the instrument panel. If any

I.5 Pulser Drive Equipment (Continued)

one pulser motor is being driven from the standby alternator, no other pulser can be started with its selector switch in the standby position. The pulser motors drive the pulsers through a gear reduction unit.

The start-stop pushbuttons and indicator lights for the main drive motors and exciter motors, the selector switches, the pulser motor ammeters, the pulse rate controls, and the pulse rate indicators are located on the instrument panels. The control equipment and contactors are located in a cabinet adjacent to the main drive motors, alternators, and the exciter sets in the electrical gallery.

Each pulse control (PUC) is simply a 1,000 ohm potentiometer and the pulse indicator (PUI) is a frequency meter calibrated 0 to 100 pulses per minute. The speed control devices are packaged, solid-state, electronic units (one for each drive) located in the control cabinet, and sensitivity and maximum speed adjustments are incorporated in each of these units.

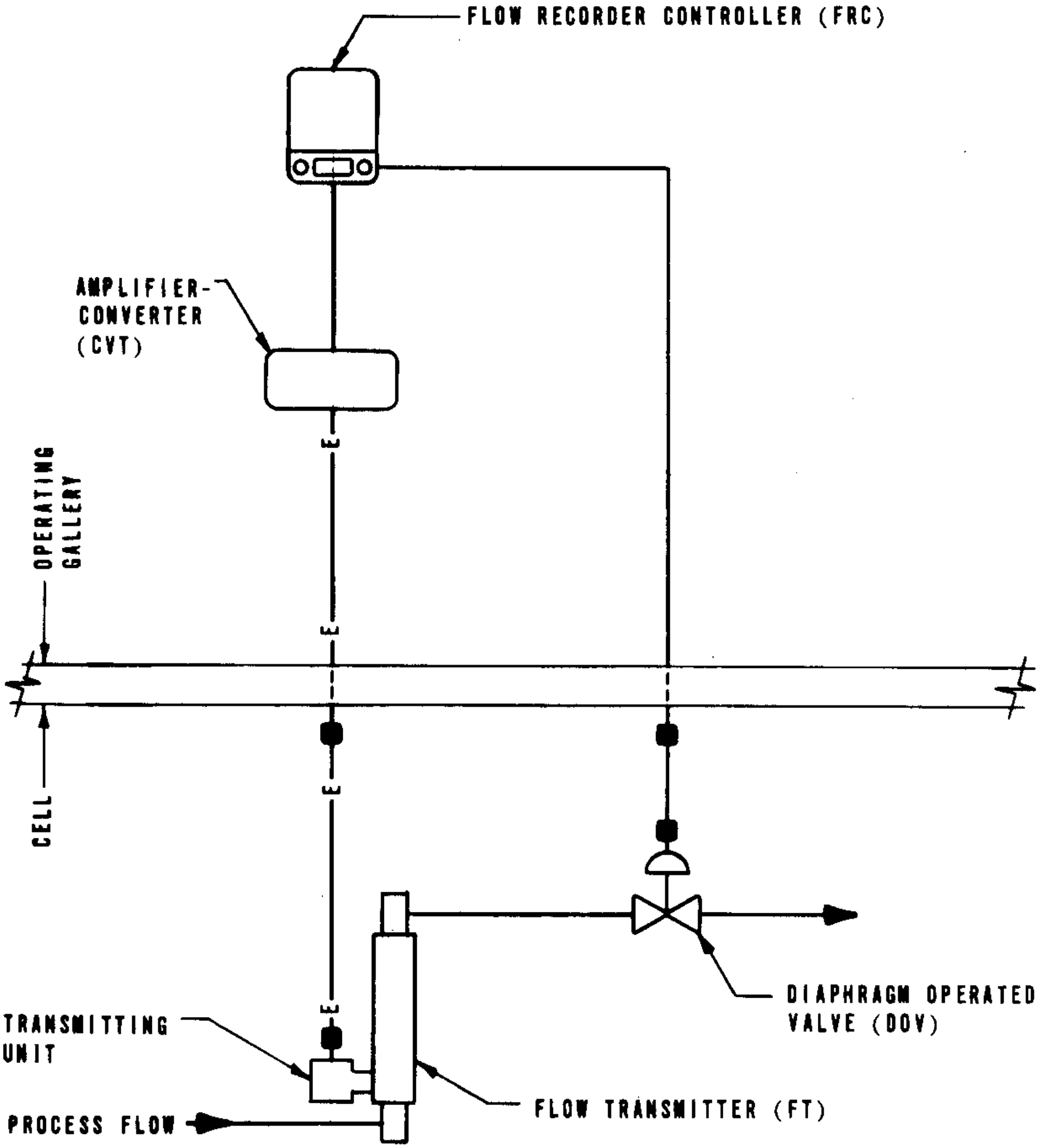

FIGURE XIII-1

Typical In-Cell Rotameter Flow System

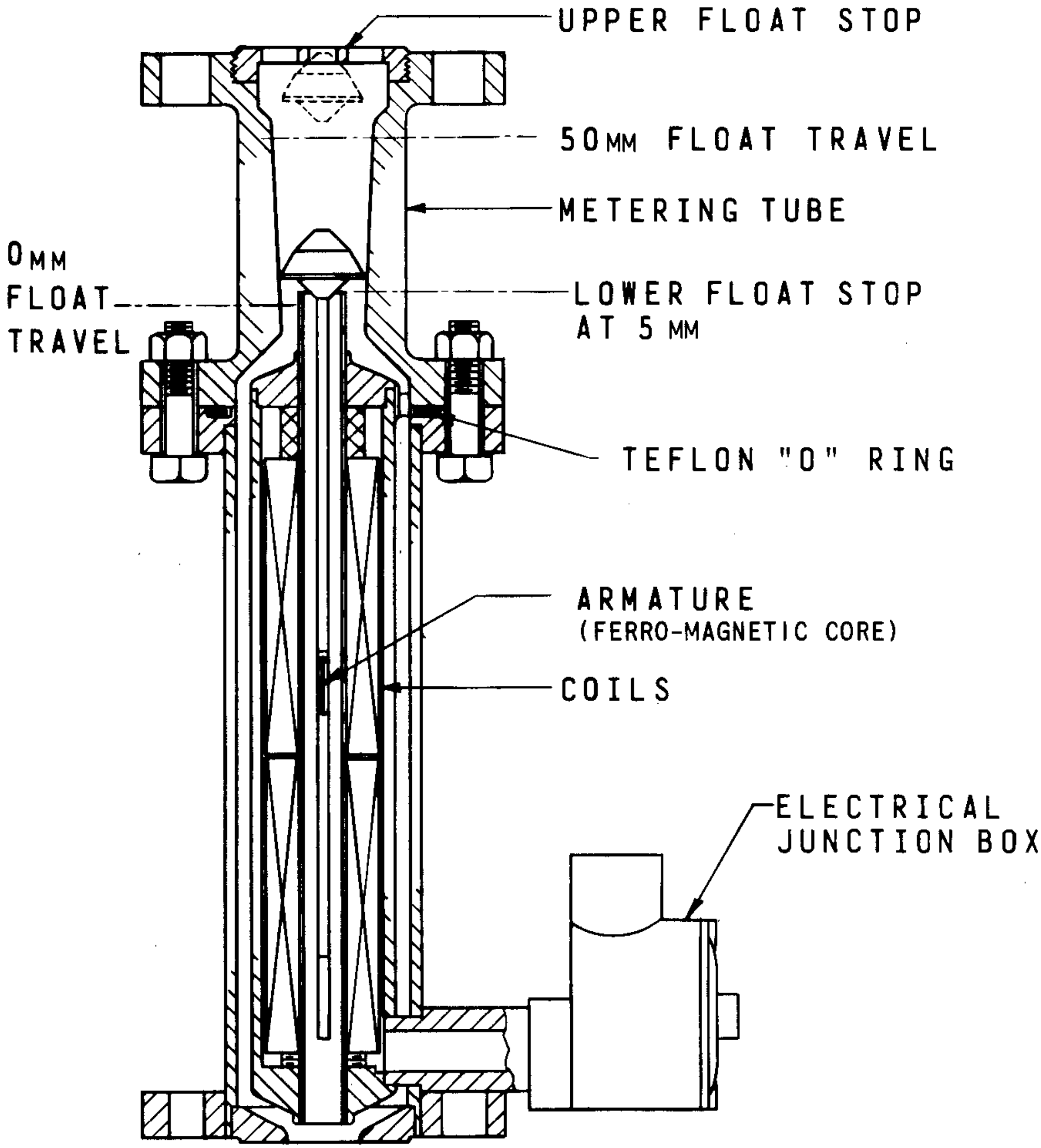

FIGURE XIII-2
Electronic Rotameter

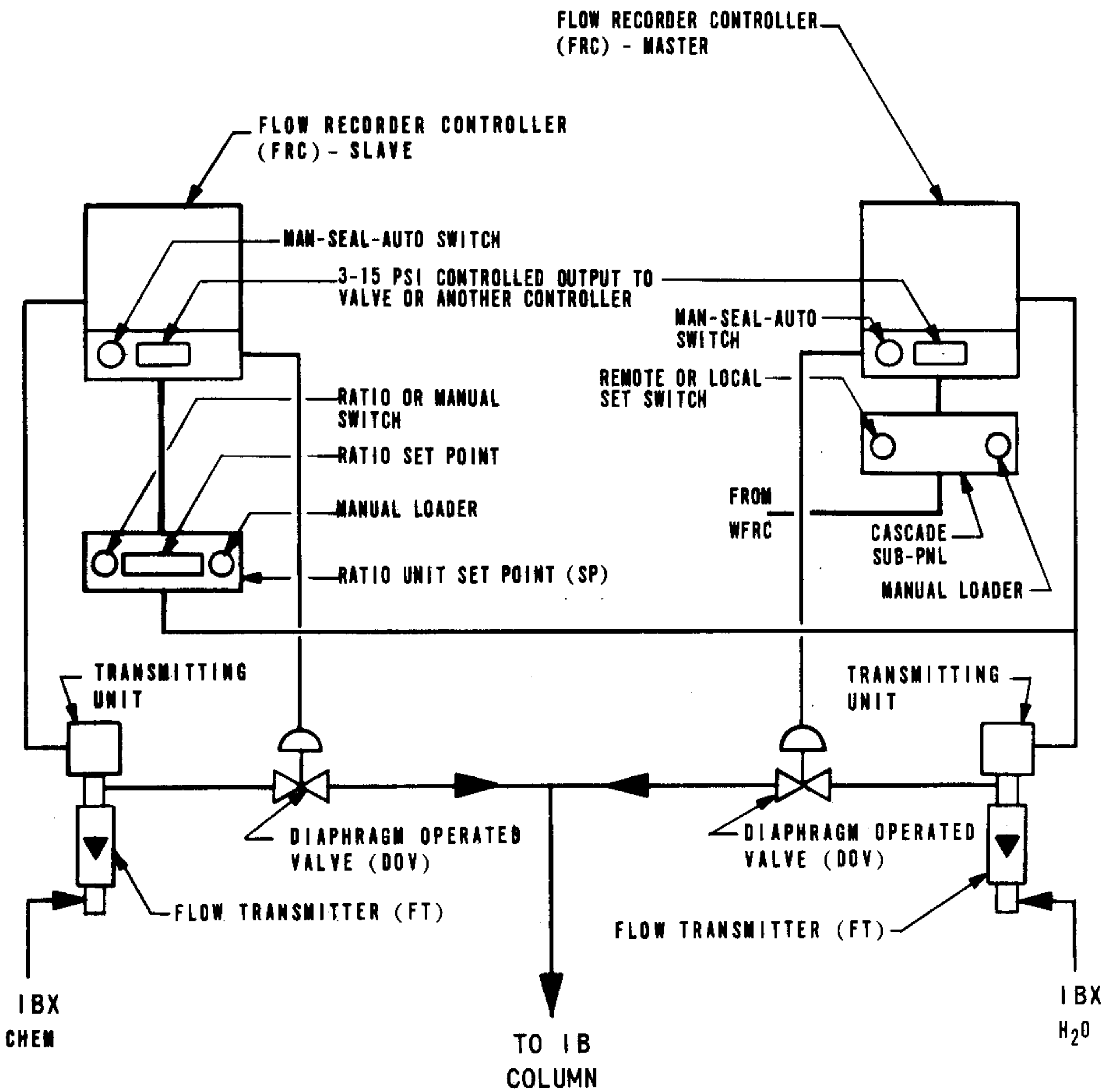

FIGURE XIII-3

Master Flow Control System

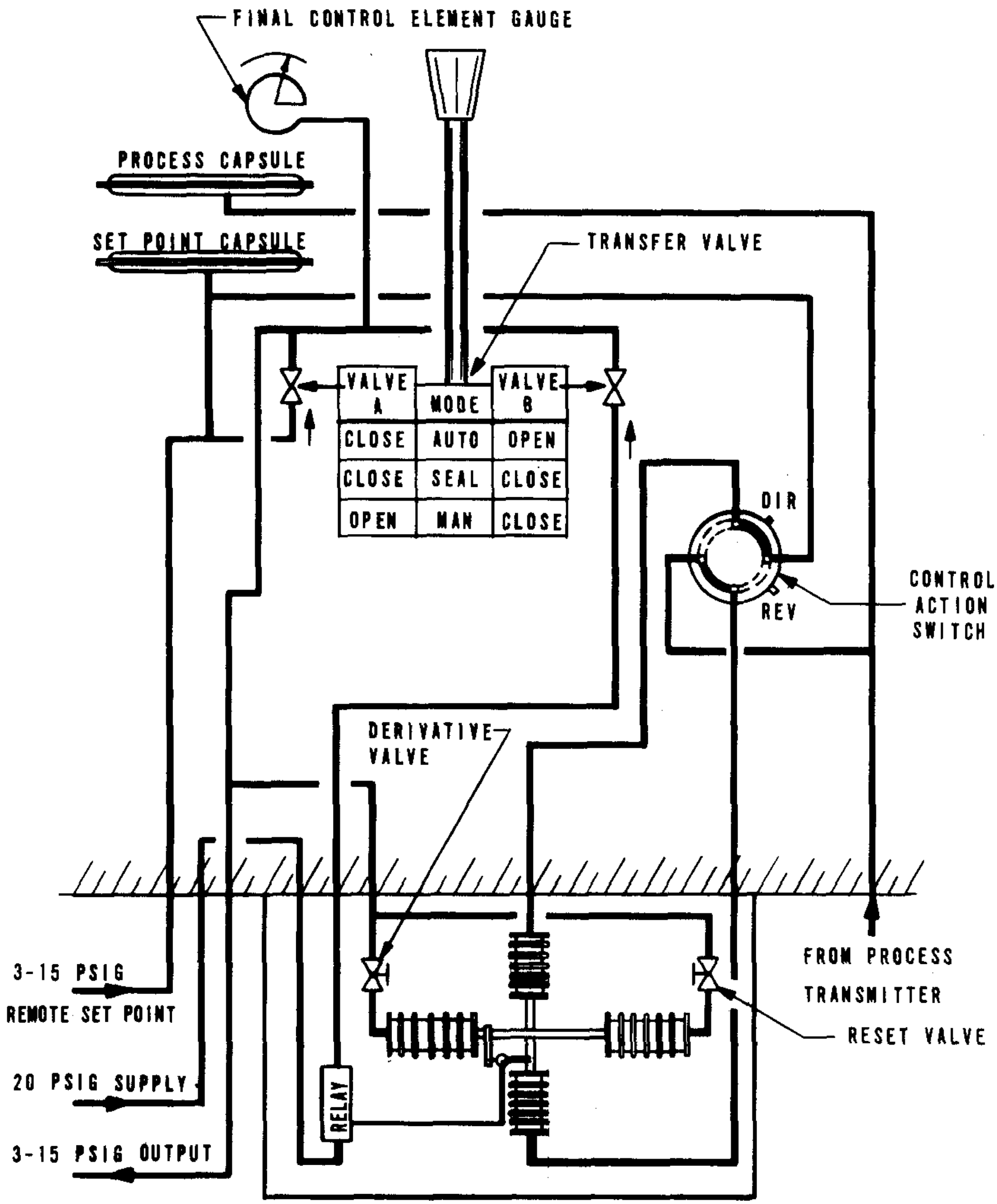

FIGURE XIII-4

Fisher Porter Controller Schematic

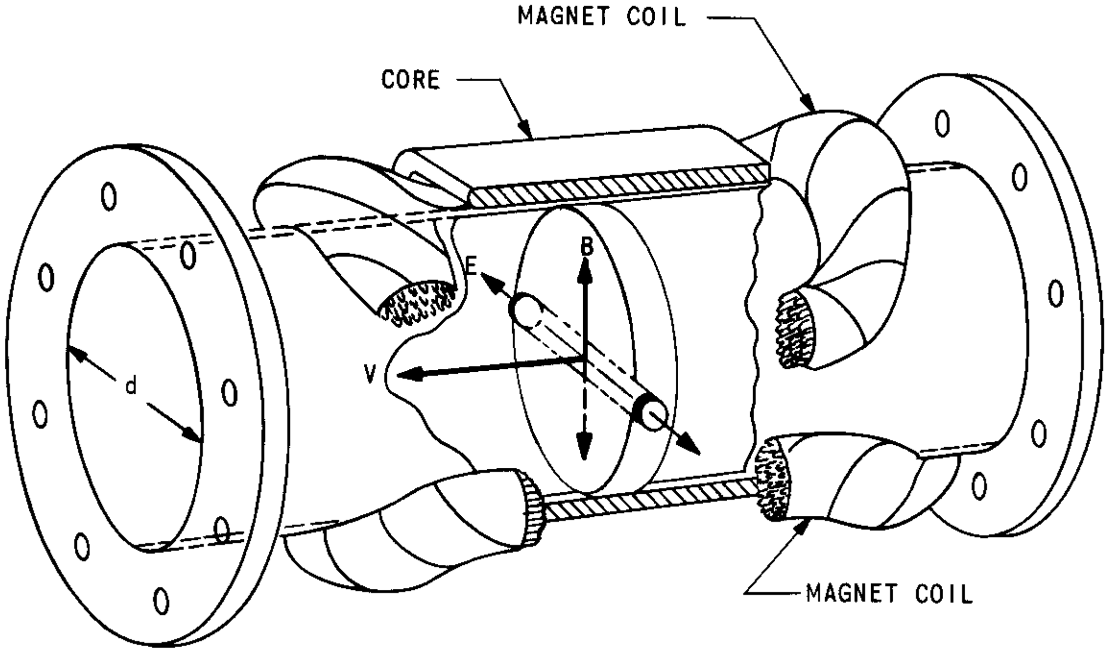

FIGURE XIII-5

Magnetic Flowmeter

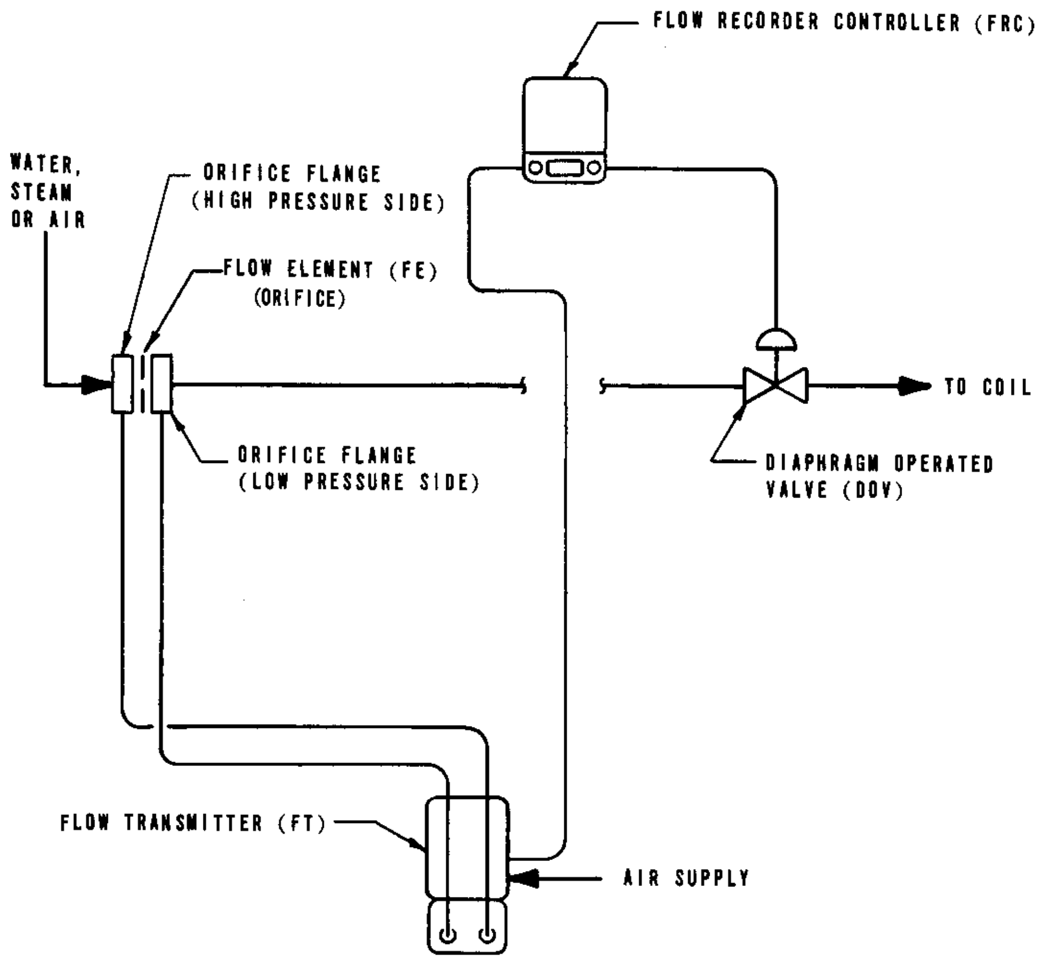

FIGURE XIII-7

Typical Orifice Flow System

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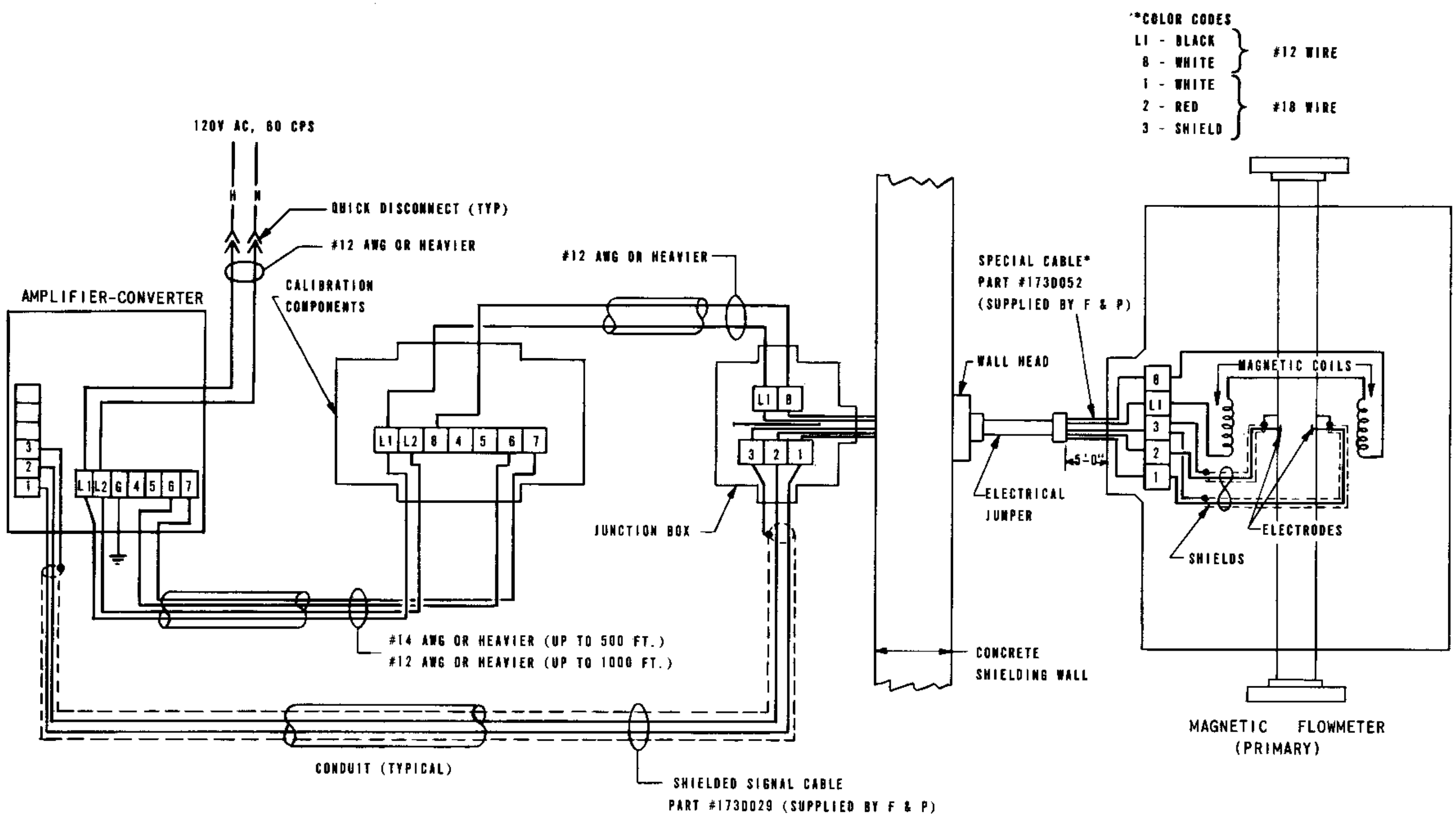

FIGURE XIII-6

"Special" Magnetic Flowmeter, Electrical Schematic

ISO-100

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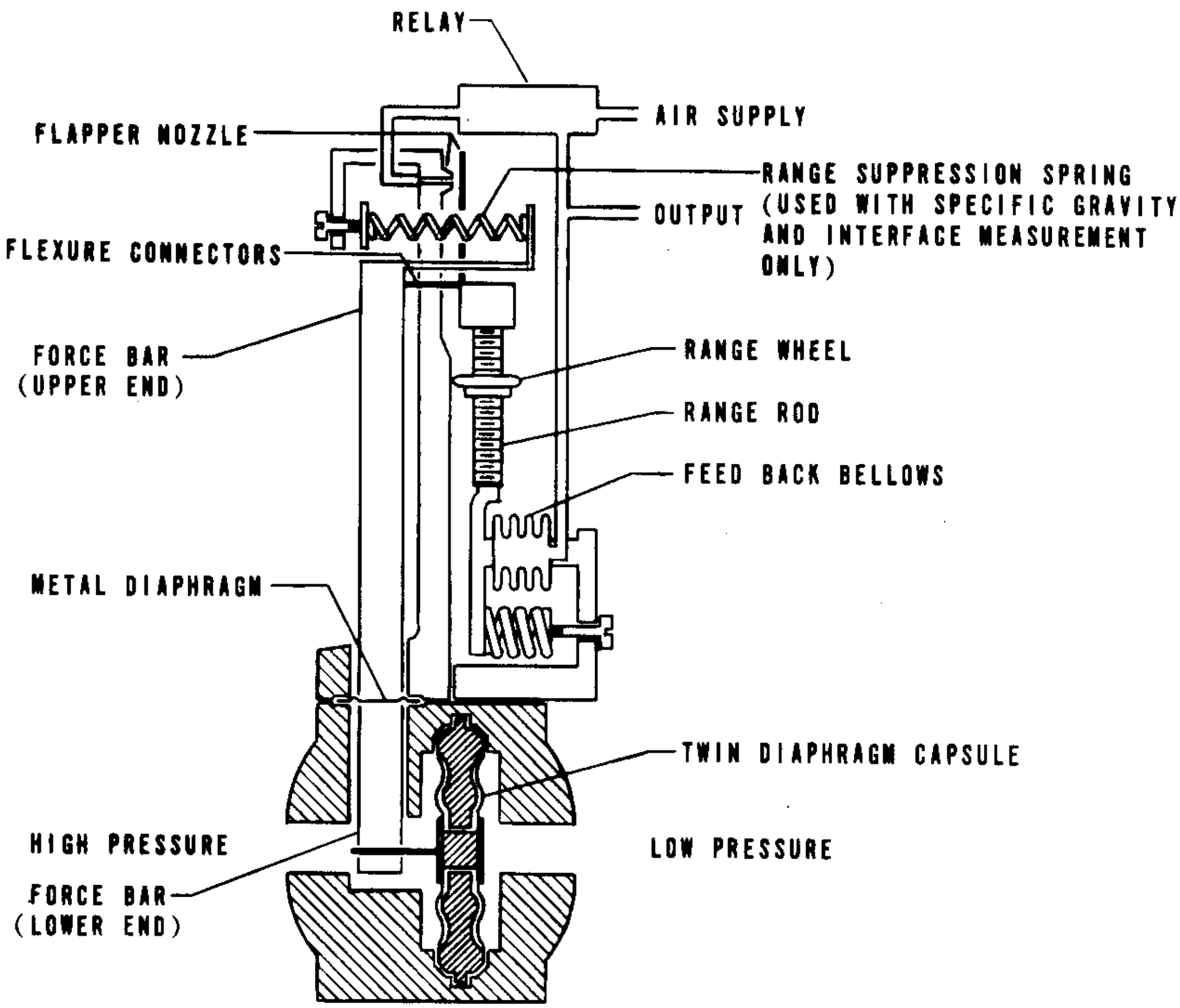

FIGURE XIII-8

Differential Pressure Transmitter
(Flow, Weight Factor, Specific Gravity and Pressure)

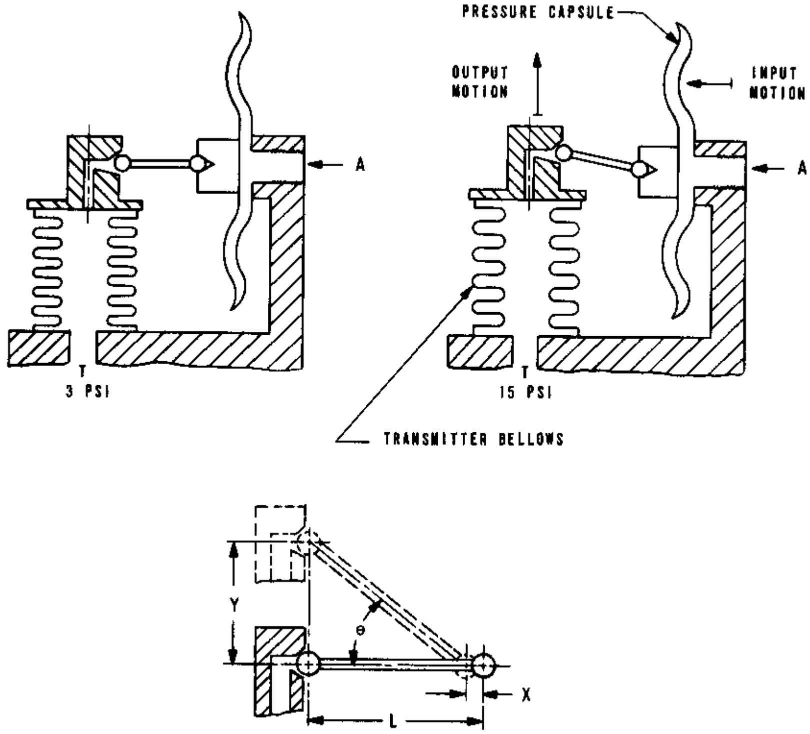

FIGURE XIII-9

Square Root Extractor

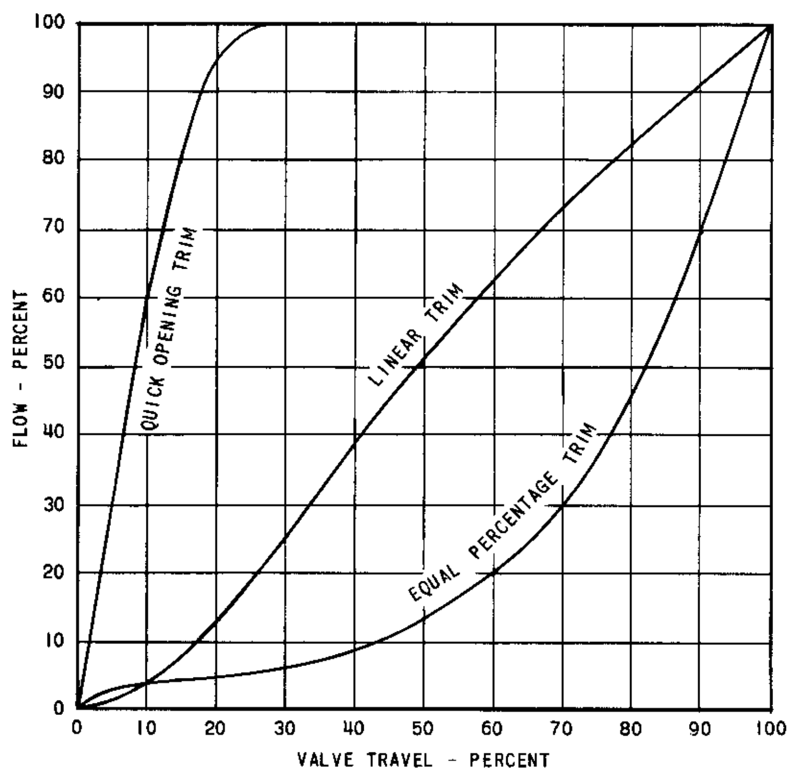

FIGURE XIII-10

Typical Control Valve Trim Characteristics

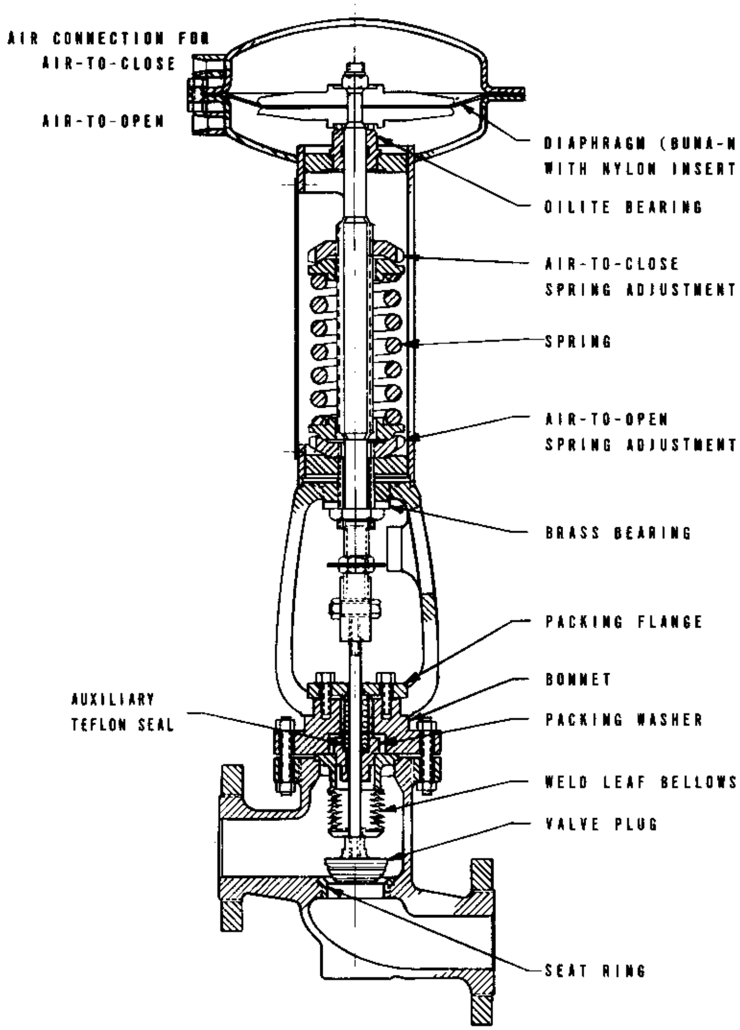

FIGURE XIII-11

In-Cell Control Valve (Hammel-Dahl Type)

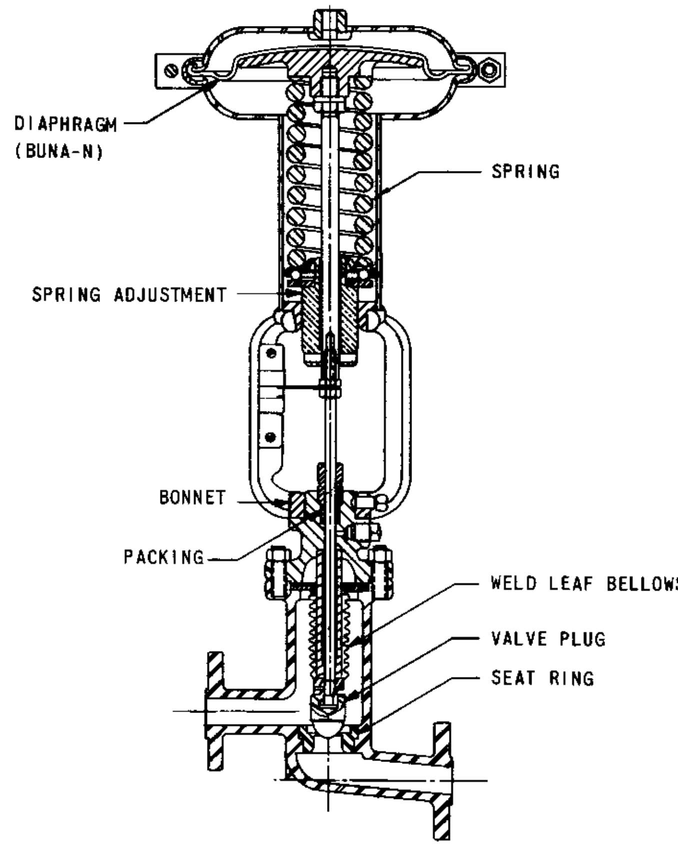

FIGURE XIII-12

In-Cell Control Valve (Kieley-Muller Type)

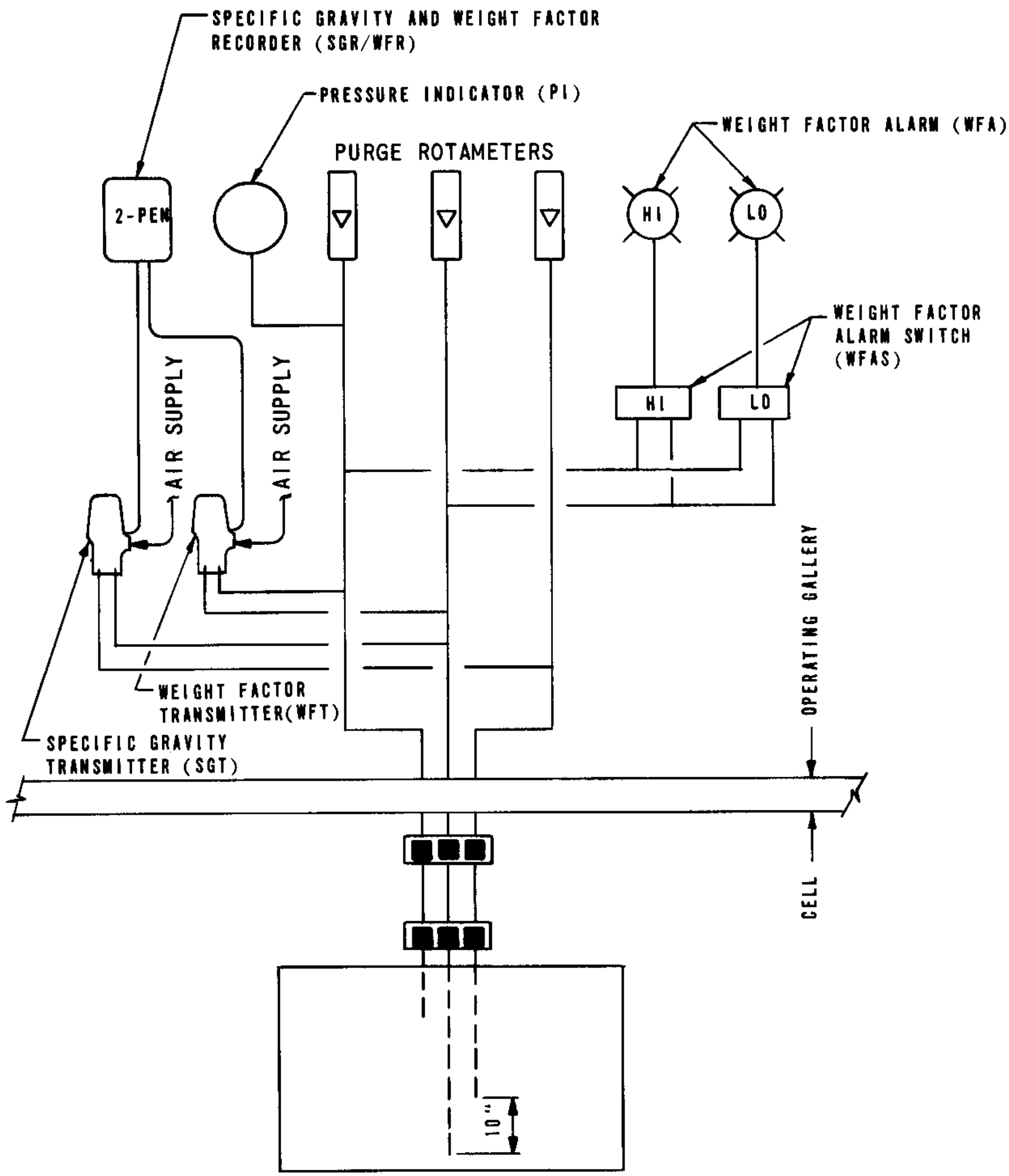

FIGURE XIII-13

Purge Dip Tube Systems
(Weight Factor, Specific Gravity and Pressure)

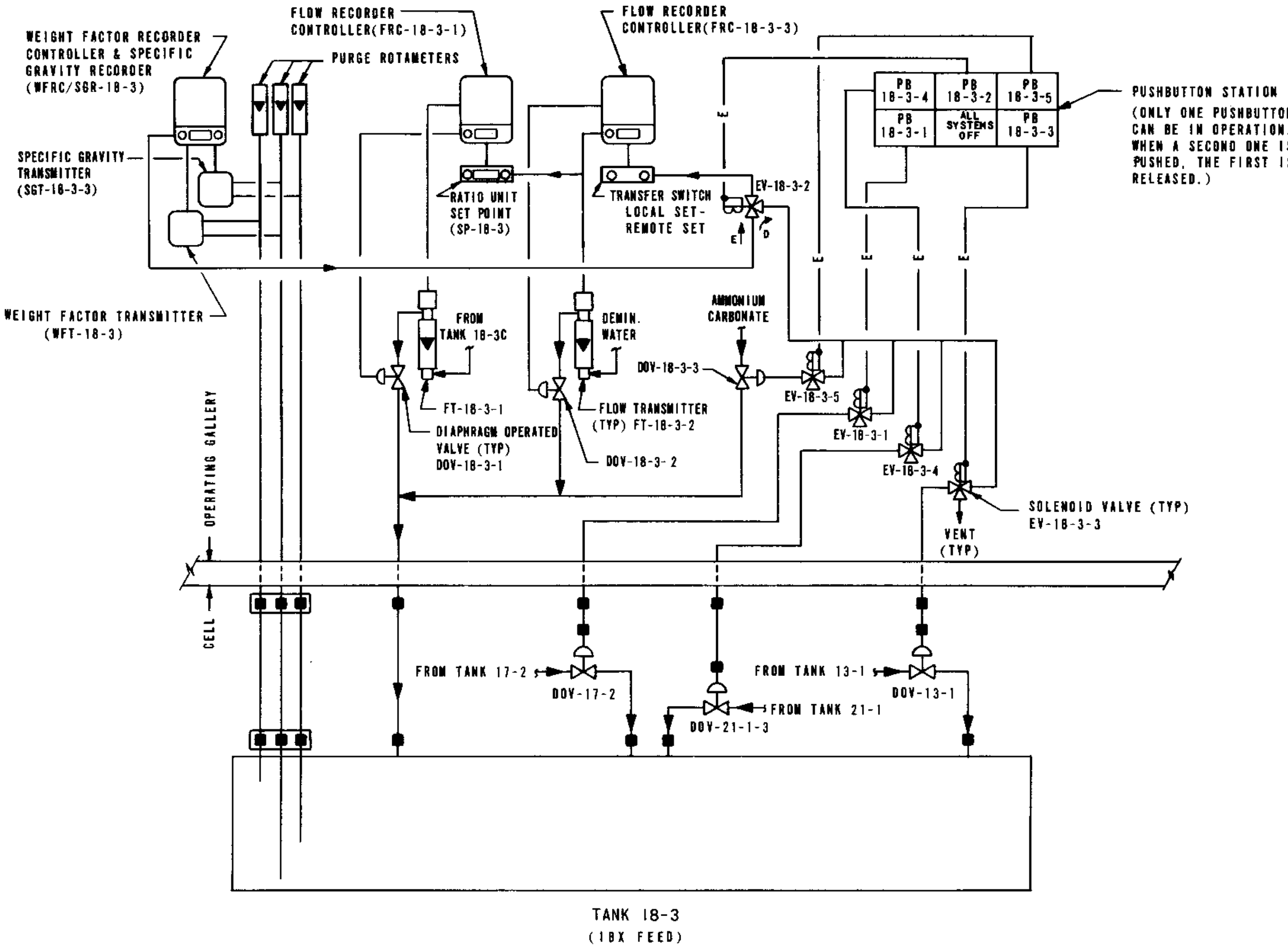

FIGURE XIII-14

Tank 18-3 Weight Factor Control System

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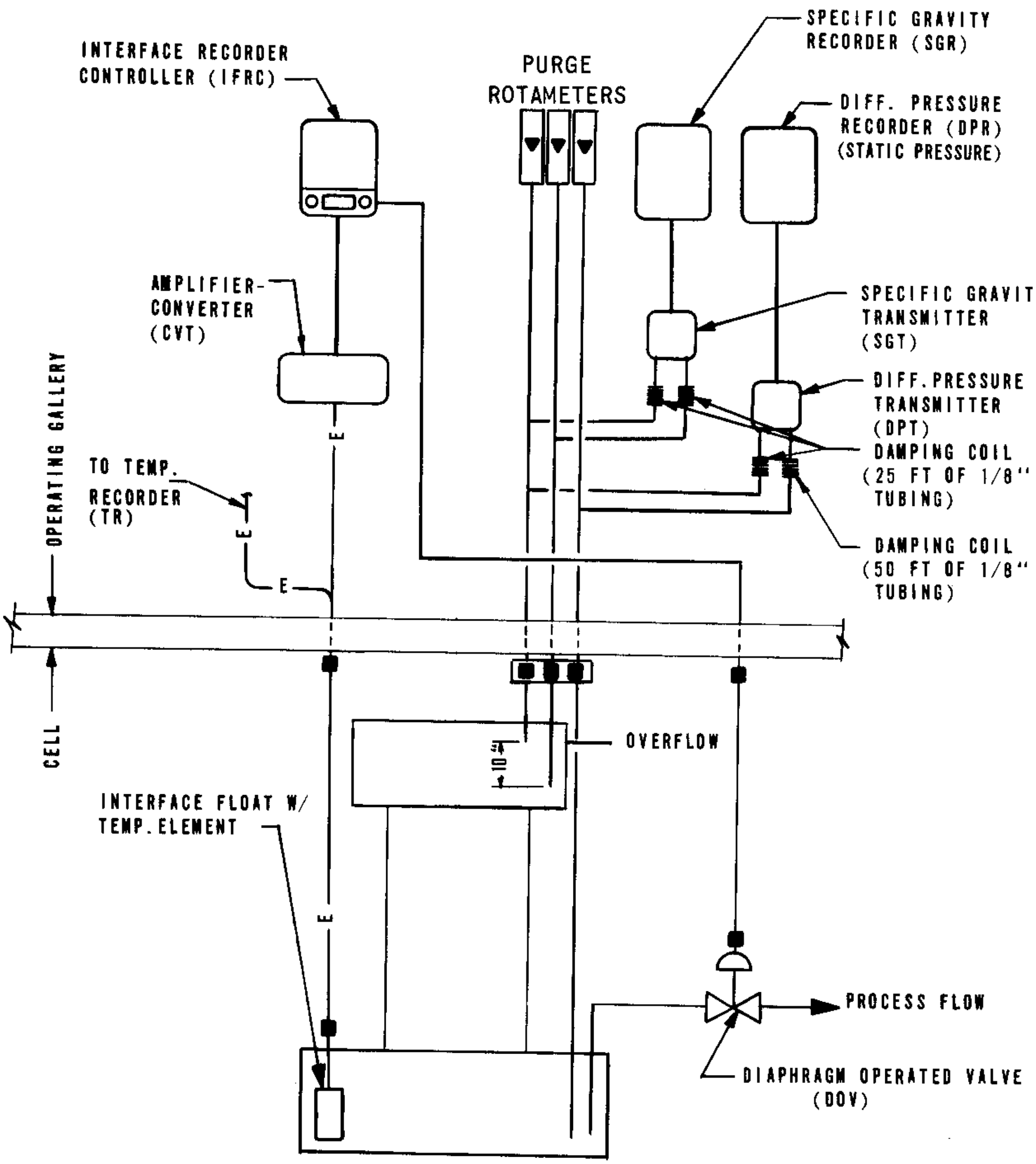

FIGURE XIII-15

Typical Column Interface, Pressure and Specific Gravity Systems

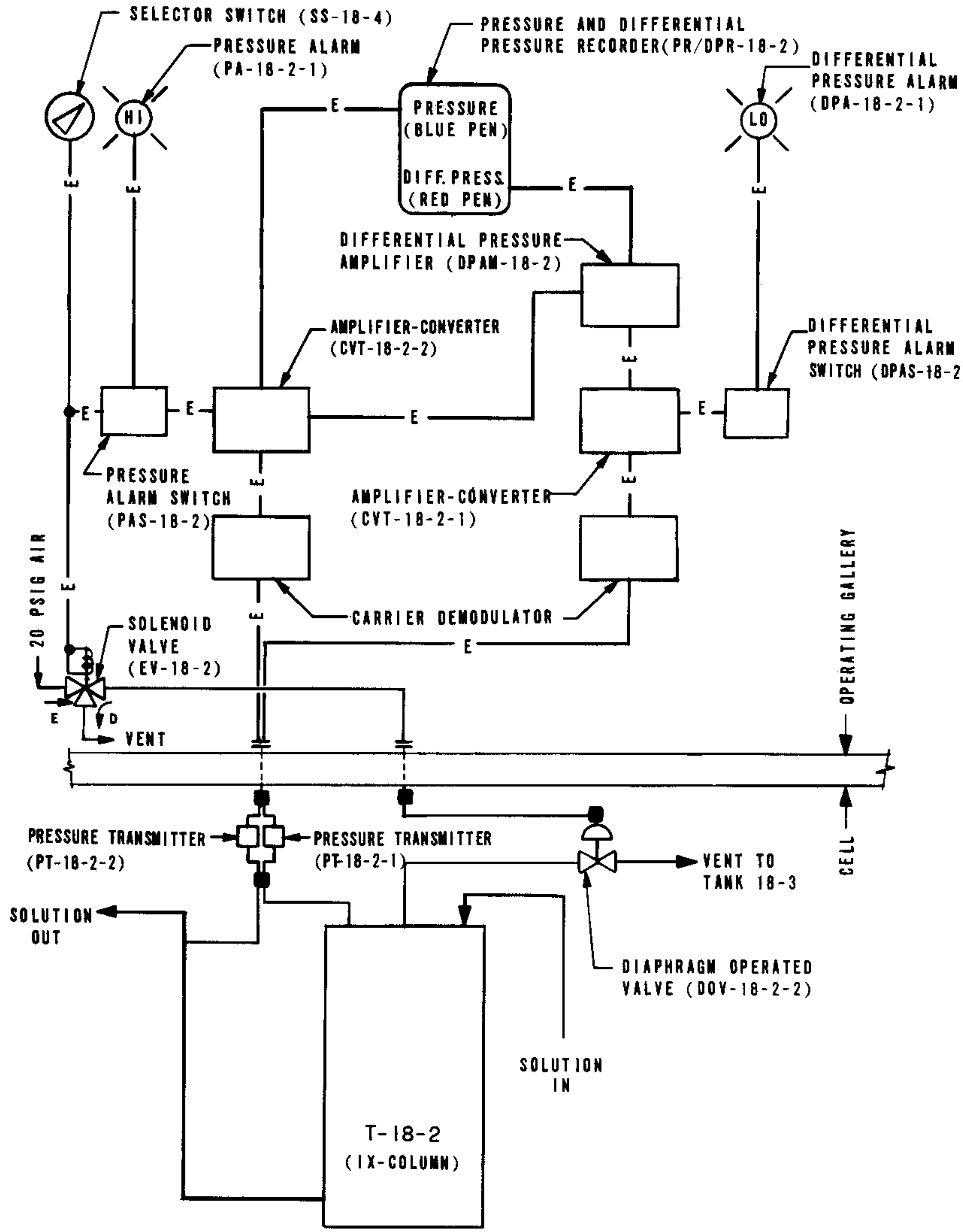

FIGURE XIII-16

Resin Column Pressure Systems

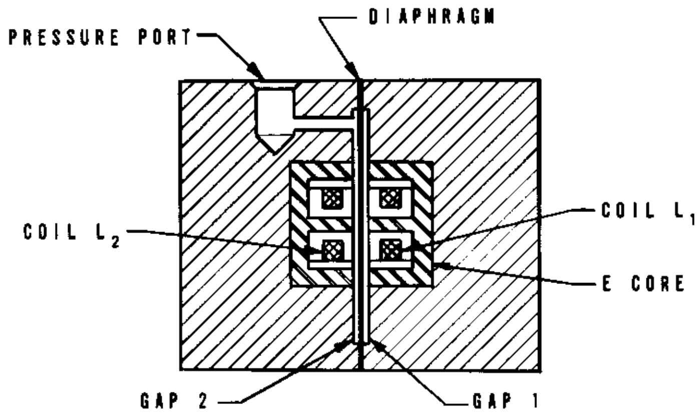

FIGURE XIII-17

Variable Reluctance Pressure Transducer

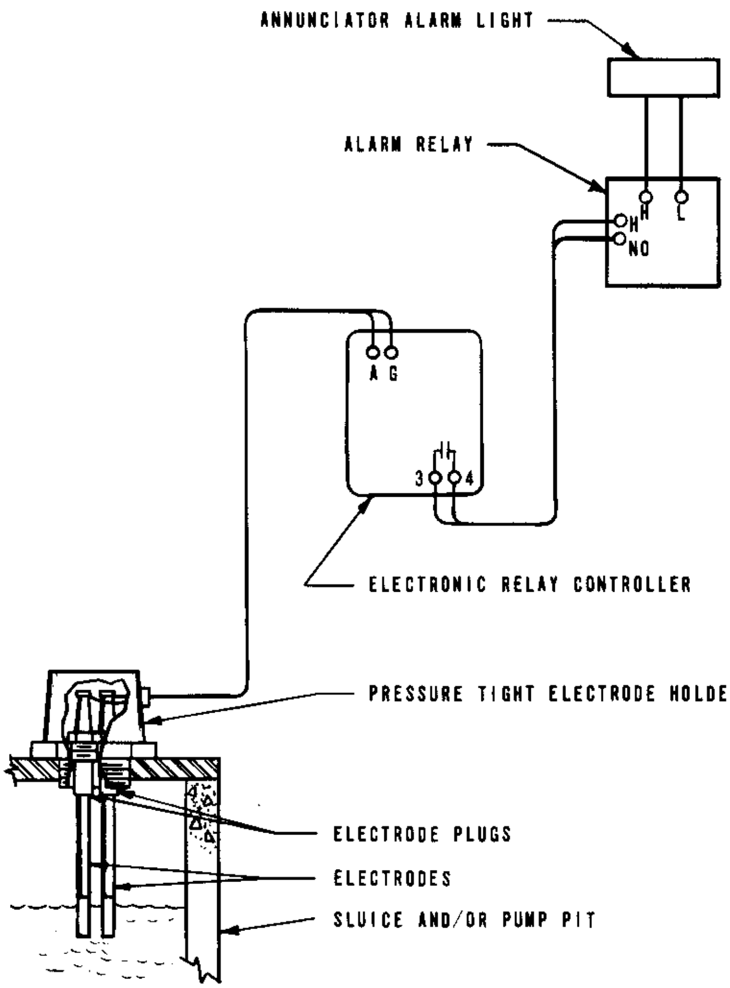

FIGURE XIII-18

Conductivity Type Level System

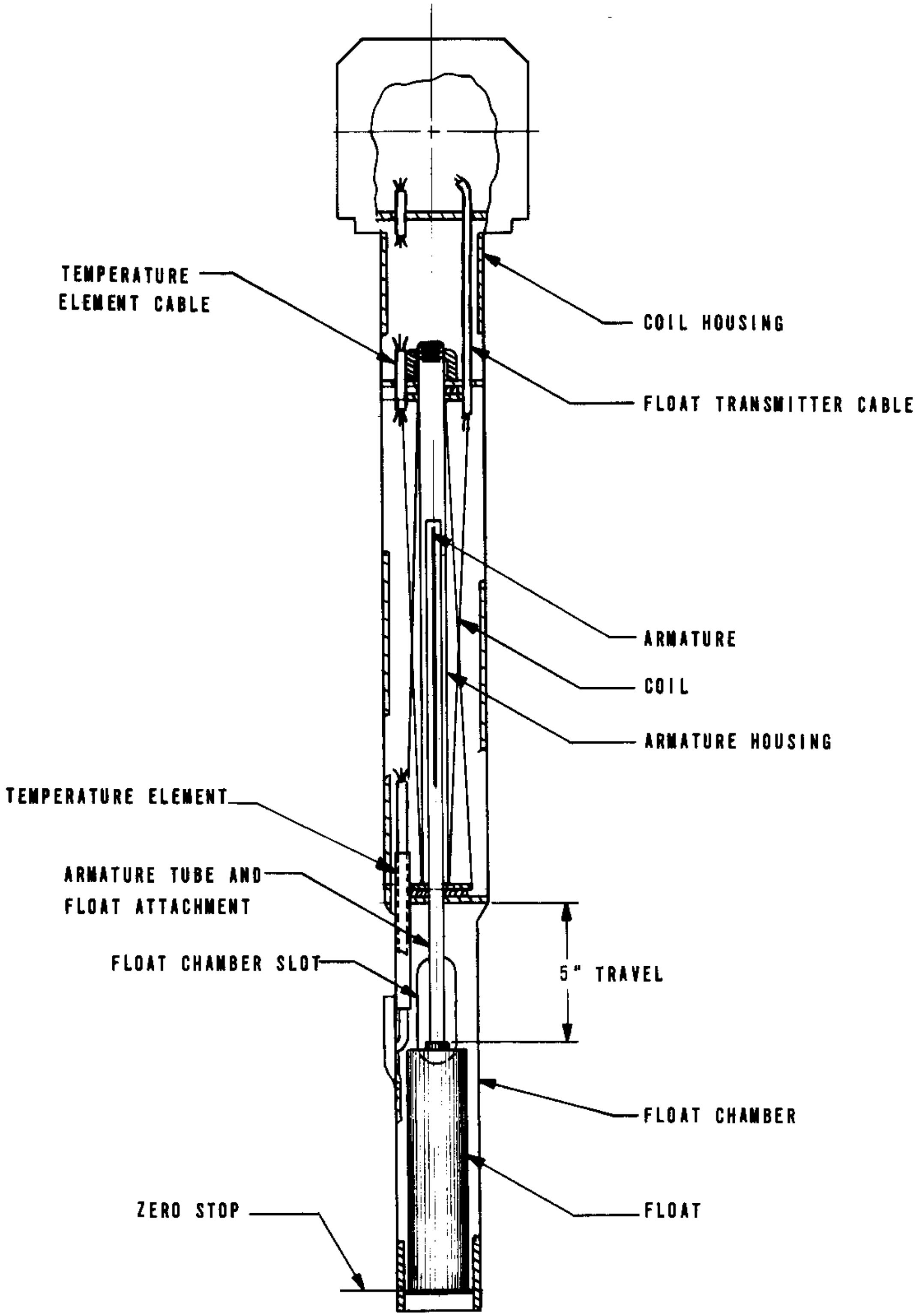

FIGURE XIII-19
Electronic Interface Float

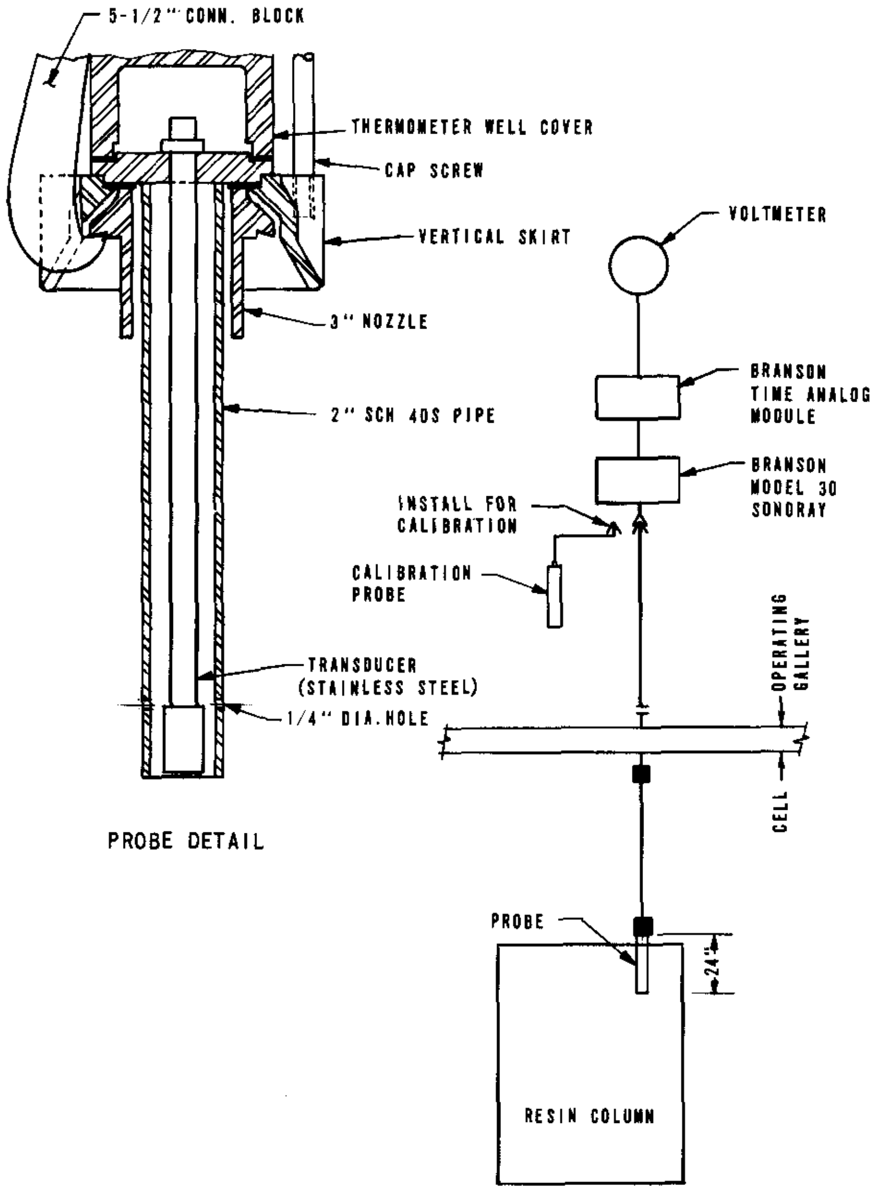

FIGURE XIII-20

Ultrasonic Probe Resin Level Detector

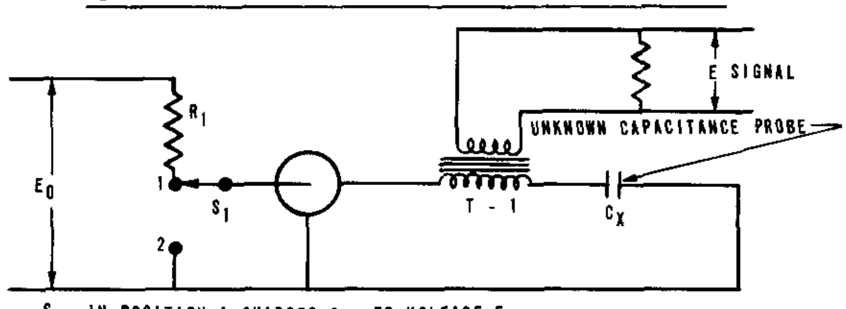

FIGURE XIII-21

Capacitance Measurement Functional Diagram

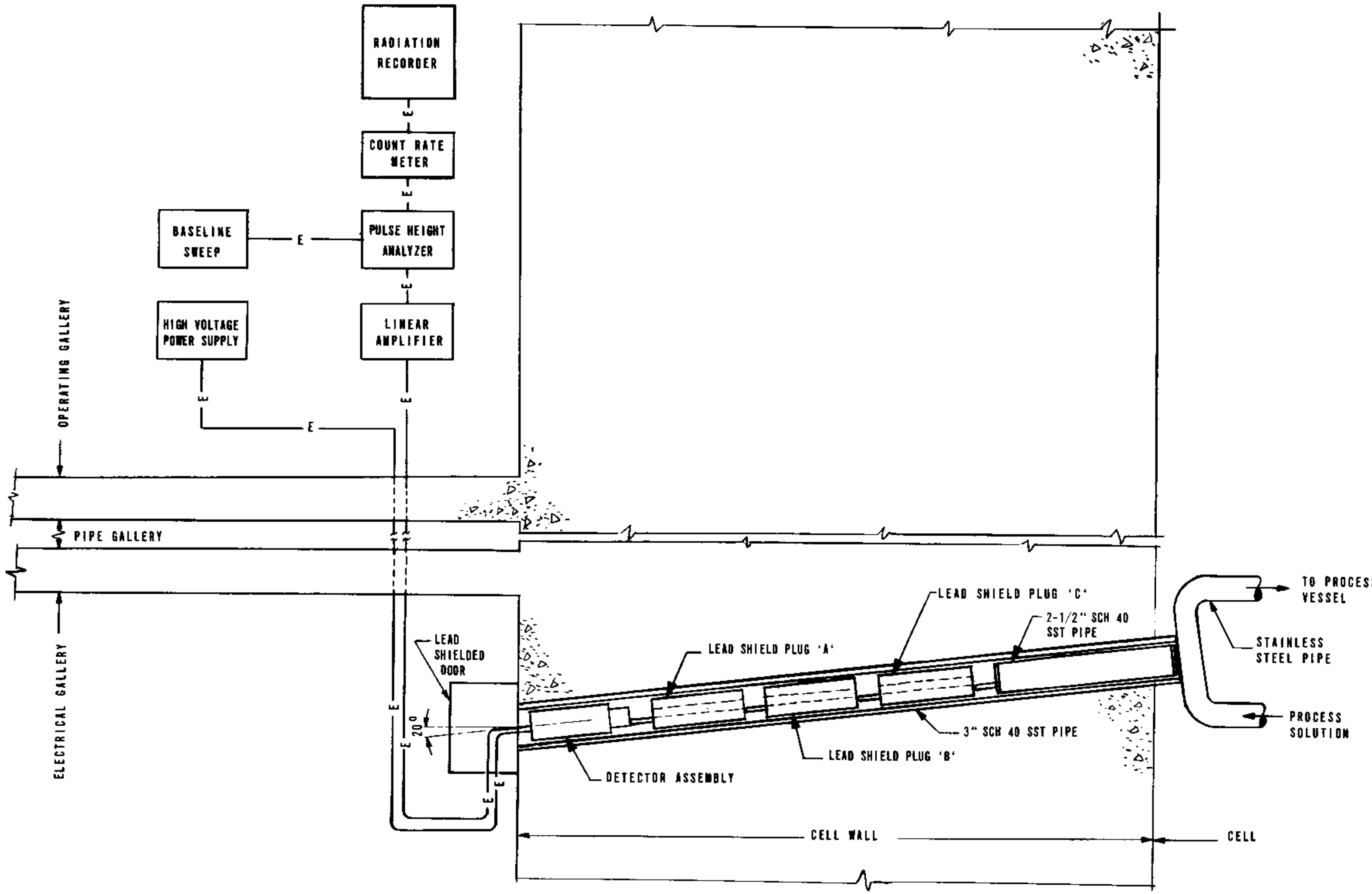

FIGURE XIII-22

Monitor Probe Encasement Assembly

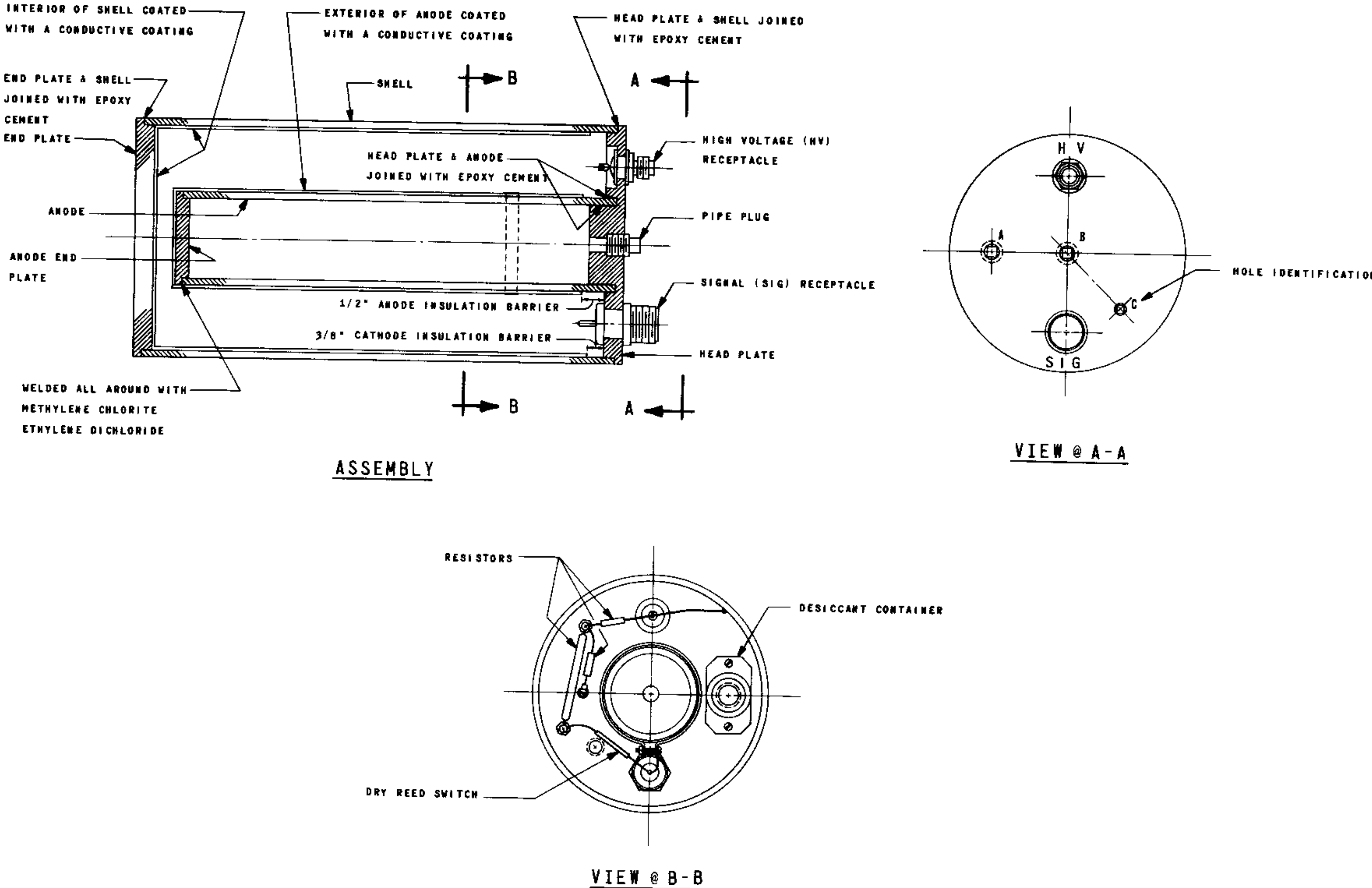

FIGURE XIII-23

Ionization Chamber

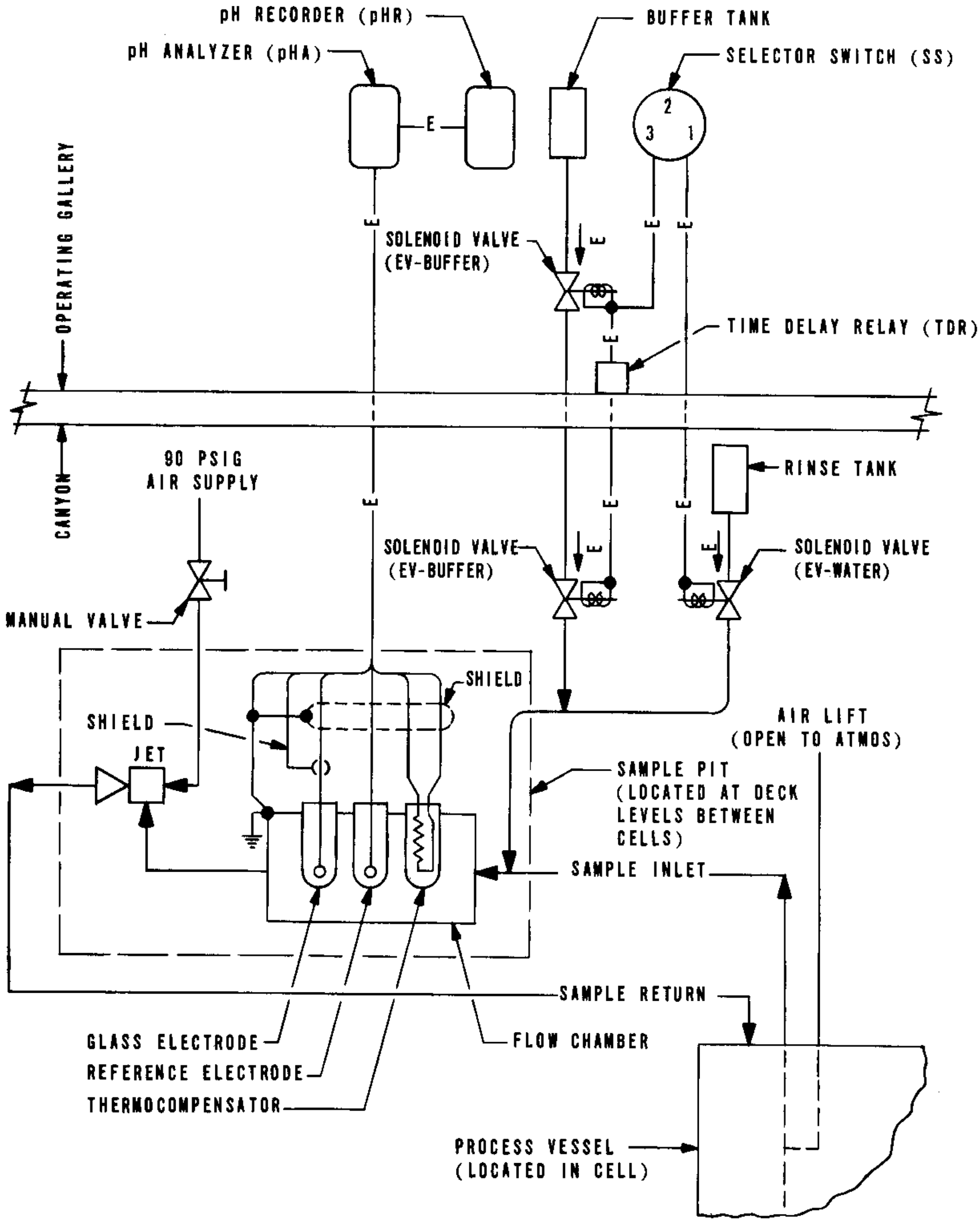

FIGURE XIII-24

pH Measurement System

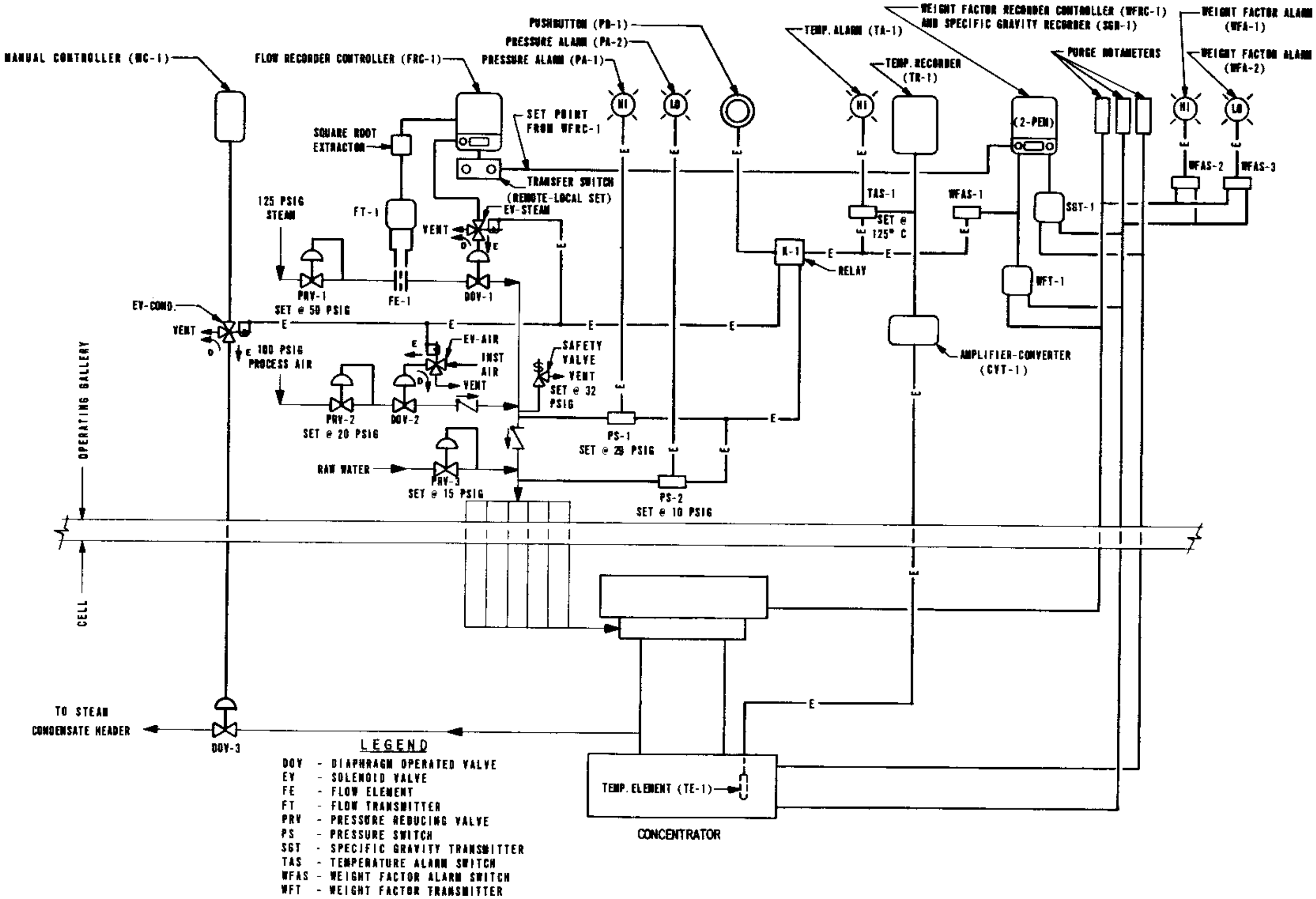

FIGURE XIII-25

Tube Bundle Control System