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Section 2 of 3

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PART II: PROCESS, continued

CHAPTER X. AQUEOUS MAKE-UP

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CHAPTER X. AQUEOUS MAKE-UP

A. DESCRIPTION OF ENGINEER'S FLOW SKETCH

The function of the aqueous make-up system is the preparation and distribution of "cold" aqueous solutions to the TBP Plant (221-U Building), the UO_3 Plant (224-U Building), the Waste Storage Tank Farms (241 Areas), and the Solvent Treatment Area (276-U). (See Figure X-1.)

The system is designed for an instantaneous plant capacity of 10 short tons of uranium per 24-hour day (13.125 tons/day for the UO_3 Plant). The compositions of regularly prepared solutions are:

Components	RA Column Scrub (RAS Stream)	RC Column Extractant (RCX Stream)	RO Column Scrub (ROS Stream)
HNO_3, Wt. %	11.7	0.06	
M	2.0	0.01	
Na_2SO_4,* Wt. %			5.0
M			0.37
$Fe(NH_4)_2(SO_4)_2 \cdot 6H_2O$, Wt. %	1.3		
M	0.05		
$H(NH_2SO_3)$, Wt. %	0.9		
M	0.10		
Specific Gravity	1.078	1.00	1.045

Raw material specifications for the components of these solutions are given in Reference(2).

Demineralized water is used in the make-up of all "cold" aqueous solvent-extraction column feed streams in the Waste Metal Recovery Plant. The Demineralized Water Unit, a two-step ion-exchange water demineralizer fed from the 200-West Area filtered water supply, is located on the third floor of the Service Building, 271-U. The daily plant requirement for demineralized water is approximately 100,000 gallons. This unit, with a maximum instantaneous capacity of 120 gallons per minute or a sustained capacity of 130,000 gallons per day is adequate to meet this requirement. The specifications for demineralized water are:

*) Other solutes such as Na_2CO_3, H_3PO_4, or H_2SO_4 may be used in the ROS.

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Component	Maximum Concentration
Total hardness (as $CaCO_3$)	2 p.p.m.
Total cations	4 p.p.m.
Total anions	4 p.p.m.
Total dissolved solids (Exclusive of SiO_2)	4.5 p.p.m.
Silica (as SiO_2)	7.5 p.p.m.
Free carbon dioxide (as CO_2)	100 p.p.m.
Hydrogen ion	pH 5 (Minimum: pH 8)

Demineralized water is collected in the 6,600-gallon Demineralized Water Head Tank, 341, on the roof of 271-U Building, and overflows to the two Demineralized Water Holdup Tanks, 342 (6,600-gallon capacity), and 343 (14,000-gal. capacity), connected in series in the Tank Farm (Building 211-U). A float-operated inlet valve on the Demineralized Water Head Tank, 341, keeps the water level slightly above the overflow to the two holdup tanks. The three tanks when full provide a 6-hour plant supply of demineralized water. The RAS Make-Up Tanks, 314 and 315, located in Building 211-U, are supplied with water pumped from TK-342. All other demineralized water is distributed by gravity flow from TK-341.

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Chemical storage facilities provide for a 2-month supply of liquid chemicals and a 4-month supply of dry chemicals. The daily chemical requirement of the plant under normal operating conditions (8 short tons of uranium per day) is:

Material	Daily Consumption
Demineralized water	100,000 gallons
60% HNO_3	14,200 gallons
50% NaOH	7650 gallons
$H(NH_2SO_3)$	1510 pounds
$Fe(NH_4)_2(SO_4)_2 \cdot 6H_2O$	3050 pounds
Na_2SO_4 (anhydrous)	2040 pounds

Sixty per cent nitric acid is delivered to the 211-AU Tank Farm by railroad tank car or tank truck and is pumped into any of nine 100,000-gallon Nitric Acid Storage Tanks, 301 through 309. Nitric acid is pumped from these tanks to the slurry removal sites via the 241-WR Diversion Station, and to the following tanks:

Tank		Location	
Functional Name	Number	Floor	Building
Nitric Acid Addition Tank	OG-2	3rd	224-U
RAS Make-Up Tanks	314 & 315	Ground	211-U
Nitric Acid Head Tank	201	3rd	271-U
Wash Solution Make-Up and Head Tank	203	3rd	271-U

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Fifty per cent sodium hydroxide, with a freezing point of 50°F. (10°C.), is pumped from heated tank cars into any of three steam-heated, 14,000-gallon Caustic Storage Tanks, TK-325 through TK-327, in the 211-U Tank Farm, or into any of the four 95,000-gallon Caustic Storage Tanks, TK-321 through TK-324, in the 211-AU Tank Farm. From these tank farms the caustic is pumped into the Wash Solution Make-Up Tank, 203, the 50% Caustic Header, the Demineralized Water Unit, and the Caustic Head Tank, 205.

Ferrous ammonium sulfate hexahydrate, sulfamic acid, and sodium sulfate are received as dry chemicals and are stored in the 271-U Building on the same floor as the make-up tanks in which they are used are located.

The 276-U Solvent Area is supplied with 60 per cent nitric acid, wash solutions from the Wash Solution Make-Up and Head Tank, 203, and demineralized water, by gravity flow of these liquids from a 400-gallon weigh tank, 276-A, in the 221-U Building operating gallery.

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B. SOLUTION MAKE-UP PROCEDURES

1. General

Dry chemicals for solution make-up are weighed on platform scales and liquid volumes are measured by weight factor or liquid level instruments. RAS and ROS are prepared batchwise; RCX, continuously. These solutions are fed into their respective headers by gravity flow from the head tanks on the third floor of the 271-U Building.

2. RAS

RAS is used at a rate of 18,650 gallons per day and is made up alternately in the two RAS Make-Up Tanks, 314 and 315, in 6,600-gallon batches. This volume of solution will satisfy plant requirements for 8.5 hours under normal operating conditions. Sulfamic acid is dissolved in demineralized water (solubility: 21 grams per 100 grams of water at 20°C.) in the Sulfamic Acid Make-Up Tank, 206, and ferrous ammonium sulfate hexahydrate is dissolved in demineralized water (solubility: 18 and 100 grams per 100 grams of water at 0 and 75°C. respectively), in the Ferrous Ammonium Sulfate Make-Up Tank, 207. These two solutions are dropped to Tank 314 or 315 and blended with demineralized water and 60 per cent nitric acid to make RAS. The make-up tanks are steam-heated and agitated. After being sampled, the RAS is pumped continuously into the RAS Feed Tank, 208, (530-gallon capacity, 50-minute holdup), where the liquid level is maintained constant by a weight-factor-actuated control valve.

3. RCX

RCX is made up in the agitated RCX Blend Tank, 204, (530-gallon capacity, 10-minute holdup) by continuous blending of demineralized water and 60 per cent nitric acid which is metered into the tank by a proportioning pump. The blend tank is kept full by an automatic, weight-factor-actuated control valve in the water inlet line. This tank also

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functions as the head tank to supply 75,000 gallons of RCX per day to the columns.

4. ROS

In the steam-heated, agitated, Sodium Sulfate Make-Up Tank, 220, sodium sulfate (or other solute to be used in the ROS) is dissolved in demineralized water in 2500-gallon batches. Each batch supplies the ROS demand of the plant for 13 hours under normal operating conditions. This solution is pumped intermittently to the ROS Head Tank, 202, (3400-gallon capacity, 17-hour holdup).

5. Wash Solutions

Wash solutions are prepared in the steam-heated, agitated, 750-gallon, Wash Solution Make-Up and Head Tank, 203, from 60 per cent nitric acid, 50 per cent caustic, or any desired dry chemical. These solutions are distributed by gravity flow from this tank to the 224-U Building or to points in the 221-U Building via the Wash Header.

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REFERENCES

(1) HW-18895 Essential Material Requirements and Specifications for Project C-362. F. A. Hollenbach. September 13, 1950.

(2) HW-19156 Specifications for Acceptance and Sampling Procedures for Essential Materials. Analytical Section, Technical Service Division. ca. April 1951.

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Fig VIII-1

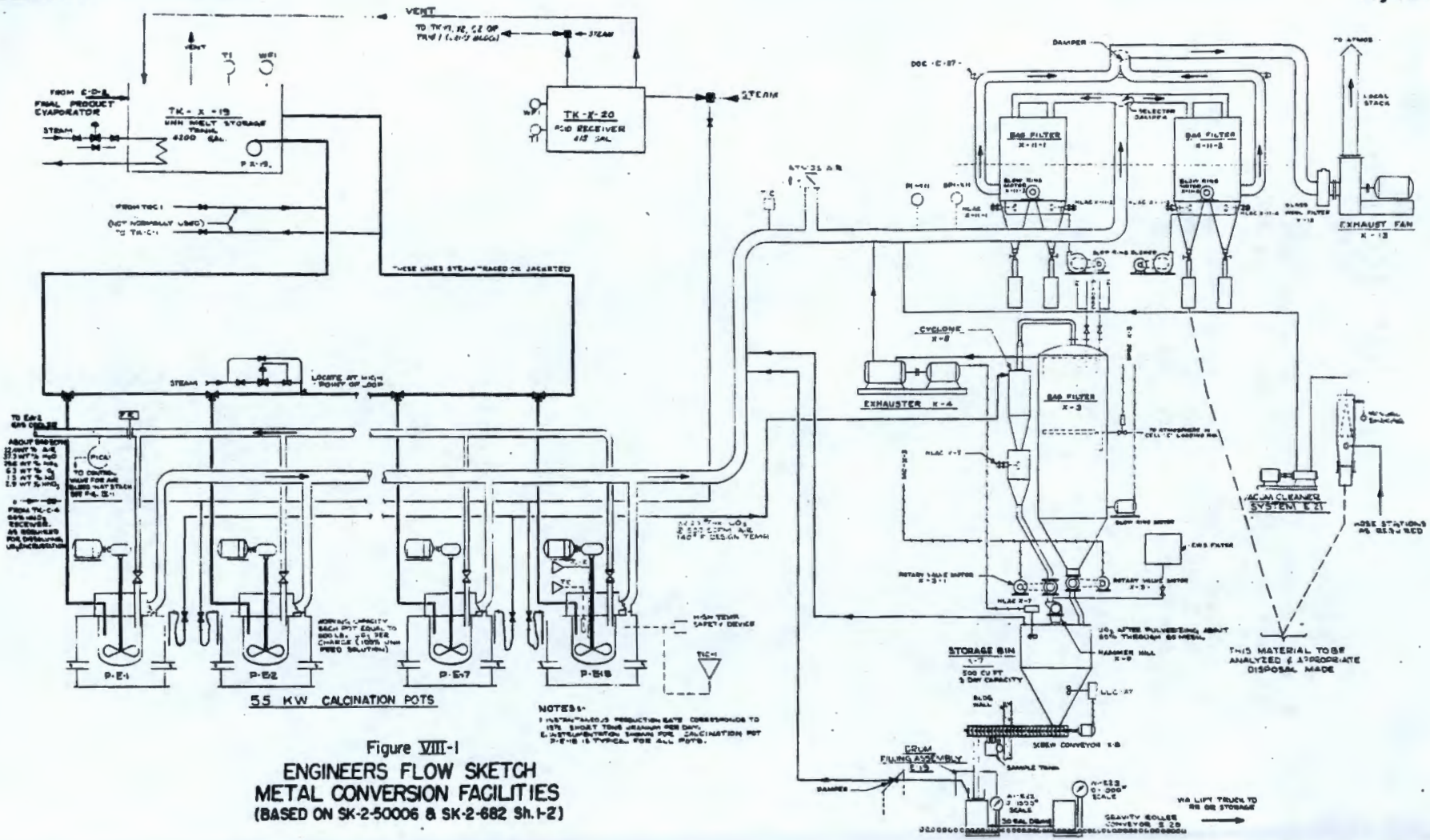

Figure VIII-1
ENGINEERS FLOW SKETCH
METAL CONVERSION FACILITIES
(BASED ON SK-2-50006 & SK-2-682 Sh.1-2)

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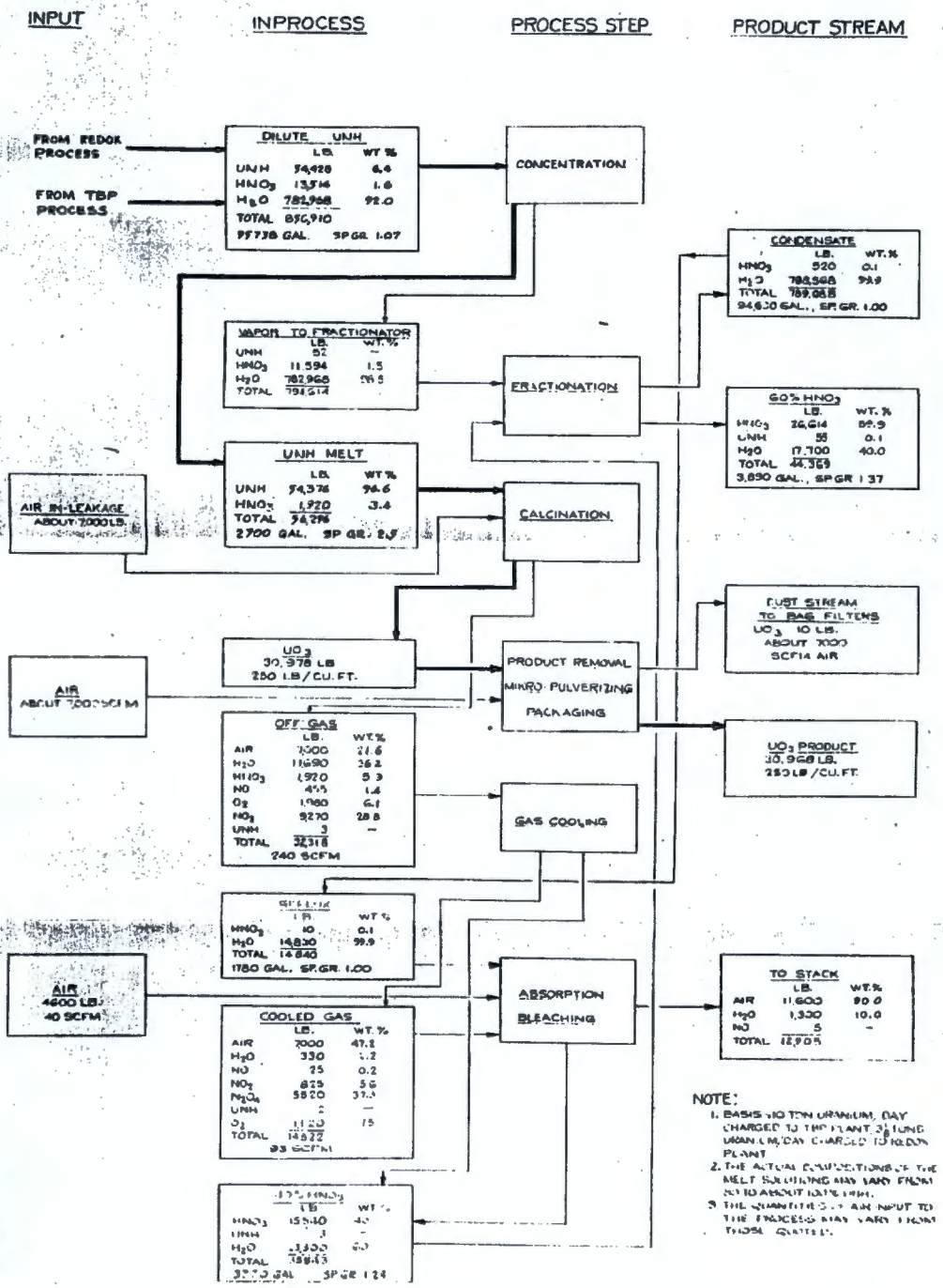
Figure VIII-2

MATERIAL BALANCE FLOWSHEET

PRODUCT CONCENTRATION, URANYL NITRATE DECOMPOSITION AND ACID RECOVERY

(Source of Data: SK-2-6220, SK-2-50006 and HW-18406)



NOTE:

1. BASIS: 10 TON URANIUM/DAY CHARGED TO THE PLANT, 3½ TONS URANIUM/DAY CHARGED TO NEDOX PLANT
2. THE ACTUAL COMPOSITIONS OF THE MELT SOLUTIONS MAY VARY FROM 30 TO ABOUT 10% UNH.
3. THE QUANTITIES OF AIR INPUT TO THE PROCESS MAY VARY FROM THOSE QUOTED.

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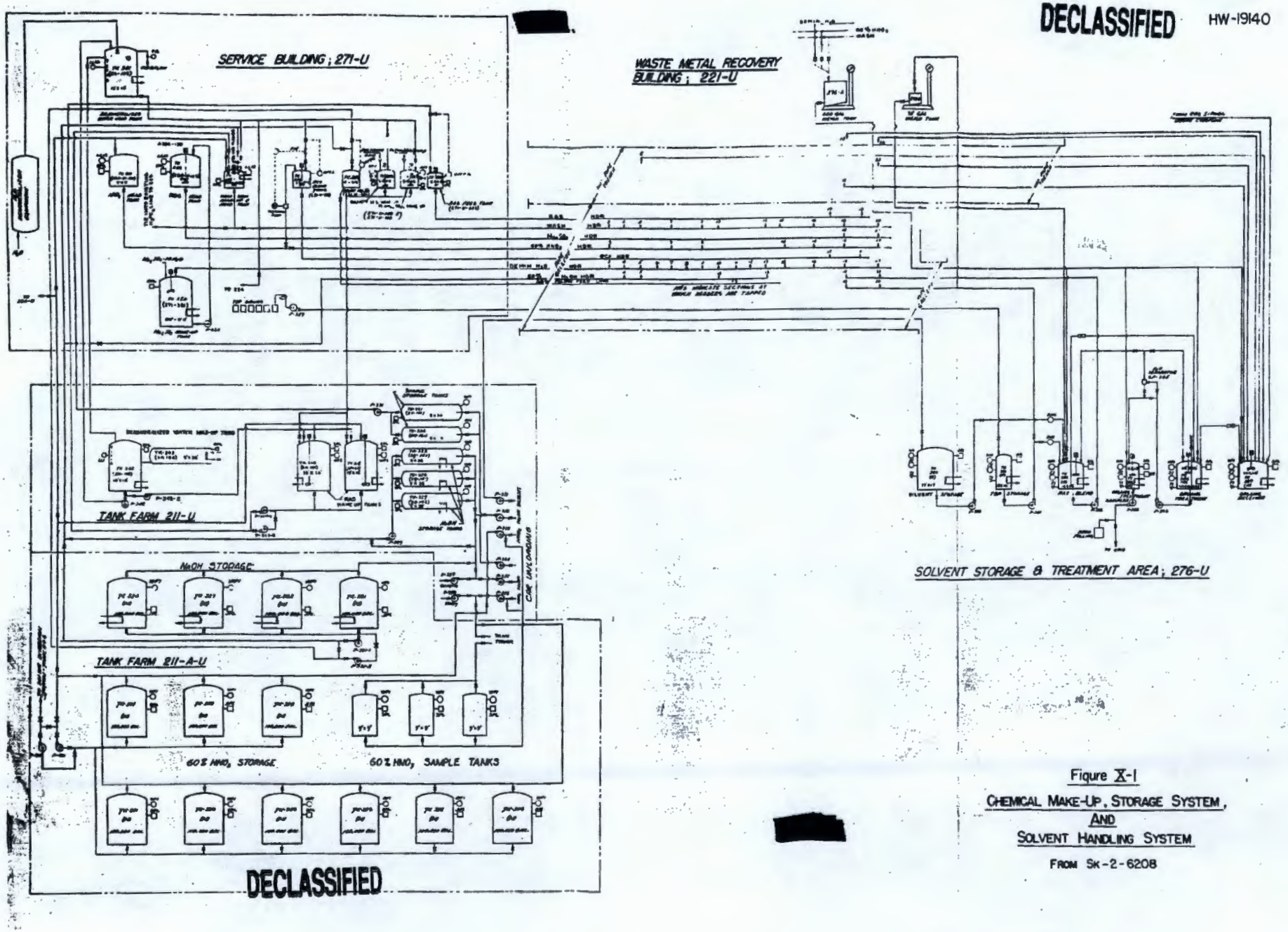

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Figure X-1

CHEMICAL MAKE-UP, STORAGE SYSTEM, AND SOLVENT HANDLING SYSTEM

FROM SK-2-6208

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PART II: PROCESS, continued

CHAPTER XI. SOLVENT TREATMENT

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CHAPTER XI. SOLVENT TREATMENT

A. INTRODUCTION

The solvent used in the TBP process for the solvent-extraction of uranium from underground stored uranium wastes is a solution of tributyl phosphate (TBP) in a hydrocarbon diluent. The nominal composition of this extractant is 12.5 per cent (by volume) TBP and 87.5 per cent hydrocarbon diluent. Specifications for TBP and hydrocarbon diluent as received from the vendor are listed in the following tables.

TBP Specifications [18]

Butanol	Reducing normality less than 0.05
Acidity	Less than 0.01 Normal
Color	Water white
Water	No turbidity when 1 volume is mixed with 19 volumes of 60° Baumé gasoline at 20°C.
Solids	Zero
Specific gravity	0.973 to 0.983 (20°/20°C.)

Hydrocarbon Diluent Specifications [2]

Specific gravity	0.8 or less at 25°/4°C.
Viscosity	2.0 centipoises or less at 25°C.
Flash point	140°F. or higher, closed cup (Tag or Pensky-Martens)
Olefins plus aromatics	2% by volume or less (A.S.T.M. Test D-875-46T)

TBP may contain the following impurities introduced in the process of its manufacture:

Impurity	Chemical Formula
Dibutyl phosphate (DBP)	$(n\text{-}C_4H_9)_2HPO_4$
Monobutyl phosphate (MBP)	$n\text{-}C_4H_9 \cdot H_2PO_4$
Phosphoric acid	H_3PO_4
Butanol	$n\text{-}C_4H_9OH$

These impurities are also formed by hydrolysis of TBP in contact with acid solutions, and in the presence of light when in contact with neutral uranyl nitrate solutions. DBP and MBP are particularly deleterious to normal column operation, adversely affecting fission-product decontamination in the RA Column [17], uranium stripping in the RC Column [1], and the throughput capacity of the RC Column [22]. Under the relatively mild conditions (room temperature and 3 M or lower nitric acid concentration) of the TBP process, hydrolysis products are expected to be formed at a low rate, and the routine reconditioning treatment in the RO Column should maintain the solvent

sufficiently low in decomposition product content so that normal column operation is not adversely affected. Chapter IV contains a more complete discussion of TBP hydrolysis products and of the deleterious effects of TBP hydrolysis products on uranium decontamination and stripping.

The presence of TBP decomposition products is revealed by a routine uranium distribution ratio (E_a^o) test performed on a sample of the recovered solvent (ROO) stream. The E_a^o test (see Chapter XX for details) is a determination of the uranium distribution between organic and aqueous phases under the conditions of the dilute end of the RC Column. It serves as a qualitative measure of the presence of hydrolysis products. Removal of these hydrolysis products normally consists of batch-washing increments of solvent diverted for the purpose to the 276-U Building. Chemical washes which most effectively remove the decomposition products are Na_2SO_4, Na_2CO_3, and NaOH. In some cases a recurrence of the need for batch washing may be avoided by changing the RO Column scrub (ROS) composition or flow rate.

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The organic inventory is depleted during operation through two mechanisms: (a) TBP loss due to its slight solubility in the aqueous phase; and (b) TBP and diluent loss due to entrainment in the aqueous phase. These inherent organic losses are discussed in Subsections C3 and D1 of this chapter.

B. PRETREATMENT

Fresh solvent is made up and pretreated batchwise according to the procedures outlined in Subsection D1 of this chapter. After blending of the TBP and hydrocarbon diluent, normal pretreatment consists of washing the solvent with a sodium carbonate solution to remove traces of DBP and MBP and other acidic impurities. This carbonate wash, five to ten weight per cent (0.5 M to 1.04 M Na_2CO_3), neutralizes the remaining DBP and MBP to their corresponding sodium salts, which are removed with the aqueous phase. Although TBP specifications (presented in Section A, above) are such that the presence of detrimental concentrations of DBP and MBP in new TBP is unlikely, semi-works practice at Hanford Works has shown carbonate washing to be a worthwhile precautionary measure. The uranium distribution coefficients of raw solvent show a significant improvement after a two-hour, single-stage wash with 5% Na_2CO_3 (at an aqueous-to-organic volume ratio of about 1:6 to 1:3).

After the two-hour agitation period, the carbonate solution is decanted to the cribs.

In addition to removing any TBP decomposition products from the solvent, the carbonate wash saturates the organic solution with water. Solubility data for water in TBP, hydrocarbon diluent, and TBP-hydrocarbon diluent solutions are presented in the following table[22]:

Solubility of Water in TBP, Hydrocarbon Diluent, and TBP-Hydrocarbon Diluent Solutions at 25°C.

Solvent	Solubility of Water g./L.	Wt. %
TBP	3.7	6.5
Hydrocarbon Diluent	0.06	<0.01
5% TBP-Hydrocarbon Diluent	0.54	0.07
15% TBP-Hydrocarbon Diluent	2.4	0.29
25% TBP-Hydrocarbon Diluent	5.8	0.69

C. SOLVENT RECOVERY

Processing of the solvent through the RO Column before recycling to the TBP process has a two-fold purpose: (a) to remove the decomposition products of TBP from the solvent; and (b) to remove residual uranium and fission products.

1. TBP Decomposition Products

1.1 Formation

The TBP hydrolysis mechanism may be described in terms of the following series of reactions[20]:

$$\underset{(TBP)}{(C_4H_9)_3PO_4} \xrightarrow{3M\ HNO_3} \underset{(DBP)}{(C_4H_9)_2HPO_4} \xrightarrow{3M\ HNO_3} \underset{(MBP)}{C_4H_9H_2PO_4} \xrightarrow{3M\ HNO_3} H_3PO_4 + \underset{(Butanol)}{C_4H_9OH}$$

The controlling rate in this hydrolysis is the TBP to DBP reaction. Data showing hydrolysis rates for pure TBP at a 1:1 organic-to-aqueous phase volume ratio are presented in the following tables:

Hydrolysis of TBP by 3M HNO_3 at 76°C. and 105°C.

Organic-to-Aqueous Phase Volume Ratio = 1:1

At 76°C. (20)		At 105°C. (21)	
Time, Days	% TBP Decomposed	Time, Days	% TBP Decomposed
8	0.00	0	0.00
9	0.07	6	0.7
16	0.28	8	1.3
19	0.49	13	1.3
25	0.74		

With the reduction of the organic-to-aqueous phase volume ratio to 1:200, the hydrolysis of pure TBP is as shown in the following table:

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Hydrolysis of TBP by 3M HNO_3 at 105°C.

Organic-to-Aqueous Phase Volume Ratio = 1:200[21]

Time (Days)	% TBP Decomposed
0	0
6	60
13	95

Organic-to-aqueous phase volume ratios in the TBP Plant are expected to range from approximately 1:1 in the RC Column and 1.67:1 in the RA Column to 20:1 in the RO Column. The hydrolysis rates under plant conditions should be lower than reported in the tables above, due to the following factors:

1. Temperatures are expected to be approximately 25°C. in the TBP Plant. (No hydrolysis rates have been determined experimentally below 76°C.)

2. Organic-to-aqueous phase volume ratios encountered in the plant are either approximately 1:1 or even considerably higher.

3. Dilution of TBP by a substantially inert diluent to 12.5 per cent (by volume) TBP is expected to reduce the rate by as much as a factor of two or more.

In the course of a routine solvent-extraction cycle (involving no reworking of off-standard material), the solvent incurs the following conditions:

Column	Chemical Environment	Estimated Time of Contact, Hours	Approximate Temperature
RA	2 to 3 M HNO_3	0.03	25 to 35°C.
RC	0.01 to 0.1 M HNO_3	0.07	25°C.
RO	0.4 M Na_2SO_4	0.03	25°C.

The above table shows that the actual contact time of organic with aqueous in the three columns is very small. The stability of TBP under normal operating conditions has been demonstrated at the Oak Ridge National Laboratory by recycling the solvent without retreatment through ten continuous solvent-extraction cycles without a significant loss of performance. However, the conditions encountered during plant operation will determine the length of operation possible before batch treatment of the solvent becomes necessary.

Concentration of aqueous solutions containing 3 M nitric acid and 0.5 per cent (by volume) TBP at 105°C. has been shown to result in sixty per cent hydrolysis of the TBP in six days and substantially complete hydrolysis in thirteen days[21]. In semi-works experience

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at Hanford Works it was found that, in addition to decomposition of the dissolved TBP by hydrolysis, exposure of solvent-saturated aqueous process solutions to elevated temperatures causes the formation of other decomposition products of unknown composition and unpredictable behavior in the solvent-extraction process. Because of these factors, off-standard waste or product streams will be reworked without concentration. Although washing aqueous solutions with hydrocarbon diluent has been found to be effective in removing small amounts of TBP, equipment is not provided in the TBP Plant for hydrocarbon washing of aqueous solutions.

1.2 Effect on solvent-extraction

In the event that some decomposition products do enter the system, it is expected that their effect will be momentary since they will normally be removed through the RAW, RCU, and ROW streams. A variety of agents may be used to wash the solvent in the RO Column (12) (13) (16), where substantially all DBP and MBP should be removed. Subsequent batch wash treatments of possible off-standard organic effluent from the RO Column may be made with these same agents. Various washing agents and their effects are discussed in greater detail later in this chapter (Subsections C2 and 3).

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The following table indicates the effect of small concentrations of DBP in the solvent on RA Column decontamination. These data were secured at Hanford Works by simple multistage laboratory contacts. One batch contact was used to simulate the RA Column extraction section, and three batch contacts using 3M HNO_3 pre-equilibrated with respect to UNH were used to simulate the scrub section. The data show the magnitude of the effect of DBP on decontamination, but should not be construed as showing the degree of decontamination to be expected in the TBP Plant since phosphate and sulfate ions were not present in the feed and because of the great difference in fission-product analysis of this feed in comparison with expected plant feed.

Effect of DBP on Decontamination (17)

Organic: 12.5 volume % TBP in CCl_4; indicated DBP concentration
IAFS: 0.2 M UNH, 3 M HNO_3 (prepared from 450 g./ton dissolver solution, "cooled" 140 days)
Scrub: 3 M HNO_3 pre-equilibrated with respect to uranium
Extractant:feed:scrub volume ratio: 10:3:2

		RA Column DF	
Vol. % DBP	G./L. DBP	Gross Beta	Gross Gamma
0	0	3.2×10^5	8.7×10^4
0.01	0.1	5.7×10^3	760
0.1	1.0	80	8.7
1.0	10.0	33	2.8

The above table shows that relatively small concentrations of DBP in the solvent had a pronounced effect upon fission-product removal in the simulated RA Column, where beta decontamination factors were reduced 10,000-fold and gamma decontamination factors were reduced 30,000-fold as the DBP concentration increased from 0 to 10 g./l. Analyses for specific fission products indicated that the distribution and scrub behavior of cerium and ruthenium were unaffected by these concentrations of DBP. At 0.01 and 0.1 per cent DBP, the activity not removed by scrubbing was essentially all zirconium while at 1.0 per cent DBP, some niobium also remained in the organic.(17)

The data in the following table show the detrimental effects of small amounts of DBP in the solvent on RC Column operation.

Effect of DBP on Uranium Distribution in the RC System (13)

Initial Aqueous	Initial Organic	E_a^o, Uranium Distribution Ratio, (G./L. Org.)/(G./L.Aq.)
1 g./l. UNH	15% TBP in Deobase	0.002
1 g./l. UNH	15% TBP in Deobase + 0.2 g./l. DBP	0.41
1 g./l. UNH	15% TBP in Deobase + 1.0 g./l. DBP	21

The uranium distribution coefficient, E_a^o, in the dilute range is increased about 10,000-fold as the DBP concentration is increased from 0 to 1.0 g./l., thus causing high uranium losses in the RC Column. For a further discussion of the adverse effects of DBP and also of MBP on RA and RC Column performance reference is made to Chapter IV.

Solvent decomposition products other than MBP and DBP may be formed from TBP under severe conditions of exposure to heat and nitric acid. Decomposition products not fully identified but believed to consist, at least partly, of nitrated aromatic hydrocarbons (10) were formed in "cold" semi-works studies at Hanford in which solvent-saturated RAW and RCU streams were repeatedly concentrated by evaporation, combined or separately, for reuse as RAFS, the concentration-reuse cycle being repeated ten times or more. These decomposition products, which may be present in both aqueous and organic solutions, result in increased E_a^o values and thus higher RC Column losses. Washing contaminated solvent with water, 10% H_3PO_4, 5% Na_2CO_3, 8% H_2SO_4, 10% and 5% Na_2SO_4, acid-dichromate, or oxalic acid failed to reduce E_a^o to less than 0.05. Consequently the semi-works solutions contaminated by these decomposition products were discarded. (The decomposition products were referred to as "red oil" because of their red or reddish-brown color.) It should be noted that the formation of these impurities took place under more extreme conditions of temperature and nitric acid concentration than are expected to be encountered in the TBP Plant.

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2. Removal of TBP Decomposition Products

The removal of DBP and MBP from TBP-hydrocarbon diluent solutions of approximate RAX composition has been studied in the laboratory at Hanford Works.[21] The RAX was 15 volume per cent TBP in Amsco 125-90W hydrocarbon, spiked in one case with MBP to 1 g./l. and in the other with DBP to 1 g./l. Test washings were made with equal volumes of aqueous wash and of spiked organic solutions followed by determination of the uranium E_a^o by equilibration with an equal volume of 1 g./l. UNH solution. The data are presented in the following table:

Removal Efficiency of Various Aqueous Solutions For Separation of MBP and DBP From RAX [21]

Scrubbing Agent	E_a^o (UNH at 1 g./l.) after Scrubbing: 1 g./l. MBP Spike	1 g./l. DBP Spike
10% NaOH	0.0006	0.0001
10% H_3PO_4	0.0170	4.5
10% Na_2SO_4	0.0020	0.28
10% Na_2CO_3	—	0.0008
H_2O	0.0030	0.55
No Spike	0.002	0.002
No Scrub	—	21

Additional testing with DBP alone established that 10 g./l. DBP was removed by one wash with 10 per cent Na_2CO_3 or NaOH and that 10 g./l. DBP plus 24 g./l. UNH was removed by one 10% Na_2CO_3 wash.

Tests carried out in the laboratory on semi-works contaminated solvent were not successful in restoring solvent E_a^o values to fresh solvent values ($E_a^o \leq 0.001$). Wash solutions used were Na_2CO_3, NaOH, $Na_2Cr_2O_7$, Na_2SO_4, Na_3PO_4, Na_2HPO_4, NaH_2PO_4, H_3PO_4, H_2SO_4, $Al(NO_3)_3$, and HNO_3. Na_2SO_4 washes were most effective in improving the E_a^o, but did not reduce the E_a^o value below approximately 0.02. However, solvent treatment investigations during Purex studies using 30 volume per cent TBP indicated 5 per cent Na_2CO_3 solutions to be the most effective wash. No reason for this difference has been established.

Washing of solvent in 1500 to 2500-gallon batches in the Hanford 321 Building Semi-Works using wash solutions found to be most effective in the laboratory was not successful in reducing E_a^o values for contaminated solvent to less than 0.05. However, when new solutions, both aqueous and organic, were made up and used with no recycling to the system of any material other than Stoddard Solvent-washed RCU and Na_2SO_4-washed RCW, the E_a^o indicated no build-up of decomposition products.

3. RO Column

Solvent from the extraction cycles (RCW streams) is continuously and counter-currently scrubbed in the RO Columns, one for each of the two

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parallel solvent-extraction processing lines. The nominal ratio of scrub to solvent is one volume to twenty volumes. Semi-works practice has shown that solvent reconditioning is improved as the aqueous-to-organic flow ratio is increased. However, a one-to-twenty ratio (aqueous to organic) is expected to be adequate for routine use. Subsection C2 shows that sodium hydroxide, sodium sulfate, and sodium carbonate wash solutions effectively remove impurities from the solvent. Of these, sodium hydroxide is the most effective but has the undesirable property of precipitating uranium which may cause plugging of the column. Consequently, sodium sulfate is used in the plant. Although sodium carbonate would react with slightly acidic RCW to evolve carbon dioxide, this would not be a problem unless the gas volume became great enough to cause flooding of the column. Although the relative effectiveness of sodium sulfate and sodium carbonate is not clearly defined, semi-works experience indicated that sodium sulfate is apparently a better wash solution for the TBP process solvent and that sodium carbonate is better for the more concentrated Purex type solvent (30 volume per cent TBP).

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When the plant operates at an instantaneous uranium processing rate of 10 tons/day (5 tons/day in each recovery line), the RO Columns (twenty-two inches in diameter) are operated at a volume velocity of approximately 800 gal./(hr.)(sq.ft.), sum of both phases. The actual flooding capacity of the RO Column has not been determined. However, based on the assumption that RO and RC-type packed columns flood at approximately the same operating conditions, the above volume velocity is less than fifty per cent of the flooding capacity of the column when packed with 1-inch Raschig rings.(7) Under these conditions H.T.U. values obtained during uranium extraction studies in the RO Column using various scrub solutions have been found to range from approximately four feet to ten feet.(11) (14) (15)

4. Retreatment

During normal operation of the TBP Plant (no aqueous wastes being recycled), continuous treatment of the solvent in the RO Column is expected to give a recycled solvent sufficiently free of TBP decomposition products, residual uranium, and fission products. Therefore, the solvent is normally returned to the RAX Feed Tank, 18-6 or 20-6, without further treatment. However, a routine sample of the solvent is taken and analyzed for per cent TBP and acidity, and the uranium distribution coefficient, E_a^o, is determined.(9) If the routine analyses of the solvent indicate an accumulation of impurities, retreatment is necessary before returning the solvent to the process.

Organic losses are estimated as the sum of the losses by two mechanisms.(4)

Mechanism	Gallons per 10 Tons U TBP	Hydrocarbon
Solution in aqueous	7.5	Negligible
Entrained in aqueous	30	210
Total	37.5	210

Data indicating the solubility of TBP in aqueous solutions are presented in the following table:(22)

Solubility of TBP (From 16.6 Volume Per Cent TBP in Amsco 125-90W) in Aqueous Solutions

Aqueous Phase	Solubility, G./L. TBP at 25°C.
Water	0.24
0.2 M UNH, 0.06 M HNO_3	0.17
0.3 M HNO_3	0.17
2 M UNH	0.01
RAW*	0.0097

*) RAW composition: 2.6M HNO_3, 1.9M $NaNO_3$, 0.2M Na_2SO_4, 0.2M Na_3PO_4, 0.03M NH_4NO_3, 0.02M $FeCl_3$, 0.03M NH_2SO_2OH.

Based on data from the above tables, the TBP concentration in the solvent requires adjustment approximately every twenty days (assuming operation between the limits 12.5 ± 0.5%), at which time the necessary butt can be made to the ROO Receivers, TK-18-1 and 20-1, or the RAX Feed Tanks, 18-6 and 20-6; or the solvent can be diverted to the Organic Treatment Building (276-U) where the necessary TBP addition is made.

Accumulation of impurities in the solvent is indicated by a high uranium distribution ratio, E_a^o. A value greater than 0.01 is indicative of poor solvent, and the need for additional treatment is indicated. Retreatment of off-standard solvent is carried out in a batchwise operation in the Organic Treatment Building, 276-U, where washing is designed to remove the impurities and to improve the uranium distribution coefficient, E_a^o. Wash solutions that may be employed in the retreatment of off-standard solvent are those that have been discussed in connection with the RO Column in Subsection C2, above.

In the washing operations, adequate time and good agitation are both essential for sufficient contact of the solvent with the washing agent. Thirty to sixty-minute agitation periods provide thorough mixing of the two phases, after which the aqueous phase containing solvent impurities and residual uranium and fission products is decanted to the cribs. The solvent is sampled to determine the effectiveness of the chemical treatment, thus indicating whether or not additional washing is necessary before returning the solvent to the process.

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D. PROCEDURES

1. Normal Procedure

1.1 Pretreatment

Fresh solvent is added to the system when the normal solvent inventory of approximately 20,000 gallons drops to approximately 14,000 gallons. Based on the assumption that routine retreatment is not necessary and disregarding TBP concentration adjustment which must be made approximately every twenty days, solvent losses to process wastes are expected to be approximately 250 gallons (40 gallons of TBP and 210 gallons of diluent) per day(4) which drops the inventory to 14,000 gallons in approximately three weeks. Figure X-1 is an engineer's flow sketch of the organic treatment facilities where fresh solvent is added. A batch of 10,000 gallons of solvent is made up and pretreated according to the procedures described below, prior to its introduction to the system:

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(a) 8750 gallons of hydrocarbon diluent is pumped into the RAX Blend Tank, 382 (working volume 13,000 gallons), from the Diluent Storage Tank, 380 (working volume 25,000 gallons).

(b) While agitating the hydrocarbon diluent, 1250 gallons of TBP is added from the TBP Storage Tank, 381 (working volume 4800 gallons).

(c) The solvent is agitated for two hours to obtain thorough mixing of the two components.

(d) At the completion of the agitation period, the solvent is jetted into the Organic Treatment Tank, 386 (working volume 13,000 gallons), where it is agitated with 2000 gallons of five to ten per cent sodium carbonate solution for two hours.

(e) Decantation is effected by pumping the solution through the Water Separator, SP-385, which directs the solvent to the RAX Blend Tank, 382, and the wash solution to the Organic Treatment Sampler Tank, 388 (working volume 2000 gallons), whence it is pumped to the 216-WR Crib.

(f) A sample of the solvent is taken and analyzed for per cent TBP, after which (provided the TBP concentration is within specifications) the solvent is suitable for use in the TBP process.

1.2 Solvent recovery

A schematic diagram of the RO Solvent Washing Column System appears on the engineer's flow sketch in Chapter VI. Solvent from each solvent-extraction column (i.e., RCW) flows at 33 gallons per

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minute into the bottom of each RO Column where it is contacted countercurrently with the scrub solution, ROS. The scrub solution of 5 per cent (0.4M) Na_2SO_4 is fed to the top of the column at 1.6 gallons per minute from the ROS Head Tank, 202 (holdup time 17 hours with both RO Columns operating) by gravity flow through a diaphragm valve. The aqueous effluent, ROW, leaves the bottom of the column through a diaphragm-operated valve remotely controlled by the interface recorder-controller and flows to the ROW Receiver, TK-18-3 (and 20-3)(working volume 1350 gallons). Provisions are made for sampling this tank, from which the solution is pumped continuously into the Pooled RAW-ROW Receiver, TK-13-6 (working volume 12,000 gallons).

The scrubbed organic, ROO, leaves the top of the RO Column and flows into the ROO Receiver, TK-18-1 (and 20-1) (working volume 4500 gallons). Normally, a routine sample is taken of the solvent while it is in Tank 18-1 (and 20-1), from which it is pumped continuously into the RAX Feed Tank, 18-6 (and 20-6) (working volume 12,000 gallons).

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2. Remedy of Off-Standard Conditions

2.1 General

Two methods are provided routinely for detection of off-standard operating conditions: E_a^o determinations, and measurement of residual radioactivity. Disengagement time determinations are secured when column operation (RA or RC) gives evidence of lowered flooding capacity, or when solids are present in the ROO. Remedial treatment should be considered when limits indicated in the following table are exceeded:

E_a^o (See Chapter XX)	0.01
Residual activity	200 counts/(min.)(ml.)
Disengagement time:	
RA	50 seconds
RC	70 seconds

A radiation recorder is installed on the ROO Receiver, TK-18-1 (and 20-1). Normally, the radiation level of the scrubbed solvent, ROO, cannot be distinguished from "background" (natural radiation level). However, in the event that radiation is detected, an investigation of the entire process should be made to determine the location and cause of improper operation. If the solvent contains a significant amount of radioactive materials, i.e., more than 200 counts/(min.)(ml.), it may be washed in Bldg. 276-U until the radioactive materials are removed.

In the case of solvent containing relatively small amounts of radioactivity, the solvent is jetted from the ROO Receiver, TK-18-1 (and 20-1) to the Organic Receiver, 387 (working volume 13,000 gallons) in the Organic Treatment Building (276-U), where it undergoes batch chemical treatment as discussed in Subsection C3, above.

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In the extremely unlikely event of obtaining RO Column organic effluent which is too high in fission-product radioactivity to allow processing in the Organic Treatment Building (276-U), solvent treatment can be effected in the extraction battery. This necessitates interrupting the flow of uranium feed solution, RAF, to the columns for several hours during which time the solvent can be purged of fission products by recycling through the system. If necessary, further treatment can be administered by shutting down the column battery and washing the solvent in the RAX Feed Tank, 18-6 (and 20-6), after which the solvent (along with the wash solution) can be processed in the extraction columns for phase separation and additional scrubbing action.

The second method for detection of off-standard conditions involves the routine sampling and analyses of the recovered solvent as it passes through the ROO Receiver, 18-1 (and 20-1). Normally, the uranium distribution coefficient, E_a^o, and the per cent TBP are determined once per day, and the acidity is determined twice per week.(9) When these analyses indicate an excessive accumulation of impurities, (see limits tabulated above) the solvent is retreated. Although such a condition is extremely unlikely, solvent may be unsatisfactory for use even after repeated retreatment; a condition which would necessitate disposal of the used solvent and replacement with fresh solvent. No facilities are provided in the TBP Plant for the disposal of large quantities of solvent. However, pumping facilities are provided at the Organic Treatment Sampler Tank, 388, for the removal of used solvent to fifty-five gallon storage drums or other containers that may be provided for the purpose until facilities for disposal (e.g., burying or burning) could be provided.

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2.2 TBP concentration adjustment

Due to unequal losses of TBP and of diluent in the process (discussed in Subsection C4, above) the TBP concentration in the solvent will require periodic adjustment. The frequency with which such adjustments must be made is a function of the TBP concentration limits within which satisfactory operation of the plant is found possible, as indicated in the following table:

TBP Concentration Limits, Vol. Per Cent	Approx. Frequency of TBP Concentration Adjustment
12.5 ± 0.5	Every 20 days
12.5 ± 1.0	Every 40 days
12.5 ± 2.0*	Every 80 days

*) Solvent phase volume losses, due to entrainment, may reduce the plant inventory of solvent to an impractically low level before TBP concentration changes reach these limits.

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The procedure described below applies to batchwise adjustment of the TBP concentration in the Organic Treatment Building (276-U) combined with a sodium carbonate wash to remove the acid phosphates and other acidic impurities from the fresh TBP. (It is possible to reduce the frequency of such adjustments, or possibly even eliminate them altogether, by combining the TBP concentration adjustment with fresh solvent make-up.)

(a) The solvent is jetted from the ROO Receivers, 18-1 and 20-1, to the Organic Receiver, 387, in 10,000-gallon batches. (Solvent may be jetted from the RAX Feed Tanks, 18-6 and 20-6, simultaneously, if desired.)

(b) The solvent is sampled and then jetted to the Organic Treatment Tank, 386, and pumped from the Organic Treatment Tank to the RAX Blend Tank, 382, bypassing the Water Separator, SP-385.

(c) The necessary amount of TBP is added to the RAX Blend Tank, 382, from the TBP Storage Tank, 381, directly or through Weigh Tank X-276-B, and the solution is agitated for thirty minutes.

(d) 2000 gallons of sodium carbonate wash solution is added to the Organic Treatment Tank, 386.

(e) The solvent in the RAX Blend Tank, 382, is then jetted to the Organic Treatment Tank, 386, and agitated for thirty minutes.

(f) Separation of the wash solution present is accomplished by pumping the solvent through the Water Separator, SP-385, which directs the solvent to the RAX Blend Tank, 382, and the wash solution to the Organic Treatment Sampler Tank, 388.

(g) Following the agitation period, the solvent is sampled and returned to the RAX Feed Tanks, 18-6 and 20-6.

2.3 Batch chemical treatment

The retreatment procedure described below applies to the batch chemical treatment of off-standard RO Column organic effluent. Reference should again be made to the schematic diagram of the organic treatment facilities on Figure X-1.

(a) 2000 gallons of wash solution (Na_2CO_3, Na_2SO_4, or other) is added to the Organic Treatment Tank, 386.

(b) A batch of 10,000 gallons of solvent is jetted from the ROO Receivers, 18-1 and 20-1, to the Organic Receiver, 387.

(c) The solvent is then jetted into the Organic Treatment Tank, 386, where it is agitated with the wash solution for thirty minutes.

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(d) Decantation is effected by pumping the solution through the Water Separator, SP-385, which directs the solvent to the RAX Blend Tank, 382, and the wash solution to the Organic Treatment Sampler Tank, 388, from where it is pumped to the 216-WR Crib.

(e) A sample of the solvent is taken and the uranium distribution coefficient, E_a^o, under dilute RC Column conditions, is determined (by the method described in Chapter XX). An E_a^o value equal to or less than 0.01 is indicative of solvent suitable for use in the TBP process.

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PART II: PROCESS, continued

CHAPTER XII. WASTE TREATMENT AND DISPOSAL

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CHAPTER XII. WASTE TREATMENT AND DISPOSAL

A. INTRODUCTION

The radioactive wastes from the Uranium Recovery Plant are treated and disposed of so that they do not cause a hazardous pollution of the environs of the Hanford Works. Liquid wastes which contain appreciable quantities of radioactivity are concentrated and stored in large underground tanks. Liquid wastes containing only trace quantities of radioactivity are discarded into cribs from which the water percolates into the ground with the accompanying adsorption of radioactive materials by the soil. Process cooling water and steam condensate, which should not be contaminated, are routed through retention basins and monitored before being discharged to a ditch from which it seeps into the ground or is evaporated. Gaseous wastes are treated to remove particulate matter and are discharged to the atmosphere from stacks. Since these facilities were designed to handle only aged material (2-year-old or older, see Chapter I) from which the I^{131} (8-day half-life) has essentially completely decayed out, no measures are required to control the discharge of that short-lived volatile fission product. (I^{131} is present in negligible amounts even in material aged only 6 months.)

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The following table delineates the problem of liquid waste disposal. It is based on the recovery of ten tons of uranium per day by the TBP Process Chemical Flowsheet TBP-HW No. 4 and the conversion of 13-1/8 tons of uranium per day from the nitrate to the oxide.

Liquid Wastes
(Based on 10 Tons U/Day from Stored Waste)

Source of Waste	Volume, Gal./Day	Approx. Radioactivity Level, γ Curies/Day	Estimated Pu Content, G./Day	Disposal Method
Main Process:				
Neutralized concentrated RAW, ROW	32,750	6,000[a] to 65,000[b]	20	Underground Storage
Condensates	129,500	0.03[a] to 0.3[b]	10^{-4}	216-ER, 216-WR Condensate Cribs
Solvent Treatment		No normal flow		216-U Cribs
Cooling water and steam condensate	4,500,000	0 to 10^{-7}	Trace	Open Ditch via Retention Basin
Miscellaneous Drainage:				
Regulated areas		No normal flow		216-U Cribs
Non-regulated areas		No normal flow		Open Ditch
Sanitary wastes				Septic Tank and Tile Field

Notes: (a) For 7-year-old 200-Mw.-day/ton waste.

(b) For 2-year-old 400-Mw.-day/ton waste.

The radioactive wastes returned from the TBP process to the underground tanks for storage occupy 75 to 100 per cent of the volume originally occupied by the stored $BiPO_4$ process first extraction cycle uranium wastes, depending on the TBP flowsheet in use and on the freezing point to which the wastes may in practice be concentrated.

The gaseous wastes from the Uranium Recovery Plant are itemized in the following table, together with pertinent information concerning their disposal.

Gaseous Wastes

(Based on 10 Tons U/Day from Stored Waste)

Source of Waste	Approximate Peak Rate, Cu.Ft./Min., S.T.P.	Estimated Radioactivity, Total Curies Per Day[a]	Disposal Method
Equipment Vents			
1. 203-U Storage Tanks, 221-U and 224-U (C-2 Tank only) Building vessels	200	0.1	291-U Ventilation Stack
2. 221-U Building condensers	50	0.01	291-U Ventilation Stack
3. 224-U Building condensers	200	(b)	Roof jet
4. 224-U 40% HNO_3 Absorber	200	(b)	Roof jet
5. 224-U Building vacuum	7500	(b)	Roof fan[d]
6. 241-WR Diversion Vault ("hot" vessels)	0.5	0.002	291-U Ventilation Stack
7. 244-BXR, CR, TXR, UR Process Tank Vault vessels	335	0.1	291-BXR, CR, TXR, UR Ventilation Stacks[c]
Ventilation Air			
8. 221-U Building (includes items 1, 2, 6, 7)	39,400	< 0.15	291-U Ventilation Stack[e]
9. 224-U Building	57,750	(b)	9 roof fans
10. 241-WR Diversion Vault ("hot" side) (includes item 6)	3400	0.002	291-U Ventilation Stack
11. 241-WR Diversion Vault ("cold" side)	4150	10^{-6}	291-WR Ventilation Stack
12. 244-BXR, CR, TXR, UR Process Tank Vaults. (includes item 7)	3300	10^{-5}	291-BXR, CR, TXR, UR Ventilation Stacks[c]

Notes: (a) These activities are expressed as "countable" curies as defined in Chapter II. They are based on the entrainment of one pound of process solution per 10^4 pounds of gas passing through that solution, or one pound of solution

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per 10^5 pounds of gas passing through a process solution and a deentrainment column.

(b) The beta-gamma radioactivity from this source is incidental, the quantity of UO_3 dust in the effluent air being the controlling factor. A concentration of 10^{-6} pounds of UO_3 per cubic foot of air is permissible for prolonged exposure.

(c) After filtration through Fiberglas.

(d) After filtration through wool cloth and Fiberglas.

(e) After filtration through sand.

B. PROCESS LIQUID WASTES

1. High-Activity Wastes

1.1 Definition of the problem

Pertinent approximate data for the high-activity liquid wastes from the uranium recovery process are listed below.

High-Activity Liquid Wastes

Basis: 10 Tons U/Day from Stored Waste
TBP-HW No. 4 Flowsheet
2-Year-Old 200-Mw.-Day/Ton Material

	RAW	ROW[a]	Neut. Wastes	Conc. Wastes
Volume, gal./day	54,500	4700	66,200	32,750
Specific Gravity @ 25°C.	1.21	1.05	1.12	1.40
Crystallization Temp., °C. (excluding diuranates and hydroxides)	<10	<10	14	30
Approximate Activity				
Beta curies/gal.	2.0	--	1.7	3.4
Gamma curies/gal.	0.8	10^{-5}	0.6	1.2
Pu, grams/day	20	0	20	20
U, pounds/day	200	200	400	400
Components, pounds per day				
H_3PO_4	7930	--	--	--
Na_3PO_4	--	--	13,270	13,270
HNO_3	52,030	50	--	--
$NaNO_3$	100,220	--	170,760	170,760
$NaHSO_4$	9710	--	--	--
Na_2SO_4[b]	--	2040	11,940	11,940
$Fe(NH_4)_2(SO_4)_2$[b]	2210	--	--	--
$Fe(OH)_3$[b]	--	--	830	830
NH_2SO_3H[b]	1510	--	--	--
NH_4OH[b]	--	--	1100	--

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	RAW	ROW[a]	Neut. Wastes	Conc. Wastes
H_2O	377,400	38,400	485,370	249,120
NaCl	~ 40	0	~ 40	~ 40
TBP (in solution)	45	4	~100	~ 50
TBP (entrained)	< 50	< 5		
Diluent (in solution)	< 0.5	< 0.05	< 380	< 1
Diluent (entrained)	< 350	< 30		

Notes: (a) The ROW composition is not certain at the time of writing, and may alternatively contain carbonate, sulfate, or phosphate ion, or combinations of these ions.

(b) The conversion of ferrous ion to ferric ion takes place slowly prior to concentration and rapidly during concentration. The hydrolysis of sulfamate takes place slowly prior to neutralization and ceases with neutralization. For simplicity, the intermediate steps are not shown here.

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1.2 Technical and process background

The large volumes of aqueous wastes from the uranium recovery process contain considerable quantities of radioactivity as described above. Since this radioactivity must be confined indefinitely, economic considerations require that the volume of such wastes be kept to a minimum. Concentration of the waste solutions by evaporation is used to attain this end.

1.21 Solvent removal from wastes

As indicated under B1.1, above, about half of the TBP and nearly all of the diluent are steam stripped from the aqueous waste during concentration. The stripped TBP and diluent are routed to the cribs with the condensates. This removal is incidental and is not required by process or safety considerations. The diluent and TBP are distilled with virtually no chemical change, and the TBP remaining with the concentrated waste undergoes only slight hydrolysis to dibutyl phosphate, monobutyl phosphate, and sodium phosphate.(13)

1.22 Neutralization

Prior to storage in the underground tanks, the aqueous wastes are neutralized to a pH greater than 9.5 to minimize corrosion of the mild steel tank liners. The neutralization is accomplished by the addition of 50% sodium hydroxide, each volume of RAW requiring 0.124 volume of 50% NaOH for neutralization to a pH of 9.5 (see Figure XII-1). As indicated under 1.23, below, some ammonia is evolved during concentration. Hence additional 50% NaOH is added (0.002 to 0.004 volume for each volume of waste), to carry the pH to at least 11.0, thereby assuring that the

pH after concentration will be 9.5 or greater. The heat of neutralization totals about 640 B.t.u. per gallon of RAW, corresponding to a temperature rise of about 65°F.[4] This heat serves to preheat the waste solution prior to concentration.

The major components of the RAW are neutralized according to the following reactions:

(1) $HNO_3 + NaOH \longrightarrow NaNO_3 + H_2O$

(2) $NaHSO_4 + NaOH \longrightarrow Na_2SO_4 + H_2O$

(3) $H_3PO_4 + 2NaOH \longrightarrow Na_2HPO_4 + 2H_2O$

or

(4) $H_3PO_4 + 3NaOH \longrightarrow Na_3PO_4 + 3H_2O$

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In the neutralization of phosphoric acid the relative prevalence of the reactions (3) and (4) depends on the pH of the solution, the neutralization proceeding entirely by reaction (3) at a pH of 7 and 50% by reaction (4) at a pH of 9 (as indicated by the gentle breaks in the curve in Figure XII-1). Any ferrous ion reaching the neutralizer is precipitated as a white flocculent or a black crystalline material according to the reactions:

(5) $Fe(NH_4)_2(SO_4)_2 + 4NaOH \longrightarrow Fe(OH)_2 + 2Na_2SO_4 + 2NH_4OH$

(6) $3Fe(OH)_2 \longrightarrow Fe_3O_4 + H_2 + 2H_2O$

However, the ferrous ion is partially air-oxidized to ferric ion in the RA system and subsequent steps, the ferric ion being precipitated according to the reaction:

(7) $Fe(NO_3)_3 + H_3PO_4 + 3NaOH \longrightarrow FePO_4 + 3NaNO_3 + 3H_2O$

The Fe_3O_4 is slowly air oxidized to the ferric precipitate by the reaction:

(8) $4Fe_3O_4 + O_2 + 12Na_3PO_4 + 18H_2O \longrightarrow 12FePO_4 + 36NaOH$

The sulfamic acid is neutralized to sodium sulfamate by the simple reaction:

(9) $NH_2SO_3H + NaOH \longrightarrow NH_2SO_3Na + H_2O$

Prior to neutralization, some of the sulfamic acid is hydrolyzed by the reaction:

(10) $NH_2SO_3H + H_2O \longrightarrow NH_4HSO_4$

This reaction ceases as the pH is raised above 7, and the acid sulfate is neutralized by the reaction:

(11) $NH_4HSO_4 + 2NaOH \longrightarrow Na_2SO_4 + NH_4OH + H_2O$

1.23 Concentration

The waste is concentrated to minimize the volume which must be stored underground. The concentration is carried out continuously in Sections 9 and 10 of 221-U Building. As indicated under B1.1, the wastes are concentrated to about one half the original volume (in the TBP-HW No. 5 Flowsheet, the waste is concentrated to about one-third volume, the concentrated material having about the same volume as the TBP-HW No. 4 waste concentrate).

The degree of concentration attainable in plant practice is determined by the physical properties of the concentrate. These properties, in turn, are determined partially by the minimum temperature at which the concentrate is handled. Some pertinent physical properties of TBP waste concentrates are given below.(7)(9)(16)

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Characteristics of Neutralized Waste Solutions

Basis: TBP-HW No. 4 Flowsheet

Volume % of Neut. Waste(a)	Volume % of Underground Storage(b)	Boiling Point, °C.	Saturation (or Freezing) Point, °C.(c)	Density G./Ml. at Freezing Point	Volume % of Suspended Solids at 25°C.
100	171	102	15	1.2	--
77	131	104	18	1.24	--
61	104	106	26	1.34	20
55	94	108	29	1.34	23
48	82	110.5	34	1.36	25
45	75	--	36	--	28
43.5	74	112.5	39	1.40	33
43	73.5	--	60	--	50
42.5	72.5	--	80	--	73

Notes: (a) This volume includes the ROW.

(b) This value is referred to the corresponding volume of bismuth phosphate uranium waste stored underground prior to the start of uranium recovery.

(c) These values are based on an original pH of 11.8 for the neutralized waste, excluding the ROW. Tripling the concentration of the sulfate ion raises the saturation point from 36° to 38°C. at a volume equivalent to 45% of the total neutralized waste. The ROW (TBP-HW No. 4 Flowsheet) will contribute sulfate ion equivalent to about 13% of that present in the RAW.

Chemical changes occurring during concentration include the oxidation of iron (discussed under B1.22) and the evolution of ammonia. In the neutralized waste solution, ammonia is present in the following set of states at equilibrium:

$$\underset{\text{vapor}}{NH_3} \rightleftharpoons \underset{\text{dissolved}}{NH_3} \overset{H_2O}{\rightleftharpoons} NH_4OH \rightleftharpoons NH_4^+ + OH^-$$

At the low temperature encountered prior to concentration, the equilibrium is predominantly to the right, and the vapor pressure of ammonia over the waste solution is low. During concentration, however, almost all of the dissolved NH_3 is vaporized. The resulting shift of the equilibrium to the left strips the ammonia almost completely from the boiling solution. The ammonia vapor, with the water vapor, passes through the deentrainment column to the condenser, where part of it condenses with the condensate. The quantity of ammonia escaping to the vent system depends mainly upon the temperature of the condensate and the volume of air (from bubbler lines and leakage) leaving the condenser. In a reasonably tight equipment installation, nearly all of the ammonia leaves the system in the condensate.

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1.24 Disposal

The concentrated wastes are cooled to about 180°F. to prolong the life of subsequent pumps and agitators. Additional cooling of the concentrated wastes is not desirable since it increases pumping problems (slurry formation at temperatures below the saturation point) or storage costs (decreased solubility necessitating less concentration or subsequent dilution to larger volumes). The cooled concentrate is pumped via the Concentrated Waste Receiver to the Waste Pump Tank, 241-WR-001. The waste is then routed to underground storage tanks through the grid of buried pipe lines.

The slurry obtained by cooling a concentrated waste below its saturation temperature tends to plug a pipe transporting that slurry in viscous flow. In turbulent flow, however, the slurry does not settle so readily, and it may be found feasible to return the waste concentrate to the underground tank farm as a slurry.

In the volume range of 75% to 100% of the original uranium waste volume, a slurry of 20 to 30 per cent solids is obtained at 80°F. This same system has very little solids at 100°F. (See table under B1.23, above.) The provision of facilities for keeping the waste concentrate above 100°F. during transit thus decreases either the solids content of the slurry being transferred, or the volume required to deliver that waste as a solution. The intererea pipe encasement is supplied with additional heat to compensate for losses to the ground by routing hot condensate to the 200 East Area Crib, 216-ER, the condensate being subcooled as little as operationally feasible. Calculations indicate that waste can be delivered to the 200 East Area at temperatures above 110°F.(4)

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1.25 Conditions in underground tanks

Since radioactivity is being returned to the ground in essentially the same volume with which it was associated prior to uranium recovery, it is anticipated that the time-temperature curves for the tank contents will be essentially unchanged by the removal of the uranium. (See Chapter II for further information.) As in the past, the concentration of fission products is expected to be the highest in the first tank of a cascade, the scavenging action of the uranium precipitate being replaced by the scavenging action of the ferric hydroxide in the waste.

1.26 Nitric acid recovery from RAW

A method of decreasing the volume of wastes to be stored by the recovery of nitric acid from the RAW appeared attractive during TBP process development days, and plans were originally made to recover nitric acid. This process[5] consists briefly of the following steps:

(a) Concentration of the RAW to about 20 per cent of its original volume, with the vaporization of essentially all of the nitric acid present.

(b) Dilution of the concentrate from step (a) to permit neutralization and storage by normal methods.

(c) Fractionation of the vapors from step (a) to yield 60% nitric acid for re-use and water condensate (pH > 2) for cribbing.

However, the presence of chloride ion, introduced with the commercial grade caustic soda used in neutralizing the $BiPO_4$ process uranium waste, would have resulted in excessive corrosion in the concentrator and HNO_3 fractionating tower, particularly for stainless steel equipment exposed to the vapor phase.[12] A review of the problem revealed no demonstrated, feasible method of removing the chloride ion.[8][11] Materials of construction capable of withstanding the corrosiveness of the process materials (i.e., tantalum or ceramics) were expensive or difficult to fabricate. Consequently, the HNO_3 recovery process was abandoned. In the event that long-term operation of the TBP Plant in conjunction with the $BiPO_4$ process proves desirable, the installation of this acid recovery process may prove justified.

1.3 Underground storage facilities

The storage facilities currently containing uranium waste solutions will be used to contain the high-activity wastes from the uranium recovery process. For a description of these facilities reference is made to Chapter XIII.

2. Low-Activity Wastes

2.1 Definition of the problem

The following table lists pertinent information concerning the low

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activity wastes anticipated from the operation of the uranium recovery and calcination operations.

Low-Activity Liquid Wastes

(Based on 10 Tons U/Day from Stored Waste and 3-1/8 Tons U/Day from Redox; TBP-HW No. 4 Flowsheet)

Sources	Approx. Volume, Gal./Day	Estimated Radioactivity Level, Curies/Gal.	Estimated Pu Content, μG./Gal.	Inert Chemicals Per Day	Disposal Method
Condensates from conc. of:					
Feed	26,000	2×10^{-6}	2×10^{-3}	< 150 lb. HNO_3	
Waste	28,400	2×10^{-6}	2×10^{-3}	550-1100 lb. NH_4OH	
Product UNH	75,000	10^{-9}	10^{-5}	< 400 lb. HNO_3	
Total	129,400				216-ER, WR Condensate Cribs
Solvent washes		No normal flow			216-U Cribs
Bldg. drainage					
221-U Bldg.		No normal flow			216-U Cribs
224-U Bldg.		No normal flow			216-U Cribs
291-U Ventilation Stack		No normal flow			216-U Cribs
241-WR Diversion Vault		No normal flow			Process vessels

2.2 Technical background

For a discussion of the technical background involved in the cribbing of low-activity waste, the reader is referred to the Redox Technical Manual, (10) Chapter X, Section 2.2.

2.21 Deentrainment

The concentrator units are designed to deliver condensate containing no more than one pound of concentrate per million pounds of condensate, provided the operating rates of the units do not exceed those listed below.(2)(3)(15) As the operating rate exceeds these design values by a factor to be determined in operation, the entrainment may be expected to increase as the gas velocities in the tower approach their loading rates.

The operating rates under which a deentrainment factor of 10^6 is anticipated in the various units are based on a superficial gas velocity

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of 1.5 feet per second in the deentrainment tower. This corresponds to the capacities noted below.

Operating Capacity for
Designed Deentrainment of 10^6

Concentrator	Deentrainment Medium	Condensate, Lb./Hr.	Uranium Ton/Day THP-HW No. 4 Flowsheet
Feed	Bubble-cap column	9350	10.3
Waste	York wire mesh	9350	9.0
UN	Bubble-cap column	10,600	---

The Uranium Product Concentrators are normally operated at rates 50% higher than those noted above, and a deentrainment factor of about 10^5 is anticipated for these units.(1) This lower deentrainment is acceptable since adequate decontamination with respect to fission products and plutonium has been established prior to this concentration, and the uranium tolerance in the condensate will probably be set at 0.01 to 1.0 g./l. (corresponding to a deentrainment factor of 10^3 to 10^5).

2.22 pH control of condensates

The condensates from the Feed Concentrators (see Chapter III) and the UN concentration (see Chapter VII) contain some acid: 0.01 M or less. The condensate from the waste concentrator will contain up to 1/8 M ammonium hydroxide (see B1.23 above). While the combined condensates leaving the 241-WR Vault will normally be sufficiently alkaline (pH greater than 5) to prevent soil leaching and consequent undesirable channeling of the cribbed liquid, condensates made during periods of inactivity of the Waste Concentrators will be too acid for safe cribbing.

The leaching of soils by acidic condensates is prevented by routinely passing the condensate through a bed of limestone prior to cribbing. Alkaline condensate passes through the $CaCO_3$ unchanged (except for a very slight dissolution of $CaCO_3$), while acidic condensate reacts with the limestone according to the reaction:

$$4HNO_3 + 3CaCO_3 \longrightarrow 2Ca(NO_3)_2 + Ca(HCO_3)_2 + H_2O + CO_2$$

The solubility or gaseous nature of all the reaction products keeps the surface of the undissolved limestone clean for continuing reaction(14). The calcium salts add no new ions to the soil, simultaneously protecting the soil from acid leaching and from the plugging action of any insoluble compounds possibly derived from reaction of ions in the condensate with the soil.

2.23 Miscellaneous wastes

As noted in Chapter XI, the pretreatment and retreatment procedures

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for the solvent in the 276-U Building facilities are subject to firming-up in actual plant operation. Since wastes from the solvent treatment, if any, may contain ions which tend to reduce the permeability of the soil, crib facilities (216-U) are provided for these wastes separate from the cribs dispersing the process condensates.

2.3 Disposal facilities

Low-activity wastes are disposed of at one of three crib locations, as follows (see Chapter XIII for plot plan):

216-ER is located about 1000 ft. northwest of 221-B Building

216-WR is located about 1000 ft. south of 224-U Building

216-U is located about 800 ft. west of 224-U Building

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The 216-ER and 216-WR Condensate Cribs are each composed of two standard Hanford cribs(10) in series. A 9-ft. by 9-ft. tank (270 Building) serves as a reaction chamber for the limestone neutralization of condensate, the water flowing from a pierced-pipe distributor upward through the limestone and overflowing the vessel to the crib. Building 270-W is located about 1000 ft. north of the 216-WR Crib, and Building 270-E is located about 300 ft. south of the 216-ER Crib. It is anticipated that no solids will be routed to these cribs, so that their capacity should remain essentially constant throughout the period of Uranium Recovery Plant operation. The 216-U Crib facility is composed of a concrete 20-ft. by 20-ft. tank, 241-U-361, and two standard Hanford Cribs(10) in series. The concrete tank serves as a settling point for any solids in the cribbed effluent.

3. Negligible-Activity Wastes

3.1 Definition of the problem

The operation of the uranium recovery units creates large volumes of liquid wastes which are not radioactive. These wastes are discharged to an open ditch at essentially background radioactivity. An approximate tolerance limit for the open discharge of these fluids is:

Plutonium	1×10^{-4} microgram/liter
Beta emitters	0.5 microcurie/liter

The anticipated volumes of these wastes are as follows:

Source	Volume, Gal./Day
Cooling Water and Condensates:	
221-U and 224-U Buildings	4,500,000
244 Process Tank Vaults, each	36,000

[redacted]

3.2 Description of the disposal facilities

The cooling water and steam condensate are collected in vitreous clay sewers and delivered to the Retention Basin. The Retention Basin is constructed in two sections, each having a capacity of 500,000 gallons. (See Chapter XIII for location (about 1600 feet west of 221-U Building) and further details.) The effluent from the Retention Basin enters a ditch about 8 feet wide and 800 feet long, from which it percolates into the soil and/or evaporates.

The cooling water from the 244-TXR Process Tank Vault facilities flows directly to the above-mentioned vitreous clay sewer, the TXR sewer flowing under pressure to the vitreous clay sewer at the 231 Building. Cooling water from the other 244 Process Tank Vaults is discharged directly to local ditches.

Chemical wastes and floor drainage from non-regulated areas of the U Area facilities flow directly to the 800-foot ditch and percolate into the ground.

Sanitary wastes from U Area flow to a septic tank and tile field about 600 feet west of the 221-U Building.

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C. GASEOUS WASTES

1. Definition of the Problem

While no volatile radioactive materials are encountered in the metal recovery processes, activity does become air-borne through entrainment. The confinement of this air-borne activity is based upon the maintenance of air movement from less contaminated to more contaminated areas, and the adequate filtration of this air prior to discharge to the atmosphere. The gaseous wastes involved are tabulated in Section A.

2. Disposal Facilities

The filtration of the process gases is accomplished with three different type media: sand, Fiberglas, and wool felt. In each case, filtration depends on particulate settling, Brownian movement, and impingement of the particles on the filtering medium as the gas follows a tortuous path through the unit. The gas disposal facilities are described separately below.

2.1 291-U Ventilation Stack system

The 291-U Ventilation Stack system handles all the gaseous wastes from the 221-U Building, 203-U Storage Tanks, vessel C-2 in the 224-U Building, and the "hot" side of the 241-WR Diversion Vault.

2.11 Gas flows

Reference is made to Chapter XIII for an overall ventilation outline. The process vents from the 203-U Storage Tanks and vessel C-2 in the 224-U

Building are connected to the main ventilation air duct in the 221-U Building by a 24-in. line. This air duct exhausts nearly 36,000 cu.ft./min. of air from the 221-U Building canyon at about one inch of water negative pressure. This flow, together with about 3700 cu.ft./min. from other sources noted below, passes through a sand filter and is discharged to the atmosphere through the 200-foot Stack, 291-U. The prime mover for this stream consists of two electrically powered fans, manufactured by Buffalo Forge and rated at 20,000 cu.ft./min. each at seven inches of water pressure differential. A third fan (for emergency use) is identical with the others but is driven at a higher speed by a steam turbine; it is rated at 40,000 cu.ft./min. at seven inches of water pressure differential, and starts automatically if the others fail. Reference is made to the Redox Technical Manual(10) for further details, since these fans are identical with those provided at the 291-S Ventilation Stack Building in the Redox Plant.

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The vessels in the 221-U Building are vented to a six-inch header which discharges into the 221-U Building ventilation duct at a blower pit between the 221-U Building and the 291-U Ventilation Stack. The prime mover is an Aladdin fan, rated at 200 cu.ft./min. at 12 inches of water pressure differential.

The condensers in the 221-U Building are vented to a four-inch header which discharges into the 221-U Building ventilation air duct at the blower pit between the 221-U Building and the 291-U Ventilation Stack. The prime mover is a Spencer Turbine blower, rated at 50 cu.ft./min. at fifty inches of water pressure differential.

The "hot" vessels in the 241-WR Diversion Vault are vented to the cell through two-inch return bend vents. The general 241-WR Diversion Vault "hot" cell area is vented directly to the 221-U Building ventilation duct through a vent line with no fan or filter.

2.12 Sand filter

The sand filter at the 291-U Ventilation Stack is a replica of the Redox sand filter, being altered only as required to fit the U Area topography. Reference is made to the Redox Technical Manual(10) for further details.

2.2 224-U Building systems

Except for the gases containing uranium oxide dusts, all waste gases from the 224-U Building are innocuous and are discharged directly to the atmosphere.

2.21 Gas flows

The 224-U Building is ventilated by about 57,750 cu.ft./min. of air, which is discharged directly to the atmosphere by nine roof fans. (See Chapter XIII.) The majority of this air is required for the removal of excess heat from the Calcination Pots and auxiliaries.

Process gases are ejected to the atmosphere by roof jets. These gases are drawn from the Nitrogen Oxide Absorber, T-A-1 (B.P.F. 2844), and the two Nitric Acid Fractionator Condensers, E-B-3 and E-D-3. Approximately 200 cu.ft./min. of air is discharged from the jet on T-A-1, the gas being cleansed by its passage through the bubble-cap column and a token filtration through 12 inches of Type 304 stainless steel York mesh. Air from the HNO_3 fractionating column jets is discharged directly to the atmosphere.

The uranium oxide dusts created in the conversion facilities are confined by a sweep of air into the handling equipment and filtered from the air by wool bag filters. The air flow in this system totals 7500 cu.ft./min., the flow being maintained by an Aladdin blower, X-13, rated at 7700 cu.ft./min. air at 8 inches of water pressure differential.

2.22 Bag filter and nominal Fiberglas filters

The 7500 cu.ft./min. of dust-laden air is filtered through one of four parallel wool bag filters (X-11). These "Mikro" bag filters are manufactured by the Pulverizing Machinery Company and are rated to remove particles above one micron diameter. A traveling blower ring is provided for cleaning the filter by locally reversing the direction of air flow through the wool cloth.

Backing up the bag filter is a Fiberglas filter, X-12. This unit is designed to act as a stop-gap measure in case one of the bag filters ruptures in service; the dust tolerance in the exhaust air will probably be exceeded during the time required to divert the gas flow to the other bag filter, but most of the dust will be contained. This unit is composed of multiple, replaceable, glass wool filter frames, 4 inches thick and having a combined face area of 4000 sq.in. The filter frames were supplied by American Air Filter Company.

2.3 291-WR Ventilation Stack system

The 291-WR Ventilation Stack facilities ventilate the "cold" side of the 241-WR Diversion Vault.

The vessels in the "cold" side of the 241-WR Diversion Vault are vented to the cell through two-inch return bends. Ventilation air is exhausted from the cells by a Western blower, rated at 4560 cu.ft./min. at two inches of water pressure differential. This air is ejected to the atmosphere without filtration through a 50-foot stack, 291-WR, located about 25 feet north of the 241-WR Diversion Vault.

2.4 Waste removal facilities, 244-BXR, CR, TXR, UR Process Tank Vaults

The stored waste removal facilities (the 244 units and the tanks being operated) are vented to the atmosphere through local vent systems (291-BXR, CR, TXR, UR Ventilation Stacks).

2.41 Gas flows

The vessels in each 244 Process Tank Vault facility are vented through a Fiberglas filter to the ventilation air for that facility. The combined

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air streams, totaling about 3300 cu.ft./min., are filtered by a second Fiberglas filter and ejected to the atmosphere through a 50-foot stack (291) by a spared Buffalo Forge fan, rated at 4200 cu.ft./min. at twelve inches of water pressure differential.

The underground storage tanks to be emptied are vented individually through Fiberglas filters. Portable vent units, composed of a Buffalo Forge fan (rated at 110 cu.ft./min. at 2-1/2 inches of water) and a 28-foot stack, are provided and will be connected with the tanks as needed.

2.42 Fiberglas filters

The filters provided for the 244 Process Tank Vault facilities are of concrete cubicle construction, packed with graded layers of Fiberglas. Pertinent details of this packing are given below.

Layer	Fiberglas Type*	Nominal Fiber Diam., In.	Depth, Inches	Density, Lb./Cu.Ft.
Cleanup	AA	0.00003 to 0.00005	1	1.2
3rd	55	0.00055	12	3.0
2nd	115K	0.00115	12	3.0
1st	115K	0.00115	18	1.5

*) Manufactured by Owens-Corning Corporation

The vessel vent filter has a face area of 36 sq.ft. and is designed to filter 335 cu.ft./min. of air at a pressure drop of about 1-1/2 inches of water. The ventilation air filter has a face area of 160 sq.ft. and is designed to filter 3300 cu.ft./min. at a pressure drop of about 5 inches water.

The canister-type filter provided for each underground storage tank to be emptied is contained in a carbon steel box. Pertinent details of the graded layers of Fiberglas used are given below.

Layer	Fiberglas Type*	Nominal Fiber Diam., In.	Depth, Inches	Density, Lb./Cu.Ft.
Cleanup	AA	0.00003 to 0.00005	1	1.2
3rd	115K	0.00115	20	6.0
2nd	115K	0.00115	12	3.0
1st	115K	0.00115	12	1.5

*) Manufactured by Owens-Corning Corporation

Each unit has a face area of 16-1/2 sq.ft. and is designed to filter 165 cu.ft./min. of air at a pressure drop of 2 inches of water.

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D. PROCEDURES

1. Normal Procedure

Reference is made to the engineer's flow sketch in Chapter VI. The design of the Uranium Recovery Plant is based on the continuous flow of materials wherever possible. Batchwise transfer of wastes is resorted to only as required for accountability reasons and to permit ascertainment that the radioactivity of a particular waste is within the safe limits for the disposal method contemplated.

1.1 High-activity wastes

The high activity wastes are routed according to the following flow pattern:

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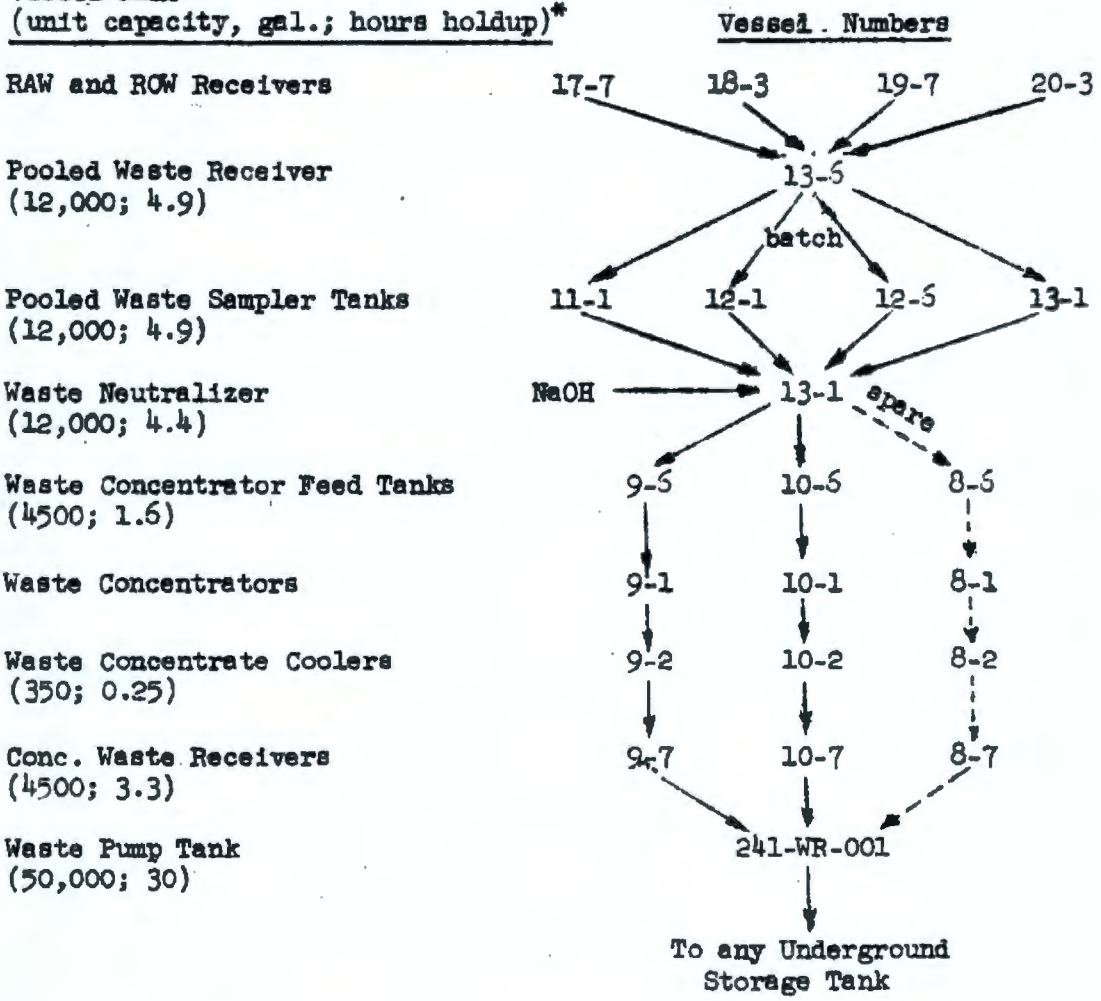

*) The holdup for each tank is based on process flows corresponding to 10 tons uranium/day.

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All of the above transfers are accomplished at automatically controlled rates except the transfer of pooled waste to the Sampler Tanks and the transfer of concentrated waste to the Tank Farms. The RAW and ROW Tank levels are maintained at constant weight-factor values, the rates of pumping to the Pooled Waste Tank being determined by the volume rates of column operation. The Samplers are filled batchwise from the Pooled Waste Tank at a rate of about 75 gal./min. All of the waste transfer rates between the Sampler Tanks (only one is pumping to the flow series at a time) and the Pump Tank, 241-WR-001, are controlled by the setting of the flow recorder-controller which controls the flow of waste to the Concentrator. The rate of flow into each vessel prior to the Waste Concentrator is controlled by its weight-factor instrument, and the rate of flow out of each vessel after this point is controlled by its weight-factor instrument.

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Sampling is accomplished batchwise on about 12,000-gallon increments of pooled waste, the batches being handled as outlined above. Each Sampler Tank is on about a 19.6-hour cycle, as follows: filling, 2.7 hr.; sampling, analyzing, and free time, 12.0 hr.; emptying, 4.9 hr. In the event that off-standard pooled waste is obtained, or column performance is suspected to be faulty, the waste streams may be sampled individually in their respective receivers.

Waste neutralization is accomplished by turning on the pump transferring the contents of a Sampler Tank to the Neutralizer. The rate of 50 per cent caustic soda addition to the Neutralizer is automatically controlled at a rate proportional to the rate of waste flow into the Neutralizer. The proportionality factor is set by the operator on the basis of laboratory titrations on samples from the Sampler Tank. As a further aid in the operation of the Neutralizer the pH of the Neutralizer contents is measured by a continuous pH indicator mounted on the panel board. However, the life expectancy of this continuous pH meter is doubtful, and may be as short as a few days.

The control of the concentration step is tentatively based on the flow control of both the feed stream and the steam to the Concentrator. The degree of concentration effected may be determined by the ratio of the flow rates of the condensate and concentrate (a volume balance may be computed), or by reading the boiling temperature or specific gravity of the concentrate. It is possible to control the steam flow by the boiling point or by the specific gravity, if such operational control proves desirable.

1.2 Low-activity wastes

The process condensates, which comprise most of the low-activity wastes, flow continuously via a gravity header from the condenser systems in 221-U and 224-U Buildings to each of the Condensate Tanks (241-WR-007, 008, and 009) in turn. The temperature of these condensates is controlled at about 175°F. by controlling the water flow to the condensers. Some heat from these condensates will be used to heat the interarea pipe trench. (See B1.24, above.)

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Sampling of the 221-U Building condensates is performed continuously in the sampler enclosure at the rear of Section 5. The 224-U Building condensates are monitored for pH only. In the event one of these samples indicates insufficient deentrainment, the offending concentrator unit (or units) may be identified by taking a line sample of each condensate. Samples of the 221-U Building condensates may be taken at the sampler enclosure at the rear of Section 5, while the 224-U Building condensates may be sampled at Cooler E-C-7. The Sampler Tanks, 241-WR-007, 008, and 009, are operated on about a 24-hour cycle: filling, 8 hr.; sampling and analyzing, 8 hr.; pumping and free time, 8 hr. The condensate may be pumped to the 216-ER Condensate Crib at about 30 gal./min., or to the 216-WR Condensate Crib at about 100 gal./min., or simultaneously to both cribs at somewhat reduced rates. The volume sent to each crib is metered and is controlled by valve settings in the 241-WR Diversion Vault.

Floor drainage is collected in Tank 5-6 in the 221-U Building and Tank C-2 in the 224-U Building. If analysis indicates cribbing is a satisfactory disposal method, the waste is jetted to Crib 216-U through Settling Tank 216-U-361. If the waste is too radioactive for cribbing, 221-U Building material may be routed to Waste Utility Holdup Tank 5-5 (12,000 gallons) for concentration as a high-activity waste; 224-U Building material may be routed either to the Product Concentrator Feed Storage Tanks, X-1 or X-2, or the Feed Utility Holdup Tank 4-1 (12,000 gallons) for reprocessing.

Any aqueous wastes from the organic recovery operations in the 276-U Building are routed to Crib 216-U through Settling Tank 241-U-361. Any organic wastes from the 276-U Building are barreled for ultimate disposal by burial or burning.

Any drainage from the main Stack, 291-U, flows by gravity to the Waste Pump Tank, 241-WR-001, where it is blended with the wastes being pumped to underground storage. Since the volume of this waste is anticipated to be negligibly small, the disposal method was chosen on the basis of simplest construction.

1.3 Negligible-activity wastes

The chemical wastes from the non-regulated ("cold") zones of the 221-U and 224-U Buildings are routed to the open ditch without check.

Cooling water and steam condensate are routed through the Retention Basin to the ditch on a continuous basis. The two sections of the basin are operated in series, the first section holding up a minimum amount necessary to operate the monitoring devices, and the second section allowing a straight-through flow with nominally zero holdup.

2. Remedy of Off-Standard Conditions

2.1 Excessive amounts of uranium in the pooled waste

Pooled waste (combined RAW and ROW) found high in uranium content may be routed to Feed Utility Holdup Tank 4-1 (12,000 gallons). From

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this point, it may be transferred to the Spare Concentrator, concentrated, and returned to the Feed Receiver, TK-3-6, for a second pass through the extraction battery; or it may be returned to either Feed Receiver, 3-1 or 3-6, directly; or it may be routed to the Waste Utility Holdup Tank, 4-6, for batch neutralization and later concentration as a high-activity waste.

2.2 Excessive radioactivity of wastes normally cribbed

If the condensate in the 241-WR Diversion Vault tanks is found to be too radioactive to be cribbed, individual stream samples are taken to identify the offending equipment. It may be possible to correct the excessive entrainment by reducing the rate of boil-up in the offending unit. If this corrective measure fails, the trouble probably lies in a defective column (either deentrainment or fractionating), and equipment maintenance is indicate. The off-specification condensate on hand may be returned to the concentrators via the Waste Utility Holdup Tank, 4-6, for redistillation.

2.3 Excessive radioactivity of Retention Basin contents

This condition may be detected by the continuous monitoring device in the first section of the Retention Basin. When detected, the gates may be closed, impounding the water, and a search started for the isolation of the offending equipment piece. If the radioactivity of the impounded water is found to be too high for disposal by ditch, portable equipment must be provided to discharge the water to a crib. Operation of the recovery facilities would, of necessity, be suspended within a few hours until the situation could be rectified, but the probability of this occurrence is judged to be so low that more elaborate provisions are considered unwarranted.

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(2) BNL-I-10 Status Report on Brookhaven Nuclear Reactor No. 1. L. B. Borst. 10-1-47.

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(8) HW-18405 Chloride in the Waste Metal Recovery Process. R. F. Maness, et al. 7-24-50.

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(12) HW-19165 Corrosion of Construction Materials in TBP (HW No. 3 Flowsheet) Process Streams. W. W. Koenig and K. L. Sanborn.

(13) HW-19739 H.W. Chemical Research Section Monthly Report, November, 1950. O. F. Hill and F. J. Leitz.

(14) HW-19852 Neutralization of Acidic Distillates with Limestone. H. L. Brandt, et al. 12-27-50.

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Figure XII - 1

NEUTRALIZATION OF RAW WITH 50% NaOH

TBP-HW No. 4 FLOWSHEET

SOURCE OF DATA: HW-21273

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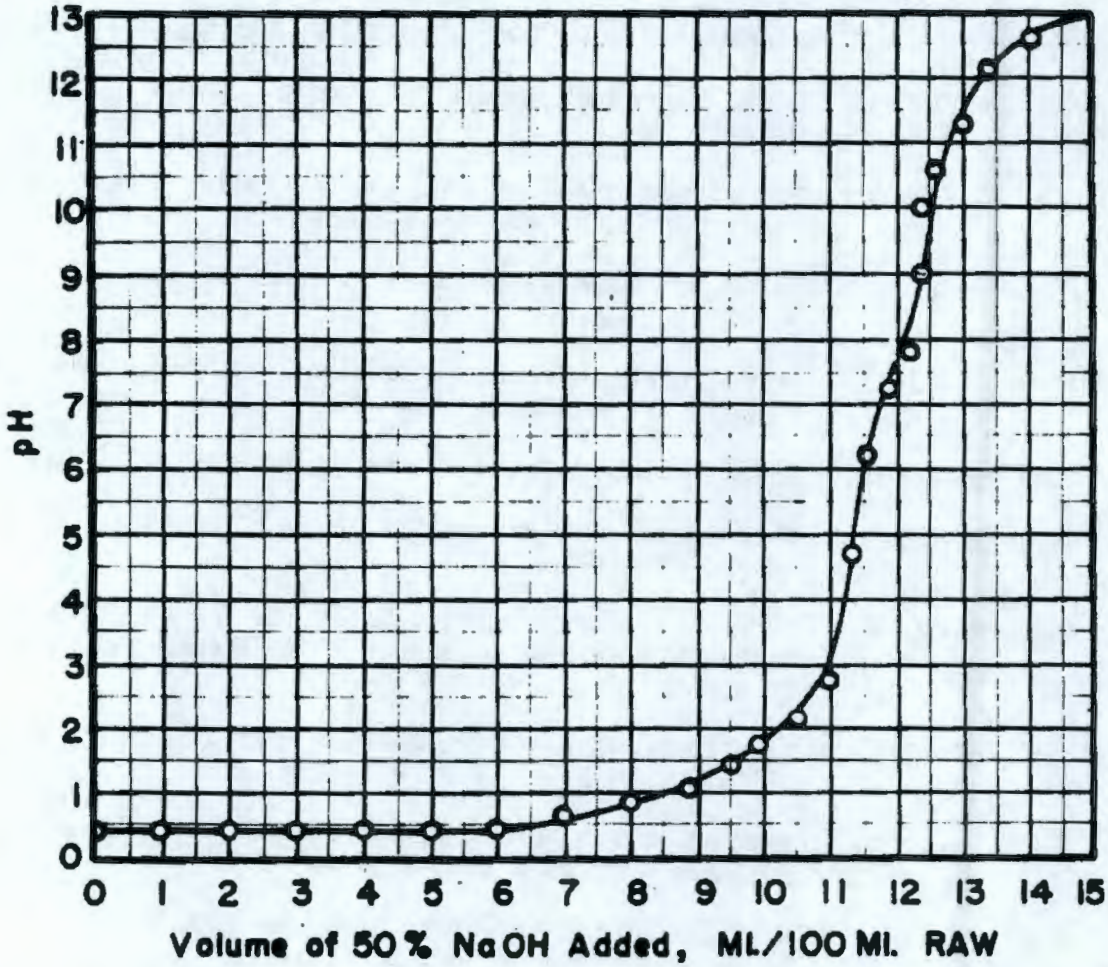

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PART III: PLANT AND EQUIPMENT

CHAPTER XIII. GENERAL DESCRIPTION OF PLANT

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CHAPTER XIII. GENERAL DESCRIPTION OF PLANT

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A. GENERAL LAYOUT OF PLANT

1. Layout of Hanford Works Production Areas

The production areas of Hanford Works, shown in Figure XIII-1, were originally set up as independent, self-contained, parallel units located in widely separated districts. The wide separation of the individual units was intended to prevent any accidents in one unit causing the spread of radioactive contamination to others. The entire plant would not have to be shut down if any single unit were damaged, since other identical units could be operated. While for some recent additions to the plant no identical parallel facilities have been provided, continued operation of the plant despite damage to any one unit is still feasible, because of the availability of other facilities with the same function. Thus, the Bismuth Phosphate and Uranium Recovery (TBP) Plants together parallel the function of the Redox Plant (recovery of plutonium and uranium).

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Production units of the plant are located in three operating areas known as the 100, 200, and 300 Areas.

The piles for the production of plutonium are located in the 100 Areas. There are four of these areas, designated 100-B, 100-D, 100-F, and 100-H. One pile is located in each area with the exception of the 100-D Area which contains both the "D" and "DR" Piles. At this writing an additional pile, to be called "C" Pile, is under construction in the 100 Areas. The product of the 100 Areas is the raw material for the 200 Areas.

The 300 Area is located 5 miles north of Richland. The uranium metal charged to the 100 Area piles is prepared in the 300 Area.

2. 200 Areas

The 200 Areas are located approximately 6 to 10 miles from the 100 Areas, and comprise the 200 North, 200 East, and 200 West Areas.

The 200 North Area contains facilities for the underwater storage of uranium after its discharge from the piles. In storage, irradiated slugs undergo "cooling" (decay of radioactive fission products) prior to processing in the separation plants. Three separate Metal Storage Basins, 212-N, P, and R, are provided in the 200 North Area.

The 200 East and West Areas are approximately 2 to 3 miles from the 200 North Area, and are about 4 miles from each other (see Figure XIII-1). Each of these areas is provided with power and service facilities.

Facilities for the separation and concentration of plutonium by the $BiPO_4$ precipitation process are located in both 200 East (Buildings 221-B and 224-B) and 200 West Areas (Buildings 221-T and 224-T). Also located

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in the 200 East and West Areas are the uranium waste removal facilities which produce homogeneous feed solution for the TBP Plant from the stored uranium waste solutions of the 200 Area B and T Plants. The TBP Plant, in which a solvent-extraction process is used to separate uranium from radioactive fission products and the UO_3 Plant, in which the concentrated UNH solution from the TBP and Redox Plants is calcined to produce UO_3, are located in the 221-U and 224-U Buildings of the 200 West Area. The U Plant was originally built to provide additional $BiPO_4$ processing capacity, but it was never used, and has been converted to house the TBP and UO_3 Plants. In addition, the 200 West Area contains facilities for plutonium isolation (Building 231-U), metal fabrication (Building 234-5), stack gas studies (Building 292-U), and health instrument experimental work (Building 222-U).

Directly south of, and adjacent to the 200 West Area, is the 200 South Area in which the Redox Plant (a new separations plant employing a solvent-extraction process for the separation of uranium and plutonium from each other and decontamination of both from radioactive fission products) and the 222-S Laboratory Building are located. The 222-S Laboratory Building houses the equipment necessary for analytical support of both the Uranium Recovery and Redox Plants.

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3. Uranium Recovery Plant

The uranium recovery facilities used to prepare UO_3 product from the underground stored uranium have been subdivided into four general groups in the following discussion:

(a) The uranium waste storage and removal facilities located at the seven Bismuth Phosphate Plant uranium underground stored waste farms in the 200 East and 200 West Areas. Also included in this section are the various facilities (diversion boxes, storage vaults, inter-area piping) used for routing of the uranium solutions into the 221-U Building.

(b) The uranium recovery (TBP Plant) facilities located in and around the 221-U Building.

(c) The UNH solution concentration and calcination facilities (UO_3 Plant) located in and around the 224-U Building.

(d) The waste disposal facilities for the various radioactivity level solutions and gases produced during the uranium recovery process. These facilities are briefly mentioned in this chapter. For a more complete treatment see Chapter XII.

A list of the buildings in each of the above groups is given in 3.1 to 3.4 below, together with its location and a brief description of its function. More detailed descriptions of the removal, recovery, and calcination facilities may be found in sections B, C, and D of this chapter, respectively. For a detailed functional description of the waste disposal facilities the reader is referred to Chapter XII.

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3.1 Uranium removal facilities

3.101 Tank Farms (241-B, BX, BY, C, T, TX, and U)

At each of the seven tank farms containing underground stored wastes (241-B, BX, BY, and C in the 200 East Area; and 241-T, TX, and U in the 200 West Area) facilities have been installed for removing the wastes from the storage tanks. Above each tank containing stored waste, Sluice Pits, Pump Pits, Heel Pits, Instrument and Electrical Enclosures, and Vent Hatchways have been constructed. When the uranium wastes have been removed from the tanks they may be refilled with TBP Plant "hot" wastes. The location of the various tank farms are shown on the 200 East and 200 West Area plot plans (Figures XIII-2 and XIII-3).

3.102 Process Tank Vaults (244-BXR, CR, TXR, and UR)

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The four Process Tank Vaults are located at the BX, C, TX and U Tank Farms. They contain the equipment necessary for pumping a high-pressure stream through the sluicing nozzles in the storage tanks. Facilities are also included in the vaults for slurry dissolution and pumping of the dissolved solution to the 241-WR Vault outside the 221-U Building.

3.103 Cascade Diversion Boxes

In the many Cascade Diversion Boxes the individual tanks of a 3, 4, or 6-tank cascade may be connected with other tanks within the same cascade or to the appropriate Master Diversion Box. By proper alignment of jumpers within the Cascade Diversion Box supernate homogenization of the cascade may be accomplished, and individual tanks may be selected for sluicing operations.

3.104 Master Diversion Boxes (241-UR-151, 241-TXR-151, 241-BXR-151, and 241-CR-151)

Each of the four Master Diversion Boxes are connected to two or three Cascade Diversion Boxes and to a Process Tank Vault. By proper installation of jumpers the various cascades serviced by a Process Tank Vault may be selected for sluicing operations. From the Master Diversion Boxes supernate may also be routed to the temporary homogenized-supernate storage tanks (241-TX-115 in the West Area, and 241-BX-109 in the East Area).

3.105 Control Houses (271-BXR, CR, TXR, and UR)

The Control House is the nerve center of the removal area. It shelters the instruments and motor controllers for operating the removal equipment. Also included in the Control House are an instrument air compressor and space for locker, toilet, lunchroom, air conditioning, and SWP facilities.

3.106 Diversion Station 241-WR

In the 241-WR Diversion Station at the northeast end of the 221-U

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Building uranium solution pumped from the Process Tank Vaults may be stored before entering the 221-U Building. Also, in 241-WR, recovered HNO_3 is stored until it is needed for dissolution at the tank farms and cribbable wastes are held-up until it has been determined that they meet cribbing tolerances. TBP Plant "hot" wastes are held temporarily in the vault until they are sent to underground storage.

3.107 Interarea Pipe Encasement

A six-line buried pipe encasement connects Diversion Box 241-UX-154 (just outside the 221-U Building) with Diversion Box 241-ER-151 (about 600 ft. southwest of 224-B Building). Through these lines uranium solution is pumped from the 200 East Area to the 241-WR Vault (through 241-UX-154) and cribbable waste, recovered nitric acid, and TBP Plant waste are pumped from the 241-WR Diversion Station (via 241-UX-154) to the 200 East Area.

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3.108 Vent Station (241-EW-151)

The Vent Station (241-EW-151) is located at the high point in the six-line East-West encasement roughly one mile from the eastern terminal (241-ER-151). The encasement lines must be vented and drained to the tanks at either end of the encasement before jumper connections involving the tanks may be made.

3.109 Diversion Box 241-ER-151

Diversion Box 241-ER-151 is the eastern terminal of the Interarea Pipe Encasement located approximately 600 ft. southwest of the 224-B Building. From this diversion box a five-line encasement connects with the 241-BXR Process Vault, a three-line encasement connects with the 241-CR Process Vault, and a single line connects with Cribs 216-ER-1, 2, and 3.

3.110 Diversion Box 241-UX-154

Diversion Box 241-UX-154 is the western terminal of the Interarea Pipe Encasement and is located approximately between the 221-U and 291-U Buildings. In addition to connecting the 241-WR Vault with the East Area facilities the box is used to connect the 241-WR Vault with the west area tank farm facilities through Diversion Box 241-TX-155. Condensate may be routed from Diversion Box 241-UX-154 directly to Waste Cribs 216-WR-1, 2, and 3, and 216-U-1 and 2.

3.111 Diversion Box 241-TX-155

Diversion Box 241-TX-155, located approximately 800 feet east of the 244-TXR Process Vault, connects the 241-WR Vault (through Diversion Box 241-UX-154) with the various West Area tank farms. Also routed through this box are "hot" $BiPO_4$ process wastes from the T Plant.

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3.2 TBP Plant

3.21 Processing Building 221-U

This building contains all the equipment for: (a) the preparation of a suitable solvent-extraction aqueous feed solution from the homogeneous solution prepared at the tank farms; (b) the separation and decontamination of uranium; and (c) the neutralization and concentration of "hot" waste solutions before routing them to underground storage.

3.22 Building 271-U

Building 271-U, adjacent to the operating-gallery side of the 221-U Building, contains the equipment required for the make-up of the various aqueous solutions used in the 221-U Building. Some dry chemicals used in making up the solutions are stored in the 271-U Building. Also housed within this building are the office, locker room, lunch room, water demineralizing, shop, small-scale laboratory, and air compressor facilities.

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3.23 Organic Treatment and Storage Building 276-U

In the 276-U Building, a concrete vault adjacent to Section 20 of the 221-U Building, organic solvents are stored and prepared for use within the 221-U Building. Also included in 276-U are facilities for the treatment of "off-standard" solvent from the 221-U Building.

3.24 Chemical Tank Farms 211-U and 211-AU

In the Chemical Tank Farms, 211-U and 211-AU located just north of the 271-U Building and adjacent to the 221-U Building, aqueous bulk chemicals and water demineralized in the 271-U Building are stored. Facilities are included in the tank farms for the make-up of RAS solution.

3.3 UO_3 Plant

3.31 Concentration and Calcination Building 224-U

In the 224-U Building is housed the equipment for concentrating the UNH solutions from the Redox and TBP Plants and the equipment for calcining the resulting concentrated uranium solutions. In addition, facilities are installed for the recovery of nitric acid from the gases given off during calcination and for fractionating the nitric acid recovered in the absorption and concentration operations.

3.32 UNH Solution Storage Buildings 203-U and 203-UX

The UNH solution from the Redox and TBP Plants is stored temporarily in the 203-U Building (for location of this building see Figure XIII-18) while awaiting processing in the 224-U Building.

The 203-UX Building is used for special UNH solution storage functions, explained under D2.2, below.

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3.33 UO_3 Warehouse Building 2714

The UO_3 powder produced in the calcining pots of the 224-U Building is temporarily stored in the 2714 Building while awaiting "off-site" shipment. Additional facilities may be built for additional storage capacity.

3.4 Waste disposal facilities

The radioactive gaseous and liquid wastes produced in the various phases of the uranium recovery process are handled in several different ways, depending upon the radioactivity and type of waste. The higher-radioactivity-level aqueous wastes containing most of the fission products are returned to empty underground storage tanks through the underground pipe encasement and diversion systems. Condenser and jacket cooling water and low-radioactivity condensates are sent to retention basins, ponds, and underground cribs, while radioactive gases are sent to the stacks enumerated below. (See Chapter XII for a detailed discussion of the waste facilities.)

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3.41 Waste Cribs 216-WR-1, 2, and 3

Low-radioactivity-level condensates from the process vessels in the 221-U and 224-U Buildings are normally routed through the 241-WR Vault facilities to the 216-WR-1, 2, and 3 Waste Cribs (through Diversion Box 241-UX-151). These cribs are located approximately 500 yards south of Diversion Box 241-UX-154. The construction of a typical Hanford Crib is shown on Figure XIII-34. (See Chapter XII for further crib discussion.)

3.42 Waste Cribs 216-U-1 and 2

Floor drainage (not process cell) from the 221-U and 224-U Buildings and aqueous chemical wastes from 276-U Building treatment operations are routed to the 216-U-1 and 2 Waste Cribs through the Settling Tank 361. These cribs are located approximately 300 yards west of the 224-U Building.

3.43 Waste Cribs 216-ER-1, 2, and 3

Waste Cribs 216-ER-1, 2, and 3, similar in function to 216-WR-1, 2, and 3 Waste Cribs, are used for the disposal of low-radioactivity-level condensates from process vessels in the 221-U and 224-U Buildings. These 200-East Area cribs, located approximately 400 yards north of Diversion Box 241-ER-151 are connected to the Interarea Pipe Encasement (and the 241-WR Vault) through Diversion Box 241-ER-151.

3.44 Retention Basin 241-U

Cooling water from the process vessels in the 221-U and 224-U Buildings is routed to the 241-U Retention Basin which is just east of the 241-U Tank Farm. In the Retention Basin the water is monitored for radioactivity before it is routed through a 24-in. line to an open

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ditch at the low point of the U Area (see Figure XIII-3).

3.45 Vent Stack and Fan Buildings (291-BXR, CR, TXR, and UR)

The Vent Stacks and Fans located at the BX, C, U, and TX Tank Farms remove the radioactive gases and vapors produced in the Blend Tanks and Slurry Accumulators of their respective Process Vaults and dilute them prior to releasing them to the atmosphere. The gases are filtered by glass wool filters before passing to the stack.

3.46 Portable (26-ft.) Stacks and Fans (241-FN)

When removal operations are carried out in an underground, stored-waste, tank-farm cascade, each tank of the cascade is vented through a glass-wool filter installed in the tank condenser hatchway to a portable stack-fan installation (one for each tank in the cascade). Ventilation air passing from the sluicing, heel removal, and pump pits into the storage tanks is vented through these stacks.

3.47 Building 291-U

The 221-U Building canyon ventilation air is vented from the ventilation duct to the atmosphere through the sand filter and stack facilities of the 291-U Building. Also vented through the 291-U filter and stack system is the ventilation air from the "hot" tank side (Tanks WR-001 through WR-005 inclusive) of the 241-WR Vault. Process tanks and condensers in the 221-U cells are vented to the 291-U Stack but pass through separate headers and a blower pit before they are discharged to the duct leading to the sand filter. Most vessels in the 224-U, 203-U, and 203-UX Buildings are vented indirectly to the 291-U facilities through a terra cotta pipe leading to the 224-U ventilation duct. (For a detailed discussion see C1.23, C2, and C3, below.)

3.48 Diversion Vault Stack and Fan 291-WR

The Nitric Acid Pump Tank and the Aqueous Pump Tanks (Tanks WR-006 through WR-009, inclusive) are vented to the atmosphere through the Diversion Vault Stack and Fan, 291-WR, located at the north corner of the 241-WR Diversion Vault. The "hot" tanks of the 241-WR Diversion Vault are vented directly into the "hot" side vault and are eventually discharged with the "hot" side ventilation air to the 291-U Stack as discussed in 3.47 above.

3.5 200 East and West Area service facilities

The 200 East and West Area service facilities which serve the Uranium Removal Plant are listed below. If the facility is located in only the East or only the West Area the facility is indicated by the letter E or W. Facilities not so designated are provided in both areas.

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277-U W Uranium Removal Mock-Up Shop
2305 — Fences and Guard Towers
2501 — Fence and Road System
2503 — Electrical Distribution System
2505 — Fire Alarm System
2506 — Telephone System
2508 W Recovered-Metal Transfer Line
2601 — Railroad System
2603 — Roads and Walks
2701 — Area Badge House
2801 — Overhead Pipe Support System
2802 — Steam Distribution System
2803 — Compressed-Air Distribution System
2901 — Water Distribution System
2903 — Sanitary Sewer System
2904 — Process Sewer System

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B. URANIUM REMOVAL FACILITIES

1. General Description

Waste removal facilities are installed at each of the seven tank farms containing stored uranium waste from the bismuth phosphate process. The tanks in each tank farm have been arranged in cascades of 3, 4, or 6 tanks (see table below) so that waste overflowing the first tank passes into the following tanks of the cascade. One or more cascades in each tank farm have been (or will be) filled with waste as indicated below:

Tank Farms	Tanks in Cascade	Cascade Diversion Box to Which Tanks of Cascade are Connected
241-B	1. B-101,102, and 103	241-BR-152
241-BX and 241-BY	1. BX-101,102,103 and BY-101,102,103	241-BXR-152 and BYR-152
	2. BX-104,105,106 and BY-104,105,106	241-BXR-153 and BYR-153
	3. BY-111 and BY-112	241-BXR-154
	4. BY-109[a]	241-BXR-154
241-C	1. C-101,102, and 103	241-CR-152
	2. C-104,105, and 106	241-CR-153
	3. C-201,202,203, and 204[b]	
241-T	1. T-101,102, and 103	241-TR-152
241-TX	1. TX-101,102,103, and 104	241-TXR-152
	2. TX-105,106,107, and 108	241-TXR-153
	3. TX-115[c]	241-TX-153

Tank Farms (Cont'd)	Tanks in Cascade	Cascade Diversion Box to Which Tanks of Cascade are Connected
241-U	1. U-101,102, and 103	241-UR-152
	2. U-104,105, and 106	241-UR-153
	3. U-107,108, and 109	241-UR-154

(a) Homogenized-supernate temporary storage tank for 200 East Area.

(b) These are special small tanks (20 ft. in diameter) of the 241-C Tank Farm which are connected directly to Master Diversion Box 241-CR-151. For a description of these tanks see B2 below.

(c) Homogenized-supernate temporary storage tank for 200 West Area.

Above each of the 75-ft.-diameter underground storage tanks three concrete pits have been constructed to house the equipment used during pumping, sluicing, and heel removal operations in the tank. The pits for the various tanks in a cascade are connected by an underground concrete pipe encasement to a Cascade Diversion Box (see table above). By proper alignment of the jumpers in these Cascade Diversion Boxes the various tanks in a cascade may be connected with one another or to other removal facilities through a Master Diversion Box.

By proper alignment of the jumpers in the Master Diversion Box, individual cascades may be selected for removal operations. The various Master Diversion Boxes connect with other facilities as indicated below:

Master Diversion Box	Cascade Diversion Boxes Connected to Master Div. Box	Other Process Facilities Connected to Master Div. Box
241-CR-151	241-CR-152 241-CR-153	Process Vault 244-CR Underground Storage Tanks C-201,202,203, and 204 Diversion Box 241-ER-151
241-BXR-151	241-BR-152 241-BXR-152 241-BXR-153 241-BXR-154 241-BYR-152 241-BYR-153	Process Vault 244-BXR-151 Diversion Box 241-ER-151
241-TXR-151	241-TR-152 (through Booster Pump Pit 241-TR-153) 241-TXR-152 241-TXR-153	Process Vault 244-TXR Diversion Box 241-TX-153 (routing of supernate for storage in TX-115) Diversion Box 241-TX-155
241-UR-151	241-UR-152 241-UR-153 241-UR-154	Process Vault 244-UR Diversion Box 241-TX-155

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Process Vaults are located at four tank farms. Each Process Vault processes the slurries produced in one or more tank farms as indicated below:

Process Tank Vault	Tank Farms Serviced By Process Tank Vault	Stack Handling Process Tank Vault Waste Gases
244-BXR	241-B, 241-BX, 241-BY	291-BXR
244-CR	241-C (Included are the four small tanks--201, 202, 203 and 204--of the C Farm)	291-CR
244-TXR	241-T, 241-TX	291-TXR
244-UR	241-U	291-UR

The homogeneous solution produced from the slurries is pumped from the various Process Tank Vaults to temporary storage in the 241-WR Vault outside the 221-U Building through a complex underground piping and diversion system. Wastes and recovered nitric acid from the TBP and UO_3 Plants are also returned to the tank farms for use or storage by the same underground piping and diversion system.

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At each of the processing areas Control Houses (271-BXR, 271-CR, 271-TXR, and 271-UR) have been built. They house tank farm instruments and motor controllers as well as air compressor, ventilation, locker, toilet, lunch room, office, and SWP facilities.

Plot plans for each of the tank farms are shown on Figures XIII-5 through 11. The underground piping system connecting the tank farms with the facilities in the 241-WR Vault has been shown on the area plot plans, Figures XIII-2 and 3.

"Hot" equipment and jumper changes at the tank farm are accomplished through the use of a gantry crane. (See Chapter XVIII.)

2. Underground Storage Tanks

The $BiPO_4$ process wastes are stored in 3 different size tanks as described below. All the 75-ft.-diameter tanks are of reinforced concrete construction with a steel liner on the bottom and sides. These tanks rest on waterproof pads and are waterproofed on the sides and top with tar and gunnite concrete.

The 75-ft.-diameter tanks of the 241-BR, CR, TR, and BXR Tank Farms store liquids to a depth of 16 ft. and hold approximately 530,000 gal. (see Figure XIII-12 for other dimensions). Above each of these tanks have been constructed concrete pump, sluice, and heel removal pits oriented as indicated on Figure XIII-13. Over-all dimensions of these pits are shown on Figure XIII-5.

The 75-ft.-diameter tanks of the 241-TX and 241-BY Tank Farms have an overflow 22 ft. from the bottom of the tank and normally hold approximately 759,000 gal. of waste (see Figure XIII-12 for dimensions).

As indicated on Figure XIII-13, the orientation of removal equipment above the tanks is different for these tanks than for the 530,000 gal. capacity tanks. There are two sluice pits on the 759,000-gal. tanks and the sludge pump is placed in the center pit along with the heel removal jet. Over-all dimensions of the pits are shown on Figure XIII-13 and on drawings in Chapter XVI.

There are four smaller 20-ft.-diameter tanks filled with stored uranium waste in the 241-C Tank Farm. These tanks have a storage capacity of 55,000 gallons at a liquid depth of 24 ft. The 20-foot tanks are not arranged in cascade and have no overflow outlets.

Early in the development of the $BiPO_4$ process consideration was given to decontaminating the uranium waste solution by a series of scavenging precipitations thereby simplifying later recovery of the uranium. The 20-foot-diameter tanks were originally constructed to hold the highly radioactive cake but were never used for this originally intended purpose.

As discussed in Chapter II, jets will be used to remove the sluiced materials from the 20-foot tanks in place of the sludge pumps used in the 75-foot tanks. Orientation of the equipment installed for the removal operations is shown on Figure XIII-13 and on Figure XVIII-8.

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3. Process Tank Vaults

The 244-BXR, 244-CR, 244-TXR, and 244-UR Process Tank Vaults are two-level concrete structures. As indicated on Figure XIII-15 the upper level is divided into a series of pump pits (one for each tank) housing jumpers, process piping, and electric motors; and a series of sampler pits (one for each tank) housing sampling equipment and instrument shafts. The lower level of all the Process Tank Vaults houses a Slurry Accumulator and two Blend Tanks. In addition, the 244-BXR and 244-CR Process Vaults house the Process Pump Tanks required for pumping the acidified uranium solution through the Interarea Pipe Encasement, and the 244-UR Process Tank Vault houses the Nitric Acid Tank. The Nitric Acid Tanks (storing recovered nitric acid) of the other processing areas (TXR, CR, and BXR) are located above ground on concrete pads near the Process Tank Vaults and flow by gravity into the Blend Tanks.

4. Diversion Boxes

4.1 Cascade Diversion Boxes

The removal facility Cascade Diversion Boxes (for a drawing of a typical box see Figure XIII-14) depart greatly from the conventional diversion-box design used in previous Hanford installations. The jumpers used within the boxes are of the wall-to-floor type rather than the wall-to-wall type previously used, and in some cases include bellows-seal valves operated by extension handles extending through the diversion box cover. Inlet connectors are on the walls of the box while outlets are on the floor. All connectors used in the removal facilities at the waste tank farms are the Redox type described and illustrated in the Redox Technical

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Manual (HW-18700).

Sprays and drains are provided for wash-down operations in case of spills or leaks. In some diversion boxes storage space for jumpers not in use is located at one end of the box. The concrete walls and floors of the diversion boxes are protected with an Amercoat 55 coating.

The construction of the Cascade Diversion Boxes varies from cascade to cascade depending upon the number of tanks in the cascade. The underground storage tanks serviced by the individual Cascade Diversion Boxes are listed in B1 above. For schematic diagrams showing the interconnection of the various diversion boxes, the reader is referred to prints SK-2-742 and SK-2-750.

4.2 Master Diversion Boxes

Although the functions of the Master Diversion Boxes are considerably different from those of the Cascade Diversion Boxes (see A3.04 and B1 above), the same general design features are incorporated in both types. The specific design features (e.g., number of connectors and types of jumpers) of individual boxes vary depending upon the process functions performed through the box and the geographic location of the boxes with respect to the other units it connects.

For a schematic drawing showing the interconnection of the diversion boxes, reference should be made to SK-2-742 (West Area) or SK-2-750 (East Area).

4.3 Diversion Box 241-ER-151

Diversion Box 241-ER-151, the East Area end of the Interarea Pipe Encasement, is a concrete pit 39 ft. 1/2 in. long, 6 feet wide and 12 ft. deep with 2-ft.-thick concrete walls. At one end of the box, separated by an 8-in.-thick concrete wall, is the 11-ft. 4-1/2 in.-long by 6-ft.-wide jumper storage space. The box is covered with 2-ft.-thick concrete cover blocks, which may be removed by a motor crane.

The rows of connectors on opposite sides of the box may be connected by jumpers. All feed solution passing to the West Area and solutions returning to the East Area tank farms or cribs pass through this diversion box.

4.4 Diversion Box 241-UX-154

Diversion Box 241-UX-154, the West Area end of the Interarea Pipe Encasement, is a concrete pit 52 ft. 4-1/2 in. long, 6 ft. wide, and 11 ft. deep lined by 2-ft.-thick concrete walls, and covered by 5-ft. 1-in.-thick cover blocks. At one end of the box, separated from the connector pit by a 1-1/2 in.-wide concrete wall, is the 9-ft. 10-1/2 in.-long connector storage space.

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The rows of 16 inlet connectors and 9 outlet connectors may be connected by jumpers. The box is connected by underground piping to the 241-WR Vault, the Interarea Pipe Encasement, Diversion Box 241-TX-155 (West Area tank farms), the sump tanks in Section 5 of the 221-U Building, and Diversion Box Catch Tank 302.

4.5 Diversion Box 241-TX-155

Diversion Box 241-TX-155, from which T and U Tank Farms are connected to the processing areas, is a concrete pit 44 ft. 1/2 in. long, 6 ft. wide and 9 ft. 11 in. deep. At one end of the box is located a 9-ft. 10-1/2 in.-long connector storage space separated from the connectors by a 1-ft. 2-in. concrete wall. The box is lined by 2-ft.-thick concrete walls and covered with 5-ft. 11-in.-thick cover blocks.

A total of 43 connectors line three walls of the box. In addition to the connectors originally used for filling the storage tanks with T Plant waste, the box is connected directly to 241-UX-154, 241-WR, the nitric acid tank at the 244-TXR Process Vault and the West Area Master Diversion Boxes (241-UR-151 and 241-TXR-151). The box drains to Catch Tank 302B.

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5. Vent Station 241-EW-151

Vent Station 241-EW-151 is located adjacent to the East-West encasement at the highest point in the encasement (roughly one mile from the eastern terminal--241-ER-151). The lines of the Interarea Encasement are vented to insure drainage of the line to the tanks at either end of the encasement before jumper changes are made. Each line is individually vented to a tank (vented in turn to the Interarea Pipe Encasement) installed in a concrete pit (16 ft. deep by 10 ft. long by 8 ft. wide) by opening an extension-handle-operated gate valve (one in each line). If "hot" solution should inadvertently be discharged into the vent tank, the tank overflows into the Interarea Encasement. Solution in the tank (detected by portable conductivity instruments) may be jetted into any of the six encasement lines by a jumper connection to a compressed-air jet installed in the tank.

6. Control Houses (271-BXR, CR, TXR, and UR)

At each of the tank farm processing areas (BXR, CR, TXR, and UR) are constructed one story frame buildings from which the tank farm removal operations are controlled (see Figure XIII-15). From the control houses electrical and instrument lines lead to the various tank farm facilities (e.g., process vaults, process stacks, portable stacks, pump pits, sluice pits, instrument and electrical pits). In addition to the control room equipment, the buildings contain lunchrooms, locker rooms, toilets, and the air-compressor equipment which supplies instrument and process air to the tank farm facilities.

7. Tank Farm Service Facilities

7.1 Raw water

All the waste tank farm systems are supplied raw water from mains

through four-inch underground headers. From the 4-in. headers a 2-in. line leads to the 271 Control House; two 3-in. branch lines lead to the 244 Process Vault Blend Tanks; and a 2-in. line services the tank farm cascade system. The latter 2-in. line supplies the various 2-in. risers which are connected by hose connections to various tank farm facilities (e.g., pit sprays, sluicing nozzle and pump jet ring sprays, etc.). The safety showers and the fire hydrant outside the buildings are connected to the raw water line.

The 271 Control House 2-in. line enters the mechanical equipment room where most of the raw water is used in the building ventilation equipment and for air-compressor and air-drying unit cooling.

7.2 Sanitary water

Sanitary water is supplied to the BXR, CR, TXR, and UR processing areas through 4-in. supply lines leading to the 271 Control Houses. In all the 271 Control Houses the sanitary water requirements consist of services to an electric hot water heater, an electric water cooler, lavatories, and showers.

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7.3 Steam

Each tank farm (except C Farm which is supplied by a new 4-in. line) is supplied by an existing 3-in. 225-lb. steam line from an area power house main. The supply lines lead to 110-lb. pressure-reducing stations within each area. Above ground 3-in. steam lines supply the 110-lb. steam to the 271 Buildings, the 244 Process Vaults, and the various 2-in. outlets located near the tanks containing stored waste. The 2-in. outlets are connected by temporary hose lines to heel-jet gang valves as required.

At the 271 Building 110-lb. steam is used to supply the instrument-air dryers during regeneration periods. Low-pressure steam for heating the 271 Building is supplied by a pressure-reducing valve within the building.

The process jets in the 244 Process Vaults are supplied by 110-lb. steam lines. A pressure-reducing valve near the process vaults provides low pressure steam for the air heating and humidification equipment which supply the process vaults.

Low-pressure steam is supplied to the heating and ventilation equipment for the Booster Pump Pit, 241-TR-153, from the T-farm 3-in., 110-lb. line through a local pressure-reducing station.

7.4 Electric power

The waste removal facilities at the various tank farms are supplied by overhead, 13,800-volt feeder lines leading from the main 251 Station. At each of the tank farms are substations (254 Buildings) which contain 13,800-volt/480-volt transformers. Distribution of the

480-volt electricity is handled differently for the removal areas containing processing facilities (BXR, CR, TXR, and UR) than for non-processing removal areas (BR, BYR, and TR). From any one of the 254-BXR, CR, TXR, and UR transformer stations, 480-volt lines lead to two buses in the corresponding tank farm 271 Control House. From the buses underground lines lead to instrument and electrical enclosures in the vicinity of the process vaults, process stacks, and processing area waste tanks for final distribution to process equipment.

From any one of the 254-BR, BYR, and TR Transformer Stations in non-processing tank farm areas, a 480-volt line leads to a bus in a motor control station. From this bus lines lead to the instrument and electrical enclosures above the storage tanks for final distribution to process equipment.

In the T Area electricity is supplied the Booster Pump Pit and the accompanying vent-stack and evaporative-cooler fans from Instruments and Electrical Enclosure T-101.

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Electrical receptacles have been installed at the pump and sluice pits for each tank containing stored waste within the tank farm areas. They are used for the operation of the scanning motors. Additional receptacles are installed at convenient locations in the removal areas (usually at instrument and electrical enclosures) for connection to the gantry crane.

Emergency power is supplied at each of the four tank farm processing areas by an emergency gasoline-engine, 480-volt, 75-kw. generator. This generator is portable and is installed at the processing area before removal operations are started. It is connected during emergency periods by a bus-interlock system to a portion of the load normally carried by one of the 480-volt 271-Control House buses. Included in the emergency load are emergency lighting, the agitators for process vault vessels, and stack fans. Since the emergency generator does not start up automatically, power is not available for a short time following interruption.

Lighting for the 271 Control Houses and outside floodlighting is provided by transformers in the control houses.

All electrical pumps and motors serviced by a process area may be operated from the 271 Control House. In addition, the pumps and motors in the TR, BYR, and BR Areas may also be operated at the local motor-control stations.

7.5 Compressed air

All the instrument and process air for the waste tank farms is supplied from the 271 Control Houses. Installed in each control house are a three-inch air compressor, a supply tank, two filter units, and two drying units. Both the process and instrument air is submitted to the same compressing, filtering, and drying procedure. The instrument air is supplied at 100-lb. pressure to a 1-in. header in the instrument and

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electrical trench. Pressure-reducing valves, installed at each instrument, supply 30-lb. air for the various instruments (e.g., recording ring balances, weight-factor instruments, air alarms). Process air, used principally for the blowing of process and sump jets, is supplied at 100-lb./sq.in. pressure by a 2-in. header.

7.6 Sanitary sewer system

The tank farm sanitary sewer system handles only 271 Control House waste. For each Control House there are two systems, one draining through a 6-in. line to a septic tank and the other through a 6-in. line to a drainage ditch or crib (only TX drains to the existing 241-TX Crib). The drainage system to the septic tank includes the floor drain in the locker rooms; the floor drain, waste closet, and lavatory in the toilet room; and the electric water cooler and sink drains in the lunch room. The drainage ditch services the mechanical equipment room which includes two floor drains, two funnel drains, and two floor clean outs.

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7.7 Process sewers

The cooling water discharged from the cooling coils in the blend tanks is sent to an open ditch in the vicinity of the tank farm processing area through a 6-in. line from the 244 Process Vault. One exception to this is the TXR processing area from which the Blend Tank cooling water is discharged to the 231 Building ditch.

8. Uranium Removal Area Ventilation

8.1 Waste storage tank ventilation, portable stack and fan

When removal operations are carried out in the individual storage tanks air is circulated through the pump and sluice pits to prevent the overheating of electrical motors. To insure a normal flow of air from the pits into the storage tanks prior to sluicing operations portable fan and stack assemblies are installed at the tank on concrete pads next to an existing ventilation hatchway. Air in passing into the tanks first enters the pits through cover block slots, then into the tanks through equipment-access risers. Air is exhausted from the tanks, passing first through a glass-wool, canister-type filter installed in the ventilation hatchway then through the fan to the stack. Approximately 110 cu.ft. of air/min. is discharged from the 26-ft.-high steel stacks (4-in. diam.).

8.2 Process Tank Vault ventilation, 291 Vent Stacks

The tank farm processing area 291 Vent Stacks and Fans exhaust both the 244 Process Vault ventilation air used to remove the heat from the vault motors and the process gases evolved in the Blend Tanks and Slurry Accumulator Tank.

Ventilation air is supplied to the vault through a 30-in. asbestos cement duct from a preheater, filter, and air-washer installation near the vault. In the summer the air is cooled by the washer unit and in the winter it is heated slightly to prevent freezing of the filters. From the main line, smaller branch lines supply the slurry accumulator pits, the blend tank pump pits, and, where installed, the nitric acid tank pit and the process pump tank pit. Air from the vault is exhausted through a glass-wool stack filter and an 18-in.-diameter 50-ft.-high stack as discussed in Chapter XII. The tanks themselves are vented first through a glass-wool process-vent filter before they are sent to the stack filter.

8.3 271 Control House ventilation

The heating and ventilating unit for the 271 Control Houses is located in the mechanical equipment room. The blower, pre-heater, and re-heater coils are located inside the building while the evaporative cooler unit, used during the summer months, is located outside the building. Air is supplied to the various rooms through sheet metal ductwork. During the winter a portion of the air is recirculated (700 cu.ft./min.). An exhaust unit with a rated capacity of 1430 cu.ft./min. is located on the roof.

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9. Diversion Station 241-WR

The 241-WR Diversion Station is a concrete vault 128 ft. long and 66 ft. wide containing nine permanently installed 50,000-gallon tanks. As indicated on Figure XIII-17, each of the tanks is in a separate 24-ft.-square concrete pit with a row of five "hot" tanks containing highly radioactive feed and waste solution (TK-WR-001 through TK-WR-005) separated by a 3-ft. concrete wall from the row of four tanks containing slightly radioactive condensate and recovered nitric acid (TK-WR-006 through TK-WR-009). Above the "hot" tanks, running the length of the vault, is the "hot" pipe tunnel which connects with the underground pipe trenches. Above each of the "hot" tanks are equipment pits, sampler pits, and instrument and sampler access shafts.

The "hot" tank pumps and agitators are mounted in the equipment pits above the "hot" tanks and attached by jumpers to wall connectors. These pumps and agitators may be remotely replaced using a gantry crane. Two-foot-thick stepped cover blocks above the equipment pits protect operating personnel from radiation.

On the top of the vault above each of the sampler pits are installed sampler shelters. In these shelters sampling equipment may be stored. The sampler shelters above the "hot" tanks must be removed before the gantry crane may be maneuvered above the equipment pits.

A concrete wall separates the four slightly radioactive tanks (WR-006 through WR-009) from the pump pit. The pumps at the bottom of the pit, connected by lines to the low points of the recovered nitric acid and condensate tanks, may be reached by a stairway from the top of the vault. Conventional piping is used in the pump pits since contact

maintenance may be made at controlled work conditions. From the pump pit, equipment and valves in the tank pits for tanks WR-006 through WR-009 may be reached through access doors.

"Hot" waste solution received in Tank WR-001 from the 221-U Building and the 291-U Stack drain may be pumped to ultimate storage in the tank farms of the East Area through Diversion Box 241-UX-154 or to tank farms of the West Area through Diversion Box 241-TX-155. All feed solution from the dissolution facilities at both the East and West Area tank farms is received in Tanks 002, 003, 004, and 005 through lines from Diversion Box 241-UX-154. The four feed tanks are inter-connected so that blending may be accomplished in the vault. Feed may be routed through pipe-trench lines to the feed receivers, TK-3-1 and TK-3-6, within the 221-U Building.

Nitric acid, received in TK-006 from the recovery facilities in the 224-U Building or from the storage tanks in the 211-U Tank Farm, may be routed to HNO_3 storage tanks at the tank farm processing vaults through Diversion Box 241-UX-154 for East Area processing vaults and Diversion Box 241-TX-155 for West Area processing vaults.

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Condensate is received in Tanks WR-007, 008, and 009 from the 221-U Building through a line from the 221-U Counting Box. After sampling, the tanks may be discharged directly to the 216-WR Crib, routed to the Waste Utility Holdup Tank 4-6 in the 221-U Building for reworking, or sent to the East Area 216-ER Crib through Diversion Box 241-UX-154.

With the exception of Waste Tank WR-001, all vault tanks are serviced by a cold chemical line from the 271-U Building.

9.1 241-WR Service facilities

Raw water is supplied the 241-WR Vault through a 2-in. underground line from the 221-U Building. It is used as seal water to the pumps for Tanks WR-006 through 009 and is supplied to the vault air conditioning and heating units and the safety showers. Piping is also installed within the vault to permit the spraying of equipment, sampler, and tank pits in the vault. Spray rings are also installed around the "hot" tank pumps and agitators to permit decontamination as the equipment piece is removed from the equipment pit. The lines leading to the various spray nozzles are not permanently piped to the water supply but terminate above ground. When spraying is necessary, the proper line is connected by hose to a supply outlet.

Steam at 225-lb./sq.in. pressure is fed to the 241-WR Vault through a 3-in. line leading from the 14-in. main Redox-282-W Powerhouse line. A pressure-reducing station at the vault reduces the steam to 125 lb./sq. in. for distribution within the vault to the various sump jet gang valves and the WR-001 Waste Tank. At the two vault air conditioning and heating units, local pressure-reducing valves supply low-pressure steam to the heating coils.

Process air is supplied at 100 lb./sq.in.ga. through a 1-in. line from the 221-U Building (271-U Compressor). At the vault, air is distributed to the various gang valves by lines leading from a 1-in. line in the instrument and electrical trench.

Dry instrument air is supplied to the vault through a 1/2-in. line leading from the 221-U Building (271-U Compressor) to the Instrument Enclosure at the vault. In the Instrument Enclosure the air is reduced to approximately 20-lb./sq.in.ga. pressure. A portion of the 20-lb. dry air is distributed directly to the various transmitters while the rest is humidified, by bubbling through an Instrument Enclosure tank, for distribution to the dip tubes in the tanks.

Electricity is received at the 254-WR Transformer Station adjacent to the north corner of 241-WR through a 2400-volt underground line from Substation 252-W-2. The 480-volt electricity from the 2400/480-volt transformer is distributed from a 254-WR bus to the various vault pumps and motors through lines in the instrument and electrical trench. Current for vault lighting is supplied by a 480/120-240 volt transformer in the Instrument Enclosure. Vault motors may be operated from either the Instrument and Electrical Enclosure or from remote push-button stations at panel boards "UC-UD" and graphic panel boards "A" and "B" in Building 221-U.

The gantry crane is connected to a 480-volt receptacle located near the gantry crane rails.

9.2 241-WR ventilation

The ventilation of the 241-WR Vault is accomplished by means of two separate systems: one servicing the side of the vault containing the five "hot" tanks and the other servicing the "cold" side containing the recovered nitric acid and cribbable condensate tanks.

A heating and evaporative cooler installation on the southeast side of the vault delivers a total of approximately 3000 cu.ft. of air/min. to an underground main duct supplying the "hot" side of the vault. From the main duct, air is distributed to each equipment pit above the "hot" tanks. The air then passes around the pump and agitator motors before passing through the air shafts into the tank pits. From the pits the ventilation air and the gases from the tank vents (vented to the vault) pass into an exhaust manifold which leads underground through a 30-in. line to the 291-U Sand Filter for eventual discharge from the 291-U Stack.

The "cold" side of the 241-WR vault is supplied 3600 cu.ft. of air/min. from an air conditioning and ventilating unit located at the middle of the northwest side of the vault. Air from the conditioner is discharged into the "cold" pump pit from which it enters the pits for Tanks WR-006, 007, 008, and 009. Air is discharged from each of the pits into a manifold above the vault. This manifold leads to a local exhaust fan and 18-in.-diameter stack (291-WR) for disposal to the atmosphere.

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C. TBP PLANT

1. TBP Processing Building, 221-U

1.1 General building layout

The TBP Processing Building, 221-U, is a reinforced-concrete building of rectangular construction 85 ft. long, and 68 ft. wide. The building is oriented on a northeast-southwest axis as indicated on Figure XIII-18. The building consists mainly of the canyon, and four galleries (Operating, Pipe, Electrical, and Crane Cab), running most of the length of the building. Included as a part of the Canyon are the "hot" pipe trench, ventilation duct, and cell drain lines which also run most of the length of the building. For a typical cross section of the building see Figure XIII-19.

In the cells of the Canyon are located the vessels which process the highly radioactive solutions entering the TBP Plant from the 241-WR Diversion Vault. These "hot" facilities are separated from the Canyon Service Area and the four "cold side" galleries by massive concrete shielding. Operation of the equipment within the Canyon cells is accomplished remotely from the Operating Gallery while maintenance of the equipment is accomplished using the remotely operated Canyon crane.

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Along the northwest side of the building are the 271-U Service Building, the 211-U and 211-AU Chemical Tank Farms, and the railroad entrance to the Canyon. Adjacent to the southwest end of the building is the Organic Treatment and Storage Building, 276-U.

1.2 Canyon

The Canyon consists of 40 equipment cells (20 forty-foot sections) arranged in a single row running the length of the building. Heavy concrete shielding walls 10 ft. 10 in. thick separate the cells from the Electrical and Pipe Galleries. The Operating Gallery is separated from the Canyon Service Area by 7 ft. of concrete and the Crane Cab Gallery is protected by a 5-ft. concrete wall. The cells are separated from the Canyon Service Area (except the concentrator cells which have 2-ft. 6-in.-thick blocks and the RA Column cells and Cell 40 which have specially designed blocks with a minimum thickness of 2 ft.) by 6-foot-thick concrete cover blocks which are stepped on the sides to eliminate a direct air path for radiation. Since additional piping has been included in the "hot" pipe trench to accomodate the TBP process, it was necessary to reduce the thickness of the trench cover blocks to 2 ft. At the northeast end of the Canyon, entering the plant at Cell 3 is the Railroad Tunnel which is used for bringing equipment into and out of the building.

1.21 Cells

The standard canyon cells are rooms 17 ft. 8 in. long, 13 ft. wide and 22 feet high separated from one another by seven-foot concrete walls.

All lines which service the cells are buried in concrete and terminate in a row of connector flanges on the cell walls 9 ft. below canyon deck level. Equipment is placed on the cell floor and held in position by guides built into the cell, thus establishing a standard relationship between the connector flanges and the vessels which makes prefabrication of the vessels possible. The functions carried out in the various cells are listed in the table below. The equipment arrangements together with the services supplied by the various connectors for Cells 5 through 40 have been shown on Figures XIII-20 through XIII-25. No arrangement diagrams for Cells 1 through 4 are included since these cells are not used to house process equipment.

Cell Functions

Section	Cell	Function
1	1 and 2	Equipment storage
2	3	Railroad tunnel
2	4	Empty cell (normally used in the $BiPO_4$ process for storage)
3	5 and 6	Feed receiving
4	7	Feed utility holdup
4	8	Waste utility holdup
5	9 and 10	Sump and aqueous and organic sump holdup
6 and 7	11,12,13, and 14	Feed concentration
8	15 and 16	Spare concentration facilities
9 and 10	17,18,19, and 20	Waste concentration
11	21	Waste sampling
11	22	Waste neutralizing
12	23 and 24	Waste sampling
13	25	Waste sampling
13	26	Waste surge storage (RAW-ROW)
14	27 and 28	Feed clarification
15	29 and 30	Product sampling
16	31 and 32	Product receiving
17	33	RC Column facilities
17	34	RA Column facilities
18	35	RO Column facilities
18	36	RAX feed storage
19	37	RC Column facilities
19	38	RA Column facilities
20	39	RO Column facilities
20	40	RAX feed storage

In some instances process lines flow directly through the wall to the adjacent cell in the same section. Since there are expansion joints between sections of the building, there are no direct through-the-wall connections from section to section, and transfer of process solutions to other sections within the building must be handled through the "hot" pipe trench.

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Cells 34 and 38 have been remodeled to house the RA Columns. For hydraulic reasons (cascade flow of RAU into the RC Column) the top of the RA Column has been placed 3 feet below canyon deck level and the cell design indicated on Figure XIII-31 was adopted to cover the column. To eliminate possible low points in the connectors leading from the cell wall to the top of the column and to permit drainage of cold process and instrument lines to the columns a new row of connectors were installed on the gallery side of Cells 34 and 38 approximately 6-5/8 in. above the normal canyon deck level.

The cell drainage system is similar to that used in the B and T $BiPO_4$ Plants. Each cell slopes to a corner drain which drops into the 24-in. tile sewer running the length of the building and emptying into Tank 5-6 of "Deep Cell" 10. From Tank 5-6 the cell drainage is sent to the tanks of Cell 9 where the organic phase is separated from the accumulated batch; and the aqueous phase, after sampling, is jetted to the 216-U-1 and 2 Cribs. Organic cell drainage is sent to Tank 387 in the 276-U Building where it is either treated for reuse or drummed out for disposal.

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1.3 Canyon piping

Most intra-cell solution transfers are made through pipe jumpers within the cells. Some intra-section transfers are made through pipes in the walls between cells of a section. All inter-section solution transfers are made through the "hot" pipe trench lines. Connections between vessels in the cells and "cold-side" gallery tanks and instruments are made through pipes buried in concrete which terminate in connectors on the cell walls. In many instances there were insufficient multiple instrument lines to service the instruments required in a cell. In these cases additional multiple instrument lines were installed in the existing 2-in. process lines.

1.31 Trench piping

All pipes in the trench are sloped to permit proper drainage. In some cases, because of space limitations within the trench, a header system was adopted. In cases where headers are used, flow from several tanks is directed through the header to a common receiver. The various pipe trench headers together with their process functions are listed in the following table:

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Header	Receives From Process Vessels	Discharges Into	Size	Sections From and to which Header Extends
Vessel Vent	All cell tanks except condensers	Blower Pit (outside building)	6 in.	20 to 1
Condenser Vent	All concentrator condensers	Blower Pit (outside building)	2 in.	10 to 1
Feed Utility	Feed Conc. Feed Tanks 6-6 and 7-6; Waste Sampler Tanks 11-1, 12-1, 12-6, and 13-1; RCU Sampler Tanks 15-1 and 15-6; RAF Feed Tanks 17-6 and 19-6	Feed Utility Holdup 4-1	4 in.	19 to 4
Waste Utility	Aqueous Sump Tank 5-2; Spare Conc. Receiver 8-7; Waste Conc. Feed Tanks 9-6 and 10-6; Neutralizer Tank 11-6	Waste Utility Holdup 4-6	3 in.	11 to 4
RAW Header	RAW Receivers 17-7 and 19-7	Pooled RAW-ROW Receiver 13-6	3 in.	19 to 13
ROW Header	ROW Receivers 18-3 and 20-3	Pooled RAW-ROW Receiver 13-6	3 in.	20 to 13
Steam Condensate	All five evaporators	24-in. Utility Header (outside building) to Retention Basin	6 in.	6 to 10

1.4 Galleries

The Electrical, Pipe, Operating, and Crane Cab Galleries are located at progressively higher levels on the northwest side of the Canyon. The Operating and Pipe Galleries are 14 feet wide and run the length of the building. The Electrical Gallery is also 14 feet wide but it extends only from Section 3 to Section 20.

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The Operating Gallery is the control center for the cell equipment. It contains the three graphic panel boards from which all major process flows may be controlled, and local panel boards from which infrequent routings or emergency routings are controlled. In addition the Operating Gallery contains weigh tanks which receive solutions from the headers in the Pipe Gallery and discharge their solutions to the appropriate cell vessel connections in the Pipe Gallery. An SWP and decontamination room has been installed in the portion of the Operating Gallery from Cell 1 to Cell 3. The equipment layout for the Operating Gallery is shown on Figure XIII-26.

All cell piping except process transfer lines is brought up to the Pipe Gallery, terminating in connections on the wall. From the various chemical headers in the Pipe Gallery, connections are made to the weigh tanks and control boards in the Operating Gallery. Remote maintenance is not required in the galleries so conventional piping methods are used and the piping is not buried in concrete. Electrical and steam distribution lines are also located in the Pipe Gallery.

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The Electrical Gallery contains principally the main electrical lines and the electrical distribution centers for the building. The main steam line also enters the building through this gallery.

1.5 221-U Building service facilities

1.51 Water

Raw water is supplied to the 221-U Building through the feeder line (originally installed for the $BiPO_4$ Plant) entering the building at Section 20. The main raw water header is located in the Operating Gallery and a cell spray header is located in the Pipe Gallery. The raw water is used for cooling coils and jackets on process tanks and condensers, and services the cell spray system.

The sanitary water line enters the 221-U Building at Section 20 in the Electrical Gallery. The system provides water for safety showers, drinking fountains, shower rooms, toilets, fire hydrants, and the demineralized water unit (271-U Building).

Demineralized water is supplied from the 271-U Building demineralizing facilities to the various scale tanks in the Operating Gallery through a header in the Pipe Gallery. It is used in all cases where water is introduced to process streams (e.g., chemical make-up and deentrainment column reflux).

1.52 Steam

The 221-U Building is served by two 225-lb./sq.in.ga. feeder lines from the 282-W Powerhouse. These lines meet south of the 221-U Building and a 10-in. line continues on to the Redox Area. The old 10-in. line, capable of carrying 60,000 lb./hr., delivers 26,000 lb./hr. to 221-U and the remaining 34,000 lb./hr. to the Redox Plant and the 241-U Tank

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Farm. It enters the northwest side of the 221-U Building at Section 18. In addition to the 10-in. line, a 14-in. line which passes along the southeast edge of the 221-224-U exclusion area on its way to the Redox Plant is tapped by a line to Section 3 of 221-U. Of the 167,000 lb./hr. carried by the 14-in. line, 57,000 lb./hr. are available for use in 221-U. The two lines, entering at Sections 3 and 18, are joined by a header passing through the Pipe Gallery. The pressure within the header is reduced to 125-lb./sq.in.ga. steam by PRV stations at each end of the header. Local PRV stations serve to further reduce the steam to 15 lb./sq.in.ga. for those places in the Building where low-pressure steam is required.

1.53 Electrical system, 221-U Building

Two 13.8-KV feeder lines lead from the 251 Station to an outdoor substation (252-W-2) in the vicinity of the 221-U Building. The substation has two transformers, each large enough to carry the load of all projects in the vicinity of the 221-U Building. From the substation, two underground 2400-volt feeder lines lead to two 2400-volt buses in the Electrical Gallery, entering the building at Section 12.

The electrical system inside the building from the 2400-volt buses to the 480-volt and 110/220-volt transformers and distribution centers is almost identical with that originally installed. Lines leading from the 221-U Building supply the 480-volt and 110-volt electricity used in the 271-U Building, 276-U Building, 211-U and 211-AU Tank Farms, and the Blower Pit. To insure a compressed air supply at all times the power supply for the 125-hp., 2400-volt, 271-U Building air compressor was switched from the normal 2400-volt bus to the 2400-volt emergency bus, which receives power from the 282-W Powerhouse. Also supplied by the 2400-volt emergency bus are the vent blower and the solenoid door-lock systems. The original lighting system is used with extra lighting provided at the Operating Gallery graphic panels. Lighting for the new 211-AU Building is provided from existing Panel "E" (one of 10 panels, A through J). The building also has a battery-operated emergency lighting system which turns on automatically in the event of failure of the regular and emergency power services.

1.54 Compressed air

Compressed air at 80 lb./sq.in.ga. is supplied for process use by the air compressors installed in the 271-U Building through the distribution header system originally installed in the building. This process air is used where air sparging is required or where coils and jackets require blowing before steam or water is admitted. Gang valves are blown with process air after process transfers to prevent possible suck-back of "hot" liquids caused by steam condensation in the transfer line.

Instrument air at 15 lb./sq.in.ga. is supplied through the distribution and pressure-reducing system originally installed from the air compressors installed in the 271-U Building. Both humidified and dry instrument air is supplied. All purge lines leading to process instrumentation in the cell vessels are supplied with humidified air to prevent crystallization and build-up of salts on dip tubes which are in contact with process liquids.

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Panel board relays are supplied with dry air to minimize corrosion. Humidification of instrument air, where required, is accomplished in humidification tubes, located behind the panel boards in the Operating Gallery, by either percolating dry air through water or mixing dry air with low pressure steam.

The compressor is supplied from the 2400-volt emergency bus in the 221-U Building.

1.55 Sewers

Three different sewage systems have been installed for the 221-U Building to handle the various wastes encountered.

Cooling water from process vessels and low-activity cell drainage are discharged into an existing 24-in. process sewer line running along the southeast side of the building. This line leads to the Retention Basin where it is monitored for radioactivity before disposal to an open ditch.

The sanitary sewer system is used as originally installed. Drainage from sinks and toilets is carried via the sanitary sewer line on the northwest side of the building to a tile field west of the exclusion area.

The chemical sewer system handles the scale tank drainage and gallery floor drains as well as the 271 Building floor drains. The various acid-proof, stainless steel pipe, branch lines discharge into a 12-in. tile line on the northwest side of the building. This tile line runs south along the building to join the line from the 222, 224, and 222-U Buildings for eventual disposal in an open ditch.

1.6 221-U Building ventilation

The 221-U Building has two separate ventilation systems. One system ventilates the process equipment area, while the other ventilates the operating areas.

As indicated in the Ventilation Diagram on Figure XIII-29, ventilation of the process equipment areas is accomplished through the use of ten separate air filtering and washing units (4500 cu.ft./min. capacity) distributed along the Operating Gallery proper. The fresh dust-free air is fed to the crane cabway from which it flows into the canyon proper. The air then flows past the cell cover blocks into either the cells or the pipe trench, then through 10-in. terra cotta ducts from each cell or section of the pipe trench into the 4-ft. by 6-ft. ventilation duct which is connected to the 291-U Building facilities. In Sections 5, 17, 18, 19, and 20 which contain organic solutions special provisions have been made to insure positive circulation from the top to the bottom of the cell. A stainless-steel header with several small inlet ports has been installed at cell floor level. These headers connect to the 10-in. terra cotta ducts leading to the large ventilation

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duct. In Cells 11, 13, 15, 17, and 19 piping has been installed to allow pressure relief pot vapors to discharge directly into the vent outlet.

The exhaust ducts are adjusted to maintain the proper pressure balance in the system and permit a minimum of 4, 8, and 6 air changes per hour for the pipe trench, organic cells, and other cells, respectively.

The Operating Gallery ventilation is accomplished by feeding fresh dust-free air from ten 4500 cu.ft./min. air filtering and washing units distributed along the Operating Gallery proper as indicated in Figure XIII-30. Some air is also supplied to the Operating Gallery from the adjoining 271-U Building. From the Operating Gallery the air flows through gratings in the floor to the Pipe Gallery. Air is exhausted to the outside from the Pipe Gallery by nine exhaust fans. The Electrical Gallery receives about 5000 cu.ft./min. of air through a duct from the 271-U Building ventilating system. This air is exhausted from the Electrical Gallery to the outside by three exhaust fans. The static pressure in the Pipe and Operating Galleries is about 0.02 inches above atmospheric while in the Electrical Gallery it is 0.01 in.

At Sections 1 and 2 the Operating Gallery has been partitioned off (and grates connecting with the Pipe Gallery have been closed off) to provide SWP and decontamination facilities. The duct lines from the Section 1 4500 cu.ft./min. blower have been divided so that 1000 cu.ft./min. are supplied to the Pipe Gallery, 1500 cu.ft./min. are supplied to the Operating Gallery, and 2000 cu.ft./min. are supplied to the SWP and decontamination facilities (see Figure XIII-29). The entire 2000 cu.ft./min. is exhausted from the SWP area through the exhaust fan for the hood in the decontamination station.

The process vessels are vented to either the condenser vent header (50 cu.ft./min., 40 in. H_2O vacuum) or the vessel vent header (200 cu.ft./min., 10 in. H_2O vacuum). These pipe-trench headers are connected to the newly constructed blower pits leaving the building at Cell 6. The vent gases are sent through entrainment eliminators in the blower pits before they are discharged into the main ventilation tunnel by mechanical blowers. (For a description of the 291-U Stack facilities see Chapter XII.)

2. 271-U Building

The 271-U Building is a four-story concrete building approximately 160 ft. long and 48 ft. wide attached to the 221-U Building. It is used for the preparation of the process chemicals used in the 221-U Building and as administrative headquarters. The layout of the building is shown on Figure XIII-27.

The basement of the 271-U Building is used for the storage of some solid chemicals (e.g., Na_2SO_4). It also contains instrument shops, maintenance shops, 271-U ventilation equipment, and the compressed air equipment which supplies the 221, 222, and 224-U Buildings.

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On the first floor are change room facilities, offices, and additional solid chemical storage space. Included on the second floor are offices and the nerve center of the 221-U Building operation, the dispatcher's office. The dispatcher's office contains the communication facilities for controlling the movements of personnel and materials in carrying out the operations in the 221-U Building. From the dispatcher's office all magnetically locked doors giving access to the canyon area are controlled.

The third floor of the 271-U Building contains facilities for the preparation of, and temporary storage of, solutions used in the process. The third floor also houses water demineralizing equipment, solid ferrous ammonium sulfate and sulfamic acid bays, and a small chemical control laboratory.

On the roof of the 271-U Building is a large (10 ft. by 14 ft.) demineralized water storage tank. It may be filled directly from the third floor demineralizer or from the storage tanks in the 211-U Tank Farm.

TBP, delivered to the 271-U loading dock in drums, is pumped from the drum to the storage tanks in the 276-U Building through the 221-U Pipe Gallery.

3. Dry Chemical Warehouse 275-UR

Building 275-UR, located adjacent to the 2714-U UO_3 Warehouse, northwest of the 271-U Building, is a frame building mounted on a 60-ft. 6-in. by 50-ft. concrete slab. It is used as the receiving station and bulk storage facility for dry chemicals (e.g., sodium sulfate, sulfamic acid, ferrous ammonium sulfate).

4. 211-U and 211-AU Tank Farms

The 211-U and 211-AU Tank Farms serve to store the bulk liquid chemicals received in tank cars (or trucks) until needed. There are 25 tanks in the farms. Included are three 60% HNO_3 Sample Tanks and nine 60% HNO_3 Storage Tanks capable of storing approximately 1,200,000 gallons, nine 50% NaOH Storage Tanks capable of storing approximately 450,000 gallons, two RAS Storage Tanks capable of storing approximately 8,200 gallons, and two Demineralized Water Storage Tanks capable of storing approximately 25,000 gal.

Facilities are included in the 211 Tank Farm Area for unloading HNO_3, NaOH, and organic diluent tank cars. The acid and base are stored in the 211 Tank Farm while the organic diluent is pumped through 221-U Pipe Gallery lines to the 276-U Building for storage.

A schematic drawing showing the storage capacities of the tanks in 211-U and 211-AU is included in Chapter X.

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5. Solvent Storage and Treatment Area 276-U

The 276-U Building, located at the southwest end of the 221-U Building, is used for the bulk TBP and diluent storage and for the make-up and treatment of the organic solutions used in the solvent-extraction batteries. As indicated on Figure XIII-28 the various organic tanks are mounted in a 66-ft. 2-in. by 54-ft. 6-in. concrete basin built to hold the contents of all tanks in case of rupture during an emergency. The basin contains no floor drains. Leakage from the tanks flows to a sump from which it may be returned to the tanks, to drum out facilities, or to the 216-U Cribs.

The tanks in the 276-U Building are connected with the 221-U Building by the "hot" pipe trench and the Pipe Gallery. Organic solutions requiring treatment are routed to the Organic Receiver through the "hot" pipe trench from the 221-U Building RAX Feed, the ROO Receiver, and the Organic Sump Holdup Tanks. Organic make-up solution from the TBP and Diluent Storage Tanks and treated organic solutions are routed to the 221-U Building vessels containing organic solution through Pipe Gallery headers. Also running through the Pipe Gallery are lines leading from the Diluent and TBP Storage Tanks to the diluent car-unloading facilities in the 211-U Tank Farm and the TBP drum-unloading facilities on the unloading dock of the 271-U Building. The TBP Storage Tank, TK-381, and the Diluent Storage Tank, TK-380, are black iron tanks capable of storing 6,000 and 29,000 gallons, respectively.

The 276-U Building facilities are serviced by two scale tanks, 276-A and 276-B located in the Operating Gallery at the 276-U end of the 221-U Building. The 276-A tank measures the aqueous chemicals used during organic treatment and 276-B measures the small amounts of TBP used to butt-up or make up process solvent.

D. UO_3 PLANT

1. Concentration and Calcination Building 224-U

The 224-U Building, originally built to serve as a low-level decontamination and product-concentration building for the bismuth phosphate process, has been altered to house the decontaminated uranium solution concentration and calcination equipment. Since the solutions processed in 224-U are relatively "cold", massive concrete shielding is not required. Maintenance may be carried out by normal procedures performed under carefully regulated working conditions.

The building, 200 ft. long and 66-1/2 ft. wide, contains six cells (A, B, C, D, E, and F), an Operating Gallery, a Pipe Gallery, and space below the Pipe Gallery used for offices and storage. For a simplified 224-U Building layout drawing see Chapter I, Figure I-7. Cells A, B, C, and D have been separated from Cells E and F by a removable partition extending from floor to ceiling. As indicated in the equipment arrangement

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drawing (Figure XIII-32), Cells A, B, C, and D, have been modified to house the equipment required for concentrating the Redox and 221-U Building UNH solutions to produce a solution suitable for introduction to the calcining pots in Cells E and F. Also included in Cells A, B, C, and D are the equipment for fractionating the nitric acid vapors evolved during concentration and the absorption equipment, in which the gases evolved during the calcining operations are converted to nitric acid. Cells E and F contain the equipment required for the calcination of the concentrated UNH solutions to produce UO_3 powder. The equipment required for packaging the UO_3 has been installed in the room (originally considered to be a portion of F Cell for the bismuth phosphate process operations) which housed the bismuth phosphate process F-10 product cage. The calcination pot area (now designated E and F Cells) has been separated from the packaging area by a removable partition.

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As indicated on Figure XIII-33, the UO_3 exhausting equipment and calcination pot air exhausting equipment are located outside the 224-U Building. The local stack, exhaust fan, and glass wool filter assembly (X-12 and X-13) which filters and discharges air from Bag Filter X-11 to the atmosphere and the Pot Unloading Exhauster X-4 are located on the roof of the 224-U Building.

In E and F Cells the concrete floor level between the rows of calcination pots has been raised to make the tops of the pots more accessible during UO_3 removal operations.

Cell C is built on two levels with the floor of half the cell built 19 ft. lower than normal cell floor level (see Figure XIII-32). For the $BiPO_4$ process the cell was used to house the tanks receiving process solution from the 221 Building. The lower floor level of the cell permitted line drainage to the 224-U Building.

In the lower portion of the cell is the Sump Tank, C-2, in which drainage from Cells A, B, C, and D, is collected. The floors of the cells have been sloped to insure drainage of process leakage.

The Operating and Pipe Galleries run along the northwest side of the 224-U Building from Cell A to Cell E inclusive (see Figure I-7). In the space below the Pipe Gallery, office, storage, lunch room, ventilation blower, and change room facilities have been installed.

The Pipe Gallery contains the chemical and service facility (steam, air, water) headers originally installed for the $BiPO_4$ process. Some of the original chemical headers which are connected to the 211-U Tank Farm and 271-U Building facilities are used to supply demineralized water, nitric acid, and wash solution.

The Operating Gallery is the control center for the equipment in A, B, C, and D Cells. It contains the graphic panel board and the scale tanks which receive solutions from the Pipe Gallery headers and discharge into the vessel connections in the Pipe Gallery.

On the second floor over F Cell and the packaging area are the electrical installations which service the calcination pots in the E and F Cells. There is no third floor over the F Cell end of the building (see Figure I-7).

1.1 224-U Building service facilities

1.11 Water

Raw water is supplied to the 224-U Building at 110 lb./sq.in. pressure through an existing 6-in. line from an existing main from the 282-W Building and an 8-in. line extending from the Redox-282-W 20-in. main. Both lines enter the building at the northeast end. Inside the building an existing 6-in. header is used. Cooling water for the B and D Cell condensers is supplied by two 6-in. branch headers connected to the new 8-in. line.

Sanitary water is delivered to the 224-U Building at 100 lb./sq.in. pressure by an existing 4-in. line leading from the 283-W Building. A shutoff valve is located in office No. 1 where the line enters the building. Distribution to the safety showers, drinking fountains, shower rooms, toilets, and fire hydrants is accomplished using the originally installed piping.

Distilled water is to be supplied as reflux for the fractionating and absorption equipment. Sanitary water is not used since harmful, extraneous (e.g., Cl^-) ions would be introduced. During early 224-U Building operations, when the building is processing only Redox uranium, distilled water is supplied through the 2-in. Operating Gallery and Pipe Gallery headers, which are supplied from the distilled water facilities on the roof of the 224-U Building. When the 224-U Building is operating on the more dilute TBP uranium solutions, the evaporator overhead condensate collected in Tank C-5 is pumped to the distilled water storage tank on the roof. It then passes into the header system discussed above. Distilled water may also be pumped directly from Tank C-5 to the fractionators.

In case the feed from Tanks X-1 and X-2 to the evaporators is stopped, distilled water is automatically supplied to the evaporators to prevent caking of the evaporator tubes.

1.12 Steam

The 224-U Building is served by an 8-in. take-off line from a new feeder line which extends from the 282-W Powerhouse to the Redox Area. The new steam feeder line, which runs along the southeast edge of the 221-224-U exclusion area, carries about 110,000 lb./hr. at 225 lb./sq.in.ga. at the point where the 224-U building take-off line is connected. About 55,000 lb./hr. is supplied to the 224-U Building through the 8-in. line. The existing 10-in. main from the powerhouse joins the Redox main south of the 224-U Building. If a break occurs in the 14-in. feeder line from 282-W to 224-U a limited amount of steam may be furnished the 224-U Building by back-flow from the 10-in. existing main.

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Three 10,000 cu.ft./min. air washer and blower units on the roof above F Cell discharge air through a duct system into the calcination pot rooms in the vicinity of the pots. Air is exhausted from the pot rooms through four roof ventilators of approximately 30,000 cu.ft./min. total capacity.

1.22 Furnace hood ventilation

As indicated on the engineers flow sketch in Chapter VIII an exhaust fan X-13 discharges approximately 7500 cu.ft./min.* of filtered air to the atmosphere through a stack on the roof of the 224-U Building. The major portion of this air (approximately 6800 cu.ft./min.), passing through bag filters X-11 and glass-wool filter X-12 on its way to the stack, comes from the calcination pot air ventilation header which services all pots. During the cooling part of the calcination pot cycle, air is drawn beneath the pots. When pot cooling has been completed and the pot is being emptied the air flowing beneath the pots is diverted by a damper arrangement so that air flows across the top of the pot thereby minimizing the spread of UO_3 into the room.

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1.23 Process vessel venting

With the exceptions of Tank C-3 and the absorber T-A-1 all A, B, C, and D process vessels are vented directly or by connection with other process vessels to the existing 24-in. terra cotta pipe which discharges into the main 221-U Building ventilation tunnel at the Cell 40 end of the building. The B and D Cell evaporator seal pots, if blown, discharge gases through 8-in. lines through the roof. The A Cell Absorber T-A-1 and Tank C-3 are vented by a jet line through a local stack and filter on the roof of the 224-U Building.

2. UNH Solution Storage Buildings 203-U and 203-UX

2.1 Building 203-U

Two 100,000-gal., 25-ft. by 30-ft., agitated stainless steel tanks have been installed in an 82-ft. by 47-ft. concrete basin (203-U) behind the 224-U Building (see Figure XIII-18). These tanks, X-1 and X-2, store uranium solution from the TBP and Redox processes until it is pumped to the concentrating equipment in the 224-U Building. The tanks are heated and the process lines leading from the building are steam traced (or electrically heated) to prevent crystallization of the concentrated solution during cold weather. The building is serviced by the 224-U Building steam, vent, power, air, and water facilities. The basin sump is connected to the existing 10-in. line leading to the retention basin and the vent lines are connected to the existing 24-in. terra cotta line leading to the 221-U Building ventilation tunnel.

*) Air flows are at standard temperature and pressure unless stated. Actual air temperatures may be appreciably above standard.

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2.2 Building 203-UX

The 203-UX Building, adjacent to the 224-U Building D Cell, is a concrete basin 18 ft. 6 in. long and 13 ft. wide covered by a shed roof attached to the 224-U Building. The basin houses two tanks, X-19 and X-20. Tank X-19, 9 ft. by 9 ft., is used as a catch tank for Evaporator D-2, and as a pump tank for the UN loop header when both the TBP and Redox Plants are operating. (During the initial period when Redox alone is operating, Tank C-1 will supply the UN loop header.) Tank X-20, 4 ft. by 5 ft., is used for storage of off-standard uranium solution received from the calcination pots. From X-20, solution may be sent to the 203-U storage tanks for 224-U Building reworking or to Tank 4-1 (through TK-C-2) in the 221-U Building for solvent-extraction process reworking. Air, steam, and electricity are supplied to the 203-UX Building from the 224-U Building. Steam condensate is routed to the existing 10-in. main leading to the retention basin and the vessels are vented to the 24-in. terra cotta main.

3. UO_3 Warehouse, Building 2714

The 2714-U Building, located northwest of the 271-U Building, is used for the storage of UO_3 prior to off-site shipment. The building is a frame structure mounted on a 60-ft. by 47-ft. 7-3/4 in. concrete pad. Pallets holding four approximately 1000-lb. UO_3 drums are delivered from the 224-U Building by a fork truck and stored in bays until released for off-site shipment. The warehouse is capable of storing approximately 300 drums with one drum layer. The fork trucks are used for car loading, passing up a concrete ramp leading directly into the railroad cars.

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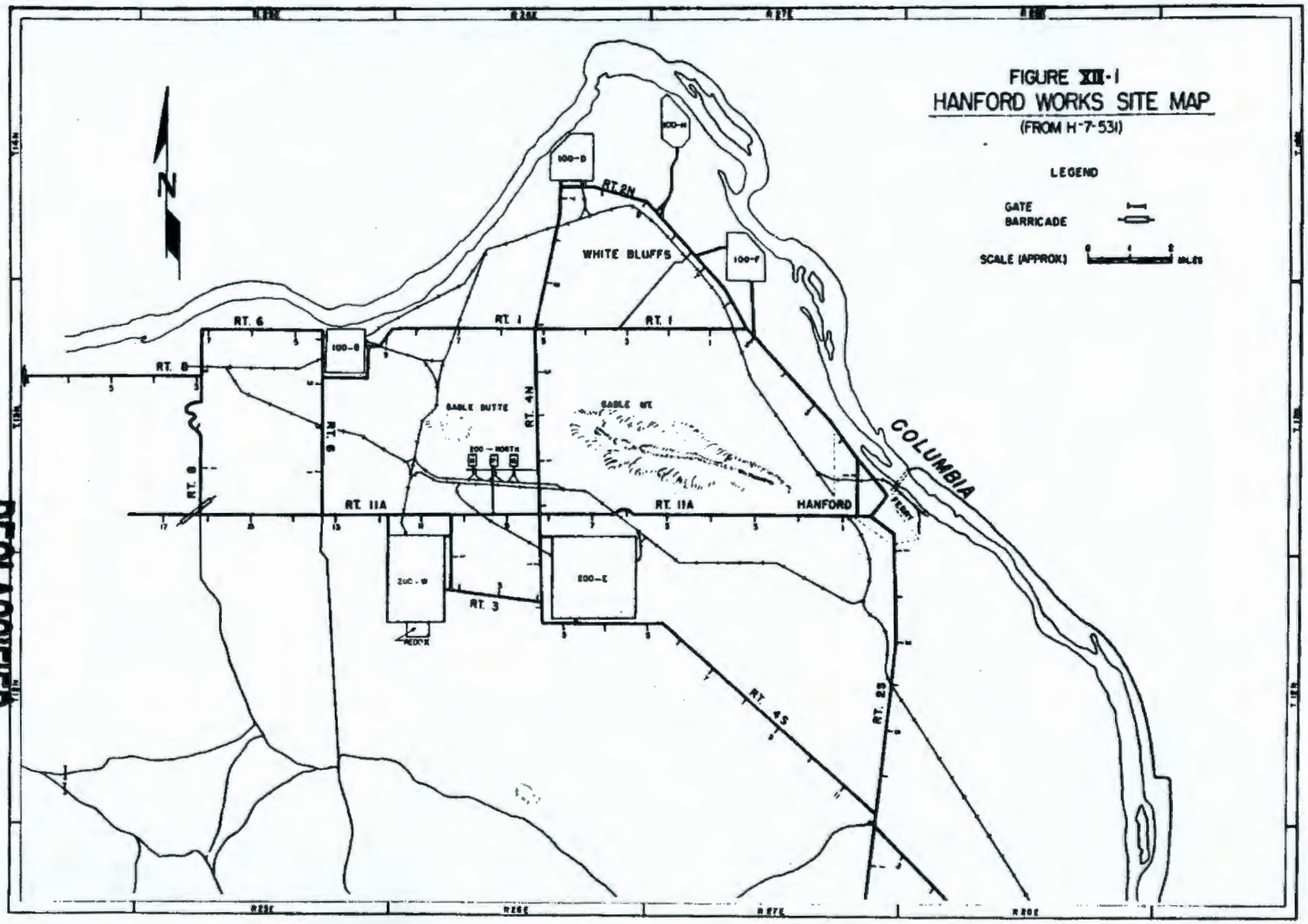

FIGURE XII-1
HANFORD WORKS SITE MAP
(FROM H-7-531)

LEGEND

GATE
BARRICADE

SCALE (APPROX.) 0 1 2 MILES

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FIG. XII-1

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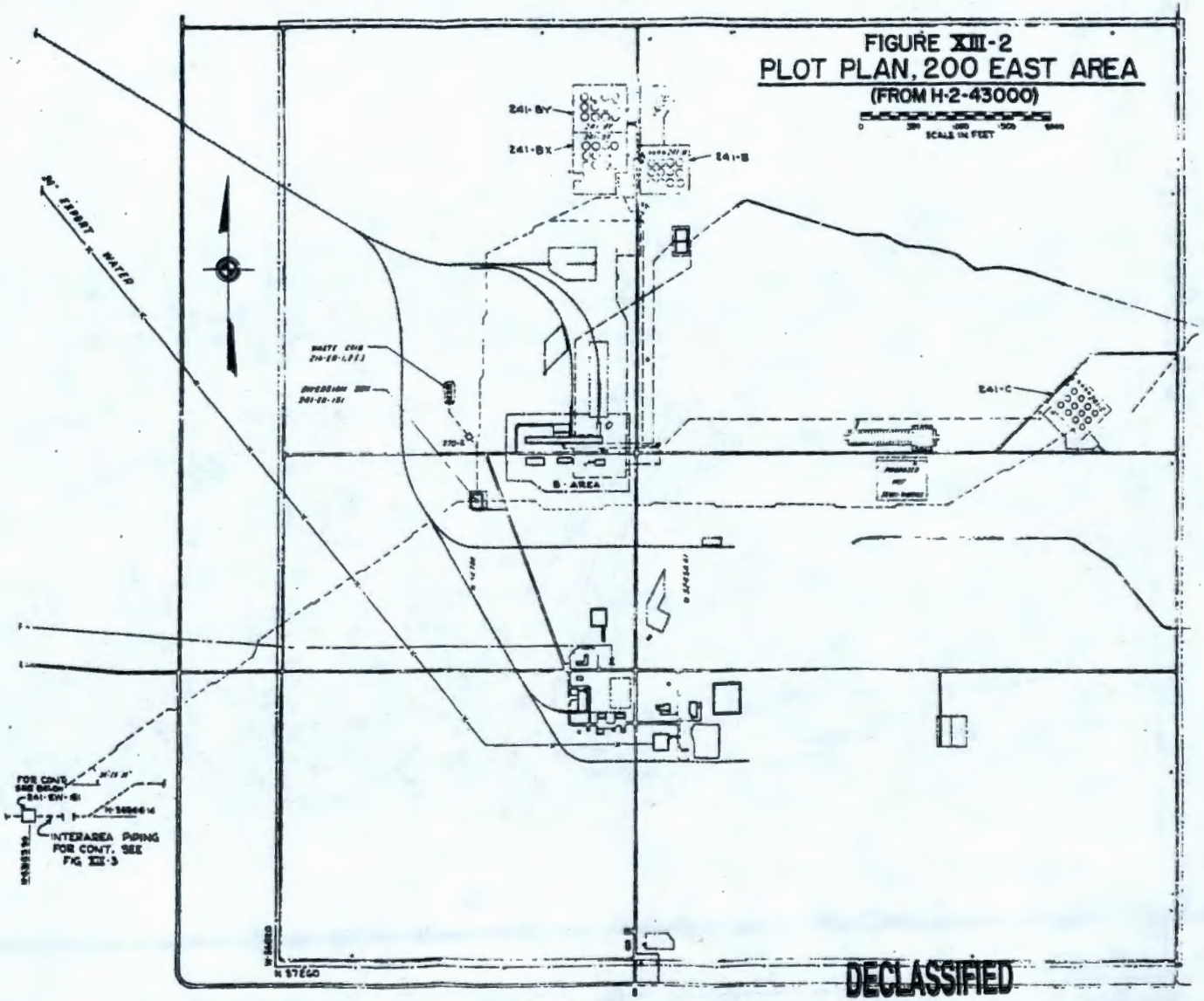

FIGURE XIII-2
PLOT PLAN, 200 EAST AREA
(FROM H-2-43000)

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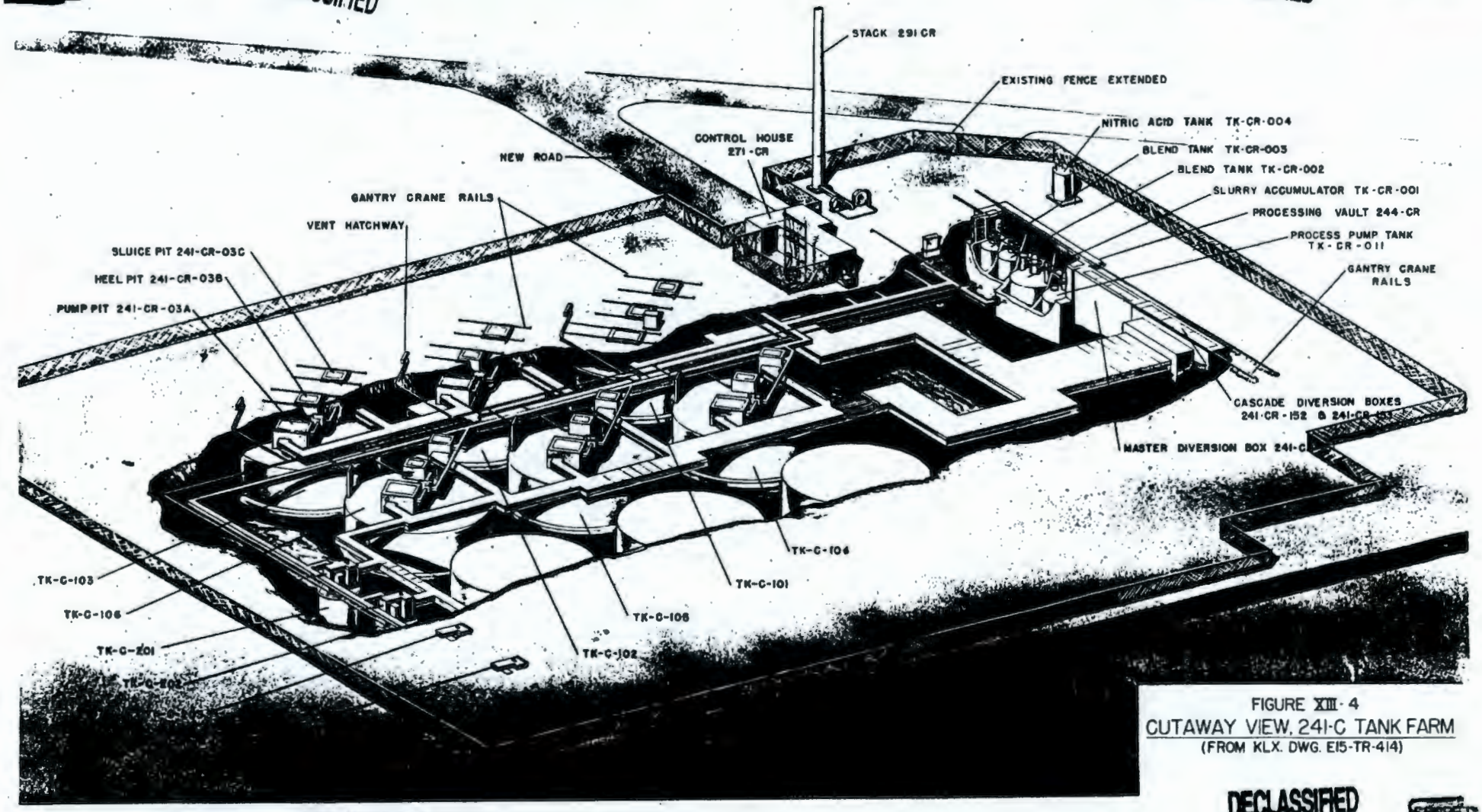

FIGURE XIII-4
CUTAWAY VIEW, 241-C TANK FARM
(FROM KLX. DWG. E15-TR-414)

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FIGURE XIII-7
PLOT PLAN, 241-BY TANK FARM
FROM DWG. Nº H-2-41649

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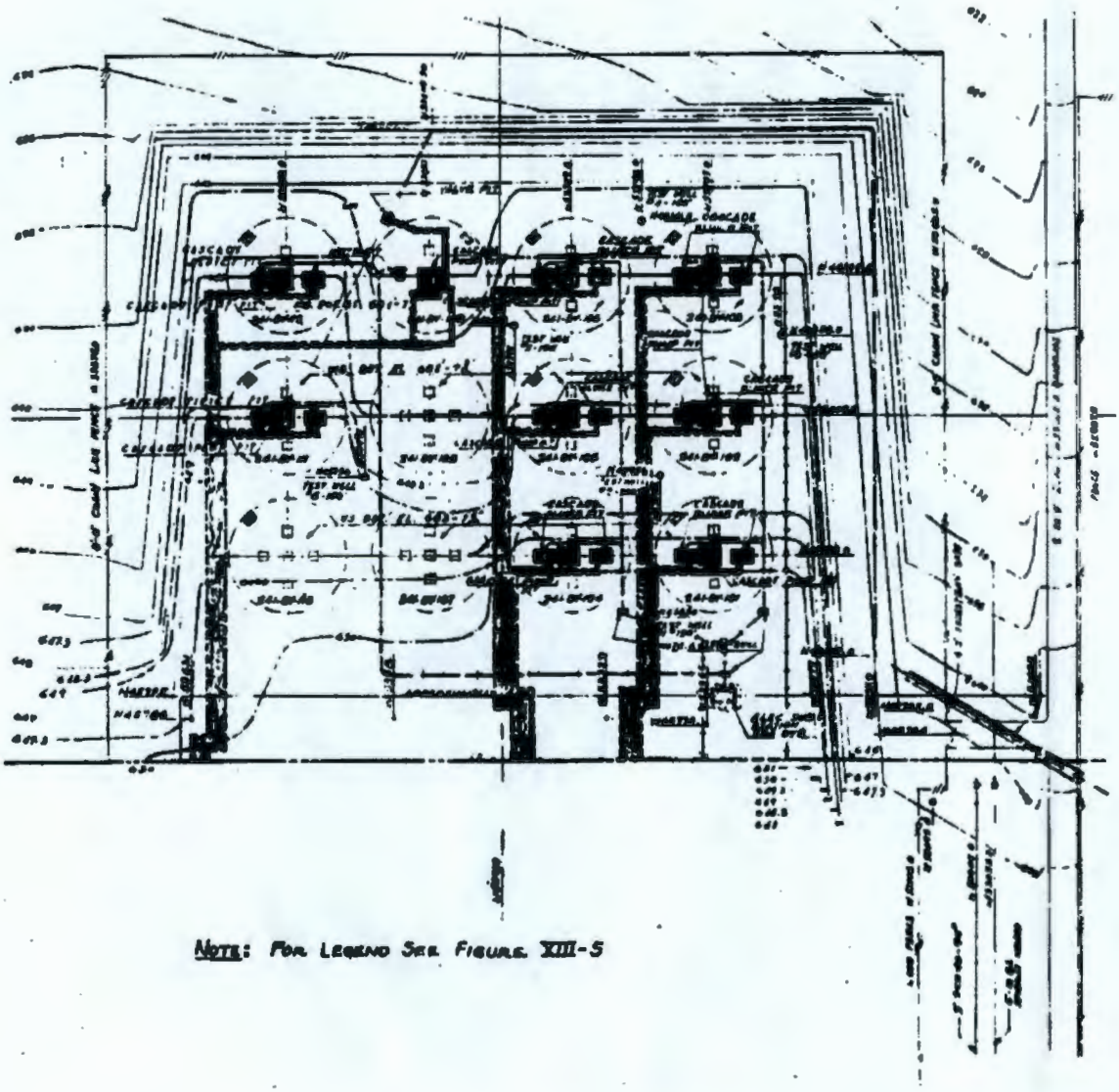

NOTE: FOR LEGEND SEE FIGURE XIII-5

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FIGURE XIII-8

PLOT PLAN, 241-C TANK FARM

(FROM H-2-40197)

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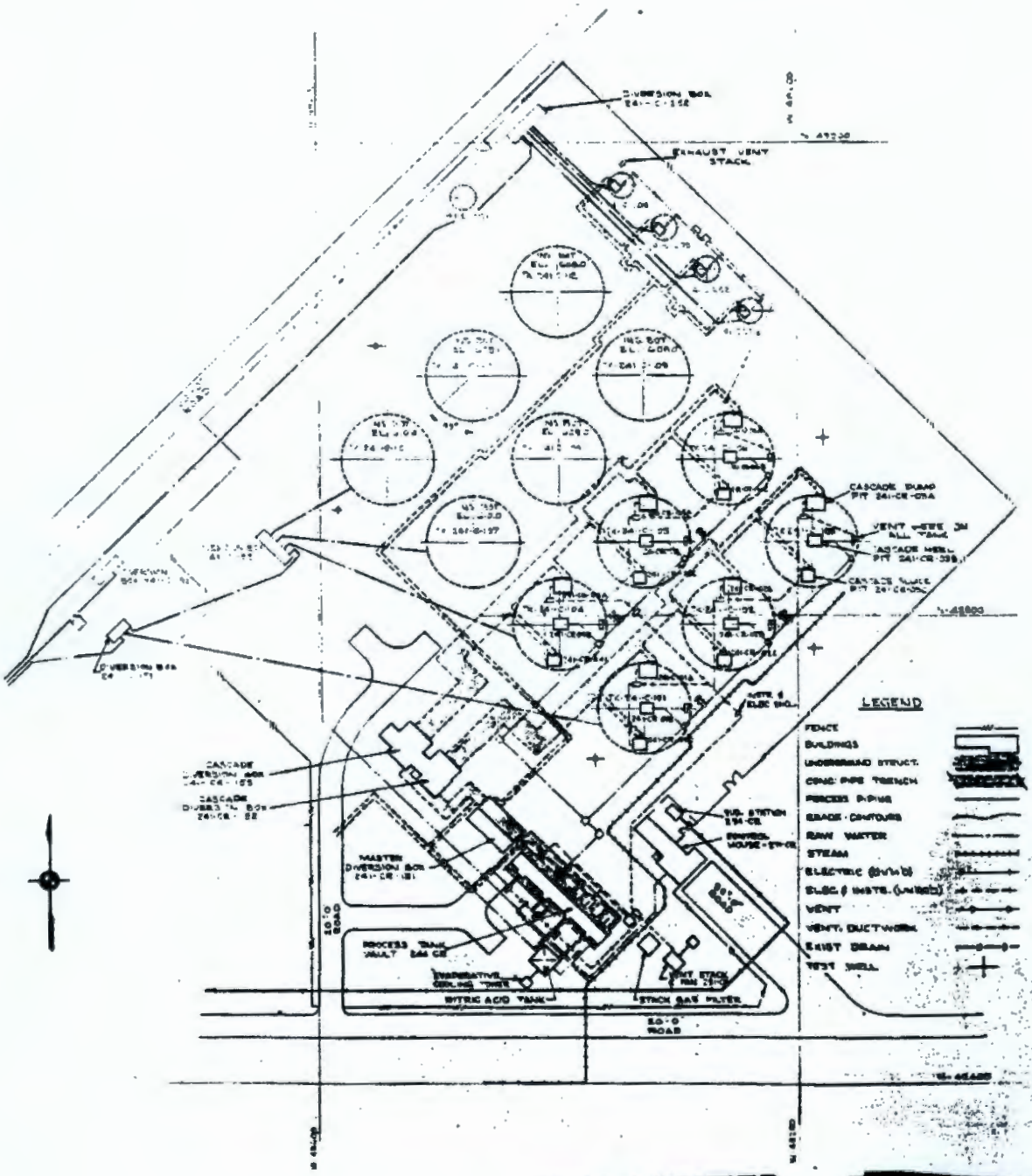

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FIGURE XIII-9
PLOT PLAN, 241-T TANK FARM
(FROM DWG. Nº H-2-40292)

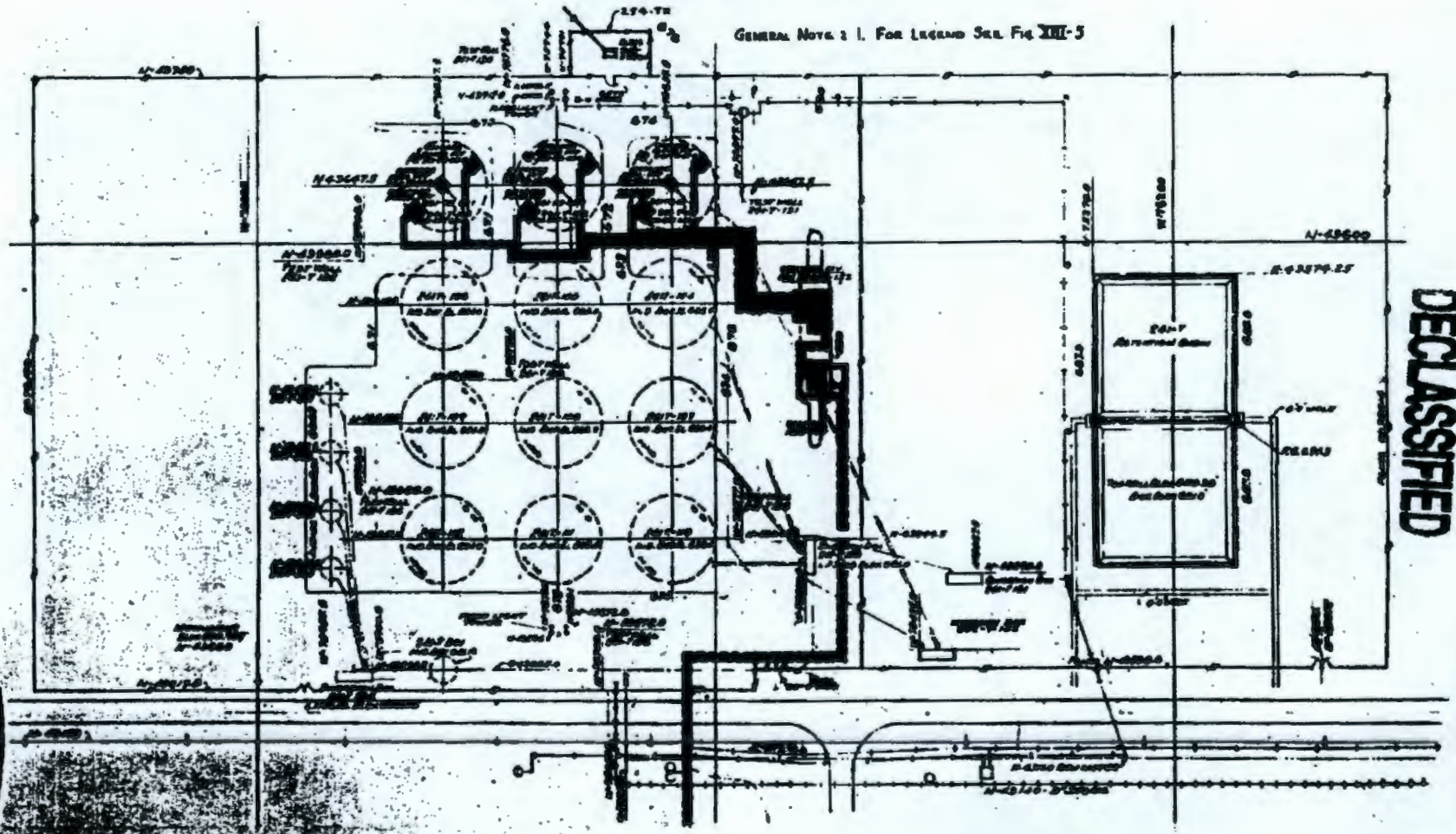

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FIGURE XIII-10
PLOT PLAN, 241-TX TANK FARM
(FROM DWG Nº H-2-40291)

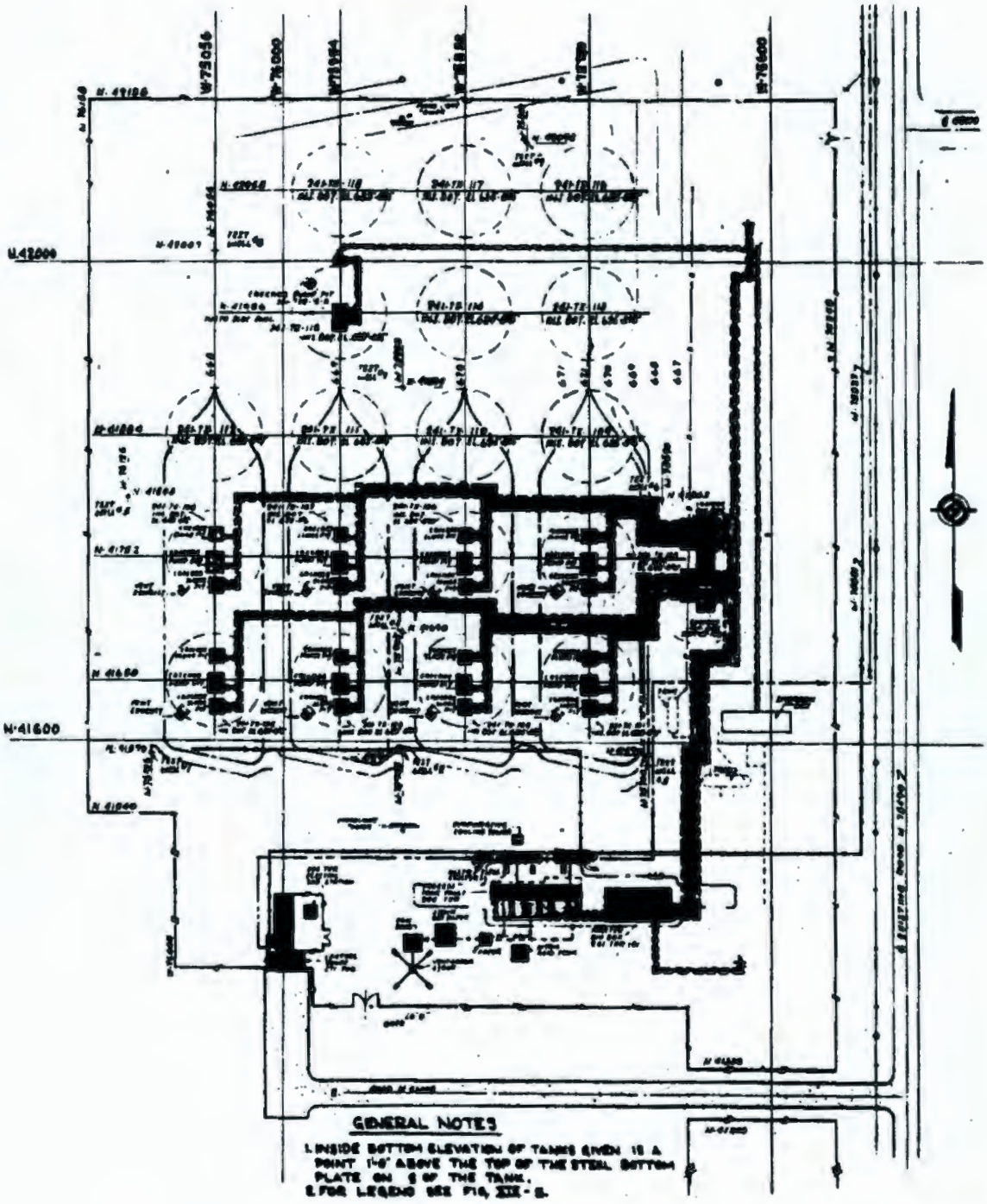

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FIGURE XIII-11

PLOT PLAN, 241-U TANK FARM

(FROM H-2-40008)

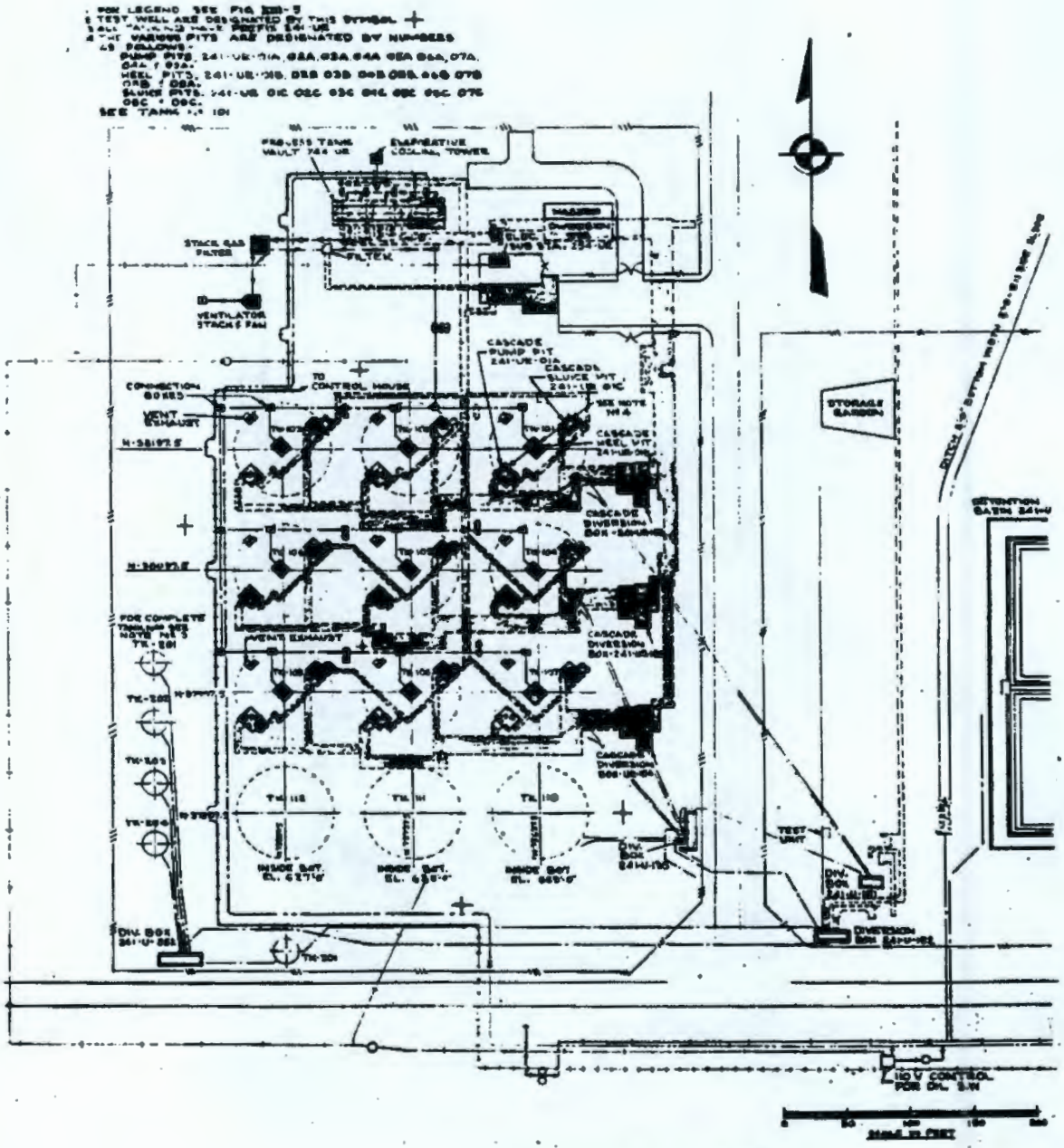

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FIGURE XIII-3
PLOT PLAN, 200 WEST AREA
(FROM H-2-43000)

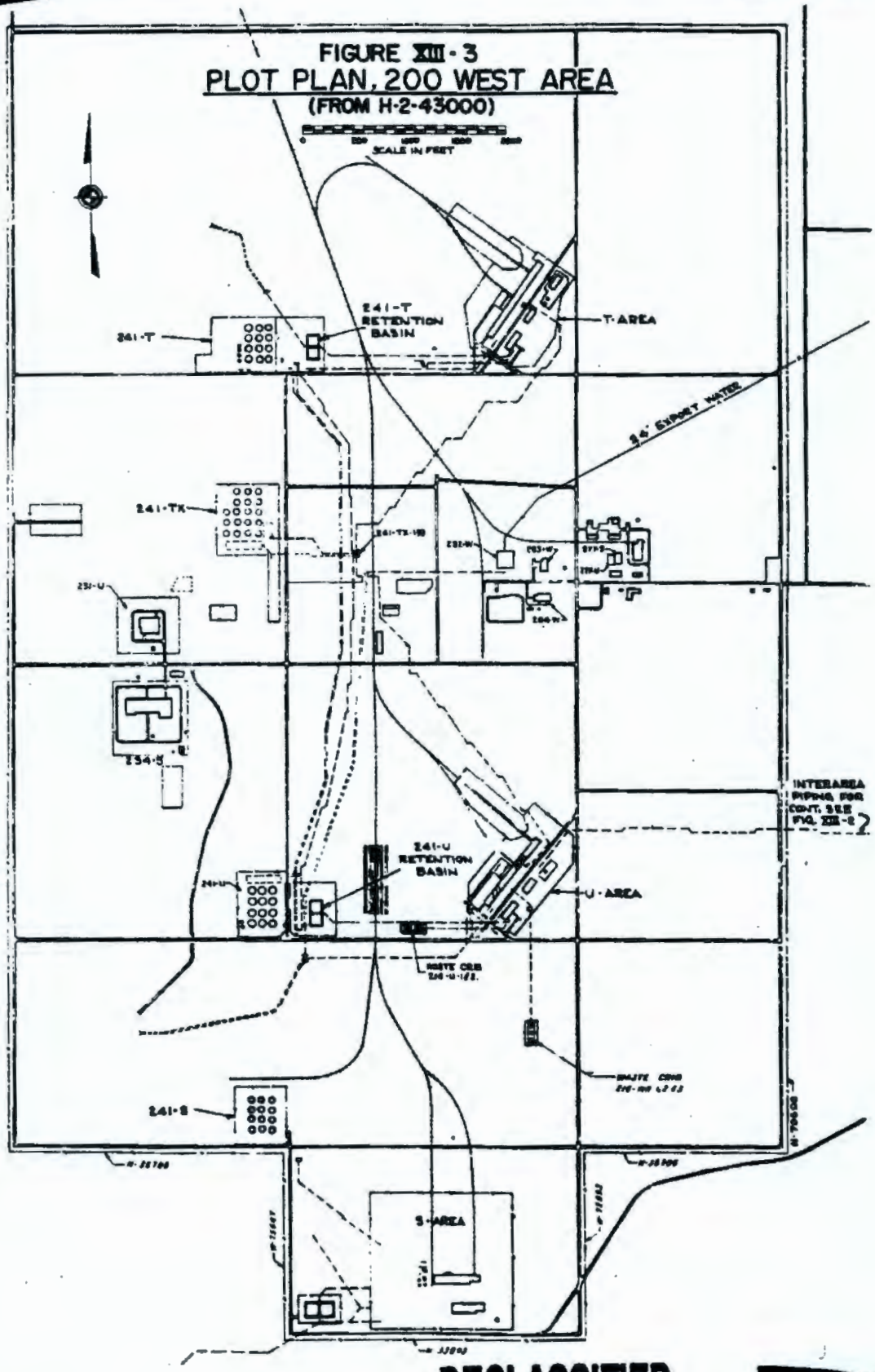

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FIGURE XIII-5
PLOT PLAN, 241-B TANK FARM
(FROM DWG. Nº H-2-40240)

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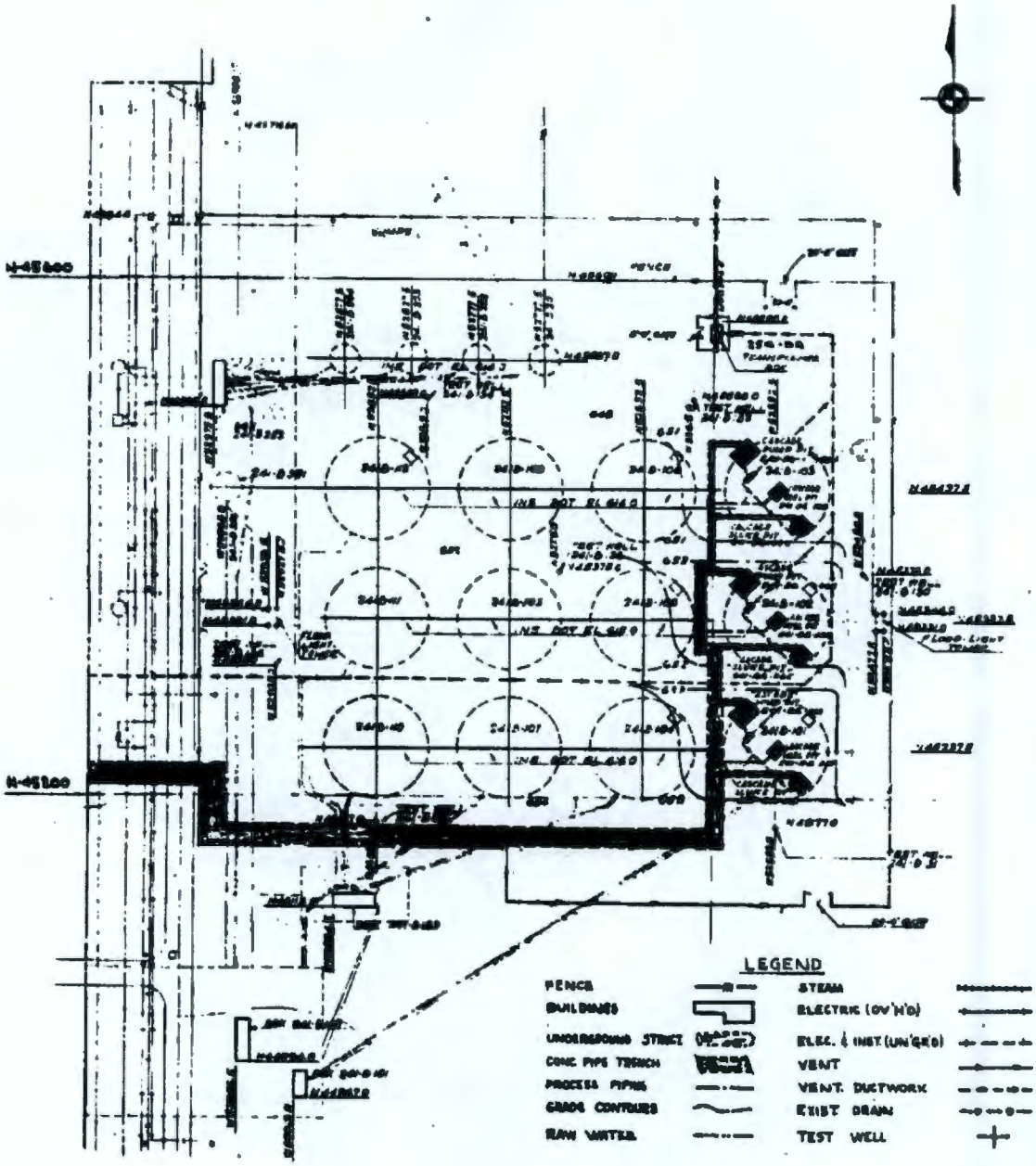

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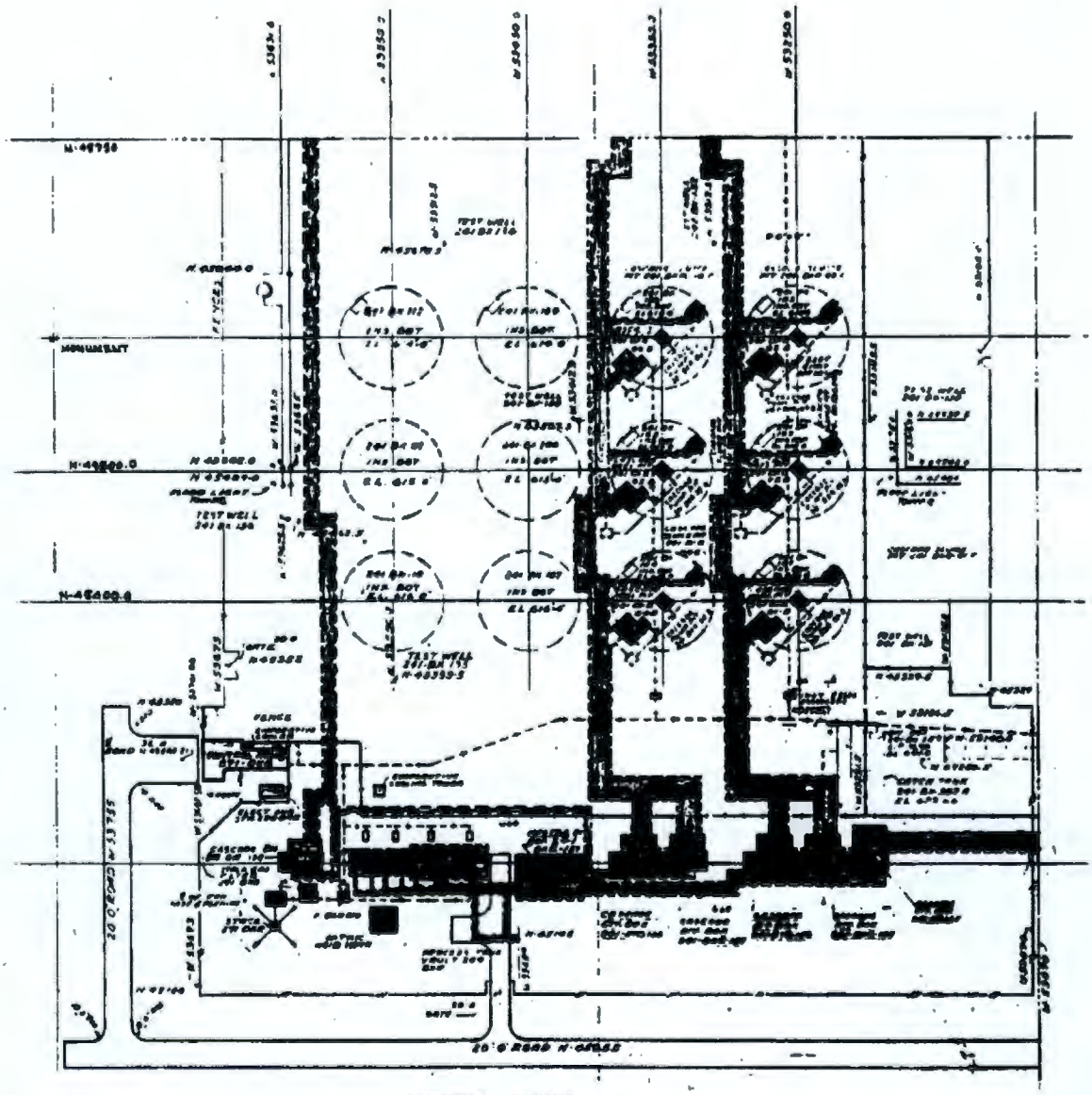
FIGURE XIII-6
PLOT PLAN, 241-BX TANK FARM
(FROM DWG. Nº H-2-40239)



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MONUMENT

GENERAL NOTES
1. FOR LEGEND SEE FIG. XIII-5.

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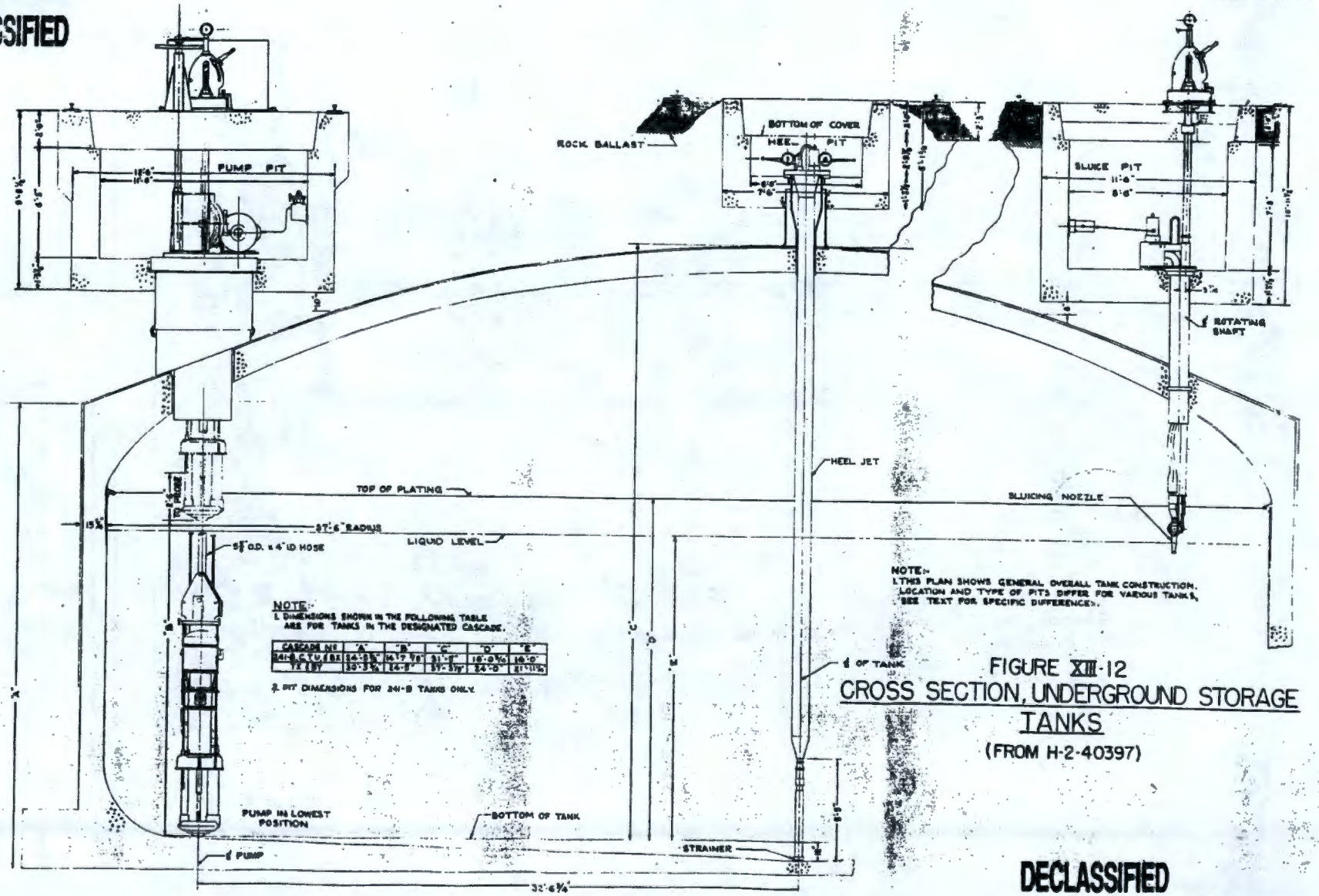

NOTE:-
1. DIMENSIONS SHOWN IN THE FOLLOWING TABLE ARE FOR TANKS IN THE DESIGNATED CASCADE.

CASCADE NO	"A"	"B"	"C"	"D"	"E"
241-B, C, T, U, BX, TX, BY	24'-3⅝"	14'-7 7/8"	31'-8"	16'-0 9/16"	16'-0"
	30'-3⅝"	24'-8"	31'-3 7/8"	24'-0"	21'-11 15/16"

℄ PIT DIMENSIONS FOR 241-B TANKS ONLY.

NOTE:-
1. THIS PLAN SHOWS GENERAL OVERALL TANK CONSTRUCTION. LOCATION AND TYPE OF PITS DIFFER FOR VARIOUS TANKS, (SEE TEXT FOR SPECIFIC DIFFERENCES).

FIGURE XIII-12
CROSS SECTION, UNDERGROUND STORAGE TANKS
(FROM H-2-40397)

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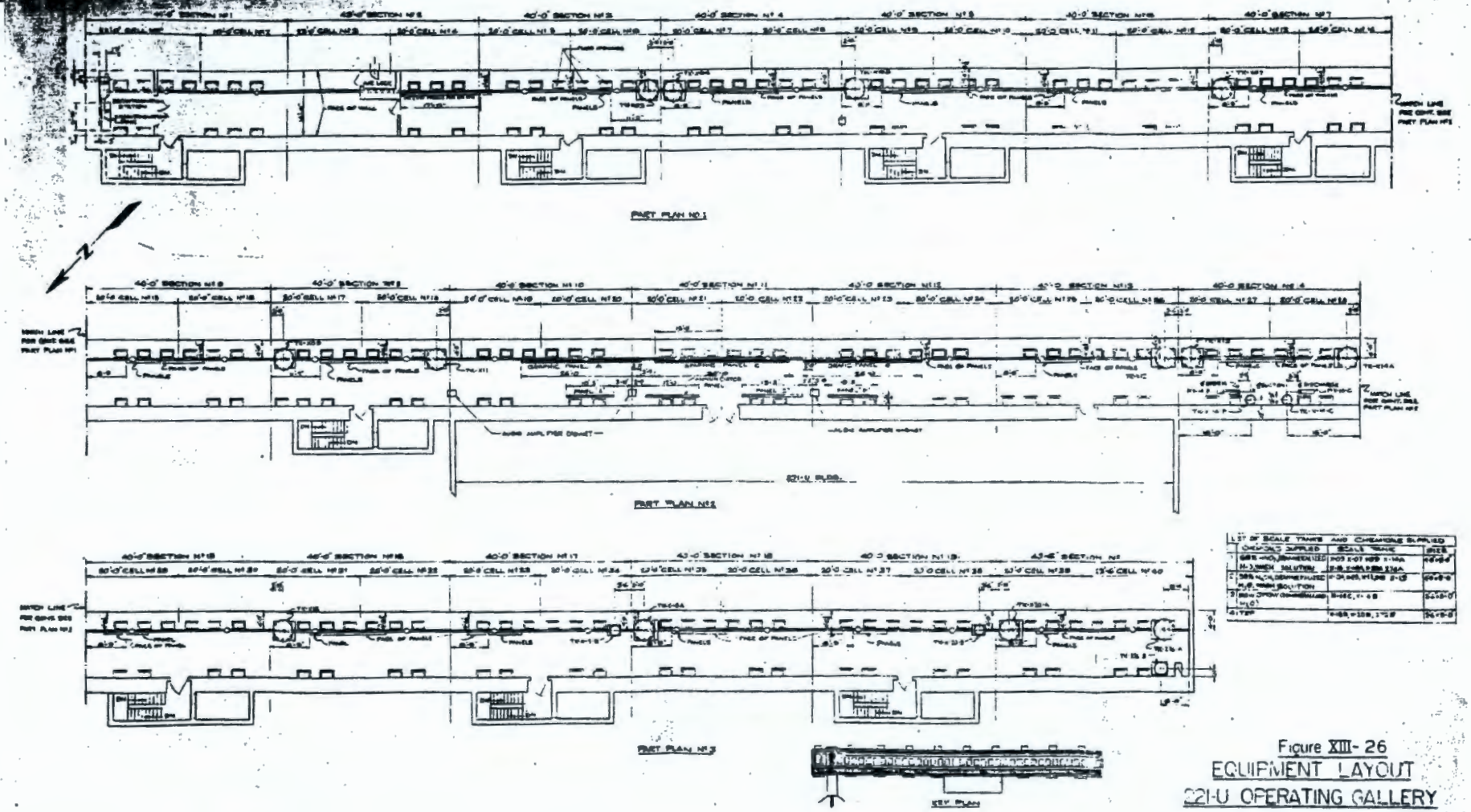

Figure XIII-26
EQUIPMENT LAYOUT
221-U OPERATING GALLERY
(From: Dwg. H-2-40307)

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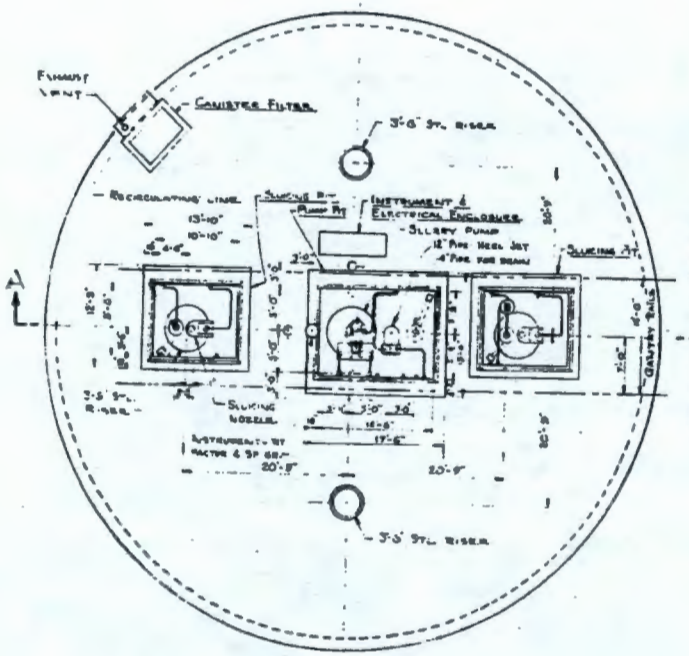
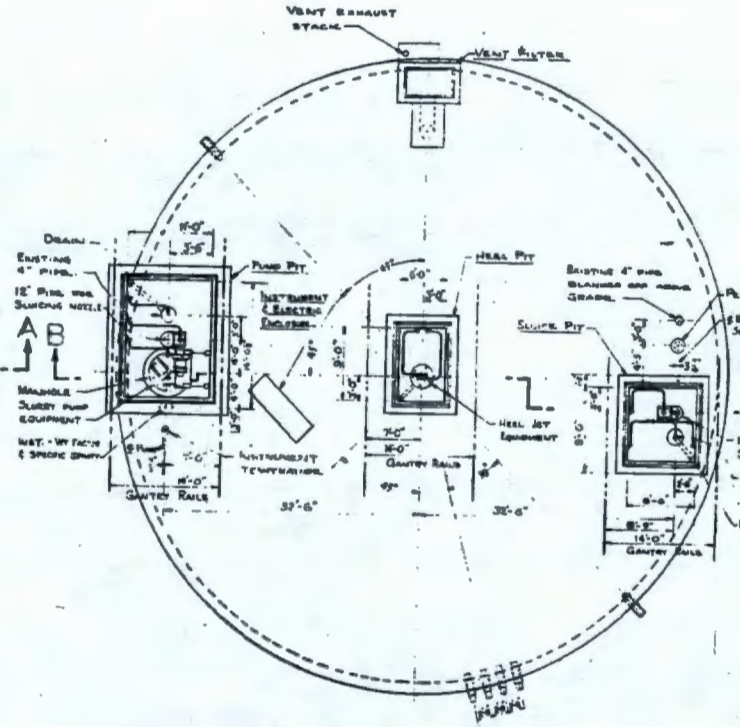


TYPICAL 241-BYR AND TXR 75-FT. DIAMETER TANK ARRANGEMENT

For Section "A-A" See Chapter XVI

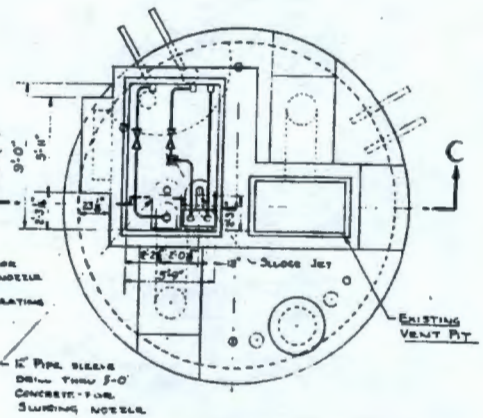
Reference: H-2-40399



TYPICAL 241-BR, CR, TR, AND BXR 75-FT. DIAMETER TANK ARRANGEMENT

For Section "B-B" See Fig. XIII-12

Reference: H-2-40396



241-CR 20-FT. DIAMETER TANK ARRANGEMENT

(TANKS 201, 202, 203, AND 204)

For Section "C-C" See Chapter XVII

Reference: H-2-40398

Figure XIII-13

EQUIPMENT ARRANGEMENT ABOVE TYPICAL TANK FARM TANKS

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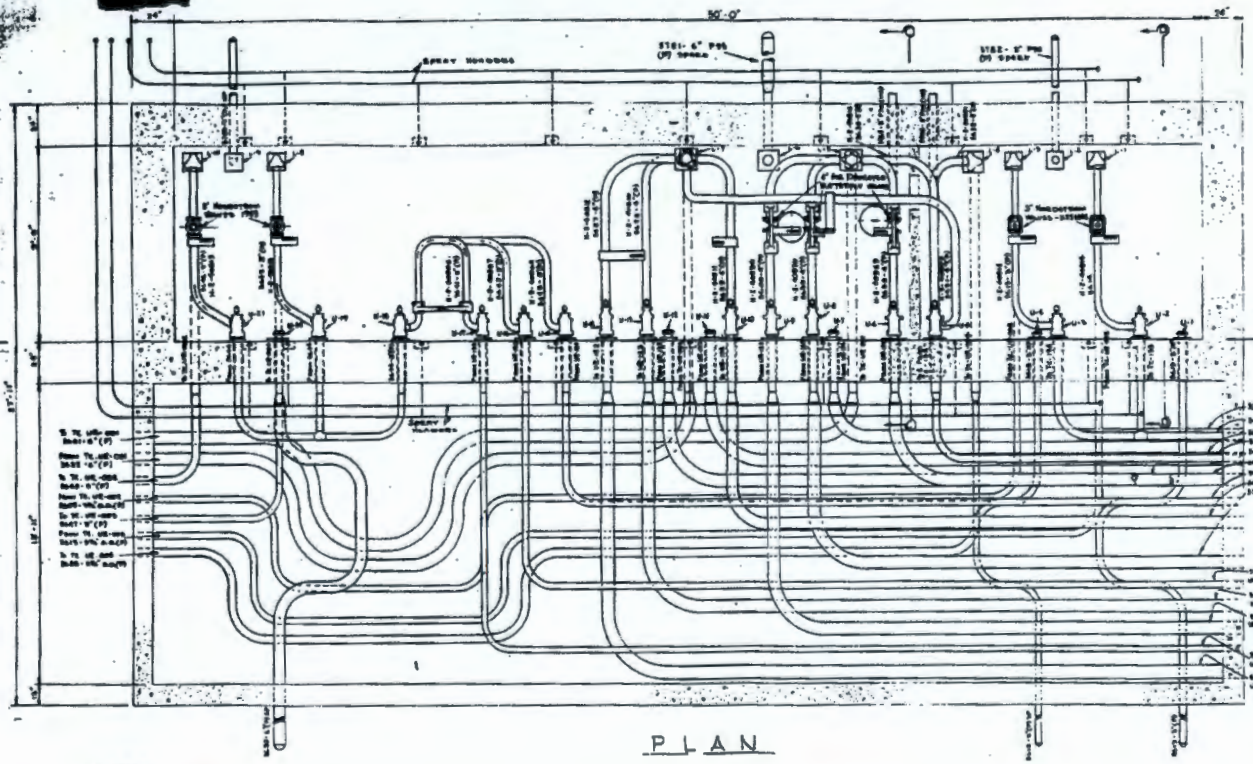

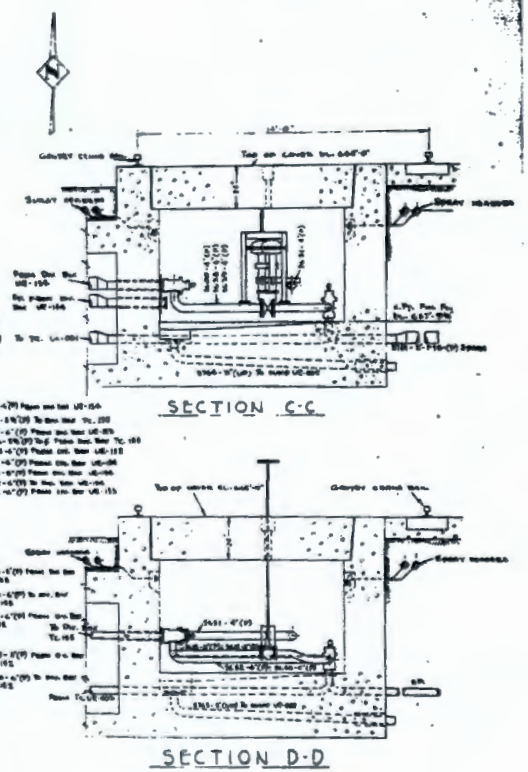

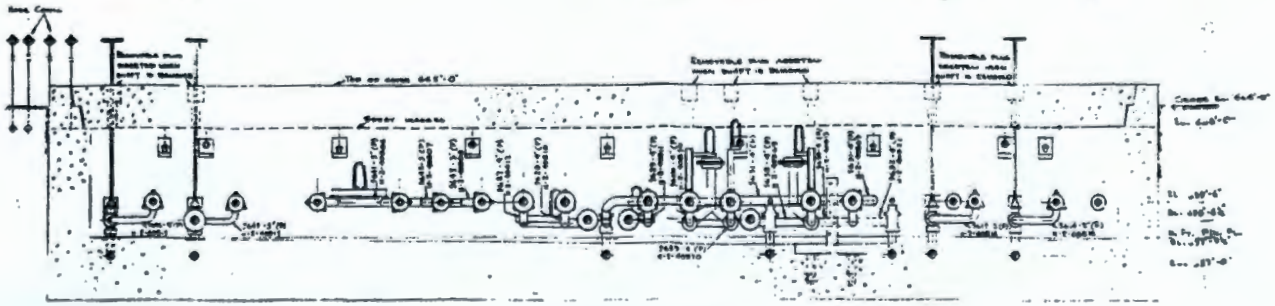

Figure XIII-14
TYPICAL TANK FARM DIVERSION BOX
PIPING ARRANGEMENT
MASTER DIVERSION BOX 241-UR-151

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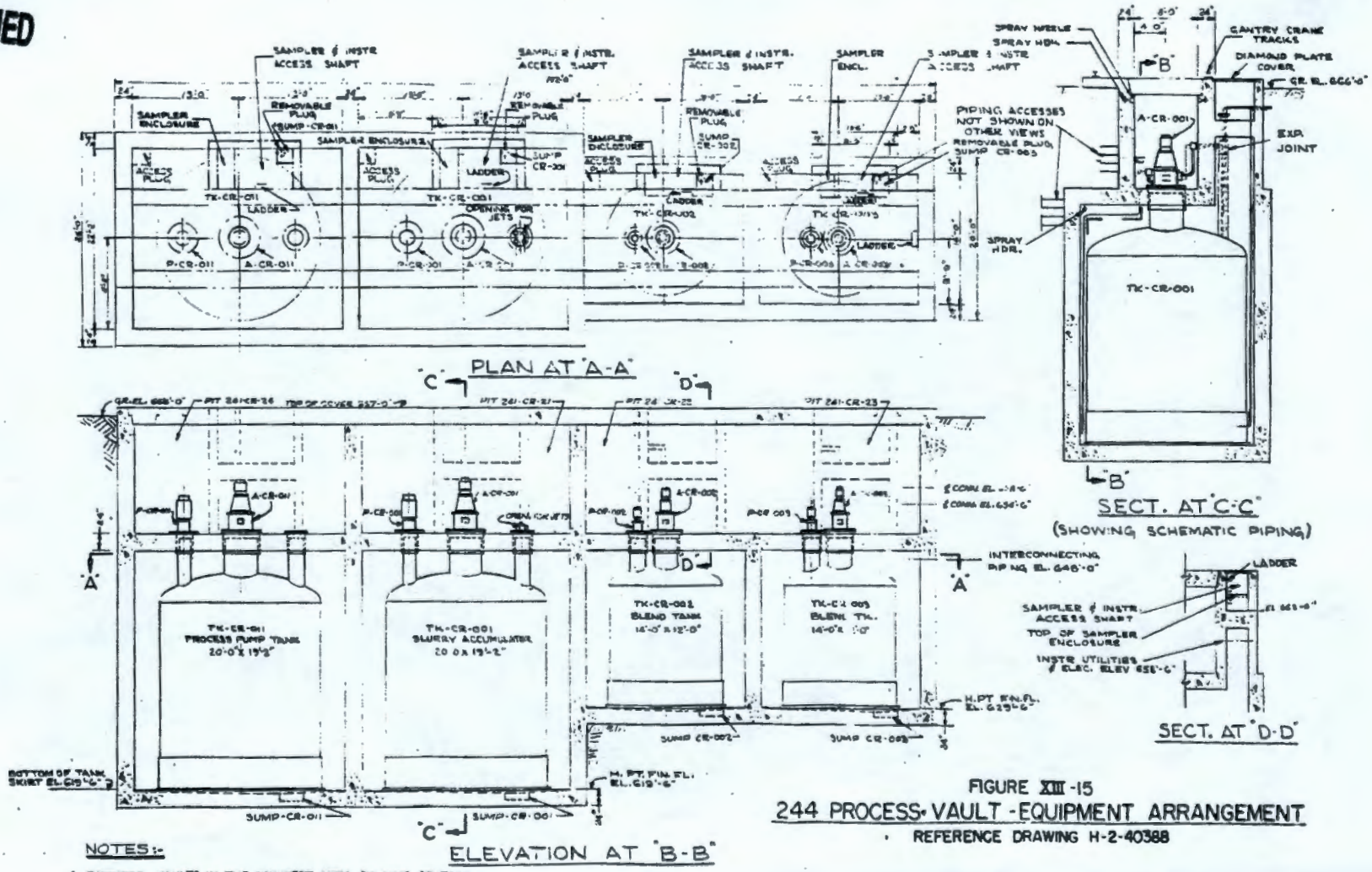

FIGURE XIII-15
244 PROCESS VAULT - EQUIPMENT ARRANGEMENT
REFERENCE DRAWING H-2-40388

NOTES:-

1. PROCESS VAULTS IN THE 200 WEST AREA DO NOT CONTAIN PROCESS PUMP TANKS. PROCESS VAULT 244-TR CONTAINS ONLY A SLURRY ACCUMULATOR & BLEND TANKS WHILE 244-UR CONTAINS THESE PLUS AN HNO_3 TANK.

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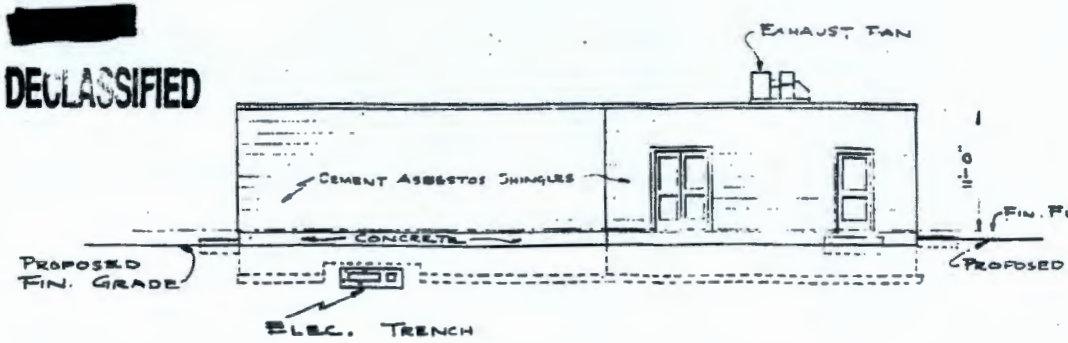
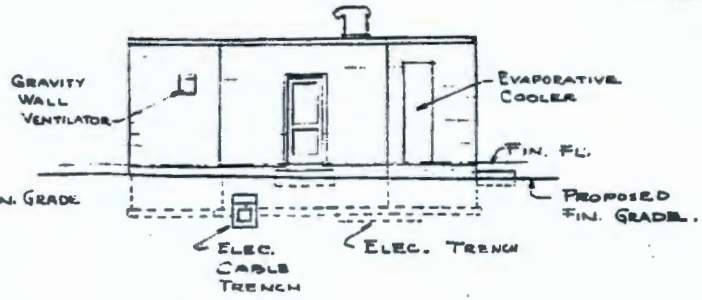
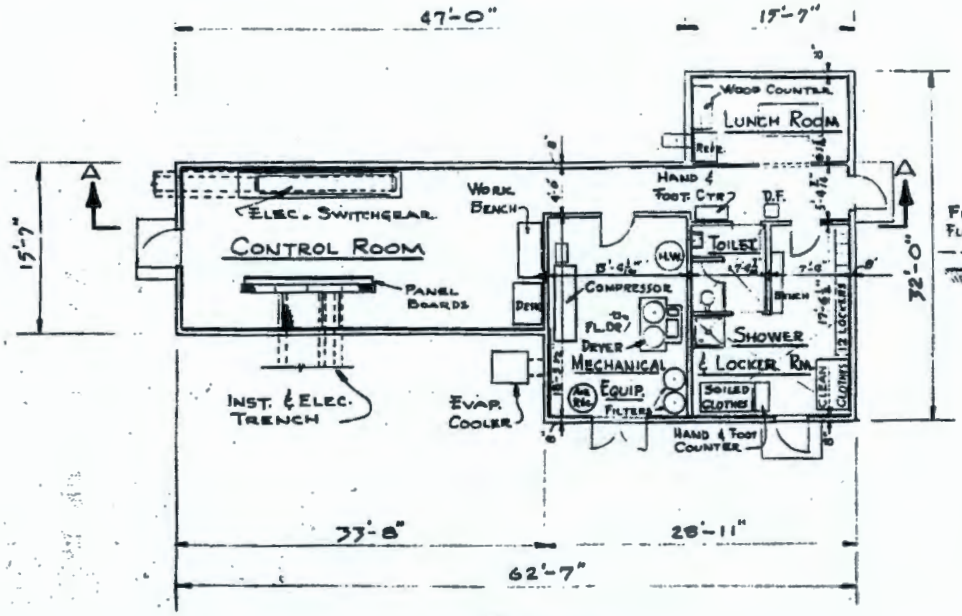
FIG XIII-16



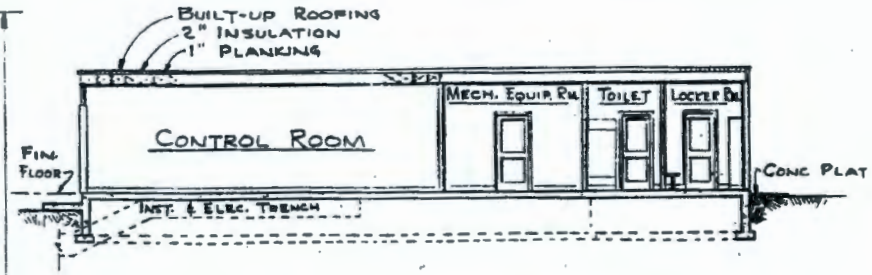
SOUTH ELEVATION



WEST ELEVATION



PLAN



SECTION A-A

FIGURE XIII-16
CONTROL HOUSE ARCHITECTURAL
PLAN, ELEVATION, AND SECTION

CONTROL HOUSE (271-BXR)

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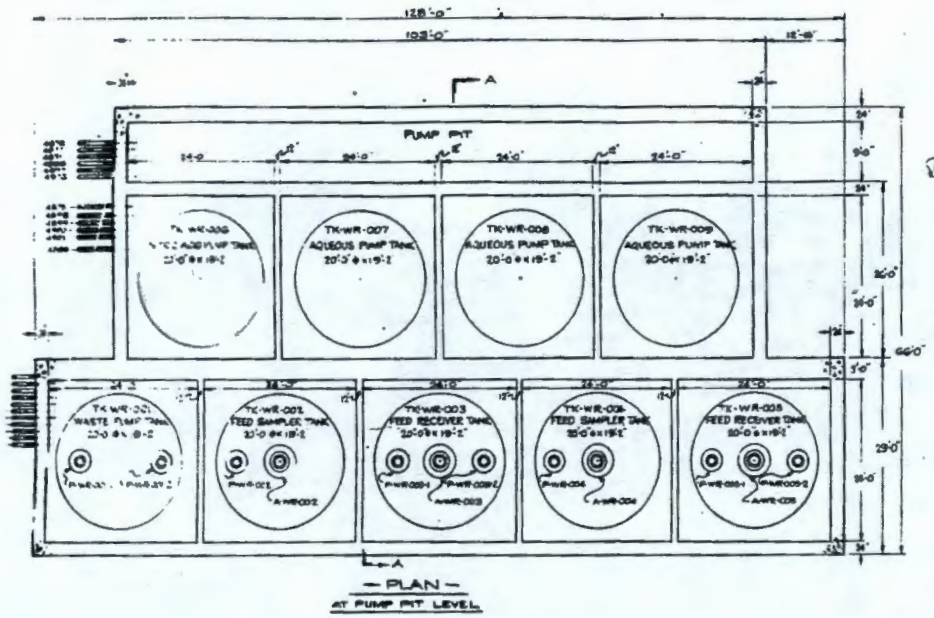

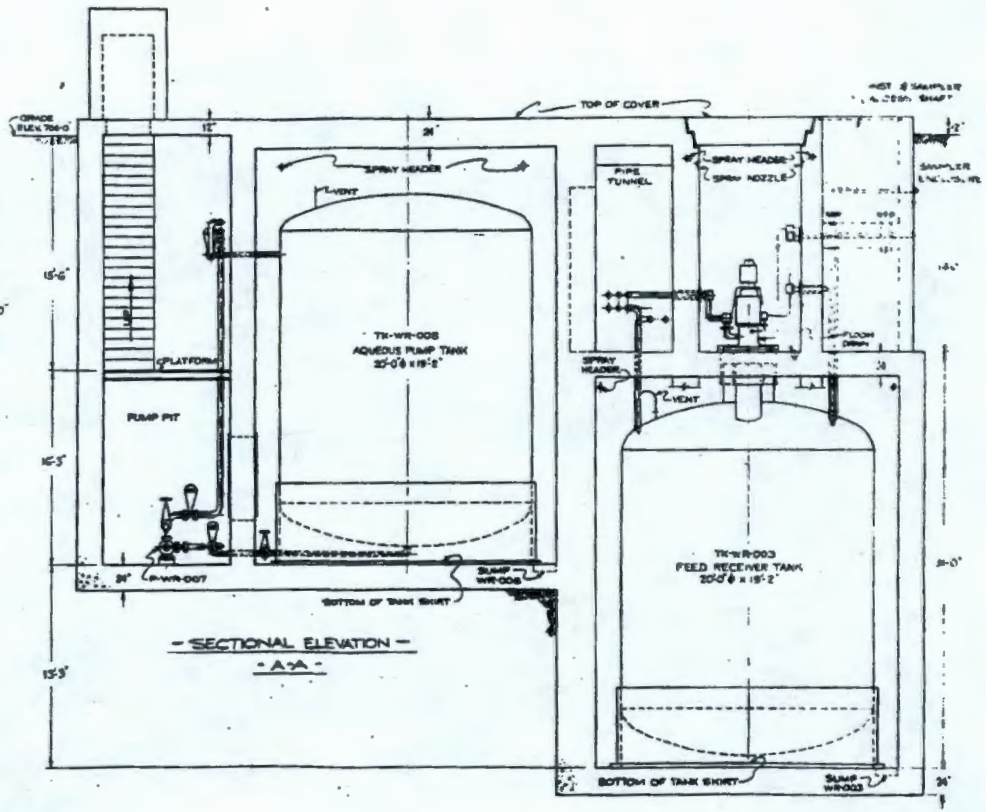

Figure XIII-17
241-WR DIVERSION VAULT
(From Dwg. H-2-40042 & H-2-40110)

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FIG. XIII-18

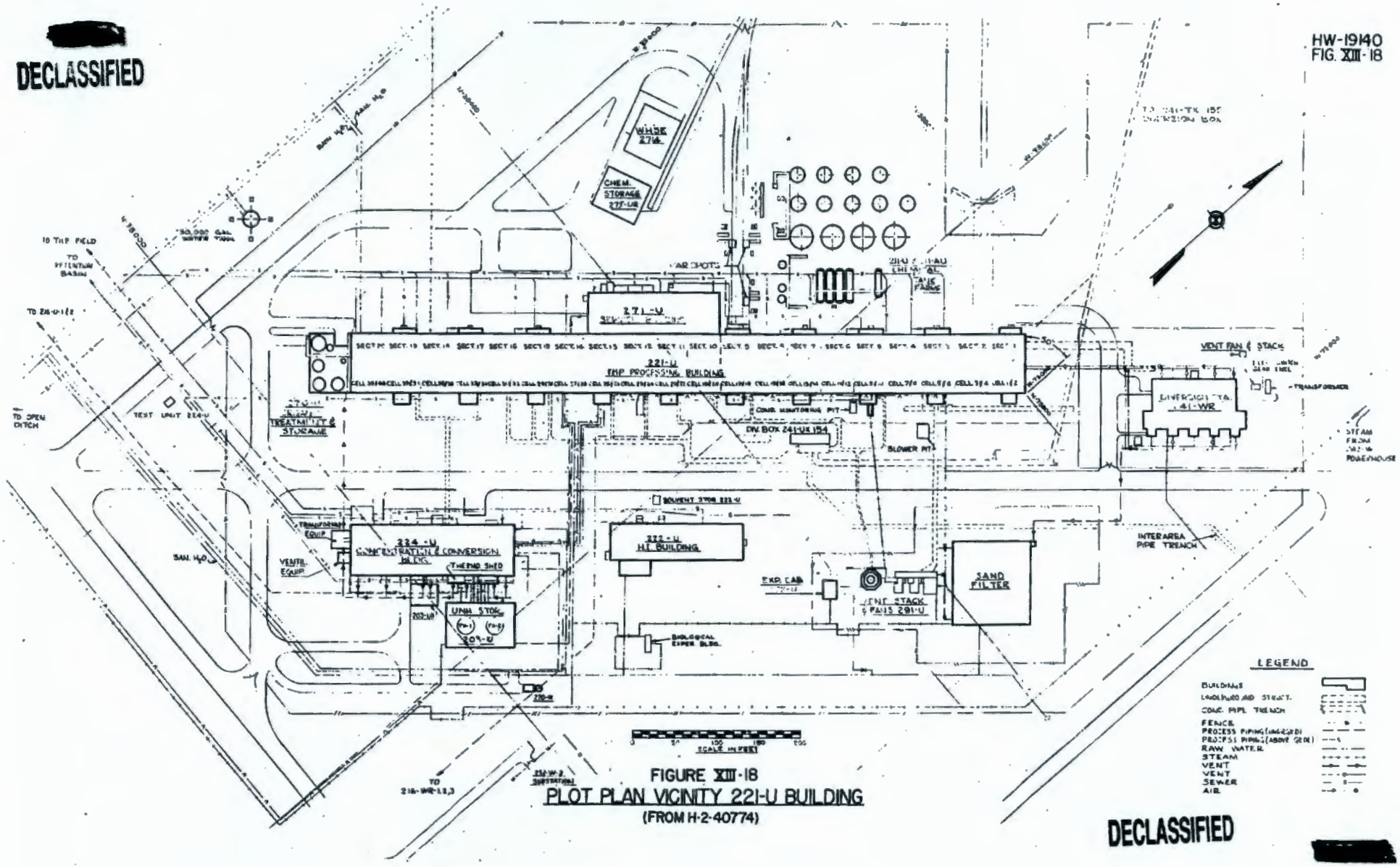

FIGURE XIII-18
PLOT PLAN VICINITY 221-U BUILDING
(FROM H-2-40774)

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FIGURE XIII- 19

CUTAWAY VIEW OF 221-U BUILDING

(FROM HW-10475, SECT. C, PG. 242)

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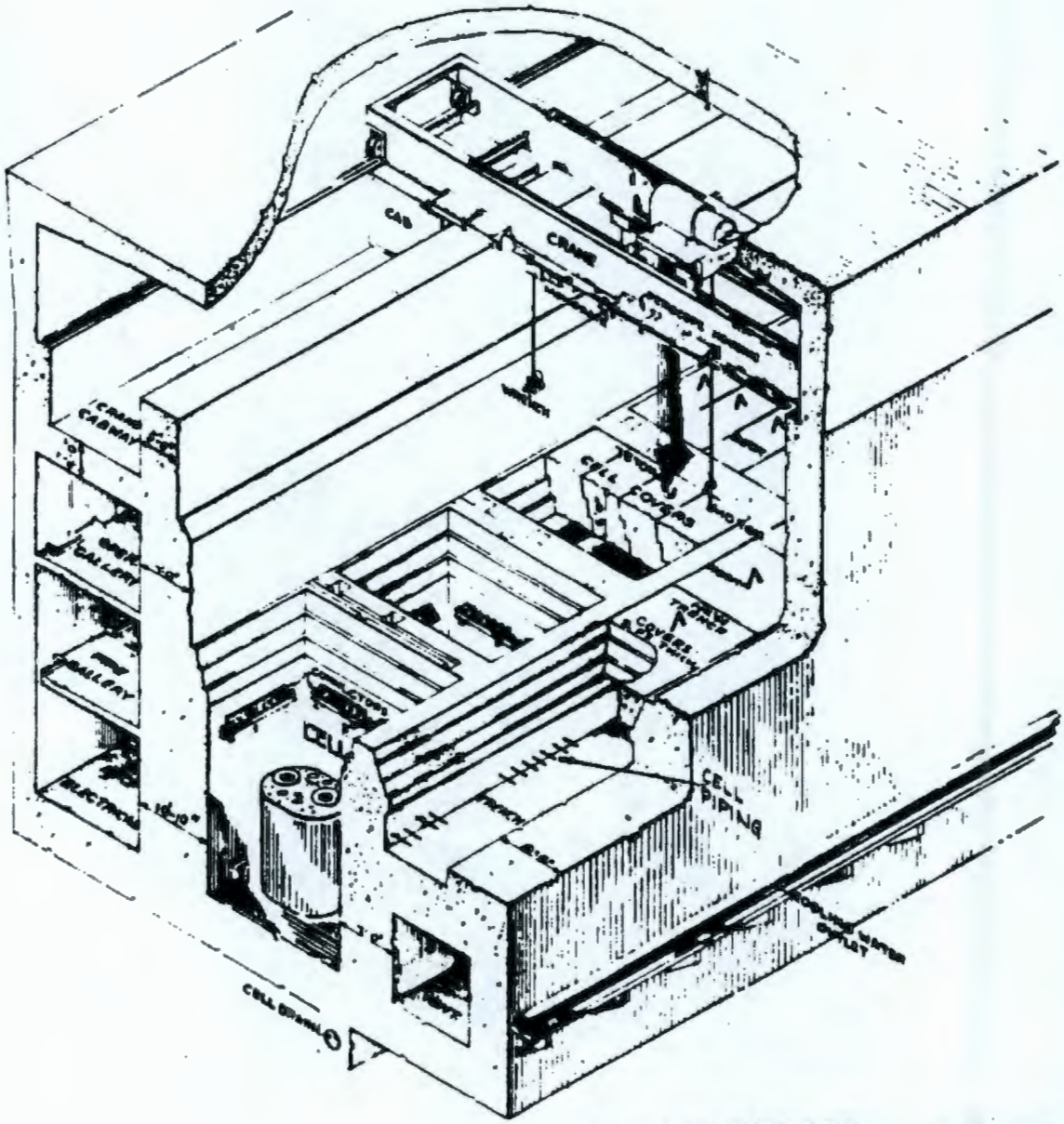

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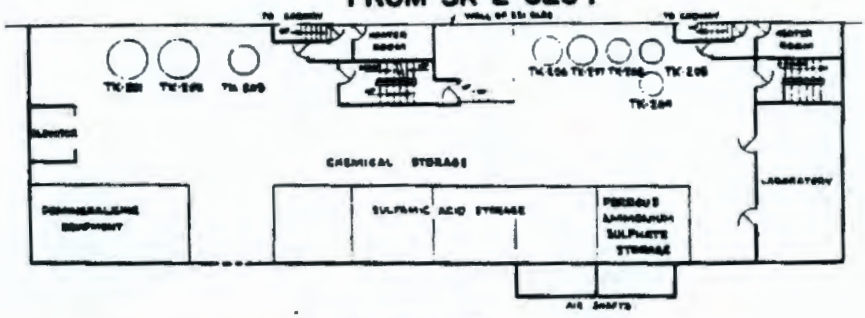
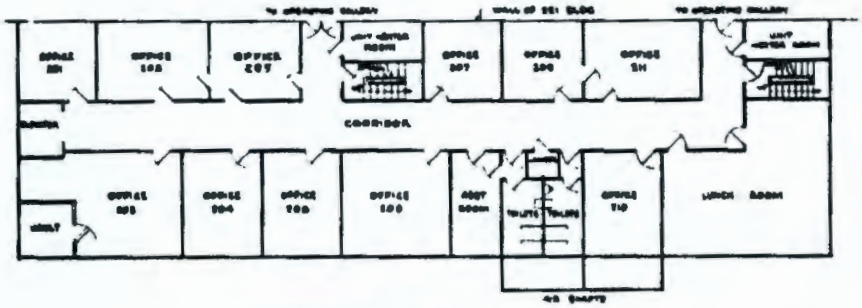
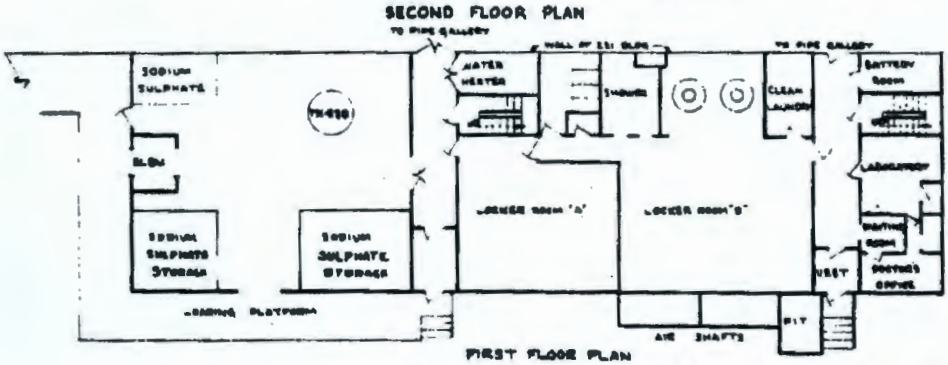
FIGURE XIII-27
FLOOR PLAN AND EQUIPMENT LAYOUT
271-U BUILDING
FROM SK-2-6207



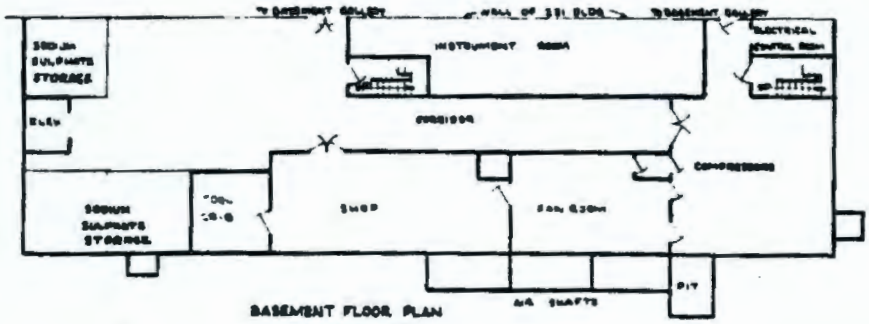
THIRD FLOOR PLAN



SECOND FLOOR PLAN



FIRST FLOOR PLAN



BASEMENT FLOOR PLAN

TANK LIST

TANK No	PROCESS USE	CAPACITY - GAL.
201	HNO_3 HEAD TANK	3,700
202	RO3 HEAD TANK	3,700
203	WASH SOLUTION MAKE-UP	900
204	RCX BLEND TANK	850
205	$NaOH$ HEAD TANK	600
206	SULFAMIC ACID MAKE-UP	900
207	FERROUS AMMONIUM SULFATE MAKE-UP	900
208	RAS FEED TANK	850
210	Na_2SO_4 MAKE UP	3000

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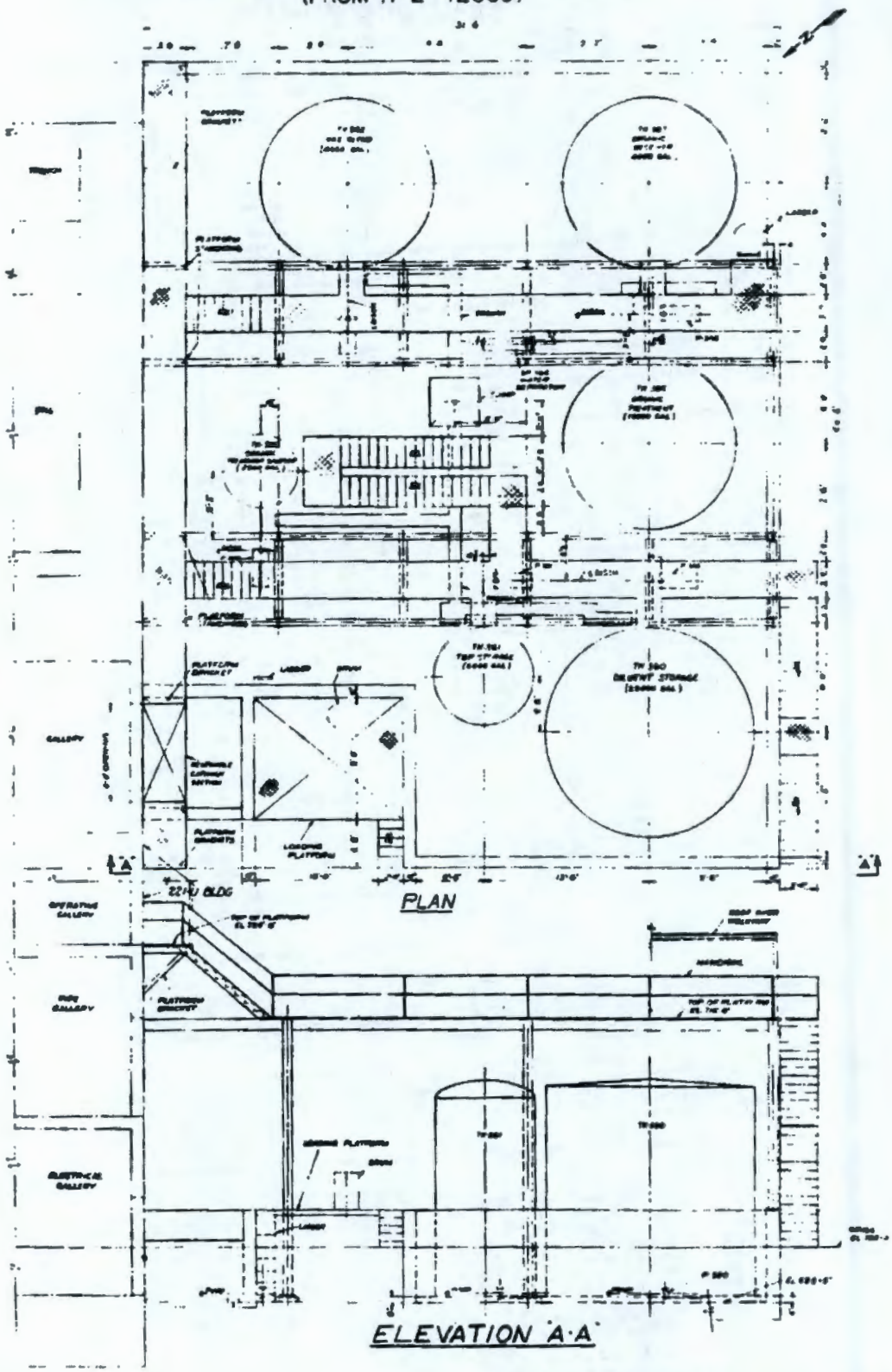
FIGURE XIII-28
LAYOUT OF 276-U BUILDING
(FROM H-2-42069)



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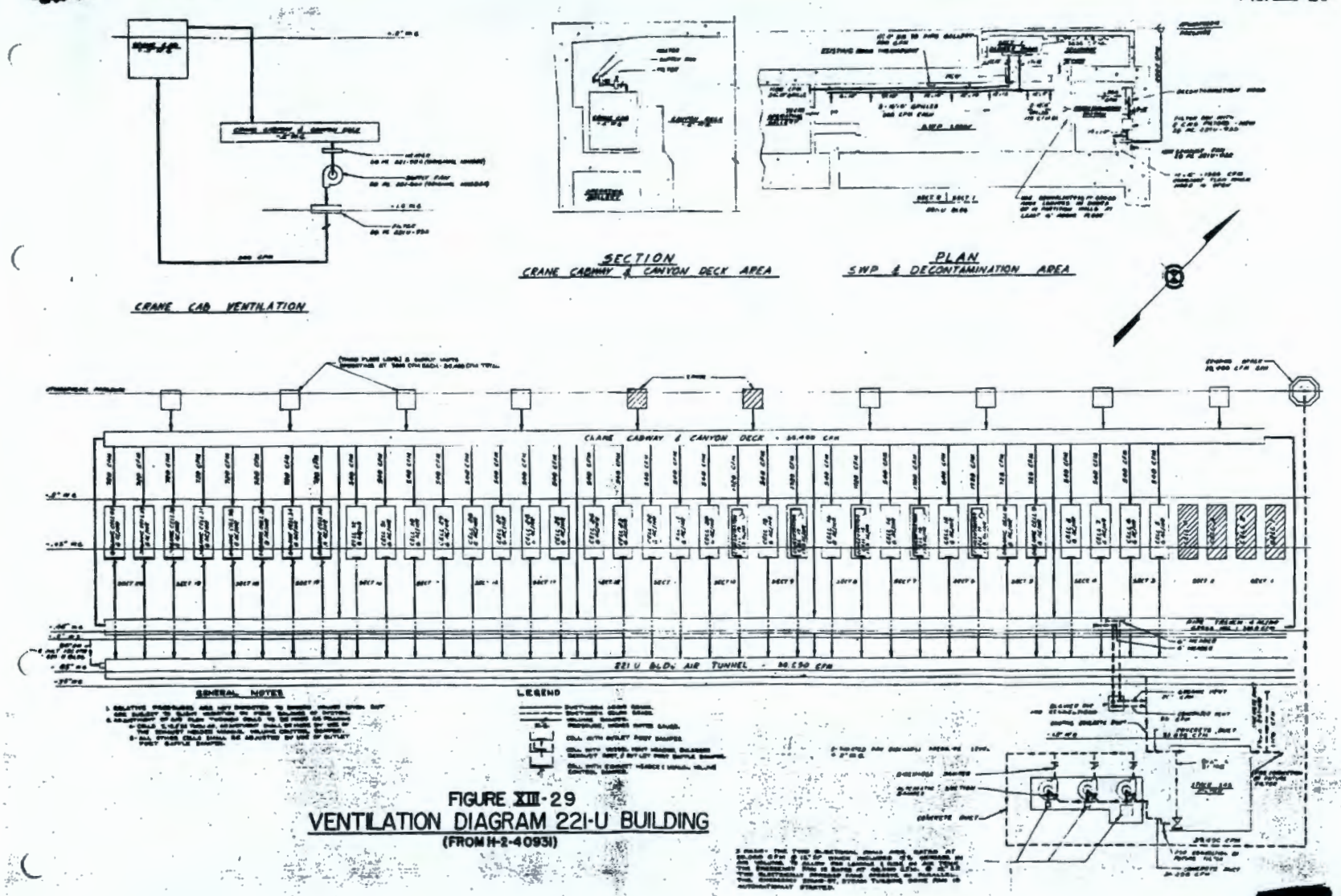

FIGURE XIII-29
VENTILATION DIAGRAM 221-U BUILDING
(FROM H-2-40931)

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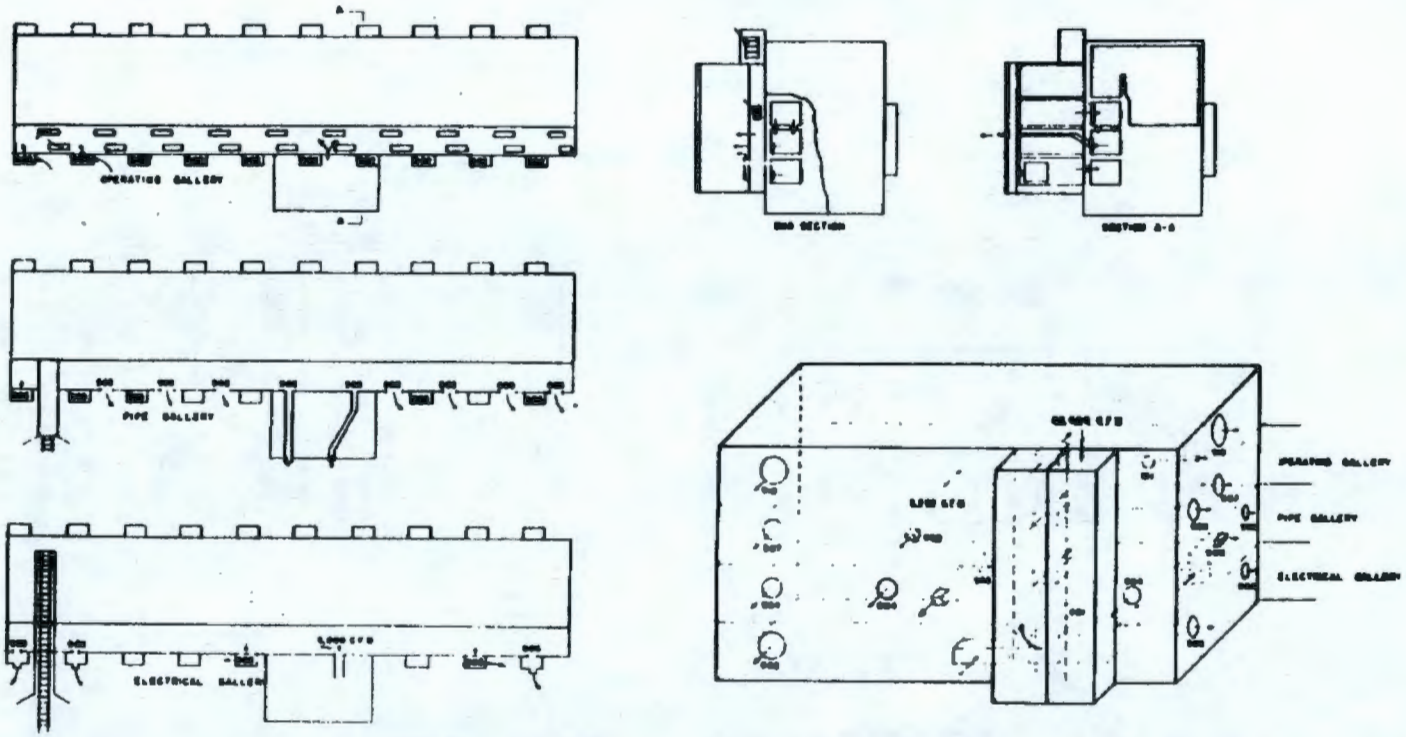

LEGEND 221 BUILDING

EF 902	CARRIER HUMIDIFYING UNIT	4000 CFM
EF 903	GALLERY EXHAUST FANS	4000 CFM
EF 905	TOILET AND BATTERY ROOM FANS	1000 CFM
EF 906	CARRIER HUMIDIFYING UNIT	4000 CFM

REFERENCE DRAWINGS

W 73547	EXHAUST FAN ARRANGEMENT	221
W 70164	UNIT HEATER ARRANGEMENT	221
W 70166	UNIT HEATER ARRANGEMENT	221
W 71176	VENTILATION	271
W 71175	VENTILATION	271

LEGEND 271 BUILDING

EF 901	BUFFALO HUMIDIFYING UNIT	20,000 CFM
EF 902	BASEMENT VENTILATING FANS	10,000 CFM
EF 903	BATTERY ROOM FANS	1000 CFM
EF 904	FIRST FLOOR VENTILATING FANS	6,500 CFM
EF 906	SHOWER ROOM BLOWER	3,200 CFM
EF 907	SECOND FLOOR VENTILATING FANS	2000 CFM
EF 908	REST ROOM BLOWER	1,900 CFM
EF 909	LUNCH ROOM FAN	4,000 CFM
EF 910	SOLUTION ROOM FAN	10,000 CFM
EF 911	HOOD BLOWER	800 CFM

FIGURE XII - 30

VENTILATION OF OPERATING AREAS

CANYON (221) AND SERVICE (271) BUILDINGS

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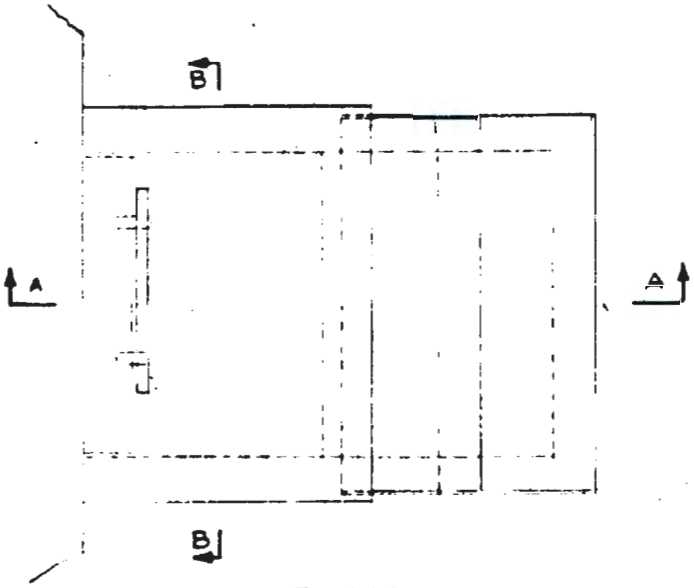
FIGURE XIII-31

LAYOUT OF COVER BLOCKS FOR CELLS 34 & 38

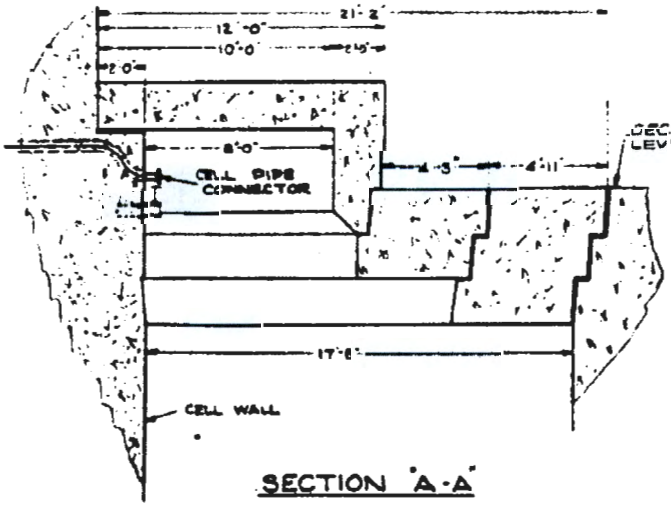
FROM H-2-41254



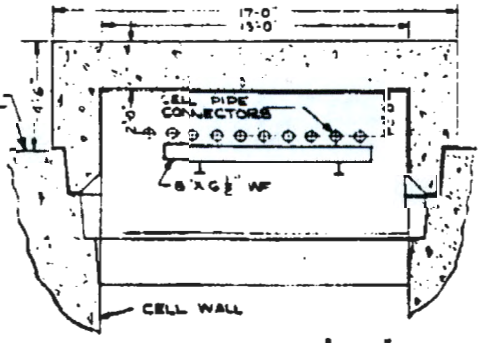
PLAN

NOTE:-

LIFTING EYES, SIMILAR TO THOSE USED ON OTHER COVER BLOCKS, ARE PROVIDED.



SECTION 'A-A'



ELEVATION 'B-B'

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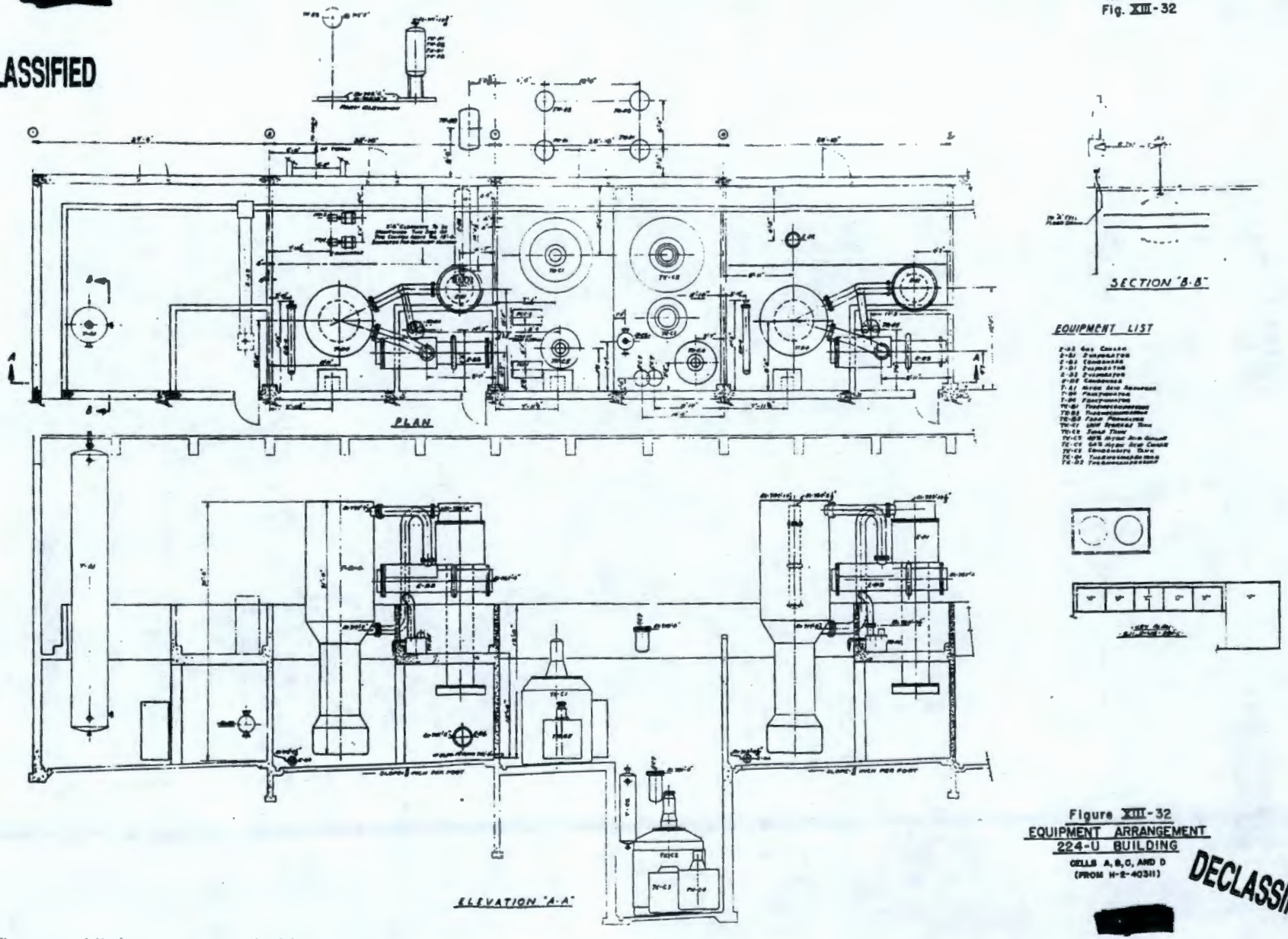

Figure XIII-32
EQUIPMENT ARRANGEMENT
224-U BUILDING
CELLS A, B, C, AND D
(FROM H-2-40311)

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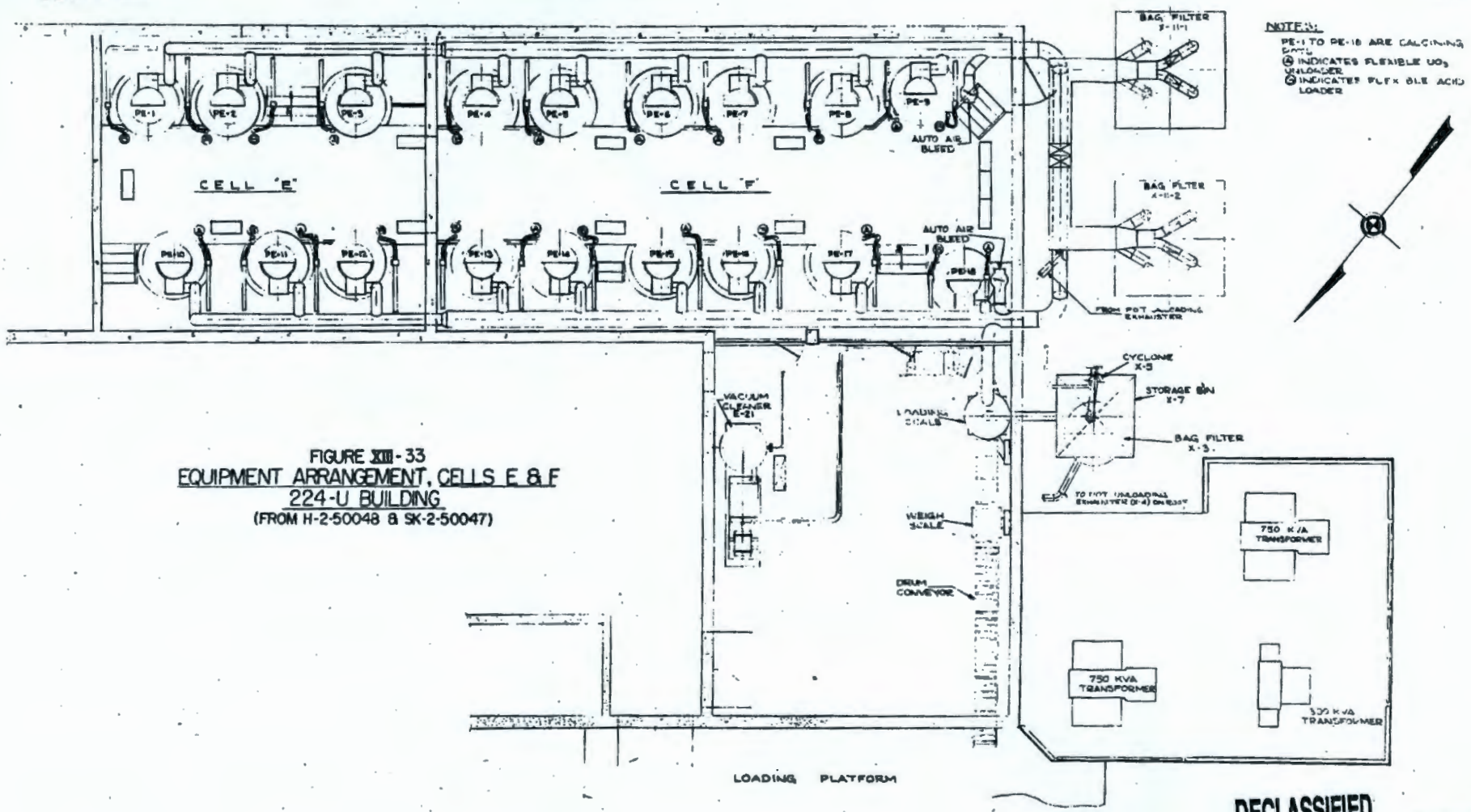

FIGURE XIII-33
EQUIPMENT ARRANGEMENT, CELLS E & F
224-U BUILDING
(FROM H-2-50048 & SK-2-50047)

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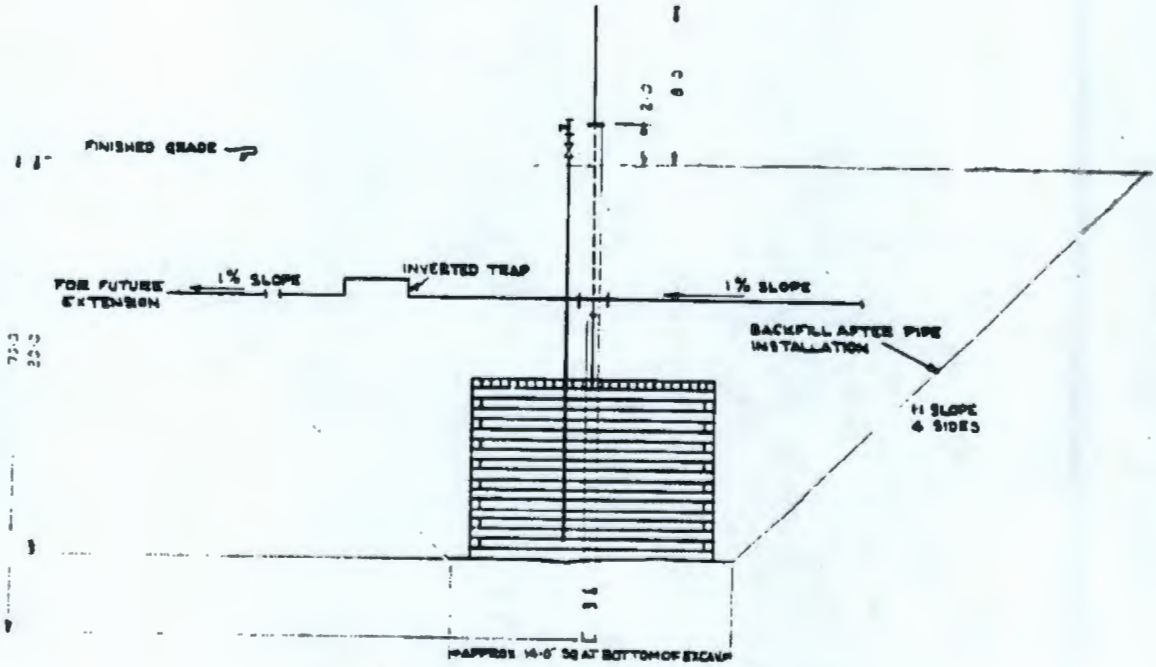
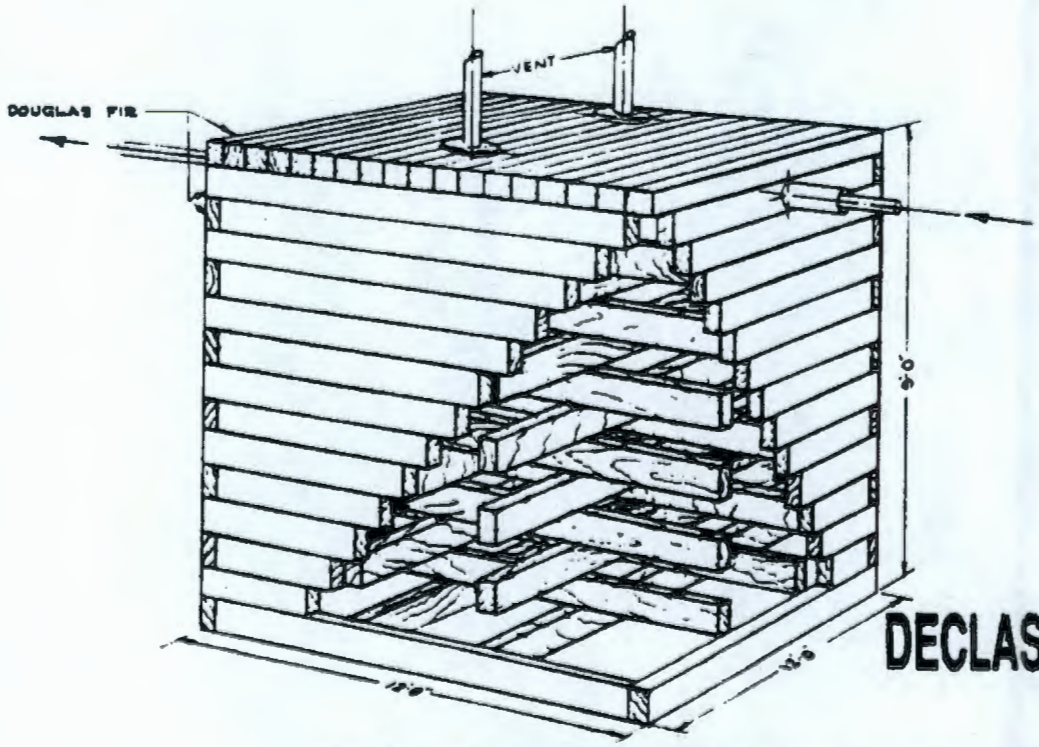
FIGURE XIII - 34
TYPICAL WASTE CRIB
(FROM H-2-50061)



TYPICAL ELEVATION OF WASTE CRIBS



TYPICAL CONSTRUCTION OF WASTE CRIBS

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PART III: PLANT AND EQUIPMENT, continued

CHAPTER XIV. ENGINEERING FLOW DIAGRAMS

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		Page
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	2. Spare Equipment and Line Policies	1403
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REFERENCES		1412

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CHAPTER XIV. ENGINEERING FLOW DIAGRAMS

A. GENERAL

1. General Design Considerations

The engineering scope of the Uranium Recovery Plant is illustrated in Figures XIV-1 through XIV-25. These drawings, known as "Engineering Flow Diagrams", expand upon the basic process flow depicted in the "Engineers' Flow Sketches" included in Chapters II, VI, VII, VIII, IX, and X. The purpose of the Engineering Flow Diagrams, which were prepared prior to the detailed design effort, was to present an accurate picture of the engineering features of the process upon which design was to be based. During the development of these design basis plans, foremost consideration was given to (a) the utilization of existing facilities in the most expeditious manner, (b) the radioactive properties of the materials handled, (c) corrosiveness of the solutions, and (d) process continuity.

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Since the existing 221-U and 224-U Buildings are utilized in the Uranium Recovery Plant, equipment design and layout conforms to the physical limitations imposed by the processing areas of these buildings. Massive concrete shield walls are provided for protection of operating personnel from the penetrating gamma radiation. All equipment that handles radioactive materials is placed in cells in the "hot", or canyon, zone and is operated remotely by means of diverse instrumentation. Since the equipment is not readily decontaminated to allow prolonged personal contact, the canyon equipment was designed for remote methods of maintenance, replacement, and servicing. The corrosive properties of the chemicals used in the process necessitated the use of stainless steel for fabrication of all tanks, piping, and auxiliaries essential to process continuity.

A most important factor that influenced the plant design effort is the continuous nature of the uranium recovery process. Although uranium removal from underground storage and acidification, blending, and preparation of metal solution prior to entrance into the 221-U Building are batch procedures, most process streams throughout the feed concentration, solvent-extraction, waste treatment, organic recovery, and uranium solution product handling systems flow continuously. Tank sizing and placement in the cells was made, therefore, to conform with good operational control.

Design Phase I of Project C-362, removal of uranium-containing solutions and slurries from the TK-U-101, 102, 103 Cascade of the 241-U Tank Farm, involves new architectural features and new construction. Phase I is illustrated by Figures XIV-1 to XIV-4. Neither Phase II, facilities for removal of uranium from all other underground storage tanks, nor Phase III, the cross-country pipeline system for transporting radioactive solutions between the 200-East and 200-West Areas, is illustrated in Engineering Flow Diagram form in the Uranium Recovery

Technical Manual. Phase II Engineering Flow Diagrams are identical in most respects with Phase I. Phase III is described in Chapter XIII. Design Phase IV, solvent-extraction and related procedures, has been scoped for existing structures, 221-U and 224-U Buildings, and is illustrated by Figures XIV-5 to XIV-23. Figures XIV-24 and 25 illustrate the calcination and acid recovery portions of the 224-U Building, and although these operations were originally defined under a different project (Project No. C-361), they are properly a part of the Uranium Recovery Plant.

Some of the standard symbols used in Figures XIV-1 through 25 are listed in a symbol legend shown on Figure XIV-1.

Some of the general design requirements with regard to equipment sparing, piping, and valving are discussed below.

2. Spare Equipment and Line Policies

With the exception of a spare concentration unit (feed tank, concentrator, fractionator tower, cooler, and receiver tank) which may be utilized for either feed or waste concentration, no spares are installed for major equipment pieces that operate either continuously or batchwise. The designed capacity of the plant, which allows for 20 per cent downtime, is considered to include adequate spare production capacity in lieu of installed spare process equipment.

Because of the large volume of dilute solutions handled in the uranium recovery process, liquid transfer on all main routings is effected by pump to avoid further dilution. Generally, pumps are spared by jets. Jets are also used for alternative routings and in places where the transfer is not of a routine nature.

Some spare lines in concrete exist in the 221-U Building from "cold" to "hot" or "hot" to "hot" zones by virtue of the existing building architecture. The number and potential utility of these spare lines varies from cell to cell.

3. Piping and Valving

Main process piping is shown on Figures XIV-1 to 25 in heavy lines. Utility piping and instrumentation lines are shown by either dotted or light lines. However, Figures XIV-5 to 20 show spare piping in concrete by means of dotted lines.

Process pipe sizing has been made by conventional, flow-pressure drop chart methods for the peak anticipated loading conditions, the calculated pipe size then being rounded to a larger, conventional size. (Since the 2-in. pipe size is the smallest pipe size used - except as noted below - this results in considerable overcapacity in many instances.) In the 221-U Building, pipe sizing is determined by the existing pipe buried in concrete. Instrument and sampler lines, in general, consist of 1/2-inch pipe in bundles of 3 or 4.

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Process additions are made to canyon area tanks via headers from feed tanks in the 271-U Building or in the operating gallery. A wash solution header is provided by means of which wash solution may be routed to feed tanks and thence to the "hot" vessel. Strainers are provided in process addition lines.

The only valves utilized in the "hot" zones of the 221-U Building are flow control valves. In addition, bellows-sealed plug valves have been employed in some Diversion Box jumpers.

Table XIV-1 lists the various pipe codes which appear on the Engineering Flow Diagrams and indicates the service corresponding to each code. Valves are designated as to type by prefix letters: G, for gate; GL, for globe; CV, for control valve; and DO, for diaphragm operated. The number following the prefix letters designates the working pressure, e.g., 1.2 = 125 lb./sq.in. The second letter, S or F, designates whether the valve is screwed or flanged. Thus, GL 1.5 F is a flanged globe valve designed for 150 lb./sq.in. working pressure. Valve Specification HW-3450 should be referred to for further details.

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4. Materials of Construction

Process equipment in the TBP and UO_3 Plants is constructed of type 347 stainless steel (or an equivalent in the 300 Series stabilized toward intergranular corrosion by virtue of a Cb-Ta additive or extra low carbon content, E.L.C.) unless it is subjected to the combination of elevated temperatures and contact with process solutions. In this case it is constructed of Type 309S Cb stainless steel (except for the Calcination Pots, as noted below). Component parts not subjected to welding during fabrication are constructed of Type 304 stainless steel. (Neither Types 347 nor 309S Cb require annealing after welding since both are columbium stabilized.)

The Slurry Accumulator Tanks are constructed of carbon steel since they handle only an alkaline process solution or slurry.

The uranyl nitrate Calcination Pots (see Figure XIV-24) are constructed of a special alloy, Esco 40-T, whose composition is approximately 18% chromium, 12% nickel, and 0.04% carbon. This alloy has been found to have very good corrosion resistance under the operating conditions contemplated.

References (4), (5), and (6) are the most important reports on the corrosion resistance of materials of construction to the process materials handled in the uranium recovery process.

5. Equipment Designation

The methods of designating equipment involved in removal of uranium from underground storage are shown in Figures XIV-1 to 4. The prefix letter before the vessel number indicates its location. Thus, as shown on Figure XIV-4, Tank WR-005 is a Feed Receiver Tank located in the 241-WR Diversion Station.

Equipment in the TBP Plant (221-U Building) is designated with a prefix number denoting the section in which it is located. Viewed from the operating gallery, each section consists of a left and a right cell. Equipment in a left cell is numbered clockwise from the farthest left-hand corner: 1, 2, or 3 for floor level equipment; 4 for intermediate level, and 5 for top level. Equipment in a right cell is numbered clockwise from the farthest left-hand corner: 6, 7, or 8 for floor level equipment. For example, TK-7-7 refers to a 221-U Building tank located in the right cell of Section 7 and positioned as the second clockwise tank from the farthest left-hand corner in that cell.

Equipment in the UO_3 Plant (224-U Building) is designated with a prefix letter denoting the cell in which it is located. Equipment is numbered clockwise from the farthest left-hand corner of the cell when viewed from the operating gallery. For example, TK-C-4 designates a 224-U Building tank located in C Cell and positioned as the fourth clockwise tank from the farthest left-hand corner of the cell.

The Engineering Flow Diagrams for the TBP Plant, (Figures XIV-5 to 19) indicate the layout of the cells in addition to providing a schematic elevation view of the equipment. The diagrams for the uranium removal facilities and the UO_3 Plant (Figures XIV-1 to 4 and XIV-20 to 25) provide only a schematic elevation view of the equipment.

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B. URANIUM REMOVAL, PHASE I[1][3]

Uranium removal from underground storage has been discussed previously in Chapter II, and the acidification, blending, and preparation of the solution for entry into the TBP Plant has been discussed in Chapter III.

Engineering Flow Diagrams for Phase I removal facilities are presented in Figures XIV-1 to 4. As mentioned previously, Phase I includes the removal of uranium solution and slurry from the 241-U-101, 102, and 103 Cascade. Included as a part of the Phase I project is the construction of the 241-U Slurry Accumulator, Blend Tanks, Nitric Acid Tank system and the construction of the 241-WR Diversion Vault. Phase I, illustrated, differs from Phase II, not illustrated, chiefly in that Phase II provides metal removal facilities for all other Cascades than 241-U-101, 102, and 103. Phase II provides three additional uranium removal installations (one each for the 241-B, BX and BY, the 241-T and TX, and the 241-C Areas) each including a Slurry Accumulator, two Blend Tanks, and a Nitric Acid Tank. (See Chapter II.)

Each of the sludge pumps shown in Figure XIV-1 in each Underground Storage Tank has a capacity of 600 gal./min. against a head of 125 ft. when handling material with a specific gravity of 1.2. These pumps will pass solids of any size that can enter their suction openings. Each pump discharges through a 4-in. line into the Slurry Accumulator, TK-UR-001, Figure XIV-3. These pumps may be raised or lowered on suspension cables, by means of a winch arrangement, to follow the liquid level as the tank is emptied.

As described in Chapter II, slurry is recirculated through sluicing nozzles in the storage tanks to slurry the sludge. The sluicing pump located in the Slurry Accumulator is a 600 gal./min. capacity pump which produces 150 lb./sq.in. discharge pressure when operating with a 1.2 specific gravity liquid. The sluicing nozzles each have a 1-3/8 in. tip which will pass 516 gal./min. of 1.2 specific gravity solution at a supply pressure of 100 lb./sq.in. Each nozzle is capable of remote adjustment for azimuth and elevation. Provision is made for the attachment of a motor operator to the azimuth adjustment mechanism to cause the nozzle to "scan" slowly within a predetermined included angle. Slurry removal operations from the Underground Storage Tanks may be observed by means of a 2-1/2 power periscope.

A jet is provided for each Underground Storage Tank for the purpose of removing the heel left in the tank after completion of sluicing and pumping operations. The jet has a capacity of 100 gal./min. of supernate against a maximum head of 100 ft. when supplied with steam at 100 lb./sq. in.

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The uranium recovery process employs the Diversion Box technique for routing solutions between certain vessels before the solution enters the TBP Plant. As indicated on Figures XIV-1 and XIV-3, supernate or slurry must be routed through Diversion Boxes 241-UR-152 and 241-UR-151 before entering the Slurry Accumulator. Changes in routings may be made by remote changes of Diversion Box jumpers. This subject is discussed in more detail in Chapter XIII.

As a general policy, all vessels and equipment handling uranium-containing solution after it has been acidified in the Blend Tanks, TK-002 and 003, Figure XIV-3, are constructed of stainless steel. Vessels and equipment handling uranium slurry or solution before the acidification step are constructed of carbon steel.

C. TBP PLANT(3)

1. Feed Concentration and Clarification

The feed concentration and clarification facilities in the TBP Plant (221-U Building) are presented in Engineering Flow Diagram form in Figure XIV-5, 6, 7, and 8. Figure XIV-5 shows a schematic elevation and layout of the Feed Receiver Tanks, TK-3-1 and TK-3-6, which receive acidified UNH solution from the 241-WR Diversion Vault. It may be noted that the pump transferring solution to a Concentrator Feed Tank, TK-6-6 or TK-7-6, is spared by another pump in this instance. Tanks 3-1 and 3-6 are representative of the "bathtub" type of vessel that is frequently used in the 221-U Building. This unusual vessel shape has been chosen in order to provide the maximum vessel capacity permitted by the architecture of the cell. It has been considered necessary to provide two agitators to attain adequate mixing in vessels of this shape.

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Tanks 3-1 and 3-6 both discharge to either of two feed concentration systems, and, in addition, the Feed Tanks are interconnected (via jet lines) such that either may discharge (via jet line) to the Feed Utility Holdup Tank, TK-4-1, which is shown in Figure XIV-18.

The system of duplicate processing facilities exists throughout the 221-U Building (except for the waste sampling and neutralizing system). Each processing line has a designed maximum capacity of 5 tons of uranium per day at nominal flowsheet operating conditions. Connection between the lines, permitting the by-passing of certain equipment, is possible at various points in the process. Generally the components of only one of the duplicate lines are illustrated and discussed in this chapter, However, duplicate facilities (not illustrated) are referred to in the succeeding discussion.

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Although the duplicate processing facilities are technically referred to as Line A or Line B, this distinction has no important practical significance since many of the vessels within a processing line are interconnected with those of the duplicate line, and vessels and equipment of the two lines are intermixed in their placement in the canyon of the 221-U Building.

Dilute acidified uranium solution is pumped from the Feed Receiver Tanks, TK-3-1 and 3-6 (working volume 12,000 gal. each, holdup time nominally about 10 hours), to the feed concentration system located in Sections 6 (illustrated by Figures XIV-6 and 7) or 7. Section 7 is not illustrated since it is a duplicate of Section 6. Dilute feed enters the Concentrator Feed Tank, TK-6-6, which serves as a pump tank for continuously feeding Concentrator E-6-1. An alternative routing for TK-6-6 contents is to the Feed Utility Holdup Tank, TK-4-1 (Figure XIV-18). Vertical space limitations in the Feed Concentrator Cell (Figure XIV-7) are responsible for the shallow shape of the Feed Cooler Tank, TK-6-2, since it is gravity fed by the concentrated Concentrator effluent. Vapor from the Concentrator passes into a bubble-cap Column, T-6-4, wherein practically all of the nitric acid is fractionated downward and eventually issues from the base of the Column and rejoins the concentrated feed solution in TK-6-2. Essentially acid-free vapor overheads are condensed in Condenser E-6-5 and eventually enter the Condensate Receiver Tanks in the 241-WR Diversion Vault.

Feed solution is continuously pumped from the Feed Cooler into the Concentrated Feed Receiver, TK-6-7. (The pump is spared by a jet.)

The normal flow pattern is such that feed solution is continuously fed to the Centrifuge, G-14-1, from the Concentrated Feed Receiver. However, Concentrated Feed Receivers 6-7 (illustrated by Figure XIV-6) and 7-7 (not illustrated) are interconnected by jet. In addition, jet-out lines allow recycle from the Concentrated Feed Receivers back to the Concentrator Feed Tanks.

The Centrifuges, G-14-1 and G-14-6, and Centrifuge Catch Tanks, TK-14-2 and TK-14-7, for both processing lines are illustrated by Figure XIV-8. Solution entering the Centrifuge continuously overflows the lip of the

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the bowl and enters the Centrifuge Catch Tank. Solution may be pumped from either Centrifuge Catch Tank to either RAF Feed Tank, TK-17-6 or TK-19-6, and, in addition, jet lines interconnect the Centrifuge Catch Tanks.

Reference is made to Chapter III for a more complete description of the feed preparation procedure. Feed preparation equipment is described in detail in Chapter XVI.

2. Solvent-Extraction

The solvent-extraction facilities of the uranium recovery process are presented in Engineering Flow Diagram form in Figures XIV-9, 10, and 13. The solvent-extraction procedures are described in Chapter VI and the solvent-extraction equipment in Chapters XV and XVI.

Layout and schematic elevation views of the RAF Feed Tank, TK-17-6, the RA Column, ET-17-8, and the RAW Receiver, TK-17-7, are shown in Figure XIV-9. The RA Pulse Column is continously pump-fed from the RAF Feed Tank (3400-gal. working volume, holdup time nominally about 4 hours). The aqueous effluent from the RA Column enters the RAW Receiver after passing a flooded jet (which can be used to empty the RA Column when the need arises) and the RAW control valve. An alternative routing for the solution in the RAF Feed Tank is via jet to the Feed Utility Holdup Tank. RAW solution is pumped to the Pooled RAW-ROW Receiver, TK-13-6, (Figure XIV-14) through a jet-spared line.

The organic effluent, RAU, from the RA Column overflows into the RC Pulse Column, ET-17-2, located in the left-hand cell of Section 17. The equipment in this cell is shown by Figure XIV-10. As in the case of the RA Column, the RC Column aqueous effluent, RCU, enters the RCU Pump-Out Tank, TK-17-3, after passing through a flooded jet and the RCU control valve. The organic effluent, RCW, from the RC Column overflows into the RCW Receiver, TK-17-1.

Section 19 (not illustrated) contains duplicate RA and RC solvent-extraction facilities.

RCW solution from the RCW Receiver is pumped to Section 18 (Figure XIV-13), where it enters the RO Column, ET-18-2. Aqueous effluent from the RO Column enters the ROW Receiver, TK-18-3, after passing a flooded jet and the ROW control valve. A pump-out line (jet-spared) is provided for transferring ROW to the Pooled RAW-ROW Receiver. The ROO Receiver, TK-18-1, receives the washed organic stream from the RO Column and normally pumps it to the RAX Feed Tank, TK-18-6, (a "bathtub" type vessel) which serves as a pump-feed tank for recycling organic extractant as RAX to the RA Column. Provision is made, however, for jet transferring the solution in the ROO Receiver to the 276-U Building for special organic treatment if desired. Treated organic again enters the normal flow cycle in the RAX Feed Tank. It is also possible to jet from the RAX Feed Tank to the 276-U Building.

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Section 20 (not illustrated) is a duplicate of Section 18.

3. Uranium Product Handling

The TBP Plant uranium product handling facilities of the uranium recovery process are presented in Engineering Flow Diagram form in Figures XIV-11 and 12. These drawings illustrate, in layout and schematic elevation views, the two "bathtub" type RCU Receivers, TK-16-1 and TK-16-6, and RCU Samplers, TK-15-1 and TK-15-6. All are 12000-gal. working volume vessels having a nominal holdup time of about 7-1/2 hours. Each of the two Receiver-Sampler systems normally serves one of the two duplicate processing lines. The two Receivers are interconnected by jets. Normally, however, RCU is pumped to the Sampler Tank by either of two duplicate pumps in each Receiver. Either of two duplicate pumps in each Sampler Tank normally transfers the UNH solution to the 203-U Area. (See Section D, below.) However, it is possible to jet from either Sampler Tank to the Feed Utility Holdup Tank for rework.

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4. Waste Treatment

The TBP-Plant waste treatment facilities are presented in Engineering Flow Diagram form in Figures XIV-14, 15, 16, 17, and 19. The "bathtub" type Pooled RAW-ROW Receiver, TK-13-6, and Waste Sampler Tank 13-1 (one of four identical Waste Sampler Tanks) are illustrated by Figure XIV-14. Figure XIV-15 shows another of the Waste Samplers (TK-11-1) and the Waste Neutralizer, TK-11-6. Sampler Tanks 12-1 and 12-6 are not illustrated. The Pooled RAW-ROW Receiver is provided with four pumps which discharge into each of the four Sampler Tanks. In addition, the pump to TK-13-1 is spared by jet. The Sampler Tanks are interconnected by jet lines so that considerable flexibility is built into the system. It is possible to jet from each Sampler Tank to the Feed Utility Holdup Tank. Solution from any of the Sampler Tanks is normally transferred by pump to the Waste Neutralizer. The Pooled RAW-ROW Receiver, the four Sampler Tanks, and the Waste Neutralizer are all 12,000-gal. working volume vessels with a nominal holdup capacity of 5 hours (with the exception of the Neutralizer, whose holdup capacity is about 4-1/2 hours). A noteworthy feature of the Neutralizer is the provision for adequate mixing during neutralization. Two agitators and two recirculation jets are provided. Neutralized waste can be pumped to either of the two waste concentration lines which normally serve the process, or to the spare (waste or feed) concentration line. (The spare concentration line can serve either the feed or waste system and is usually called the "spare concentration line".)

One of the duplicate waste concentration lines (located in Section 9) is illustrated by Figures XIV-16 and 17. Section 10 is not illustrated. The waste concentration line is almost identical with the feed concentration system described in C 1 above. The only important difference is that the feed concentration system embodies a bubble-cap Column for fractionation of nitric acid from Concentrator overheads, while the waste concentration system utilizes a packed Column for deentrainment of Concentrator overheads since fractionation is not required. Concentrated, neutralized waste from the Waste Receiver Tank, TK-9-7 (4500-gal. working volume,

5-1/2 hour nominal holdup capacity), is pumped (jet spared) to the Waste Pump Tank, TK-WR-001 (50,000-gal. working volume, 30-hours nominal holdup capacity), located in the 241-WR Diversion Vault and illustrated by Figure XIV-23.

The Organic, Deep-Cell, and Aqueous Sump Holdup Tanks, TK-5-1, 5-6, and 5-2, respectively, are illustrated by Figure XIV-19. Organic wastes are generally routed (via jet) to the Organic Receiver, TK-387, in the 276-U Building. Aqueous wastes may be routed (via jet) either to cribs or to the Waste Utility Holdup Tank, TK-4-6.

5. Rework Facilities

Rework facilities are generally associated with the Feed Utility Holdup Tank, TK-4-1, which permits either RCU or pooled RAW-RCW waste to be back-cycled through the solvent-extraction system, or with the Waste Utility Holdup Tank, TK-4-6, which permits waste solutions to be recycled to one of the waste concentration units for additional concentration. Both of these vessels are illustrated in Engineering Flow Diagram form by Figure XIV-18.

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The spare concentration facility (Section 8, 221-U Building) which can be utilized either for feed or waste concentration, is served by either TK-4-1 or 4-6. (This concentration facility is similar to that illustrated by Figures XIV-6 and 7.)

D. UO_3 PLANT(2)

1. UNH Solution Storage

The UNH solution storage facilities located in the 203-U Area are illustrated in Engineering Flow Diagram form by Figure XIV-20. Storage Tanks X-1 and X-2 (100,000-gal. working volume, 24-hour nominal holdup capacity) are provided for receiving the dilute RCU solution (about 6% UNH) from the TBP Plant (221-U Building) and partially concentrated 3EU solution (about 60% UNH) from the Redox Plant. The concentrated, mixed UNH solution is received in Tank X-19, which serves as a feed tank for the loop header by means of which concentrated UNH solution is fed to the UNH Calcination Pots. Provision is made, by the use of Tank X-20, to recycle dissolved material from the Calcination Pots to any of the three storage tanks. Detailed operating procedures and equipment for the UNH solution storage system are described in Chapters VII and XVI, respectively.

2. UNH Concentration and Nitric Acid Fractionation

Figures XIV-21, 22, and 23 illustrate the UNH concentration system and its related facilities in Engineering Flow Diagram form. Reference is made to Chapter VII for a detailed operating procedure for the system and to Chapter XVI for a description of the equipment. Pump feed from Storage Tank X-1 or X-2 passes through Feed Preheater E-B-6 (not

illustrated) before dividing into two portions and entering Concentrators E-B-1 and E-D-1. These duplicate Concentrators (together with their corresponding Fractionators) are shown in schematic elevation only by Figure XIV-21. Solution leaving E-B-1 and E-D-1 collects in TK-C-1 (Figure XIV-25) and from there is pumped to Concentrator E-D-2 for final concentration. E-D-2 liquid effluent flows to Tank X-19. Some of the concentration auxiliaries are illustrated in Figure XIV-22. Duplicate Condensers E-B-3 and E-D-3 both condense Fractionator vapors and feed the condensate to Tank C-5. Condensate is continuously pumped from Tank C-5 to TK-WR-007, 008, and 009 in the 241-WR Diversion Vault. (These vessels are illustrated by Figure XIV-23.) The liquid effluent from the Fractionator (60% HNO_3 nominally) enters the 60% HNO_3 Receiver, TK-C-4, and then is pumped to TK-WR-006, Nitric Acid Pump Tank, in the 241-WR Diversion Vault. (See Figure XIV-23.)

3. Calcination and Acid Recovery

Engineering Flow Diagrams for the calcination and acid recovery operations in the 224-U Building are shown by Figures XIV-24 and 25. Reference is made to a detailed discussion of the procedures employed in operating these facilities given in Chapters VIII and IX. Equipment is described in Chapters XVI and XVII. Figure XIV-24 shows the Calcination Pot Room with its eighteen, electric-furnace-heated Calcination Pots. The loop header, PS-E-25, which delivers highly concentrated UNH solution to the Pots is lagged and heated to prevent "freezing" of the solution. The fume exhaust system, PS-E-24, for the Pots delivers nitrogen oxides evolved during UNH decomposition to Gas Cooler E-A-2 (Figure XIV-25). The dust exhaust system, PS-E-27, discharges through Bag Filters and a glass wool capsule to remove entrained UO_3 powder. The product removal system, PS-E-26, is designed to deliver UO_3 to unloading Cyclone X-5 and thence through the solids handling and packaging systems.

The nitric acid recovery system is shown in Figure XIV-25. Gases from UNH decomposition are routed to the Nitric Absorber, T-A-1, after being cooled in Gas Cooler E-A-2. To maintain favorably low gas absorption temperatures (discussed in Chapter IX), cooling coils are provided on some of the plates of the Absorber.

The 40% HNO_3 Cooler, TK-C-3, receives solution from the Absorber. The solution is then normally pumped to Fractionator T-B-4 or T-D-4. An alternate routing (by pump or jet) is to Storage Tank X-1 or X-2.

The Sump Tank, TK-C-2, receives sump drainage. The contents of TK-C-2 may be routed via jet (depending upon composition) to (a) Tank X-1 or X-2, (b) the Feed Utility Holdup Tank, TK-4-1, in the 221-U Building, or to (c) the Retention Basin.

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REFERENCES

(1) KLX-1071 Design Proposal, Phase I, Waste Metal Removal. 5-27-50.

(2) HDC-1837 Project Proposal C-361, Metal Conversion Facility. 7-28-50.

(3) HDC-1853 Project Proposal - Waste Metal Recovery Facilities - Project C-362. 8-21-50.

(4) HW-17626 Corrosion of Austenitic Stainless Steels in MJ4 RAW Streams. W. W. Koenig. 4-25-50.

(5) HW-19165 Corrosion of Construction Materials in TBP (HW-3 Flowsheet) Process Streams. W. W. Koenig and K. L. Sanborn. 11-1-50.

(6) HW-21520 Corrosion of Stainless Steel by Concentrated UNH Solutions. K. L. Sanborn. 7-3-51.

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TABLE XIV-1

PIPE CODES AND SERVICE - FROM SPECIFICATION HW-4314, Rev. 2

Code	Service
P-12	Steam, Compressed Air, Condensate and Exposed Water Lines--100 to 125 lb./sq.in. maximum working pressure. Carbon Steel.
P-13	Steam and Condensate--15 lb./sq.in. maximum working pressure. Carbon Steels.
P-60	Inside Sanitary Sewer - maximum working pressure, gravity. Carbon Steel--Galvanized.
P-76	Nitrogen, Methane, Propane, Special Solvent--50 to 125 lb./sq.in. maximum working pressure. Carbon Steel.
P-80	Sodium Hydroxide Solution--100 lb./sq.in. maximum working pressure. Carbon Steel.
P-90	General Canyon Service--150 lb./sq.in. maximum working pressure. Stainless Steel Type 347 (or Type 309S Cb where specified)
P-91	General Canyon Service--60% Nitric Acid--Process and Utility--100 lb./sq.in. maximum working pressure. Stainless Steel Type 347.
P-93	Process--200 lb./sq.in. maximum working pressure. Carbon Steel.
P-94	Indoor Chemical Waste Lines--Gravity Flow. Duriron.
P-95	Demineralized Water--Distilled Water--75 lb./sq.in. maximum working pressure. Aluminum Alloy 61S, 61S-T6, 63S, or 3S.
P-100	Process Piping Liquid and Vapor--50 lb./sq.in. and full vacuum. Type 347 Stainless Steel (or 309S Cb where specified).

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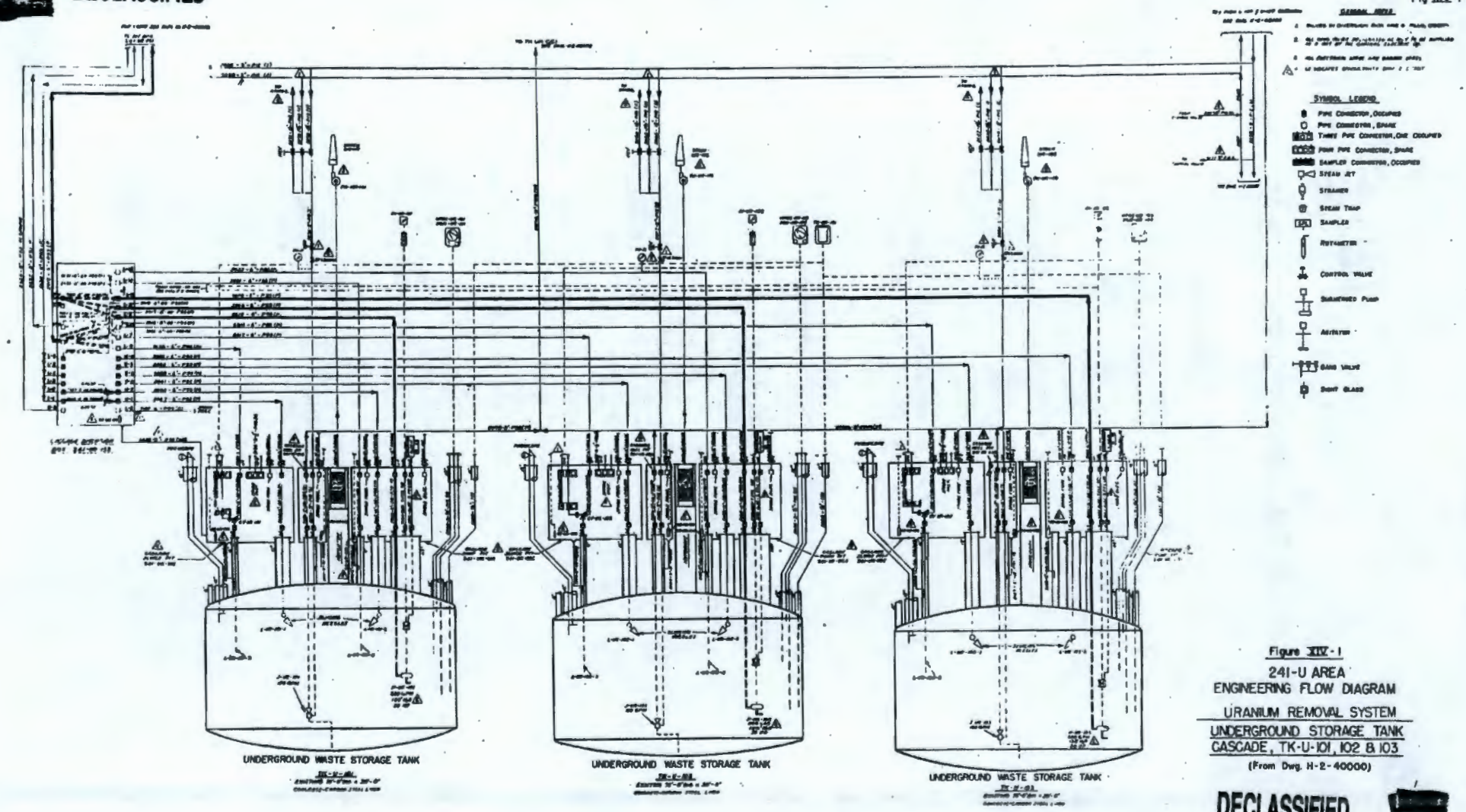

Figure XIV-1
241-U AREA
ENGINEERING FLOW DIAGRAM
URANIUM REMOVAL SYSTEM
UNDERGROUND STORAGE TANK
CASCADE, TK-U-101, 102 & 103
(From Dwg. H-2-40000)

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GENERAL NOTES

1. ALL LINES DESIGNATED H' SHALL BE 1/4 CR 1.6A. TUBING.
2. CE INDICATES CONDUCTIVITY DRAIN ELEMENT.

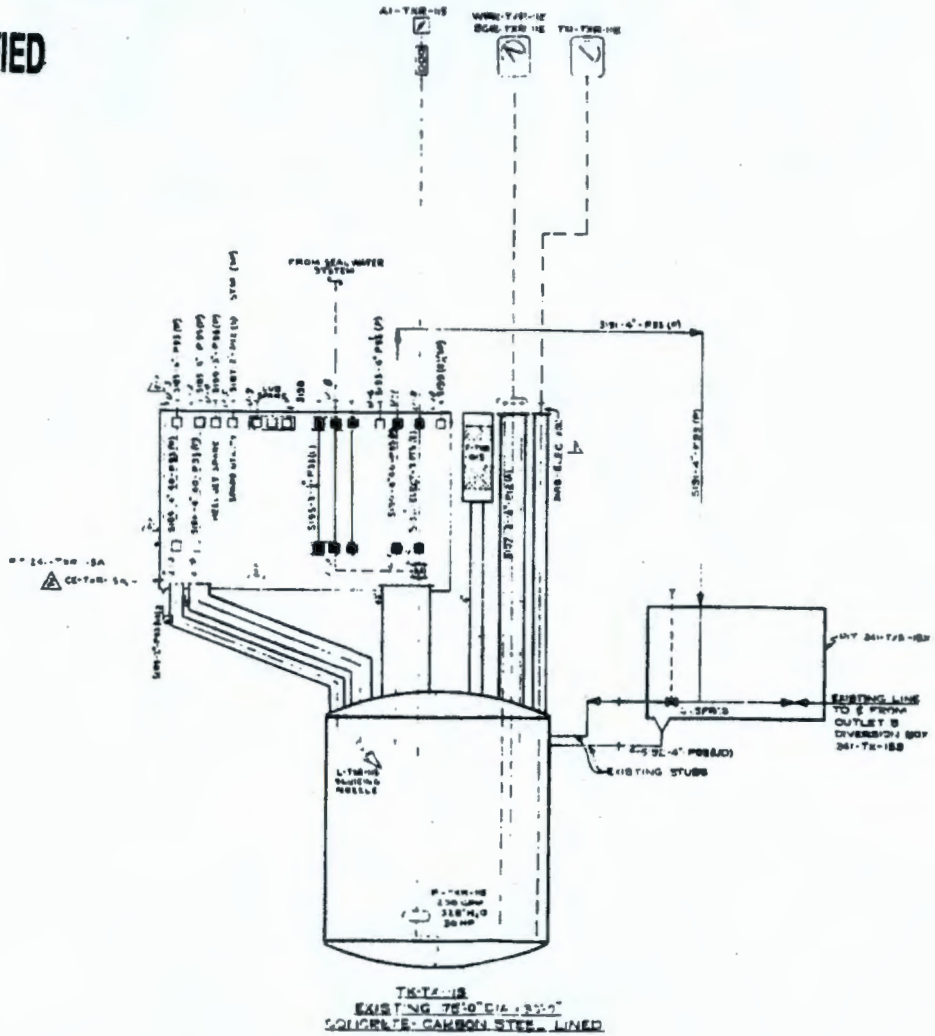

Figure XIV-2

ENGINEERING FLOW DIAGRAM

SUPERNATE HOLDUP TANK, TK-TX-115

(From Dwg. H-2-40035)

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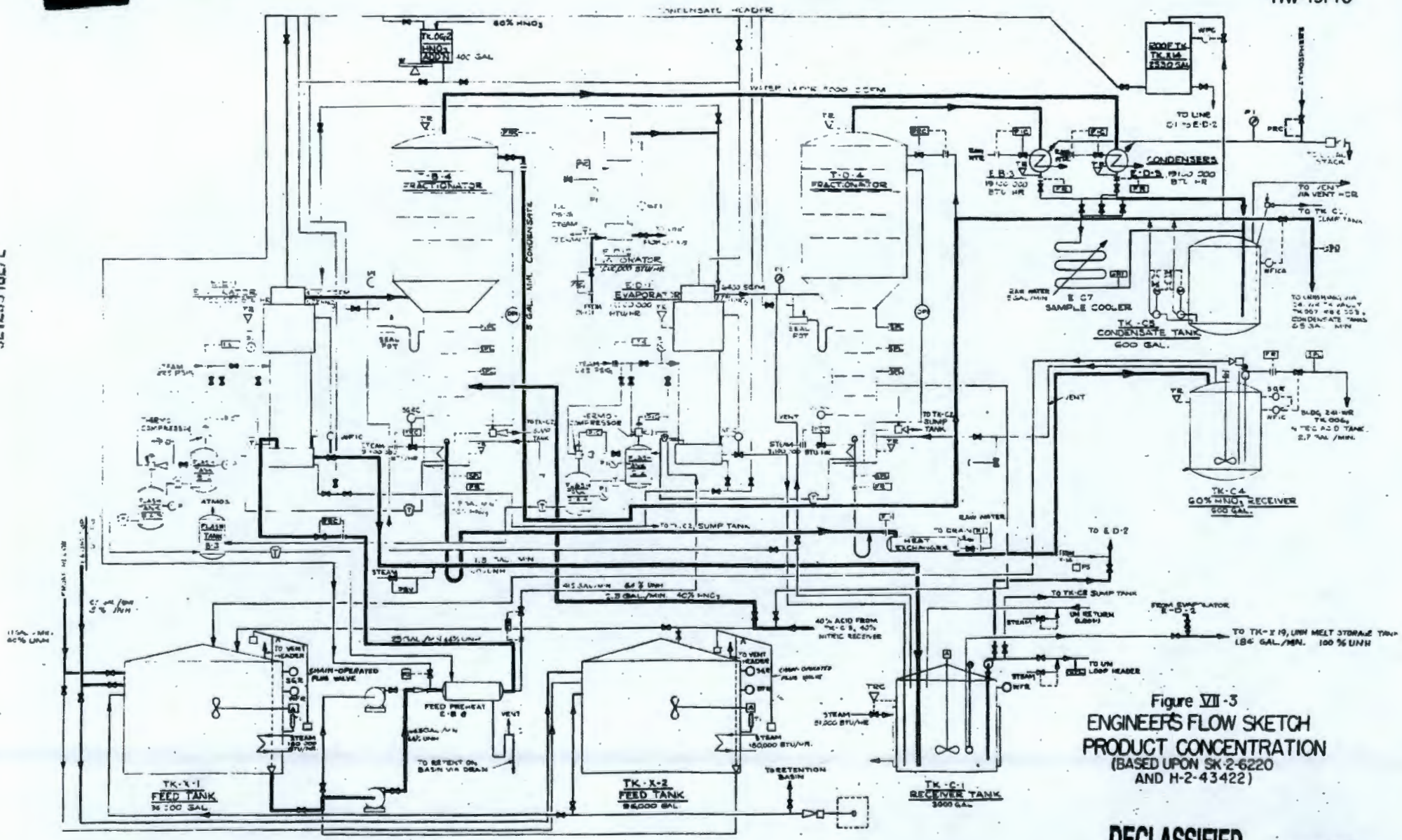

Figure VII-3
ENGINEER'S FLOW SKETCH
PRODUCT CONCENTRATION
(BASED UPON SK-2-6220
AND H-2-43422)

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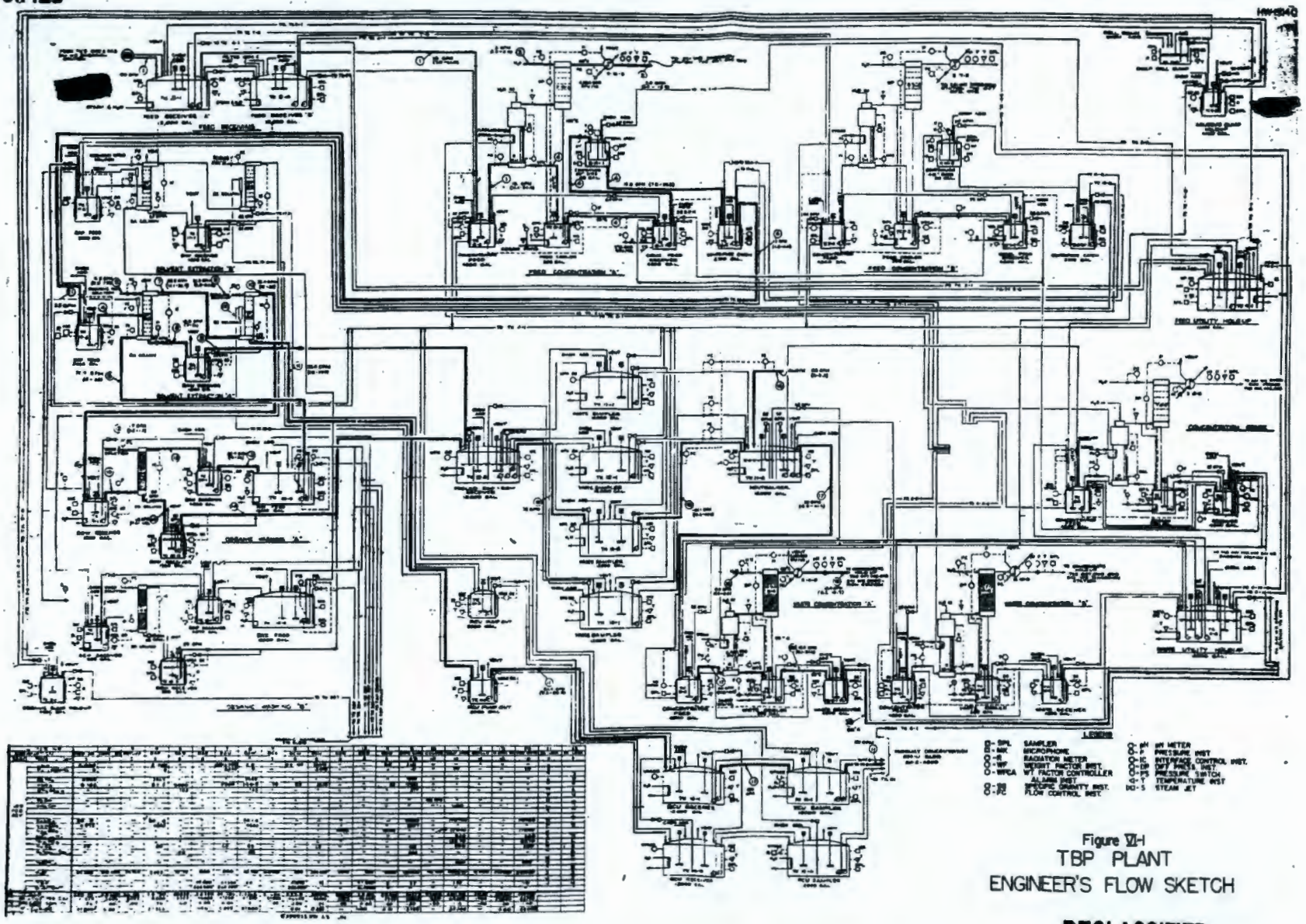

Figure VI-1
TBP PLANT
ENGINEER'S FLOW SKETCH

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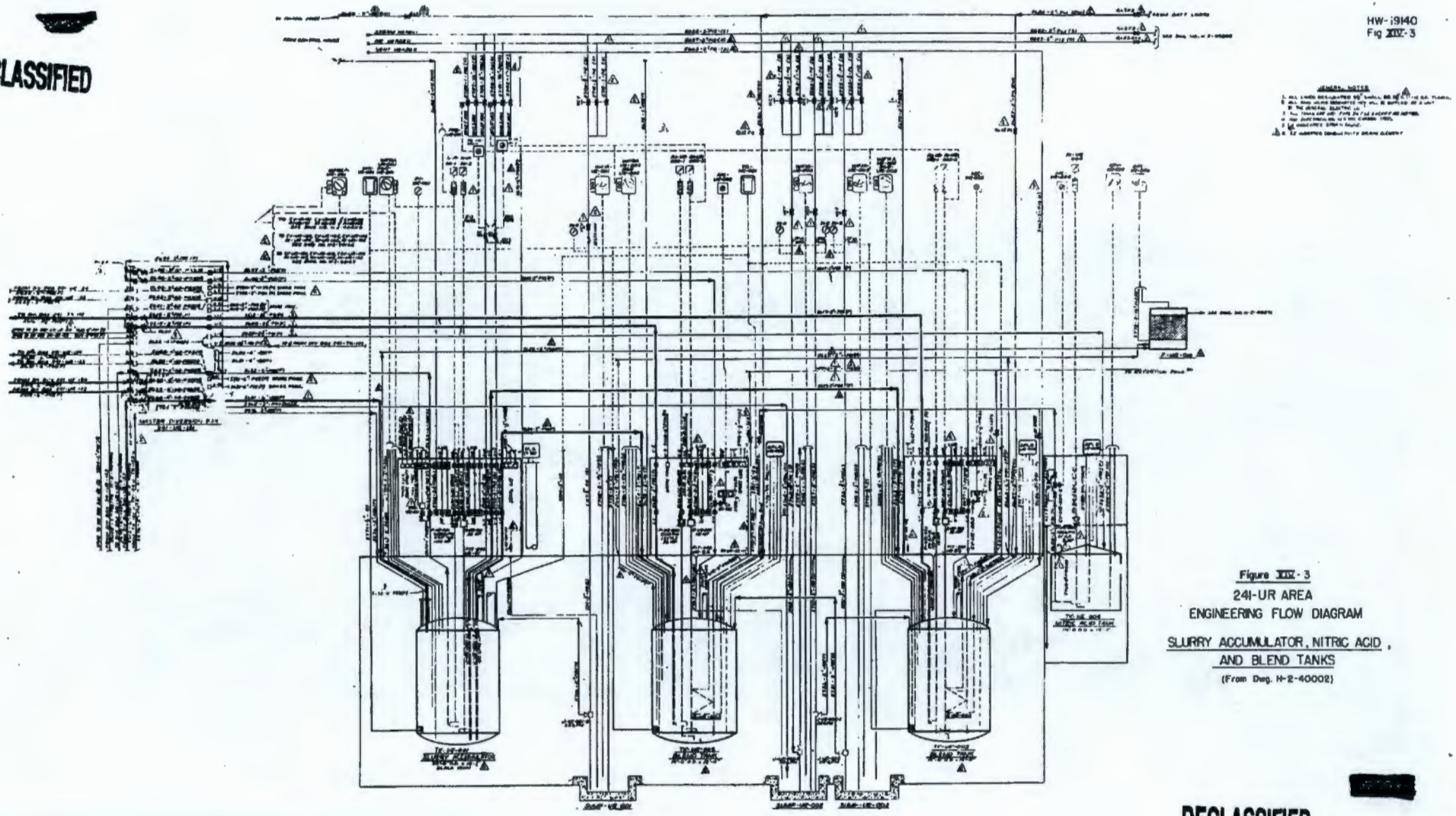

Figure XIV-3
241-UR AREA
ENGINEERING FLOW DIAGRAM
SLURRY ACCUMULATOR, NITRIC ACID, AND BLEND TANKS
(From Dwg. H-2-40002)

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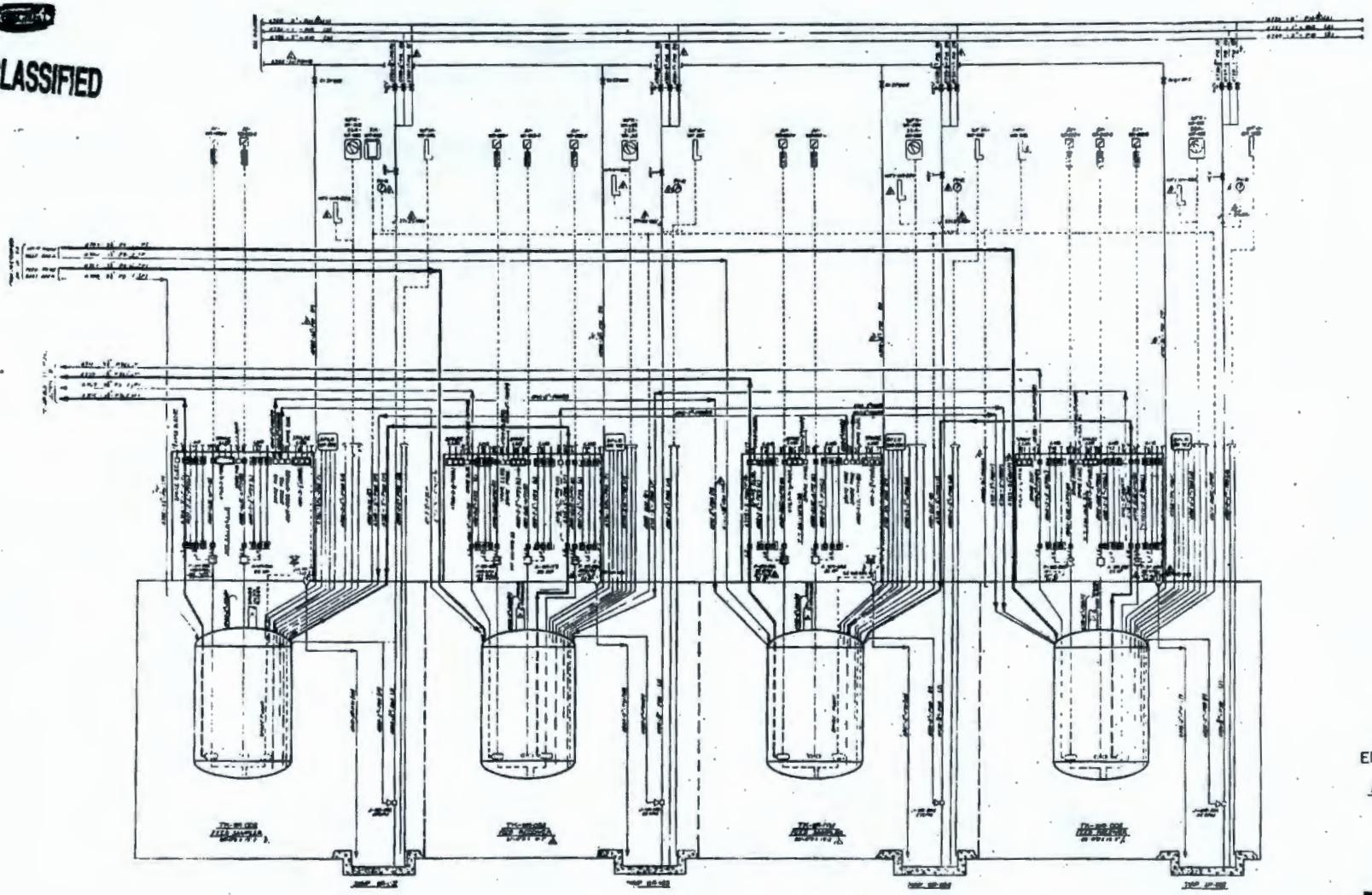

Figure XIV 4
241-WR VAULT
ENGINEERING FLOW DIAGRAM
ACIDIFIED FEED STORAGE
(From Dwg. H-2-40001)

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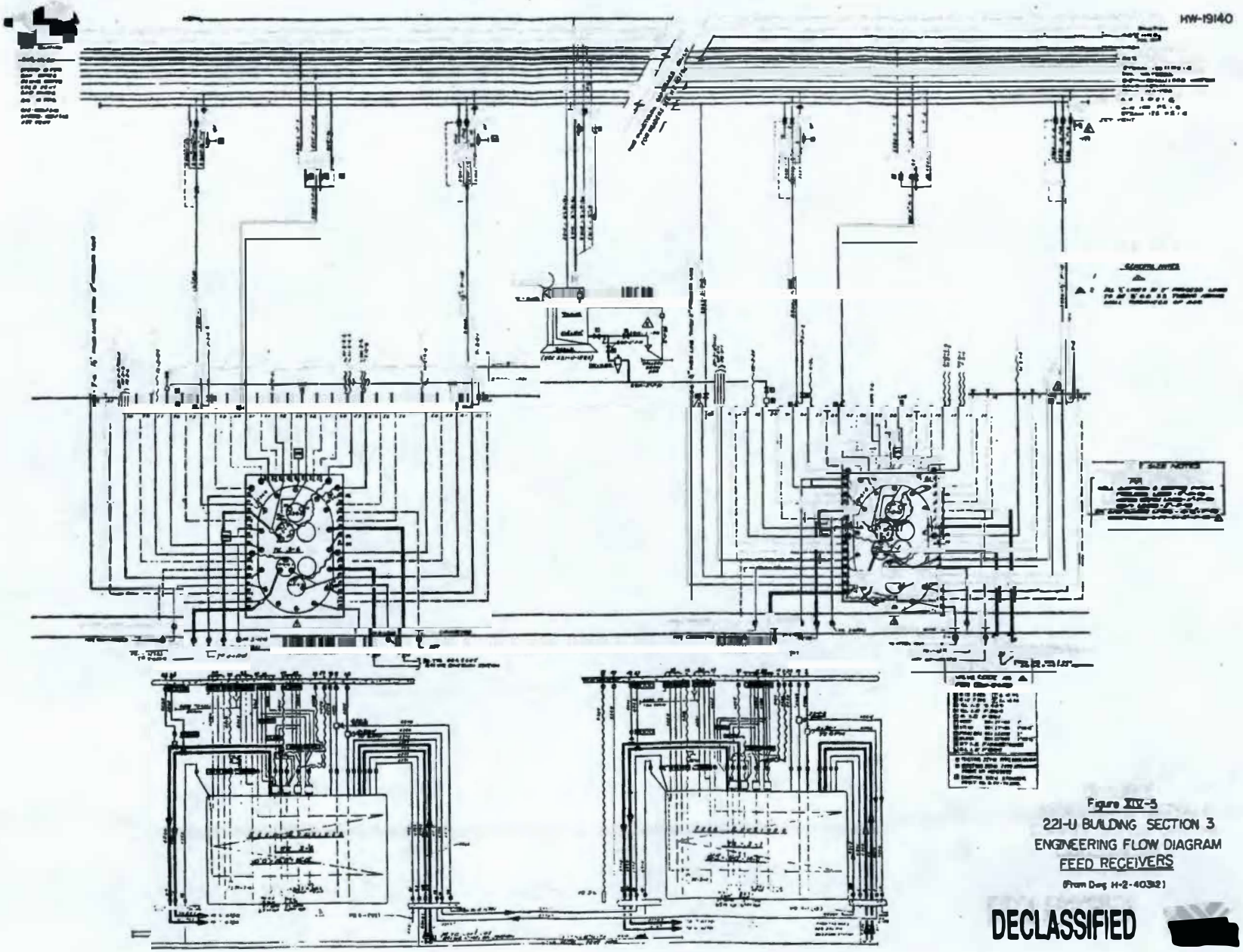

Figure XIV-5
221-U BUILDING SECTION 3
ENGINEERING FLOW DIAGRAM
FEED RECEIVERS
(From Dwg H-2-40321)

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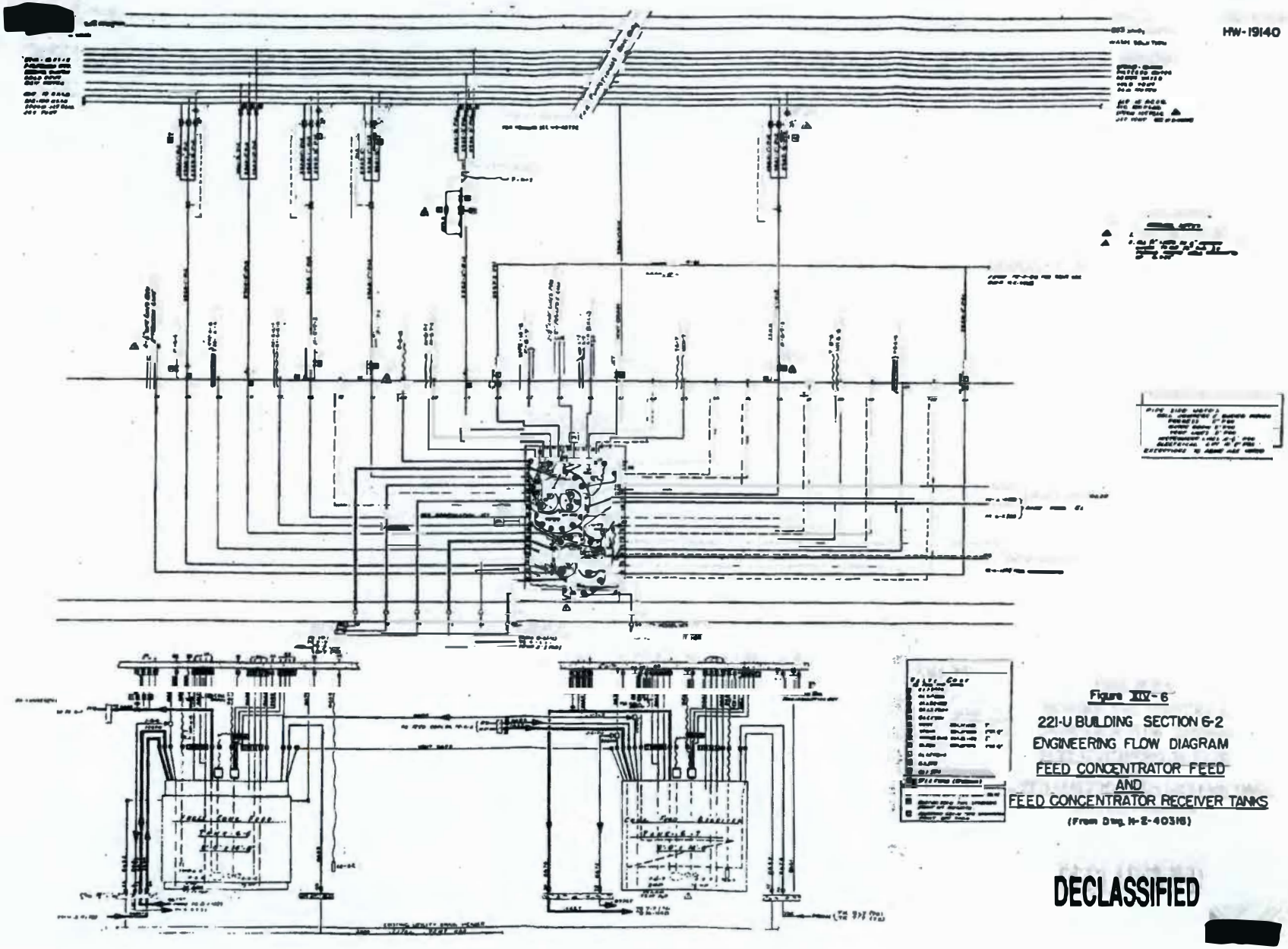

Figure XIV-6

221-U BUILDING SECTION 6-2
ENGINEERING FLOW DIAGRAM
FEED CONCENTRATOR FEED
AND
FEED CONCENTRATOR RECEIVER TANKS

(From Dwg. H-2-40316)

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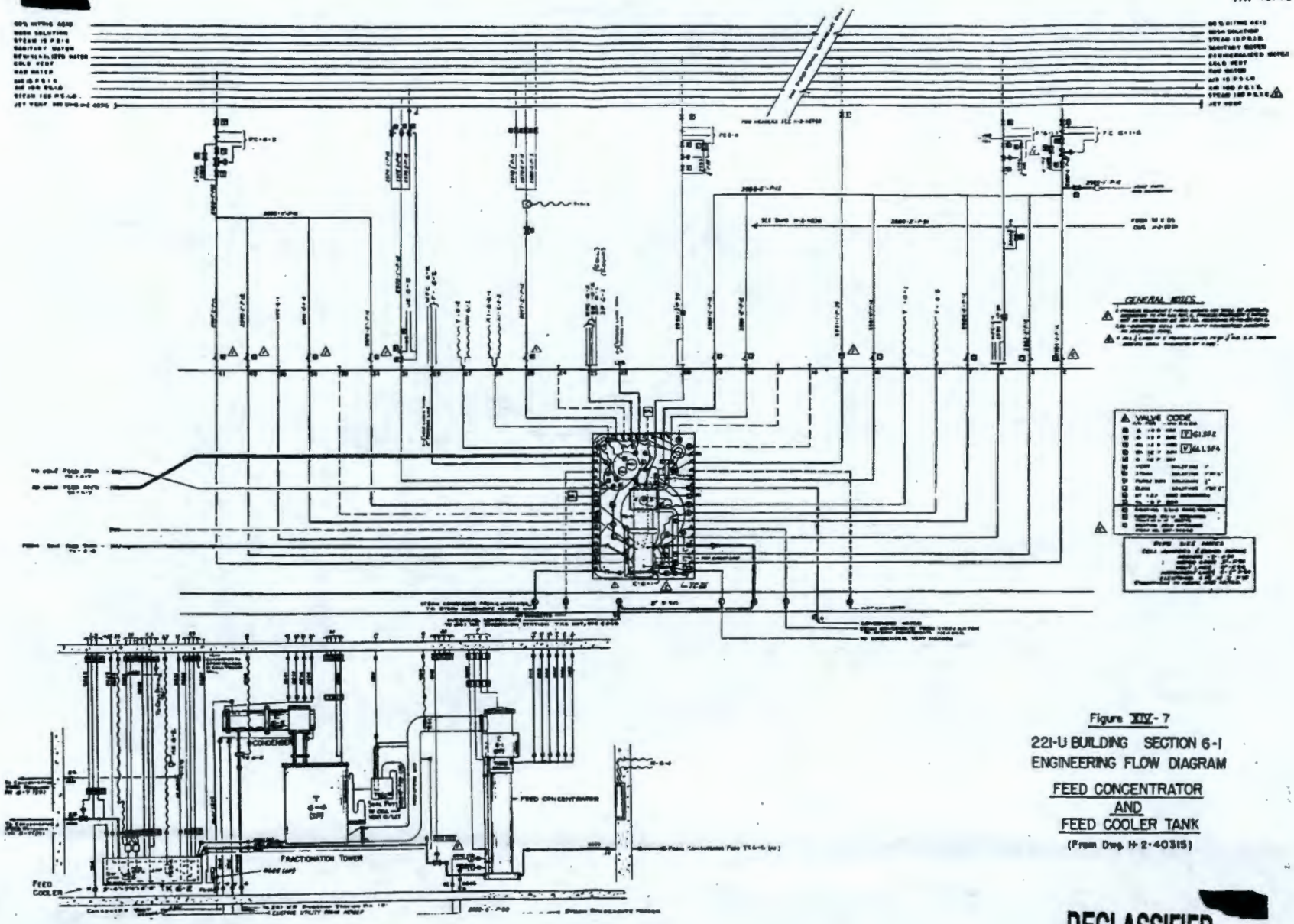

Figure XIV-7

221-U BUILDING SECTION 6-1
ENGINEERING FLOW DIAGRAM

FEED CONCENTRATOR
AND
FEED COOLER TANK

(From Dwg. H-2-40315)

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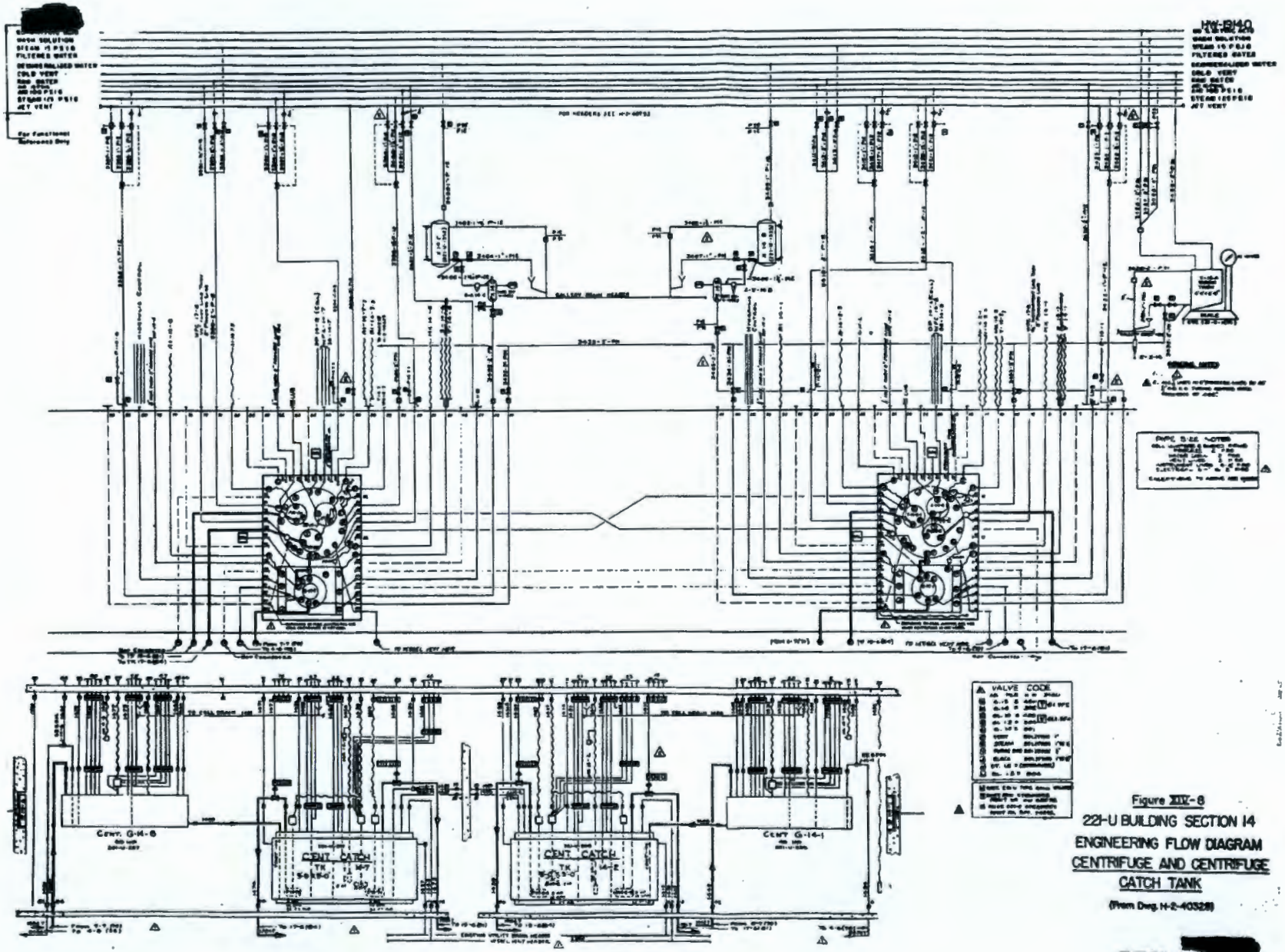

Figure XIV-8
221-U BUILDING SECTION 14
ENGINEERING FLOW DIAGRAM
CENTRIFUGE AND CENTRIFUGE
CATCH TANK
(From Dwg. H-2-40328)

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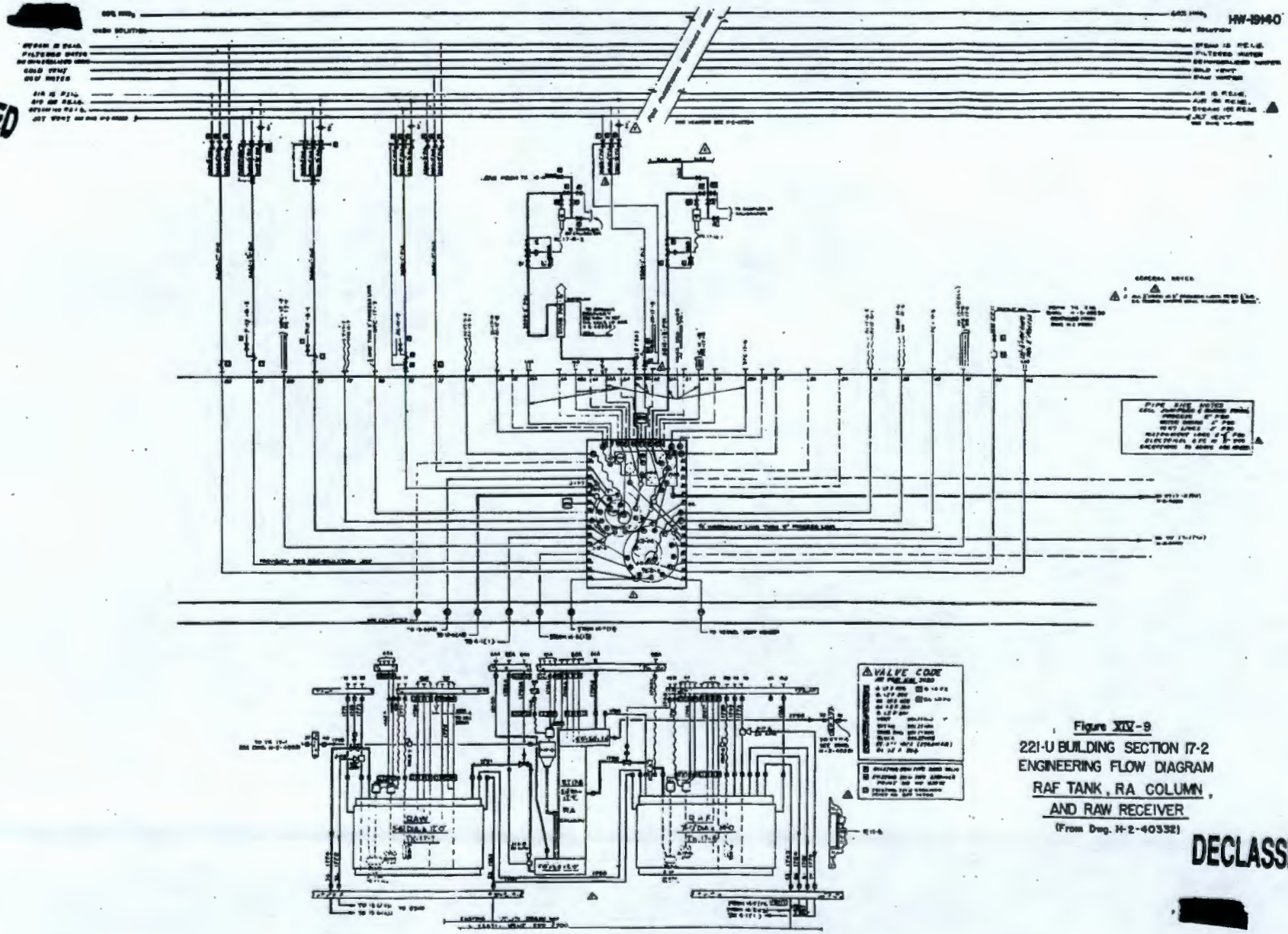

Figure XIV-9
221-U BUILDING SECTION 17-2
ENGINEERING FLOW DIAGRAM
RAF TANK, RA COLUMN,
AND RAW RECEIVER
(From Dwg. H-2-40332)

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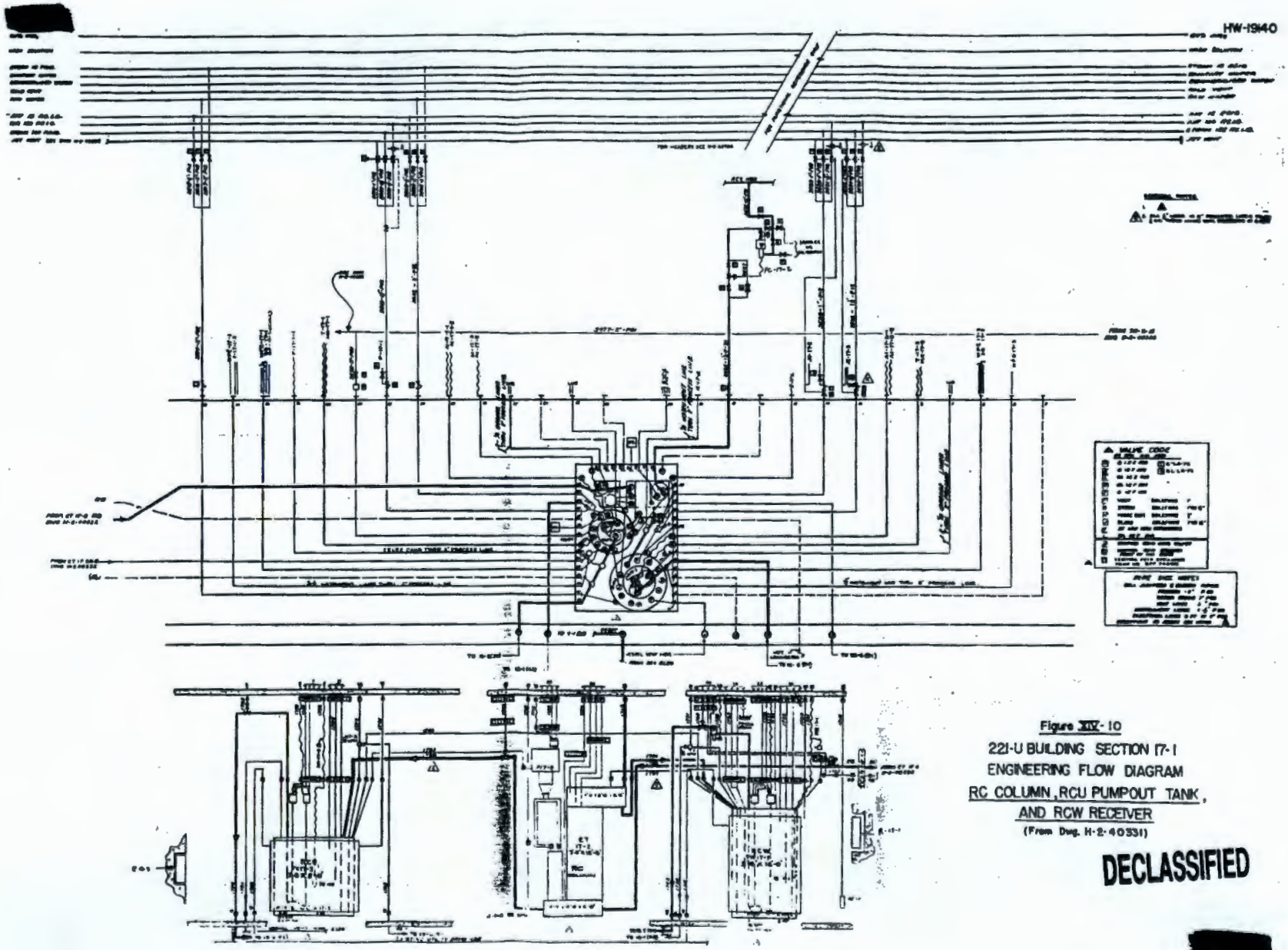

Figure XIV-10
221-U BUILDING SECTION 17-1
ENGINEERING FLOW DIAGRAM
RC COLUMN, RCU PUMPOUT TANK,
AND RCW RECEIVER
(From Dwg. H-2-40331)

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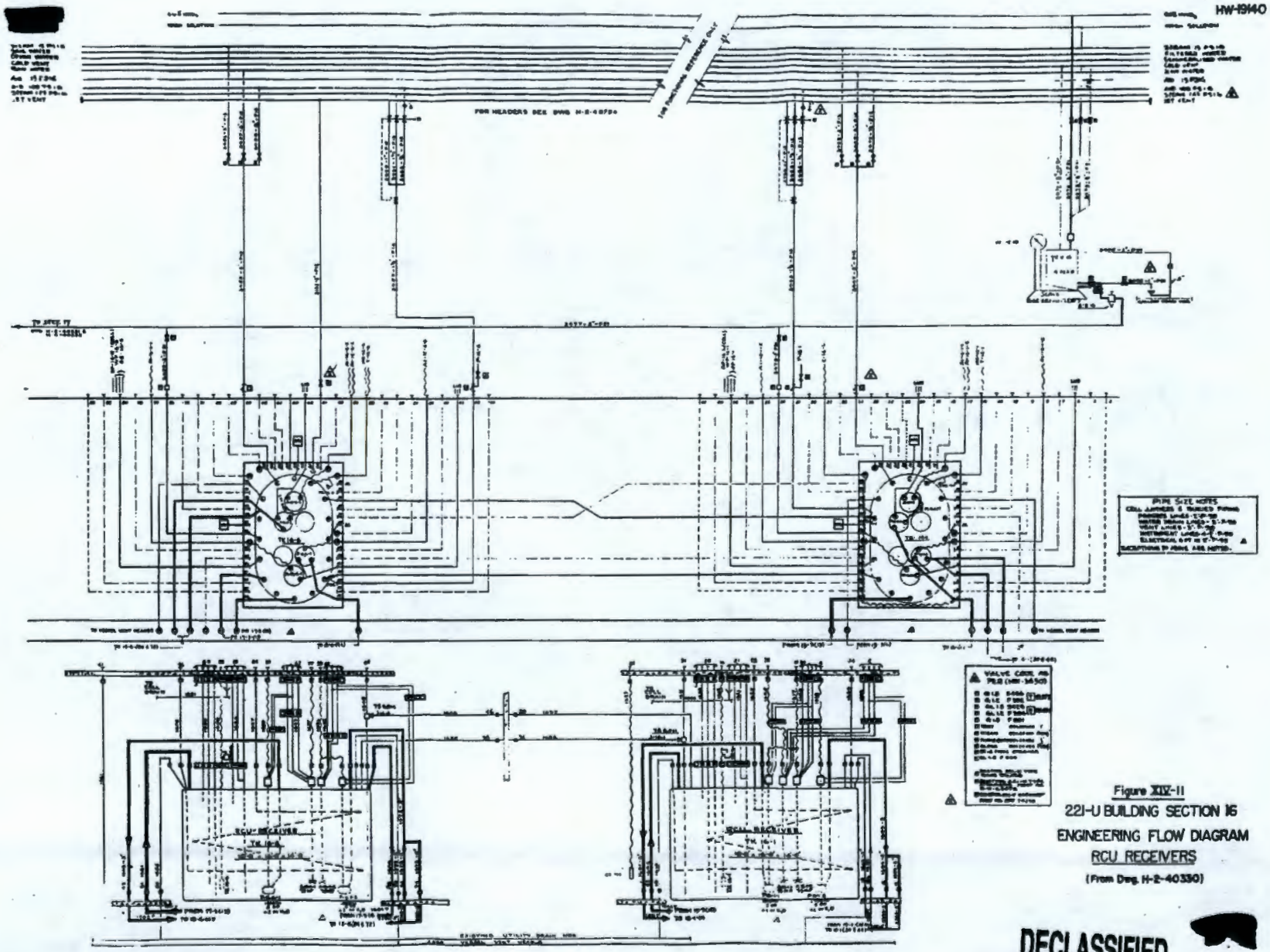

Figure XIV-11
221-U BUILDING SECTION 16
ENGINEERING FLOW DIAGRAM
RCU RECEIVERS
(From Dwg. H-2-40330)

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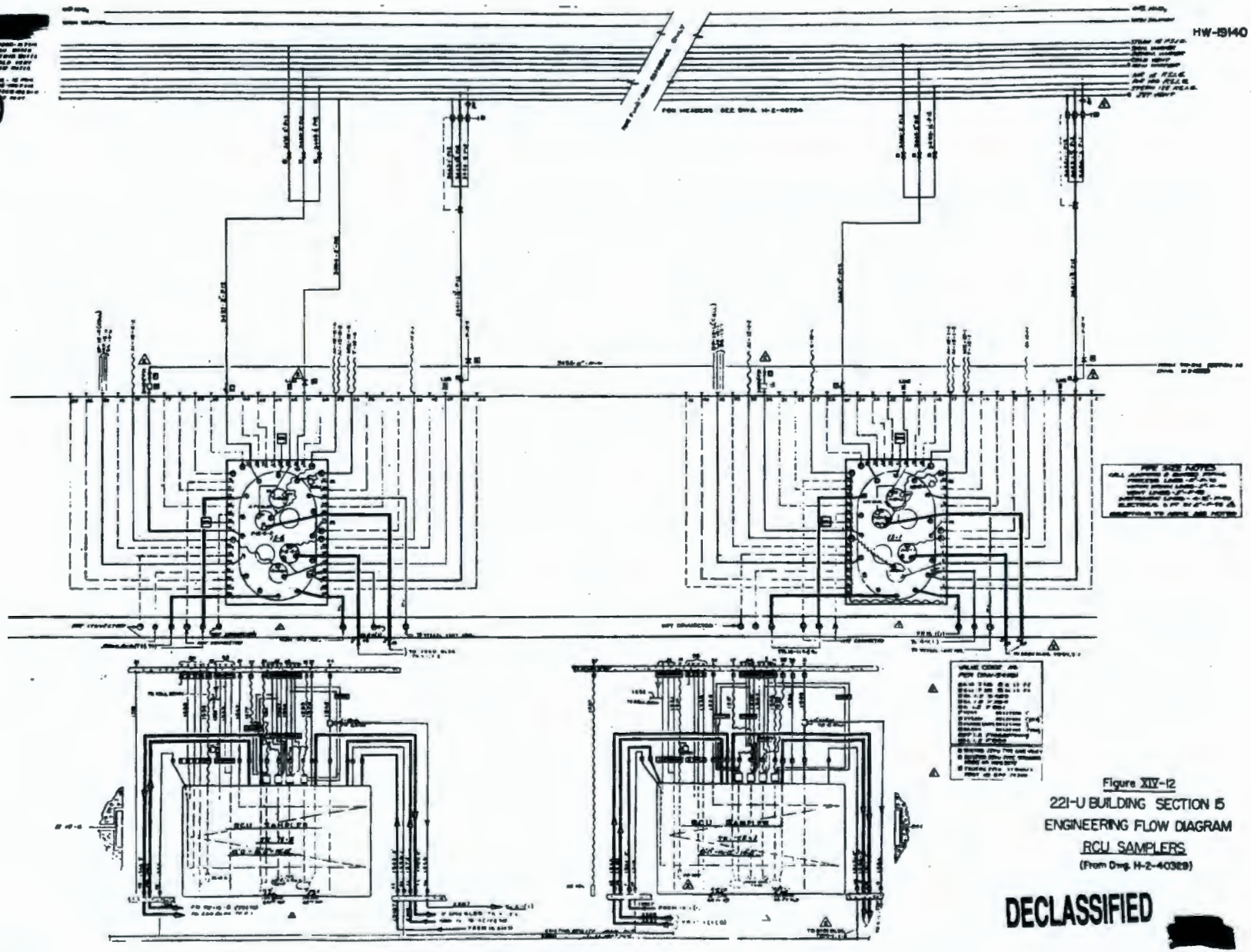

Figure XIV-12
221-U BUILDING SECTION 15
ENGINEERING FLOW DIAGRAM
RCU SAMPLERS
(From Dwg. H-2-40329)

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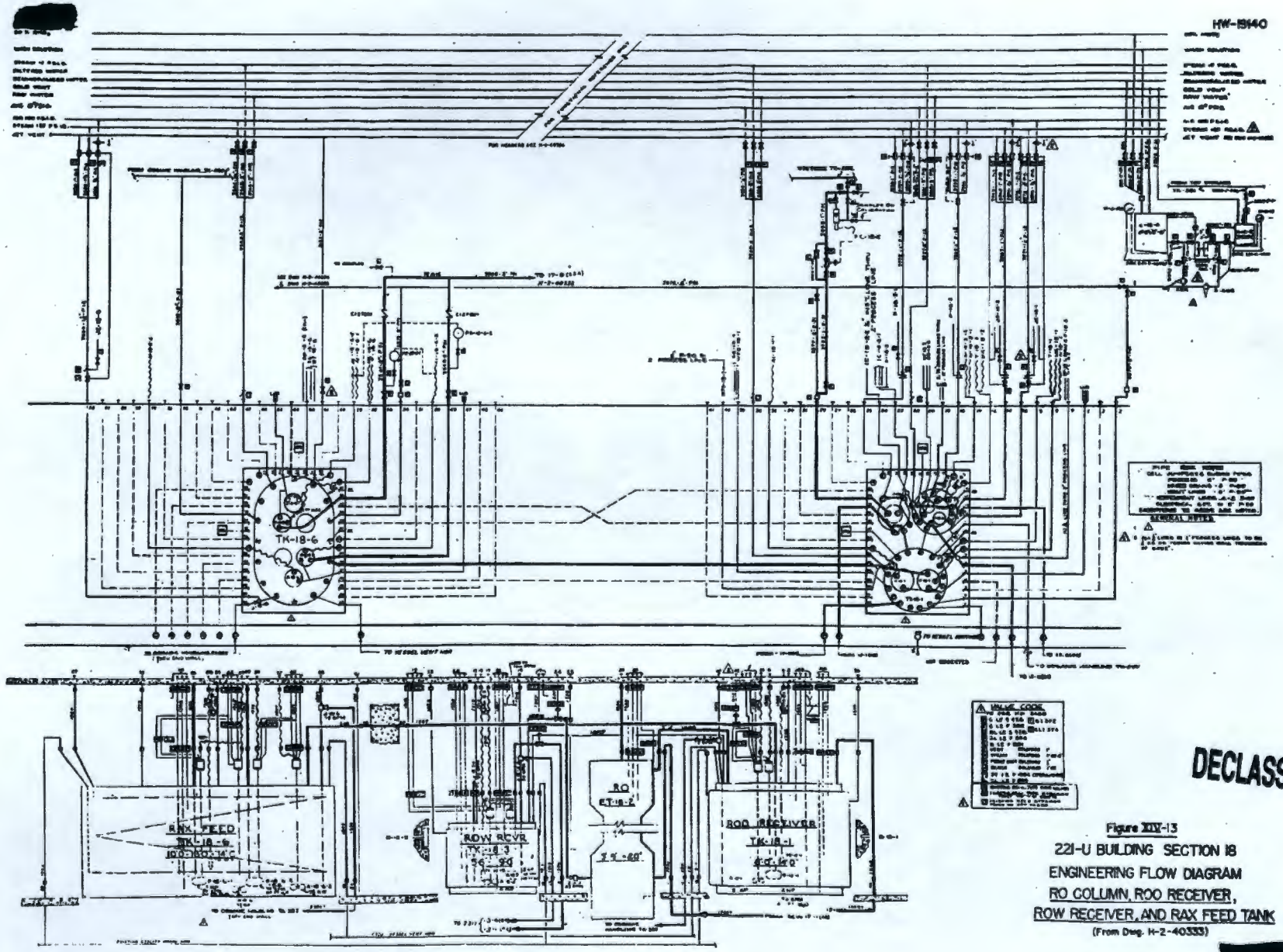

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Figure XIV-13

221-U BUILDING SECTION 18

ENGINEERING FLOW DIAGRAM

RO COLUMN, ROO RECEIVER,

ROW RECEIVER, AND RAX FEED TANK

(From Dwg. H-2-40333)

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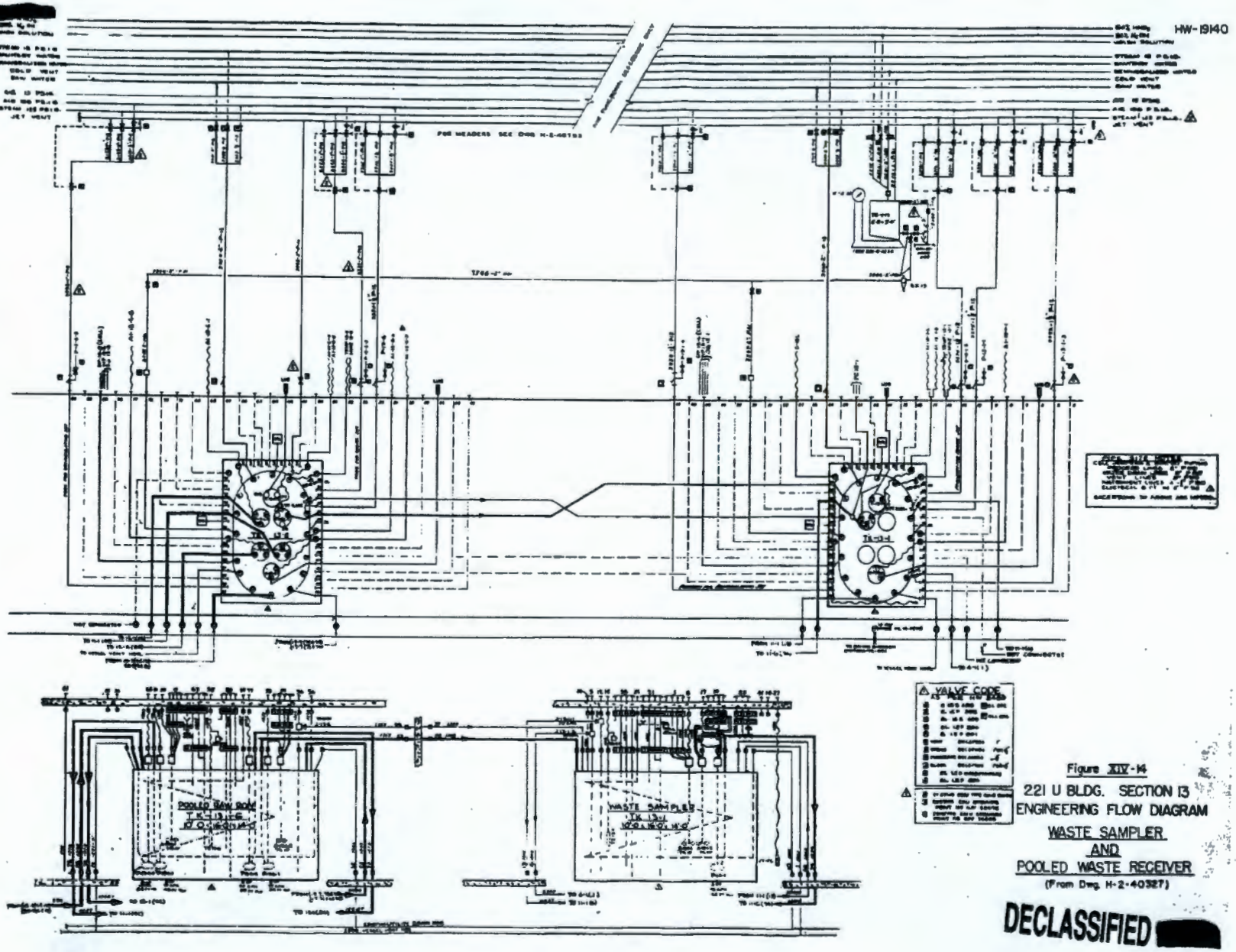

Figure XIV-14

221 U BLDG. SECTION 13
ENGINEERING FLOW DIAGRAM

WASTE SAMPLER
AND
POOLED WASTE RECEIVER

(From Dwg. H-2-40327)

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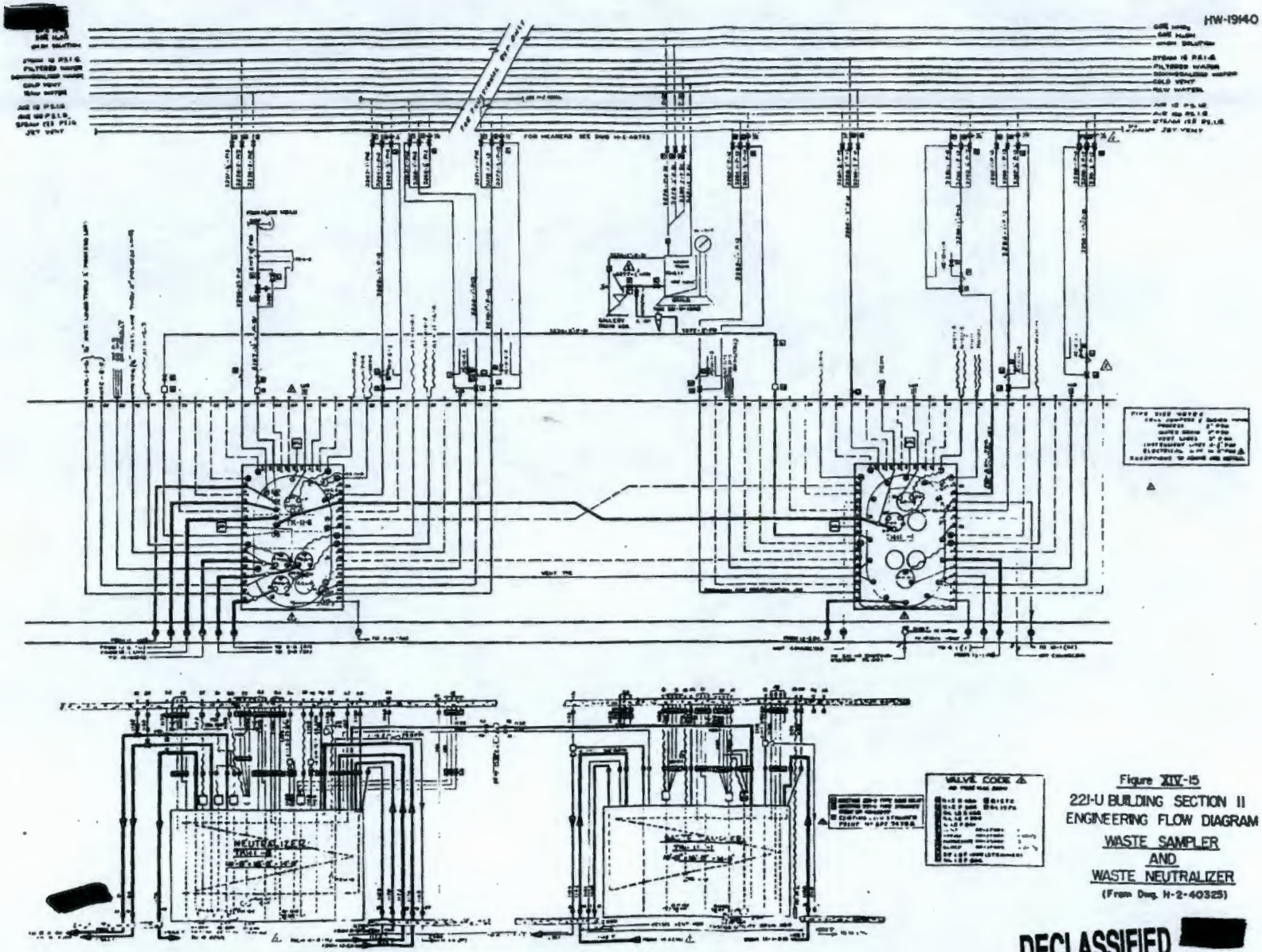

Figure XIV-15
221-U BUILDING SECTION II
ENGINEERING FLOW DIAGRAM
WASTE SAMPLER
AND
WASTE NEUTRALIZER
(From Dwg. H-2-40325)

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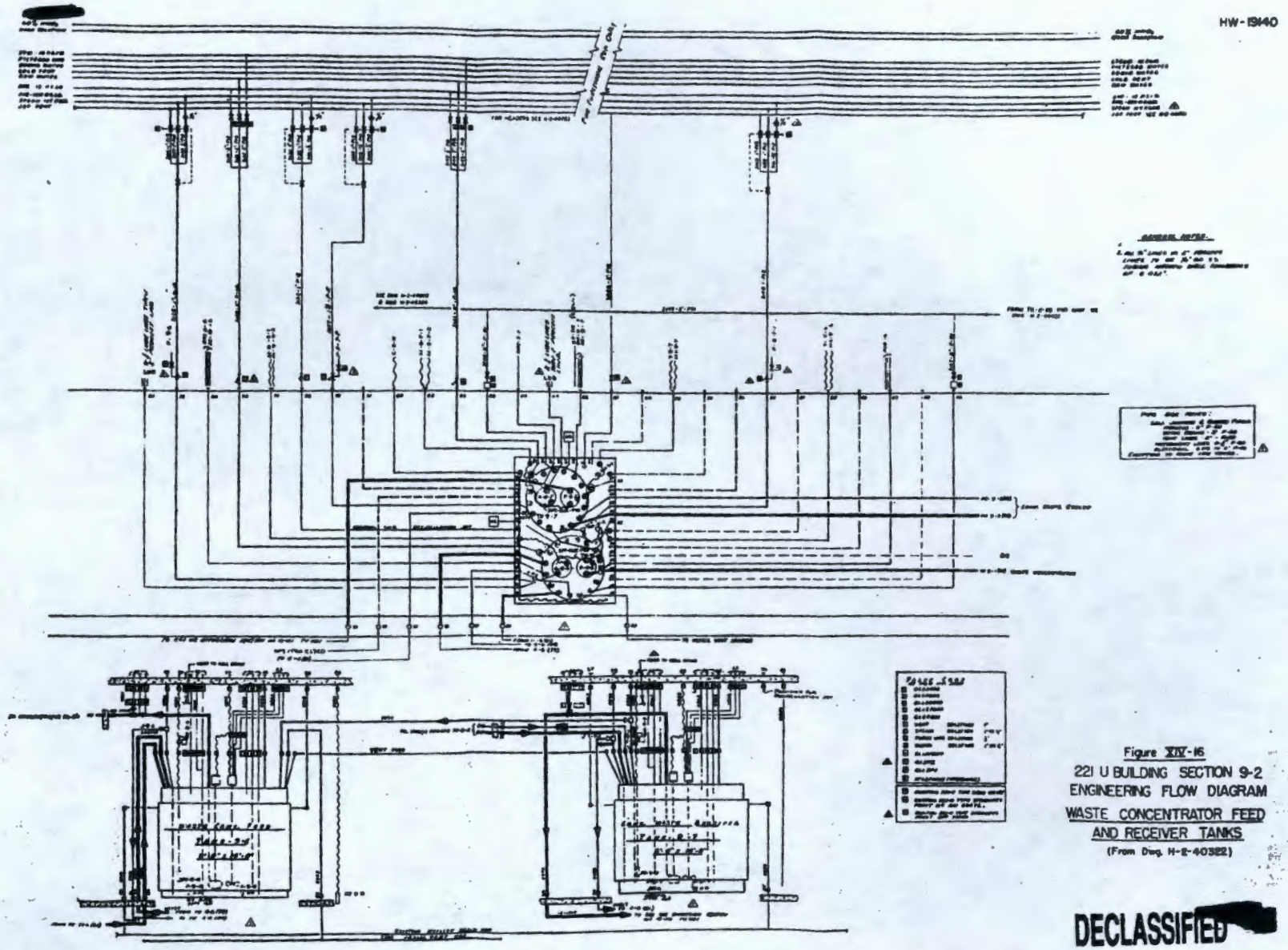

Figure XIV-16
221 U BUILDING SECTION 9-2
ENGINEERING FLOW DIAGRAM
WASTE CONCENTRATOR FEED
AND RECEIVER TANKS
(From Dwg. H-2-40322)

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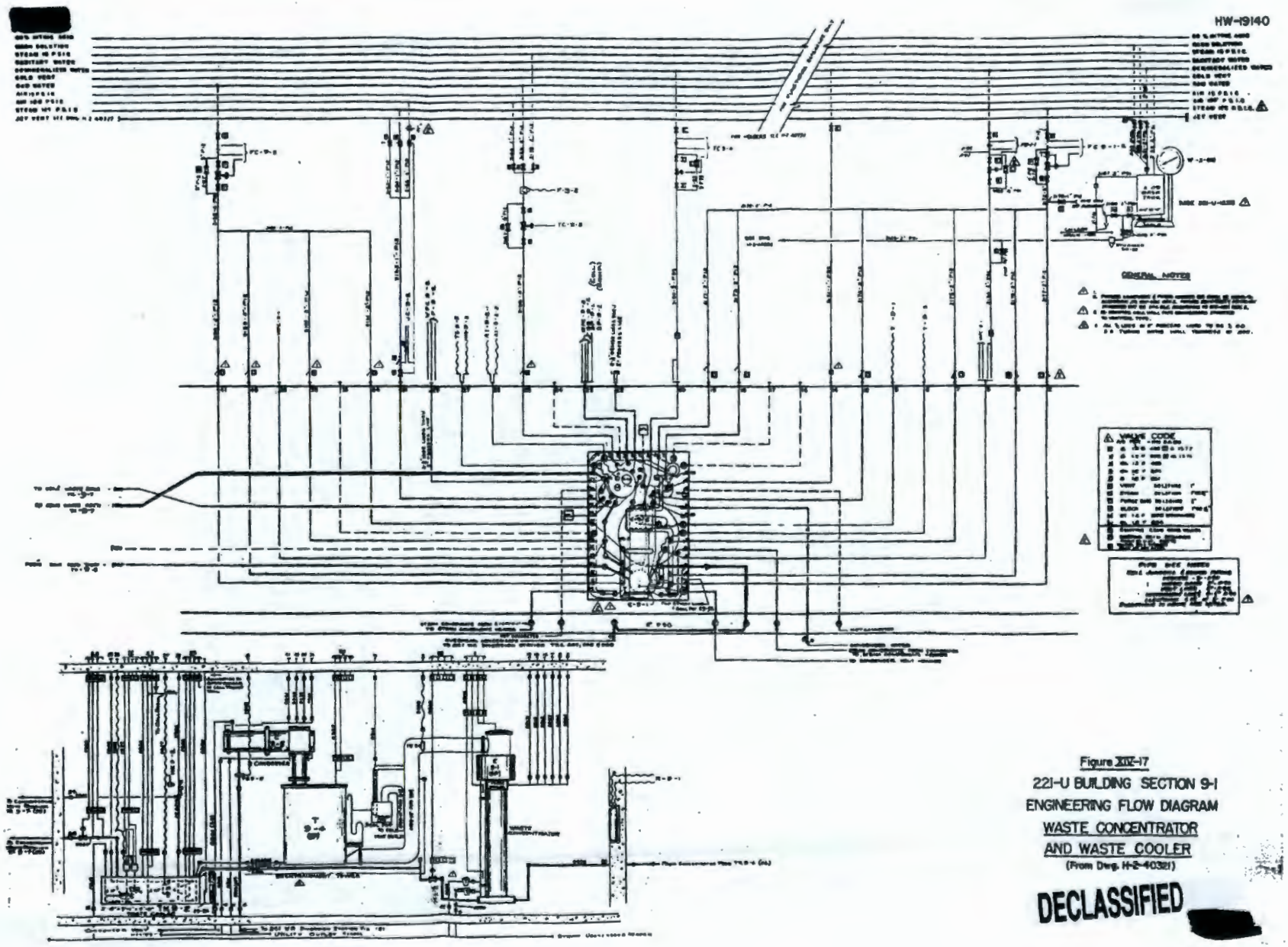

Figure XIV-17

221-U BUILDING SECTION 9-1

ENGINEERING FLOW DIAGRAM

WASTE CONCENTRATOR

AND WASTE COOLER

(From Dwg. H-2-40321)

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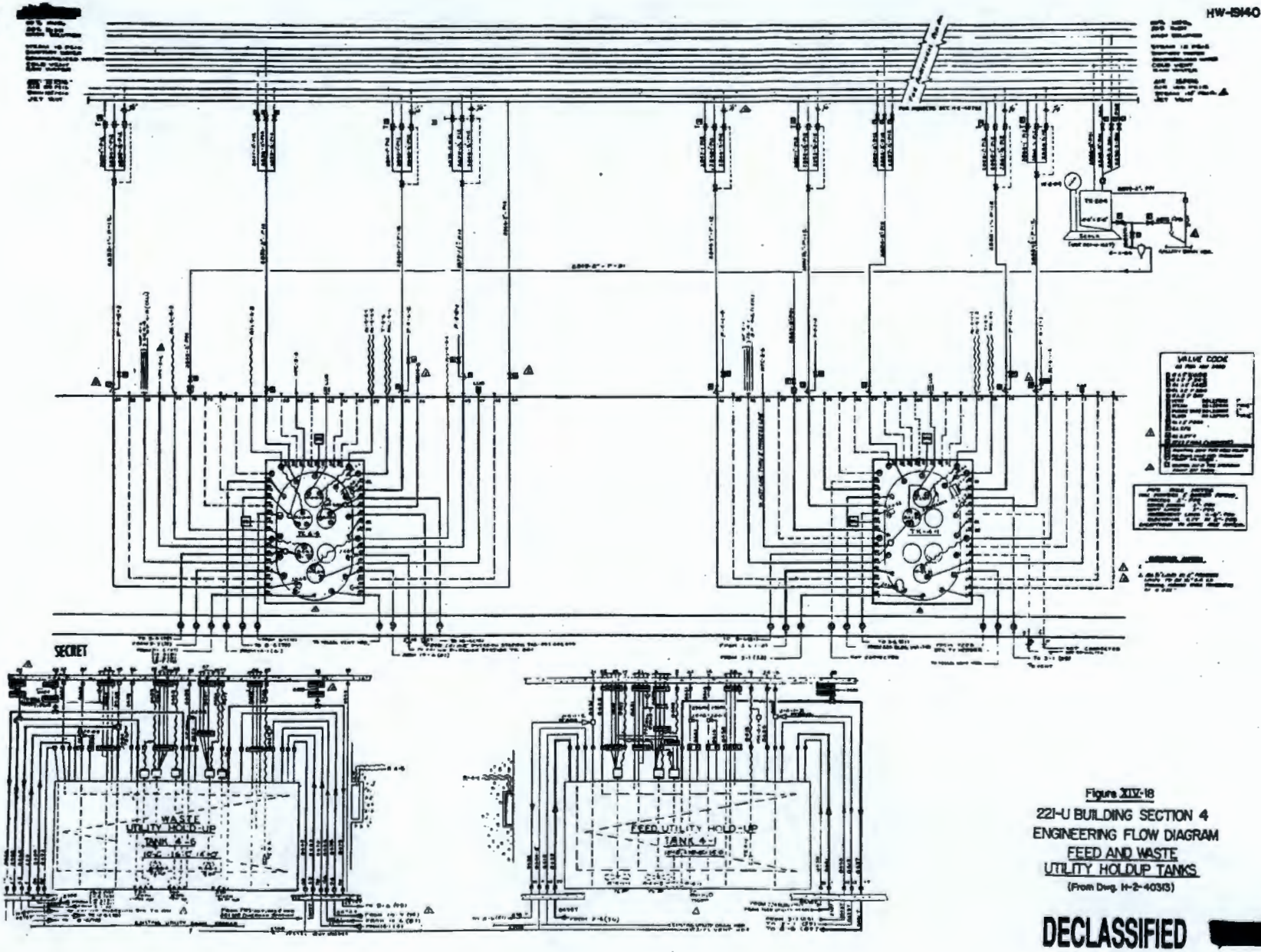

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Figure XIV-18

221-U BUILDING SECTION 4
ENGINEERING FLOW DIAGRAM
FEED AND WASTE
UTILITY HOLDUP TANKS
(From Dwg. H-2-40313)

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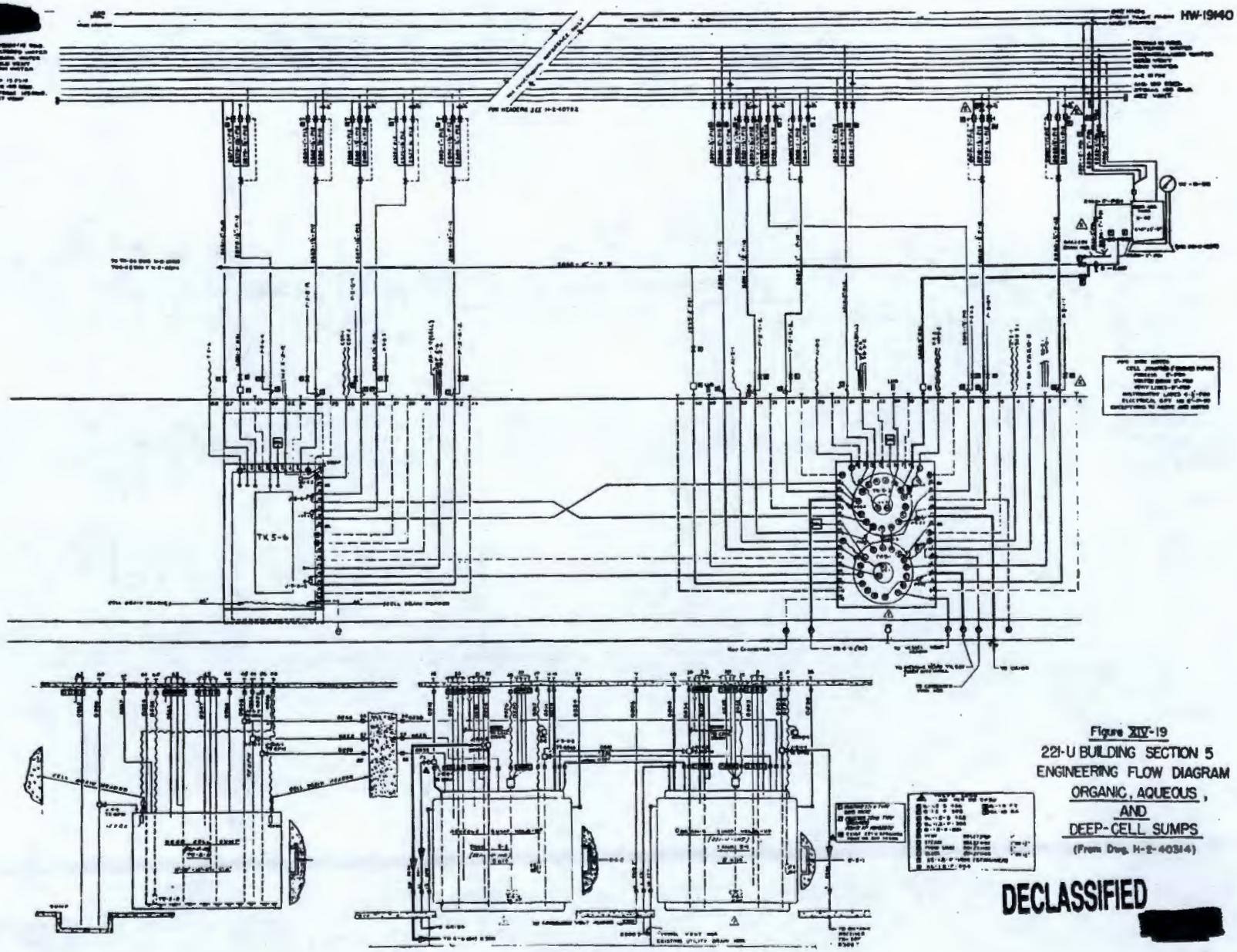

Figure XIV-19
221-U BUILDING SECTION 5
ENGINEERING FLOW DIAGRAM
ORGANIC, AQUEOUS,
AND
DEEP-CELL SUMPS
(From Dwg. H-2-40314)

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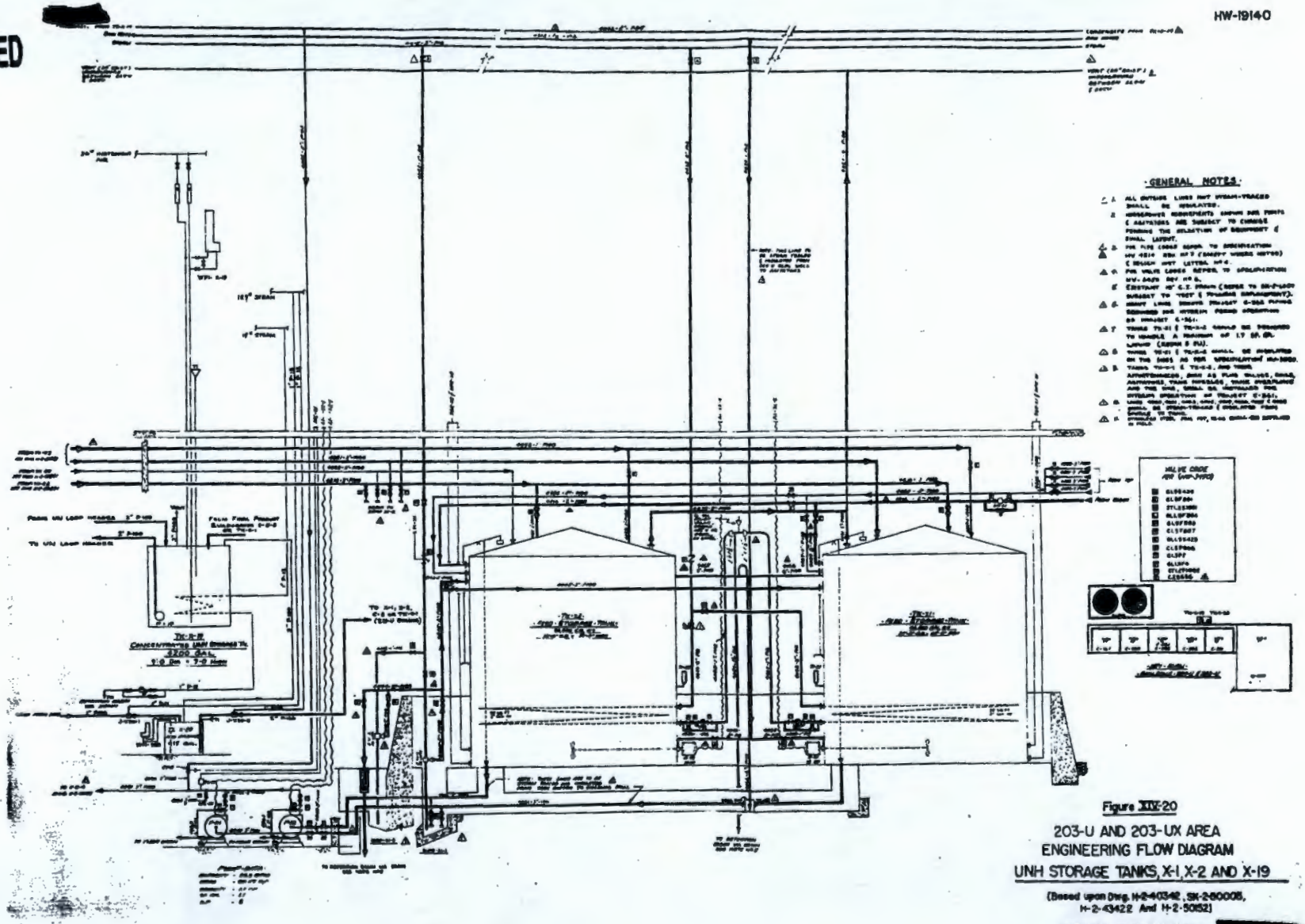

Figure XIX-20

203-U AND 203-UX AREA
ENGINEERING FLOW DIAGRAM
UNH STORAGE TANKS, X-1, X-2 AND X-19

(Based upon Dwg. H-2-40342, SK-260005, H-2-43422 And H-2-50152)

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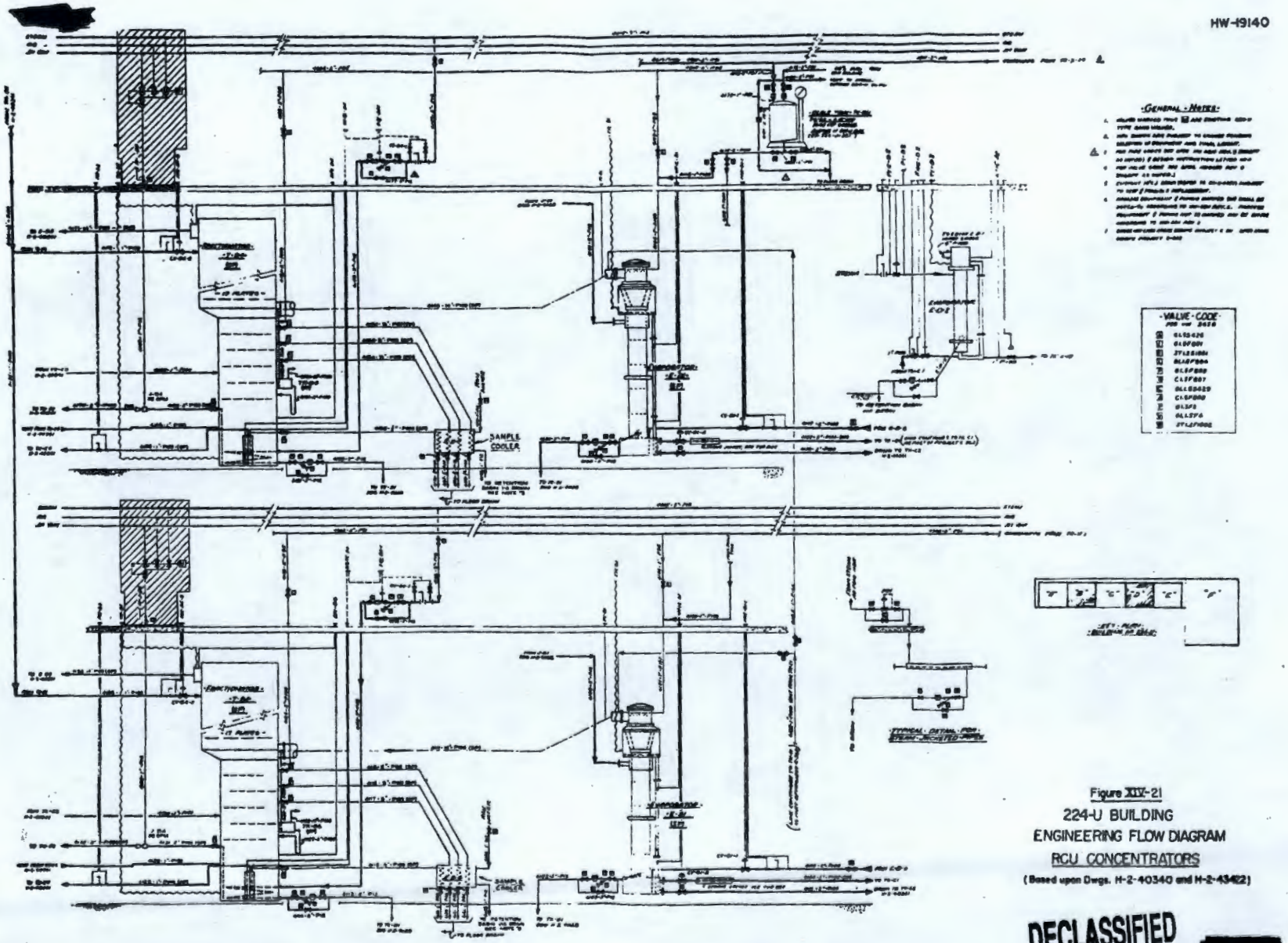

Figure XIV-21
224-U BUILDING
ENGINEERING FLOW DIAGRAM
RCU CONCENTRATORS
(Based upon Dwgs. H-2-40340 and H-2-43422)

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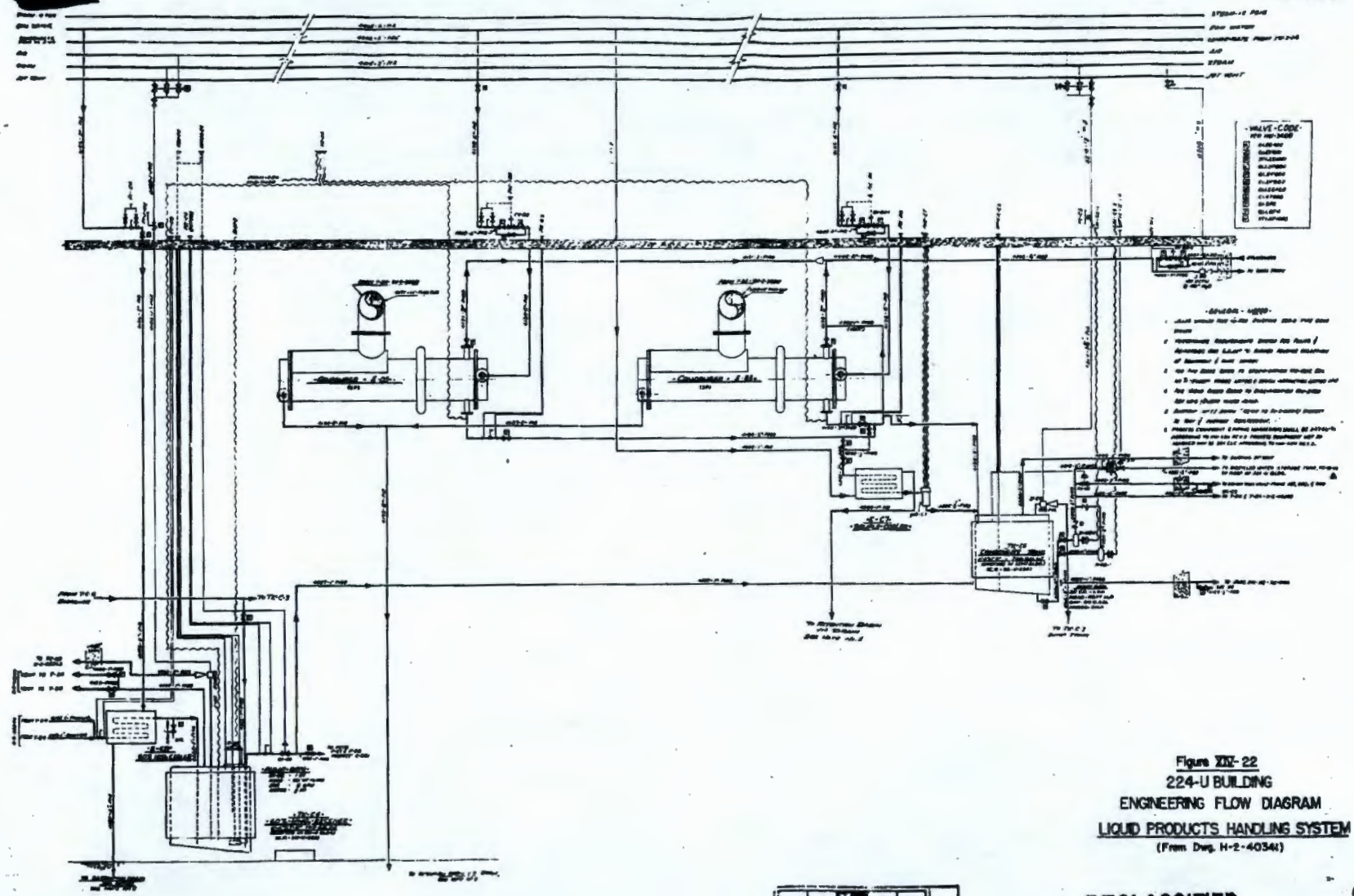

Figure XIV-22
224-U BUILDING
ENGINEERING FLOW DIAGRAM
LIQUID PRODUCTS HANDLING SYSTEM
(From Dwg. H-2-40341)

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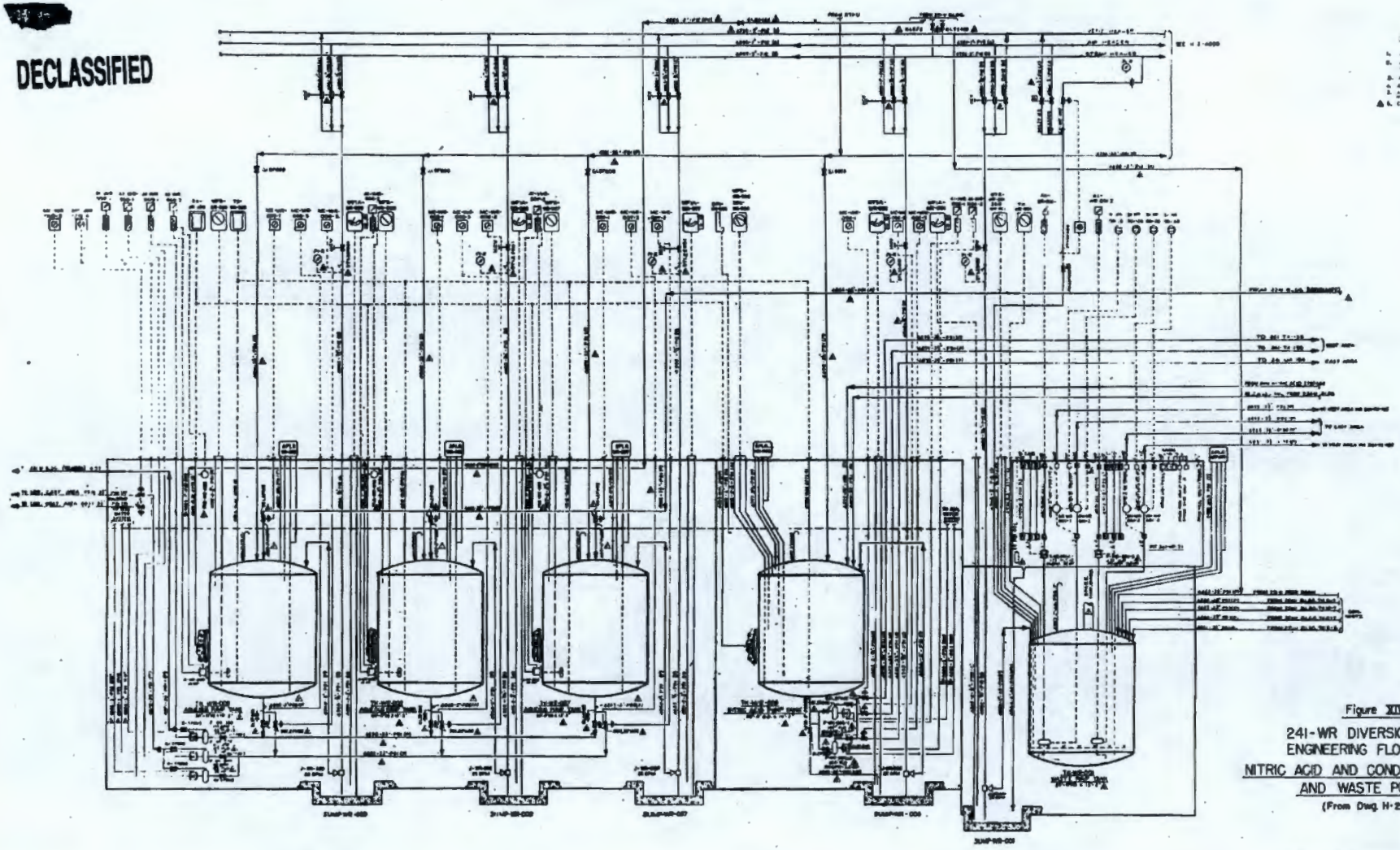

Figure XIV-23

241-WR DIVERSION STATION
ENGINEERING FLOW DIAGRAM
NITRIC ACID AND CONDENSATE RECEIVERS
AND WASTE PUMP TANK
(From Dwg. H-2-40003)

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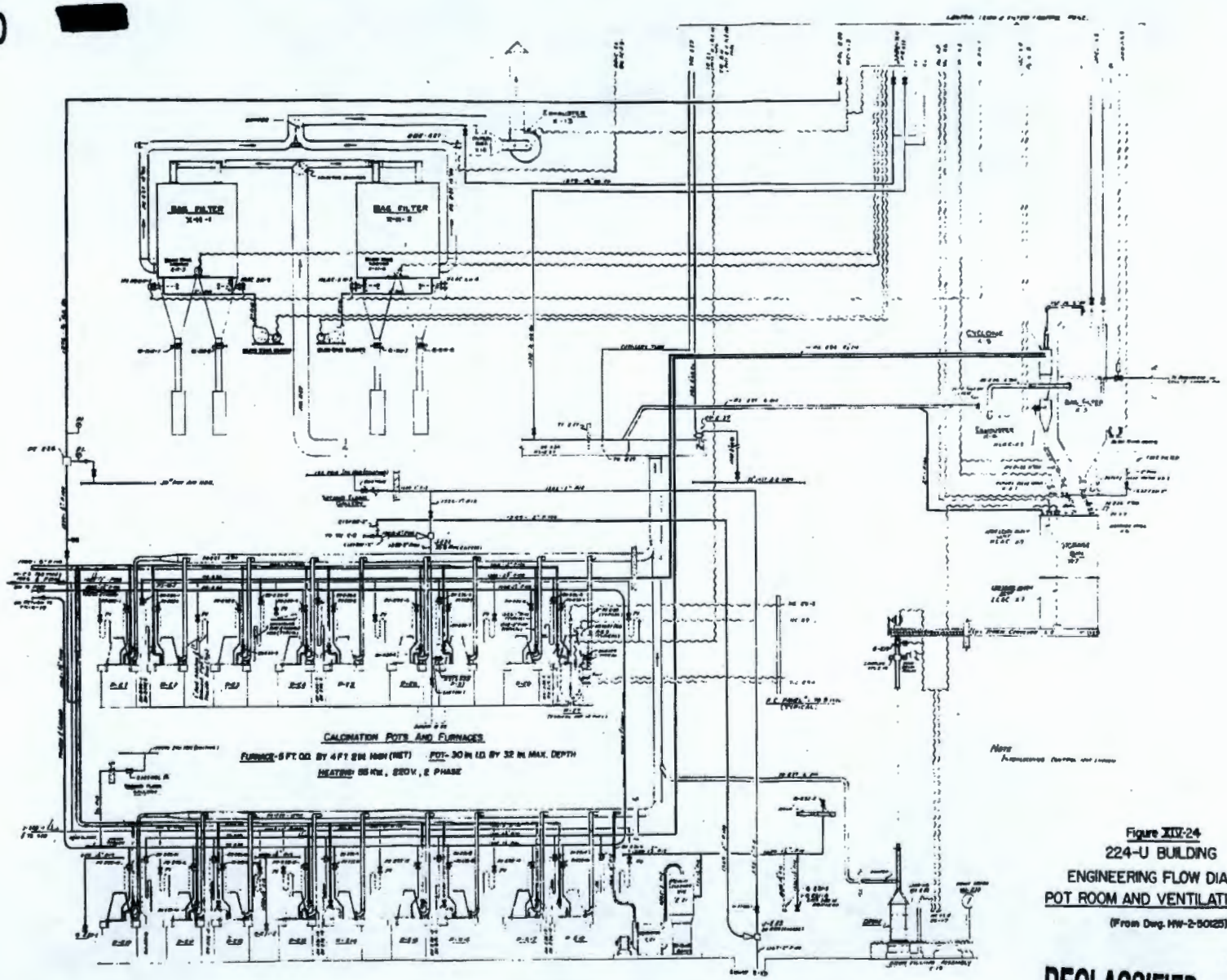

Figure XIV-24
224-U BUILDING
ENGINEERING FLOW DIAGRAM
POT ROOM AND VENTILATION SYSTEM
(From Dwg. HW-2-50125)

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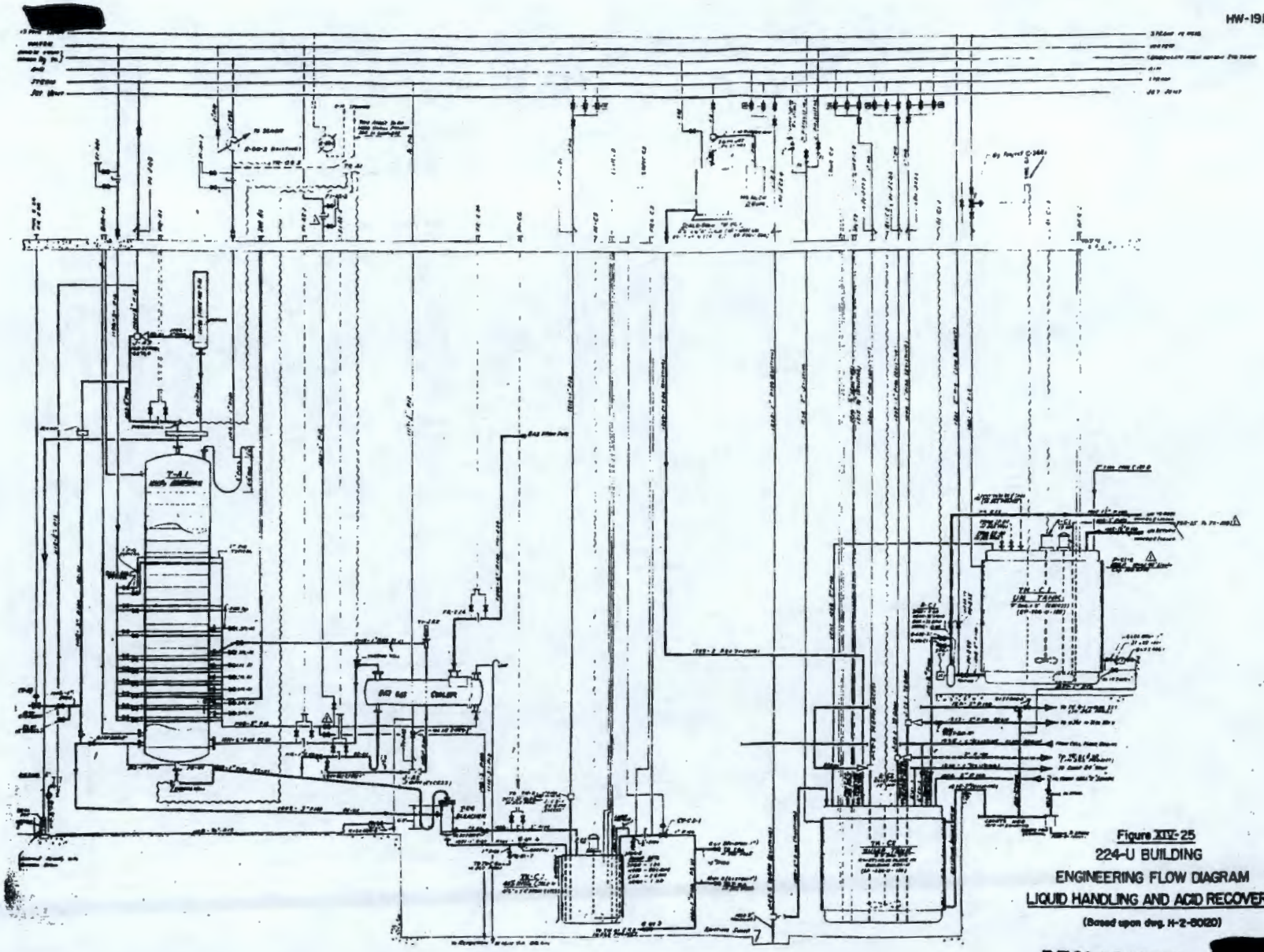

Figure XIV-25
224-U BUILDING
ENGINEERING FLOW DIAGRAM
LIQUID HANDLING AND ACID RECOVERY
(Based upon dwg. H-2-8020)

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PART III: PLANT AND EQUIPMENT, continued

CHAPTER XV. PULSE COLUMNS AND PULSE GENERATORS

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CHAPTER XV. PULSE COLUMNS AND PULSE GENERATORS

A. INTRODUCTION

The solvent-extraction columns are the "heart" of the TBP Plant. In view of their functional importance, a great amount of experimental work was devoted to their development. Because of the simplicity of packed columns and the ready availability of pilot-plant packed columns at Hanford Works, solvent-extraction contactor development studies were initially conducted with these units. On the basis of "cold" pilot-plant studies at Hanford with 3-in., 8-in., and 16-in. diameter units, it was found that heights of 50 ft. and 38 ft., respectively, would be required for packed RA and RC Columns. In order to permit the installation of the TBP Plant in the existing 221-U Building, the height requirements of the packed columns would have necessitated up to 35-ft. deep excavations to be made in four of the existing 221-U Building cells. It was realized that these excavations would be costly and might prove structurally hazardous. Accordingly an extensive further experimental program was undertaken with a view to developing shorter columns. On the basis of promising laboratory-scale results, "cold" pilot-plant studies in 3-in., 8-in., and 16-in. diameter pulse columns were conducted at Hanford Works. The success of this development program made possible the use of the existing 221-U Building cells with no major structural changes.

A pulse column is a liquid-liquid extraction column containing a series of horizontal, spaced perforated plates, in which the liquid phases undergo an up-and-down pulsing motion superimposed on the net flow.

The decontamination performance of the solvent-extraction columns for the TBP process was studied in "hot" runs in 2-in. and 3-in. diameter packed columns at Oak Ridge National Laboratory. Much of the O.R.N.L. Purex-process "hot" pilot-plant work in 2-in. to 4-in. diameter pulse columns is also applicable. The mechanical design of the pulse generators for the TBP Plant pulse columns is based largely on development work by Proportioneers, Inc.

The purpose of the present chapter is to present the salient design features of the TBP-Plant pulse columns and their associated pulse generators. For a technical discussion of the performance of the pulse columns reference is made to Chapter V.

B. COLUMN DESIGN SPECIFICATIONS

A summary of the more important specifications for the RA and RC Columns is listed in the table below. A more detailed description of the physical dimensions of the columns appears in Section C, below, and in Figures XV-1 and XV-2.

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Design Specifications

RA and RC Columns

Column	Over-All Height, Ft.	Net Height of Plate Section, Ft.	Column Inside Diam., In.	Design Capacity[a] Tons U/Day Min.	Tons U/Day Max.	Gal./(Hr.)(Sq.Ft.)[b] Min.	Gal./(Hr.)(Sq.Ft.)[b] Max.
RA	22	3.3 (scrub section) 11.8 (extn. section)	20	2	5	570	1430
RC	21	11.8	30	2	5	290	720

Notes: (a) For each of two columns in parallel.

(b) Sum of both phases, TBP-HW No. 4 Flowsheet conditions.

(c) The pulse frequency in both the RA and RC Columns may be varied from 25 to 90 cycles/min. The volume of liquid pulsed by the pulse generators corresponds to a displacement (amplitude) of 1.28 in. in the RA Column or 0.57 in. in the RC Column.

The plate sections of both the RA and the RC Columns contain pierced stainless steel plates with 1/8-inch diameter holes, 23% free area, and 2-inch plate spacing.

C. COLUMN DETAILS

1. RA Column

Figure XV-1 shows the principal physical dimensions of the RA Column. Exact dimensions and other detailed data on any particular component are available from the vendor's (A. O. Smith) drawings.

Material originally specified for the entire vessel was Type 347 stainless steel. Due to difficulties in procurement, it was necessary to make a few of the less critical parts (for both the RA and RC Columns) from Type 304 stainless steel.

1.1 Column dimensions and construction

The over-all height of the RA Columns including the topmost connector is 22 feet. The extraction section of the column is constructed from 1/4-in. plate rolled to a nominal 20-in. I.D. cylinder. The plate

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assemblies or "cartridge" (including both scrub and extraction sections) which are within the columns have an over-all height of 16 ft. 10 in. The horizontal dimensions of both the top and bottom phase-disengagement sections are 4 x 5 feet. The top disengagement section is 30 in. in height, the bottom section is 24 in. in height. The connectors as shown in Figure XV-1 are standard Hanford (Bismuth Phosphate Plant type) 2, 3, and 4-in. connectors. The column is supported on brackets as indicated on Figure XV-1. Two lifting bails are provided for use in removing the column with the remotely operated crane.

1.2 Cartridge geometry

There are two separate assemblies which comprise the plate assembly or "cartridge" in the RA Column. The lower, or extraction, section is formed from 71 plates 1/16 in. thick by just under 20 in. in diameter to allow a 1/16 to 1/8-in. diametrical clearance between the plates and the 20-in. I.D. column. The perforated plates are spaced 2 in. apart, center-to-center.

Four stainless steel strips located at 90° to each other at the edges of the plates and a 3/4-in. rod through the center of the plates tie the series of plates into a unit 12 ft. 2-1/16 in. long. Each plate is pierced with 1/8-in. holes located on 1/4-in. equilateral triangular centers, which provides an over-all plate "free area" of about 23%. The extraction section plate cartridge is secured in place by a continuous weld between the top spider ring, (see Detail 3 on Figure XV-1) and the inside wall of the column.

The upper (or scrub) section is formed in an identical manner with the lower section except that the center hole in the plates is larger (2-7/16 in. diameter), to allow passage of the pipe leading to the RAF (feed) distributor. The scrub section contains 20 pierced plates spaced at 2-in. center-to-center intervals.

1.3 Connectors and distributors

The connectors as shown in Figure XV-1 are all standard Hanford (Bismuth Phosphate Plant type) remote connectors. The RAS, RAW, RAF, vent, and jet steam inlet nozzles are standard 2-in.-diameter nozzles; the RAU, RAX, and interface controller nozzles are 3 in. in diameter; and the pulse generator nozzle is 4 in. in diameter. The bottom leg of the RAX inlet line is constructed of standard 8-in. pipe in order to minimize the acceleration pressure between the pulse generator and the column. The 8-in. pipe is reduced to a 4-in. diameter at the pulse generator nozzle in order to enable the use of a standard 4-in. connector. The connector which is labeled as the static pressure tap has three "blind" 1/2-in. openings and one 1/2-in. pipe opening, leading to the bottom of the column. The steam inlet connector and steam jet (although connected) are normally not used. Under normal operating conditions, the RAW is displaced from the column by hydrostatic pressure within the column. When it is necessary to drain the column, for maintenance or other reasons, the steam jet is utilized for that purpose.

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The RAF and RAS distributors are detailed in Figure XV-1. The RAF distributor is a piece of 2-in. pipe curved to a doughnut shape 12 in. in diameter with six 3/4-in. holes on top to distribute the feed stream.

The RAX stream does not have a special distributor. RAX flows down through the pulse generator leg, across the top of the bottom disengagement section, and into the RA Column.

2. RC Column

2.1 Column dimensions and construction

The over-all height of the RC Column, including the topmost connector, is 21 feet. The stripping section is constructed from 1/4-in. plate rolled to a nominal 30-in. I.D. cylinder. The plate assembly which fits within the column has an over-all length of 12 ft. 7-1/16 in. The horizontal dimensions of both the top and bottom disengagement sections are 4 x 5 feet. The top disengagement section is 30 in. high, the bottom section is 2 ft. high. The connectors as shown in Figure XV-2 are standard Hanford 2, 3, and 4-in. (Bismuth Phosphate Plant type) connectors. The column is supported on brackets as indicated on Figure XV-2. Two lifting bails are provided for use in removing the column with the remotely operated crane.

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2.2 Cartridge geometry

The plate cartridge for the RC Column is composed of 71 plates, 1/16 in. thick, with a diameter permitting 1/16 to 1/8-in. diametrical clearance between the plates and the 30-in. (nominal) I.D. column. The perforated plates are spaced 2 in. apart, center-to-center. Four stainless steel strips located at 90° to each other at the edges of the plates and a 3/4-in. rod through the center of the plates tie the series of plates into a unit. Each plate is pierced with 1/8-in. holes located on 1/4-in. equilateral triangular centers, which provides a plate "free area" of about 23%. The bundle of plates is secured in place by a continuous weld between the top spider ring and the inside wall of the column.

2.3 Connectors and distributors

The connectors as shown on Figure XV-2 are all standard Hanford (Bismuth Phosphate Plant type) remote connectors. The RCU, RCX, RCF, vent, and inlet steam nozzles are standard 2-in. diameter nozzles; the RCW, interface controller, and the nozzle labeled "blank", are 3 in. in diameter; and the two nozzles which connect to the pulse generator are 4 in. in diameter.

The connector for the pulse generator is made from two 4-in. nozzles, connected in parallel, in order to minimize the acceleration pressure between the pulse generator and the column. The static pressure tap and the steam inlet nozzles function as described above for the RA Column.

The two distributors for the RC Column are detailed in Figure XV-2.

D. PULSE GENERATORS

The aqueous and organic liquid phases in the TBP pulse columns are squirted alternately upwards and then downwards through the perforated plates in the columns, to cause intimate mixing of the phases and hence good extraction. This "pulsing" of the liquid contents of the columns is done by reciprocating piston devices which are called pulse generators. Each pulse generator in the TBP Plant is comprised of a 16-in.-diameter reciprocating piston which is driven in a cylinder by a suitable drive mechanism. Operating with a fixed stroke of 2 in. and a frequency which can be varied from 25 to 90 cycles/min., the piston displaces 402 cu.in. at each down stroke or up stroke. This displacement is transmitted by liquid to the liquid contents of the column through a connecting pipe or pulse leg.

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Figure XV-3 shows a schematic arrangement of the RA Column, pulse generator, and pulse leg. The arrangement for the RC Column is similar, the major difference (aside from the height of the pulse leg) being that the organic feed stream (RAX) enters the pulse leg of the RA Column, whereas no feed stream enters the pulse leg of the RC Column. As shown on Figure XV-3, RAX (organic phase) fills the pulse leg of the RA Column and transmits the pulse from the piston to the RA Column. The pulse leg of the RC Column is filled with aqueous phase (RCU), which transmits the pulse from the piston to the RC Column.

The design bases and features of the pulse generators are discussed in the following sections.

1. Principles and Basis of Design

1.1 Hydraulic considerations

Under dynamic conditions, three forces act in the hydraulic system formed by the column, pulse leg, and reciprocating piston. The magnitude of these combined forces determines the theoretical horsepower required to pulse the fluid and define the conditions of incipient cavitation.* The three forces are (a) the force exerted by the static head of fluid at a given point, (b) the force required to overcome the frictional resistance of the pulsed fluid to flow through the piping and perforated plates, and (c) the force required to accelerate the fluid during a pulse cycle. A detailed analysis of these forces as they apply to pulse columns, and methods for determining the conditions of incipient cavitation has been reported(5). The maximum hydraulic power requirements for pulse generator systems have also been analyzed(1) and have been found to be a function of the pressure under piston and the piston velocity.

*) Cavitation is defined as a condition which occurs when the absolute pressure at any point in the system is less than the vapor pressure of the fluid at that point. Under conditions of cavitation, vapor pockets form in the pulsed fluid which not only affect the amplitude of pulsation but produce severe vibration and pounding in the equipment.

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1.2 Mechanical considerations

The two basic factors which establish and define a pulse system are (a) the amplitude of pulsation or the unidirectional distance which a volume of solution contained in a vessel of constant cross section is displaced, and (b) the pulse frequency or the number of displacements occurring in a given time. These two factors are important to pulse column performance and are specified by column design considerations. Other factors which influenced the design basis for the TBP Plant pulse generators were:

a. Space limitations. The pulse generator and column assembly were required to fit into the existing 221 Building cells.

b. Service life. A mechanical unit was desired which would operate without the necessity for replacement for as long as the the plant was operated.

c. Mechanical know-how. In the interest of saving time and money, it was desirable that the pulse generators be developed and proof-tested in cooperation with equipment vendors who already possessed a background of mechanical know-how for this type of equipment.

d. Leakage. All leakage in the pulse-producing mechanism was to be contained, to avoid spreading radioactive contamination.

Based upon the considerations listed above, a vertical reciprocating piston was selected to pulse the fluid. The piston is mounted at the upper end of a pulse leg at an elevation(2) which will minimize the static head on the lower face of the piston, and thus minimize leakage(3) of fluid past the piston. A slider crank (scotch yoke) directly connected to the piston rod and driven by a variable speed electric motor generates a reciprocating motion at the piston.

1.3 Process requirements

The process requirements were established so that one design of pulse generator could be used for either the RA or the RC Column. Inasmuch as more mechanical difficulties were associated with a pulse generator design which would allow amplitude adjustment than were associated with a design which would allow frequency adjustment, the amplitude or piston travel distance was fixed.* The process requirements are defined as follows:

*) Difficulties associated with amplitude adjustment were two-fold: (a) a remotely operated, calibrated adjustment, mechanical device would be necessary to adjust the stroke, and (b) extended operation at a small constant amplitude might wear the cylinder slightly and form a ridge at the extremes of piston travel. Subsequent increase in amplitude would shatter the piston rings as they passed over the ridges.

Column	Column Displacement, In.	Column Diameter, In.	Pulse Frequency, Cycles/Min.
RA	1.28	20	25 to 90
RC	0.57	30	25 to 90

These requirements allow the selection of one pulse generator design for both the RA and RC Columns. Since a minimum piston travel distance was desirable for minimum frictional wear on the piston rings and maximum dynamic rigidity of the piston and rod, the cylinder diameter was selected as the largest that could be manufactured without undue difficulty. Thus, the pulse generator was designed with a cylinder diameter of 16 inches and a piston travel distance of 2 in., or the equivalent of a 402 cu.in. displacement volume.

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2. Description

The pulse generator unit is discussed in two parts for ease of description. The cylinder, piston, piston rod, and component items are considered as one major part, and the mechanical assembly (motion box) with the electric driving motor is considered as the second major part. In addition to the two major parts, the electrical system which is designed to provide speed variation to the driving motor is considered sufficiently unique to be described separately. (See 2.3, below.) Figure XV-4 shows the complete assembly of the pulse generator. Figure XV-5 shows the power supply in block diagram form.

2.1 Piston and cylinder assembly

2.11 Function

The piston which is equipped with four spring-loaded segmental piston rings which form a tight sliding fit with the cylinder wall produces by reciprocating motion an alternating pulse in the liquid column of the pulse leg.

2.12 Description

Cylinder: The cylinder is centrifugally cast Type 304 stainless steel, honed to an inside diameter of 16.001/16.002 inches at the surface in contact with the piston rings. The honed surface has a finish of 2 microinches. The cylinder is 27 in. long and has a nominal wall thickness of 1/2 in. It is flanged at the lower end to a reducer which adapts the 16-inch cylinder to the 8-in. pulse leg. The top of the cylinder is flanged to a cylinder head which contains a bushing of Graphitar 41 centered concentrically with the bore of the cylinder. The bushing, with a nominal bore of 3 inches provides a 4-mil 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, with a center line 8 in. below the cylinder flange allows solution which leaks past the piston to flow to the RCW Receiver (RA Column) or to the RCU Receiver (RC Column).

Piston: The piston is Type 304 stainless steel with a nominal diameter of 15 inches and an actual diameter that is 20 to 25 mils less than the cylinder bore. The piston is rigidly fixed to a piston rod which extends upward through the cylinder bushing and is rigidly attached to the yoke arm of the motion box. The piston is cup shaped with the bottom of the cup (1 inch in thickness) acting as the flat face of the piston. Webs inside the cup strengthen the piston walls. The piston cup is drainable through a 3/16-inch hole drilled 3/4-inch deep followed by a 3/32-inch hole drilled through. This vented construction also allows air trapped under the piston at start up to bleed out from under the piston. A circular splash guard 15-7/8 in. in diameter fabricated from 1/16-inch Type 304 stainless steel is mounted on the piston rod to form a cap over the open top of the piston cup and prevent solution from jetting and splashing up to the vapor bushing. Six circumferential grooves of rectangular cross section are provided on the outside diameter of the piston to retain the four segmental piston rings and two segmental rider rings. The rider ring grooves have a nominal width of 1 inch and are located 1/2 inch from either end of the piston. The piston ring grooves are equally spaced 0.63 inches apart near the middle of the piston, and have a nominal width of 7/8 in.

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Piston rings and guide rings: The four spring-loaded piston rings are designed to form a tight seal with the cylinder wall and restrict leakage of pulsed fluid past the piston. The rider rings are designed to guide the piston in the cylinder and prevent lateral movement. Both the rider rings and the piston rings are Graphitar No. 41 (U.S. Graphite Co.). Each rider ring is segmented into four equal pieces which, when fitted together (flat-face butt joint) to form a circle, have an outside diameter of 16.000/15.997 inches. This provides an average diametrical clearance of 3 mils with the cylinder bore. The rings with an average inside diameter of 14.7495 in. fit into grooves in the piston wall. The bottom of each groove has an average diameter of 14.7455 in.

The piston rings are also cut into four equal segments and are fitted together to form a circle by means of a step joint. The average outside diameter of the circle formed by the segmented rings is 15.9995 in. Each ring is backed by a split ring type expander, (0.125 in. thick and 31/64 in. wide) which when compressed to a true circle exerts a diametral force of 12 to 17 pounds. When compressed, the expander contains a 1/2-in. gap between the spring ends. This gap engages a small pin in the piston wall and prevents rotation of the expander (and the rings) during operation. Each expander is assembled on the piston in such a way that the gap is displaced 90° for each ring in order to balance unequal ring loading.

2.2 Motion box

2.21 Function

The motion box reduces the speed of the variable-speed vertical drive shaft of the motor and converts the rotary motion of the drive shaft to reciprocating motion.

2.22 Description

Driving motor: Power is supplied to the motion box by means of a vertically mounted, 15-horsepower, 1800-rev./min., 440-volt, 3-phase, 60-cycle, totally enclosed-fan cooled, 55°C.-rise, induction motor having Class B insulation. The motor will operate over a speed range of approximately 1800 to 497 rev./min. from a variable-frequency motor-generator set power supply (see 2.3, below) with constant torque loading.

Gear set: The vertically mounted driving motor is directly connected to a worm shaft by means of a spline joint. The hardened steel worm shaft is rigidly mounted within the motion box on ball bearings at the top and bottom of a 28 in. long, nominal 3-in. diameter shaft. The worm threads engage a bronze worm gear having an over-all diameter of 20 in., and a reduction ratio of 18-1/2 to 1. The worm gear is keyed to a nominal 4-1/4 in. diameter worm gear shaft between two single-row roller bearings. Nominal play in the gear set is expected to be about 1 mil end play of worm, 3 mils end play of worm gear, and 7 to 7.5 mils back lash or play between the worm and worm gear. The worm gear shaft is provided with an overhanging stub, 3 in. in diameter, which is eccentric to the shaft. The displacement of the centerlines of the two shafts is 1.002/0.998 in.

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Slide block, yoke, and yoke assembly: A hardened steel slide block is fixed to the eccentric shaft of the worm gear by means of lock nuts. The shaft rotates freely in the slide block on bronze bearings. The slide block supports on its upper and lower faces, a cast iron yoke which is free to move vertically up and down but is otherwise fixed in position on steel guide rods containing bronze bushings. Thus, eccentric movement of the shaft is transmitted to the slide block which moves both laterally and vertically. The yoke which slides on the slide block can only move vertically, being restrained from lateral movement by the guide rods. The total vertical yoke movement is equal to twice the shaft eccentricity, or 2 inches. Normally, the piston rod would extend through the bottom of the motion box case, through an oil seal, and be rigidly fixed to the yoke. In order to eliminate openings in the bottom of the motion box case through which oil might leak, the connection of the piston rod to the yoke is made through the top of the box through yoke arms and tie rods.

Lubrication: All moving parts in the motion box are lubricated by oil which is directed, through nozzles, to the gear set and moving parts. The motion box case is designed to contain 20 gals. of Texas Oil Co. Regal Oil K. The oil is recirculated through the nozzles by means of a gear pump driven from the worm gear shaft. Oil is changed at regular intervals by introducing fresh oil to the motion box case, through a remote, three pipe, connector. One pipe carries oil to the case. An overflow line in the motion box case allows the waste oil to be flushed to a waste oil container mounted on the side of the unit.

2.3 Power supply

2.31 Function

The function of the electric power supply is to deliver a constant current of variable frequency to the constant torque, variable speed induction motor which drives the pulse generator.

2.32 Description

The electrical power-supply system is shown schematically on the block diagram in Figure XV-5.

Variable-frequency alternating current is supplied to the driving motor by means of a General Electric Company Type AT1-924, four-pole, 9.0/2.75-KVA, 1800/497-rev./min., 440/122-volt, 60/16.6-cycle, drip-proof alternator directly connected to a General Electric Company Type ACA-444, (brush shifting) 30/7.5-horsepower, 1800/450-rev./min., 440-volt, 3-phase, 60-cycle drip-proof motor provided with a pilot motor which automatically shifts the brushes (and varies the speed) in response to a signal from a remote station. An exciting current is supplied to the field of the alternator by means of a General Electric Company Type B-254, 3-Kw., 1750-rev./min., 125-volt, direct-current generator directly connected to an 1800-rev./min., 220/440-volt, 3-phase, 60-cycle induction motor. An indication of the pulse generator motor speed is obtained by means of a General Electric Company Type DJ-13 frequency-sensitive speed indicator rated at 28 volts maximum and operated through a 440/28-volt transformer in the 3-phase line to the pulse generator motor.

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3. Operation and Performance

The pulse generator is designed to operate at any frequency between 25 and 90 cycles per minute and will produce an amplitude of 0.57 inch in the RC Column (1.28 inches in RA) provided that (a) leakage past the piston on each stroke is small compared to the volume pulsed, (b) cavitation does not occur in the system, and (c) all trapped air is bled from the system before operation. The system is designed to avoid cavitation. Air trapped under the piston during start-up periods should be given time (approximately 30 minutes) to bleed out through the vent hole in the piston. (This is also important in order to allow liquid to wet the cylinder and rings before operation.) Initially, the demonstrated leakage past the piston rings and through the vent hole of a pulse generator did not exceed 0.25 gal./min. with either aqueous or organic solution under a positive static head of 3 to 4 feet of water. Maximum leakage occurred at low frequencies. The leakage rate decreased as the frequency increased. At a frequency of 60 cycles per minute, the pulse generator displaces 3.5 gal./cycle or 210 gal./min. A leakage rate of 0.25 gal./min. is only 0.12 per cent of the total volume displaced.

The theoretical hydraulic horsepower required to pulse the fluid can be readily calculated and is a function of the pressure under the piston and the stroke frequency. At 90 cycles per minute the calculated maximum theoretical hydraulic horsepower is only 2.5. Additional power is required to accelerate the rigid elements in the motion box and to overcome mechanical friction losses.

REFERENCES

(1) Letter, V. R. Cooper to R. C. Hollingshead, Supplementary Design Information, TBP Plant Pulse Generator, September 20, 1950.

(2) Letter, W. S. Figg to J. G. Bradley, Pressure-Frequency Considerations in the TBP RA and RC Pulse Column Design, September 8, 1950.

(3) Letter, W. S. Figg to J. G. Bradley, Study of Leakage at the Pulse Generator Piston of Proposed TBP RA and RC Column, September 1, 1950.

(4) HW-18945 Experimental Bases for TBP Pulse Column Specifications, R. B. Richards and F. W. Woodfield. September 25, 1950.

(5) HW-20305 Design Considerations for a Pulse Column. V. R. Cooper and C. Groot. March 9, 1950.

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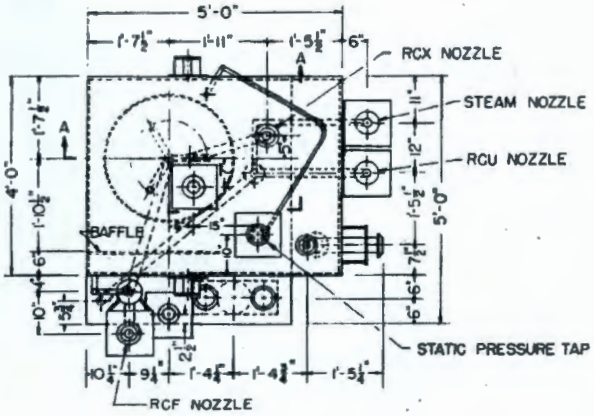
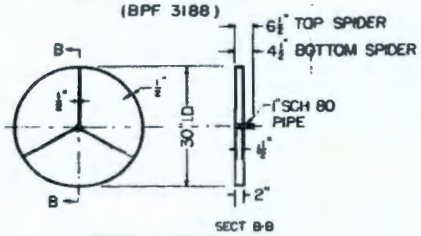
Figure XV-2

RC COLUMN

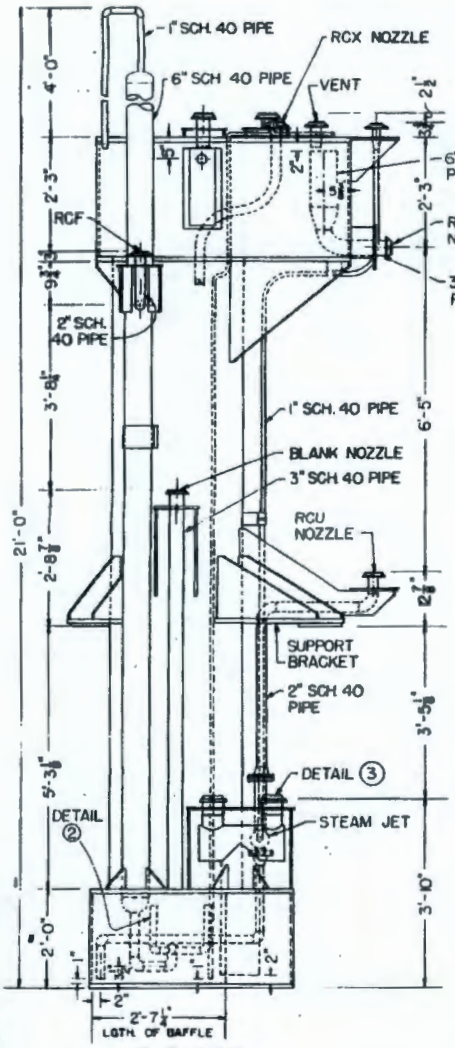
EQUIP PIECE NO.- ET 17-2 & ET 19-2
REFERENCE DRAWINGS:
KELLEX: H-2-40791
H-3-41862
A.O. SMITH: MV-4005
(BPF 3188)



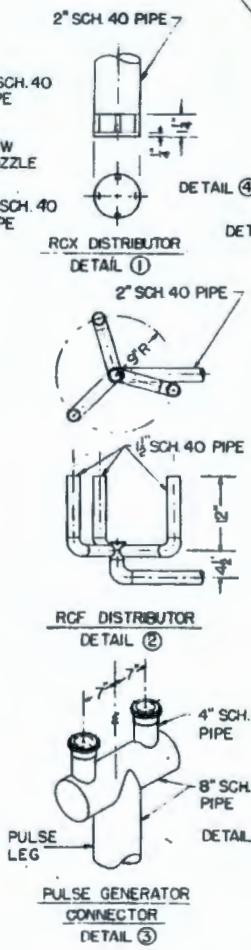
PLAN

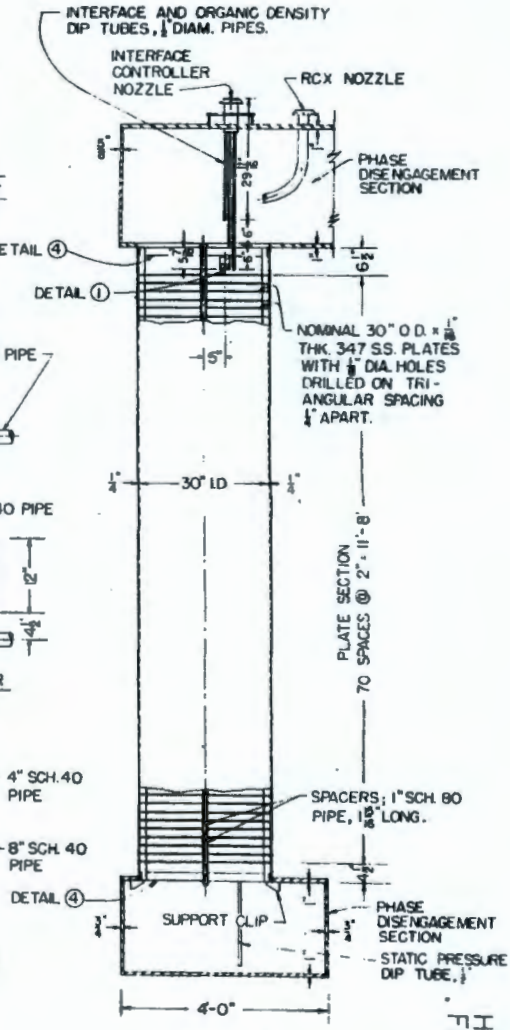


SPIDER ASSEMBLY
DETAIL ④



ELEVATION





SECTION A-A

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HW-19140
Fig. XV-2

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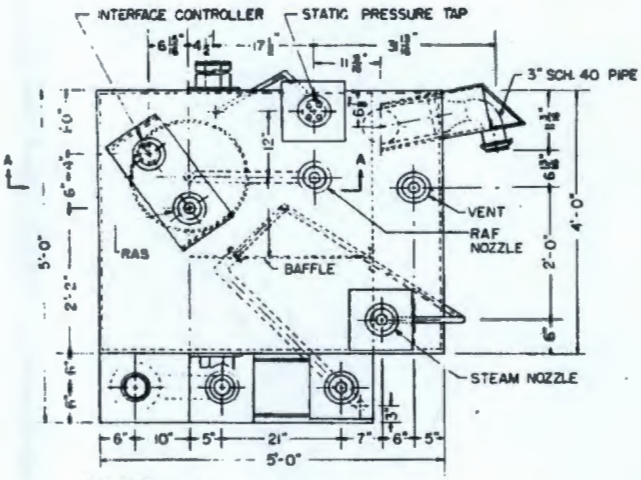
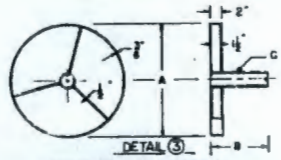
Figure XV-1

RA COLUMN

EQUIP PIECE NO. - ET-17-8 & 19-8
REFERENCE DRAWINGS:
KELLEX: H-2-40790
H-2-41863
A.O SMITH: MV-4004
(B.P.F: 3188)

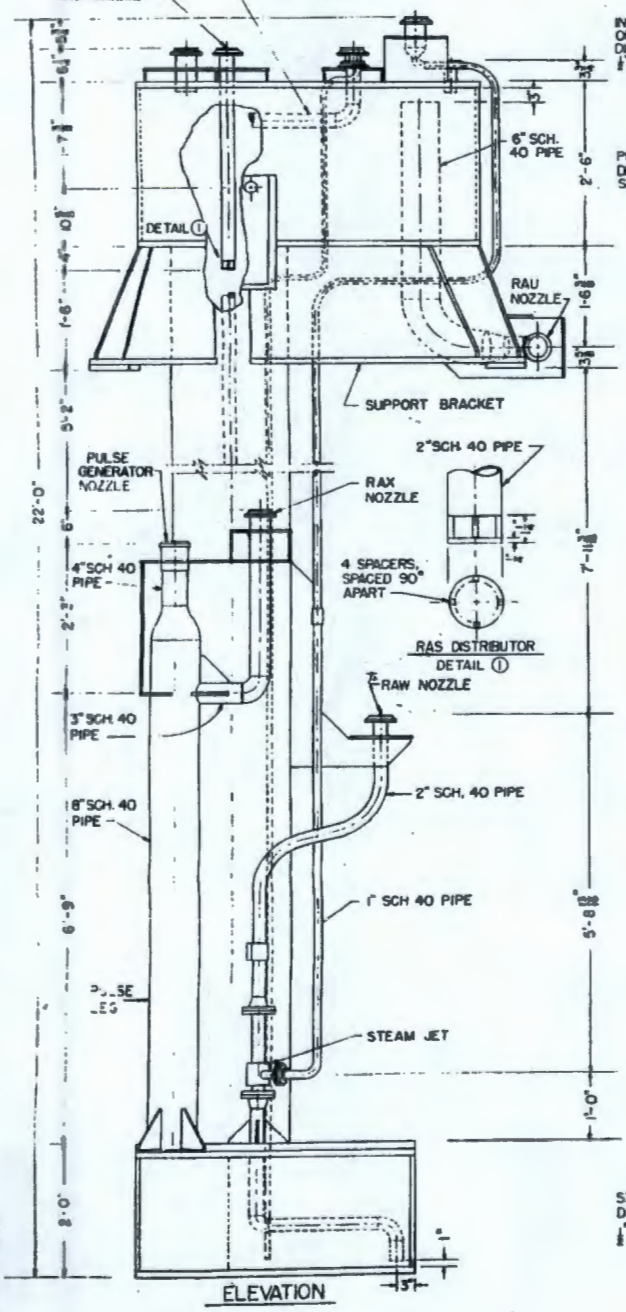


PLAN

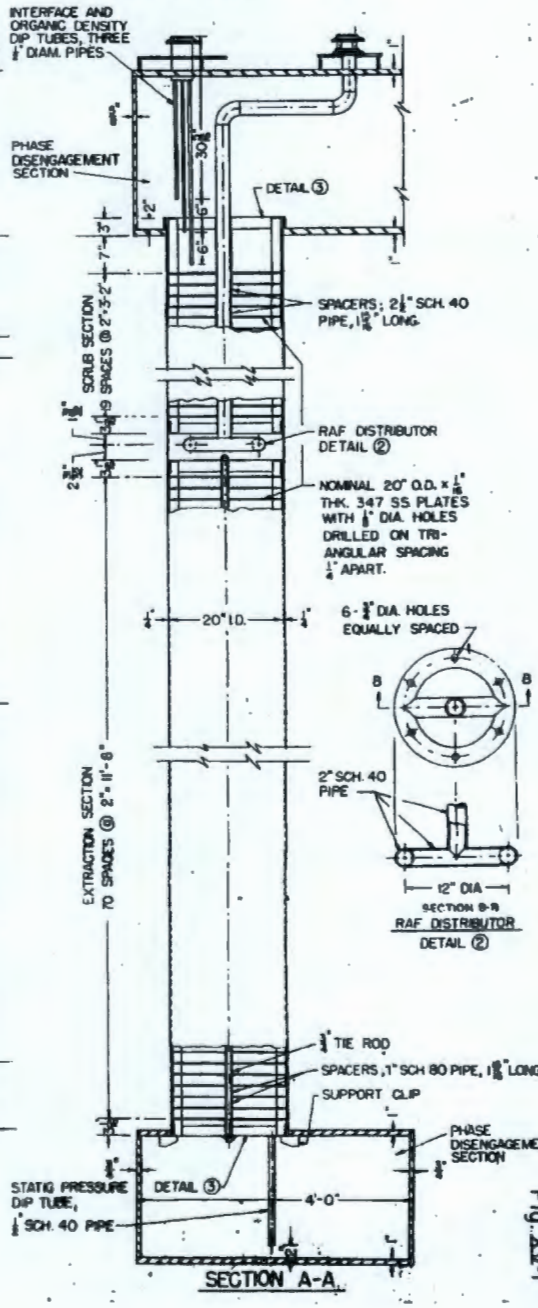


SPIDER ASSEMBLY DETAILS

	SCRUB CARTRIDGE		EXTRACTION CARTRIDGE	
	UPPER SPIDER	LOWER SPIDER	UPPER SPIDER	LOWER SPIDER
A	20 1/2 in O.D.	20 in. O.D.	20 in O.D.	20 in O.D.
B	10 in.	5 in	3 in.	3 in.
C	2 1/2 in Sch. 40 Pipe		1 in. Sch. 80 Pipe	



ELEVATION



SECTION A-A

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Fig. XV-1

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A 3-in. outlet pipe is located in the center of the bottom head. Top head nozzles include seven process nozzles, a 16-in. manway, and a 36-in. I.D. agitator mounting flange. To facilitate thief sampling, the manway cover has a 5-in.-diameter hole with a Varec -type (flame-arrester) cover.

Internal design features include a coil, a sparger, wall baffles, and a stilling chamber for the weight-factor and density dip tubes. The coil consists of about 264 ft. (seven 12-ft.-diameter turns) of 2-in. pipe. The sparger is a 10-ft.-diameter perforated ring of 1-in. pipe, located just above the dish of the bottom head or approximately 2-1/2 ft. above the bottom head low point. The four vertical wall baffles, at 90° spacing, extend radially 19 in. toward the vertical axis of the tank.

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The stilling chamber is a 4-in. pipe 15-1/2 ft. long, perforated by forty-three 1/2-in.-diameter holes at 4-in. spacing. This chamber is attached vertically to the tank shell by means of brackets and is located directly below a 3-in. head nozzle so that weight-factor and density dip tubes may be inserted therein. The bottom end of the chamber extends toward the dished bottom head to a point about 1 ft. above the low point.

The vessel is supported by a skirt made of 5/16-in. carbon steel, welded to the shell. Carbon steel support lugs for a grating are attached to the vessel head near the 16-in. manway.

Other vessels, similar in design to TK-386, include the RAX Blend Tank, TK-382, the Organic Receiver, TK-387, and the Organic Treatment Sampler Tank, TK-388.(11) The TBP Storage Tank, TK-381, is also similar, except it has a flat bottom head.(19)

2.3 UNH Feed Storage Tanks, TK-X-1 and TK-X-2(7)(12)

The UNH Feed Storage Tanks, TK-X-1 and TK-X-2, located in the 203-U Building, are typical of several "cold" storage vessels designed according to the A.P.I. Code for Oil Storage Vessels. These tanks are stainless steel, 25-ft. O.D. by 30-ft. tanks, having a nominal capacity of 96,000 gal. (104,000 gal. to overflow). Construction details are shown in Figure XVI-5. On the floor of each tank is a 2-in. heating coil approximately 97 ft. long. The side-entering agitator is inserted through a 30-in. agitator nozzle. The conical roof of the tank is supported by external steel channel rafters.

C. HEAT EXCHANGERS

1. Concentrators, E-6-1, E-7-1, E-8-1, E-9-1, E-10-1, E-B-1, E-D-1, and E-D-2(15)

Concentrators are provided for the volume reduction of the aqueous column feed solutions, aqueous column waste streams, and combined Redox and TBP Plant decontaminated uranium product solutions. Each of these

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solutions is routed to its respective concentrator(s), where the desired amount of concentration takes place. The vapors from the top of the concentrators pass through a deentrainment or stripping column to remove entrained droplets of liquid and/or strip nitric acid before the vapors are condensed.

Aqueous column feed concentration: The uranium concentration of the dissolved slurry from the underground tanks is increased, after receipt of the solution in the 221-U Building, by evaporation in the Feed Concentrators, E-6-1, E-7-1, E-8-1 (spare). (Additional information concerning the operation of these concentrators may be found in Chapter III of this manual.)

Aqueous column waste concentration: Aqueous column waste solutions (ROW and RAW) are blended and neutralized with 50 per cent caustic in the Neutralizer, TK-11-6. These neutralized aqueous waste solutions are continuously concentrated in the Waste Concentrators, E-9-1 and E-10-1, prior to storage in underground tanks. (See Chapter XII for additional information.)

Product concentration: The dilute uranium solution received in the Uranium Storage Tanks, TK-X-1 and TK-X-2, from the Redox Plant and the 221-U Building of the TBP Plant requires concentration before conversion into UO_3. This concentration is accomplished in two steps in the Product Concentrators, E-B-1 and E-D-1, and in the Final Product Concentrator, E-D-2. (See Chapter VII for additional information.)

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1.1 Basic principles of design

All of the Uranium Recovery Plant concentrators are vertical, long-tube, steam-jacketed units, selected as being more suitable for continuous operation and less likely to collect salt deposits than the coil-in-pot type of concentrator used in the Redox Plant. Each concentrator assembly includes a Peerless Mist Separator mounted on top of the concentrator and either a bubble-cap or packed deentrainment column situated next to the concentrator. The use of the mist separators and of adjacently located deentrainment columns minimizes the total required equipment height, which is limited by the height of the cells. A single-effect evaporator was specified because of the limited space, the deentrainment specifications, the low vapor temperatures, and the remote maintenance requirements. The foaming tendency of the solutions being concentrated and mechanical simplicity required for remote maintenance indicated the choice of natural circulation over forced circulation.

1.2 General description

All the concentrators are similar in construction but differ in size. They are vertical, long-tube, single-effect, natural-circulation-type evaporators. Diameters vary from 38-1/2 in. to 17 in. while the heights range from approximately 24 feet to about 14 ft. The tubes are all 1 in. in diameter but vary in number according to the diameter of the evaporator. The Feed and Waste Concentrators are Class I vessels, while the Uranium Product Concentrators are Class II vessels.

1.3 Construction details

The construction details of the various concentrators are listed in the following tabulations. Figure XVI-7 presents a drawing of a typical concentrator design, that of the Product Concentrators, E-B-1 and E-D-1.

Product Concentrators E-B-1 and E-D-1

Tubes:	
Number	751
Diameter	1 in. (#12 B.W.G.)
Length	14 ft. 11-3/4 in.
Heat transfer area	2930 sq.ft.
Height:	
Over-all	23 ft. 9 in.
Deentrainment section	42 in.
Vapor section	51 in.
Steam jacket	38 in.
Bottom enlarged section	12 in.
Diameter: (O.D.)	
Deentrainment section	66-1/2 in.
Vapor section	72 in.
Steam jacket	42-1/2 in.
Shell	38-1/2 in.
Bottom enlarged section	72 in.
Downcomer	8-in. pipe

Final Product Concentrator E-D-2

Tubes:	
Number	55
Diameter	1 in. (#12 B.W.G.)
Length	10 ft.
Heat transfer area	143 sq.ft.
Height:	
Over-all	13 ft. 14-1/16 in.
Deentrainment section	13 in.
Vapor section	12 in.
Steam jacket	7-3/4 in.
Diameter: (O.D.)	
Deentrainment section	19-1/2 in.
Vapor section	19-1/2 in.
Steam jacket	19-1/2 in.
Shell	17 in.
Downcomer	3-in. pipe

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Feed, Waste, and Spare Concentrators,
E-6-1, E-7-1, E-8-1, E-9-1, and E-10-1

Tubes:	
Number	307
Diameter	1 in. (#12 B.W.G.)
Length	14 ft. 2-3/4 in.
Heat transfer area	1197 sq.ft.
Height:	
Over-all	21 ft.
Deentrainment section	32-3/16 in.
Vapor section	37-1/16 in.
Steam jacket	35-1/2 in.
Bottom enlarged section	12 in.
Diameter: (O.D.)	
Deentrainment section	54 in.
Vapor section	54 in.
Steam jacket	29-1/2 in.
Shell	25-1/2 in.
Bottom enlarged section	54 in.
Downcomer	8-in. pipe

Located in the vapor shell above the tube sheet is a reverse-dished impingement plate which deflects the percolated liquid, thus effecting a separation of liquid and vapor. The deentrainment shell, directly above the vapor shell, contains the mist separator and spray nozzles. The mist separator, consisting of "Z" baffles, removes the entrained droplets of liquid from the vapors and returns the liquid to the deentrainment section through a seal pot, which prevents vapors from by-passing the impingement plate and traveling directly to the mist separator. On the two Product Concentrators, E-B-1 and E-D-1, a vapor inlet is provided into the deentrainment section for handling vapors from the Final Product Concentrator, E-D-2, which is not provided with a dentrainment column. The downcomer connects the vapor shell with the bottom enlarged section to allow for recirculation of the concentrated material. Semicircular baffles, acting as tube supports, are located in each evaporator, thus preventing channeling of the steam through the tube bundle. Expansion joints in both the evaporator shells and downcomers minimize strain due to large temperature changes.

2. Condensers, E-6-5, E-7-5, E-8-5, E-9-5, E-10-5, E-B-3, and E-D-3

Condensers are used in the Uranium Recovery Plant for condensing overhead vapors from concentrator deentrainment columns.

Figure XVI-8 presents the construction of a typical condenser. The following table gives the salient details of the two types of horizontal, multiple-pass, water-tube condensers used in the plant.

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Feed and Waste Condensers, E-6-5, E-7-5, E-8-5, E-9-5, and E-10-5

Over-all length	11 ft. 4-3/4 in.
Outside diameter (shell)	30-3/4 in.
Number of tubes	342
Number of tube passes	9
Tube size	1 in. (#12 B.W.G.)
Tube length	10 ft.
Heat transfer area	895 sq.ft.
Design heat load	12,548,000 B.t.u./hr.
Class of vessel	I

Product Condensers, E-B-3 and E-D-3

Over-all length	14 ft. 10-3/4 in.
Outside diameter	33-3/4 in.
Number of tubes	425
Number of tube passes	5
Tube size	1 in. (#12 B.W.G.)
Tube length	12 ft.
Heat transfer area	1335 sq.ft.
Design heat load	19,100,000 B.t.u./hr.
Class of vessel	II

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An impingement baffle, located directly beneath the vapor shell, and seven segmental baffles spaced throughout the length of the condenser distribute the vapor flow through the shell. One expansion joint in the condenser shell is provided to relieve stresses caused by shell temperature changes.

3. Feed Preheater, E-B-6

Steam condensate is used to preheat the dilute uranium feed in the Feed Preheater, E-B-6, before it is routed to the 224-U Building Product Concentrators, E-B-1 and E-D-1, for concentration.

The Feed Preheater, E-B-6, is a horizontal, U-tube heat exchanger with sixty-nine 1-in. (#12 B.W.G.) type 347 S.S. U-tubes. The dished head shell, 12 ft. 2 in. long and 2 ft. in diameter, is also constructed of type 347 S.S. Seventeen 1/4-in. baffles on 6-in. spacing are installed in the center 8-ft. portion of the shell. It is built to Class II vessel specifications.

4. Gas Cooler, E-A-2[21]

Fumes from the Calcining Pots, P-E-1 to P-E-18, are routed to the Gas Cooler, E-A-2, a radial-finned water-tube cooler, which is designed to condense the water vapor and cool the remaining gases to 120°F. for efficient nitrogen oxide absorption in the Nitric Acid Absorber, T-A-1.

The construction details of the horizontal, water-tube, Class II, Gas Cooler, E-A-2, shown in Figure XVI-9, are tabulated below.

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Over-all length	17 ft. 1-3/8 in.
Diameter	32 in.
Tubes:	
Number	86
Diameter	1-in. (#12 B.W.G.)
Length	15 ft.
Heat transfer area:	
Gas side	2477 sq.ft.
Water side	264 sq.ft.
Heat transfer duty	550,000 B.t.u./hr.

In order to increase the heat transfer area on the gas side, twenty radial fins are attached to each tube. A gas inlet box distributes the fumes as they enter the cooler, and mixing inside the cooler is promoted by three "A" type and two "B" type baffles. The "A" baffles consist of a ring around the tube bundle while "B" baffles are solid except for the holes through which the tubes pass. These holes are 1/16 in. larger than the radial diameter of the fins. Each baffle is flat on the bottom to allow condensed vapors to flow to the condensate outlet of the cooler.

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5. Liquid Coolers

Hot concentrator effluent streams, nitric acid effluent from the absorber, and solutions after jet transfer require cooling, which is accomplished in tanks equipped with water coils and jackets. In addition to such tanks (which are described in Section B above) the Uranium Recovery Plant contains six special liquid coolers: the Condensate Sample Cooler, E-C-7; the 60% Nitric Acid Cooler, E-C-9; the Nitric Acid Absorber Reflux Cooler, E-OG-3; and the Fractionator Plate Sample Coolers, E-B-4 and E-D-4 all of which are located in the 224-U Building plus the Condensate Sample Cooler located in the Overhead Condensate Instrument Pit east of 221-U Building. The Condensate Sample Cooler, E-C-7, cools the condensate sample from the 224-U Building Product Concentrator Condensers, E-B-3 and E-D-3, for continuous pH determination. The 60% Nitric Acid Cooler, E-C-9, cools the effluent acid from the Nitric Acid Fractionators prior to holdup in the receiver. These two Class III vessels are similar in construction. Both utilize Type 347 stainless steel spiral coils in a carbon steel shell. Salient details are listed below:

	Condensate Sample Cooler, E-C-7	60% Nitric Acid Cooler, E-C-9
Height	18 in.	18 in.
Diameter (B.D.)	28 in.	40 in.
Coil diameter	12 in.	12 in.
Coil length	48.8 ft.	42.5 ft.
Pipe size	1/2 in.	1 in.

The Nitric Acid Absorber Reflux Cooler, E-OG-3, cools the reflux as it flows from the Distilled Water Tank, TK-X-14, to the top of the

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absorption column. This Class II vessel, a horizontal, four-pass, water-tube cooler 7 ft. 5-1/2 in. long and 12 in. in diameter, contains sixty-two 1/4-in. stainless steel tubes, making a total tube length of 864 ft.

The Fractionator Plate Sample Coolers, E-D-4 and E-B-4, are Class III, horizontal U-tube exchangers designed to cool samples taken from the lower eight plates of the Nitric Acid Fractionators, T-B-4 and T-D-4. The U-tubes are constructed of Type 347 stainless steel and the shell is 8-in. Schedule 40 carbon steel pipe 7 ft. long.

The Condensate Sample Cooler, E-6-A, cools samples of condensate from the Feed and Waste Concentrators for continuous pH determinations. This Class III vessel, a horizontal cooler, consists of five 1/2-in. Type 347 stainless steel U-bends (one for each condensate stream) inside of a 7-ft. section of 10-in. carbon steel pipe. Each U-bend contains 13 ft. 5 in. of pipe.

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D. BUBBLE-CAP PLATE COLUMNS

1. Nitric Acid Fractionators, T-B-4 and T-D-4[18]

The Nitric Acid Fractionators, T-B-4 and T-D-4, located in B and D Cells of the 224-U Building, are utilized to convert 40 per cent nitric acid (recovered from the UO_3 conversion in the Nitric Acid Absorber, T-A-1) into 60 per cent nitric acid by fractional distillation. In addition, these fractionators receive the overhead vapors from the Product Concentrators E-B-1 and E-D-1 and strip nitric acid from them before the vapors are condensed and sent to the cribs. (For further information about the function and operation of the fractionators reference is made to Chapters VII and XIV.)

1.1 General description

The Nitric Acid Fractionators, T-B-4 and T-D-4, are Class II vessels fabricated in two sections with a total height of approximately 32 feet: 16 feet for the lower column section with reboiler, and 16 feet for the upper column section. Diameters of the sections are as follows: the reboiler, 7 feet; the lower column section, 5 feet; and the upper column section, 8-1/2 feet. The upper section contains 9 plates while the lower section has 8 plates, all on 18-in. spacing.

1.2 Construction details

The construction details of a Nitric Acid Fractionator, shown in Figure XVI-10, are listed in the table below.

Item	Description or Dimension
Reboiler:	
Outside diameter	7 ft.
Over-all height	4 ft. 8 in.
Heating provision	39 U-bends (480 ft. of 2-in. pipe)
Heat transfer area	299 sq.ft.
Heat transfer duty	3,100,000 B.t.u./hr.
Column:	
Lower section:	
Outside diameter	5 ft.
Over-all height	11 ft. 1-3/4 in.
Shell thickness	1/4 in.
Number of bubble-cap plates	8
Number of bubble caps per plate	78
Number and size of slots per cap	20 slots, 3/16 in. by 9/16 in.
Number and size of downcomers per plate	Four, 3-in. pipe
Number and size of manholes	Eight, 12-in. by 18-in. oval
Transition cones thickness	1/2 in.
Upper section:	
Outside diameter	8 ft. 6 in.
Over-all height	15 ft. 11-1/8 in.
Shell thickness	1/4 in.
Number of bubble-cap plates	9
Number of bubble caps per plate	448
Number and size of slots per cap	20 slots, 3/16 in. by 9/16 in.
Number and size of downcomers per plate	Six, 3-in. pipe
Number and size of manholes	Ten, 12-in. by 18-in. oval
Reflux provision	1-1/2 in. pipe to top tray
Reflux rate	5 gal./min.

All the plates are formed from 1/4-in. stainless steel plate, with stiffener bars across the bottom, and are welded into the column sections on an 18-in. spacing. Inlet and outlet weirs with rectangular slots promote even distribution of liquid on each plate.

The flanged 14-in. standard pipe vapor inlet bolts to the transition cone between the upper and lower sections of the column, and the 14-in. vapor exit line connects to the top of the column.

Eighteen oval manholes, one above each plate and one in the transition cone between the lower column section and the reboiler, provide openings into the column. Sampling nozzles are provided for each of the lower-section column plates. The reboiler side-entering tube bundle is welded to a 2-inch-thick tube sheet. This tube sheet and the steam chest are bolted to the flanged opening on the reboiler.

An 8-in. by 10-in. box is welded to the straight side of the reboiler section and is connected to the reboiler near the bottom and the top.

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This box contains the liquid-level and control instrument elements.

2. Nitric Acid Absorber, T-A-1[22]

The nitrogen oxides evolved in the calcination process are chemically absorbed in water in the Nitric Acid Absorber, T-A-1, to form 40 per cent nitric acid. Further details of the reactions and design considerations involved are discussed in Chapter IX.

2.1 General description

The Nitric Acid Absorber, T-A-1, is a Class II vessel approximately 37-1/2 ft. high and 4-1/2 ft. in diameter. It is constructed in 13 sections, which are flanged together. The absorber contains 20 bubble-cap plates, 9 of which are provided with water cooling coils.

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2.2 Construction details

The construction details of the Nitric Acid Absorber, T-A-1, shown in Figure XVI-11, are listed in the table below.

Item	Description or Dimension
Outside diameter	4 ft. 7 in.
Over-all height	37 ft. 5 in.
Shell thickness	1/2 in.
Number of bubble-cap plates	20
Number of bubble caps per plate	36
Number and size of slots	16 slots, 0.1 in. by 0.656 in.
Number and size of downcomers	Three, 2-in. pipe
Number of plates with cooling coils	9
Heat transfer area	292 sq.ft.
Heat transfer duty	104,000 B.t.u./hr.
Reflux provision	1-1/2 in. pipe to top plate
Reflux rate	1.25 gal./min.

The column is fabricated in 13 sections, 10 of which contain bubble-cap plates. The bottom plate in each section is welded in place, but the other plates in the section are supported by rods which rest on the tops of the bubble caps in the welded plate. Inlet and outlet weirs with four rectangular slots 1 in. wide by 1/4 in. deep produce an even distribution of liquid on each plate.

Nine of the plates are each provided with two separate cooling coils. These 1-in. pipe coils make either 10 or 20 return tube passes per plate (see table below) and connect to the cooling water inlet and outlet headers. Pipe length is 32 and 64 feet, respectively, for the 10-pass and 20-pass coils.

The sections vary in height and design as shown by the following table.

Section No. (From Top)	Number of Plates per Section	Number of Plates With Coils per Section	Number of Coils per Plate	Number of Passes per Coil	Height of Section
1	(Vapor outlet)				1 ft. 7 in.
2	3	0	--	--	6 ft.
3,4	4	1	2	10	6 ft.
5,6	2	1	2	10	3 ft.
7	1	1	2	10	1 ft. 6 in.
8,9,10,11	1	1	2	20	1 ft. 6 in.
12,13	(Vapor inlet and bottom outlet)				

3. Feed Concentrator Stripping Columns, T-6-4, T-7-4, and T-8-4[17]

Vapors from the Feed Concentrators, E-6-1, E-7-1, and E-8-1, are routed through the bubble-cap plate Feed Concentrator Stripping Columns, T-6-4, T-7-4, and T-8-4, for removal of nitric acid and entrained droplets of liquid, which are removed by a reflux entering the top and traveling down through the column. Additional information concerning the operation of these columns is found in Chapter III.

3.1 General description

The Feed Concentrator Stripping Columns, T-6-4, T-7-4, and T-8-4, are Class I vessels and are approximately 12 ft. high and 8 ft. in diameter. Each column contains 12 plates, and each plate contains 168 bubble caps.

3.2 Construction details

The construction details of a Feed Concentrator Stripping Column, shown in Figure XVI-12, are listed in the table below.

Item	Description or Dimension
Outside diameter	8 ft.
Over-all height	12 ft.
Shell thickness	1/4 in.
Number of bubble-cap plates	12
Number of bubble caps per plate	168
Number and size of slots	32 slots, 0.1 in. by 0.75 in.
Number and size of downcomers	Four, 3-in. pipe
Reflux provision	Two, 1/2-in. pipes
Reflux rate	3 gal./min.

The column is flanged to the concentrator by means of the 14-in. inlet line and cannot be removed by remote-maintenance methods. However, the 14-in. top vapor outlet is equipped with a dowel pin and 3 remote-type nuts so the condenser may be removed remotely. The bubble-cap plates are formed from 1/4-in. stainless steel plate to a friction fit with the shell, and each is supported by twenty-three 1-1/4 in.-diameter rods. Inlet and

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outlet weirs produce an even distribution of liquid on each plate. The vapor inlet is connected to a seal pot designed to relieve at 10 inches water pressure and 48 inches of water vacuum. The seal pot vents to the cell exhaust duct and drains to the column.

E. PACKED COLUMNS

1. RO Columns, ET-18-2 and ET-20-2

Spent solvent (RCW) is conditioned for reuse in the RA Columns by contacting it countercurrently with an aqueous scrub stream (ROS) in the RO Columns, ET-18-2 and ET-20-2. The TBP decomposition products, which are scrubbed from the organic solvent by the ROS, leave the bottom of the column with the aqueous effluent. (For further information about the function of this column see Chapter XI.)

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The RO Columns are Class I vessels and stand approximately 17 ft. high, with a packed section 22-1/2 in. in diameter. The construction details of the RO Column, shown in Figure XVI-14, are listed in the table below.

Item	Description or Dimension
Over-all height	17 ft. 4 in.
Diameter of packed section (O.D.)	1 ft. 10-1/2 in.
Height of packed section	11 ft. 6 in.
Diameter of disengaging sections:	
Upper	4 ft.
Lower	2 ft. 6 in.
Height of disengaging sections:	
Upper	3 ft. 5 in.
Lower	1 ft. 11 in.
Size of Raschig rings	1 in. by 1 in. by 1/16 in.

The organic feed is introduced into the column through a 15-in.-diameter doughnut-type distributor made of 2-in. pipe with fourteen 1/2-in. pipe nozzles welded to it. The aqueous effluent drains by gravity through an open-throat jet which may be used to empty the column to the ROW Receiver.

2. Waste Concentrator Deentrainment Columns, T-9-4 and T-10-4[17]

The overhead vapors from the Waste Concentrators, E-9-1 and E-10-1, are passed through the Waste Concentrator Deentrainment Columns, T-9-4 and T-10-4, for the removal of entrained droplets of liquid, which collect on and are washed from the column packing by a small water reflux entering the top of the column. (Additional information concerning the operation of these columns is found in Chapter XII.)

2.1 General description

The Waste Concentrator Deentrainment Columns are Class I vessels and

are approximately 12 ft. high and 8 ft. in diameter. Each column contains 24 inches of York Mesh packing (see below).

2.2 Construction details

The construction details of the Waste Concentrator Deentrainment Column are shown on Figure XVI-13. The column has the same external dimensions and connections as the Feed Concentrator Stripping Column (Subsection D3, Figure XVI-12). However, the Waste Concentrator Deentrainment Column has a packed section rather than bubble-cap plates and a different reflux provision. The reflux is introduced through two 1/2-in. lines to a spray ring made of 2-in. pipe with eight 1/2-in. nozzles to distribute the flow over an 80-in.-diameter distributor plate. The distributor consists of a conventional drip-type plate with 151 drip points.

The packing used in the column is York Mesh, a loosely knit wire fabric which is rolled around a mandrel to give a section of packing of any diameter. The packed section contains 12 inches of #676 York Mesh (0.006-in.-diameter wire) on top of 12 inches of #148 York Mesh (0.011-in.-diameter wire). The packing rests on a grate with 4-in.-square openings and is held in place by a grate, which is welded to the column shell and has 8-in. openings.

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3. Nitric Acid Bleacher, T-C-6[22]

Dissolved oxides of nitrogen are removed from the 40 per cent nitric acid leaving the Nitric Acid Absorber, T-A-1, and nitric acid formed in the Gas Cooler, E-A-2, by introducing it into the top of the Nitric Acid Bleacher, T-C-6, where it is contacted with a countercurrent flow of air. The function of the Nitric Acid Bleacher is discussed in Chapter IX.

The Nitric Acid Bleacher is a Class II vessel standing 9-1/2 ft. high with a diameter of 1-1/2 ft. and is packed with 1-in. Raschig rings.

The construction details of the Nitric Acid Bleacher, shown in Figure XVI-15, are listed in the table below.

Item	Description or Dimension
Over-all height	9 ft. 6 in.
Outside diameter	1 ft. 6 in.
Height of packing	6 ft. 7 in.
Size of Raschig rings	1 in. by 1 in. by 3/32 in.
Liquid rate	1.5 gal./min.
Gas rate	40 std.cu.ft./min.

F. CALCINING POTS, P-E-1 to P-E-18[9]

Batchwise conversion of uranyl nitrate hexahydrate (UNH) to uranium oxide (UO_3) is accomplished by evaporating and decomposing the UNH solution in electrically heated, agitated pots. Eighteen of these calcining pots

are located in E Cell of the 224-U Building. The process details of this operation are discussed in Chapter VIII. A sketch of a calcining pot is presented in Figure XVI-16.

1. General Description

The main components of each calcining pot are (a) a cylindrical, pot-type, electrically heated furnace approximately 5 ft. in diameter and 4 ft. high; (b) the charge pot, 30 in. in diameter and 32 in. deep with a hemisphereical bottom; and (c) an anchor-shaped pot agitator driven by an electric motor and a speed reducer mounted on the furnace superstructure. The furnace superstructure and agitator drive mechanism extend approximately 6 ft. above the top of the furnace and, radially, 4 ft. from the furnace vertical axis. The entire unit is mounted on a foundation, but is not secured.

Each furnace has a power rating of 55 kw. (57.7 kw. design rating) and uses 220-volt, 2-phase, 60-cycle alternating current. The furnace is designed for a maximum chamber temperature of 1600°F., measured 1/4 in. from the exterior surface of the pot.

The rated instantaneous capacity for each pot is 600 pounds of UO_3 (500 lb. U) per charge, with approximately 7-1/3 hours required for a complete calcination cycle.

2. Construction Details

2.1 Furnace

The carbon steel furnace shell is of all-welded construction except for the top plate, which is secured by machine bolts. Plate thickness for the bottom, side wall, and top are 1/2 in., 3/8 in., and 3/4 in., respectively. Exterior insulation, a 1-in. layer of Fiberglas, is provided for the furnace cooling duct only.

Furnace-shell insulation, a 1-in. layer of magnesia and 1-1/2 in. of Johns-Manville SX insulating material (a silicious material with an asbestos binder) is secured to the inside of the steel shell. This is protected by a 4-1/2 in.-thick layer of Armstrong A-25 refractory brick (firebrick). Additional thickness of brick is provided under the top plate around the pot periphery.

The heating element consists of two No. 1 gauge nichrome (80% nickel-20% chromium) wire coils. Each coil extends half way around the furnace and is mounted on eight 7-1/16 in.-wide by 30-in.-long "radiant plates", which rest on end inside the refractory lining. The nichrome wire is wound on projections on the inside face of these plates. The plates are supported by H-shaped spacers attached to bolts which extend outward through the refractory and insulating material and are secured to the shell by either nuts or welding. Coil terminals and exterior wiring are enclosed in the steel terminal guard ring on the outside of the furnace shell.

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The furnace chamber temperature is measured and controlled by a thermocouple which is inserted through a pipe in the shell side wall and extends through an opening in the radiant plate. A similar pipe and plate opening are provided for a fuse of pure silver, which melts and breaks the furnace heating circuit at a chamber temperature of 1700 to 1750°F.

The furnace and pot are cooled by an air sweep through the annular space between the refractory lining and the outside of the pot wall. A negative pressure in the 8-inch I.D. ventilating duct draws room air into the furnace chamber through the 10-inch I.D. opening in the center of the shell bottom and out into the furnace cooling duct through six 4-inch I.D. openings near the top of the chamber. From the cooling duct the air flows into the duct connection box, which connects the ventilating duct to the furnace, and out through the ventilating duct. Air flow is controlled by means of the furnace cooling damper and the sliding cover over the furnace cooling air inlet.

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2.2 Pot

The charge pot is 30 in. in diameter and 32 in. deep at the center of the hemispherical bottom. It is cast to Type 309S Cb stainless steel and has a minimum wall thickness of 5/8 inch. Slightly more than half of the pot top is covered by a fixed plate secured by studs and nuts. The fixed cover serves as a mounting for the agitator shaft stuffing box, the pot charging line, the fume outlet line, and the dip tube for the high-liquid-level alarm. To facilitate routing of these lines to either side of the unit, a spare fume outlet connection is provided. The remainder of the pot is covered by a removable plate secured by four clamps. Pot cover material is 1/2-in.-thick Type 309S Cb stainless steel plate. A 1/2-in.-square-cross-section asbestos gasket is provided to seal cover-to-cover and cover-to-pot joints.

2.3 Agitator

The sweep-type pot agitator is designed to scrape solids away from the pot wall up to a height of 21 inches, or 11 inches down from the top of the pot. The outer blades conform to the pot wall configuration and have a maximum wall clearance of 1/8 in. The 3-in.-diameter hollow shaft has a 1-in.-diameter bore extending to 1-1/2 inches from the bottom end. A thermocouple for measurement of charge temperature is inserted in this opening. The shaft and blades are made of Type 309S Cb stainless steel.

The agitator is driven at 37 rev./min. by a 7.5-h.p. 440-volt motor through a speed reducer. The speed reducer and agitator shafts are connected by a rigid coupling. Below this coupling and approximately 10 inches above the pot cover, a shaft alignment bearing is provided. A stuffing box provides a seal between the shaft and the fixed pot cover.

Room air may be drawn across the pot cover and into the ventilating duct connection box through a rectangular opening in the reducer support. This air flow is controlled by the ventilating damper. Since the air above the pot cover may contain corrosive process fumes, the

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reducer support (made of carbon steel) is provided with a stainless steel sheet metal liner and liner cover. The liner cover is split to allow installation of flanged pipes. The duct connection box and the bearing support bar are also stainless steel.

2.4 Transformer

Each furnace is supplied with 220-volt, 2-phase alternating current by a 58 k.v.a. dry-type transformer rated for a 485/460/425-volts, 3-phase primary current. (For details of the power service system, reference is made to Chapter XIII.)

G. CENTRIFUGE(8)(24)

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Centrifuges are used to clarify the concentrated uranium-bearing aqueous feed before it is processed in the solvent-extraction columns. Two centrifuges, G-14-1 and G-14-6, are provided in Cell 14 of the 221-U Building. (For process details, reference is made to Chapter III.)

The centrifuges, Class I vessels manufactured by the Bird Machine Company, are of the same design and size as those presently installed in the Bismuth Phosphate and Redox Plants and utilize certain modifications incorporated in the Redox centrifuge. These modifications are designed to reduce cell air contamination by minimizing the escape of mist or droplets from the centrifuge case. To supplement the description below, reference is made to drawings of the centrifuge in Chapter XVI of the Redox Technical Manual (HW-18700).

The solid bowl is 40 in. in inside diameter by 24 in. deep. It is driven by an overhead, vertically mounted 40-h.p. motor at a speed of 870 rev./min. ("slow") or 1740 rev./min. ("fast"), thus producing a centrifugal force at the bowl wall equal to 430 or 1730 times the force of gravity. The "inch" circuit on the motor maintains any set speed up to maximum.

The upper lip of the bowl extends 6 inches toward the center and provides a 60-gallon holdup. This allows about 5 minutes holdup time at the nominal feed rate of 13 gal./min. The inside wall of the bowl has three 1/2-in.-thick circumferential baffles spaced 5-5/8 in. apart (wall to wall) and extending 6-1/2 in. toward the center. These baffles are notched at the bowl, permitting holdup reduction to about 10 gallons by either of two single hydraulically operated skimmers. A bowl spray is provided for washing and slurrying the cake.

Process nozzles: The case is provided with six 3-in. pipe nozzles for access to the bowl interior. These nozzles slant outward to clear the motor. Five extend about 4-1/2 ft. above the case top, while one, which is blanked extends about one foot. The five extended nozzles are used for chemical addition from the Chemical Addition Weigh Tank X-14A, feed inlet from the Feed Concentrator Receiver Tank, weight-factor dip tubes, outlet jet to the Waste Utility Holdup Tank, and a sampler. The sampler nozzle terminates in a standard 3-in. male connector. However, because of difficulties in jumper handling imposed by the slanted nozzles,

two-inch pipe dip legs are inserted in the other four nozzles and extend to 1/4 in. from the bottom of the bowl. The 3-in. male connectors on these nozzles are circumferentially split, with the lower portion welded to the nozzle, and the upper welded to the dip leg. A lifting bail attached to the face of the upper connector portion permits remote handling of the dip leg. This bail fits inside of the female connector when the jumper is in place. No gasket is provided between the two portions of the male connector. The case outlet terminates in a 4-in. standard connector nozzle.

Other connectors: Five of the six connectors mounted on the centrifuge frame are used for motor electrical leads, hydraulic lines, bowl spray, lubrication and tachometer, and vibration meter. A microphone at the end of a separate cell jumper contacts the outside of the case. A seventh connector on the case, attached to a thermometer well, is not in use.

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Shroud and fume cover: To reduce air contamination in the cell, passage of mist or droplets through the spindle opening in the case is restricted by a fume cover with two baffle-type seals. In addition, the spindle from the fume cover to the motor-mount is enclosed by an air-purged shroud. Air enters the stainless steel sheet-metal shroud through a 1/2-in. pipe and sweeps downward through the fume cover seals into the case, leaving the case through the process solution effluent line. Each of the two seals in the fume cover consists of two parts: (a) a stationary ring, attached to the fume cover assembly, concentric with the spindle; and (b) a slinger disk, larger in diameter than the fixed ring, rigidly attached to the spindle. This slinger disk is mounted below the fixed ring with a vertical clearance of 1/64 inch between the two parts.

Lubrication: A remotely operated Farval grease metering system lubricates the motor and spindle bearings. This system is described in Chapter XVI of the Redox Technical Manual (HW-18700). Waste grease is collected in a can mounted on the side of the centrifuge case.

H. AUXILIARIES

1. Agitators(3)(14)(23)

1.1 Design basis

The Uranium Recovery Plant agitators were designed to provide three types of agitation: mild, medium, and violent. "Mild" agitation is defined as that which produces a slight swirling effect on the surface of the liquid. "Medium" agitation produces waves in the liquid without disturbing surface continuity. "Violent" agitation is that which produces waves, frothing, and splashing. Reference is made to Table XVI-2 at the end of this chapter for agitator classification as to type of mixing.

1.2 Description

1.21 Agitators used in uranium removal facilities (241-WR Diversion Vault and 244 Process Tank Vaults)

The location of the agitators in the 241-WR and 244 Vaults is shown in Figures XIV-3 and 4. A typical agitator, A-WR-002, is shown on Figure XVI-17 with pertinent details of all agitators used in these vaults listed in Table XVI-2. The agitator shaft is connected through a flexible coupling to the output shaft of the speed reducer, which is directly connected to the motor shaft. The agitator shaft is fabricated in two sections for protection from damage during transit. The upper portion of the shaft carries both thrust and radial bearing loads, while the lower portion, which is joined to the upper section with a rigid, flange-type coupling, carries the agitator blading. 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 into 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.

All agitators are of stainless steel construction except the Slurry Accumulator agitator which is cast steel.

1.22 TBP Plant (211-U, 271-U, 276-U, and 221-U Building) agitators

Pertinent details of the agitators employed in the 211-U Tank Farm, 271-U, 276-U, and 221-U Buildings of the TBP Plant are listed in Table XVI-2. The agitator shafts are connected through a rigid sleeve coupling directly to the motor shaft in the case of high-speed agitators (1140 and 1150 rev./min.), and by a rigid sleeve coupling to the output shaft of a speed reducer, which is connected through a flexible coupling directly to the motor shaft, for the lower-speed agitators (70 to 188 rev./min.).

The high-speed agitator units employ one to three propeller-type impellers, and the lower speed, gear-driven agitators use curved or straight-blade, turbine-type impellers.

Agitators located in "cold" tanks more than six feet in depth employ a tripod step bearing with a Graphitar #41 bushing at the lower end of the shaft. "Hot" tank agitator shafts pass through a cylindrical tube welded in the mounting flange. This vertical tube contains a process-lubricated, Graphitar #41, sleeve-type bearing at its lower end to provide shaft support near the point of load application. A labyrinth-type seal consisting of alternate Graphitar #2 rings and stainless steel spacers is located at the upper end of the tube to prevent leakage around the agitator shaft. "Cold" tank agitators employ stuffing boxes with Graphitar #41 bushings.

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1.23 UNH Storage Tank (203-U Building) agitators

Agitation in the UNH Storage Tanks, TK-X-1 and TK-X-2, is obtained by means of agitators located in the sides of the tanks just above the tank bottom. The extremely large size (approximately 25 ft. by 30 ft.) of these tanks led to the adoption of side-entering agitators, thereby eliminating the design problems associated with abnormally long agitator shafts, as required by vertically mounted agitators.

The UNH Storage Tank agitator shaft is connected through a Falk Steelflex coupling directly to the gear-reducer shaft. The agitator shaft is provided with two steel flanged bearings to absorb thrust and radial loading. The impeller is a three blade, left-hand propeller, 24 in. in diameter with a 24-in. pitch.

In order to minimize process solution leakage around the agitator shaft, the shaft is sealed with a water-lubricated, pump-type stuffing box. Stuffing consists of rings of Garlock packing interspaced with lantern rings.

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1.24 UO_3 Plant (224-U Building) agitators

Agitators employed in the UN Storage Tank, TK-C-1, and the Sump Tank, TK-C-2, are described in Section C of the Hanford Works Technical Manual (HW-10475).

The Calcining Pot agitators are described under F2.3, above.

2. Sluicing Nozzles

Sluicing nozzles are used in the underground storage tanks to break up and slurry the uranium-bearing sludge in order that it may be removed by the sludge pump. Two sluicing nozzles, placed diametrically opposite each other, are located in each of the 75-ft.-diameter underground storage tanks. The 20-ft.-diameter tanks are equipped with only one sluicing nozzle each. The locations of the sluicing nozzles are shown in Figures XIV-1 and XVI-1. Construction details of the sluicing system are presented in Figure XVI-18.

The sluicing nozzle is installed through either a 12 or 42-in. riser in the storage tank. The upper part of the nozzle assembly is housed in the sluice pit (or pump pit) with operating rods extending through the pit shielding covers to an operating mechanism above the cover. The nozzle is capable of remote adjustment for azimuth and elevation so that its stream may be directed for maximum sluicing efficiency.

The nozzle can be rotated through a 150° angle (from -45° to + 105° from vertical) in the vertical plane by a rack-and-pinion arrangement. The rack actuating rod, which is housed in a lead-filled torque tube to provide shielding from radiation, is operated manually by means of a nozzle positioning lever located above the cover block. The rack actuating rod, which is a stainless steel tube, is also filled with lead for shielding purposes. The torque tube is connected to the nozzle at the

lower end and to a turntable above the cover block. The nozzle is connected to the 4-in. supply line by means of two Chiksan rotating joints and a rubber hose.

Nozzle rotation in the horizontal plane is effected by rotating the turntable by means of a 1/2-h.p. driving motor and one of two gear boxes through an adjustable drive linkage. The maximum angle of oscillation which can be obtained is 98.5°, at speeds of 1 cycle/min. and 1 cycle/hr., depending upon the gear box used. Through lever length adjustments of the driving linkage, the 98.5° angle of oscillation can be made available over a range of 240°. Two Microswitches, which when contacted reverse the rotation of the driving motor, limit the sluicing angle to 120° on either side of a reference line.

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Sluicing nozzles used in the 75-ft.-diameter tanks have a 1-3/8 in. tip, which will pass 516 gal./min. of 1.2 specific gravity solution at a supply pressure of 100 lb./sq.in. gauge. The 20-ft.-diameter tanks utilize nozzles with a 5/8-in. tip which will pass 100 gal./min. at 100 lb./sq. in. gauge. The sluicing nozzle is connected to a 14-in. section of 2-in. pipe by a standard threaded joint. The cross-sections of both the nozzle and the 2-in. pipe are divided into quadrants by four internal vanes located equidistantly from each other. Maximum sluicing efficiency is obtained by securing the nozzle in a position such that all vanes are 45° apart.

Since the liquid being handled is non-corrosive, all sluicing nozzle parts are constructed of carbon steel.

3. Gang Valves[8]

Two types of gang valves are used to operate the jets in the TBP Plant: (a) direct-operated gang valves such as are used in the Bismuth Phosphate Plants; and (b) remote air-operated gang valves such as are used in the Redox Plant.

The design principles for both types of valves are similar in that jet operation is effected through the simultaneous opening and closing of spring-loaded valves. Redox-type gang valves consist of four sequence-controlled, air-operated diaphragm valves in the pipe gallery operated by means of a remote, manual air controller in the operating gallery. For a detailed explanation of the operation of this type of gang valve, reference is made to the Redox Technical Manual (HW-18700).

The direct-operated gang valves consist of four sequence-controlled, spring-loaded valves which are manually operated through a rack and pinion arrangement. An operating diagram of this type of gang valve is presented in Figure XVI-19. Additional descriptive information may be found in Section C of the Hanford Works Technical Manual (HW-10475).

4. Samplers

Remote samplers are employed in the Uranium Recovery Plant to obtain small quantities of radioactive process materials for analysis. Samplers

in the TBP Plant (221-U Building) are located in the cell walls in lead-shielded pits approximately two feet below deck level. Although the UO_3 Plant (224-U Building) does not process any highly radioactive materials, a shielded sampler located in the pipe gallery is used for convenience to sample the Sump Tank, TK-C-2. Sampler pits located above the tanks provide sampling facilities for the 244 Process Tank Vaults used in uranium removal from underground storage. Samplers for tanks in the 241-WR Diversion Vault are located directly above the tanks in sampling enclosures.

All remote samplers utilize an air jet, which is operated in conjunction with an air lift. The component parts of a remote sampler of the type used in the TBP Plant are shown in the schematic sketch in Figure XVI-20. A detailed explanation of the operation of the sampler appears in Section C of the Hanford Works Technical Manual (HW-10475).

Samplers employed in the 241-WR and 244 Buildings differ from those used in the 221-U Building in that the air lift is supplied with compressed air rather than air at atmospheric pressure. The height to which liquid must be raised in the 241-WR and 244 tanks (30 to 40 ft.) necessitated this design revision.

Samples are collected by means of "bayonet" or "trombone" type samplers, depending upon the radioactivity level of the solution being sampled. Construction details of these samplers are shown in Figure XVI-21, and a description is presented in Section C of the Hanford Works Technical Manual (HW-10475). The "bayonet" is placed in a portable shield for transfer of the sample to the laboratory. A heavily-shielded sample carrier known as a "Door Stop" is used for transporting the "trombone" pipette containing the sample. "Trombone" type samplers are used on all waste samples and all uranium-bearing process samples from the feed tanks to the RC Column. The "bayonet" type sample is taken of waste accumulations in Section 5, process streams from the RC Column to the RCU tanks, and other organic and aqueous streams which are normally low in radioactivity.

The Waste Neutralizer Tank, TK-11-6, is provided with a pH sampler. Its purpose is to maintain a continuous record of the pH of the neutralized aqueous column wastes (RAW and ROW streams) prior to concentration. This sampler is identical with the other 221-U Building samplers with the exception that its sampler cup is provided with Beckman electrodes by means of which the pH of the solution is monitored. The pH measurement is then transmitted through an electronic bridge circuit to the recorder in the operating gallery.

5. <u>Strainers</u>

Basket-type strainers are used in the aqueous make-up facilities to remove any insoluble material which may enter the system in the dry chemicals.

In the standard basket-type strainer the stream enters a flanged inlet in the filter, flows downward into the screen basket, through the screen, and out through the flanged outlet, which is in line with the

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inlet. The screens used range from 10 to 100-mesh. The cast stainless steel strainer body has a bolted lid, which may be opened to permit the removal of the basket for cleaning.

6. Phase Separator, SP-385

In the 276-U Building a separator, SP-385, is used to separate the aqueous phase from the organic phase after treatment of the organic solvent in the Organic Treatment Tank, TK-386.

The separator is a Type 347 stainless steel, horizontal tank-like vessel approximately 6-1/2 ft. long and 14 in. in diameter, with a vertical, 8-5/8 in. O.D. by 2-ft. drain leg at one end. The mixed phases enter the separator, pass through a coalescing medium (wood excelsior), and then pass between flat, horizontal, parallel plates (about 1/4 in. apart) to produce laminar flow. In the settling chamber beyond the plates, the aqueous phase drops into the vertical drain leg and is drawn off through a manually operated valve at such a rate as to maintain an interface in the vertical drain leg sight glass. The organic phase leaves through the top outlet of the separator.

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REFERENCES

(1) Design Instruction Letter M-1, Materials of Construction for Process Equipment - Waste Metal Recovery Plant, 7-12-50.

(2) Design Instruction Letter M-2, Process Equipment - Waste Metal Recovery Plant, 7-20-50.

(3) Design Instruction Letter M-3, Rotating Equipment - Waste Metal Recovery Plant, 5-2-50.

(4) Design Instruction Letter M-5, Special Protective Coatings - Waste Metal Recovery Plant, 6-28-50.

(5) HW-3791 Design Division Standard Specification-Surface Roughness Rev. 2. G. H. Hill. 4-13-49.

(6) HW-4311 General Specification for Material Procurement and Shop Fabrication of Class I, II, and III Vessels -- Job 15. The Kellex Corporation. 10-25-50.

(7) HW-4608 General Specifications for Material Procurement and Erection of Outside Storage Tanks -- Job 15. The Kellex Corporation. 11-28-50.

(8) HW-10475 H.E.W. Technical Manual, Section C. Author not stated. 5-1-44. Centrifuges Pp. 515-518; Gang Valves Pp. 245, 249, 250; Samplers Pp. 526-531.

(9) BPF 2874 Calcining Pots.

(10) BPF 2890 Slurry Accumulator and 241-WR Diversion Vault Tanks.

(11) BPF 2961 Concentrate Receiver Tanks.

(12) BPF 3021 UNH Storage Tanks.

(13) BPF 3023 Organic Treatment Tank.

(14) BPF 3102 7-1/2 Hp. Agitators.

(15) BPF 3103 Evaporators.

(16) BPF 3103 Concentrate Cooler Tanks.

(17) BPF 3103 Bubble-Cap Columns.

(18) BPF 3106 Product Concentrator Fractionators.

(19) BPF 3120 Organic Treatment Sampler Tank.

(20) BPF 3170 TBP Storage Tank

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REFERENCES (continued)

(21) BPF 3190 Condensers.

(22) BPF 3191 HNO_3 Absorber.

(23) BPF 3272 25 and 40-Hp. Agitators.

(24) BPF 71238 Centrifuges.

(25) BPF 73550 Underground Storage Tanks.

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Figure XV-3

RA COLUMN AND PULSE GENERATOR SCHEMATIC LAYOUT

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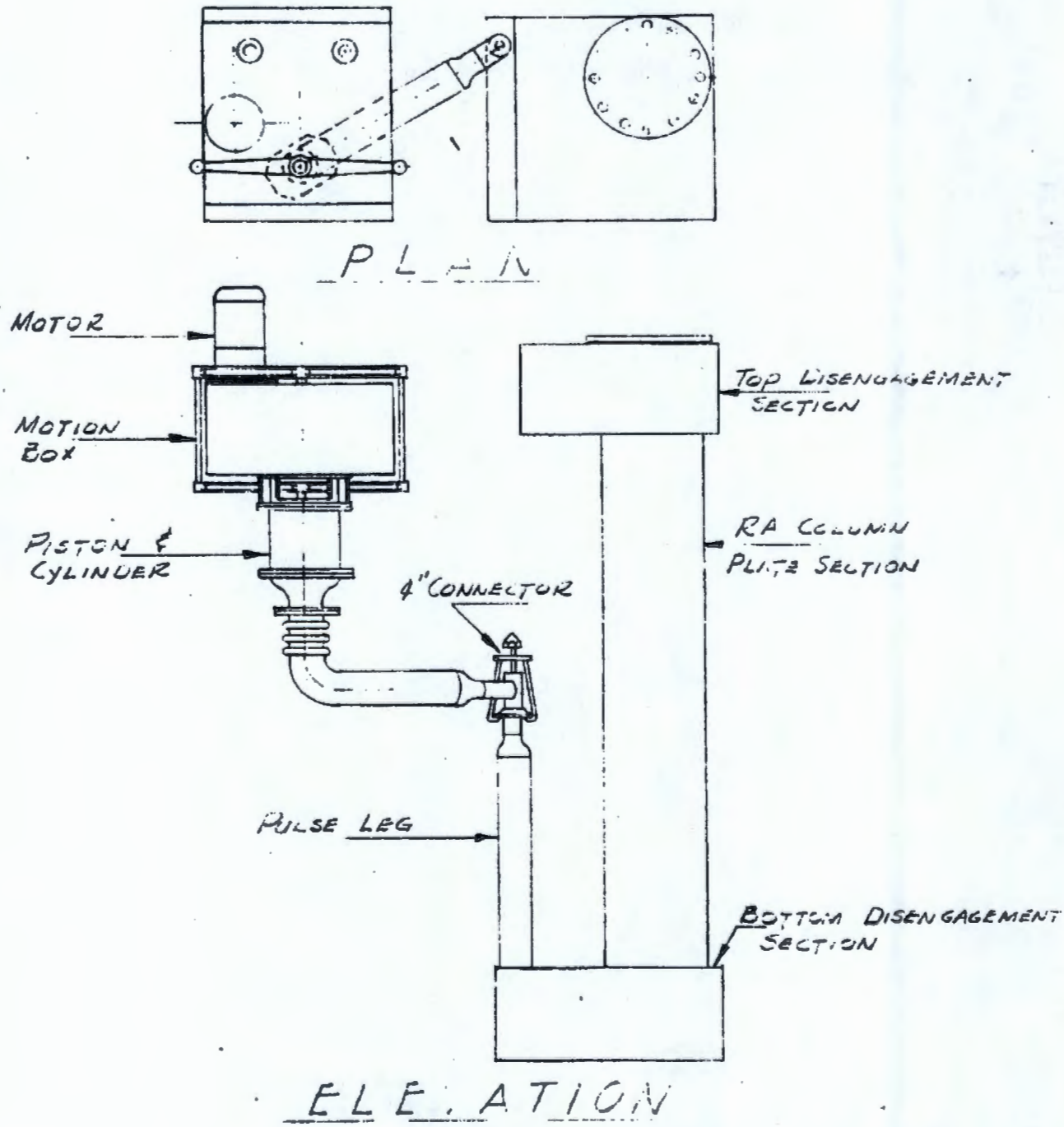

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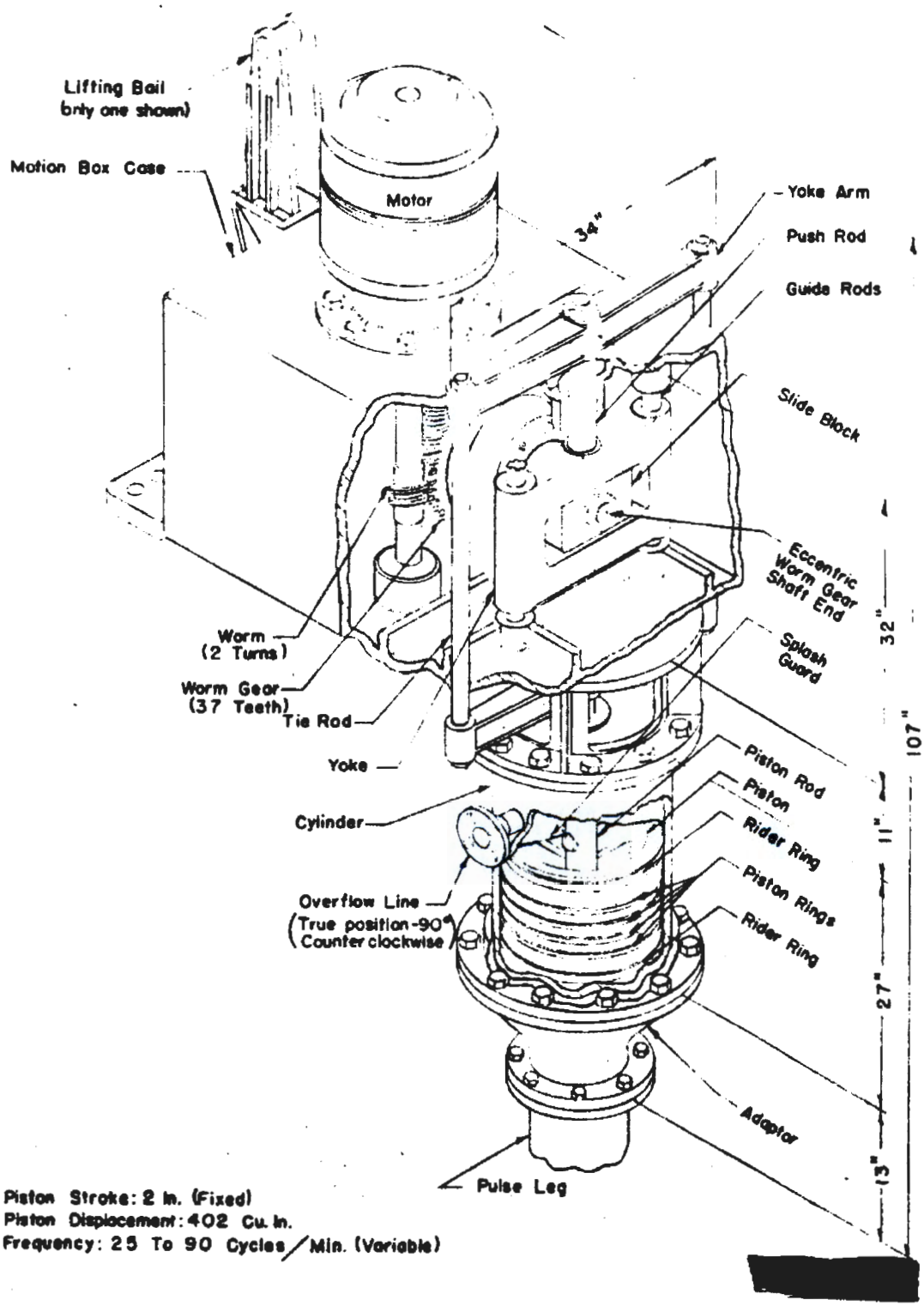
Figure XV-4
PULSE GENERATOR

NOTE: Lubrication And Electrical Connectors, And Waste Grease And Oil Overflow Lines And Receiver Are On The Motion Box Case And Are Not Shown.



Piston Stroke: 2 in. (Fixed)
Piston Displacement: 402 Cu. in.
Frequency: 25 To 90 Cycles/Min. (Variable)

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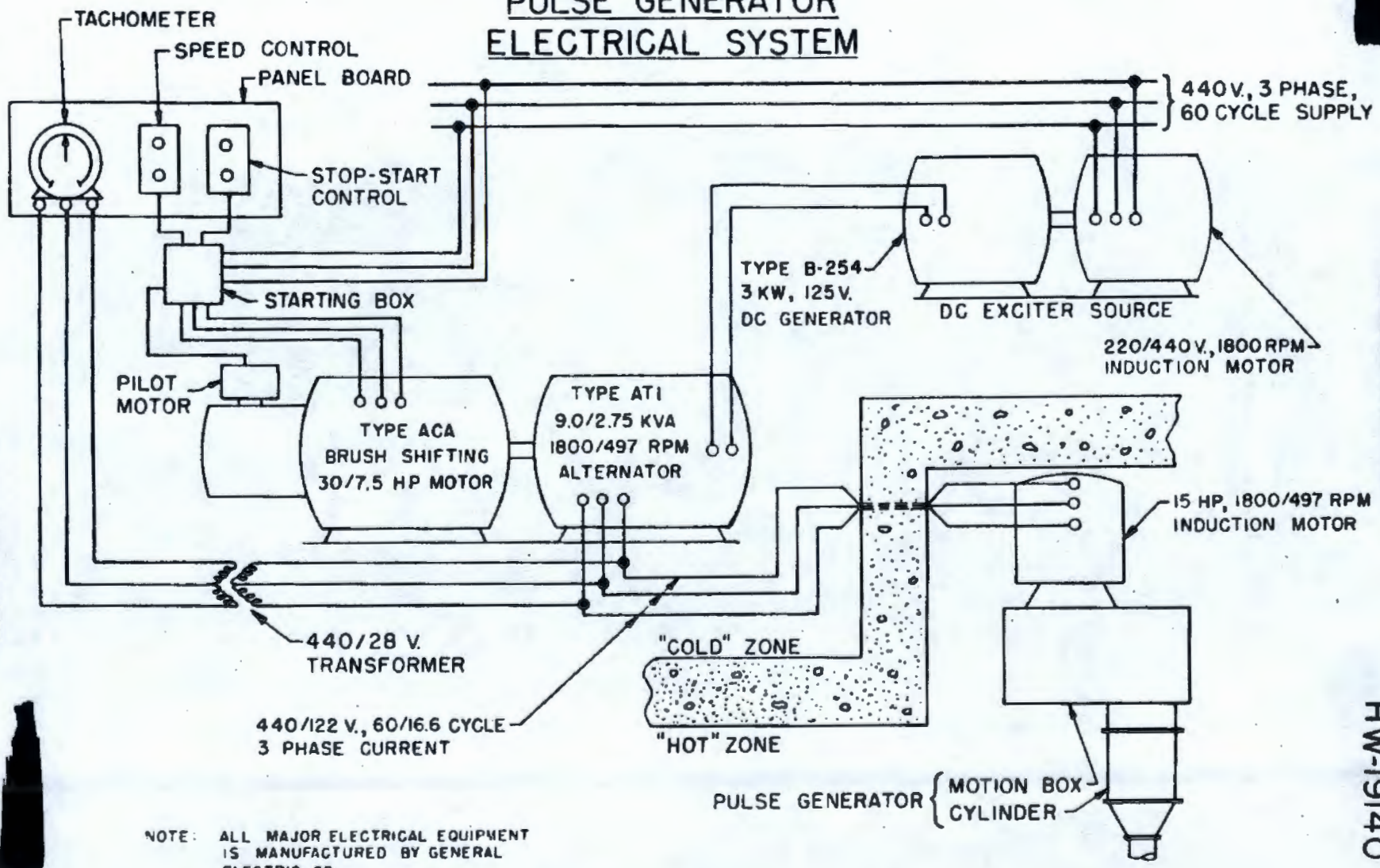
Figure XV-5
PULSE GENERATOR ELECTRICAL SYSTEM



NOTE: ALL MAJOR ELECTRICAL EQUIPMENT IS MANUFACTURED BY GENERAL ELECTRIC CO.

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PART III: PLANT AND EQUIPMENT, continued

CHAPTER XVI. OTHER PROCESS EQUIPMENT

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CHAPTER XVI. OTHER PROCESS EQUIPMENT

A. GENERAL DESIGN FEATURES OF PROCESS EQUIPMENT

1. Introduction(2)

In the design of the process equipment for the Uranium Recovery Plant several factors in addition to the fulfillment of the specific process requirements had to be considered. These factors included: (a) the restrictions (i.e., size, shape, and number) imposed by the use of available buildings existing at the time of design (the stand-by Bismuth Phosphate Plant Buildings 221-U and 224-U); (b) the necessary design features to allow for remote handling and maintenance of all "hot" equipment (i.e., equipment used for highly radioactive solutions); (c) the standardization of equipment to allow for interchangeability; and (d) the modifications required to permit the use of spare Bismuth Phosphate Plant vessels that were on hand.

On the basis of process and remote maintenance requirements, vessels have been classified as follows:

Class I -- all "hot", stainless steel vessels designed for remote maintenance and handling;

Class II -- all stainless steel vessels designed for contact maintenance and used for "cold" or low-level radioactive solutions; and

Class III -- "cold" vessels made of carbon steel. Vessels constructed of material other than carbon steel or stainless steel are included in Class III-Special.

The vessels in the 241 Tank Farms, 244 Process Tank Vaults, and the 241-WR Diversion Vault are not included in any of the above classifications.

2. Class I Vessels

2.1 Materials of construction (1)

Class I vessels are of all-welded construction fabricated from either Type 347 or 304 E.L.C. (extra low carbon) stainless steels except for the tubes in concentrators. These tubes are Type 309S Cb stainless steel.

2.2 Heads

Except for condensers, both bottom and top heads of Class I vessels are the flanged, flat (not dished) type with a rounded inside corner between the head and the shell. Bottom heads of new vessels are level, but the old bismuth phosphate process tanks adapted for use in the Uranium Recovery Plant have a bottom-head slope toward one edge of the vessel.

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2.3 Shells

Tank shells are normally designed for an internal pressure range of -0.5 to + 5 lb./sq.in. gauge at a temperature of 250°F. However, the range of design pressures and temperatures for concentration equipment (evaporators, deentrainment columns, condensers, and coolers) is greater. In general, design pressures are 1-1/2 to 2-1/2 times the estimated working pressure.

2.4 Tank coils and jackets

Tank coils are designed for use with 100-lb./sq.in. gauge steam at 337°F. Fabrication is with as few welds as possible, and the coils are stress-relieved prior to installation in the tank. In general, coil nozzles are a part of the top head nozzle pattern and are welded to this head. Tank jackets are designed for a working pressure of 40 lb./sq.in gauge at 250°F. Jacket nozzles are attached to the top head and upper shell but are not a part of the top head nozzle pattern.

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2.5 Remote maintenance and handling features

To fulfill remote maintenance and handling requirements, (see Chapter XVIII for discussion of procedures and description of equipment) vessel design features include the following:

Connectors: All lines, including instrument, lubrication, and electrical lines are connected to vessels and associated equipment by means of remotely operated connectors. Tank nozzles providing access to the vessel interior are located on the top head, generally near the periphery, in a pattern approximating the head shape. On vessels other than tanks, connectors are located wherever suitable to fulfill process and remote maintenance requirements. Mounting braces and kickplates are provided where the vessel body or head does not serve these functions of supporting the nozzle and loosening the jumper.

Mating equipment: Mating equipment pieces are generally secured to their respective vessels by means of "captive" studs and remotely manipulated "free" nuts. When the equipment is removed, the gasket between the flanges is retained by the piece which is removed first. On engagement of mating pieces, correct alignment is assured by means of two dowel pins and companion holes in the mating flanges.

Lifting bails and trunnions: All vessels and removable auxiliaries are provided with lifting bails or trunnions, which permit remote handling by means of standard hooks or yokes. Structurally, these bails or trunnions are strong enough to lift the empty vessel and all auxiliary equipment and are so located that the vessel will balance when lifted with the equipment removed.

Dimensional tolerances: Close tolerances are maintained on vessel support and nozzle location dimensions, thus allowing the major portion of the over-all cell tolerance for dimensional variation in the cell jumpers. Except for vessels in the concentration cells, gasket faces for

connectors and auxiliary equipment mounting flanges have a tolerance of ± 1/64 in. from a datum plane (usually the plane of a vessel support pad). The tolerance on connector nozzle and flange center lines is ± 1/16 in. On concentrator cell equipment, the tolerance on both the nozzle gasket face and the center lines is ± 1/32 in., this tolerance being increased to ± 1/8 in. where thermal expansion of the vessel may have a significant effect.

Vessel positioning; Vessels are horizontally positioned by means of V-block guides attached to the cell floor and positioning arms which are bolted to lugs on the vessel shell. Vertical positioning is accomplished by the addition of shims and floor plates attached to the vessel support pads. In a concentration cell, the evaporator, deentrainment column, and condenser are mounted on a steel framework, and the framework is positioned in the cell by means of the guides and lugs mentioned above.

Draining and flushing: All vessels can be completely drained or emptied and flushed. Generally, there are no internal or external liquid-retention pockets.

Finishes:(4)(5)(6) The vessel interiors have a standard No. 1 mill finish, substantially unmarred by hammer marks or weld spatter. All welds are ground smooth, and welds securing studs and dowels to equipment mounting flanges are flush with the parent metal. Stainless steel surfaces are cleaned, pickled, and passivated after fabrication of the vessel. Non-stainless steel parts are coated with a chemical-resistant paint, Amercoat No. 23 to 55.

3. Class II and Class III Vessels

Class II and Class III vessels differ in that the former are made of stainless steel and the latter of carbon steel. Vessels made to Class II or III specifications of materials other than carbon steel or stainless steel are designated as Class III-Special. All Class II and Class III (including Class III-Special) vessels are of all-welded construction and are designed according to normal chemical plant practice.

Vessel bottom and top heads may be any of the following three types of construction: (a) flanged and flat (not dished); (b) flanged and dished; or (c) conically shaped (tops only). The flat bottoms on some of the old bismuth phosphate process vessels adapted for use in the Uranium Recovery Plant are sloped toward one edge. Nozzles may be located in any part of the shell or head.

Non-stainless steel components are painted with Amercoat No. 33 or 55. Mineral wool or fiber glass insulation and weather-proof coating is provided wherever necessary to maintain the chemicals in a fluid condition in cold weather.

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B. TANKS

Tanks used in the Uranium Recovery Plant may be divided into two groups: (a) "hot" tanks, designed for remote maintenance and handling; and (b) "cold" tanks, used for "cold" or low-radioactivity-level solutions and designed for contact maintenance. "Hot" tanks include the Underground Waste Storage Tanks (241 Buildings), some vessels in the 244 Process Tank Vault and 241-WR Diversion Vault Buildings, and Class I vessels in the TBP Plant (221-U Building canyon cells. "Cold" tanks include vessels in the "cold" process solution make-up facilities, the 221-U Building operating gallery, UO_3 Plant (224-U Building), and some vessels in the 244 Process Tank Vault and 241-WR Diversion Vault Buildings. The general principles of design for these vessels are summarized in Section A. A tabulation of the salient design features of the Uranium Recovery Plant tanks is presented in Table XVI-1.

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1. "Hot" Tanks

1.1 Underground Waste Storage Tanks(25)

1.11 General

Underground storage tanks are located in the 241-B, BX, BY, C, T, TX, TY (under construction at time of writing), and U Tank Farms in the 200-East and 200-West Areas. These tanks contain the bismuth phosphate process uranium wastes, which constitute the radioactive feed to the Uranium Recovery Plant and also serve as storage vessels for "hot" waste from the TBP Plant. (Reference is made to Chapters II, XII, and XIV for process details.) There is a total of 108 underground storage vessels in the above tank farms: (a) sixty 75-ft.-diameter tanks with a capacity of 530,000 gallons each; (b) thirty-six 75-ft.-diameter, 750,000-gallon tanks; and (c) twelve 20-ft.-diameter, 55,000-gallon tanks. Those from which uranium is to be recovered include twenty-seven type (a), fifteen type (b), and four type (c). (See Chapter II for a complete list of tanks from which uranium is to be removed.) The tanks are all of the vertical cylinder type, made of concrete with a carbon steel liner.

1.12 Typical vessel

A section-elevation drawing of a typical underground storage tank, including the uranium removal equipment, is presented in Figure XVI-1. This is one of the 750,000-gallon tanks located in the 241-TX and BY Buildings.

The carbon steel liner forms a 75-ft.-diameter storage bowl, 24 ft. deep at the edge and 25 ft. deep at the low point in the center. The rounded corner between the bottom and the wall has a 4-ft. inside radius. The tanks are arranged in cascades of three, four, or six vessels. The first tank is provided with four 4-in. inlet pipes for receiving solution from a diversion box. A 4-in. overflow pipe is provided, feeding into the succeeding tanks through a 4-in. nozzle and allowing the maximum liquid level to be 2 ft. below the top of the steel liner. Inlet pipes are not welded to the vessel shell, but are fitted into a sleeve to allow for

thermal expansion and contraction.

The top head (dome) is provided with thirteen risers extending to grade level. These include five 42-in., three 12-in., and five 4-in. -diameter risers. As shown in Figure XVI-1, some of these risers are used for uranium removal equipment and are enclosed by concrete pits. In so doing, two of the 12-in. risers are blocked off by the pit side walls. The sluicing nozzles, recirculating lines, and slurry pump are installed on 42-in. risers. In the pump pit, the heel jet is installed on a 12-in. riser, and the pit drain enters the vessel through a 4-in. riser. Remotely operated connectors located on the pit wall and on the uranium removal equipment facilitate attachment of process piping. Remote maintenance and handling of equipment is accomplished by use of a gantry crane (described in Chapter XVIII).

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1.2 244 Process Tank Vault and 241-WR Diversion Vault Tanks[10]

Buildings 244-TXR and UR each contain three "hot" tanks: a Slurry Accumulator and two Blend Tanks. However, the 244-BXR and CR Buildings contain four "hot" tanks, the extra tank being the Process Pump Tank. The 241-WR Diversion Vault Building contains five "hot" tanks: two Feed Receivers, TK-WR-003 and TK-WR-005; two Feed Samplers, TK-WR-002 and TK-WR-004; and a Waste Pump Tank, TK-WR-001.

The Slurry Accumulators are constructed of carbon steel and all other tanks in the vaults are fabricated of stainless steel. All tanks are vertical, cylindrical tanks with dished heads. Spray rings are provided around all equipment nozzles for cleaning the equipment as it is withdrawn from the tank.

1.21 Slurry Accumulator TK-UR-001

The Slurry Accumulator is a carbon steel, 20-ft. O.D. by 19-ft. 2-in. tank, having a capacity of 50,000 gal. Construction details are shown in Figure XVI-2. Three large equipment nozzles (18 in., 24 in., and 50 in. O.D.) and 10 smaller instrument and process nozzles are provided in the top head. Special features include spray rings around the large equipment nozzles with which the agitator, pump, or jet may be rinsed as it is removed. The sluice pump fits into a "pump boot" so located that 28,000 gal. of solution is required for the pump to take suction. Three 1-in. holes in the bottom of the boot allow it to drain whenever the tank is emptied. Four 15-in.-wide baffles are provided in the tank to improve agitation of the slurry. The tank is supported by four legs which rest on strain gauges. The gauges are used to determine the weight of the tank contents. (See Chapter XIX for a discussion of the strain gauge.)

1.22 Other "hot" tanks

The Blend Tanks are stainless steel, 14-ft. O.D. by 12-ft. tanks, having a capacity of 15,000 gallons. Each is equipped with an agitator, pump, and cooling coils. The 2-concentric-ring coil (7 turns high) is made of 3-1/2 in. O.D. (0.203-in. wall) stainless steel tubing. Ten

instrument and process nozzles are provided in the top head.

The Process Pump Tanks are stainless steel, 50,000-gal. tanks constructed the same as the Slurry Accumulator except for the number of nozzles. These tanks are equipped with a pump and 10 nozzles for instrument and process lines. The Feed Sampler and Feed Receiver Tanks in the 241-WR Diversion Vault Building are 50,000-gal., stainless steel tanks constructed identical to each other. Except for nozzles and type of support, their construction is the same as the Slurry Accumulator. Three equipment nozzles contain an agitator and two pumps, and 9 other nozzles supply instrument and process addition lines. An integral skirt base provides support for the tanks.

The Waste Pump Tank is identical to the Feed Receiver and Sampler Tanks, except that it is equipped with a sparger and has three nozzles to accommodate pumps.

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1.3 221-U Building canyon vessels

The TBP-Plant "hot" tanks, located in the 221-U Building canyon cells, are Class I vessesl designed in accordance with the general specifications summerized in Section A. Except for the Deep Cell Sump Tank (Subsection B1.33), these tanks are either of the vertical cylinder type, or of the vertical "oval" type. The "oval" tanks have parallel plane sides and semi-cylindrical ends.

1.31 Vertical cylindrical tanks(11)

The Concentrated Feed Receiver, TK-6-7, is a typical vertical cylindrical tank, a drawing of which is presented in Figure XVI-3. This vessel is 8 ft. in diameter by 14 ft. high (not including top-head projections) with a working volume of 4500 gal. The flat, flanged top head is provided with sixteen 3-in. connector nozzles and separate flanges for mounting a pump and an agitator. The head is reinforced internally by four radial stiffening ribs. The coil is made of 2-in. pipe and is approximately 68 ft. long. It is supported at four points by cross members on vertical columns which are welded to the bottom head. The four vessel supports are made of 8-in. pipe, welded to the bottom head. The slope of the plane of support conforms to the cell floor slope, so that the vessel is level.

Other 8-ft. by 14-ft. tanks are identical in design except that they are provided with a jacket in place of a coil. The jacket is made of 3/16-in. plate and encloses the entire shell (5/8 in. thick) except for 12 in. at the bottom and the top. Between the jacket and shell, five circumferential baffles are provided, spaced 2 ft. apart, welded to the shell only. Each baffle has a 15° opening at 180° orientation from openings in adjacent baffles. Near the top, the jacket is vented to its outlet line through a 1/8-in. pipe. Jacket inlet and outlet nozzles are 2 in. and 3 in. in diameter, respectively.

Other vertical cylindrical tanks include sizes ranging from 1350 to 4500 gallons working volume. These vessels are similar in design to the

8-ft. by 14-ft. tanks described above with the following chief exceptions.

(a) A single mounting flange is provided for the pump and agitator assembly on the 5-1/2 ft. and 7-ft.-diameter tanks.

(b) The number of process nozzles is reduced to 9 and 10 for 5-1/2 ft.-diameter tanks, and 11 and 12 for 7-ft. tank.

(c) The Centrifuge Catch Tanks, TK-14-2 and TK-14-7, and the Aqueous and Organic Sump Holdup Tanks, TK-5-1 and TK-5-2, are modified Bismuth Phosphate Plant vessels which have the bottom heads sloped 3/8 in. per diametrical foot, conforming to the cell floor slope. Other design features of these modified vessels include interior vertical baffle plates attached to the vessel shell, a short jacket (enclosing approximately the lower half of the shell) on TK-14-2 and TK-14-7, and a special type of connector on TK-14-2 and TK-14-7 for the inlet line from the centrifuge.

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1.32 Oval tanks[16]

Of the oval tanks, the type most extensively used is 10 ft. wide by 16 ft. long by 14 ft. high (not including top head projections) with a working volume of 12,000 gal. A drawing of this type of vessel is presented in Figure XVI-4. The flat, flanged bottom head is reinforced by the vessel supports extending the entire width of the head. The slope the plane of support conforms to the cell floor slope, so that the vessel will be level. The shell and the top head are reinforced by internal stiffeners. The top head is provided with sixteen 3-in. connector nozzles and six flanges for mounting two agitators and four pumps. The coil is made of 2-in. pipe and is approximately 245 ft. in length.

A second type of oval tank, the Waste Neutralizer, TK-11-6, is the same in over-all size and shape as the oval tank discussed above. However, because of its unique process function, the following features are included in its design:

(a) Six of the nineteen connector nozzles discharge into a 6-in. pipe manifold located inside the tank approximately 12 in. below the top head. These nozzles are for acid waste and caustic addition. The manifold discharges into the intimate mixing zone of an agitator located near one end of the tank.

(b) The intimate mixing zone of the agitator referred to in (a) is surrounded by a double-row coil, fabricated from 2-in. pipe, approximately 470 ft. long. Coils are 36 in. and 45-1/2 in. in diameter.

(c) Three interior baffle plates, 10-1/2 ft. high by 7-1/2 ft. wide are provided to preclude "short-circuiting" of liquid from the inlet end of the tank to the discharge pumps. These baffles, spaced 21 in. apart, are welded to the bottom head on the 7-1/2 ft. edge and to the vessel wall on the 10-1/2 ft. edge. Alternate baffles are attached to opposite walls of the tank.

(d) Four mounting flanges for one agitator and three pumps are located near the end of the tank opposite the agitator referred to in (a).

The Feed and Waste Coolers, E-6-2, E-7-2, E-8-2, E-9-2, and E-10-2 are oval tanks of a third type. These coolers are 3-1/4 ft. wide by 7 ft. long by 4 ft. high with a working volume of 450 gallons. Flat sections of the shell are 1/2 in. thick, and curved sections are 1/4 in. thick. The top and bottom heads are flat and flanged, the bottom being 3/8 in. thick and the top 1/2 in. thick. The top head is provided with seven 3-in. connector nozzles and a single mounting flange for the pump and agitator assembly. A double-row coil is provided, fabricated from 2-in. pipe, approximately 390 ft. long. The coil is supported at six points by cross members on columns welded to the bottom head. Coil ends pass through the shell, rather than through the top head of the vessel, and inlet and discharge nozzles are located outside of the head nozzle patterns. The vessel is supported at six points by 6-in. pipe stubs welded to the bottom head.

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1.33 Deep Cell Sump Tank TK-5-6

The Deep Cell Sump Tank, TK-5-6, is a rectangular open-top tank, 11 ft. wide by 18 ft. long by 7 ft. high with a working volume of 10,000 gallons. It is box-like in construction, fabricated from 3/8-in.-thick plate with extensive internal reinforcing.

2. "Cold" Tanks

2.1 General

"Cold" tanks are generally designed in accordance with the specifications for Class II, III, and III-Special vessels given in Section A. The vertical-cylinder-type tank is used most extensively, with a height-to-diameter ratio varying from 1 to 2. The chief exceptions in this respect are the 9-ft.-diameter by 36-ft.-long horizontal storage tanks. Common design features for "cold" tanks include bottom outlets, side-entering coils, overflows, top-head vents, and manways. In addition, stilling chambers for weight-factor and density dip tubes are attached to the shells on agitated tanks. Flat, dished, or conical heads are used. The conical shape is employed for top heads only, and these are externally reinforced. Vessels that were on hand prior to plant design are used extensively. Some of these have sloping bottom heads and are fitted with remote-maintenance-type connectors, modified to permit direct maintenance.

2.2 Organic Treatment Tank TK-386[13][19][20]

The Organic Treatment Tank, TK-386, located in the 276-U Tank Farm, is a typical Class II process vessel (see Figure XVI-5). This stainless steel vessel has a 14-ft.-diameter by 14-ft.-high shell with 12-ft.-radius dished heads. The 3-in. overflow is located approximately one foot below the shell top, allowing an overflow volume of 16,600 gallons. The over-all height of the vessel, including the mounting skirt, is 21 feet.

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TABLE XVI-3

WASTE RECOVERY PLANT AGITATORS

Building	Vessel	Agitator No.	Motor H.P.(a)	Speed, Rev./Min.	Approx. Length of Shaft Within Vessel	Approx. Dist. Blade From Bottom	Impeller(s) Motor	Impeller(s) Type	Diameter, Inches	No. of Blades	Type of Agitation
244-SR	Slurry Accumulator	A-SR-001	40	82	28 ft.	3 ft. 5 in.	3	Turbine	40	10(b)	Violent
	Blend Tank	A-SR-002	10	82	18 ft. 10 in.	2 ft. 7 in.	3	Turbine	33	10(b)	Medium
	Blend Tank	A-SR-003	10	82	18 ft. 10 in.	2 ft. 7 in.	3	Turbine	33	10(b)	Medium
244-SXR	Slurry Accumulator	A-SXR-001	40	82	28 ft.	3 ft. 5 in.	3	Turbine	40	10(b)	Violent
	Blend Tank	A-SXR-002	10	82	18 ft. 10 in.	2 ft. 7 in.	3	Turbine	33	10(b)	Medium
	Blend Tank	A-SXR-003	10	82	18 ft. 10 in.	2 ft. 7 in.	3	Turbine	33	10(b)	Medium
244-TXR	Slurry Accumulator	A-TXR-001	40	82	28 ft.	3 ft. 5 in.	3	Turbine	40	10(b)	Violent
	Blend Tank	A-TXR-002	10	82	18 ft. 10 in.	2 ft. 7 in.	3	Turbine	33	10(b)	Medium
	Blend Tank	A-TXR-003	10	82	18 ft. 10 in.	2 ft. 7 in.	3	Turbine	33	10(b)	Medium
244-CR	Slurry Accumulator	A-CR-001	40	82	28 ft.	3 ft. 5 in.	3	Turbine	40	10(b)	Violent
	Blend Tank	A-CR-002	10	82	18 ft. 10 in.	2 ft. 7 in.	3	Turbine	33	10(b)	Medium
	Blend Tank	A-CR-003	10	82	18 ft. 10 in.	2 ft. 7 in.	3	Turbine	33	10(b)	Medium
211-UR	Feed Sampler	A-UR-002	25	82	27 ft. 6 in.	3 ft. 5 in.	3	Turbine	42	10(b)	Medium
	Feed Receiver	A-UR-003	25	82	27 ft. 6 in.	3 ft. 5 in.	3	Turbine	42	10(b)	Medium
	Feed Sampler	A-UR-004	25	82	27 ft. 6 in.	3 ft. 5 in.	3	Turbine	42	10(b)	Medium
	Feed Receiver	A-UR-005	25	82	27 ft. 6 in.	3 ft. 5 in.	3	Turbine	42	10(b)	Medium
221-U	Feed Receiver	A-3-1-1, A-3-1-2	7.5	186	13 ft. 6 in.	13 in.	1	Turbine	19.5	6(b)	Mild
	Feed Receiver	A-3-6-1, A-3-6-2	7.5	186	13 ft. 6 in.	13 in.	1	Turbine	19.5	6(b)	Mild
	Feed Utility Hold-Up	A-1-1-1, A-1-1-2	7.5	186	13 ft. 6 in.	13 in.	1	Turbine	19.5	6(b)	Mild
	Waste Utility Hold-Up	A-1-6-1, A-1-6-2	7.5	186	13 ft. 6 in.	13 in.	1	Turbine	19.5	6(b)	Mild
	Organic Sump Hold-Up	A-5-1	5	180	13 ft. 6 in.	11 in.	1	Turbine	20	6(b)	Medium
	Aqueous Sump Hold-Up	A-5-2	7.5	186	13 ft. 6 in.	11 in.	1	Turbine	19.5	6(b)	Mild
	Concentrated Feed Cooler	A-6-2	2	1150	3 ft. 4 in.	10.5 in.	1	Propeller	8	3	Violent
	Feed Concentrator Feed	A-6-6	7.5	186	13 ft. 6 in.	13 in.	1	Turbine	19.5	6(b)	Medium
	Concentrated Feed Receiver	A-6-7	7.5	186	13 ft. 6 in.	13 in.	1	Turbine	19.5	6(b)	Medium
	Concentrated Feed Cooler	A-7-2	2	1150	3 ft. 4 in.	10.5 in.	1	Propeller	8	3	Violent
	Feed Concentrator Feed	A-7-6	7.5	186	13 ft. 6 in.	13 in.	1	Turbine	19.5	6(b)	Medium
	Concentrated Feed Receiver	A-7-7	7.5	186	13 ft. 6 in.	13 in.	1	Turbine	19.5	6(b)	Medium
	Concentrated Spare Cooler	A-8-2	2	1150	3 ft. 4 in.	10.5 in.	1	Propeller	8	3	Violent
	Spare Concentrator Feed	A-8-6	7.5	186	13 ft. 6 in.	13 in.	1	Turbine	19.5	6(b)	Medium
	Concentrated Spare Receiver	A-8-7	7.5	186	13 ft. 6 in.	13 in.	1	Turbine	19.5	6(b)	Medium
	Concentrated Waste Cooler	A-9-2	2	1150	3 ft. 4 in.	10.5 in.	1	Propeller	8	3	Violent
	Waste Concentrator Feed	A-9-6	7.5	186	13 ft. 6 in.	13 in.	1	Turbine	19.5	6(b)	Medium
	Concentrated Waste Receiver	A-9-7	7.5	186	13 ft. 6 in.	13 in.	1	Turbine	19.5	6(b)	Medium
	Concentrated Waste Cooler	A-10-2	2	1150	3 ft. 4 in.	10.5 in.	1	Propeller	8	3	Violent
	Waste Concentrator Feed	A-10-6	7.5	186	13 ft. 6 in.	13 in.	1	Turbine	19.5	6(b)	Medium
	Concentrated Waste Receiver	A-10-7	7.5	186	13 ft. 6 in.	13 in.	1	Turbine	19.5	6(b)	Medium
	Waste Sampler	A-11-1-1, A-11-1-2	7.5	186	13 ft. 6 in.	13 in.	1	Turbine	19.5	6(b)	Mild
	Neutralizer	A-11-6-1, A-11-6-2	7.5	186	13 ft. 6 in.	13 in.	1	Turbine	19.5	6(b)	Mild
	Waste Sampler	A-12-1-1, A-12-1-2	7.5	186	13 ft. 6 in.	13 in.	1	Turbine	19.5	6(b)	Mild
	Waste Sampler	A-12-6-1, A-12-6-2	7.5	186	13 ft. 6 in.	13 in.	1	Turbine	19.5	6(b)	Mild
	Waste Sampler	A-13-1-1, A-13-1-2	7.5	186	13 ft. 6 in.	13 in.	1	Turbine	19.5	6(b)	Mild
	Pooled RAS-RCW	A-13-6-1, A-13-6-2	7.5	186	13 ft. 6 in.	13 in.	1	Turbine	19.5	6(b)	Mild
	Centrifuge Catch	A-14-2	5	190	8 ft. 4 in.	12 in.	1	Turbine	20	6(b)	Mild
	Centrifuge Catch	A-14-7	5	190	8 ft. 4 in.	12 in.	1	Turbine	20	6(b)	Mild
	RCW Sampler	A-15-1-1, A-15-1-2	7.5	186	13 ft. 6 in.	13 in.	1	Turbine	19.5	6(b)	Mild
	RCW Sampler	A-15-6-1, A-15-6-2	7.5	186	13 ft. 6 in.	13 in.	1	Turbine	19.5	6(b)	Mild
	RCW Receiver	A-16-1-1, A-16-1-2	7.5	186	13 ft. 6 in.	13 in.	1	Turbine	19.5	6(b)	Mild
	RCW Receiver	A-16-6-1, A-16-6-2	7.5	186	13 ft. 6 in.	13 in.	1	Turbine	19.5	6(b)	Mild
	RCW Receiver	A-17-1	5	1150	11 ft. 5 in.	14 in.	1	Propeller	9	3	Violent
	RCW Pump Out	A-17-3	5	1150	7 ft. 5 in.	14 in.	1	Propeller	9	3	Violent
	RAF Feed	A-17-6	5	1150	13 ft. 5 in.	14 in.	1	Propeller	9	3	Mild
	RAF Receiver	A-17-7	5	1150	11 ft. 5 in.	14 in.	1	Propeller	9	3	Violent
	ROO Receiver	A-18-1	5	188	13 ft. 6 in.	11 in.	1	Turbine	20	6(b)	Medium
	RON Receiver	A-18-3	2	1150	8 ft. 5 in.	14 in.	1	Propeller	8	3	Medium
	RAX Feed	A-18-6-1, A-18-6-2	7.5	186	13 ft. 6 in.	13 in.	1	Turbine	19.5	6(b)	Mild
	RCV Receiver	A-19-1	5	1150	11 ft. 5 in.	14 in.	1	Propeller	9	3	Violent
	RCV Pump Out	A-19-3	5	1150	7 ft. 5 in.	14 in.	1	Propeller	9	3	Violent
	RAF Feed	A-19-6	5	1150	13 ft. 5 in.	14 in.	1	Propeller	9	3	Mild
	RAF Receiver	A-19-7	5	1150	11 ft. 5 in.	14 in.	1	Propeller	9	3	Violent
	ROO Receiver	A-20-1	5	188	13 ft. 6 in.	11 in.	1	Turbine	20	6(b)	Medium
	RON Receiver	A-20-3	2	1150	8 ft. 5 in.	14 in.	1	Propeller	8	3	Medium
	RAX Feed	A-20-6-1, A-20-6-2	7.5	186	13 ft. 6 in.	13 in.	1	Turbine	19.5	6(b)	Mild
211-U	RAS Make-Up	A-314	5	117	15 ft. 6 in.	2 ft.	2	Turbine	26	6(c)	Medium
	RAS Make-Up	A-315	5	117	15 ft. 6 in.	2 ft.	2	Turbine	26	6(c)	Medium
271-U	RON Seed Tank	A-202	3	117	8 ft. 8 in.	2 ft.	2	Turbine	28	6(c)	Mild
	Wash Solution Make-Up	A-203	2	1140	4 ft. 9 in.	8 in.	2	Propeller	8	2	Medium
	RCS Blend Tank	A-204	1	1140	4 ft. 4 in.	7 in.	2	Propeller	7	3	Medium
	Sulfamic Acid Make-Up	A-206	1.5	1140	4 ft. 9 in.	8 in.	2	Propeller	8	2	Violent
	Ferrous Ammonium Sulfate Make-Up	A-207	1.5	1140	4 ft. 9 in.	8 in.	2	Propeller	8	2	Violent
	RAS Feed Tank	A-208	1	1140	4 ft. 6 in.	7 in.	2	Propeller	7	3	Medium
	Na_2SO_4	A-220	5	70	8 ft. 11 in.	2 ft.	1	Turbine	40	6(d)	Violent
276-U	RAX Blend	A-362	7.5	88	17 ft. 6 in.	3 ft. 6 in.	2	Turbine	33	6(c)	Medium
	Organic Treatment	A-366	7.5	88	17 ft. 6 in.	3 ft. 11 in.	2	Turbine	33	6(c)	Medium
	Organic Receiver	A-367	7.5	88	17 ft. 6 in.	3 ft. 6 in.	2	Turbine	33	6(c)	Medium
	Organic Treatment Sampler	A-368	2	1140	14 ft. 3 in.	13 in.	3	Propeller	8	6	Medium
203-U	Feed Storage Tank	A-2-1	20	420	2 ft. 8 in.	2 ft.	1	Propeller	24	3	Mild
	Feed Storage Tank	A-2-3	20	420	2 ft. 8 in.	2 ft.	1	Propeller	24	3	Mild
224-U	UNH Storage Tank	A-C-1	35	46	10 ft. 2 in.	9 in.	1	Turbine	38	4	Violent
	Sump Tank	A-C-2	35	46	20 ft. 2 in.	9 in.	2	Turbine	38	4	Violent
	Decomposition Pots	A-P-E1 to A-P-E16	7.5	37	38 in.	1/8 in.	1	Scoop	30	2	-------

(a) All motors are 440-volt, 3-phase, 60-cycle, vertically flange-mounted.

(b) Blades are inclined 10° from vertical (downward scoop).

(c) Curved-blade turbine.

(d) Blades are pitched 45°.

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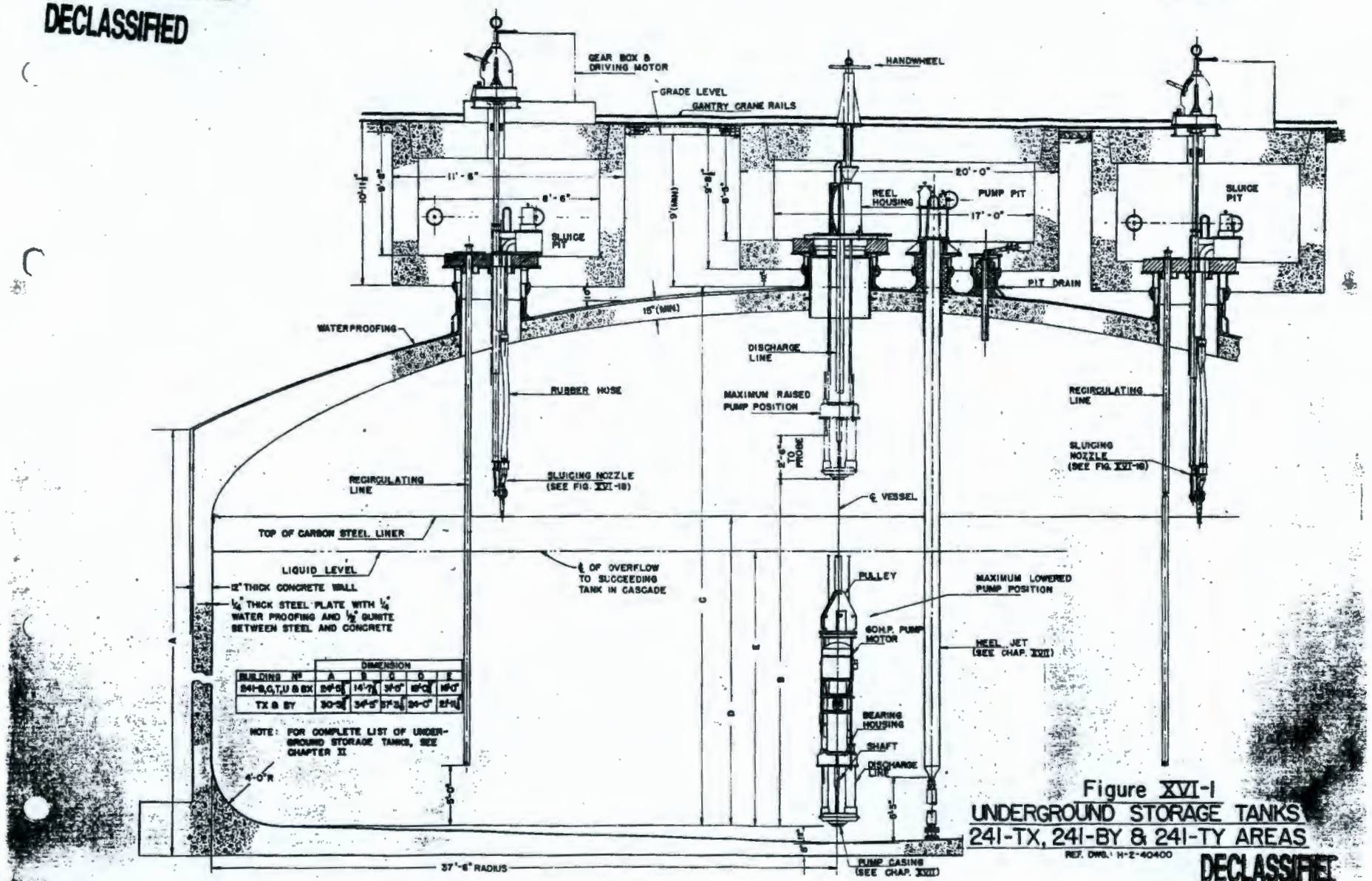

BUILDING Nº	DIMENSION A	B	C	D	E
241-B,C,T,U & BX	24'-6 1/2"	14'-7 1/2"	39'-0"	18'-0"	18'-0"
TX & BY	30'-3"	34'-5"	37'-3 1/2"	24'-0"	21'-9 1/2"

NOTE: FOR COMPLETE LIST OF UNDERGROUND STORAGE TANKS, SEE CHAPTER II

Figure XVI-1
UNDERGROUND STORAGE TANKS
241-TX, 241-BY & 241-TY AREAS

REF. DWG.: H-2-40400

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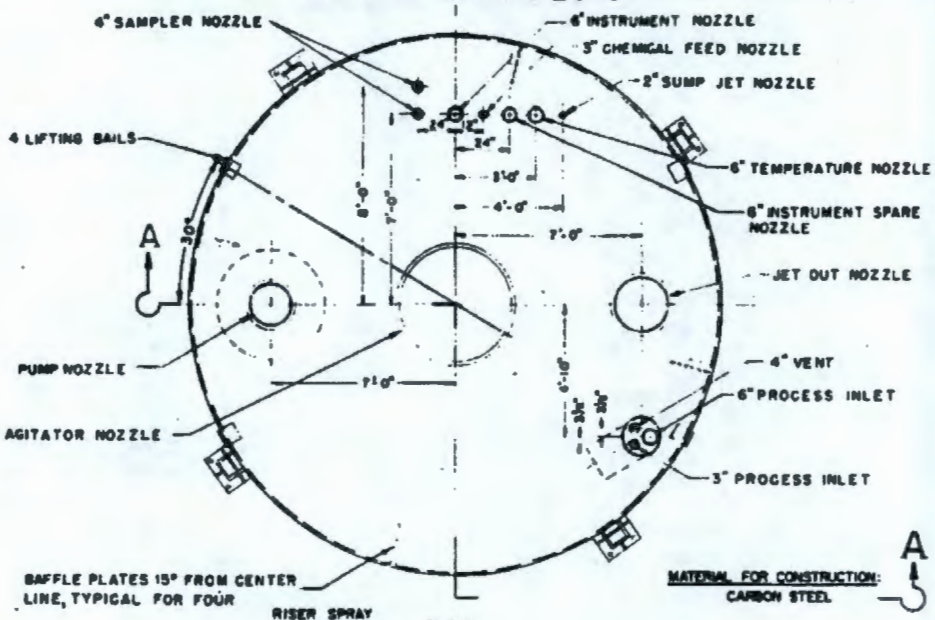
HW-19140

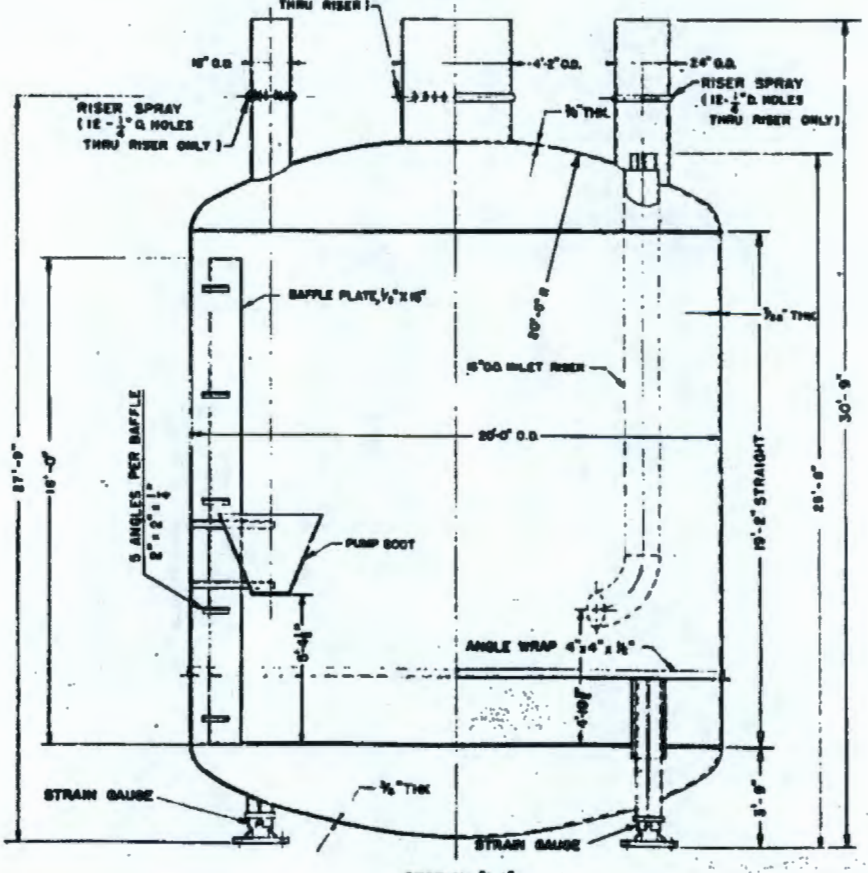
Figure XVI-2

SLURRY ACCUMULATOR, TK-UR-001, 244-UR BLDG.

REF. DWG: BPF No. 2890



PLAN



SECTION "A-A"

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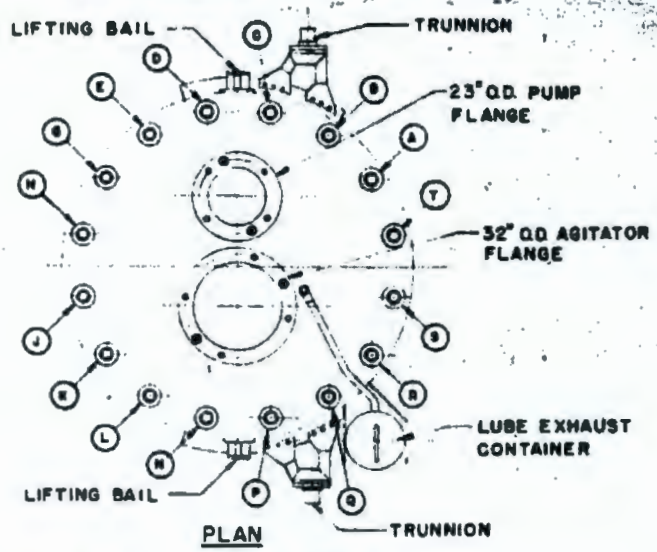
Figure XVI-3

CONCENTRATED FEED RECEIVER, TK-6-7

CLASS I VESSEL, 221-U BLDG

REF. DRAWING: BPF No. 2961

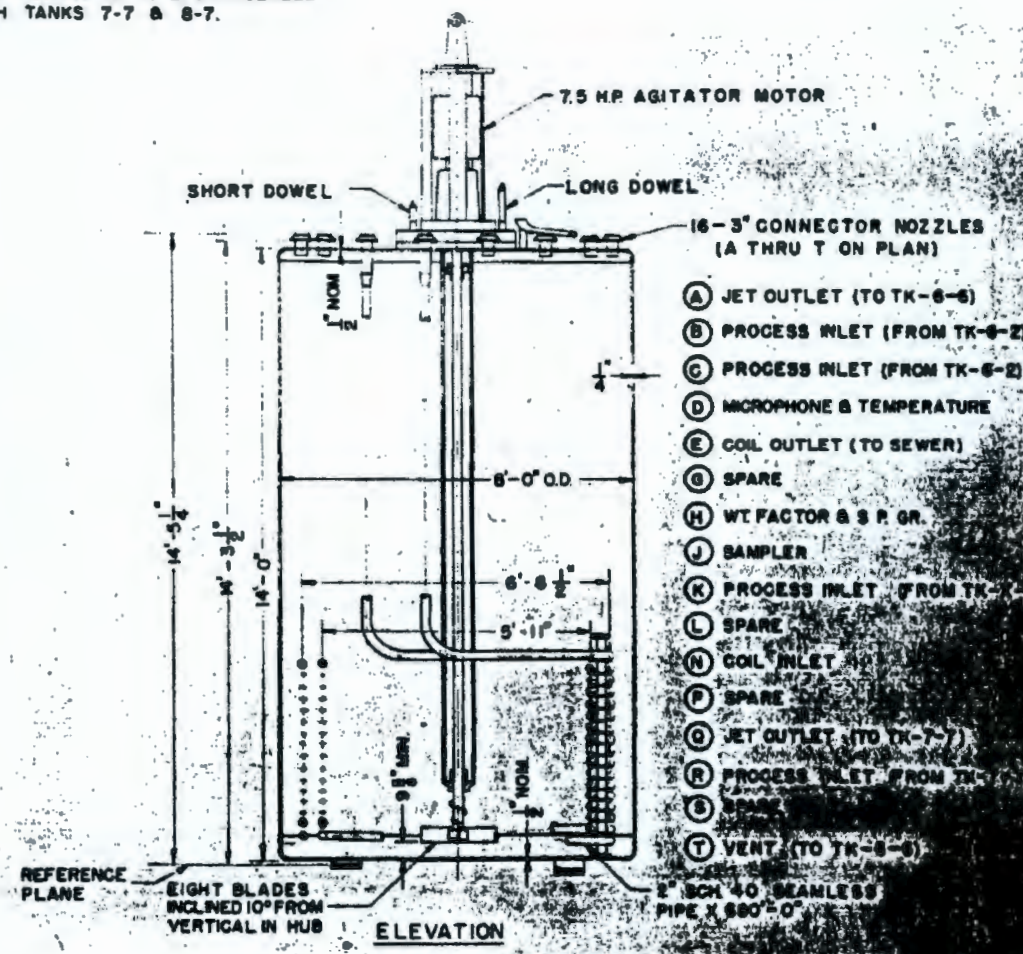


PLAN

(AGITATOR & PUMP REMOVED)

NOTE:

THIS VESSEL IS INTERCHANGEABLE WITH TANKS 7-7 & 8-7.



ELEVATION

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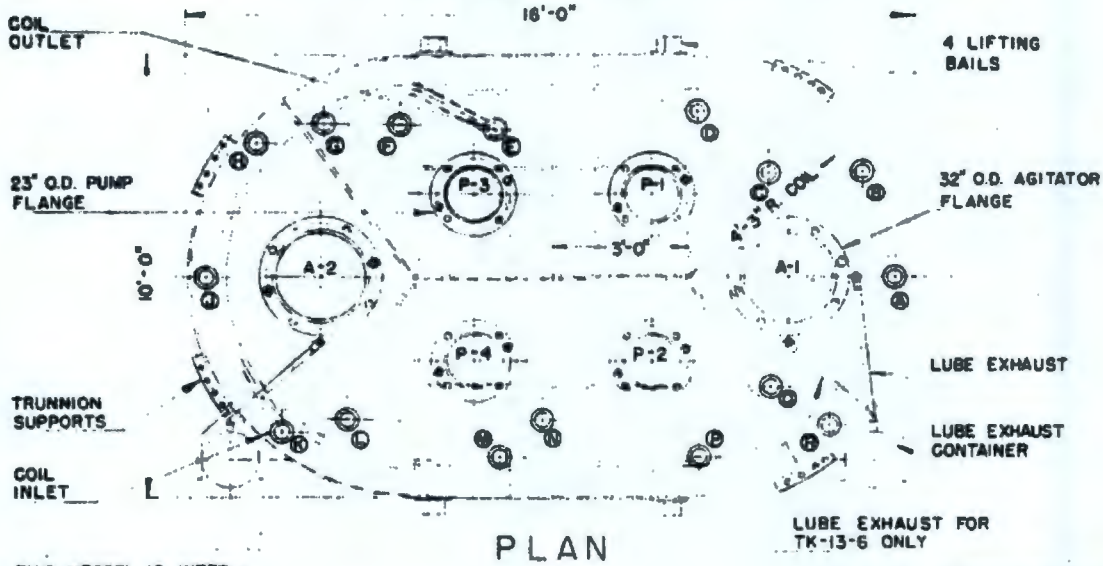
Figure XVI - 4

TYPICAL OVAL TANK, FEED RECEIVER, TK-3-1, CLASS I VESSEL, 221-U BLDG.

REF. DWG.: H-2-40473



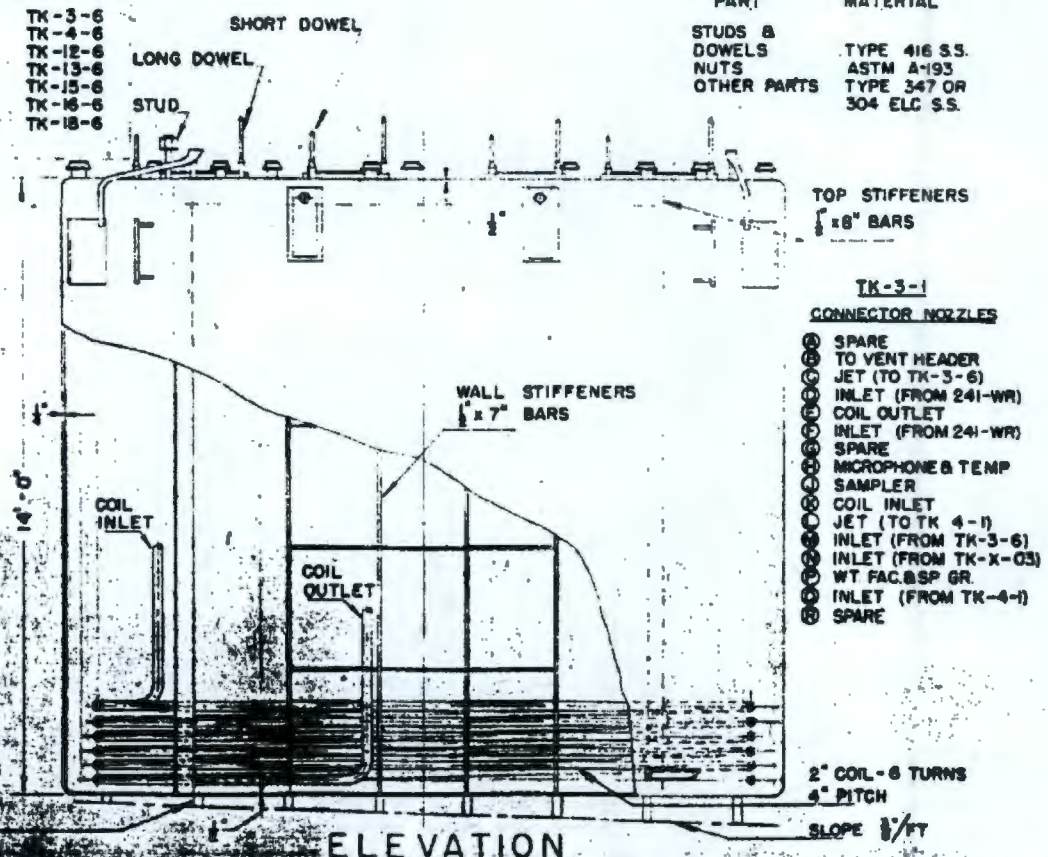
PLAN

THIS VESSEL IS INTERCHANGEABLE WITH TANKS:

TK-4-1	TK-3-6
TK-11-1	TK-4-6
TK-12-1	TK-12-6
TK-13-1	TK-13-6
TK-15-1	TK-15-6
TK-16-1	TK-16-6
TK-20-6	TK-18-6

MATERIALS OF CONSTRUCTION

PART	MATERIAL
STUDS & DOWELS	TYPE 416 S.S.
NUTS	ASTM A-193
OTHER PARTS	TYPE 347 OR 304 ELC S.S.



TK-3-1

CONNECTOR NOZZLES

- SPARE
- TO VENT HEADER
- JET (TO TK-3-6)
- INLET (FROM 241-WR)
- COIL OUTLET
- INLET (FROM 241-WR)
- SPARE
- MICROPHONE & TEMP
- SAMPLER
- COIL INLET
- JET (TO TK 4-1)
- INLET (FROM TK-3-6)
- INLET (FROM TK-X-03)
- WT FAC.&SP GR.
- INLET (FROM TK-4-1)
- SPARE

ELEVATION

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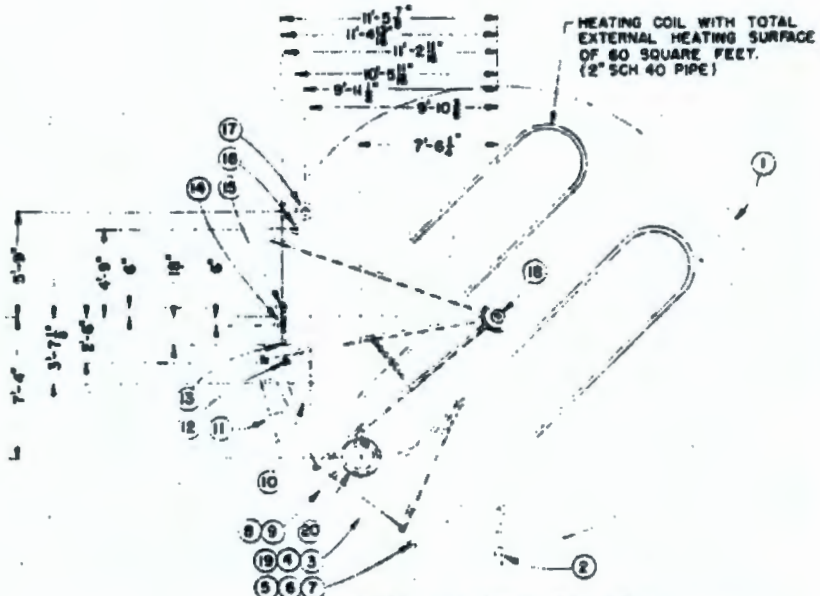
Figure XVI-5

UNH FEED STORAGE TANKS, TK-X-1 & TK-X-2
CLASS II VESSELS, 203-U BLDG.

REF. DWG.: BPF № 3021

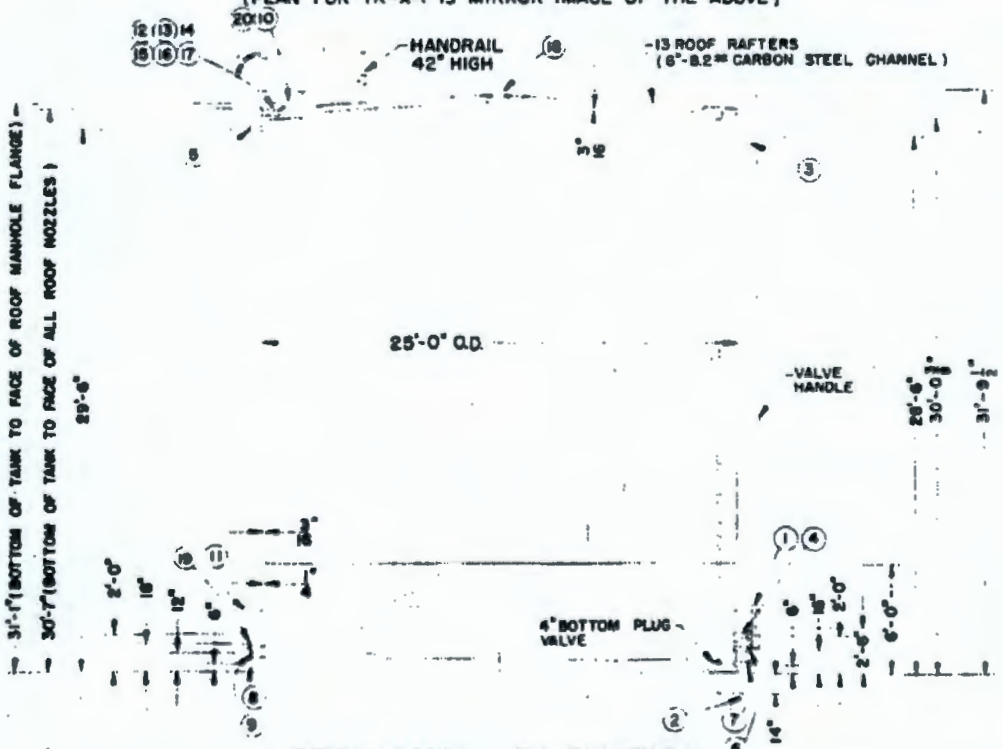
FLANGED CONNECTORS

1. 20" MANWAY
2. 3" BOTTOM OUTLET
3. 6" OVERFLOW
4. 1" TEMP. ELEMENT
5. 1" W.F.R. & S.G.R.
6. 1" W.F.R. & S.G.R.
7. 1" W.F.R. & S.G.R.
8. 2" COIL INLET
9. 2" COIL OUTLET
10. 20" ROOF MANWAY
11. 30" AGITATOR
12. 1" PROCESS INLET (FROM TK-C-3)
13. 2" PROCESS INLET (FROM TK-C-3)
14. 3" PROCESS INLET (FROM TK-C-2)
15. 2" PROCESS INLET (FROM TK-C-4)
16. 2" PROCESS INLET (FROM REDOX)
17. 4" PROCESS INLET (FROM TBP)
18. 3" VENT
19. 1½" SPARE FOR TEMP. ELEMENT
20. 14" ROOF FLANGE



PLAN FOR TK-X-2

(PLAN FOR TK-X-1 IS MIRROR IMAGE OF THE ABOVE)



SECTIONAL ELEVATION

(FOR TRUE ORIENTATION SEE PLAN)

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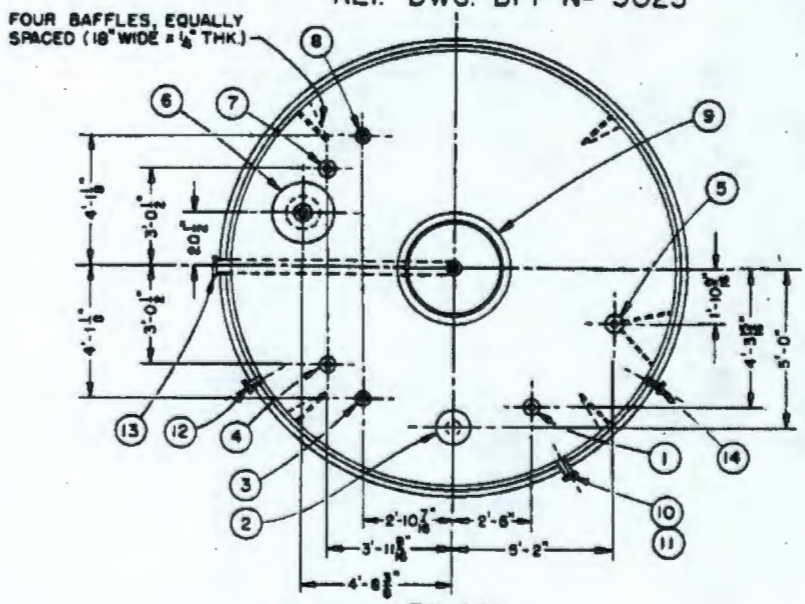
Figure XVI-6
ORGANIC TREATMENT TANK, TK-386
CLASS II VESSEL, 276-U BLDG.

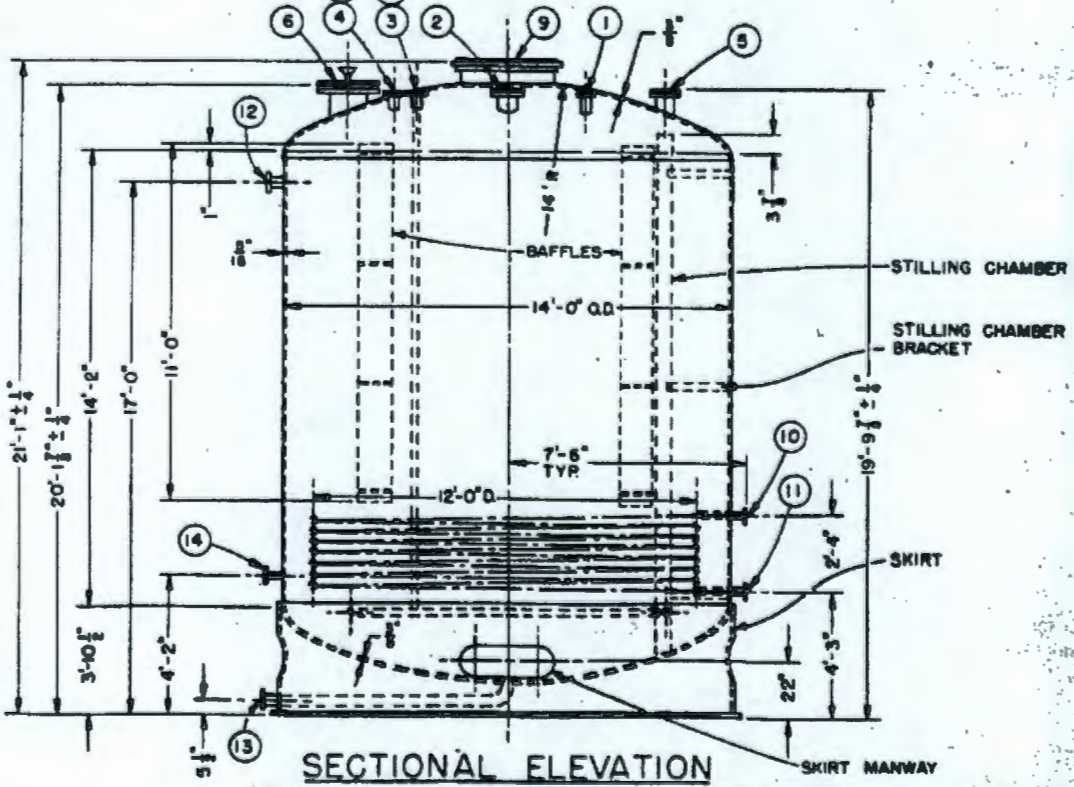
REF. DWG. BPF Nº 3023



PLAN

FLANGE CONNECTORS

1. 2" PROCESS INLET
2. 6" SPARE
3. 2" PROCESS INLET
4. 2" PROCESS INLET
5. 3" WEIGHT FACTOR INDICATOR
6. 16" MANWAY
7. 2" PROCESS INLET
8. 1" SPARGER INLET
9. 36" AGITATOR NOZZLE
10. 2" COIL INLET
11. 2" COIL OUTLET
12. 3" VENT & OVERFLOW
13. 3" PROCESS OUTLET (TO DRAIN & SP-385)
14. 1" TEMP. INDICATOR NOZZLE



SECTIONAL ELEVATION
(FOR TRUE ORIENTATION SEE PLAN VIEW)

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Figure XVI-7

PRODUCT CONCENTRATORS, E-B-1 & E-D-1
CLASS II VESSELS, 224-U BLDG.

REF. DWG: BPF 3103

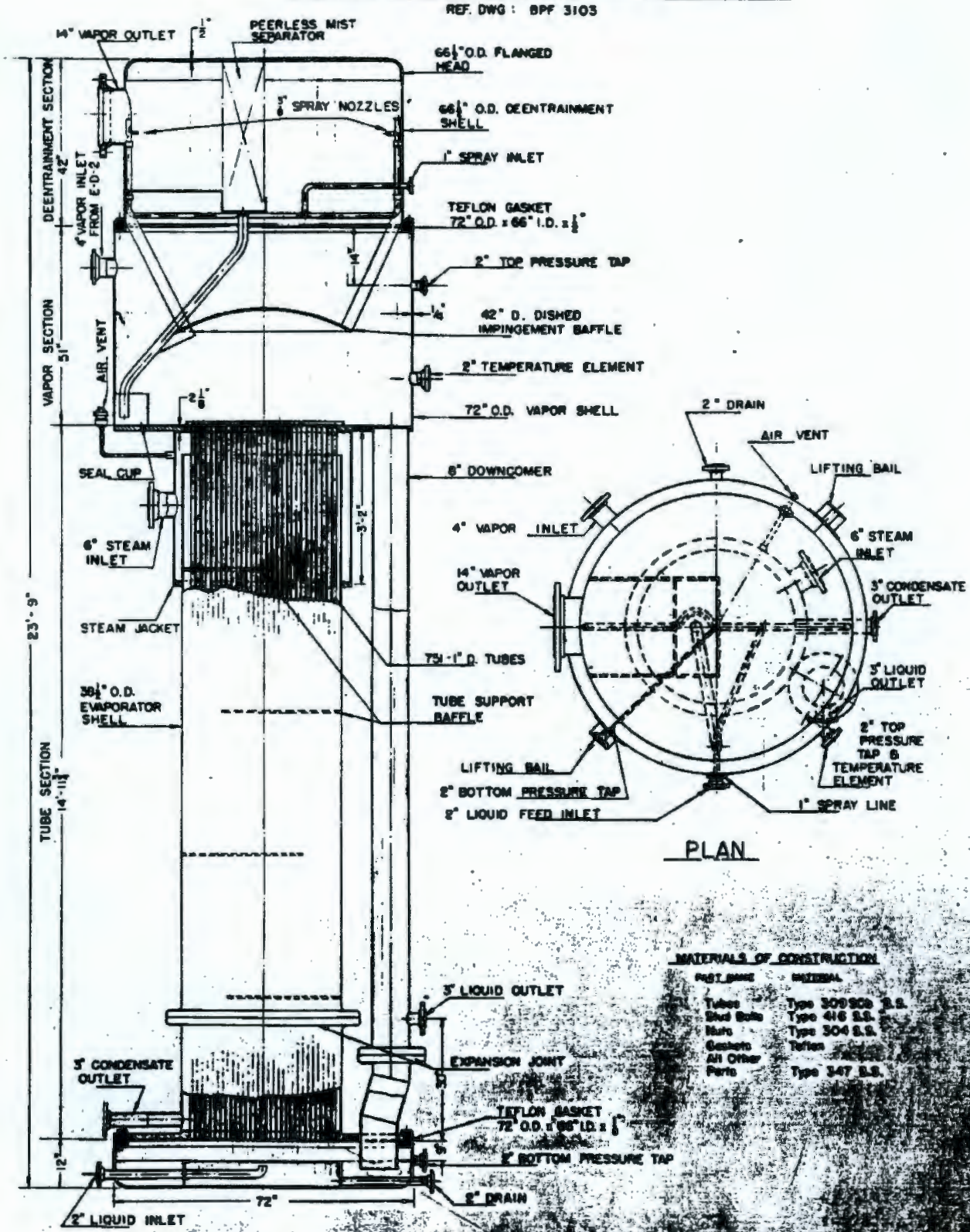

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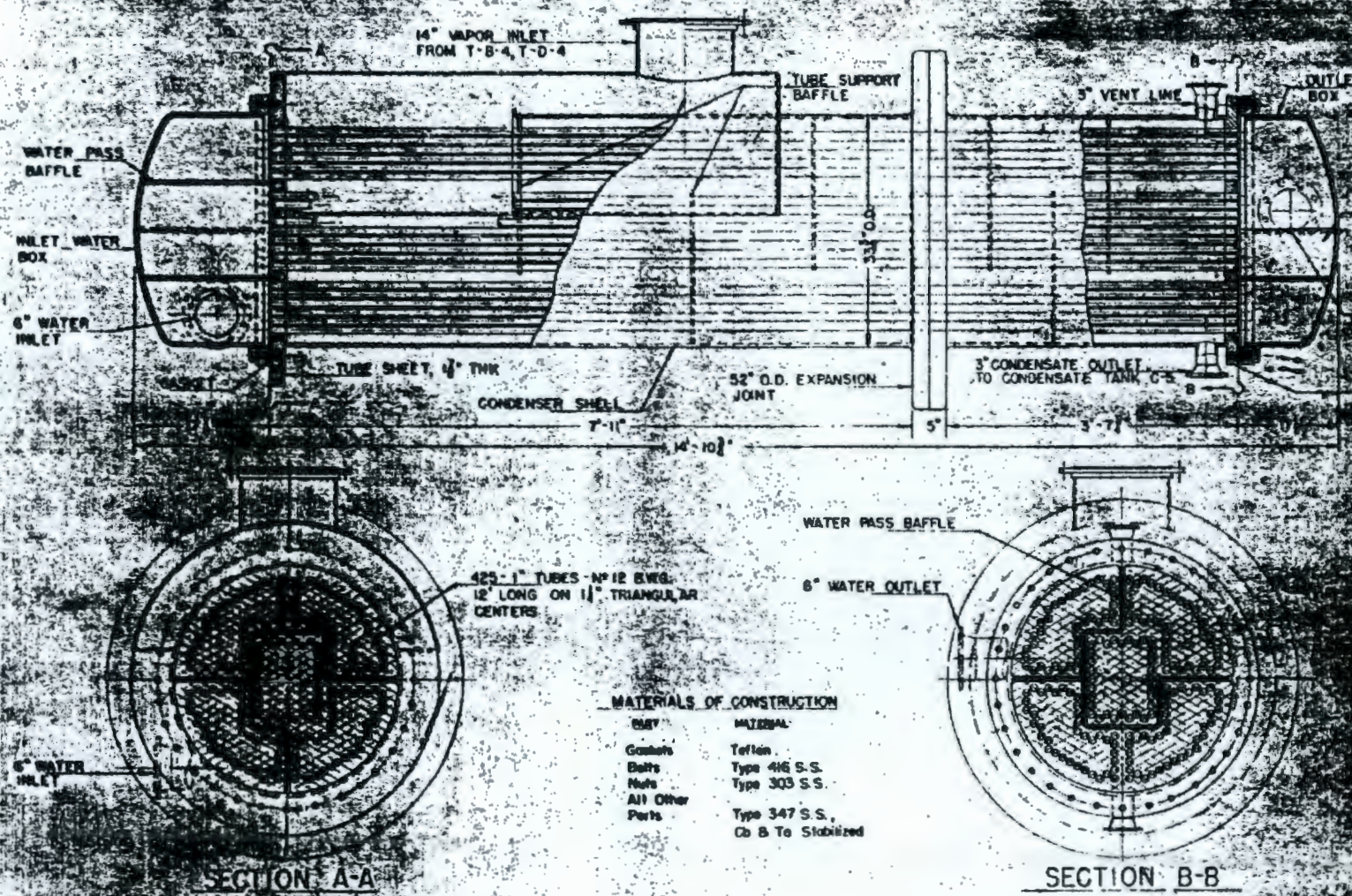
Figure XVI - 8

NITRIC ACID FRACTIONATOR CONDENSERS, E-B-3, 8, E-D-3
CLASS II VESSELS, 224-U-BLDG.

REF. DWG.: H-2-40795



MATERIALS OF CONSTRUCTION

PART	MATERIAL
Gaskets	Teflon
Bolts	Type 416 S.S.
Nuts	Type 303 S.S.
All Other Parts	Type 347 S.S., Cb & Ta Stabilized

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Figure XVI-9
GAS COOLER E-A-2
CLASS II VESSEL, 224-U BLDG

REF. DWG. H-2-50008

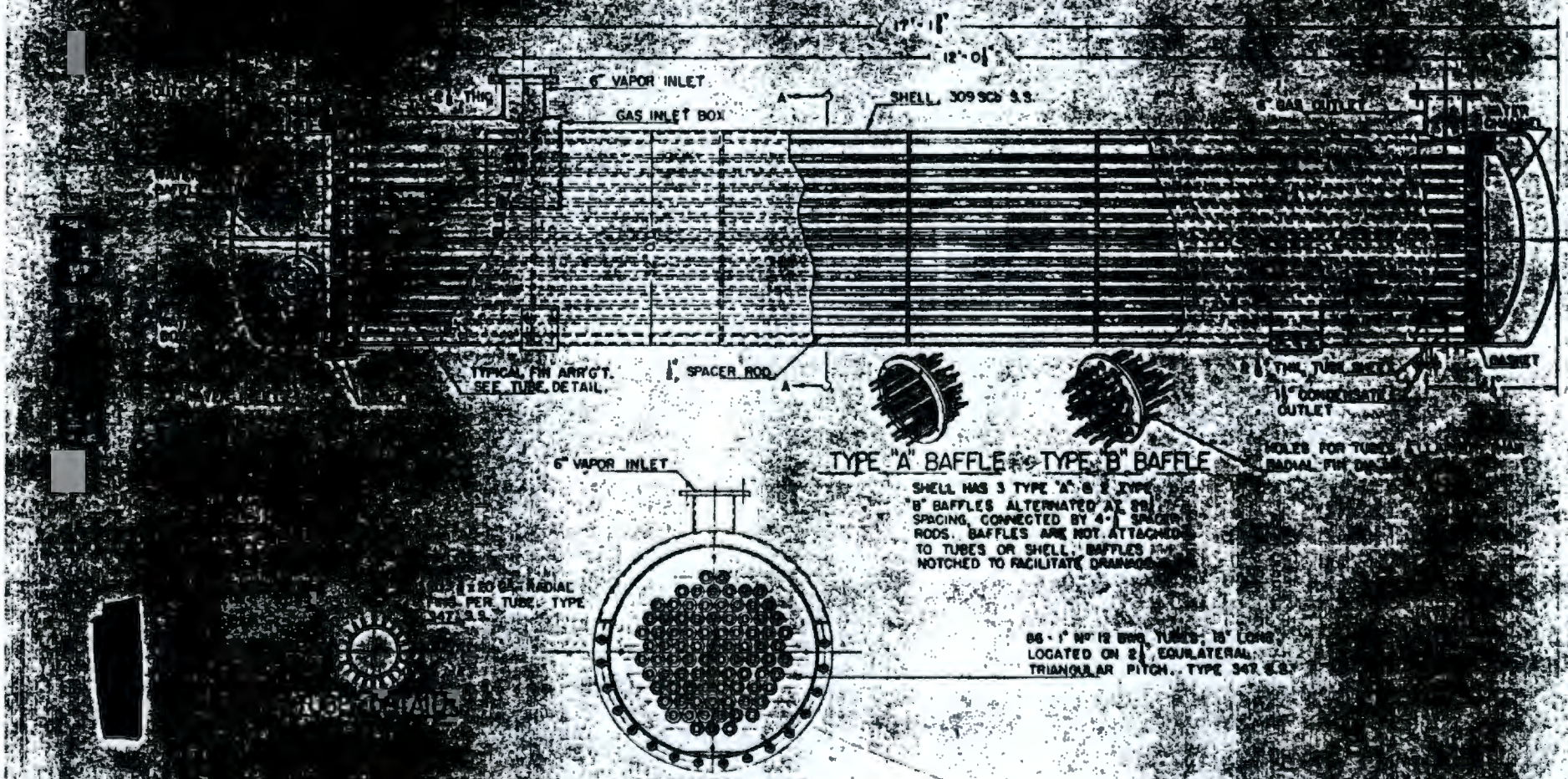

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Figure XVI-10

NITRIC ACID FRACTIONATORS, T-B-4 & T-D-4 CLASS II VESSELS, 224-U BLDG.

REF. DWG.: BPY 3406

MATERIAL OF CONSTRUCTION
TYPE 347 S.S.

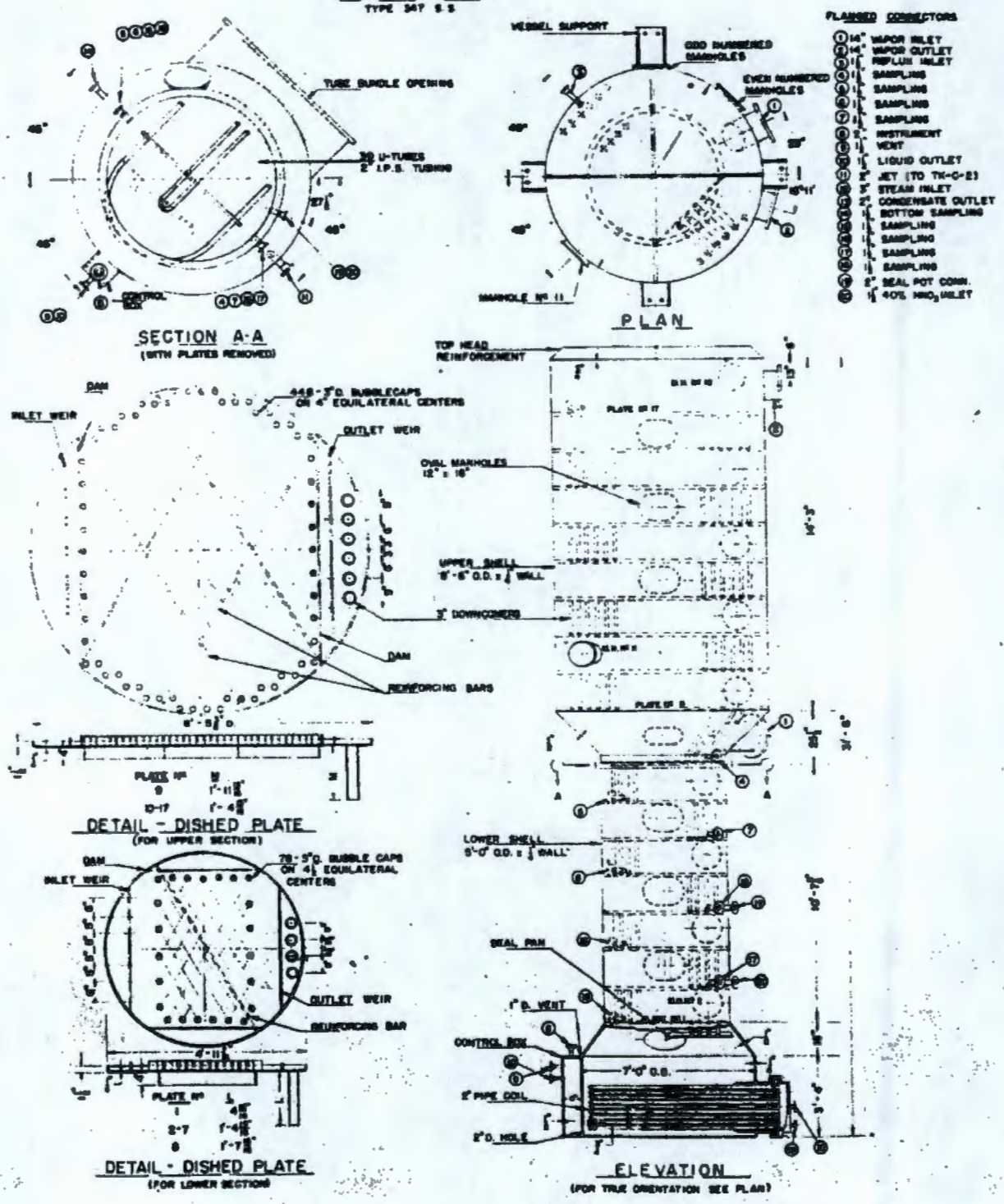

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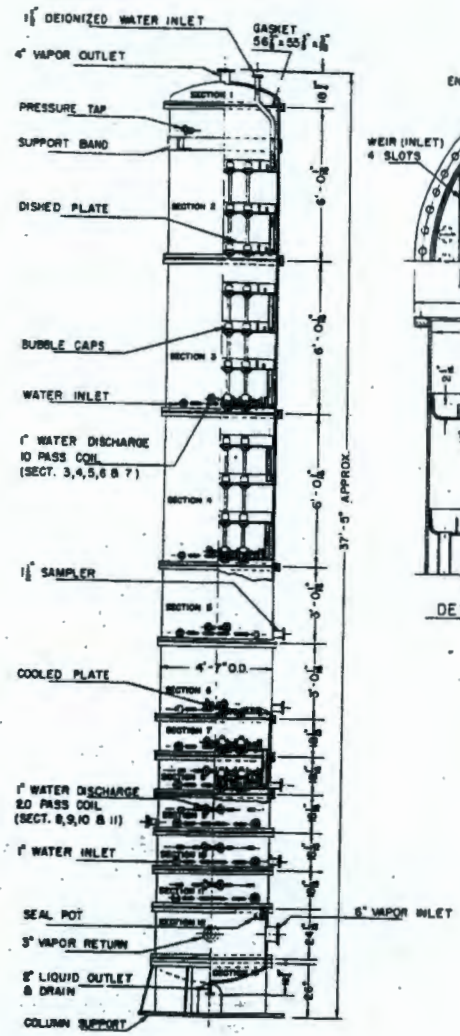
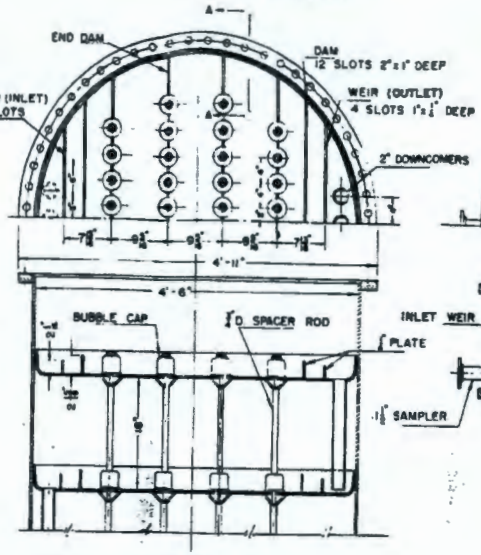
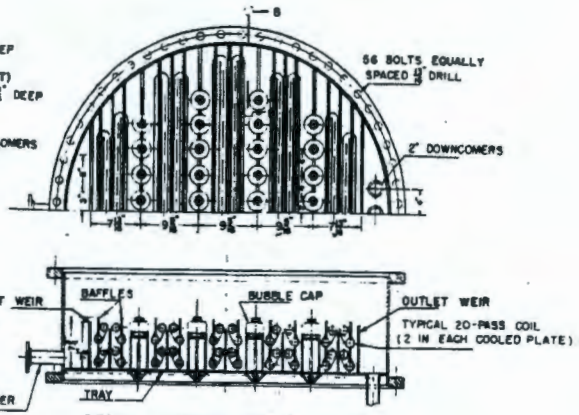
Figure XVI-11
NITRIC ACID ABSORBER, T-A-1
CLASS II VESSEL, 224-U BLDG.

REF DWG: H-2-50006
H-2-50007
H-2-50008





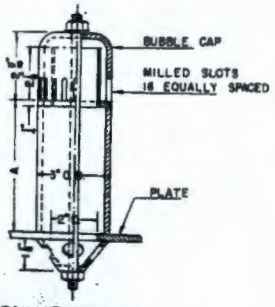
DETAIL - TYPICAL DISHED PLATE



DETAIL - TYPICAL COOLED PLATE

MATERIALS OF CONSTRUCTION

PART	MATERIAL
Column Shell	Type 347 S.S.
Plate	Type 347 S.S.
Coils	Type 347 S.S.
Bubble Caps	Type 304 S.S.
Spacer Rods	Type 303 S.S.
Column Support	Type 410 S.S.
Gaskets	Asbestos
Nuts (External)	Type 302 S.S.
(Internal)	Type 303 S.S.
Bolts (External)	Type 416 S.S.
(Internal)	Type 304 S.S.



DETAIL - BUBBLECAP

COLUMN SECTION	DIMENSION "A"	TYPE PLATE
8, 9, 10 & 11	3.312" ± .005"	Cooled
3, 4, 5, 6 & 7	2.125" ± .005"	Cooled
2, 3, 4, 5 & 6	0.250" ± .005"	Dished

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Figure XVI-17
FEED SAMPLER TANK AGITATOR
241-WR BLDG.

REF. DWG.: BPF No. 3272

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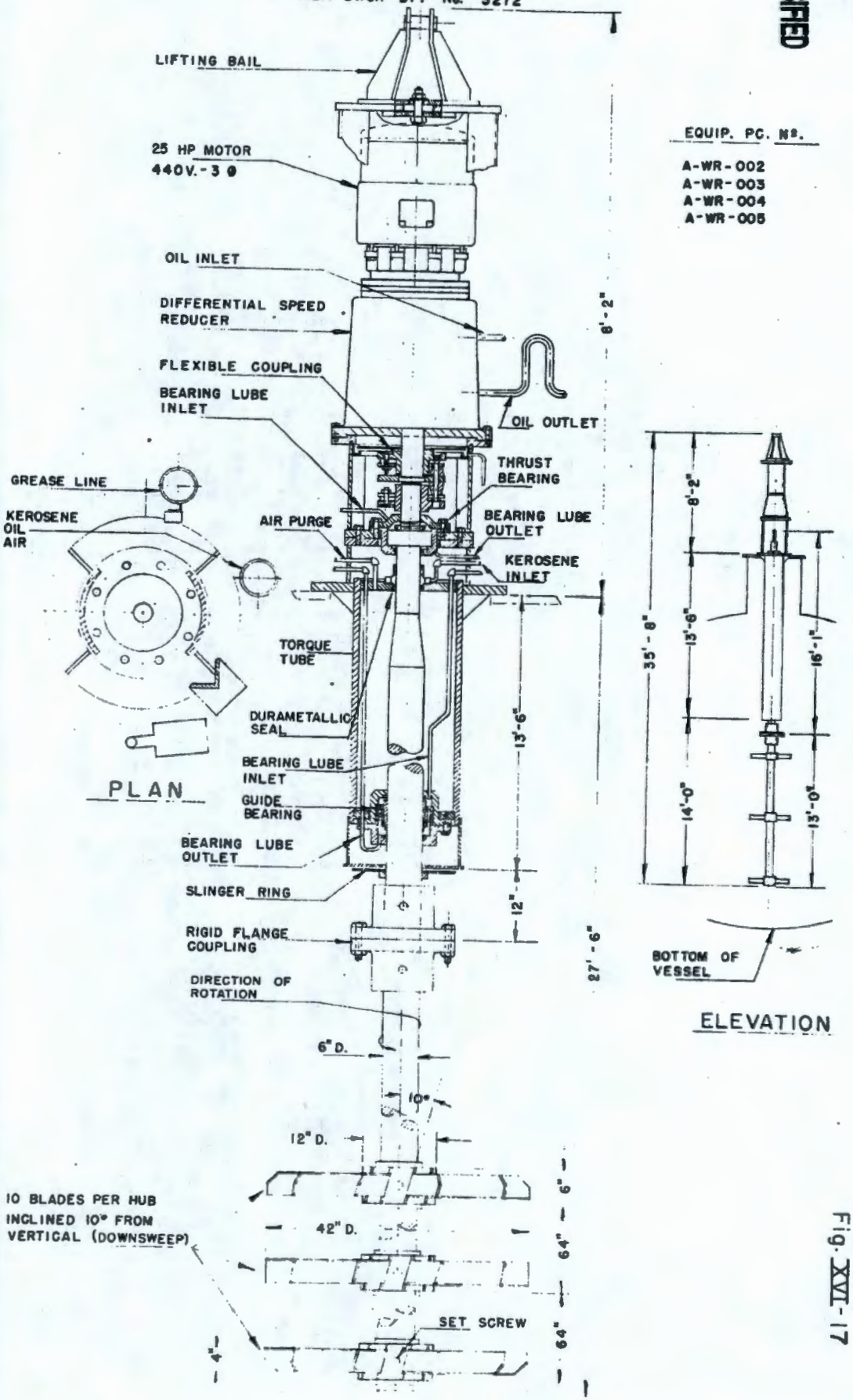

EQUIP. PC. Nº.

A-WR-002
A-WR-003
A-WR-004
A-WR-005

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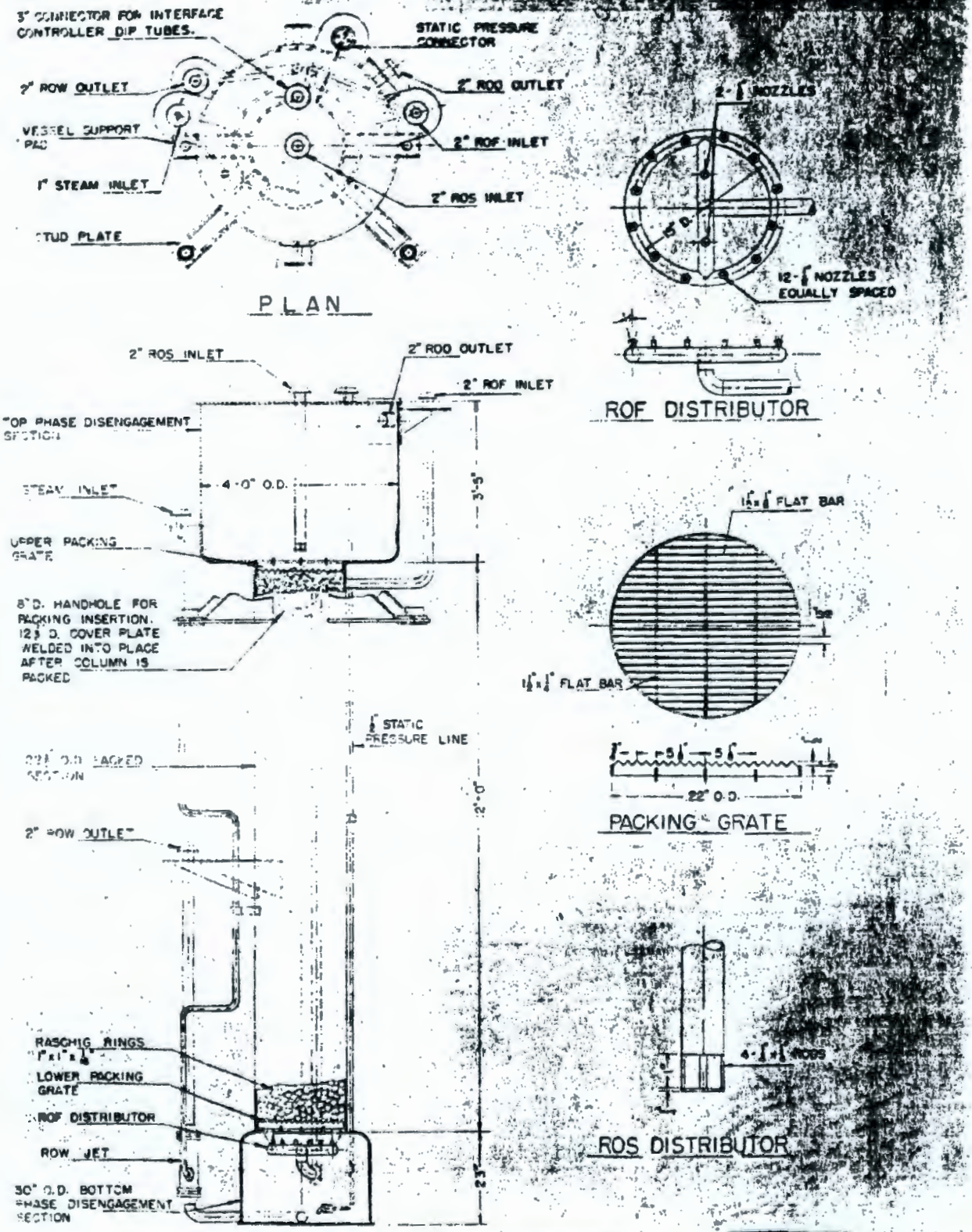
Figure XVI-14

RO COLUMNS, ET-18-2 & ET-20-2
CLASS I VESSELS, 221-U BLDG.

REF. DWG.: H-2-40771 [redacted]



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[redacted]

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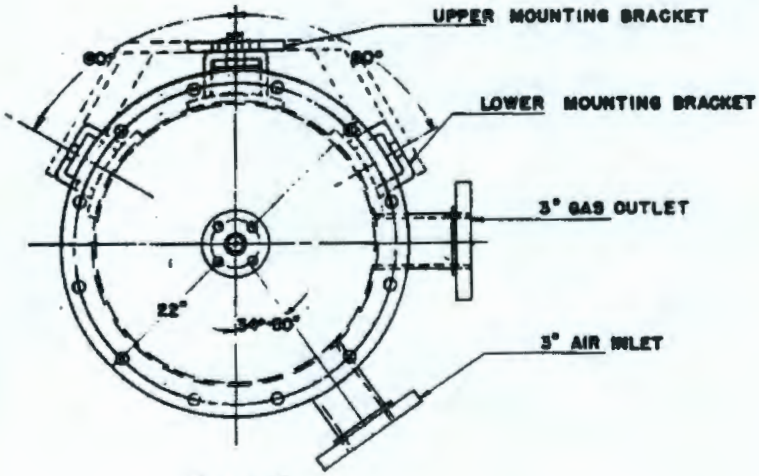
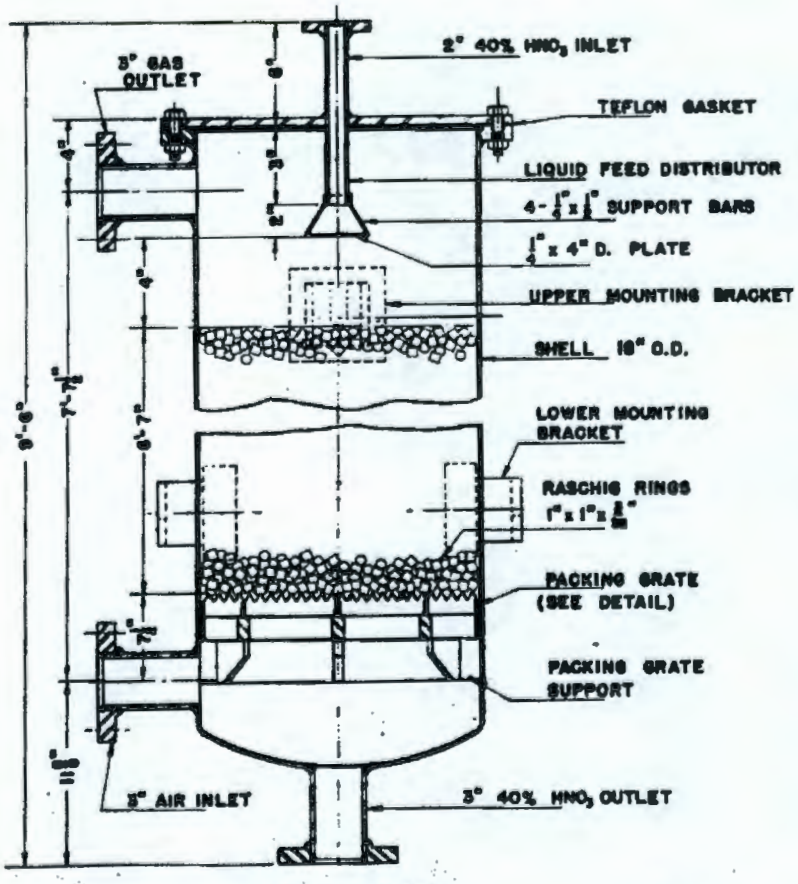
Figure XVI-15
HNO_3 BLEACHER, T-C-6
CLASS II VESSEL, 224-U BLDG.

REF. DWG.: H-2-50010

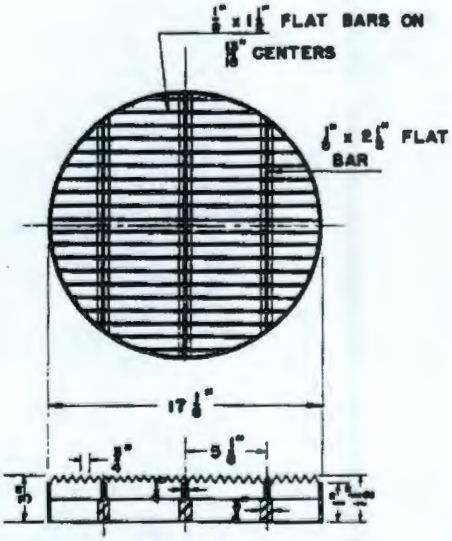


PLAN



ELEVATION

FOR ORIENTATION SEE PLAN



DETAIL - PACKING GRATE

MATERIALS OF CONSTRUCTION

PART	MATERIAL
Gasket	Teflon
Raschig Rings	Type 304 S.S.
Tank Brackets	Type 304 S.S.
Wall Brackets	Steel, ASTM A-7
Nuts	Type 302 or 303 S.S.
Bolts	Type 416 S.S.
Other Parts	Type 347 S.S.

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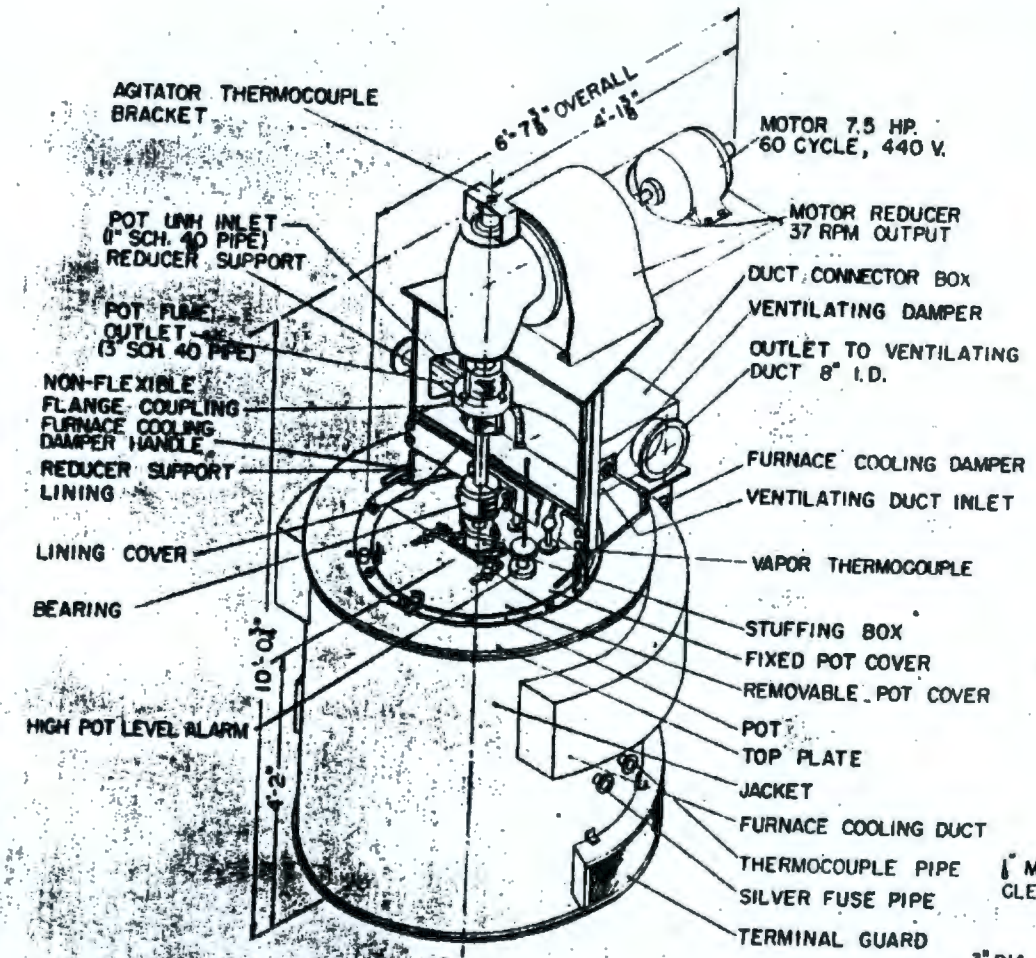
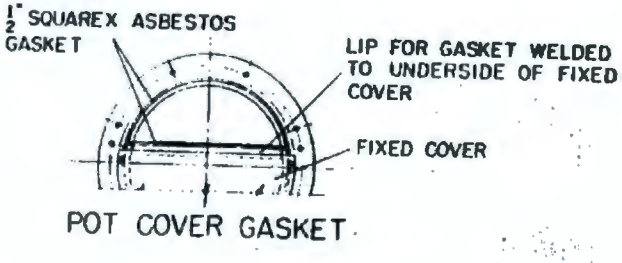
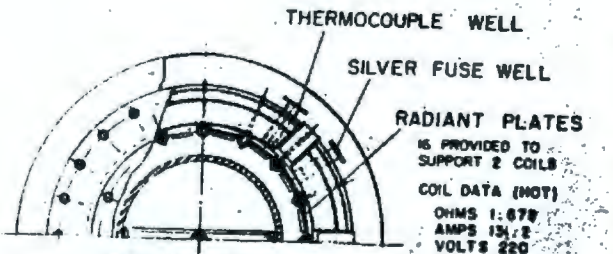
Figure XVI-16
CALCINING POTS, P-E 1 TO P E-18
REFERENCE DWG: BPF 2874

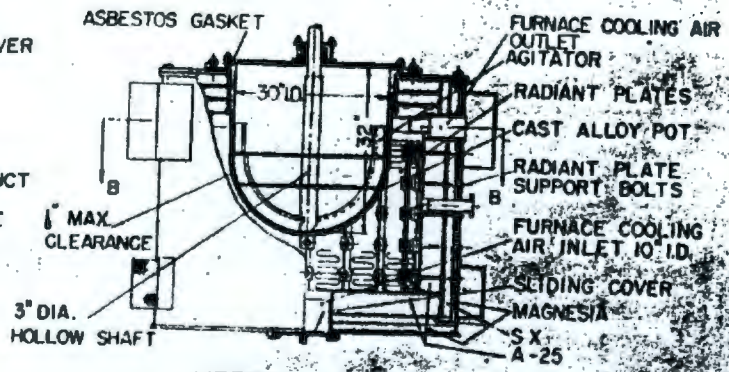




POT COVER GASKET



SECTION B-B



VERTICAL SECTION

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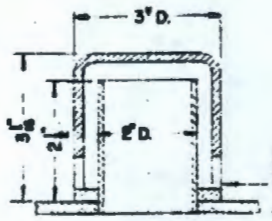
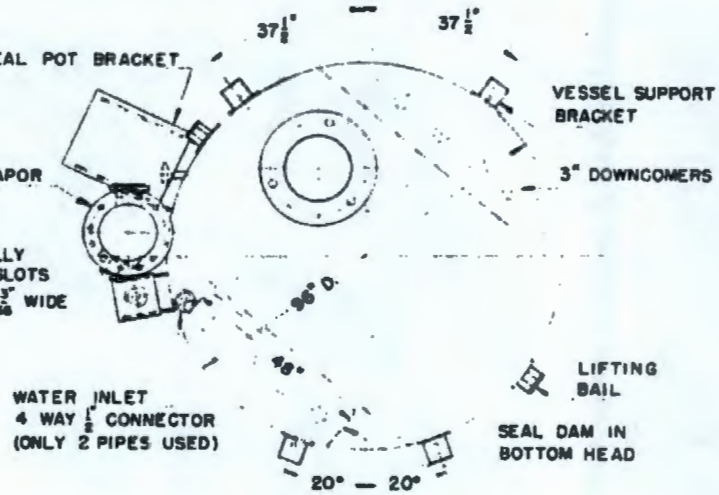
Figure XVI-12
FEED CONCENTRATOR STRIPPING COLUMNS, T-6-4, T-7-4, T-8-4, CLASS I VESSELS, 221-U BLDG.

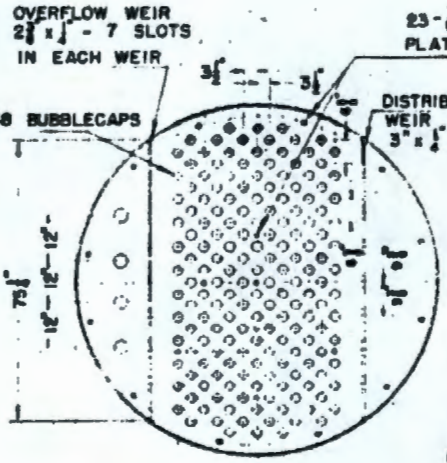
REF. DWG.: 17850 & 17851 (BPF 3103)

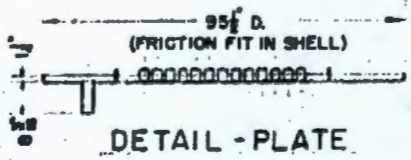


DETAIL - BUBBLE CAP

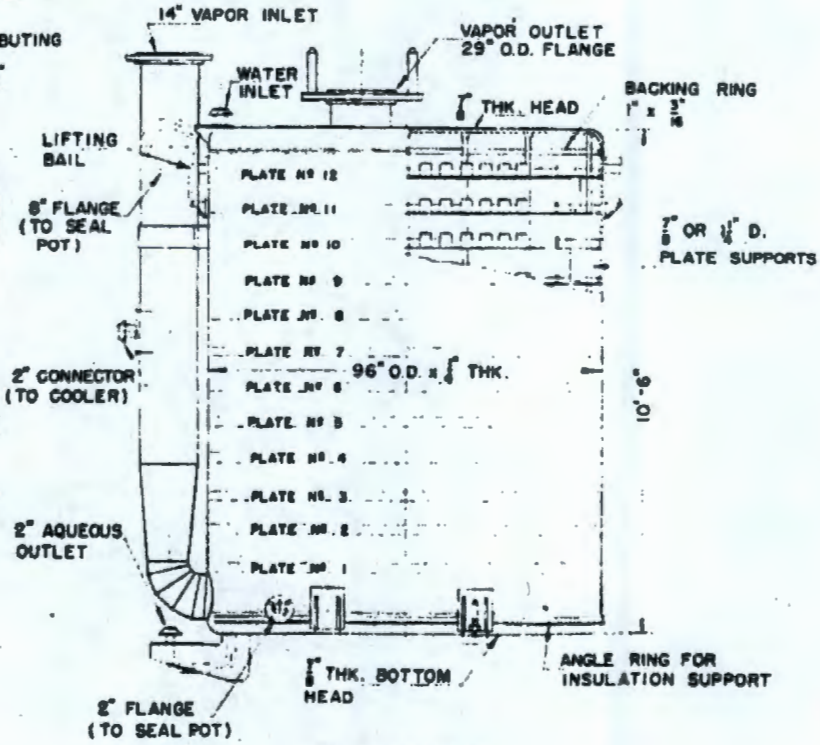


PLAN





DETAIL - PLATE



ELEVATION

MATERIALS OF CONSTRUCTION

PART	MATERIAL
Vapor Outlet Studs	Type 416 S.S.
Vapor Outlet Stud Nuts, Shell Support Studs & Nuts, Vessel Locating Dowels	Steel, SAE 1020
Seal Pot Support, Shell Support Base, Lifting Bail Gussets & Plates	Steel, ASTM A-7
Other Parts	Type 347 S.S.

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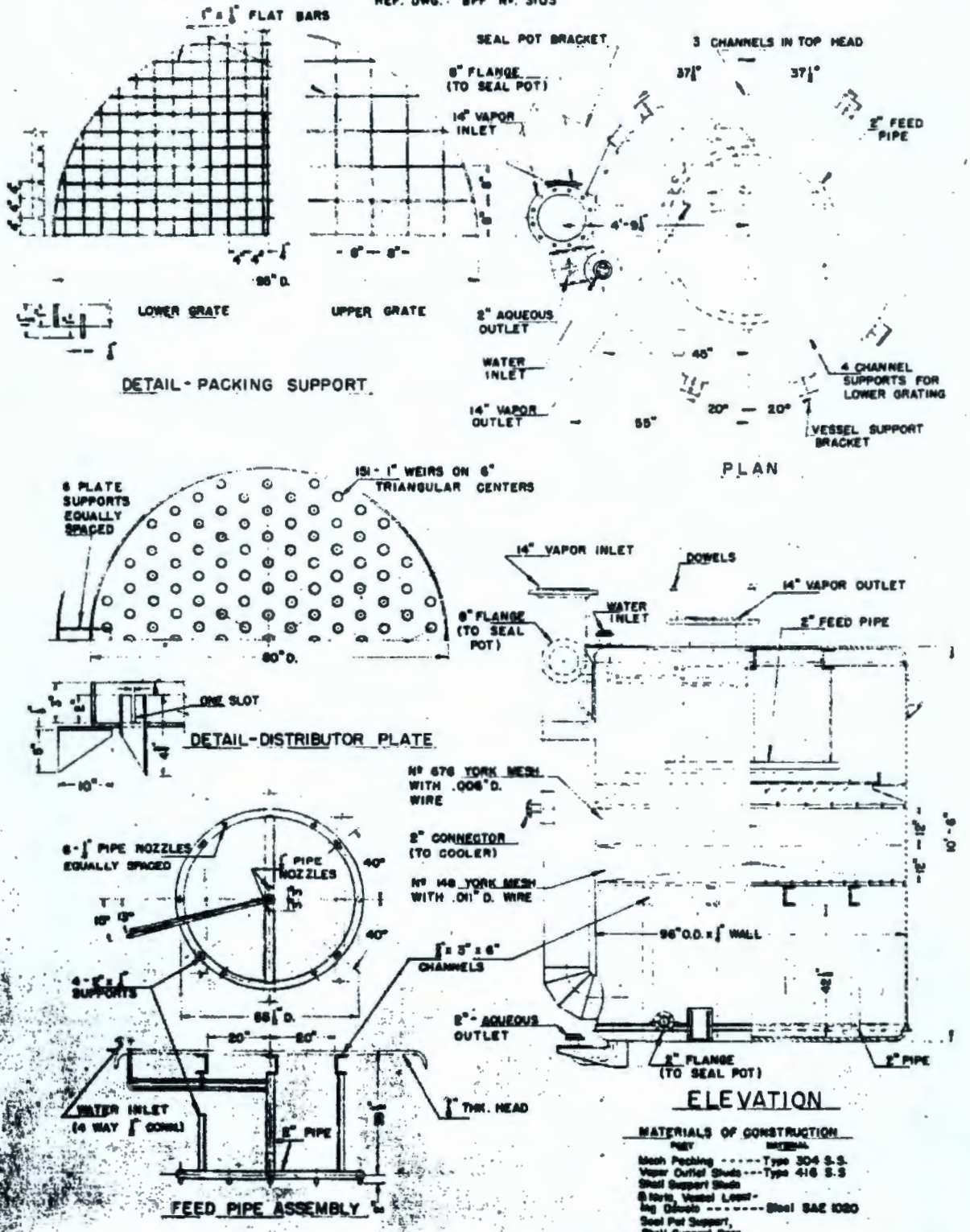
Figure XVI-13

WASTE CONCENTRATOR DEENTRAINMENT COLUMNS T-9-4, T-10-4, CLASS I VESSELS, 221-U BLDG.

REF. DWG.: BPF Nº 3103



MATERIALS OF CONSTRUCTION

PART	MATERIAL
Mesh Packing	Type 304 S.S.
Vapor Outlet Studs	Type 416 S.S.
Shell Support Studs	
Bolts, Vessel Lowering Studs	Steel SAE 1020
Seal Pot Support, Shell Support Base, Lifting Bail, Gusets & Plates	Steel ASTM A-7
Other Parts	Type 347 S.S.

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Figure XVI - 18

SLUICING SYSTEM FOR 75FT. D. UNDERGROUND STORAGE TANKS

PHASE I, 241-U AREA

REF. DWG.: H-2-40012, H-2-40067-68-69-70

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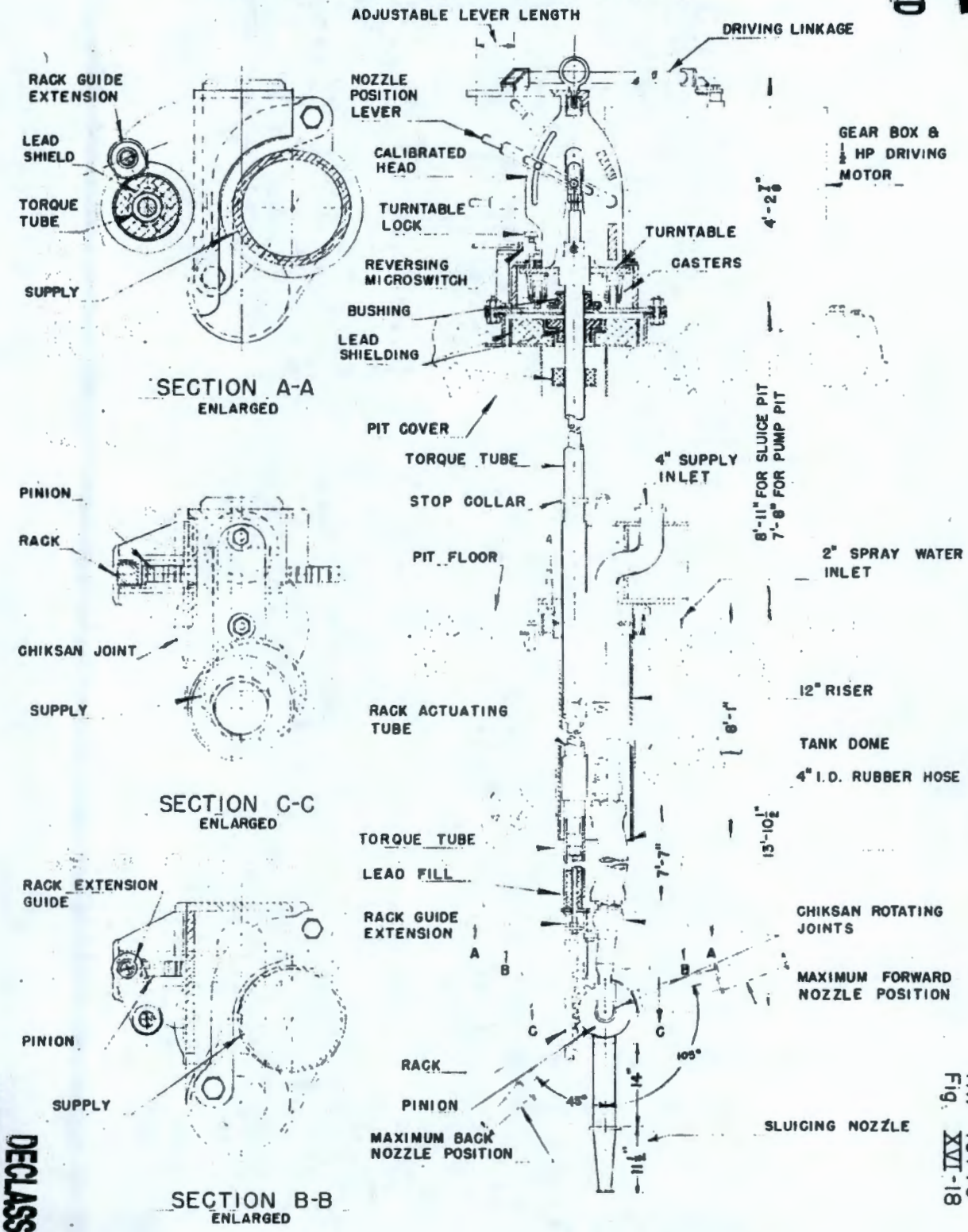

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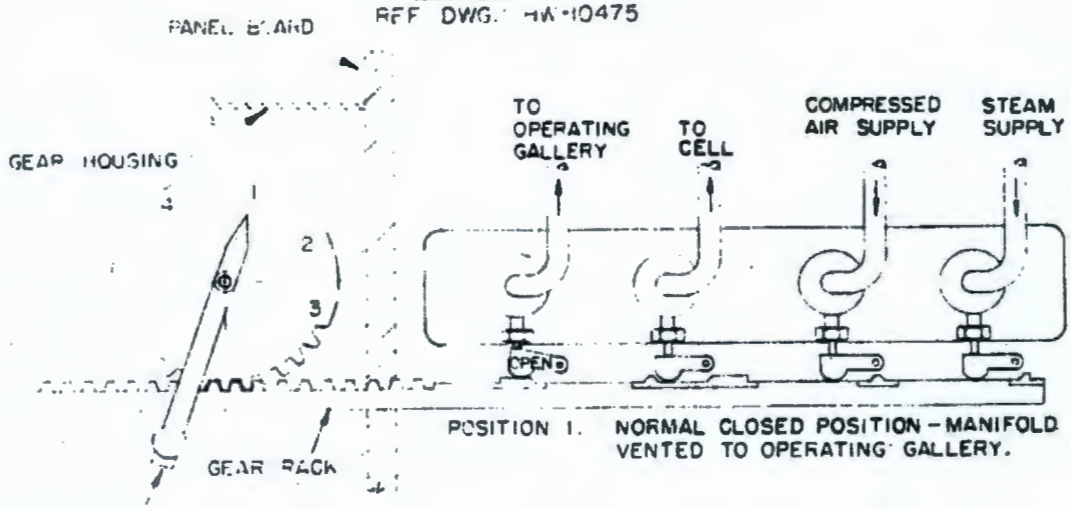
Figure XVI-19

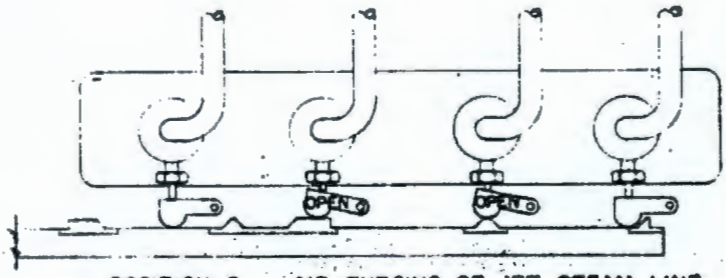
OPERATING DIAGRAM OF GANG VALVE

221-U BLDG

REF DWG. HW-10475

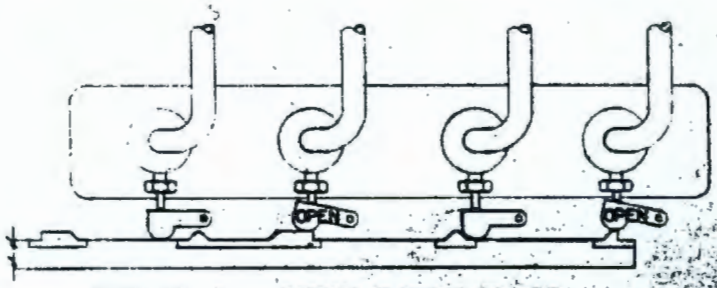


POSITION 1. NORMAL CLOSED POSITION – MANIFOLD VENTED TO OPERATING GALLERY.

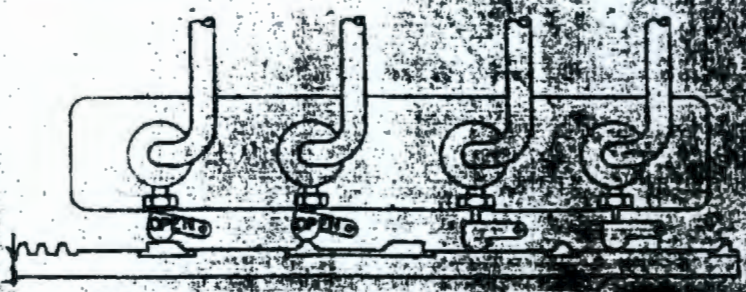


POSITION 2. AIR PURGING OF JET STEAM LINE

NOTE:
ALL VALVES ARE CLOSED EXCEPT AS NOTED



POSITION 3. STEAM FLOWING TO JET



POSITION 4. JET VENTED TO OPERATING GALLERY.

[redacted]

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Figure XVI-20

PROCESS SOLUTION SAMPLER

221-U BLDG.

REF.: HW-10475

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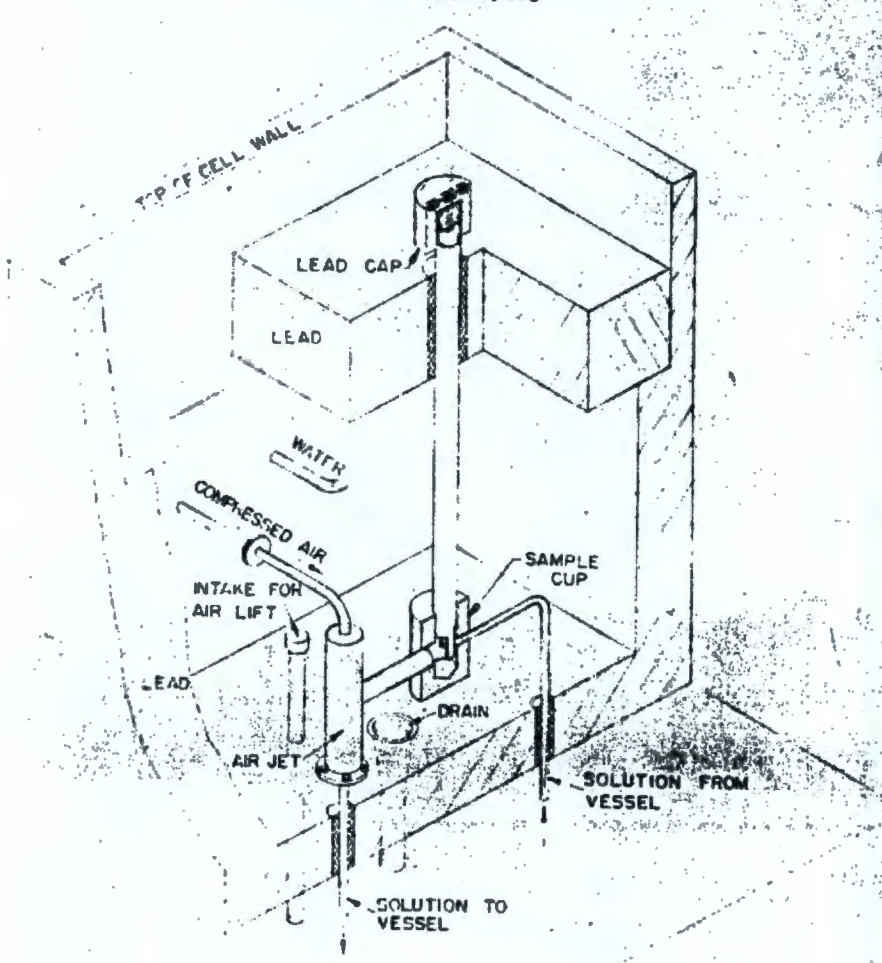
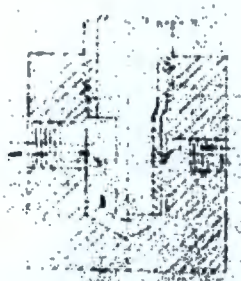
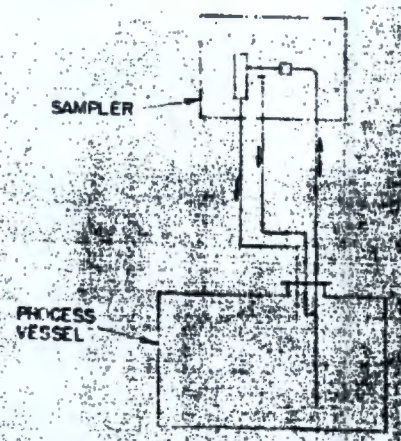




SECTION - SAMPLE CUP



FLOW DIAGRAM

NOTE: NOT TO SCALE

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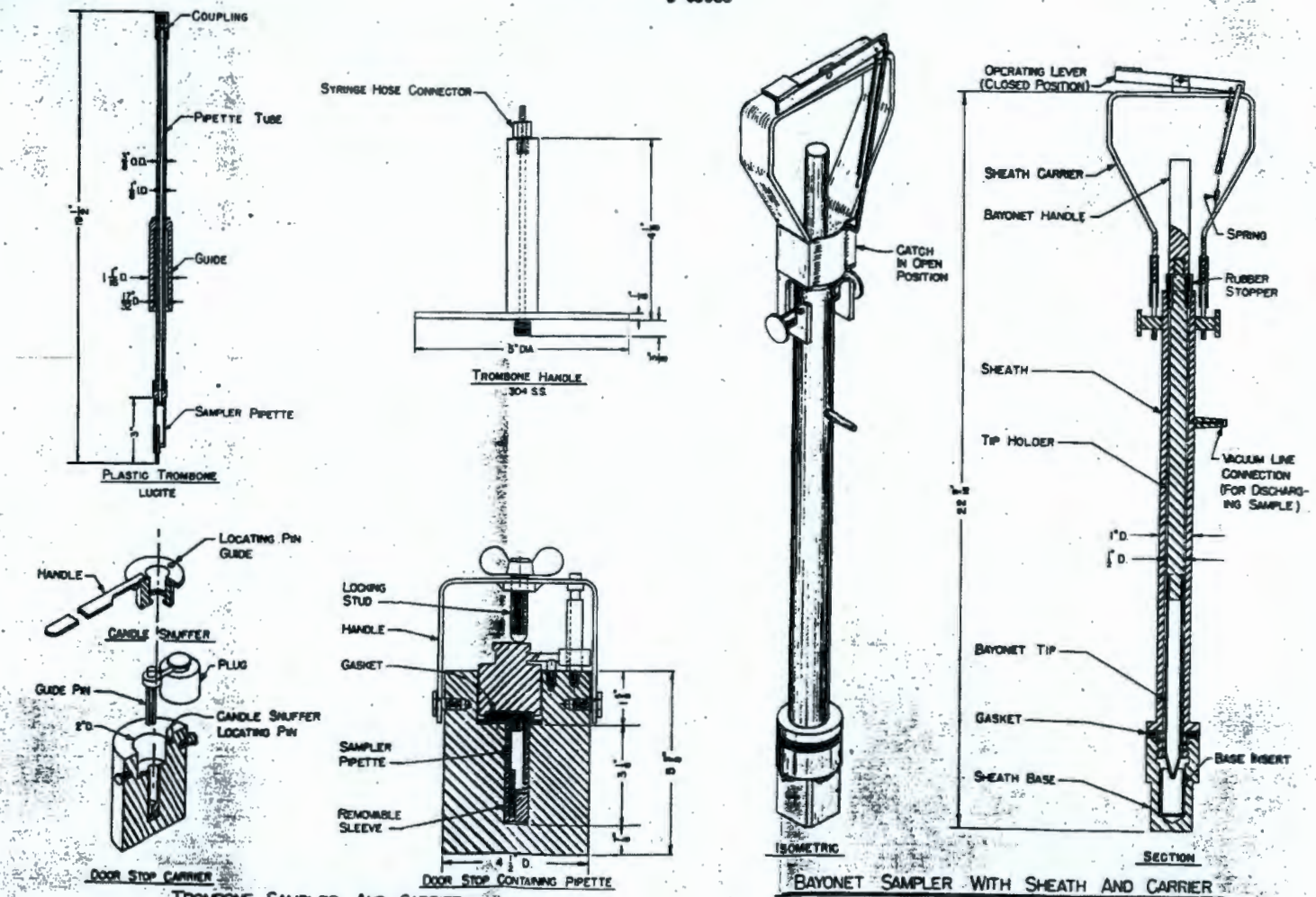
Figure XVI-21
SAMPLING DEVICES
221-U BLDG.

REF. DWG.: D-65232
D-63958



TROMBONE SAMPLER AND CARRIER

BAYONET SAMPLER WITH SHEATH AND CARRIER

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PART III: PLANT AND EQUIPMENT, continued

CHAPTER XVII. MATERIAL TRANSFER AND HANDLING

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2. Basis of Selection and Design 1703
3. Description 1703

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2. Basis of Selection 1706
3. Description 1706
4. Performance 1707

C. "HOT" LIQUID AND SLURRY PUMPS 1707

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5. Description of Production Units 1709

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2. Heel Jets 1716
3. Sludge Jets 1717
4. Vacuum Jets 1717
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3. Hammer Mill 1720
4. Packaging System 1721
5. Vacuum Cleaning System 1722

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CHAPTER XVII. MATERIAL TRANSFER AND HANDLING

A. "HOT" SLUDGE PUMPS(1)

1. Introduction

Sludge pumps are used to remove supernate and a homogenized slurry of sludge and supernate from the underground waste storage tanks in the tank farms for further processing in the Uranium Recovery Plant.

2. Basis of Selection and Design

The sludge pump was designed to meet the following requirements and limitations:

(a) Head-capacity characteristics: A capacity of 500 gal./min. is required at a head of 126 ft. of pumped fluid.

(b) Internal pump clearances: The sludge pump handles a slurry which contains 10 to 15% by volume of 200-mesh solids. Critical clearances which might be affected by erosion or abrasion and thus affect the pump capacity are undesirable.

(c) Leakage: No leakage of the radioactive slurry is permissible, except contained leakage which is completely drained back to the tank.

(d) Mobility: Because of the poor suction lift characteristics of pumps which fulfill the requirements listed above, vertical movement of the pump is required to compensate for the rise and fall of liquid level in the underground tanks.

(e) Length of service: It is expected that the pump will be in intermittent service for a period of four to six months.

A centrifugal pump of the mine-dewatering type was chosen to meet the above requirements. This type of pump is a vertical, single-stage, centrifugal pump, close-coupled to a driving motor. The motor-pump assembly is mounted on a pulley block and is raised and lowered into the tank by means of a cable which passes around the pulley and which is wound on a winch operated from ground level through a worm gear.

3. Description

A sketch of the sludge pump is presented as Figure XVII-1. The several component parts of the pump are briefly described below.

3.1 Pump

The pump, manufactured by the Nagle Pump Company, is 16 in. in diameter and has a fully shrouded impeller, screwed to the lower end of

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a vertical shaft. Slurry enters the pump from the bottom through a 6-in., axial, vertical suction nozzle, passes through the impeller, and leaves the pump casing through a 6-in. vertical discharge line. The suction nozzle is covered by 1/4-in. wire mesh made of steel wire, welded in place. The pump and impeller are made of manganese steel. The external surfaces of the assembled pump are painted with gray Amercoat No. 23. A cross-sectional assembly of the pump is shown in Figure XVII-1.

The pump is designed to develop a head of 126 ft. of fluid when pumping 500 gal./min. of slurry. Figure XVII-2 shows the head and horsepower of the pump at various capacities.

3.2 Shaft and bearings

The vertical shaft drives, supports, and locates the rigidly mounted impeller. Two ball bearings guide and support the shaft. A mechanical seal protects the lower bearing from liquid spray and splash in the tank.

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The nominal 4-in. diameter shaft is 6 ft. long and is guided by sealed-for-life ball bearings, one at each end of a 12-in. diameter bearing support tube. No bearings are located within the pump casing. The impeller is mounted on the manganese steel shaft three feet below the lower bearing. An unlubricated standard Duraseal with No. 1 carbon and stellite seal faces is mounted just below the lower bearing for protection from splashes occurring during pump operation.

The standard steel ball bearings are not corrosion resistant and must not be submerged in the pumped fluid. A conductance-type liquid level detector, located 2 ft. 6 in. above the pump suction port and 12 in. below the lower ball bearing, actuates an alarm when covered with liquid.

3.3 Discharge line

The pump discharge line is flexible and extensible in order to allow vertical movement of the pump assembly.

The discharge piping consists of a vertical section of 6-in. schedule 40 steel pipe 28 in. long, two cast steel Chiksan, ball-bearing, flat-face, swivel joints, which allow rotation in one plane, and two sections of 4-in. I.D. rubber hose. The fluid passes upward from the pump through the vertical steel pipe. A 90° welded elbow and a 90° Chiksan joint are connected to a rubber hose which extends downward for 13 ft. 5/8 in. The hose then makes a U-bend through a 180° Chiksan joint and extends upward for 21 ft. 3-1/2 in. to the pump mounting flange which is fitted with a 4-in. remote connector.

As the pump is lowered, the lower U-bend of the discharge line swings to one side and the Chiksan joints rotate, thus allowing the pump to be lowered to the bottom of the tank.

3.4 Motor

The driving motor is 60-h.p. output (75-h.p. rated input), 440-volt,

3-phase, 1200-rev./min., vertical flange mounted, totally enclosed, fan cooled, and is equipped with sealed-for-life ball bearings.

Actual horsepower-capacity tests with water indicate that the motor will be 20 to 30% overloaded when a solution having a specific gravity of 1.26 is being pumped at 600 gal./min. Under these conditions the motor manufacturer expects the motors to last approximately one year based on an intermittent operating schedule of 12 hours running and 12 hours idle. The bearings are packed with Dow Corning silicone grease No. 44, to resist the heat developed under these conditions.

A 40-ft. flexible power cable, consisting of four conductors of number 2 wire, is led to the motor from a spring wound Reelite cable reel installed on the mounting flange.

3.5 Mounting

The pump assembly is suspended from a mounting flange which supports the power cable reel, an instrument cable reel, a reel for the pump suspension cable, two electrical remote connectors, and the discharge connector nozzle. The mounting flange is supplied with a lifting bail.

The mounting flange is positioned on an adapter flange with two dowels and is retained with four free nuts. The adapter flange is welded to a 3-ft. diameter casing which extends downward from the bottom of a pump pit through the tank top and surrounds the pump assembly when the mechanism is in its uppermost position. The casing is equipped with a circumferential water spray for flushing the assembly prior to its removal from the tank.

3.6 Raising and lowering facilities

A 30-in. diameter hand wheel mounted on a pedestal above the pump pit cover turns a 3-1/2 in. diameter vertical shaft which terminates in a worm at the pump mounting flange. The worm engages a worm gear on the 12-in. diameter cable reel. The reel holds 100 ft. of rectangular cross section (1/4 by 1-1/2 in.) support cable. The cable extends downward through the mounting flange, passes around a 16-7/8 in. diameter sheave above the pump, and is connected to a lug on the bottom of the mounting flange. The pump and motor assembly is slung on two 1-in. diameter support rods from a pulley block. The pump suction nozzle may be lowered to the bottom of the tank by manipulation of the hand wheel.*

3.7 Process piping and control

Routing of the pump discharge is accomplished by jumpers in the pump pit. Approximate flow rate measurement may be determined by the use of a

*) After installation of the pump assembly, it was found that several men were required to turn the hand wheel which raises and lowers the pump. A horizontal lever attached to the hand wheel was therefore installed to aid this operation.

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strain gauge which measures the weight of the Slurry Accumulator to which the sludge pump discharges. The gauge is described in Chapter XIX.

B. "HOT" BOOSTER PUMPS

1. Introduction

Only one uranium removal installation (described in Chapters XIII and XIV) has been provided for the T and TX Tank Farms. The installation is located at the TX Farm. Booster pumps are required to aid the transfer of liquid through approximately 1/2 mile of pipe connecting the two farms. One booster pump aids transfer of slurry from the T cascades to the TX Farm Slurry Accumulator (TK-TXR-001). Another pump boosts the pressure of the supernate returned from the Slurry Accumulator to the sluicing nozzles in the T Tank Farm.

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2. Basis of Selection

The following specifications served as a basis for selecting the two booster pumps.

(a) Head-capacity characteristics: The pumps are required to have the same capacity as the sludge pump and the Slurry Accumulator pump (sluicing pump) which are boosted. The requirements are 600 gal./min. at a head of 119 ft. of pumped fluid.

(b) Internal pump clearances: Small clearances which might be affected by erosion and abrasion and result in changes in the pump characteristics are undesirable.

(c) Orientation of suction and discharge nozzles: The TX Tank Farm is at a higher elevation than the T Farm. In order for the booster pumps to drain completely, the unit which pumps down-hill from the TX Farm to the T Farm should have its suction nozzle at a higher elevation than the discharge nozzle, and the unit which pumps up-hill should have its suction nozzle lower than the discharge nozzle.

(d) Length of service: The pumps are required to operate 12 hours every three days for a period of two to three months.

Because of the very short service life required and since only two pumps are necessary, standard centrifugal pumps were selected for the required service. Shaft-seal leakage is collected and returned to the vessel from which the leakage came.

3. Description

A horizontal centrifugal pump and a vertical-shaft centrifugal pump were selected for booster service. A cross-sectional view of both units is shown in Figure XVII-3.

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3.1 Impeller, shaft, and casing

The semi-shrouded impeller in each pump is made of cast iron, and is keyed to the carbon steel shaft and fastened in place with a lock nut. The cast iron, volute-type casings have 5-in. flanged, tangential discharge nozzles and 6-in. flanged, axial suction nozzles. As shown on Figure XVII-3, the slurry enters the vertical pump from the bottom, while slurry leaves the horizontal pump through the horizontal, tangential discharge nozzle at the bottom.

3.2 Bearings

The horizontal pump has two grease lubricated, double-sealed, pillow-block ball bearings, mounted on a cast iron cradle.

The vertical pump has a grease-lubricated radial-thrust ball bearing mounted below the shaft coupling. A water-lubricated bronze sleeve bearing above the impeller guides the lower end of the shaft. Water is supplied to the bearing through a 1/4-in. pipe from the seal water supply system.

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3.3 Shaft seal

Both pumps have standard double Dura Seals, with carbon and stellite seal faces. The seals are lubricated with water supplied from a special water seal system, which comprises a pump, tanks, and regulators arranged to supply water to the seal at a pressure slightly higher than the discharge pressure.

3.4 Motor and coupling

The pumps are driven by 50-h.p., 1800-rev./min., 220/440-volt, 3-phase, 60-cycle motors of totally-enclosed, fan-cooled construction. Motor controls are located on the panel board in the 271-TXR Building.

The pump shafts are driven through standard flexible couplings.

4. Performance

The specifications require that these pumps boost the head of a 600-gal./min. stream by at least 119 ft.

C. "HOT" LIQUID AND SLURRY PUMPS(2)(3)

1. Introduction

The majority of the "hot" pumps for the Uranium Recovery Plant are of one general design and are of the deep-well turbine type. These pumps are used throughout the 221-U Building for pumping of radioactive liquids and slurries and in all other locations where "hot" pumps are required, except for the sludge pumps and booster pumps.

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2. Basis of Selection and Design

The selection of pumps for "hot" liquid and slurry service was based on the following requirements:

(a) Head-capacity characteristics. Pumps are required to meet a wide range of head and capacity conditions in the 221-U Building, the tank farms, and the diversion stations. Heads range from 20 to 393 ft. of fluid and flow rates range from 13 to 600 gal./min.

(b) Materials of construction: Construction materials must resist corrosion by the process solutions and erosion due to the slurries which are pumped.

(c) Life expectancy: A minimum life expectancy of one year without contact maintenance is desired.

(d) Leakage: No leakage of radioactive solution from the pump is tolerable.

(e) Flushing and draining: The pump must contain no pockets that are not flushable from the discharge line and must be completely drainable through the suction port.

(f) Strength: The pump must be strong enough to withstand impacts and strains imposed by the remote handling equipment.

A multi-stage, vertical, deep-well turbine pump was selected for the "hot" liquid and slurry pumps.

3. Deep-Well Turbine Pump

3.1 Theory of operation

The pump fluid enters the suction port of a deep-well pump axially at the bottom and passes directly into the eye of an impeller. The fluid is accelerated as it passes between the impeller blades. This acceleration is termed an "impulse" and is due to the difference in peripheral speeds between the inner and outer ends of the impeller blades. In general, the acceleration is proportional to the square of the impeller diameter, the shaft speeds being equal.

After leaving the impeller, the fluid enters a diffuser which consists of a set of channels leading to the eye of the impeller in the next stage. Since the fluid enters the pump at the same rate as it leaves the pump, the increase in velocity head gained by the fluid as it passes through the impeller is converted to pressure head in the diffuser.

The head developed by a multi-stage pump is approximately equal to the head developed in a single stage times the number of stages.

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3.2 Effect of process variables on pump characteristics

The head-capacity curve of a pump is not affected by differences in density of the fluid pumped, but the discharge pressure and the brake horsepower of a pump at any flow rate are directly proportional to the density of the pumped fluid. Viscosities up to 25 centipoises do not significantly affect the head developed at any flow rate as compared to the head developed when pumping water. A more detailed discussion of the effect of density and viscosity on pump performance may be found in Chapter XVII of the Redox Technical Manual, HW-18700.

4. Process Requirements

In 221-U Building, 62 pumps are used for transferring "hot" solutions and slurries. The 241-WR Diversion Station requires eight "hot" pumps. Four pump vaults in the various waste storage tank farms require a total of 17 deep-well turbine pumps, including two pumps installed in underground supernate holdup tanks (241-TXR-115 and 241-BY-109). One pump in the Slurry Accumulator in each of the pump vaults supplies solution under pressure to the sluicing nozzles in the waste storage tanks. Information defining each "hot" deep-well turbine pump is given in Table XVII-1.

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5. Description of Production Units

The pumps used for "hot" liquid and slurry service in the TBP Plant are vertical shaft, multistage, deep-well turbine pumps made by the Johnston Pump Co., Los Angeles, California. A typical pump is shown in Figure XVII-4. Each pump is supported and fixed on the top of the vessel to be serviced by means of a mounting flange which rests on a nozzle flange of the vessel. A vertical column extends downward from the mounting flange and contains the pump stages as an integral part of the column assembly. The column length is determined by the height of the vessel, and the number of stages by the desired head-capacity characteristics of the pump. Solution enters the pump axially at the lower end of the column and passes 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. At each stage an impeller is fixed to the shaft. The drive shaft is rigidly coupled to the shaft of a vertical electric motor mounted above the mounting flange. The weight of the shaft and 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. The close clearance between shaft and bushing restricts the flow of solution. Leakage past the throttle bushing is returned to the vessel.

5.1 Pumps

The fully shrouded pump impellers are cast, Type 304 stainless steel, except the impellers for pumps in the Slurry Accumulators, the Supernate Holdup Tanks, and the Waste Receiver Tank in the 241-WR Diversion Station, which are cast iron. The impellers are locked to the shaft with tapered

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collets of Type 304 stainless steel. (The cast iron pumps have Type 416 stainless steel collets.)

The diffuser bowls which separate the impellers of two adjacent stages are cast, Type 304 stainless steel or cast iron. The diffusers act as channels to guide the discharge of one impeller into the suction of the impeller. One bowl is bolted to the next with eight studs with safety wired nuts. Each bowl section is registered (tongue and groove arrangement) to insure proper alignment with the adjacent bowl. All diffuser bowls in any one pump are similar. Bowls range in outside diameter from 6 to 10 inches. A wear ring of Graphitar No. 41 is shrunk fit into each bowl and provides a close running clearance with the outside of the suction opening of the impeller. The wear ring restricts intrastage recirculation of liquid. Sleeve bearings in each bowl, above and below the impeller, guide the shaft and restrict interstage recirculation of liquid. Table XVII-1 lists the number and size of stages in each pump. Figure XVII-5 presents typical head-capacity curves for pumps of each size (bowl diam. and no. of stages).

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5.2 Column and shaft

A column is used to support the pump stages, to protect the shaft, and to carry the discharge stream through the pump to the discharge nozzle.

A 3-in. to 6-in. i.p.s. flanged pipe, fabricated from Type 347 stainless steel or mild steel, fixes the position of two stages at the bottom of the pump from the remainder of the stages which are fixed near the top of the column. Other sections of column of the same pipe size are welded to the mounting flange and suspend the entire pump assembly below the flange. The horizontal 2 to 6-in. i.p.s. discharge nozzle is welded to the column above the flange. The lengths of the two sections of pipe column depend on the depth of the vessel. (Phase I and II pumps have all stages located at the bottom end of the column.)

The vertical pump shaft runs concentrically within the column. Nominal shaft diameters are 3/4 in. to 1-1/2 in., with lengths which range from 4 ft. 2 in. to 39 ft. 4 in.

Shaft alignment is essential to the operation of any pump and assumes particular importance in an assembly containing a long shaft guided by several bearings. Extreme caution must be exercised during remote handling of the pump to insure that the column and shaft are not bent or misaligned.

5.3 Bearings

Sleeve bearings are used to guide the shaft. The motor bearings absorb thrust loads and guide the upper end of the shaft.

One bearing bushing is mounted in the diffuser bowl at each stage. In addition, a large bushing, called a "foot" bearing, is mounted in the suction bell at the lower end of the shaft. Additional bearings are located in spiders (bearing retainers which allow solution to flow freely around them) at intervals along the shaft, so that the greatest length of unsupported shaft in any pump is 7 ft. 10 in. This arrangement provides a sleeve bearing above and below each pump impeller and adequately guides the shaft.

Two throttle bushings above the uppermost stage form the shaft seal and are not intended to guide the shaft. The upper end of the shaft is guided by the motor bearings through a rigid coupling. The motor bearings also support the shaft and absorb the unbalanced hydraulic thrust load of the impellers.

The Slurry Accumulator pumps in the tank farms and the Waste Receiver pumps in the 241-WR Diversion Station have cast iron sleeve bearings. Fifteen slurry pumps in the 221-U Building have boron carbide and Graphitar No. 41 bearings. The boron carbide, which has demonstrated a high resistance to abrasion in slurry service, is used at salient points along the shaft, i.e., the foot bearing, the column bearings, and the lower throttle bushing. All other deep-well turbine pumps have Graphitar No. 41 sleeve bearings throughout.

The cast iron and Graphitar No. 41 bearings are finished internally to 15 microinches (r.m.s.) or better, and the boron carbide bearings are finished to 5 microinches (r.m.s.) or better. The boron carbide bearings are provided with a diametrical shaft clearence of 5 to 7 mils and the Graphitar No. 41 and cast iron bearings with 9 to 10 mils diametrical clearance.

The bearings are end-lubricated with process solution. The Graphitar bearings have four axial lubricant distribution grooves in the bearing surface. The grooves are semi-circular in cross section, 1/8 in. wide. The cast iron and boron carbide bearings have no lubrication grooves.

The motor bearings are standard anti-friction ball bearings, mounted within grease chambers in the motor. Lubrication is accomplished with a Farval remote lubrication system and a waste grease collection system, as described in Chapter XVI of the Redox Technical Manual, HW-18700.

Journal bearings require constant lubrication for long life. The "hot" pumps must never be run without a flooded suction inlet. Dry operation will quickly score and wear the bearings and shaft journals and cause rapid failure.

5.4 Shaft seal

A shaft seal, consisting of two throttle bushings, is provided at the point where the shaft emerges from the column at the mounting flange. The seal is designed to prevent leakage of radioactive process chemicals into the cell and thus prevent the spread of contamination.

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A shaft sleeve is located within the column near the upper end of the shaft. The upper end of the sleeve is welded into the column below the rigid coupling, and the lower end of the sleeve is welded into the stainless or cast steel discharge case which is located between the upper stage and the upper column section. The upper end of the sleeve and the lower end of the discharge case contain press-fitted throttle bushings. The bore of the Graphitar No. 2 bushings is relieved with concentric grooves, 3/16 in. wide, 3/32 in. deep, and spaced 1/4 in. apart. The boron carbide and cast iron throttle bushings do not have relief grooves.

The discharge case has two diametrically opposite vent or drain holes above the lower throttle bushing. Solution which leaks past the throttle bushing into the shaft sleeve is drained through these holes back to the vessel. A slinger ring is mounted on the shaft near the top of the vent holes. The slinger ring acts to deter solution from rising up into the shaft sleeve. The upper throttle bushing serves as a labyrinth-type vapor seal to contain mists and vapors within the vessel.

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5.5 Coupling and motor

Coupling: An adjustable, cast iron, rigid, flanged coupling is used to connect the vertical motor shaft to the pump shaft. The coupling consists of three flanged parts. The upper and lower parts may slide vertically on the two shafts, but are feathered to the shaft with square keys. The third flanged part lies between the other two and has a lip which fits into a concentric groove around the lower end of the motor shaft and a threaded hole which engages threads cut on the upper end of the pump shaft. The distance between shaft ends may be altered by rotating this central flanged part in relation to the other two parts. The three flanges are bolted together with steel bolts and nuts. The coupling is painted with Amercoat No. 55.

Motor: The vertical, flange-mounted motors used on the "hot" submerged pumps are 1750-rev./min., 440-volt, 3-phase, squirrel cage type induction motors. Motor cases are totally enclosed, fan cooled. Sizes range from 2 to 125 horsepower. The external surfaces of the motor are painted with Amercoat No. 55.

5.6 Mounting

All but fifteen of the pumps in the 221-U Building are supplied with irregularly shaped adapter flanges. The fifteen pumps not supplied with separate flanges are each mounted on a flange along with an agitator. The adapter flanges provide support for the discharge pipe connector nozzle, the remote lubrication valve and connector nozzle, and the electrical supply male connector.

The flanges are located on the tank nozzles by dowel pins and fastened down with free nuts. A bail is provided for lifting the assembly.

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D. "COLD" SERVICE PUMPS

1. Introduction

Thirty-two pumps are used for non-radioactive solution transfer in the Uranium Recovery Plant. The pumps are located in the 221-U, 271-U, 224-U, 211-U, 276-U, and 203-U Buildings.

2. Basis of Selection

Each pump was selected to meet the following requirements:

(a) Performance characteristics: A pump with the proper head-suction-capacity characteristics was selected for each application.

(b) Corrosion resistance: The materials of construction of each pump were specified to resist corrosion by the solution to be pumped.

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Three general types of "cold" pumps were chosen for specific applications. Standard, single-stage centrifugal pumps are used for general transfer duty. Self-priming centrifugal pumps unload tank cars in the 211-U Chemical Tank Farm. Deep-well turbine-type pumps, which are inherently leakproof, are used to transfer 40% and 60% nitric acid in the 224-U Building.

3. Standard Horizontal Centrifugal Pumps(4)(5)(6)

3.1 Requirements

Standard chemical transfer pumps range in operating heads from 30 to 156 ft. of pumped fluid and in capacity from 5 to 100 gal./min. Table XVII-2 lists the specific operating requirements for each pump.

3.2 Description

Figure XVII-6 shows cross-section drawings of each type of standard centrifugal pump. All pumps are of single-stage design. The pumps were made by the Worthington Pump and Machinery Corp., Harrison, N.J.

The pumps fall essentially into two classes, shrouded impeller pumps with screwed suction and discharge nozzles, and semi-shrouded impeller pumps with flanged suction and discharge nozzles. Both types of pumps have cantilever impellers keyed to the shafts and fastened in place with nuts. All pump cases are vertically split. The materials of construction, type, and nozzle sizes of each pump are listed in Table XVII-2.

Two pumps(6), P-X-1 and P-X-2, which transfer uranium solution from the feed tanks in the 203-U Area to evaporators in the 224-U Building, have Worthington Type EA mechanical seals. All other "cold" pumps have packing glands supplied with lantern rings. The pumps with screwed

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connections have internal bleeds for lubricating the glands with pumped solution. The flange-connected pumps have glands supplied with taps for water lubrication. The type of packing used in each pump is listed in Table XVII-2.

The pump shafts are guided and supported by two grease-lubricated ball bearings mounted in a cast iron cradle between the coupling and the pump. The bearing on the coupling end of the cradle acts as a thrust bearing. There are no bearings within the pump casing.

The pumps are driven through pin and leather spider-type flexible couplings by totally enclosed, fan-cooled motors. Motor speeds and horsepowers are listed in Table XVII-2.

3.3 Performance and operation

Table XVII-2 lists the actual heads developed by each pump at process flow rates and at no flow (blocked discharge). A typical head-capacity curve may be constructed through the two points defined by this data, if it should become necessary to estimate the capacity of a pump at any other operating head.

The pump manufacturer recommends that the water used to lubricate packing glands be supplied at pump suction pressure plus 10 lb./sq.in.

The grease recommended for bearing lubrication is No. 2, acid-free ball-bearing grease, and should be replenished after each 1000 hours of operation.

4. Self-Priming Centrifugal Pumps(7)

4.1 Requirements

Eight self-priming centrifugal pumps were selected to unload tank cars in the 211-U Chemical Tank Farm. The pumps have a capacity of 50 to 150 gal./min. against 75 to 136 ft. of pumped fluid with suction lifts of 8 to 10 ft. of water.

4.2 Description

A cut-away drawing of a typical pump is shown in Figure XVII-6. The pumps were made by Nagle Pumps, Inc., Chicago Heights, Ill.

Each pump has an open, cantilever-mounted impeller, screwed on the end of the shaft. A large suction trap with a removable top, containing a coarse strainer, acts as a reservoir to retain sufficient liquid to re-prime the pump each time it is stopped. The pump casing is of vertically split construction. The vertical discharge line contains an air-separation chamber. All pumps except 211-U-P-351 and 211-U-P-354, which pump hydrocarbon diluent and 40% HNO_3, respectively, have shaft sleeves which extend through the stuffing boxes and packing glands. Table XVII-2 shows the sizes of the flanged suction and discharge nozzles and the materials of construction of each pump.

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The shaft is sealed by a stuffing box containing five rings of packing, a lantern ring, and a packing gland which is further sealed to the shaft by two rings of packing compressed by a packing gland follower. The gland and gland follower are grease lubricated through Alemite fittings. The packing in each pump is described in Table XVII-2.

The shaft is guided by two grease-lubricated ball bearings mounted in a cradle. The inboard bearing acts as a thrust bearing. The grease is retained by grease seals.

The pumps are driven by totally enclosed, fan-cooled, 1800-rev./min. motors through flexible couplings. Motor horsepowers are listed in Table XVII-2.

Table XVII-2 lists the heads developed by each pump at process flow rates and at no flow.

The pumps must be primed through the removable top of the suction trap before they can be operated the first time.

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5. Deep-Well Turbine Pump(8)

5.1 Requirements

Two tanks, TK-C-3 and TK-C-4, located in a pit in the floor of the 224-U Building have no bottom outlets and are used to contain 40 to 50% HNO_3. Deep-well turbine pumps which deliver 5 gal./min. against 60 feet of pumped fluid are used for this service. Specific characteristics of the pump are listed in Table XVII-2.

5.2 Description

Due to its leakproof characteristics, a deep-well turbine pump, similar to the "hot" pumps described in Section C, was chosen for this service. The pumps were made by the Johnston Pump Co., Los Angeles 58, Cal. Figure XVII-4 presents a cross-section view of the pumps. Each pump is 7 ft. 7 in. long, has four stages, a 3/4-in. (nominal) shaft, and Graphitar No. 41 bearings. The pumps are driven by a 2-horsepower weatherproof motor. Materials of pump construction are listed in Table XVII-2.

5.3 Performance and operation

Table XVII-2 lists the actual developed heads at process flow rates and at no flow. A head-capacity curve may be constructed through these points if required.

It is essential for long bearing life that the pump be operated with a flooded suction.

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E. JETS

1. Introduction

Steam jets are used in the Uranium Recovery Plant for draining the heel from waste storage tanks, drawing vacuum on evaporators, stand-by for "hot" pumps, transferring solutions, and draining sumps. Water jet eductors are used to drain the 20-ft.-diameter waste storage tanks in the 241-CR Tank Farm.

2. Heel Jets

2.1 Requirements

After a sludge pump empties the slurry from a waste storage tank, a heel remains which must be removed by a jet. A heel jet, which is designed for remote handling and operation, is installed in the center of each tank for this purpose.

2.2 Description

A heel jet consists of a steam jet eductor(9) suspended inside the tank,approximately thirty feet below a mounting flange, on a pipe which acts as the discharge pipe of the jet. The jet has a flexible suction line approximately six feet long which rests on the bottom of the tank. A second pipe extends downward from the mounting flange and carries steam to the jet. A sectional view of the heel jet assembly is shown in Figure XVII-7.

The jet is of open-throat design, made of carbon steel, and equipped with screwed union nozzle connections. The jet has a top discharge outlet, a bottom suction inlet, and a bottom steam supply inlet.

The jet is mounted on the lower end of a 28-ft. section of 3-in. Schedule 40 carbon steel pipe which acts as the discharge pipe. The 3-in. Schedule 40 carbon steel suction pipe contains a 4-ft. 4-in. section of 4-in. I.D. flexible rubber hose and a suction strainer on its lower end. The 2-in. Schedule 40 steam supply pipe between the mounting flange and the jet contains 3-1/2 turns of expansion loop around the discharge pipe. A 10-in. Schedule 40 pipe welded to the bottom of the mounting flange surrounds and protects the jet and connecting piping.

The mounting flange is located on the floor of a concrete pit built around a nozzle over the center of the tank in the tank farm. The floor of the pit contains a floor drain and a flush water pipe. The discharge pipe and steam pipe are connected to the piping on the side of the pit by means of remote jumpers.

2.3 Performance and operation

With a 90-lb./sq.in. ga. steam supply pressure, the jet delivers 6000 gal./hr. against a discharge head of 55 ft. of 1.23 specific gravity slurry with a static suction lift of 7 ft. 3 in. of slurry. The steam

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is controlled by manually operated gang valves located on a bracket near the instrument shelter at each tank.

3. Sludge Jets[10]

3.1 Requirements

Sludge Jets are used to pump slurried sludge and supernate from the four 20-ft.-diameter underground waste storage tanks in the 241-CR Tank Farm.

3.2 Description

A typical unit consists of a water jet eductor submerged in the tank and resting on the bottom of the tank. Although a water-actuated-type jet is used, the operating fluid for the jet is supernate, pumped from the Slurry Accumulator by the Sluicing Pump, P-244-CR-001. The supernate is supplied to the jet through a rubber hose extending downward from a mounting flange which is located in the floor of a concrete pit above the tank. A second rubber hose carries the jet discharge up to the mounting flange. A sectional view of the tank with jet installed may be seen in Figure XVII-8.

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The cast steel eductor assembly is 8 ft. 6 in. long, including supernate inlet piping. The unit is sized to pass through a 12-in. i.p.s. riser. With the assembly in a vertical position, the supernate passes downward through a 4-in. rubber hose, and enters the eductor through a 3-in. steel pipe. The eductor discharges upward through a 3-in. rubber hose. The sludge in the tank enters the tapered, 21-5/8 in. long discharge throat through two openings in the side of the eductor. When installed, the eductor lies on its side on the bottom of the tank.

3.3 Performance

The eductor is sized to pump 125 gal./min. of 1.26 specific gravity slurry against a discharge head of 110 ft. of liquid when supplied with 125 gal./min. of supernate under 140 lb./sq.in. pressure.

4. Vacuum Jets[11]

4.1 Requirements

One steam jet is required to evacuate water-saturated air from the Nitric Acid Fractionating Tower Condensers E-B-3 and E-D-3 in B and D Cells in the 224-U Building. This jet discharges to the local stack on top of the 224-U Building.

4.2 Description

The jet is of standard design. It is made of Type 347 stainless steel and has 4-in. flanged suction and discharge nozzles and a 1-in. flanged steam nozzle.

4.3 Performance and operation

The jet has a capacity of 6000 cu.ft./hr. of vapor with a suction pressure of 2.9 in. mercury absolute when supplied with steam under 90 lb./sq.in. ga. pressure. The steam to the jet is controlled from a valve located near the graphic panel board in the 224-U Building Operating Gallery.

5. Process Jets

All process jets used in the 221-U Building are the original equipment of the building, purchased when the building was intended for use as a Bismuth Phosphate Plant, but used in the TBP Plant without modification.

5.1 Requirements and operation

Forty-four jets have a capacity of 75 gal./min. and thirty-nine have a capacity of 25 gal./min. The jets are used as stand-by equipment for "hot" pumps, solution transfer, and sump drainage. Six jets are used to drain the pulse columns located in the cells of 221-U Building. All jets are controlled by manual gang valves which are described in Section C of the Hanford Works Technical Manual, HW-10475, or by pneumatic Redox-type gang valves, as described in the Redox Technical Manual, HW-18700.

5.2 Description and performance

A description of the Schutte and Koerting jets may be found in Section C of the Hanford Works Technical Manual, HW-10475.

F. UO_3 POWDER TRANSFER AND HANDLING

1. Introduction

Uranium trioxide is prepared in powder form in the calcination pots in 224-U Building. A method is required for removing the powder from the pots and loading it into drums for further handling without creating a dust hazard. A Vacuum Transfer and a Packaging System has been installed for this purpose. A Vacuum Cleaner System, for removing any spillage from the floors of the pot room, is also installed in 224-U Building.

2. Vacuum UO_3 Transfer System

2.1 Process requirements

Powder must be removed from the furnaces at the rate of 3200 lb./hr., ground to a maximum particle size of 80 mesh, and transported to the packaging system without creating a dust hazard.

2.2 Description of equipment

The system consists of pipe and fittings, a cyclone collector, a bag filter and exhauster, a hopper, and a rotary valve. All parts of the system

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are located outside the building except the pipes leading from the pots. Figure VIII-1 shows a schematic diagram of the system. Figire XVII-9 shows a schematic isometric view of the Vacuum Transfer System and the Furnace Ventilation System. The ventilation system is described in Chapter XIII.

Eighteen calcination pots are located in 224-U Building in two banks. Each bank of nine pots is serviced by five unloading stations, two pots per station. The third and twelfth pots (PE-3 and PE-12) are serviced by individual unloading stations. A 4-ft. section of 2-in., Type 18-8 stainless steel pipe acts as a pickup nozzle at each of the ten unloading stations. The nozzle is provided with hand grips for ease of manipulation. The nozzle is connected to a 10-ft. section of 2-in. flexible lightweight vacuum hose made of Type 18-8 stainless steel. A normal charge of 500 lb. of UO_3 can be unloaded from a pot in 10 to 20 minutes. A quick-opening slide gate valve at each station shuts off the vacuum to the nozzle when not in use. Before the vacuum is shut off, the nozzle is inserted in a receptacle which catches any dust which falls from the nozzle. Clean-outs at the lower end of vertical pipe risers in the system consist of quick-opening gate valves similar to the valves at the unloading stations. Two headers, one for each bank of pots, transfer the powder from the unloading stations to the cyclone separator. The transfer headers are made of 2-1/2 in. Schedule 10, Type 18-8 stainless steel pipe. The greatest length of header is approximately 130 ft.

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The cyclone collector, which removes the UO_3 powder from the air coming from the pots, has a maximum capacity of 650 cu.ft./min. of loaded air at 180°F.

The separated powder in the bottom of the cyclone is fed into a hopper and thence through a rotary valve to a Mikro-Pulverizer hammer mill. The exhaust air passes to a bag filter. All metal parts of the collector in contact with powder are fabricated from Type 18-8 stainless steel.

The Hersey-type bag filter is designed to remove 99.8% of the powder from the exhaust air leaving the cyclone collector. The bag is made of wool and will remove uranium oxide particles of one micron diameter or larger from the air. The filtered dust is automatically blown from the bag by a motor-driven blow-ring-type mechanism. The blow ring moves up and down the vertical, cylindrical bag, actuated by a motor-driven belt running on pulleys. The motor is automatically started when the pressure drop across the bag has been increased to approximately 3-1/2 in. of water by blinding of the bag, and automatically stopped when the pressure drop returns to normal, i.e., approximately 1-1/2 in. of water. The filtered UO_3 is fed from the bottom of the bag to a storage bin through a rotary air lock valve similar to the unit on the hopper. All metal parts of the blow ring mechanism and bag housing are made of Type 18-8 stainless steel.

A 3500-rev./min. centrifugal exhauster[12], made by the U.S. Hoffman Machinery Corp.. Model 4207-S, evacuates the air from the system. The exhauster is driven by a 30-horsepower electric motor which is controlled

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from the pot room. The nominal capacity of the exhauster is 750 cu.ft. of air per min. at a pressure differential of 10 in. of mercury. This is sufficient capacity to supply two nozzles with a minimum air pickup velocity of 9000 ft./min. The discharge of the exhauster is fed into the furnace ventilation bag filters. This is the only tie-in of the Vacuum Transfer with the Furnace Ventilation System. The characteristics of the exhauster are shown in Figure XVII-10.

The powdered UO_3 drops from the cyclone collector into a 5-cu.ft. hopper which feeds the powder to a rotary valve. A high-level controller stops the exhauster when the powder reaches a certain level in the hopper. The valve is utilized to supply the powder to a Mikro-Pulverizer hammer mill at a rate of three tons per hour and at the same time act as an air lock to contain the vacuum within the transfer system. The valve is driven at 1.18 rev./min. by a 1/2-h.p. gear-head electric motor through a chain and sprocket drive. The valve and hopper are made of Type 18-8 stainless steel.

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3. Hammer Mill[13]

3.1 Process requirements

A hammer mill receives the dry, hard UO_3 with a bulk density of 250 lb./cu.ft. from the rotary valve, grinds it to pass 80-mesh screen, and drops it into a storage bin.

3.2 Description

The mill is a standard No. 2W Mikro-Pulverizer with top inlet and bottom outlet. A horizontal shaft, guided by two self-aligning, double-row ball bearings, drives a hub within the grinding chamber. Twelve rows of light forged stirrup-type hammers are pivoted axially to the hub and spaced equally around the hub periphery. The hammers are surrounded by a cover on the top containing a 5-in. flanged inlet and a semi-cylindrical perforated plate on the bottom. The plate is of 16-gauge stainless steel, perforated with 1/8-in. round holes. The ground material falls through the perforated plate and through a discharge chute with a 12-in.-square bottom opening which is flanged to the top of a storage bin.

The mill is driven at 5100 rev./min. through six V-belts. The 3450-rev./min., 15-h.p. motor is controlled from a panel in the pot room.

All metal parts of the Mikro-Pulverizer in contact with UO_3 are made of Type 18-8 stainless steel.

3.3 Notes on operation

A second screen, made of 20-gauge stainless steel with 1/16-in. round holes, is supplied with the mill in case the screen installed in the mill does not grind the material to the proper specifications.

The bearings are lubricated with SAE No. 20 cylinder oil. The bearings should be flushed with kerosene after 30 days operation.

The Mikro-Pulverizer manufacturer recommends that the unit be grounded to prevent packing of the ground material due to undissipated static charges.

4. Packaging System

4.1 Process requirements

The packaging system is designed to receive the ground UO_3 from the Mikro-Pulverizer, measure it into drums at the nominal instantaneous rate of 15.8 tons per day (corresponding to 13.125 tons U/day), and move the drums out of 224-U Building to trucks for storage or shipment.

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4.2 Description of equipment

The ground UO_3 drops from the bottom of the storage bin into a screw conveyor. The conveyor carries it to a drum filling assembly, where drums are weighed, filled, reweighed, and carried by a gravity roller conveyor to a fork lift truck, which takes the drums to the 2714-W Warehouse.

The Type 18-8 stainless steel storage bin has a 500-cu.ft. capacity and will contain a three-day supply of 250-lb./cu.ft. material. The powder is fed from the Mikro-Pulverizer into the top of the bin at the nominal instantaneous rate of 15.8 tons/day. The bottom of the storage bin is wedge-shaped with sides sloped 50° from the horizontal. The material is fed into the screw conveyor from the bottom of the bin. The bin has a high-level controller which stops the vacuum transfer exhauster and a low-level controller which stops the screw conveyor motor.

The 6-in.-diameter screw conveyor, 15.5 ft. long, carries material from the storage bin to the drum filling mechanism located inside the building. The 18-8 stainless steel screw is driven at 20 rev./min. by a 3-h.p. Synchrogear motor through a chain and sprocket drive. The motor has a starter located at the drum filling site.

The packaging mechanism is used to fill and weigh drums and to convey them to the truck loading area. The screw conveyor discharges into a drum filling spout. When a drum is placed on the roller conveyor under the spout, it is supported by a rough-weight-type scale which stops the screw conveyor when the drum has received 900 to 950 lb. of UO_3. The drum is moved in an upright position down the gravity roll conveyor over another scale which automatically records the weight of each drum. Gross, net, and tare weights are stenciled on each drum. Drums can be filled at a rate of about 10 thirty-gallon drums per hour.

A carbon steel ventilation hood provides a 400-ft./min. air sweep up around the drums during the filling operation. A carbon steel duct carries the air to the pot ventilation bag filters.

All parts of the packaging system in contact with the UO_3 powder are made of Type 18-8 stainless steel.

The 224-U Building has storage space for about 100 empty stainless steel drums or the equivalent of a three-day supply.

The drums are maintained in an upright position during all stages of handling and are moved by a fork lift truck from 224-U Building to the 2714-W Warehouse on special wooden pallets. Four drums are strapped together on each pallet and remain stored in this manner throughout railroad shipment.

The 2714-W Warehouse has a holdup capacity of about 450 full drums or the equivalent of 15 days normal operating capacity. Space is also provided in the warehouse for 3000 empty drums.

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5. Vacuum Cleaning System

5.1 Process requirements

The function of the vacuum cleaning system is to pick up spilled uranium oxide, dust, and dirt from the floors of 224-U Building and to collect the sweepings for salvage or disposal.

5.2 Description of equipment

The equipment consists of hose stations, a dust separator, exhauster, and various pipes and fittings. Figure VIII-1 shows a simplified schematic view of the system.

There are four hose stations distributed in 224-U Building as follows: two in the pot room; one in the packing room; and one outside the building near the bag filter. Each station has 50 ft. of 1-1/2 in.-diameter flexible neoprene hose and 4 ft. of approximately 1-1/4 in. thin-wall tubing to act as a pickup nozzle. Three fan-type floor sweeping nozzles are provided at each station, as well as a rack for the hose when it is not in use.

The dust separator consists of a wool sock-type bag filter mounted integrally on top of a cyclone separator. The dust, which is manually shaken from the bag, drops into the cone of the cyclone separator which empties freely into a removable bucket. Access openings are provided in the bag house for the replacement of bags.

The centrifugal exhauster is sized to provide 7000 ft./min. pickup velocity for one 2-in. nozzle with air at 70°F. The exhauster is driven by a 3500-rev./min., 5-h.p. electric motor. A start-stop switch is provided at each hose station. The exhausted air is fed to the local stack on 224-U Building through the furnace ventilation system bag filters.

All pipe and fittings in the vacuum cleaning system are butt-welded or flanged carbon steel. Clean-outs are provided at the bottom of all vertical pipe risers.

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REFERENCES

(1) BPF-2778 Sludge Pumps, Hanford Works.

(2) BPF-3362 "Hot" Liquid and Slurry Pumps, Hanford Works.

(3) BPF-3359 "Hot" Liquid and Slurry Pumps, Hanford Works.

(4) BPF-3006 "Cold" Pumps, Hanford Works.

(5) BPF-3007 "Cold" Pumps, Hanford Works.

(6) BPF-2873 "Cold" Pumps, Hanford Works.

(7) BPF-3061 Self Priming "Cold" Pumps, Hanford Works.

(8) BPF-3159 Deep-Well Turbine Type "Cold" Pumps, Hanford Works.

(9) BPF-2695 Heel Jet Eductors, Hanford Works.

(10) BPF-3060 Sludge Jets, Hanford Works.

(11) BPF-3378 Vacuum Jet, Hanford Works.

(12) BPF-2679 Vacuum Transfer Exhauster, Hanford Works.

(13) BPF-2686 Hammer Mill, Hanford Works.

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Table XVII-1
"HOT" PUMPS

Pump No.	Process Requirements: Head, Ft. of Fluid	Capacity, Gal/Min. Nor.	Capacity, Gal/Min. Max.	Pumps To	Pump Stages(a) No.	Size (Diam.)	Set Length(b)	Motor Horse-Power	Construction Materials: Bowls	Shaft	Bearings	Solution: Tank	Type: Liq.	Slurry	Sp.Gr.	Visc. Centipoises	Temp. °F.	Approx. Activity, W Curies/Gal.
241-SX-																		
001	393	600	—	241-SX	13	10" CC	22' - 0"	125	Cast Iron	416 S.S.	Cast Iron	Slurry Acc.		x	1.27	10-100	110	6.3
002	100	50	—	241-SX-005	10	6" AC	20' - 2"	5	347 S.S.	304 S.S.	Graphitar 41	Blend Tank	x		1.27	1.5	160	1.01
003	100	50	—	241-SX-005	10	6" AC	20' - 2"	5	347 S.S.	304 S.S.	Graphitar 41	Blend Tank	x		1.27	1.5	160	1.01
004	30	100	—	244-SX-002	3	7" BC	14' - 4"	3	347 S.S.	304 S.S.	Graphitar 41	HNO_3 Tank	x		1.37	1.0	80	—
241-CR-																		
001	393	600	—	241-CR	13	10" CC	22' - 0"	125	Cast Iron	416 S.S.	Cast Iron	Slurry Acc.		x	1.27	10-100	110	6.3
002	100	50	—	244-PCR-011	10	6" AC	20' - 2"	5	347 S.S.	304 S.S.	Graphitar 41	Blend Tank	x		1.27	1.5	160	1.01
003	100	50	—	244-PCR-012	10	6" AC	20' - 2"	5	347 S.S.	304 S.S.	Graphitar 41	Blend Tank	x		1.27	1.5	150	1.01
244-PCR-011	158	25	—	241-SX-003	15	6" AEC	29' - 7"	3	347 S.S.	304 S.S.	Graphitar 41	Pump Out	x		1.27	1.5	120	1.71
241-TXR-																		
001	393	600	—	241-TXR	13	10" CC	22' - 0"	125	Cast Iron	416 S.S.	Cast Iron	Slurry Acc.		x	1.27	10-100	113	6.3
002	100	50	—	241-SX-005	10	6" AC	20' - 2"	5	347 S.S.	304 S.S.	Graphitar 41	Blend Tank	x		1.27	1.5	160	1.01
003	100	50	—	241-SX-005	10	6" AC	20' - 2"	5	347 S.S.	304 S.S.	Graphitar 41	Blend Tank	x		1.27	1.5	160	1.01
241-TXR-115	290	200	—	244-TXR-001	21	7" CC	39' - 4"	30	347 S.S.	304 S.S.	Graphitar 41	Supernate Holdup	x		1.12	0.7-1.7	113	6.3
241-SXR-																		
001	393	600	—	241-SXR	13	10" CC	28' - 0"	125	Cast Iron	416 S.S.	Cast Iron	Slurry Acc.		x	1.27	10-100	110	6.3
002	100	50	—	244-SXR-011	10	6" AC	20' - 2"	5	347 S.S.	304 S.S.	Graphitar 41	Blend Tank	x		1.27	1.5	160	1.01
003	100	50	—	244-SXR-011	10	6" AC	20' - 2"	5	347 S.S.	304 S.S.	Graphitar 41	Blend Tank	x		1.27	1.5	160	1.01
011	158	25	—	241-SX-003	15	6" AEC	29' - 7"	3	347 S.S.	304 S.S.	Graphitar 41	Pump Out	x		1.27	1.5	120	1.71
241-SXR-139	290	200	—	244-SXR-001	21	7" CC	39' - 6"	30	347 S.S.	304 S.S.	Graphitar 41	Supernate Holdup	x		1.12	0.7-1.7	113	6.3
241-WR-				241-Tank														
001-1	125	50	—	Farms	13	6" AC	28' - 10 1/2"	7 1/2	Cast Iron	416 S.S.	Cast Iron	Waste Rec.		x	1.40	4.0	180	1.6
001-2	125	50	—	241	13	6" AC	28' - 10 1/2"	7 1/2	Cast Iron	416 S.S.	Cast Iron	Waste Rec.		x	1.40	4.0	180	1.6
002	100	100	—	3-1	7	7" BC	29' - 0 1/2"	7 1/2	347 S.S.	304 S.S.	Graphitar 41	Feed Splr.	x		1.24	1.5	75	0.99
003-1	100	100	—	241-WR-002	7	7" BC	29' - 0 1/2"	7 1/2	347 S.S.	304 S.S.	Graphitar 41	Feed Rec.	x		1.24	1.5	75	0.99
003-2	100	100	—	241-WR-002	7	7" BC	29' - 0 1/2"	7 1/2	347 S.S.	304 S.S.	Graphitar 41	Feed Rec.	x		1.24	1.5	75	0.99
004	100	130	—	3-1	7	7" BC	29' - 0 1/2"	7 1/2	347 S.S.	304 S.S.	Graphitar 41	Feed Splr.	x		1.24	1.5	75	0.99
005-1	100	100	—	241-WR-004	7	7" BC	29' - 0 1/2"	7 1/2	347 S.S.	304 S.S.	Graphitar 41	Feed Rec.	x		1.24	1.5	75	0.99
005-2	100	100	—	241-WR-004	7	7" BC	29' - 0 1/2"	7 1/2	347 S.S.	304 S.S.	Graphitar 41	Feed Rec.	x		1.24	1.5	75	0.99
221-U-																		
3-1-1	65	19	21.0	6-6	6	6" AEC	14' - 2"	2	347 S.S.	304 S.S.	Graphitar 41	Feed Rec.	x		1.24	1.5	75	0.99
3-1-2	65	21	—	7-6	6	6" AEC	14' - 2"	2	347 S.S.	304 S.S.	Graphitar 41	Feed Rec.	x		1.24	1.5	75	0.99
3-6-1	65	21	—	6-6	6	6" AEC	14' - 2"	2	347 S.S.	304 S.S.	Graphitar 41	Feed Rec.	x		1.24	1.5	75	0.99
3-6-2	65	21	—	7-6	6	6" AEC	14' - 2"	2	347 S.S.	304 S.S.	Graphitar 41	Feed Rec.	x		1.24	1.5	75	0.99
4-1	90	75	—	8-6	5	7" BC	14' - 2"	5	347 S.S.	304 S.S.	Graphitar 41	Feed Holdup	x		1.24	1.5	75	0.99
4-6-1	91	75	—	9-6	5	7" BC	14' - 2"	5	347 S.S.	304 S.S.	(e)	Waste Holdup		x	1.25	2.0	150	1.6
4-6-2	108	75	—	10-6	5	7" BC	14' - 2"	5	347 S.S.	304 S.S.	(e)	Waste Holdup		x	1.25	2.0	150	1.6
4-6-3	92	75	—	8-6	5	7" BC	14' - 2"	5	347 S.S.	304 S.S.	(e)	Waste Holdup		x	1.25	2.0	150	1.6
6-2	37	37	—	6-7	4	6" AEC	4' - 2"	2	347 S.S.	304 S.S.	Graphitar 41	Conc. Feed	x		1.36	1.5	150	1.46
6-6	37	19	14.2	6-1	6	6" AEC	14' - 2"	2	347 S.S.	304 S.S.	Graphitar 41	Feed to Conc.	x		1.24	1.5	75	0.99
6-7	73	13	23.3	14-1	6	6" AEC	14' - 2"	2	347 S.S.	304 S.S.	Graphitar 41	Conc. Feed	x		1.36	1.8	100	1.46
7-2	36	23	—	7-7	4	6" AEC	4' - 2"	2	347 S.S.	304 S.S.	Graphitar 41	Conc. Feed	x		1.36	1.5	150	1.46
7-6	61	36	—	7-1	6	6" AEC	14' - 2"	2	347 S.S.	304 S.S.	Graphitar 41	Feed to Conc.	x		1.24	1.5	75	0.99
7-7	80	23	—	14-6, 14-7	6	6" AEC	14' - 2"	2	347 S.S.	304 S.S.	Graphitar 41	Feed Rec.	x		1.36	1.8	120	1.46
8-2	37	24	—	8-7	4	6" AEC	4' - 2"	2	347 S.S.	304 S.S.	(e)	Conc. Feed	x	x	1.36	1.5	200	1.46
8-6	66	41	—	8-1	6	6" AEC	14' - 2"	2	347 S.S.	304 S.S.	(e)	Feed to Conc.	x	x	1.27	[illegible]	150	0.99
8-7	66	23	—	6-7	6	6" AEC	14' - 2"	2	347 S.S.	304 S.S.	(e)	Feed Rec.	x	x	1.36	1.3	180	1.46
9-2	37	13.5	24.3	9-7	4	6" AEC	4' - 2"	2	347 S.S.	304 S.S.	(e)	Waste Conc.		x	1.40	4.0	200	1.6
9-6	70	41	—	9-1	6	6" AEC	14' - 2"	2	347 S.S.	304 S.S.	(e)	Waste to Conc.	x	x	1.25	2.5	150	0.89
9-7	50	24	—	241-WR-001	7	6" AC	14' - 2"	3	347 S.S.	304 S.S.	(e)	Waste Rec.		x	1.40	4.0	180	1.6
10-2	37	24	—	10-7	4	6" AEC	4' - 2"	2	347 S.S.	304 S.S.	(e)	Waste Conc.		x	1.40	4.0	200	1.6
10-6	66	41	—	10-1	6	6" AC	14' - 2"	2	347 S.S.	304 S.S.	(e)	Waste to Conc.	x	x	1.25	2.5	150	0.89
10-7	55	24	—	241-WR-001	7	6" AC	14' - 2"	3	347 S.S.	304 S.S.	(e)	Waste Rec.		x	1.40	4.0	180	1.6
11-1	66	46	—	11-6	6	6" BC	14' - 2"	2	347 S.S.	304 S.S.	Graphitar 41	Waste Splr.	x		1.20	1.5	75	0.93
11-6-1	78	41	—	8-6	6	6" AC	14' - 2"	2	347 S.S.	304 S.S.	(e)	Waste Neut.		x	1.25	3.0	150	0.89
11-6-2	63	23	41.4	9-6	6	6" AC	14' - 2"	2	347 S.S.	304 S.S.	(e)	Waste Neut.		x	1.25	3.0	150	0.89
11-6-3	60	41	—	10-6	6	6" AC	14' - 2"	2	347 S.S.	304 S.S.	(e)	Waste Neut.		x	1.25	3.0	150	0.89
12-1	65	46	—	11-6	6	6" AC	14' - 2"	2	347 S.S.	304 S.S.	Graphitar 41	Waste Splr.	x		1.20	1.5	75	0.93
12-6	65	41.4	49.6	11-6	6	6" AC	14' - 2"	2	347 S.S.	304 S.S.	Graphitar 41	Waste Splr.	x		1.20	1.5	75	0.93
13-1	61	46	—	11-6	6	6" AC	14' - 2"	2	347 S.S.	304 S.S.	Graphitar 41	Waste Splr.	x		1.20	1.5	75	0.93
13-6-1	43	75	—	11-1	5	6" CC	14' - 2"	3	347 S.S.	304 S.S.	Graphitar 41	Pooled Waste	x		1.20	1.5	75	0.93
13-6-2	20	75	—	12-6	5	6" CC	14' - 2"	3	347 S.S.	304 S.S.	Graphitar 41	Pooled Waste	x		1.20	1.5	75	0.93
13-6-3	24	75	—	13-1	5	6" CC	14' - 2"	3	347 S.S.	304 S.S.	Graphitar 41	Pooled Waste	x		1.20	1.5	75	0.93
13-6-4	36	75	—	13-1	5	6" CC	14' - 2"	3	347 S.S.	304 S.S.	Graphitar 41	Pooled Waste	x		1.20	1.5	75	0.93
14-2-1	61	13	14.4	19-6	5	6" AEC	8' - 10"	3	347 S.S.	304 S.S.	Graphitar 41	Cont. Caten	x		1.36	1.8	75	1.46
14-2-2	61	14	—	17-6	5	6" AEC	8' - 10"	2	347 S.S.	304 S.S.	Graphitar 41	Cont. Caten	x		1.36	1.8	75	1.46
14-7-1	61	14	—	19-6	5	6" AEC	8' - 10"	2	347 S.S.	304 S.S.	Graphitar 41	Cont. Caten	x		1.36	1.8	75	1.46
14-7-2	61	14	—	17-6	5	6" AEC	8' - 10"	2	347 S.S.	304 S.S.	Graphitar 41	Cont. Caten	x		1.36	1.8	75	1.46
15-1-1	66	150	—	203-U-E-1	5	7" BC	14' - 2"	5	347 S.S.	304 S.S.	Graphitar 41	RCU Splr.	x		1.04	1.1	75	3.4
15-1-2	66	150	—	203-U-E-1	5	7" BC	14' - 2"	5	347 S.S.	304 S.S.	Graphitar 41	RCU Splr.	x		1.04	1.1	75	3.4
15-6-1	66	150	—	203-U-E-1	5	7" BC	14' - 2"	5	347 S.S.	304 S.S.	Graphitar 41	RCU Splr.	x		1.04	1.1	75	3.4
15-6-2	66	150	—	203-U-E-2	5	7" BC	14' - 2"	5	347 S.S.	304 S.S.	Graphitar 41	RCU Splr.	x		1.04	1.1	75	3.4
16-1-1	42	150	—	15-1	5	7" BC	14' - 2"	5	347 S.S.	304 S.S.	Graphitar 41	RCU Rec.	x		1.04	1.1	75	3.4
16-1-2	42	150	—	15-1	5	7" BC	14' - 2"	5	347 S.S.	304 S.S.	Graphitar 41	RCU Rec.	x		1.04	1.1	75	3.4
16-6-1	42	150	—	15-6	5	7" BC	14' - 2"	5	347 S.S.	304 S.S.	Graphitar 41	RCU Rec.	x		1.04	1.1	75	3.4
16-6-2	42	150	—	15-6	5	7" BC	14' - 2"	5	347 S.S.	304 S.S.	Graphitar 41	RCU Rec.	x		1.04	1.1	75	3.4
17-1	46	36	65	18-2	5	6" AEC	12' - 2"	2	347 S.S.	304 S.S.	Graphitar 41	RCX Rec.	x		0.80	1.8	75	—
17-3	44	24	—	16-6	5	6" AEC	8' - 2"	2	347 S.S.	304 S.S.	Graphitar 41	RCU Pumpout	x		1.04	1.1	75	3.4
17-6	71	14	25	17-6	6	6" AEC	14' - 2"	2	347 S.S.	304 S.S.	Graphitar 41	RAF Feed	x		1.36	1.8	75	1.46
17-7	73	21	37	13-6	5	6" AEC	12' - 2"	2	347 S.S.	304 S.S.	Graphitar 41	RAF Rec.	x		1.21	1.5	75	1.31
18-1	61	36	65	18-6	6	6" AC	14' - 2"	2	347 S.S.	304 S.S.	Graphitar 41	RCO Rec.	x		0.80	1.8	75	—
18-3	43	18	—	13-6	6	6" AEC	4' - 2"	2	347 S.S.	304 S.S.	Graphitar 41	ROX Rec.	x		1.04	1.0	75	—
18-6-1	80	36	65	17-6	7	6" AC	14' - 2"	3	347 S.S.	304 S.S.	Graphitar 41	RAX Feed	x		0.80	1.4	75	—
18-6-2	80	36	65	17-6	7	6" AC	14' - 2"	3	347 S.S.	304 S.S.	Graphitar 41	RAX Feed	x		0.80	1.8	75	—
19-1	46	36	65	20-2	5	6" AEC	12' - 2"	2	347 S.S.	304 S.S.	Graphitar 41	RCX Rec.	x		0.80	1.8	75	—
19-3	44	20.4	28.3	16-1	5	6" AEC	8' - 2"	2	347 S.S.	304 S.S.	Graphitar 41	RCU Pumpout	x		1.04	1.1	75	3.4
19-6	71	15	25	19-6	6	6" AEC	14' - 2"	2	347 S.S.	304 S.S.	Graphitar 41	RAF Feed	x		1.36	1.8	75	1.46
19-7	73	21	37	13-6	5	6" AEC	12' - 2"	2	347 S.S.	304 S.S.	Graphitar 41	RAF Rec.	x		1.21	1.5	75	1.31
20-1	61	31.4	36	20-6	6	6" AC	14' - 2"	2	347 S.S.	304 S.S.	Graphitar 41	RCO Rec.	x		0.80	1.8	75	—
20-3	43	18	—	13-6	4	6" AEC	9' - 2"	2	347 S.S.	304 S.S.	Graphitar 41	ROX Rec.	x		1.05	1.5	75	—
20-6-1	80	32.4	36	19-6	7	6" AC	14' - 2"	3	347 S.S.	304 S.S.	Graphitar 41	RAX Feed	x		0.80	1.8	75	—
20-6-2	80	30.4	36	19-6	7	6" AC	11' - 2"	3	347 S.S.	304 S.S.	Graphitar 41	RAX Feed	x		0.80	1.4	75	—
241-BX-101 to 109	126	600		244-BX-001	1	—	—	60	(d)	(d)	Ball	Underground Storage		x	1.1 - 1.6	0.6 - 1.6	40 - 105	0.11 - 0.46
241-BY-101 to 109	126	600		244-BXR-001	1	—	—	60	(d)	(d)	Ball	Underground Storage		x	1.1 - 1.4	0.6 - 1.8	40 - 95	0.104
241-BXR-101 to 103	126	600		244-BXR-001	1	—	—	60	(d)	(d)	Ball	Underground Storage		x	1.1 - 1.4	0.6 - 1.8	95 - 195	0.208
241-CR-101 to 106	126	600		244-CR-001	1	—	—	60	(d)	(d)	Ball	Underground Storage		x	1.1 - 1.6	0.6 - 1.8	65 - 95	1.11 - 3.12
241-TX-153-1	119	600		241-TX	1	—	—	90	Cast Iron	Carbon Steel	Ball	Slurry Accumulator		x	1.27	10 - 120	100	6.3
153-2	119	600		244-TXR-001	1	—	—	90	Cast Iron	Carbon Steel	(e)	Underground Storage		x	1.1 - 1.4	0.6 - 1.8	40 - 145	0.108

NOTES: (a) The letters following stage sizes are the Johnston Pump Company symbols indicating shape of impeller and diffuser assembly.
(b) "Set Length" is the distance from the suction inlet to the bottom of the mounting flange.
(c) Foot bearing, column bearings, and lower throttle bushing are boron carbide. All others are Graphitar No. 41.
(d) Manganese steel.
(e) Ball bearing and water-lubricated bronze sleeve bearing.

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Table XVII-2
"COLD" PUMPS

Pump No.	Process Requirements: Head, Ft. of Fluid	Capacity, Gal./Min.	Suction Head, Ft. of Water	Solution	Spec. Grav.	Viscosity, Centipoises	Type Pump: Semi-Shrouded Impeller	Shrouded Impeller	Horizontal Self-Priming	Deep-Well Turbine	Motor: Speed, Rev./Min.	H.P.	Size Series: Suct., In.	Disch., In.	Pump Characteristics: Shut-Off Head, Ft.	Process Flow Rate Jet., Gal./Min.	Actual # Head, Ft.	Construction Materials: Pump, Shaft, Impeller	Frame, Baseplate	Packing
224-B P-6-2 P-6-3	60	5	—	40-60% HNO_3	1.37	2.3				x	1750	2	—	2	*	*	*	304 S.S. or 347 S.S.	304 S.S. or 347 S.S.	—
P-6-4	60	5	—	40-60% HNO_3	1.37	2.3				x	1750	2	—	2	*	*	*	304 S.S. or 347 S.S.	304 S.S. or 347 S.S.	—
P-65-1	69	80	—	Condensate	1.0	1.0		x			1750	3	2	1 1/2	95	80	65	"Durtite"**	Cast Iron	Square plaited braid white asbestos lubricated and graphited or equal.
P-65-2	69	80	—	Condensate	1.0	1.0		x			1750	3	2	1 1/2	95	80	65	"Durtite"**	Cast Iron	Square plaited braid white asbestos lubricated and graphited or equal.
P-5-1	60	55.5	—	[illegible]	1.7	1.1	x				3600	5	2	1 1/2	72	100	56	"Durtite"	Cast Iron	Durthington mechanical seal.
P-5-2	60	55.5	—	[illegible]	1.7	1.1	x				3600	5	2	1 1/2	72	100	56	"Durtite"	Cast Iron	Durthington mechanical seal.
211-B-1 P-302	90	100	—	60% HNO_3	1.37	2.3	x				3600	15	3	2	130	100	120	"Durtite"	Cast Iron	Square plaited braid blue African asbestos lubricated and graphited or equal.
P-307	90	100	—	60% HNO_3	1.37	2.3	x				3600	15	3	2	130	170	120	"Durtite"	Cast Iron	Square plaited braid blue African asbestos lubricated and graphited or equal.
P-314-1	110	15	—	RAS	1.08	1.0	x				3500	5	1 1/2	1	130	65	90	"Durtite"	Cast Iron	Square plaited braid blue African asbestos lubricated and graphited or equal.
P-314-2	110	15	—	RAS	1.08	1.0	x				3500	5	1 1/2	1	130	65	90	"Durtite"	Cast Iron	Square plaited braid blue African asbestos lubricated and graphited or equal.
P-325-1	80	100	—	40% NaOH	1.53	100		x			3600	7 1/2	2 1/2	1 1/2	140	100	110	Cast Iron or Cast Steel	Cast Iron	Square plaited braid blue African asbestos lubricated and graphited or equal.
P-325-2	90	6	—	40% NaOH	1.53	100		x			3500	2	1	3/4	95	80	65	Cast Iron or Cast Steel	Cast Iron	Square plaited braid blue African asbestos lubricated and graphited or equal.
P-327	80	100	—	40% NaOH	1.53	100		x			3600	7 1/2	2 1/2	1 1/2	140	100	110	Cast Iron or Cast Steel	Cast Iron	Square plaited braid blue African asbestos lubricated and graphited or equal.
P-331	95	30	—	60% HNO_3	1.37	2.3	x				3600	7 1/2	1 1/2	1	130	65	90	"Durtite"	Cast Iron	Square plaited braid blue African asbestos lubricated and graphited or equal.
P-363-1	195	100	—	Dmin. Water	1.0	1.0	x				3500	25	2	1 1/2	210	100	190	"Durtite"	Cast Iron	Square plaited braid white asbestos, lubricated and graphited or equal.
P-363-2	195	100	—	Dmin. Water	1.0	1.0	x				3500	25	2	1 1/2	210	100	190	"Durtite"	Cast Iron	Square plaited braid white asbestos, lubricated and graphited or equal.
P-351	75	50	6	Dilute	1.0	1.3			x		1800	5	2 1/2	2	78	50	76	Cast Iron or Cast Steel	Cast Iron	Square plaited braid white African asbestos lubricated and graphited or equal.
P-352	135	100	10	40% NaOH	1.53	100			x		1800	25	4	3	140	100	140	Cast Iron or Cast Steel	Cast Iron	Square plaited braid blue African asbestos lubricated and graphited or equal.
P-353	110	150	10	60% HNO_3	1.37	2.3			x		1800	30	6	5	115	150	115	347 S.S.	Cast Iron	Square plaited braid blue African asbestos lubricated and graphited or equal.
P-354	75	50	6	40% HNO_3	1.37	2.3			x		1800	7 1/2	2 1/2	2	78	50	76	347 S.S.	Cast Iron	Square plaited braid blue African asbestos lubricated and graphited or equal.
P-355	135	100	10	40% NaOH	1.53	100			x		1800	25	4	3	140	100	140	Cast Iron or Cast Steel	Cast Iron	Square plaited braid blue African asbestos lubricated and graphited or equal.
P-356	110	150	10	60% HNO_3	1.37	2.3			x		1800	30	6	5	115	150	115	347 S.S.	Cast Iron	Square plaited braid blue African asbestos lubricated and graphited or equal.
P-358	110	150	10	60% HNO_3	1.37	2.3			x		1800	30	6	5	115	150	115	347 S.S.	Cast Iron	Square plaited braid blue African asbestos lubricated and graphited or equal.
P-359	135	100	10	40% NaOH	1.53	100			x		1800	25	4	3	140	100	140	Cast Iron or Cast Steel	Cast Iron	Square plaited braid blue African asbestos lubricated and graphited or equal.
276-B-1 P-300	30	50	—	Kerosene	0.8	1.3		x			3600	1	1 3/4	1	42	50	35	Cast Iron or Cast Steel	Cast Iron	Square plaited braid blue African asbestos lubricated and graphited or equal.
P-301	56	25	—	TBP	1.0	3.3		x			3600	1	1 3/2	1	65	25	62	Cast Iron or Cast Steel	Cast Iron	Square plaited braid blue African asbestos lubricated and graphited or equal.
P-302	45	50	—	RAS	1.5	5.0	x				1750	3	2	1 1/2	55	50	48	"Durtite"	Cast Iron	Square plaited braid blue African asbestos lubricated and graphited or equal.
P-306	45	50	—	Caustic, Acid Aluminate Solution	1.5	5.0	x				1750	3	2	1 1/2	55	50	48	"Durtite"	Cast Iron	Square plaited braid blue African asbestos lubricated and graphited or equal.
P-308	30	25	—	Caustic, Acid Aluminate	1.0	1.0	x				3500	2	3/4	3/4	66	25	46	"Durtite"	Cast Iron	Square plaited braid blue African asbestos lubricated and graphited or equal.
271-B-1 P-320	70	200	—	Sodium Sulfite	1.05	1.1	x				1750	7 1/2	2	2	85	100	65	"Durtite"	Cast Iron	Square plaited braid blue African asbestos lubricated and graphited or equal.
P-399	56	25	—	TBP	1.0	3.3		x			3600	1	1 3/2	1	65	25	62	Cast Iron or Cast Steel	Cast Iron	Square plaited braid blue African asbestos lubricated and graphited or equal.

*Information not available when manual was prepared.
**"Durtite" is Ind Mn, 20% Cr, 18 Ni, 3.36 Si, 1.25% C.

Actual head developed at process flow rate.

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Figure XVII-1
SLUDGE PUMP

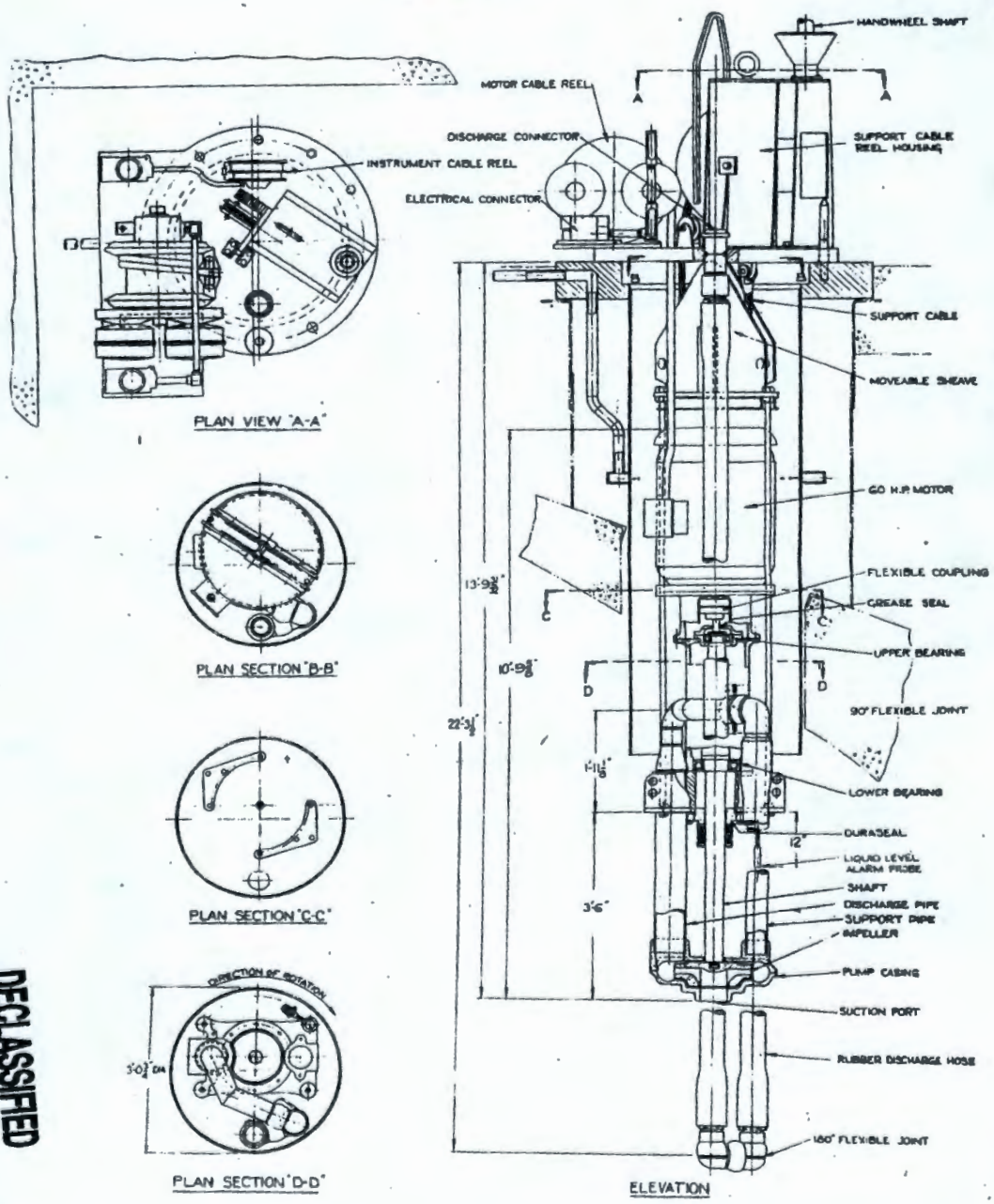

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Figure XVII - 2

SLUDGE PUMP CHARACTERISTICS

Speed 1180 Rev./Min.

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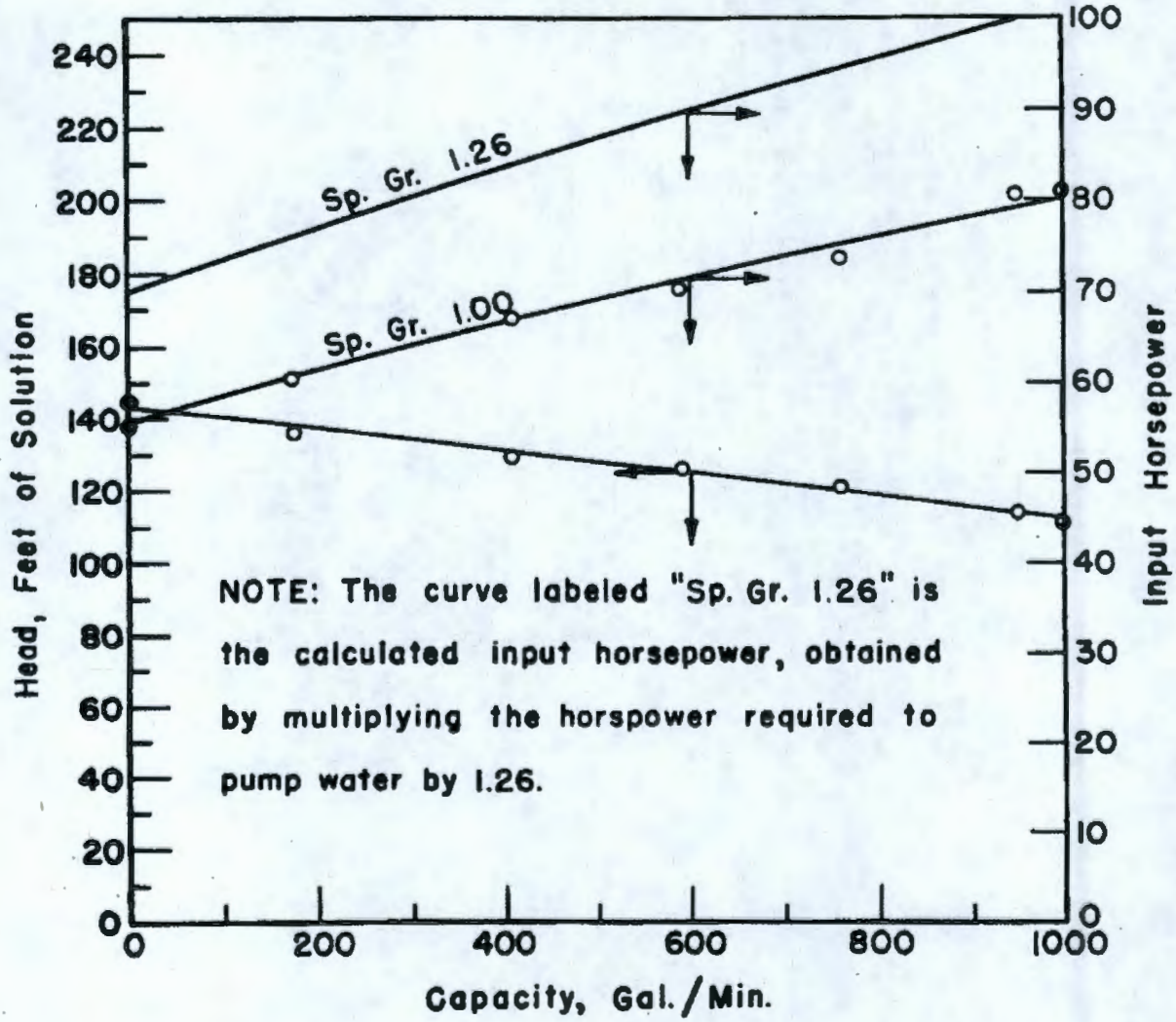

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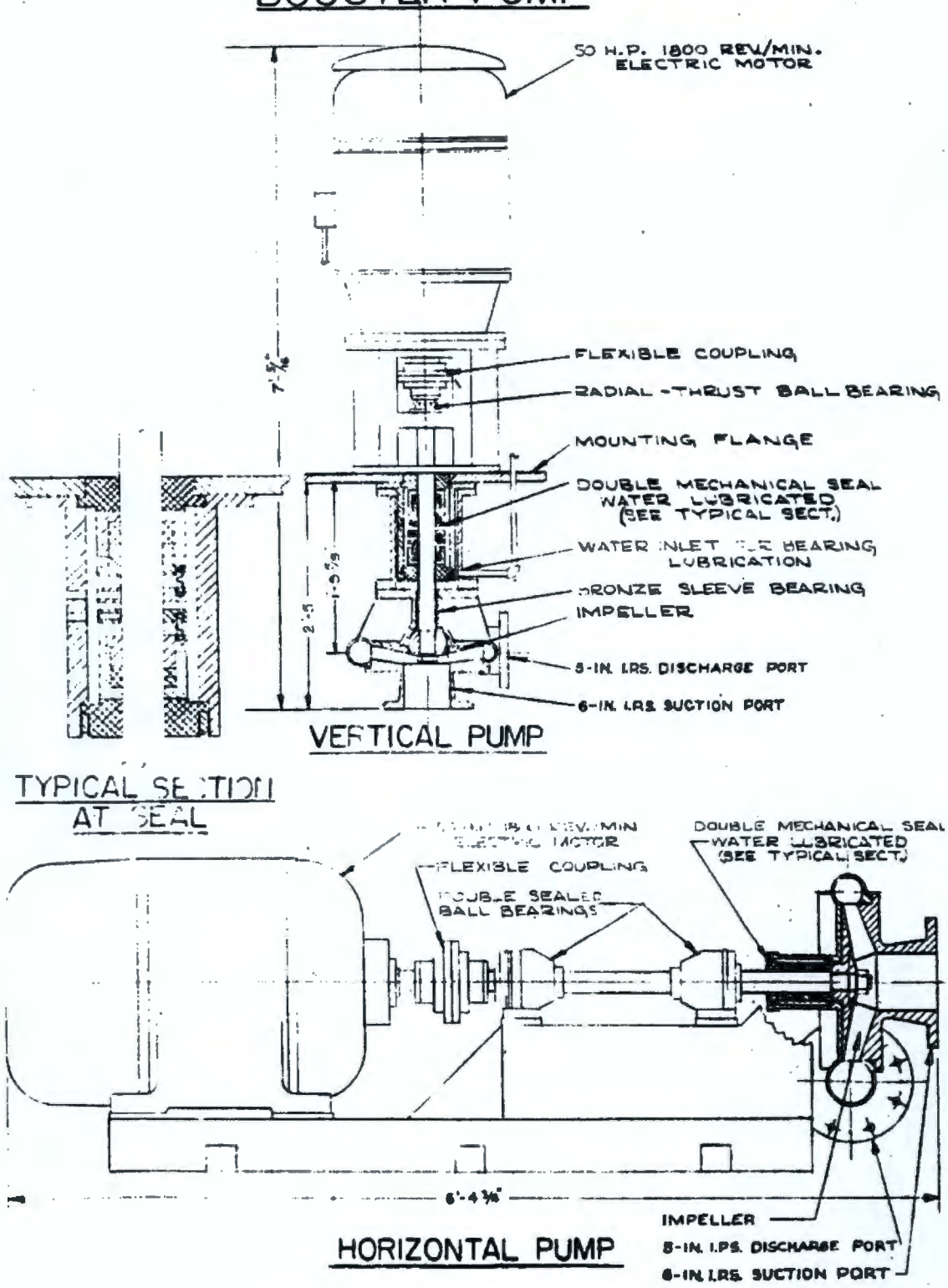
Figure XVII-3

BOOSTER PUMP



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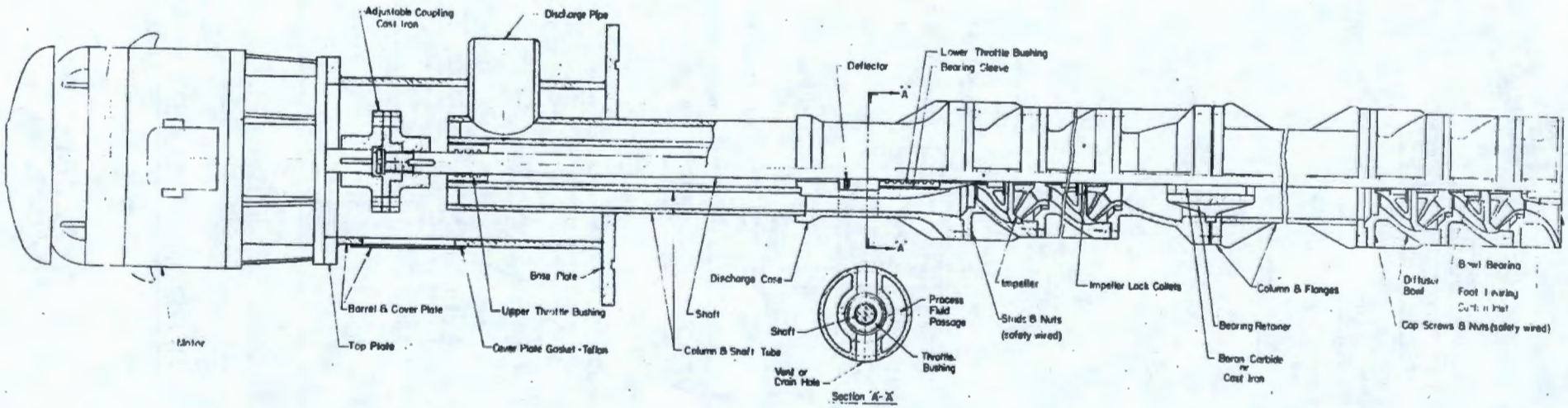

Figure XVII-4

TYPICAL "HOT" PUMP

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Figure XVII-5
"HOT" PUMP CHARACTERISTICS

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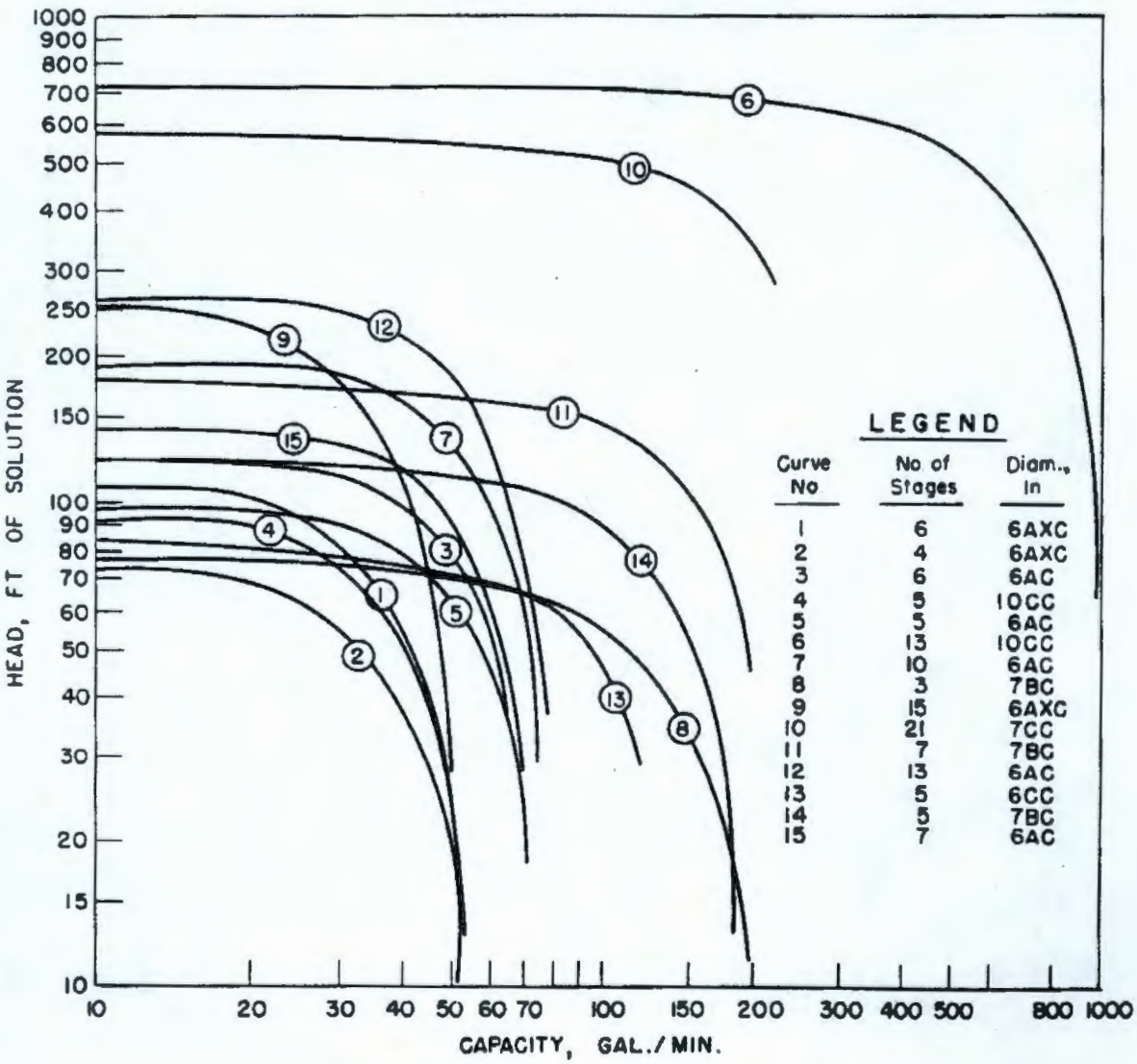

NOTE: The letters following stage diameters are Johnston Pump Co. symbols indicating shape of impellers & diffuser bowls.

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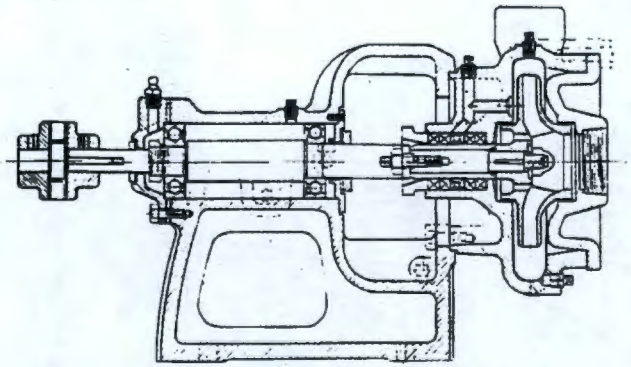
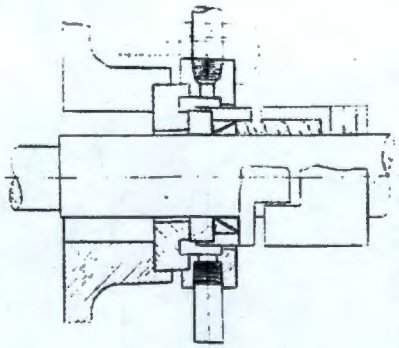
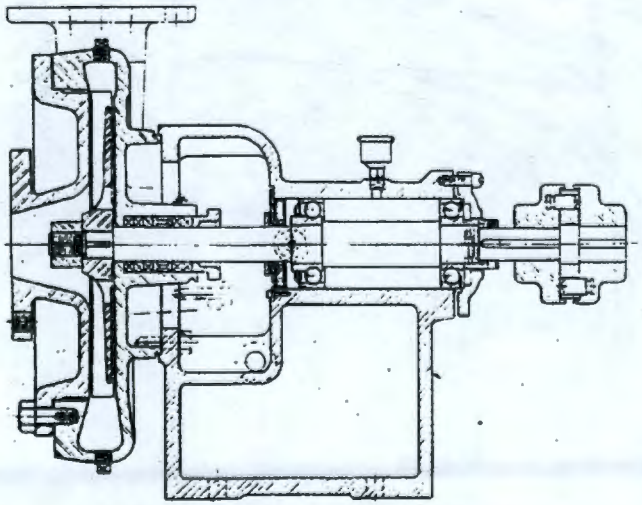
Figure XVII-6
"COLD" PUMPS



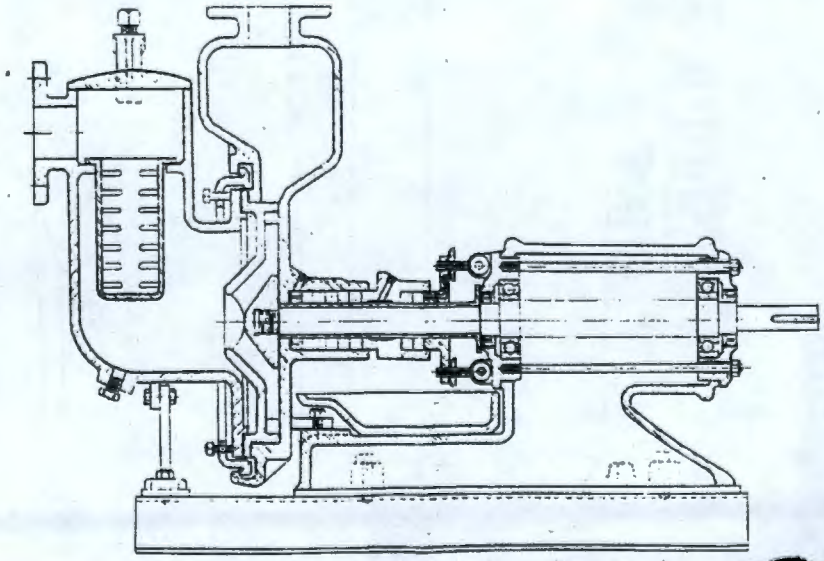
Worthington Type CN
Standard Pump



Seal for Worthington Type CG Pump



Worthington Type CG
Standard Pump



Nagle Self-Priming Pump

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FIGURE XVII-7
HEEL JET ASSEMBLY
(FROM-H-2-41294)

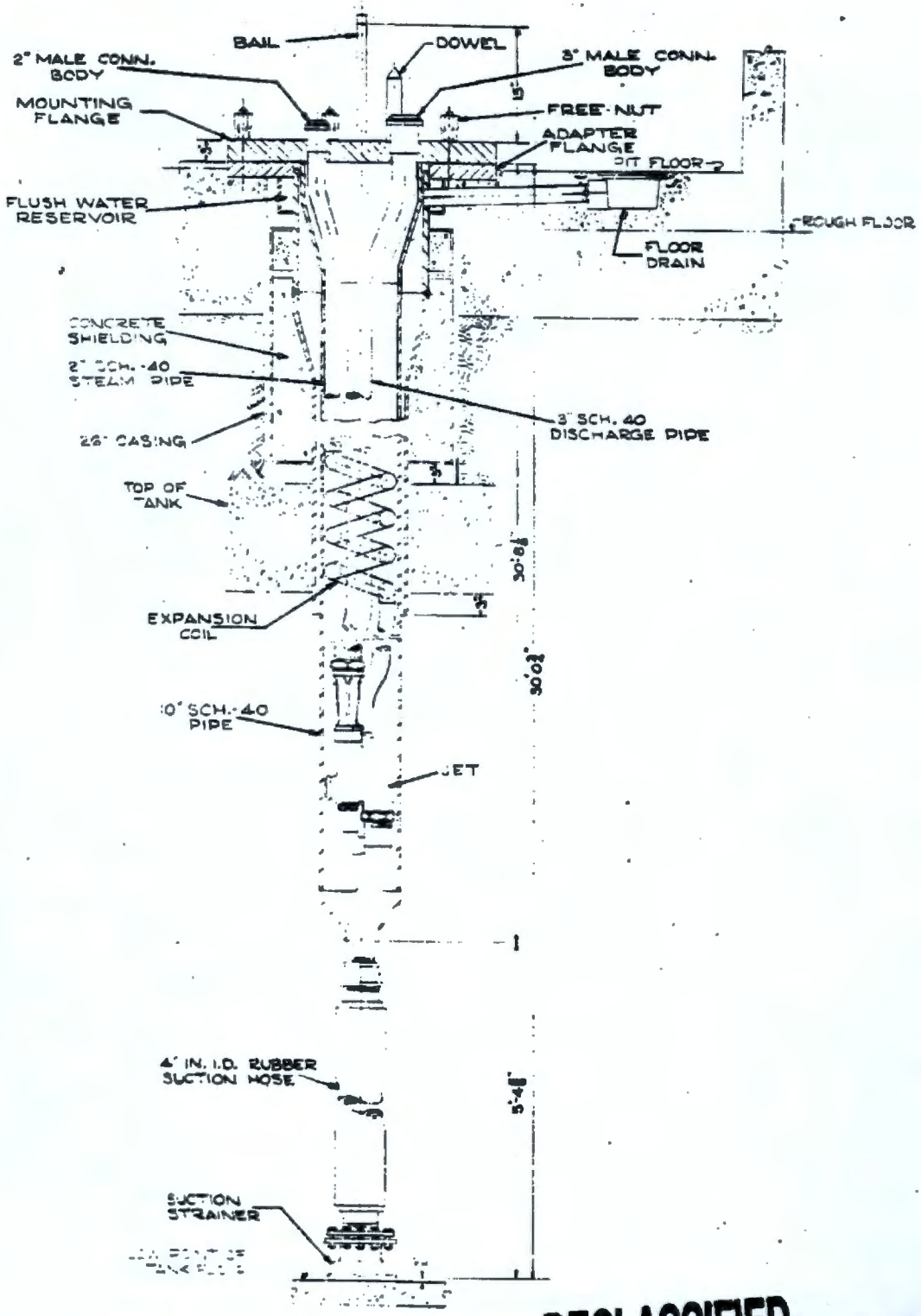

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Figure XVII-8

SLUDGE JET

(20 FT. DIAMETER STORAGE TANK)

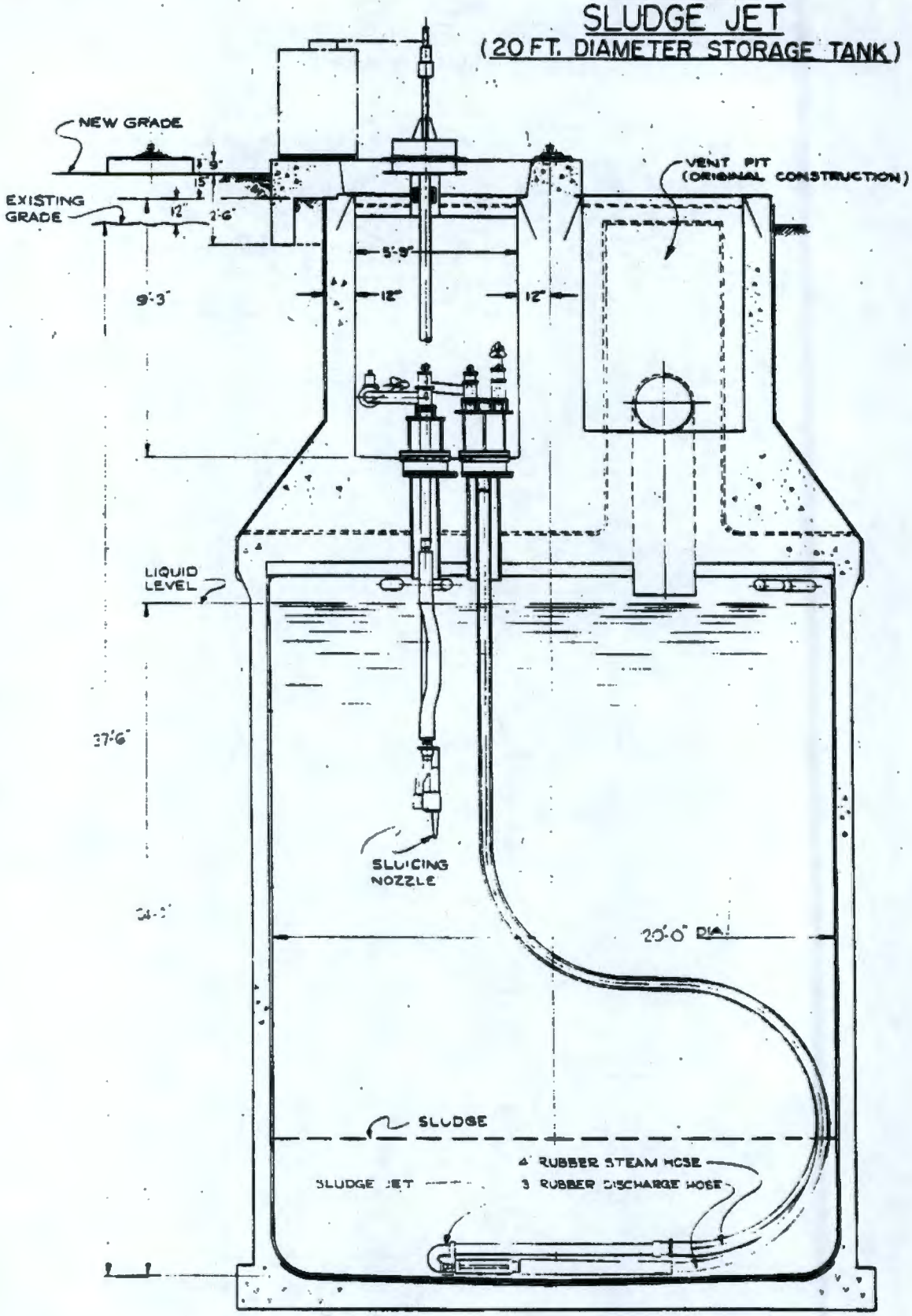

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Figure XVII-9

VACUUM TRANSFER SYSTEM
AND
FURNACE VENTILATION SYSTEM

224-U BLDG
ISOMETRIC SCHEMATIC

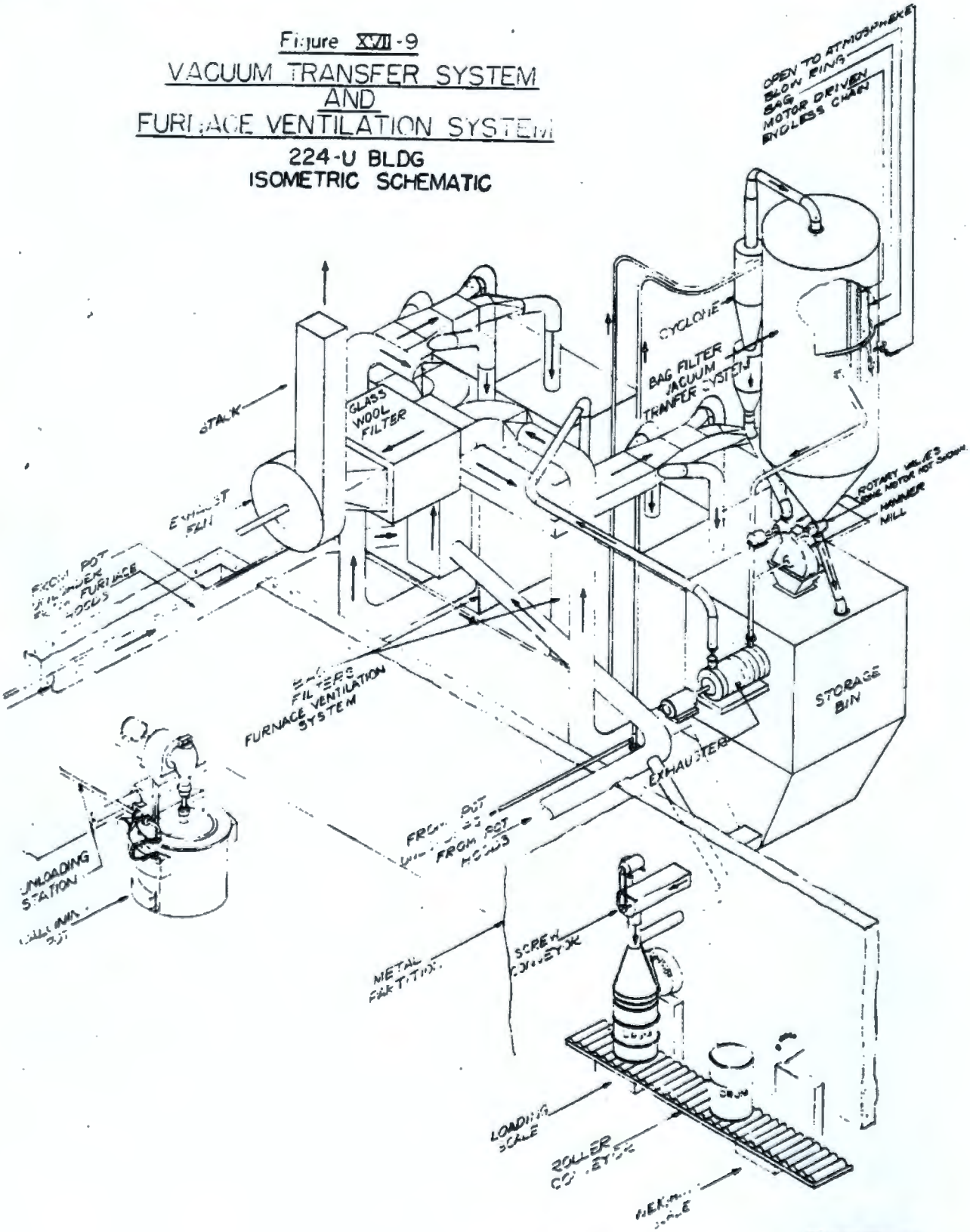

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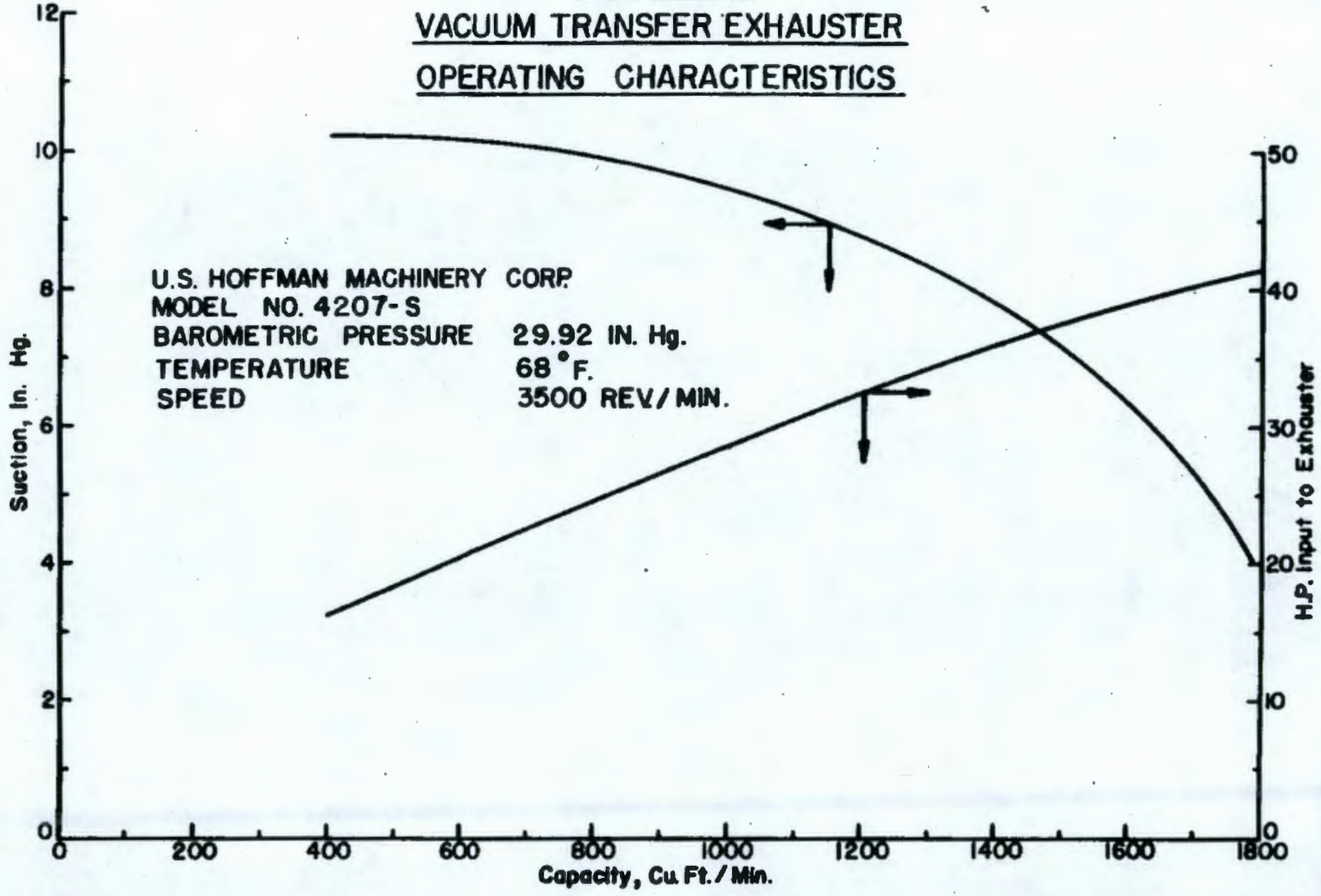
Figure XVII-10

VACUUM TRANSFER EXHAUSTER

OPERATING CHARACTERISTICS



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PART III: PLANT AND EQUIPMENT, continued

CHAPTER XVIII. REMOTE OPERATION AND MAINTENANCE

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A. PRINCIPLES OF REMOTE OPERATION AND MAINTENANCE 1802

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CHAPTER XVIII. REMOTE OPERATION AND MAINTENANCE

A. PRINCIPLES OF REMOTE OPERATION AND MAINTENANCE

The uranium removal and TBP process equipment has been designed to give trouble-free service and to require a minimum of maintenance and attention. However, it is recognized that it will be desirable or necessary to remove and replace certain equipment pieces or to revise piping. In order to accomplish equipment removal, replacement, or revision without exposing personnel to radiation hazards, remote handling equipment has been provided. A railway crane, with a shielded control cab equipped with periscopes, allows personnel to carry out a veriety of operations in the cells without danger of excessive exposure to radiation. A gantry crane with mirror type viewing devices is provided for use in uranium removal from underground storage. The cranes are equipped with travelling hoists, remote wrenches, and other specialized handling equipment.

Process piping, electrical conduit, and auxiliary lines are terminated in each cell or diversion box with male portions of remote connectors. Connection is made to cell equipment or other piping by means of removable jumpers, which are equipped at each end with the female portions of remote connectors. Process equpment is provided with male connector halves which mate with the female connector half on one end of the jumper. Each remote connector may be tightened or loosened by rotating a single hexagonal nut with an impact wrench operated from the crane. Each jumper has a lifting bail or eye positioned at the balance point. Thus intracell and diversion box piping may be removed remotely by breaking two connections with an impact wrench and lifting the piping from position with a crane hook.

Elements of process equipment are fastened together with studs and nuts that can be operated by an impact wrench. Thus, elements of process equipment may be removed independently from each other, e.g., pumps and agitators may be removed from process vessels. In order to change the routing of various process streams without using valves and interconnected piping, diversion boxes (special cells or trenches) are employed. Process streams which must be routed to various locations are transferred through pipe to a diversion box. The ends of the pipe terminate with male connector halves at the diversion box walls. Prefabricated, removable jumpers are used to make the desired pipe connections for routing the process streams to different locations.

Fixed relationships between piping and process equipment are maintained by the use of positioning guides and pins. In addition, piping and process equipment are fabricated to specific dimensions and checked for alignment in a Mock-up Shop (Building 277-U) before attempting installation in the "hot" area. The Mock-up Shop duplicates the process equipment positions in the cells.

A liquid-tight cylindrical casing, or "equipment removal thimble", is used in the uranium removal facilities areas to encase slurry pumps and sluicing nozzle units when the equipment is moved from tank to tank, to prevent the spreading of contamination.

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Contrasting colors are used to aid the crane operator in handling equipment remotely. The color system is the same as that used in the Redox and bismuth phosphate processes. In general, all lifting bails, connector nuts, dowel pins, etc., are painted yellow. The cell walls and floors are painted white. Equipment pieces, jumpers, connectors, cell covers, etc., are numbered in black.

B. CRANES

1. Canyon Cranes

1.1 75-ton crane(1)(2)

1.11 Function

The 75-ton capacity canyon crane is used to lift cover blocks, install and remove equipment, and perform other remote maintenance operations in the 221-U Building canyon area.

1.12 Description

The 75-ton crane is similar (identical except for minor revisions) to the cranes used in the bismuth phosphate process and is described and illustrated in the H.E.W. Technical Manual (HW-10475-C), pages 242-245.(1) The crane has a 75-ton capacity main hoist for lifting cell covers and heavy equipment, a 10-ton capacity secondary hoist, and two auxiliary hoists of 1/2 and 1-1/2 ton capacities on each of two trolleys for use with impact wrenches, grabbers, or other tools.

1.2 10-ton auxiliary crane(1)

1.21 Function

The 10-ton capacity auxiliary canyon crane, in the 221-U Building, is used for maintenance work where radiation hazards are not present.

1.22 Description

The 10-ton auxiliary crane is similar to those used in the 221-B and 221-T Buildings and has no provisions for shielding or ventilation. The crane utilizes the same railway and power supply as does the 75-ton crane.

2. Gantry Crane(5)

2.1 Function

The gantry crane is used in the uranium removal facilities for installing and removing pumps, sluicing nozzles, and other equipment and for making jumper changes in the diversion boxes.

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2.2 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 each diversion box or pit. Figure XVIII-1 is a sketch of the gantry crane.

2.21 Superstructure

The superstructure of the gantry crane is a steel frame supported on side members which are equipped with railway wheels that support and position the hoist monorail directly over the working area. The monorail is an 18-in. I-beam 26 ft. 7 in. long, positioned transversely 12 ft. 9 in. above the crane rails. One end of the monorail overhangs the railway 8 ft., and the other end overhangs 4 ft. 7 in. The side members allow a transverse clearance of 12 ft. 8 in. The center-to-center distance between the 70-lb. rails is 14 ft. 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 ft.

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2.22 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 are tabulated below.

Hoist Data

	10-Ton Hoist	1-Ton Hoist
Model	XE-1DC30M1Z	PC-1C38M15
Maximum Clearance, Hook Face to Top of Rails	7 ft.	9 ft. 10 in.
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.

2.23 Power system

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.

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A portable push-button control panel is provided for operating the crane. The control leads are of sufficient length to allow the operator to be at least 30 ft. from either side of the crane.

2.24 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.

2.25 Optical system

A system of mirrors may be employed to assist the crane operator in carrying out remote operation.

2.3 Operation

The crane and hoists may be operated from any point within 30 ft. 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 capacity hoist is used with an impact wrench for loosening and tightening remote connectors and equipment hold-down nuts.

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C. REMOTE CONNECTORS

1. Function

A remote connector is a device for remotely connecting process piping, electrical conduits, or auxiliary lines by means of an impact wrench operated from a crane.

2. Description

Each connector depends on three hooks or latches, which are mounted on the female portion of the connector and are actuated by the rotation of a hexagonal operating nut, to grasp or release the fixed, or male, portion of the connector. Two types of connectors are used. The connectors in the canyon area are Bismuth Phosphate Plant type connectors which have flat mating surfaces and flat gaskets. They are described and illustrated in the H.E.W. Technical Manual, Section C, pages 241 to 244 (HW-10473-C). The connectors in the waste storage areas are of the Redox Plant type and have spherically ground mating faces. They are described and illustrated in the Redox Technical Manual, Chapter XVIII (HW-18700). The Redox-type connectors, when used with non-corrosive solutions, are fabricated from carbon steel and are provided with stainless steel mating faces to resist atmospheric corrosion. When used with corrosive fluids, the mating surfaces and other parts in contact with

the fluid are of stainless steel. Three-inch operating nuts are used on the Redox-type connectors so that the same impact wrench may be used on both connector types.

D. SPECIAL TOOLS

1. Impact Wrench(2)

1.1 Function

Impact wrenches are used to make and break the remote connectors and to rotate the remote hold-down nuts on tanks, columns, and other equipment.

1.2 Description

An electrically driven, reversible impact wrench is described and illustrated in the Redox Technical Manual, Chapter XVIII (HW-18700). The wrenches are suspended from auxiliary hoists which are integral with the canyon and gantry cranes.

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2. Grabber(2)

2.1 Function

A grabber is a clam-shell bucket device suspended from a crane hoist and is used for the remote handling of small pieces of equipment that cannot be easily picked up with a crane hook.

2.2 Description

A grabber is described in the Redox Technical Manual, Chapter XVIII (HW-18700).

E. DIVERSION BOXES(1)(2)(3)(4)(5)

1. Function

Diversion boxes are provided to reduce duplication of piping and to allow desired changes in piping arrangements without the use of valves. For example, the same aqueous waste line may be used to fill several cascades of waste tanks by changing jumpers to the next cascade feeder line as each cascade is filled. The use of diversion boxes is discussed in the H.E.W. Technical Manual, pages 293, 905-911 (HW-10475-C) and the Redox Technical Manual, Chapter XI (HW-18700).

2. Description

The diversion boxes are concrete-lined pits with concrete cover blocks. The ends of underground transfer lines, fitted with male connector halves, are imbedded in the walls and floors of the boxes. Jumper lines ending with female connector halves are used to connect the piping in the desired arrangement.

The diversion boxes built for use with the Bismuth Phosphate Plant have all male connector halves on one wall and use the Bismuth Phosphate Plant type connectors.

The diversion boxes built for the Waste Metal Recovery Plant are similar in design, but have both wall and floor connectors of the Redox Plant type. Where frequent jumper changes would be necessary during routine operation, jumpers equipped with valves are used. The valve handles extend through the diversion box cover blocks with labyrinth-type radiation shielding around the valve handle extension. Nordstrom lubricated plug valves are used in jumpers carrying alkaline solutions and bellows-sealed Y-valves are used in acid lines. Storage space for spare and contaminated jumpers is provided. Each diversion box is equipped with spray flushing nozzles and drains.

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F. EQUIPMENT REMOVAL THIMBLE

1. Function

The equipment removal thimble is used in the uranium removal facilities area to encase "hot" slurry pumps or sluicing nozzle assemblies. The equipment may then be moved to another tank or to the disposal area without spreading contamination.

2. Description

The equipment removal thimble consists of a cylindrical shell about 7 ft. in diameter and about 40 ft. high. The upper end is closed and provided with a lifting bail. A 5-ton capacity air-operated winch equipped with a safety hook is located inside the shell at the upper end.

The bottom of the thimble is fitted with a neoprene gasketed closure pan, which is held in place by air operated latches. The latches also have manually-operated eccentric closing levers. The diameter of the pan is enlarged below the gasketed joint to allow a liquid holdup capacity of several gallons. Thus, any drainage of process solution from encased equipment is prevented from submerging the joint between the pan and the thimble when the assembly is transported in a horizontal position. A quick-opening valve and a short length of flexible tubing are used to drain the pan.

Both ends of the thimble are equipped with trunnions that match trunnion supports on a special truck used to transport the thimble. The thimble is transported in a horizontal position.

3. Operation

To remove a pump or sluicing nozzle from a tank, the thimble is lowered with a jib crane over the open pit. The hook of the air operated

winch is lowered and engaged with the lifting bail of the equipment to be removed. The equipment piece is then raised by the winch into the thimble. The safety hook closes when load is applied. This prevents the hook from disengaging the lifting bail while the thimble is in transit. The thimble, containing the equipment, is next lowered over the closure pan, the air operated latches are engaged, and the manually-operated eccentrics are tightened. The entire unit is moved over the trunnion supports of the truck, the bottom trunnions are engaged, and the thimble is lowered to a horizontal position. The operation is reversed to install the equipment at its new location.

G. REMOTE INSTALLATION AND REMOVAL OF EQUIPMENT(1)(2)

General methods of remote installation and removal of equipment are discussed in the Redox Technical Manual, Chapter XVIII (HW-18700).(2)

An S.W.P. area and a decontamination room have been provided at the northeast end of the operating gallery in Building 221-U. The S.W.P. area is 14 ft. wide and 50 ft. long and may be entered from the operating gallery through a 3-ft. by 7-ft. doorway. The canyon may be entered at the deck level between cells 3 and 4 from the S.W.P. area through an air lock and a 1-ft. 11-1/2-in. by 6-ft. 9-in. doorway. The decontamination room is 12 ft. by 14 ft. and is entered from the S.W.P. area through a doorway 6 ft. wide and 7 ft. high. The decontamination room is equipped with a hooded sink. No remote shop is provided in the 221-U Building.

New equipment is tested for alignment in a Mock-up Shop (Building 277-U). After each equipment piece is fabricated, it is assembled in a dummy cell and inspected for proper fit and operation before installation in a "hot" process cell.

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REFERENCES

(1) HW-10475-C H.E.W. Technical Manual, Section C. Author not stated. 5-1-44. Pp. 240-245.

(2) HW-18700 Redox Technical Manual. Chapter XVIII. Author not stated.

(3) HDC-1799 General Description of Underground Fluid Transfer System for the Waste Metal Recovery Project. J. M. Frame and W. P. Lamb. 6-13-50.

(4) KLX-1071 (INDC-4297) Waste Metal Removal and Recovery Facilities, Design Proposal, Phase I, Waste Metal Removal, Job 15E. G. White, Jr. 5-27-50.

(5) KLX-1077 Waste Metal Removal and Recovery Facilities, Design Proposal, Phase II, Waste Metal Removal, Job 15E. G. A. Vincent. 9-15-50.

(6) BPF 2973 Mobile Gantry Crane.

(7) BPF 65106 Canyon Cranes.

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Figure XVIII-1
MOBILE GANTRY CRANE
(FROM B.P.F. Nº 2973)

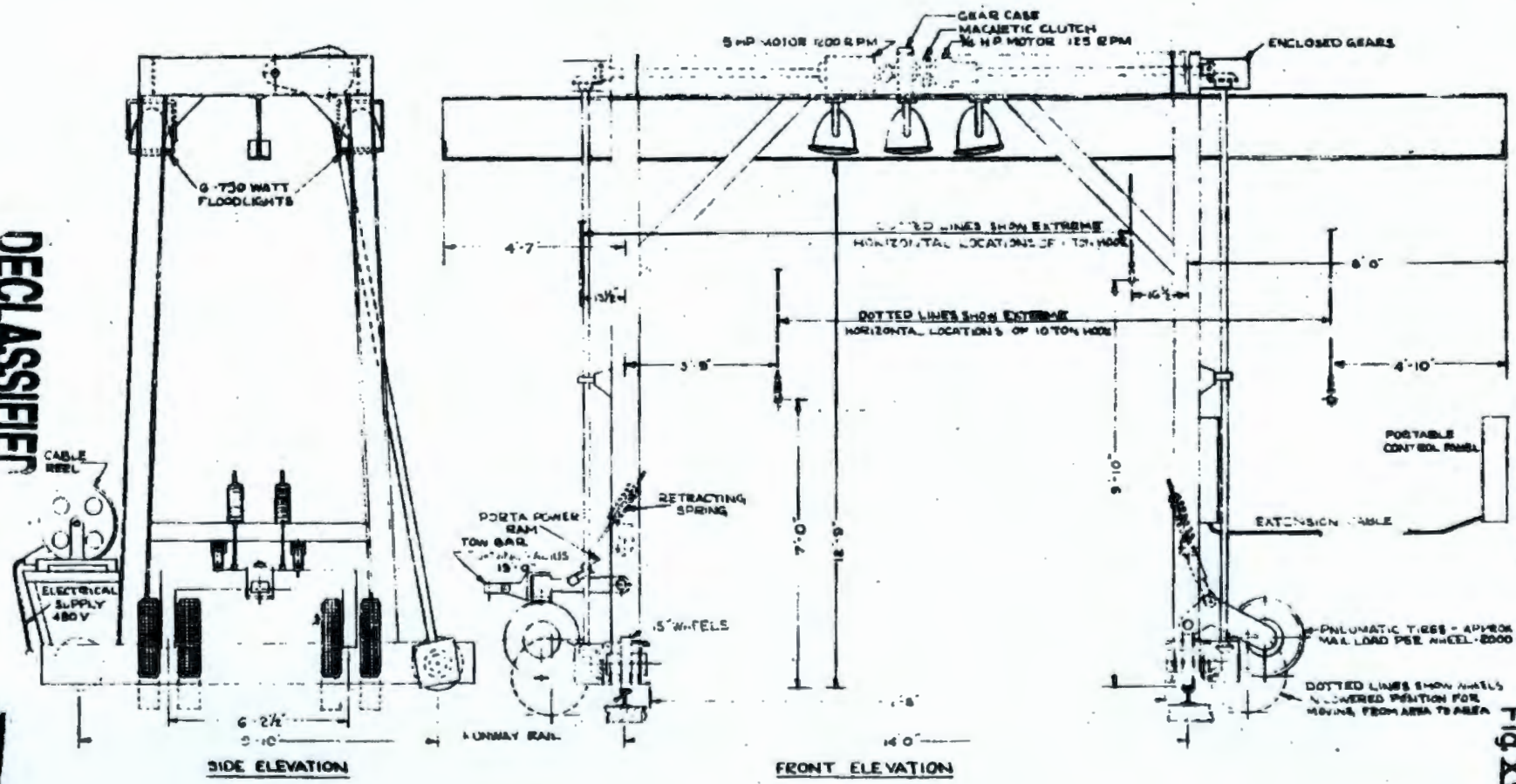

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Fig. XVIII-1

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PART IV: PROCESS CONTROL

CHAPTER XIX: INSTRUMENTATION

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CHAPTER XIX. INSTRUMENTATION

A. INTRODUCTION

In the Uranium Recovery Plant, industrial instruments are used for measuring, recording, and controlling the process variables to maintain steady operating, to monitor mechanical performance, and to aid in determining energy and material balances. Continuous processing, which is employed in extraction columns and in concentrators, requires that automatic instrumentation assume most of the control functions for flow rate, specific gravity, weight factor, and temperature of numerous streams and vessels. The control functions, performed automatically by instrumentation or manually by operating personnel, must also be detected by indicating or recording instruments, which, in many instances, supply the only information available to the operator of the status of the equipment and the process. In addition to the instruments required by the process, instruments are used for numerous non-process applications, as in the determination of radioactivity and in detecting abnormal mechanical conditions.

This chapter is intended to be supplemented by the Redox Technical Manual, the H.E.W. Technical Manual, and by standard reference works on instrumentation, such as "Chemical Engineers' Handbook", by J. H. Perry, and "Industrial Instruments for Measurement and Control", by T. J. Rhodes.

B. INSTRUMENT FLOW DIAGRAMS (Figures XIX-1 to XIX-9)

The instrument flow diagrams show schematically, for each instrument, (a) the location with respect to process functions and equipment, (b) the variable measured, and (c) the type of instrument, i.e., indicating, recording, transmitting, or controlling. They also show schematically the instrument piping or wiring system and the component functional parts of each instrument. The diagrams are essentially simplified engineering flow diagrams emphasizing the instrumentation.

The diagrams are presented on several sheets, each being designed to represent equipment in a single cell or section. The location of the equipment on the sheets is intended to follow a generalized pattern: (a) the instruments on the graphic panel boards are shown in the upper portions of the sheet, (b) the instruments on local panel boards and non-radioactive process lines are shown in the middle of the sheet, and (c) the equipment and instruments which are in contact with "hot" solutions or which are located in radioactive areas of the plant are shown on the lower portion of the sheet, which is schematically separated from the "cold" process areas by a simulated wall section.

The following information appears in the legend near the instrument symbols: (a) the equipment piece designation, which indicates both the type of instrument and its location; (b) the range through which the measured variable may vary without exceeding the useful range of the instrument; and (c) the number of the pertinent instrument data sheet,

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which is a further source of information about the instrument.

Since many of the vessels in the plant are instrumented according to the same scheme, only typical instrument flow diagrams are shown. The reader may refer to the engineering flow diagrams, presented in Chapter XIV, and determine what instrumentation is provided on particular vessels. This information may then be used to compare instrument systems which are shown in the instrument flow diagram with those for which the diagrams have been omitted to avoid duplication. The instrument flow diagrams, showing typical instrument installations and details, are shown in Figures XIX-1 through XIX-9. Instrument symbol legends for the instrument flow diagrams are presented on Figure XIX-9 and in Table XIX-1.

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C. INSTRUMENT PANEL BOARDS

The recording and indicating elements for instruments associated with process functions are mounted on steel panel boards located either near the cell or on centrally located graphic panel boards in the Operating Gallery. The local boards consist of standard panel sections containing weight factor and specific gravity instruments, either manometers or ring-balance-type recorders, radiation dectection equipment, purge-gas bubblers, cell pressure draft gauges, centrifuge and agitator motor controls, and jet controls. In addition to the local panel boards, four graphic panels, shown in Figures XIX-10 through XIX-12, provide a centrally located control station for the continuous operations of the process, viz., concentration, solvent-extraction, and distillation. These panels contain (a) temperature, weight factor, specific gravity, flow, pH, interface and static pressure recorders, which are circular-chart, single- or multiple-point recorders, located at the bottom of the panel board, and (b) indicators and indicator-controllers for weight factor, pH, temperature, flow, pressure, and interface, which are placed either in silhouettes which represent the vessels or near the line representing the streams which are measured.

D. INSTRUMENT DESCRIPTIONS

Because the instrumentation in the Uranium Recovery Plant is similar to that used in the Redox Plant, the reader is referred to the Redox Technical Manual, HW-18700, Chapter XIX, for information concerning the theory, application, and description of instruments which are common to the two plants. The information presented in this Chapter supplements the information presented in Chapter XIX of the Redox Technical Manual by emphasizing and describing only those instruments in the Uranium Recovery Plant which differ from those used in the Redox Plant.

1. Radiation Instruments

Ion chamber radiation detection instruments are installed in the process and operating areas of the Uranium Recovery Plant to measure and

record the intensity of gamma radiation as aids to process control and health protection. The instruments are described in the Redox Technical Manual, HW-18700, Chapter XIX.

2. Visual and Auditory Aids

2.1 Visual aids

Periscopes and mirrors are used to view around opaque shielding into radioactive areas. The 221-U Building (TBP Plant) crane has two periscopes, which are described in the H.E.W. Technical Manual, HW-10475, page 1011. These periscopes may be adjusted to two magnifications and may be rotated and traversed to view the entire canyon.

Other optical devices are used in the 241 Tank Farms. A periscope is lowered into a steel and glass sheath in the underground storage tanks to inspect the sludge-removal operation. The gantry crane operator makes use of a mirror to view radioactive areas from behind shielding.

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2.2 Auditory aids

Microphones are installed on the two centrifuges and on all tanks equipped with agitators and pumps. Sound originating in the cells actuates a microphone, and the signal is transmitted to a speaker on the panel boards. From the quality of the sound, operating personnel may detect irregular mechanical operation as well as monitor normal operation.

3. Flow Measurement and Control Devices

The Redox Technical Manual, HW-18700, contains a detailed description of the basic principles of flow measurement and control as obtained by means of rotameters, orifice meters, and metering pumps. The Uranium Recovery Plant employs the same types of flow measuring and controlling instruments with few major exceptions.

The flow rate measurement of controlled process streams is performed by means of rotameters and orifice meters. Electrical transmitting rotameters measure the flow rate of all the extraction column feed streams. The ranges of the rotameters and the specific gravity of the measured streams are listed in Table XIX-2. All other flow measuring devices for radioactive controlled streams, as well as for steam and water, are orifice meters. Data pertinent to orifice meters which are used to measure the flow rate of radioactive process streams may also be found in Table XIX-2.

The specific instruments which are used in the Uranium Recovery Plant and which have not been described in the Redox Technical Manual, HW-18700, Chapter XIX, are: (a) a pneumatic transmitting rotameter, which measures the flow rate of RCX make-up water; (b) small indicator-controllers, which are located in the graphic pattern of the graphic panel boards; (c) pneumatic relays, which convert the signal from an electrical transmitting rotameter into a pneumatic signal required to

activate the graphic panel board indicating instruments; (d) a flow ratio controller, which proportions the flow of caustic soda solution to that of waste solution into the Waste Neutralizer; and (e) a turbine-type flow meter, which measures the volume of waste solution transferred to underground storage tanks. These instruments are described below.

3.1 Pneumatic rotameter

A pneumatic transmitting rotameter is used to measure the flow rate of RCX make-up water and to control the stroke length of a metering pump which feeds nitric acid into a blend tank in which RCX is prepared. The water flow rate, which is controlled to maintain a constant liquid level in the blend tank, determines the position of the rotameter float. The attraction between magnets, located in an extension on the float and on a lever outside the tube in which the float extension moves, causes the lever and an air relay to be positioned according to the float position and the flow rate. A pneumatic signal from the relay actuates a flow recorder and also controls the stroke length of the nitric acid metering pump. The stroke of the pump may be controlled either manually or automatically, according to the position of a valve in the air line between the rotameter air relay or pressure control station, and the stroke control. This arrangement allows from 5.8 to 58 gal./min. of water to be acidified continuously with from 0.0 to 0.05 gal./min. of nitric acid.

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3.2 Manual-automatic control station

Small, easily read indicator controllers are used on the graphic panel board for nearly all automatic control operations. The instruments, which are Foxboro Consotrol controllers, are 3-3/8 inches wide by 7-3/8 inches tall and are mounted on the graphic panel board near the symbol of the equipment which is operated. The instrument comprises two parts: a lower unit, which is equipped with a selector valve, a pressure regulating valve and a pressure gauge, allows the selection of either manual or automatic control; and the upper unit, which is equipped with an indicating pointer and a control set pointer on a vertical linear or square-root scale, provides, through bellows and relays, the control air signals necessary for automatic control.

With the selector valve set for manual control, the controlled element is pneumatically loaded by manual adjustment of the pressure-regulating valve. Under automatic control, however, the control set point is positioned either automatically by a signal from another controller or manually. The control station adjusts the air pressure to the controlled element (either a diaphragm-motor valve or another controller) according to the difference in scale reading of the indicator pointer and the set pointer, until the indicated flow coincides with the desired flow.

3.3 Electric-to-pneumatic converter

The electrical signal from induction-type rotameters is converted into an air signal by an air relay connected through mechanical linkages

to the recorder pen. This air signal actuates either an indicator or an indicator-controller. The signal pressure varies linearly from 3 to 15 lb/sq.in.ga. as the chart reading changes from 0 to 100 per cent.

3.4 Flow ratio controller

The aqueous waste solutions from the solvent-extraction columns are neutralized with caustic soda solution semi-continuously in a neutralizer tank. The flow rates of both the waste and the caustic soda solution are measured by orifice meters and are controlled automatically by Foxboro Consotrol instruments. An intermediate instrument, the flow-ratio controller, may also be used to adjust the set pointer of the caustic soda solution controller according to the flow of waste solution. The flow-ratio controller, which is actuated by the same pneumatic signal that actuates the waste stream flow controller, transmits to the caustic solution flow controller a pneumatic signal that varies from the actuating signal by a ratio with which the ratio controller is manually adjusted. In this manner, the two flow rates into the Neutralizer may be maintained in the proper ratio.

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3.5 Turbine-type flow meter

The flow rate of concentrated neutralized aqueous process waste solution is measured as the material is pumped to underground storage tanks. The measuring instrument, which is manufactured by the Potter Aeronautical Company, utilizes a stainless steel rotor having a magnetic core inside the pipeline to generate an alternating electric current in a pick-up coil mounted in the pipe wall. The rotor, which is especially shaped to reduce thrust on the graphite-teflon bearings, rotates at a speed proportional to the velocity of the fluid in the pipe. The generated electric current, which has a frequency proportional to the volumetric flow rate, is amplified, rectified, recorded, and integrated by an electronic potentiometer. Thus a measure of the rate and of the total flow that has passed through the pipe is provided.

The volumetric accuracy of the system is ± 1/2 per cent. The measurement is essentially independent of viscosity, temperature, and specific gravity. The range of these instruments is from 3.5 to 90 gal./min.

4. Purge-Type Instruments

As in the Redox Plant, gas-purged pressure instruments are used in the Uranium Recovery Plant to measure interface level, weight factor, specific gravity, and static and differential pressures. Most of the applications of purge-type instruments are similar in the two plants. The following applications, however, are specific for the Uranium Recovery Plant:

(a) The differential pressure sensed by weight factor dip tubes is transmitted to panel board recorders by a Foxboro d/p Cell as a 3 to 15-lb./sq.in.ga. air pressure signal.

(b) Interface dip tubes have a six-inch span.

to 30 inches of water and is nearly the same as the gauge pressure in the Concentrator, is transmitted by a Foxboro d/p Cell to a dial pressure indicator. The pressure thus indicated may be used as a guide in operating both the Concentrator and the Nitric Acid Fractionator.

5. Pressure Instruments

Most of the pressure instruments in the Uranium Recovery Plant are standard Bourdon-tube dial gauges. Two types of controllers, however, are used: (a) The fractionating tower condenser and the calcination pots are maintained under partial vacuum by a steam jet evacuator. Excessive negative pressures are prevented by bleeding air into the suction side of the jet. (b) In the vapor recovery flash tank system, in which the condensate from the RCU Concentrators is flashed from high (approximately 100-lb./sq.in.) pressure to lower pressure and the vapors are compressed to controlled pressures (approximately 30 and 100 lb./sq.in.) by steam jets, the pressure is controlled by throttling the 225-lb./sq.in. motive steam into the jets. The discharge pressure of each jet actuates the indicator of a pressure indicator-controller, which then sends a control air signal to a diaphragm motor valve on the jet steam supply line, thus throttling the motive steam and thereby controlling the jet discharge pressure.

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6. Temperature Instruments

The principles and application of mercury and resistance thermometers are discussed in the Redox Technical Manual, HW-18700, Chapter XIX. These principles apply to many of the Uranium Recovery Plant instruments. The following discussion describes some specific temperature instrument installations in the Uranium Recovery Plant which differ from those used in the Redox Plant. These instruments, described below, are (a) resistance thermometers with pneumatic transmitters and (b) thermocouples with indicating-controlling pyrometers.

6.1 Resistance thermometers with pneumatic transmitters

The use of air-operated temperature indicators on the graphic panel board requires that in many instruments the electrical measurement of temperature be converted into an air signal. This is accomplished by a Foxboro Dynalog instrument, which measures the impedance of a temperature-sensitive resistance element, records the temperature, and, through an air relay connected mechanically to the recording mechanism, transmits an air signal (3 to 15 lb./sq.in.) to the receiving instrument (either an indicator or an indicator-controller). For a multipoint record, a six-point single-pen chart recorder is used. One recorder-converter may measure six different temperatures and indicate them on individual indicators.

6.2 Calcination furnace pyrometers

The temperatures of the calcination furnace pots and heaters are measured and controlled by thermocouples and indicating controlling pyrometers. Each calcination pot is heated and cooled through a cycle

(c) Water is used as a purge fluid in measuring static pressure in the vapor space of the RCU Concentrators to prevent plugging of the tube by crystals. Humidified air is used as the purge gas in all other purged instruments. The low volatility and flammability of the solvent that is used renders it unnecessary to use an inert-gas purge.

4.1 Weight factor instruments

In many installations the weight factor signal is transmitted to the panel board recorders by a Foxboro d/p Cell. If the weight factor signal is required to actuate two or more instruments (a panel board recorder and a controller, for example), it is necessary to boost the signal, as measured in the dip tubes, by a transmitter which boosts the pressure in the long transmission lines to 3 to 15 lb./sq.in.ga. In addition, since the output signal from the transmitters has a standard range of 3 to 15 lb./sq.in.ga. pressure, the receiving elements of the instruments have been standardized to receive signals in this pressure range.

Ring-balance-type instruments, which are in some installations used for recording weight factor and specific gravity, are mounted on the local panel boards. This type of instrument is described in the H.E.W. Technical Manual, Section C, HW-10475.

4.2 Interface instruments

Three dip tubes, spaced vertically at 6-in. intervals, are installed in the top of each solvent-extraction column to measure the position of the interface and the specific gravity of the organic phase above the interface. The differential pressure between the top dip tube and the center dip tube is transmitted as a 3 to 15-lb./sq.in.ga. air signal, by a Republic Instrument Company transmitter to a six-point recorder. The transmitter has an input range of 4.8 to 6.8 inches of water pressure (equivalent to a specific gravity range of 0.80 to 1.13). The differential pressure between the center and bottom dip tubes, which is proportional to the apparent average of the specific gravities of the liquids between the dip tubes, is also transmitted by a Republic transmitter and is recorded on the same chart that records the specific gravity of the organic phase above the interface (top pair of dip tubes). In addition, the transmitted signal from the lower dip tubes actuates the indicating pointer of an interface controller. This controller, a Foxboro Company Consotrol, controls the position of the column interface by controlling the stem position of the valve on the column aqueous effluent line.

4.3 Water-purged static-pressure instrument

Water instead of air is used as a purge fluid in the static pressure tubes of the RCU Concentrators to prevent crystals from accumulating and plugging the tubes. The purge line into the vapor space of the RCU Concentrators is continuously flushed with from 20 to 200 ml./min. of water. The gauge pressure of this water, which is in the range of zero

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recorded on a Bristol Company single-point chart recorder. When the conductivity of the sump liquid reaches a specified value (to be determined by "cold" operation), an alarm is activated on the annunciator board.

7.5 Alarm annuciator

A panel board in the 221-U Building Operating Gallery is equipped with lights, horns, and drop tabs to annunciate unusual conditions in process equipment to which it is connected by switches. The various conditions which actuate the Panalarm Company annunciator include the following: high and low weight factors, high sump conductivity, and low water flow rates to concentrator cooler coils.

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TABLE XIX-1

INSTRUMENT SYMBOL LEGEND

Symbol	Instrument or Equipment Piece
AH	Alarm Horn
AI	Ampere Indicator
AMP	Amplifier
CE	Conductivity Instrument, Sensitive Element
CR	Conductivity Recorder
CV	Control Valve
DM	Displacement Meter
DMC	Displacement Meter with Volume Limit Control
DPI	Differential Pressure Indicator
DPM	Differential Pressure Transmitter
EOAS	Electrical Operability Alarm Switch
FAL	Flow Alarm Light
FAS	Flow Alarm Switch
FE	Flow Sensing Element
FI	Flow Indicator
FIC	Flow Indicator Controller
FIM	Indicating Flow Transmitter
FM	Flow Transmitter
FR	Flow Recorder
FRC	Flow Recorder Controller
FR(C)	Flow Recorder with air signal to Controller
FR(I)	Flow Recorder with air signal to Indicator
FRI	Flow Recorder Integrater
FT	Flow Transmitter
GG	Gauge Glass
II	Interface Indicator
IM	Interface Transmitter
IR	Interface Recorder
IRC	Interface Recorder Controller
JC	Jet Control
LC	Level Controller
LLI	Liquid Level Indicator
MC	Manual Automatic Control Station
MK	Microphone ("MK" also refers to the Mark Number on the Instrument Data Sheet)
MKS	Microphone Selector Switch
ML	Motor Light
MS	Motor Switch
N.C.	Normally closed, air-to-open
N.O.	Normally open, air-to-close
P	Pump
pHA	pH Amplifier
pH AMP	pH Amplifier
pHE	pH Electrode
pHI	pH Indicator
pHR	pH Recorder
PI	Pressure Indicator
PIC	Pressure Indicator Controller
PM	Pressure Transmitter
PR	Pressure Recorder
PRV	Pressure Regulating Valve
PS	Pressure Switch
PSI	Pulse Speed Indicator
R	Purge Gas Rotameter
RA	Radiation Amplifier
RE	Radiation Ion Chamber
RR	Radiation Recorder
RS	Radiation Selector Switch
RS	Reset Switch
SC	Speed Control
SE	Speed Instrument, Sensitive Element
SGI	Specific Gravity Indicator
SGIC	Specific Gravity Indicator Controller
SGM	Specific Gravity Transmitter
SGR	Specific Gravity Recorder
SI	Speed Indicator
SPK	Speaker
SV	Safety Valve
SV	Selector Valve
TAL	Temperature Alarm Light
TAS	Temperature Alarm Switch
TC	Temperature Controller
TCV	Temperature-Controlled Valve
TE	Temperature-Sensitive Element
TI	Temperature Indicator
TR	Temperature Recorder
TR(C)	Temperature Recorder with air signal to Controller
VE	Vibration-Sensitive Element
VE	Electrically Operated Valve
VI	Vibration Indicator
VOL.C.	Volume Control
WFAL	Weight Factor Alarm Light
WFAS	Weight Factor Alarm Switch
WFI	Weight Factor Indicator
WFIA	Weight Factor Indicator Alarm
WFIC	Weight Factor Indicator Controller
WFM	Weight Factor Transmitter
WFR	Weight Factor Recorder
WFRC	Weight Factor Recorder Controller

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TABLE XIX-2

FLOW RATE INSTRUMENTS

COLUMN FEED ROTAMETER INSTALLATIONS

Stream	Designation of Rotameter	Approx. Rotameter Range, Gal./Min.	Specific Gravity at 75°F.
RAX	FIM-17-8-2 FIM-19-8-2	10 to 70	0.82
RAS	FIM-17-8-1 FIM-19-8-1	2 to 12	1.08 to 1.17
RAF	FM-17-6 FM-19-6	5 to 25	1.38 to 1.44
RCX	FIM-17-2 FIM-19-2	8 to 40	1.0
ROS	FIM-18-2 FIM-20-2	0.8 to 10	1.05
ROF	FM-17-1-1 FM-19-1-1	10 to 70	0.82

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"HOT" PROCESS ORIFICE METER INSTALLATIONS

(221-U Building)

Solution	Designation of Orifice Assembly	Approx. Orifice Meter Range, Gal./Min.	Specific Gravity[a]
Concentrated Feed Solution	FE-6-2	7 to 30	1.36 (125°F.)
Dilute Feed Solution	FE-6-6	11 to 50	1.24
Concentrated Feed Solution	FE-6-7	7 to 30	1.36 (125°F.)
Concentrated Feed Solution	FE-7-2	7 to 30	1.36 (125°F.)
Dilute Feed Solution	FE-7-6	11 to 50	1.24
Concentrated Feed Solution	FE-7-7	7 to 30	1.36 (125°F.)
Concentrated Feed or Waste	FE-8-2	7 to 30	1.38 (150°F.)
Dilute Feed or Waste	FE-8-6	11 to 50	1.25 (110°F.)
Concentrated Feed Solution	FE-8-7	7 to 30	1.38 (130°F.)
Concentrated Neutralized Waste	FE-9-2	8 to 30	1.40 (175°F.)
Dilute Neutralized Waste	FE-9-6	13 to 50	1.25 (110°F.)
Concentrated Neutralized Waste	FE-10-2	8 to 30	1.40 (175°F.)
Dilute Neutralized Waste	FE-10-6	13 to 50	1.25 (110°F.)
Pooled Aqueous Waste	FE-11-1	15 to 60	1.20
NaOH Solution	FE-11-6	2 to 7	1.53
Pooled Aqueous Waste	FE-12-1	15 to 60	1.20
Pooled Aqueous Waste	FE-12-6	15 to 60	1.20
Pooled Aqueous Waste	FE-13-1	15 to 60	1.20
RAX Pulse Leakage	FE-17-1	1 to 4	0.80
RAX Pulse Leakage	FE-19-1	1 to 4	0.80

Note: (a) The values listed in the specific gravity column were used to calculate the orifice sizes. Where temperature is not listed, the reference temperature is 75°F.

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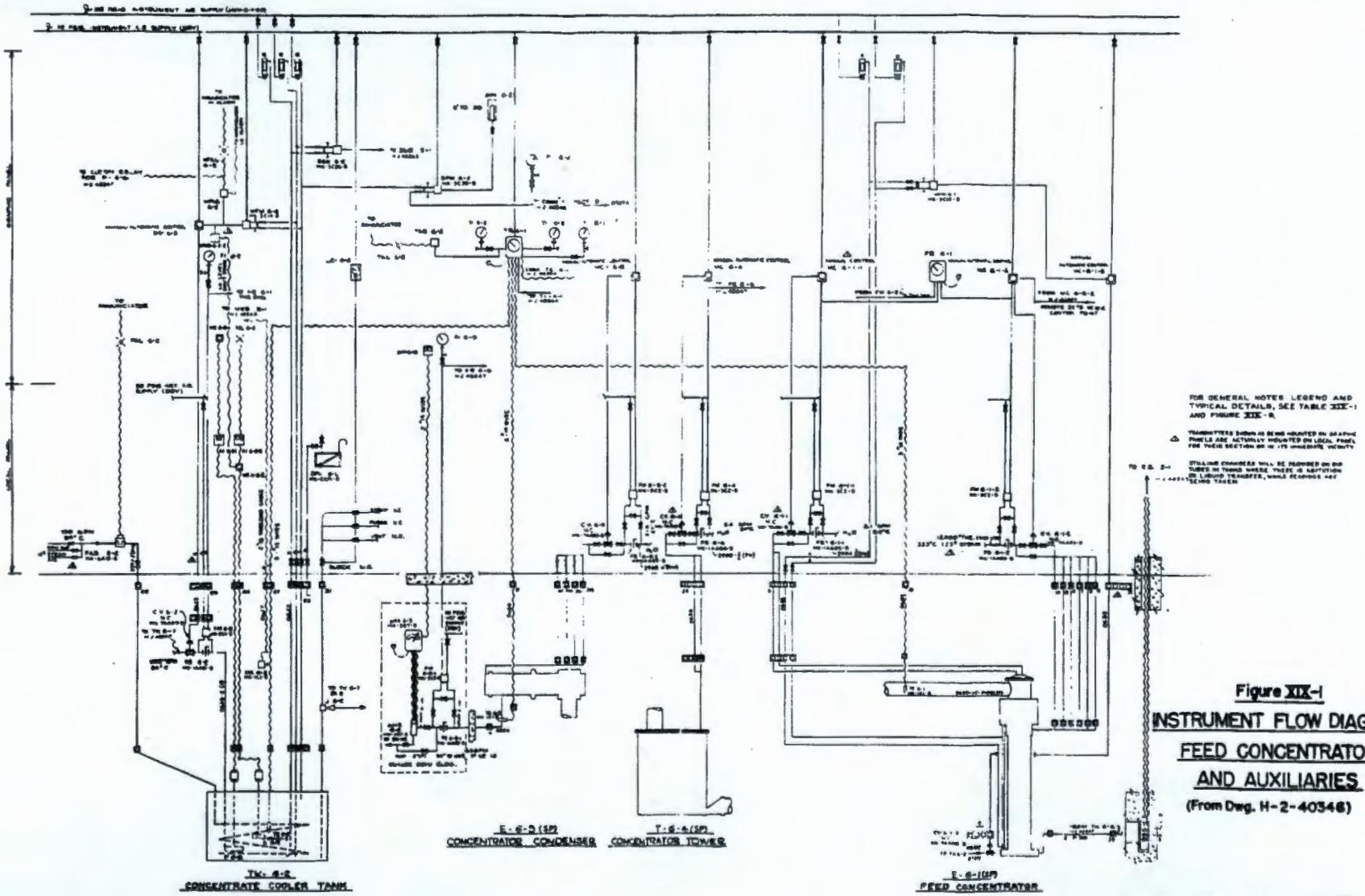

Figure XIX-1

INSTRUMENT FLOW DIAGRAM

FEED CONCENTRATOR

AND AUXILIARIES

(From Dwg. H-2-40346)

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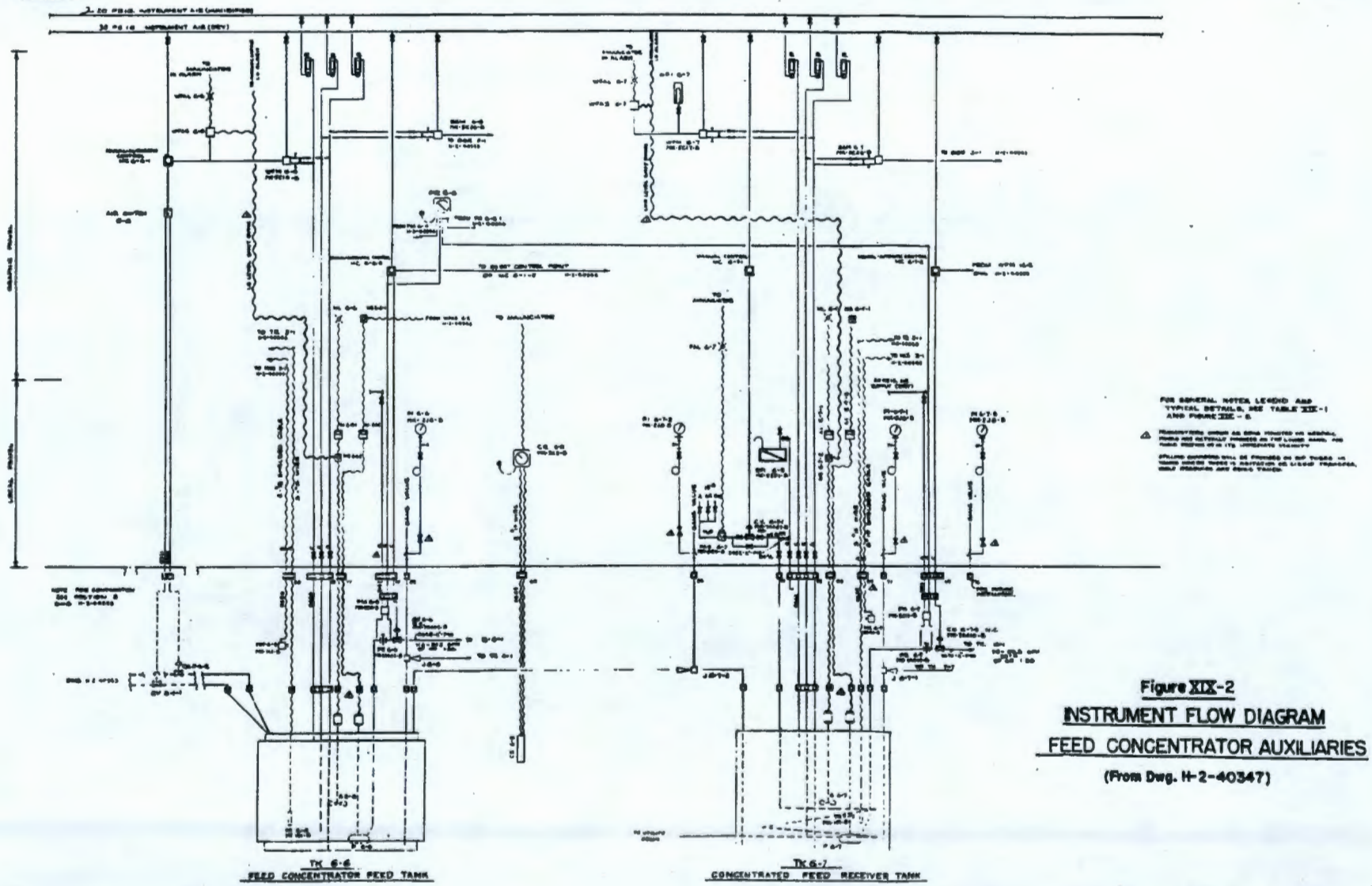

Figure XIX-2
INSTRUMENT FLOW DIAGRAM
FEED CONCENTRATOR AUXILIARIES
(From Dwg. H-2-40347)

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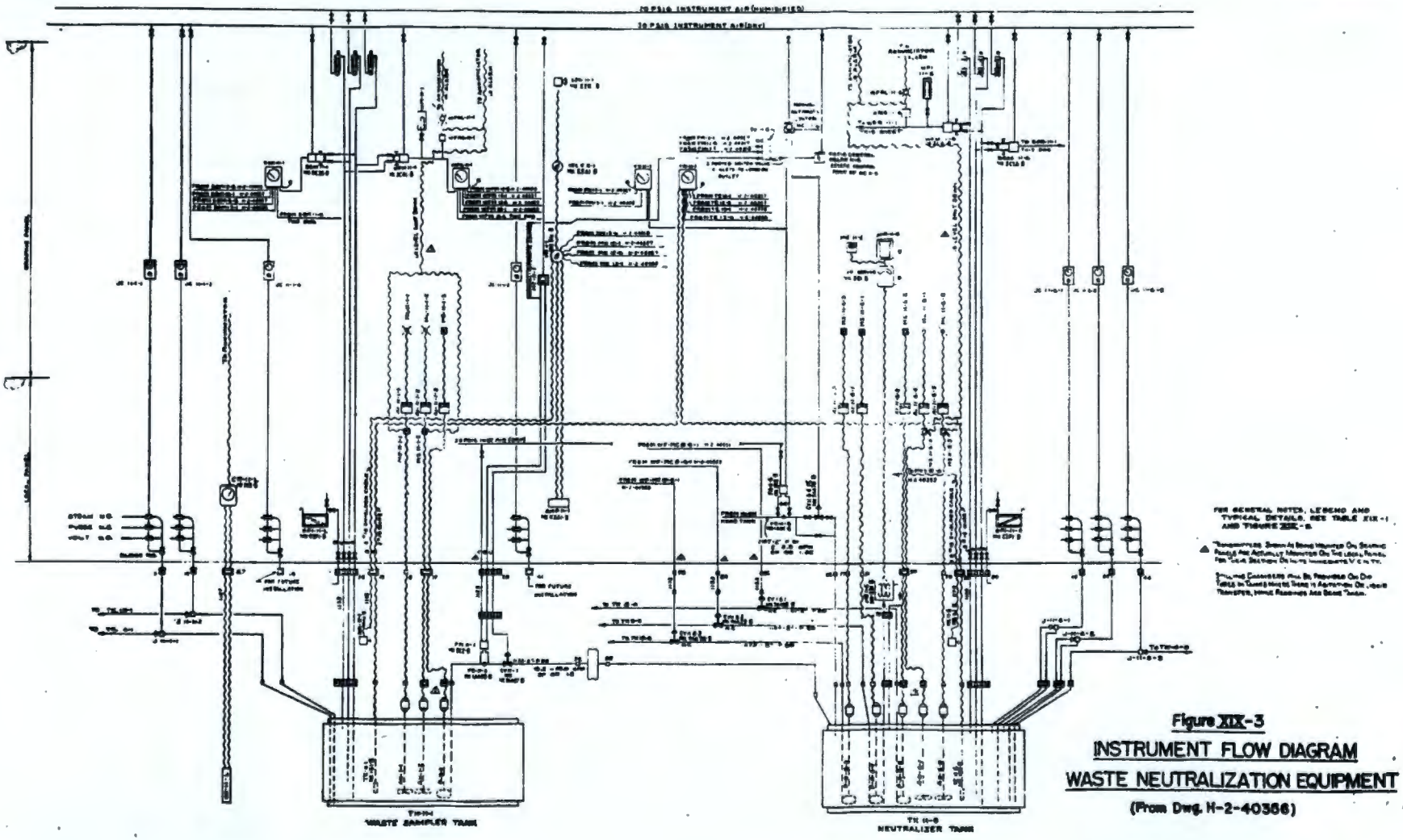

Figure XIX-3

INSTRUMENT FLOW DIAGRAM

WASTE NEUTRALIZATION EQUIPMENT

(From Dwg. H-2-40366)

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[redacted]

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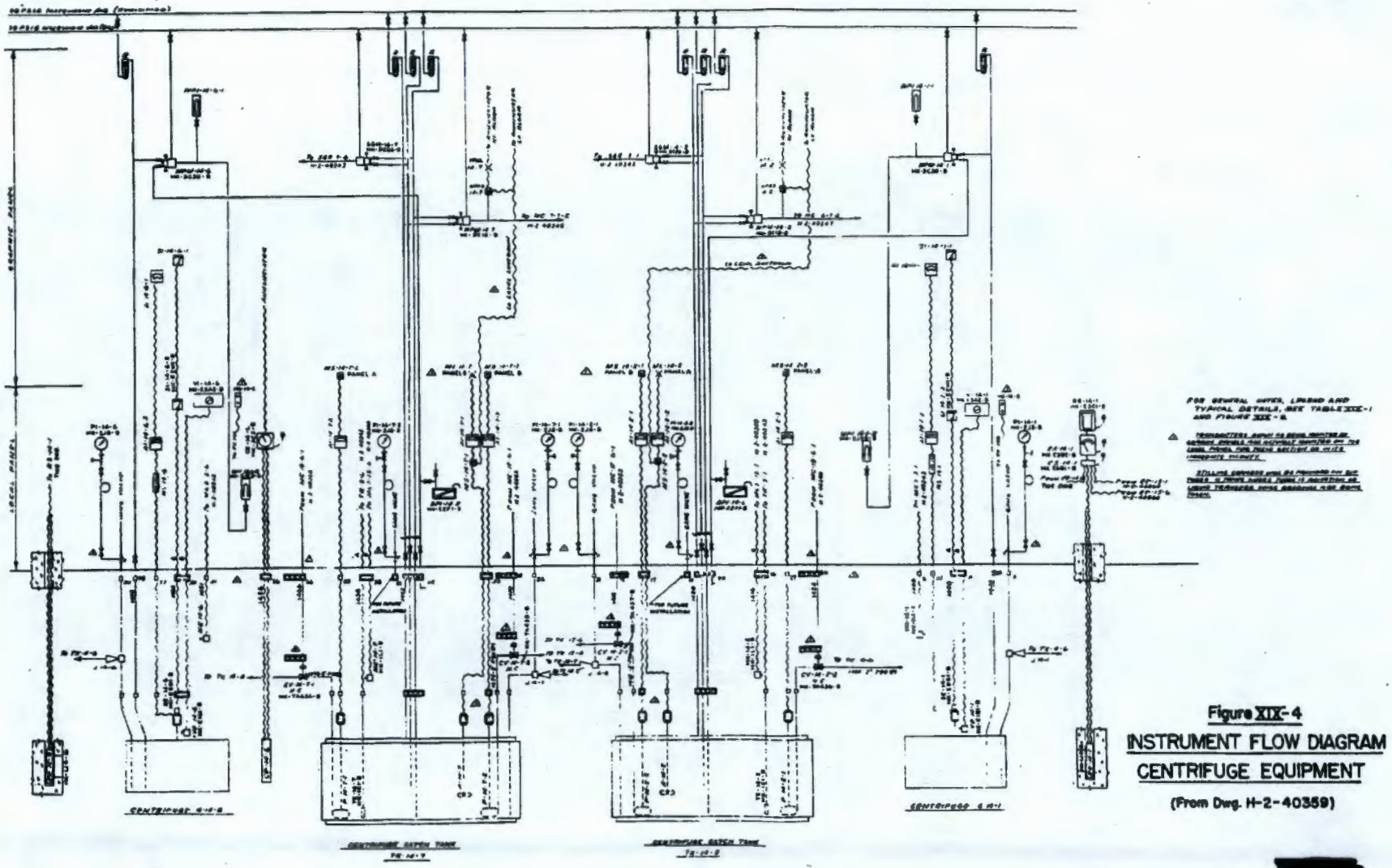

Figure XIX-4

INSTRUMENT FLOW DIAGRAM

CENTRIFUGE EQUIPMENT

(From Dwg. H-2-40359)

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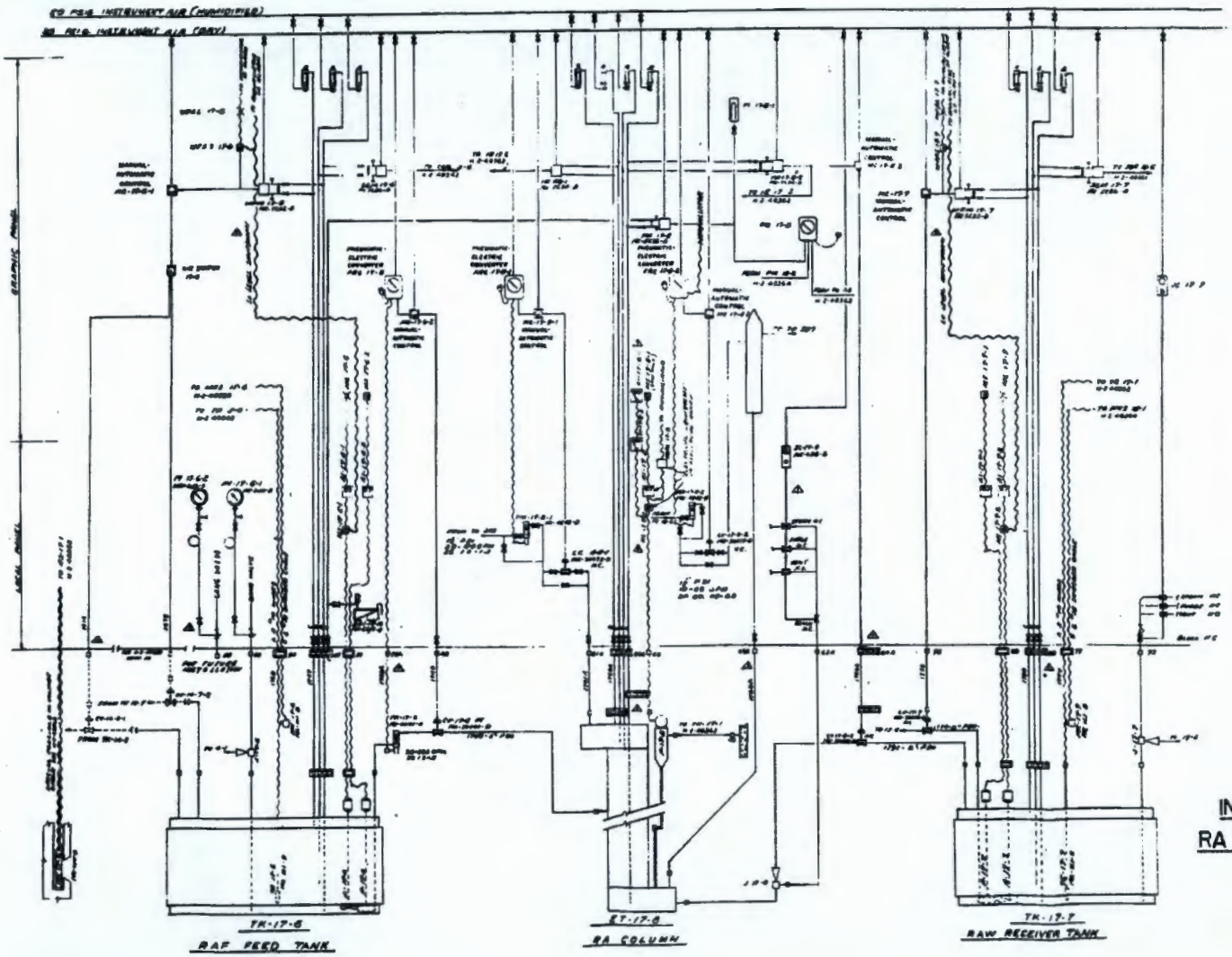

Figure XIX-5

INSTRUMENT FLOW DIAGRAM

RA COLUMN AND ACCESSORIES

(From Dwg. H-2-40363)

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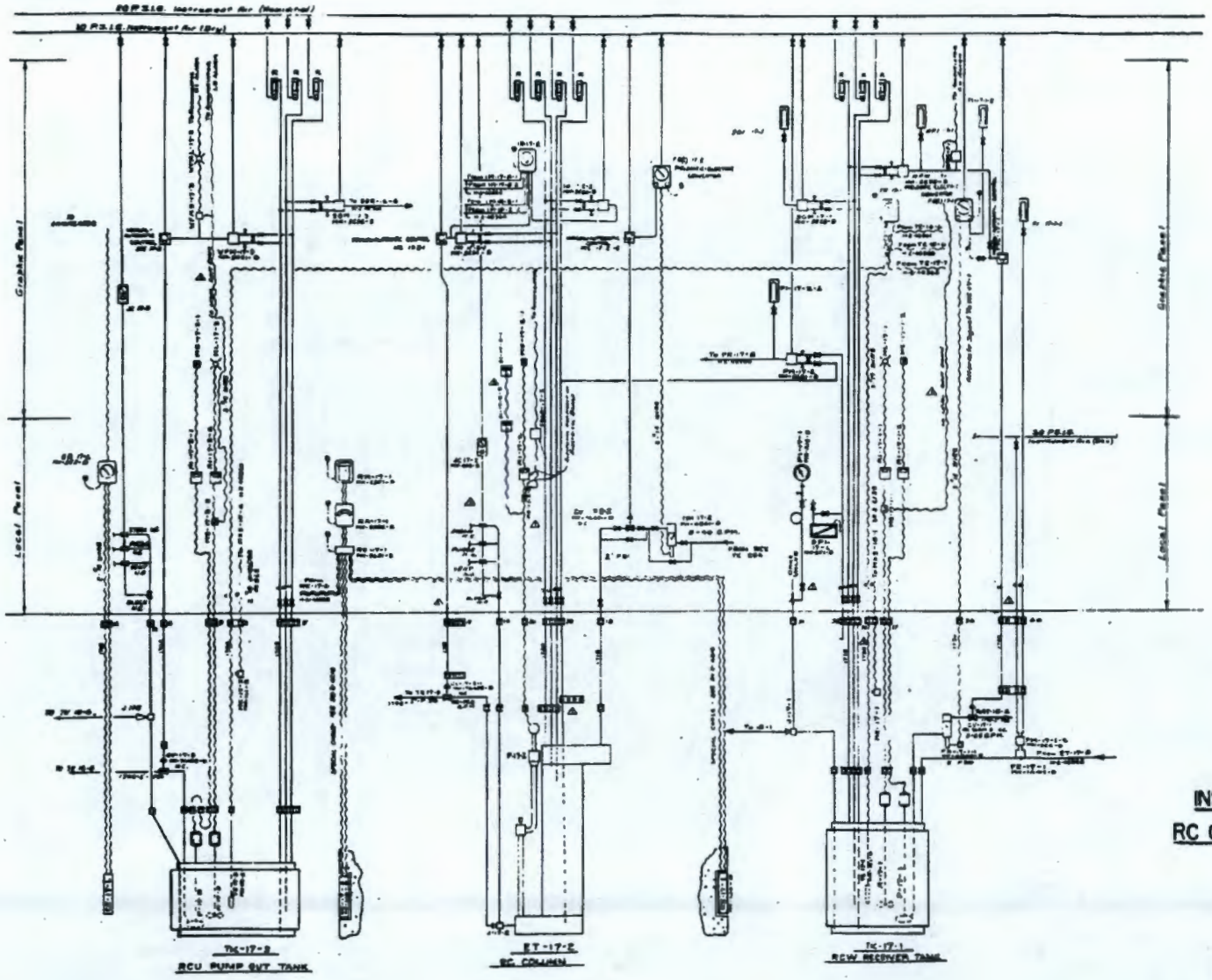

Figure XIX-6

INSTRUMENT FLOW DIAGRAM

RC COLUMN AND ACCESSORIES

(From Dwg. H-2-40362)

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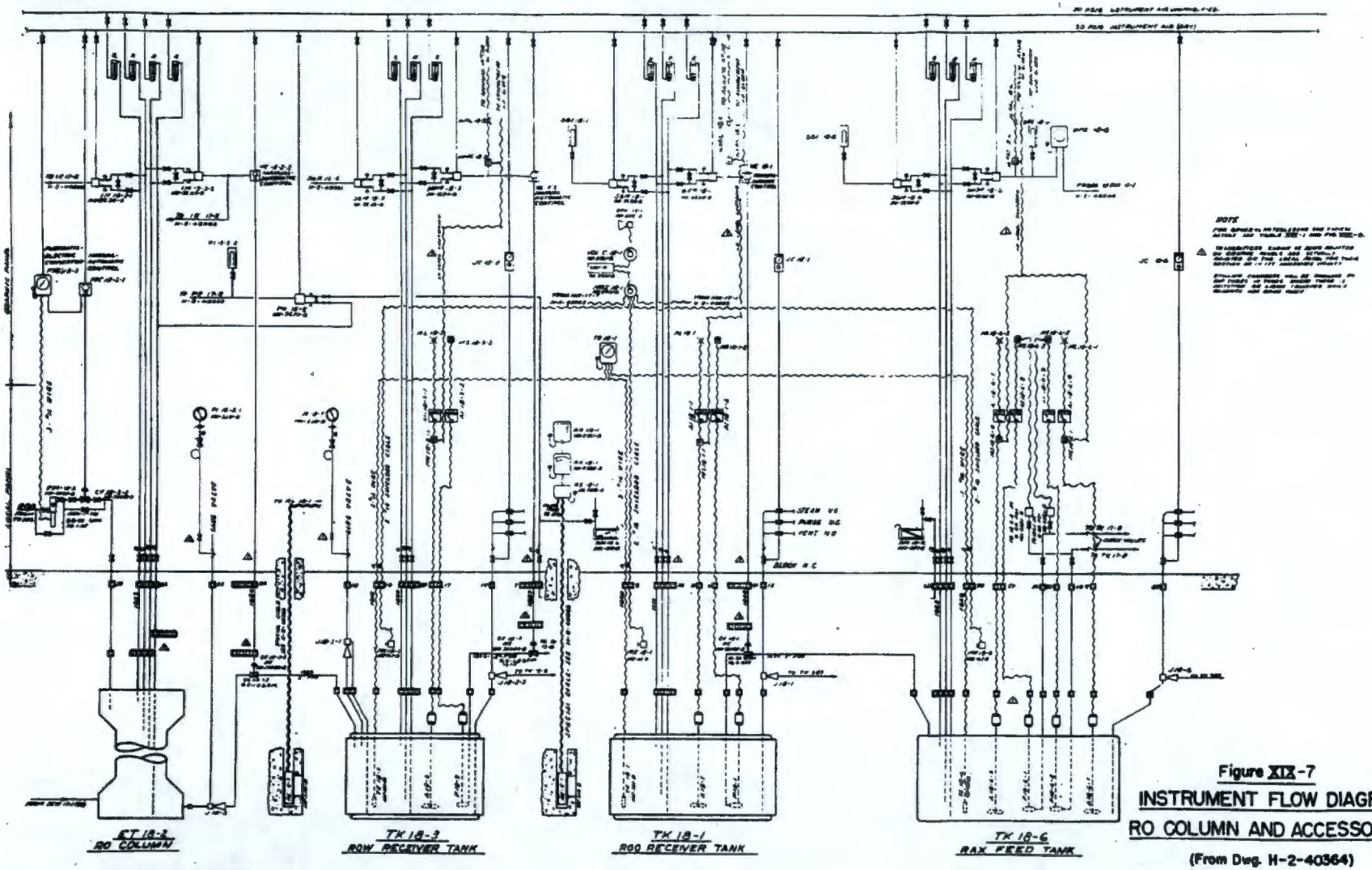

Figure XIX-7
INSTRUMENT FLOW DIAGRAM
RO COLUMN AND ACCESSORIES
(From Dwg. H-2-40364)

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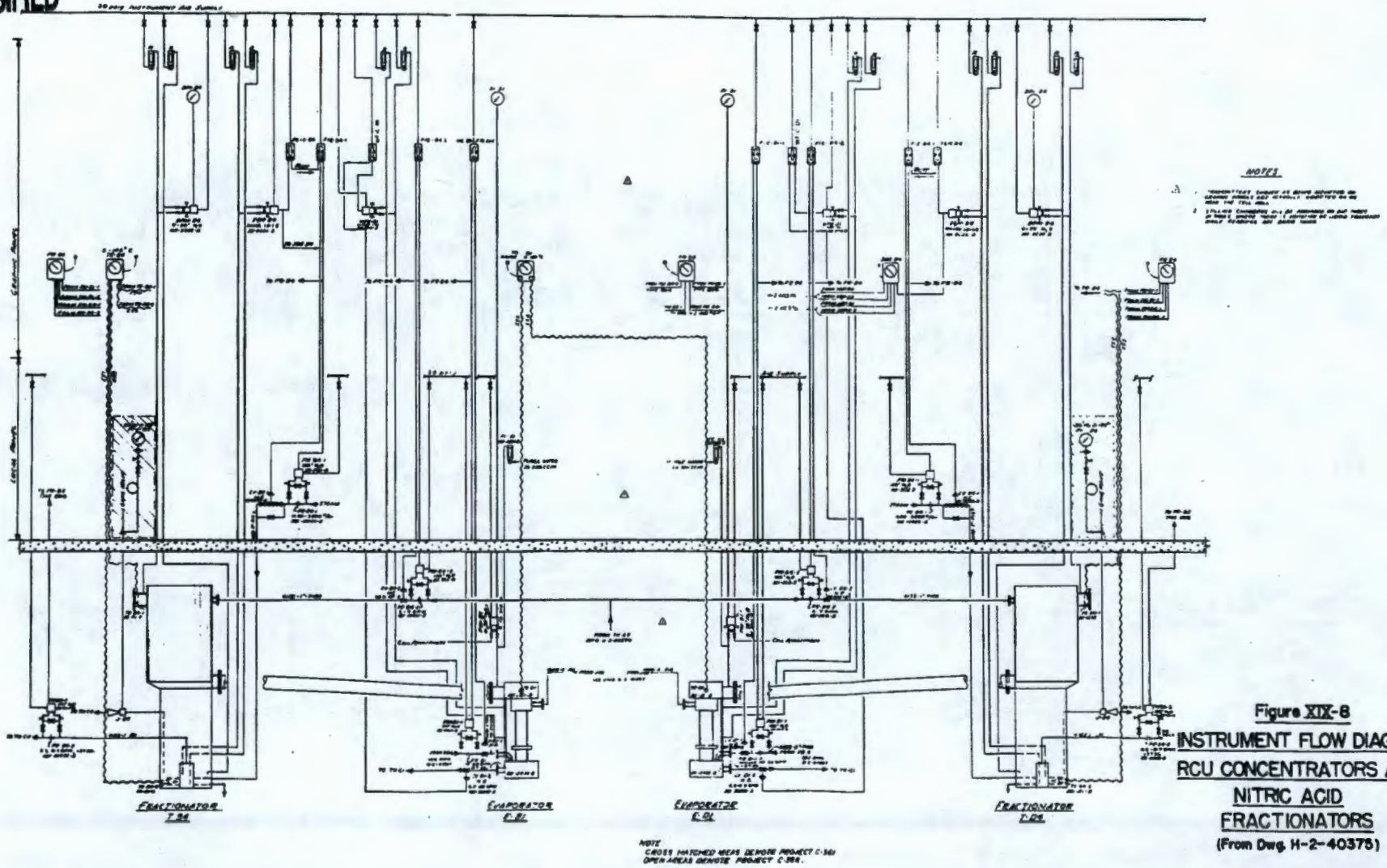

Figure XIX-8
INSTRUMENT FLOW DIAGRAM
RCU CONCENTRATORS AND
NITRIC ACID
FRACTIONATORS
(From Dwg. H-2-40375)

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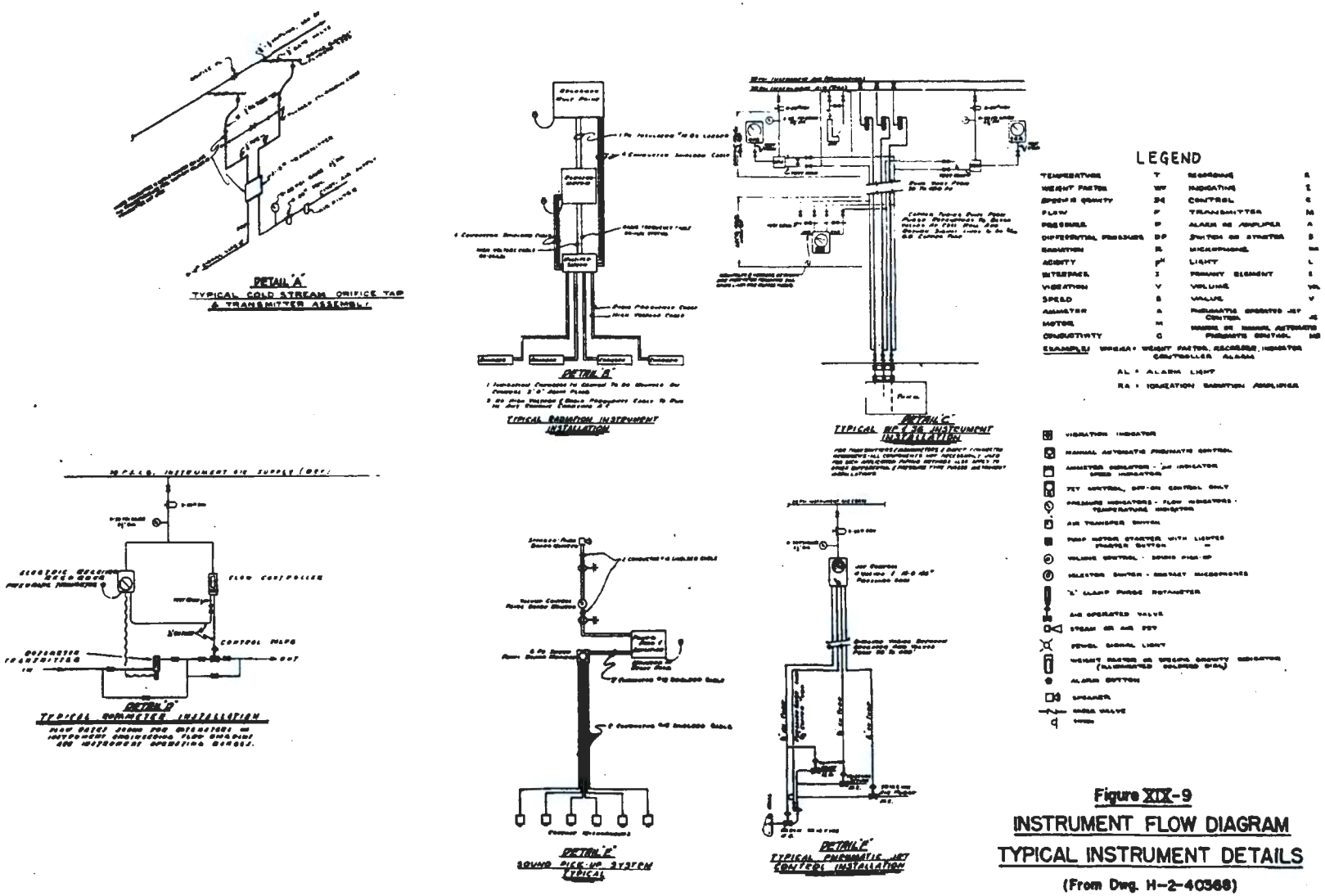

Figure XIX-9

INSTRUMENT FLOW DIAGRAM

TYPICAL INSTRUMENT DETAILS

(From Dwg. H-2-40568)

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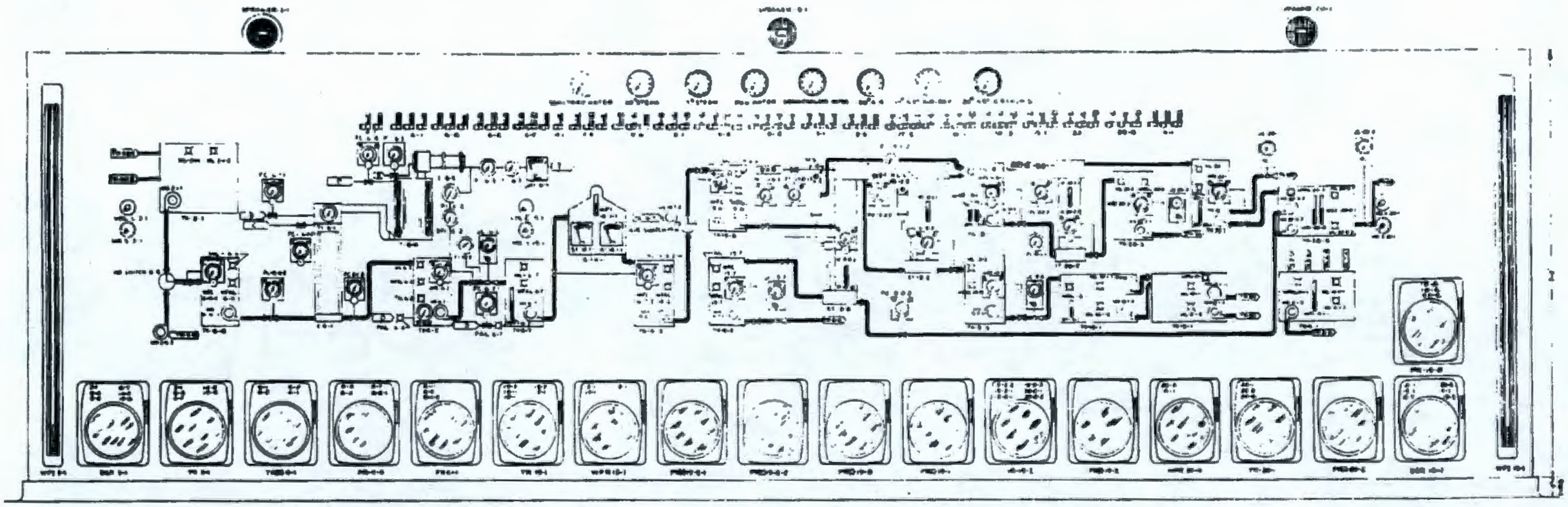

FRONT ELEVATION

LEGEND

REFERENCE PLATES		
[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]

Figure XIX-10
INSTRUMENT PANEL BOARD
GRAPHIC PANEL "A"
(From Dwg. H-2-40369)

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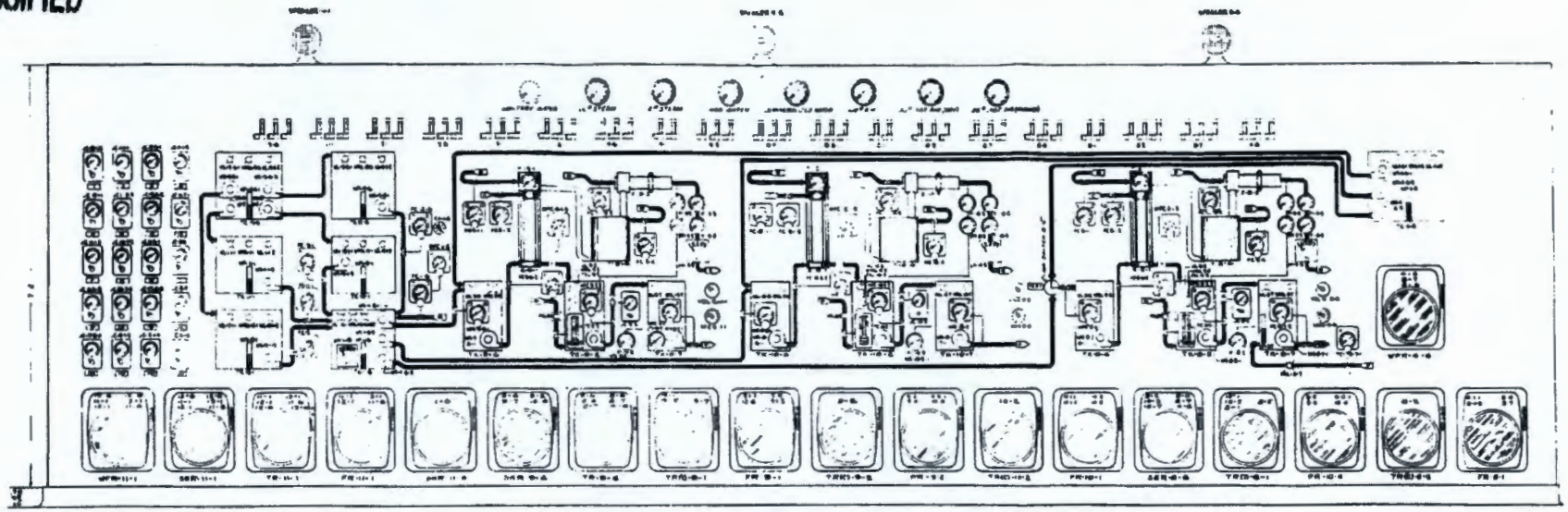

Front Elevation

Legend

	Recorder, Automatic Pneumatic Control & Indicator
	Remote Indicator on pH Indicator or Speed Indicator
	Jet Control, On-Off Control Only Automatic Manual Control
	Recorder, Automatic, Pneumatic Control & Indicator
	Pressure Indicators, Flow Indicators or Temperature Indicators
	Volume Control for Sound Pick-Up
	Selector Switch for Color Wheelbarrow
	Power Motor Starter with Lighted Starter Button
	"C" Clamp Place Potentiometer
	Air Operated Valve
	Steam or Air Jet
	Jewel Signal Light
	Weight Factor or Specific Gravity Indicator

WFR	Weight Factor Recorder
SGR	Specific Gravity Recorder
TR	Temperature Recorder
FR	Flow Recorder
WFI	Weight Factor Indicator
TI	Temperature Indicator
TC	Temperature Control
FI	Flow Indicator
DPI	Differential Pressure Indicator
WFIL	Weight Factor Alarm Light
RL	Rotator Motor Light
[illegible]	[illegible]
[illegible]	[illegible]
[illegible]	[illegible]
[illegible]	[illegible]
[illegible]	[illegible]
[illegible]	[illegible]
[illegible]	[illegible]
[illegible]	[illegible]
[illegible]	[illegible]
[illegible]	[illegible]
[illegible]	[illegible]
[illegible]	[illegible]
[illegible]	[illegible]
[illegible]	Valve

Reference Plates

Designation	Quantity	Inscription
A	1	Caustic
B	6	Demineralized Water
C	3	100# Steam
D	7	Raw Water
E	3	[illegible]
F	3	[illegible]

Jet Control Label Plates

Designation	Quantity	Inscription
1	1	[illegible]
2	1	[illegible]
3	1	[illegible]
4	1	[illegible]
5	1	[illegible]
6	1	[illegible]
7	1	[illegible]
8	1	[illegible]
9	2	[illegible]
10	7	[illegible]
[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]

Figure XIX-11

INSTRUMENT PANEL BOARD

GRAPHIC PANEL "C"

(From Dwg. H-2-40371)

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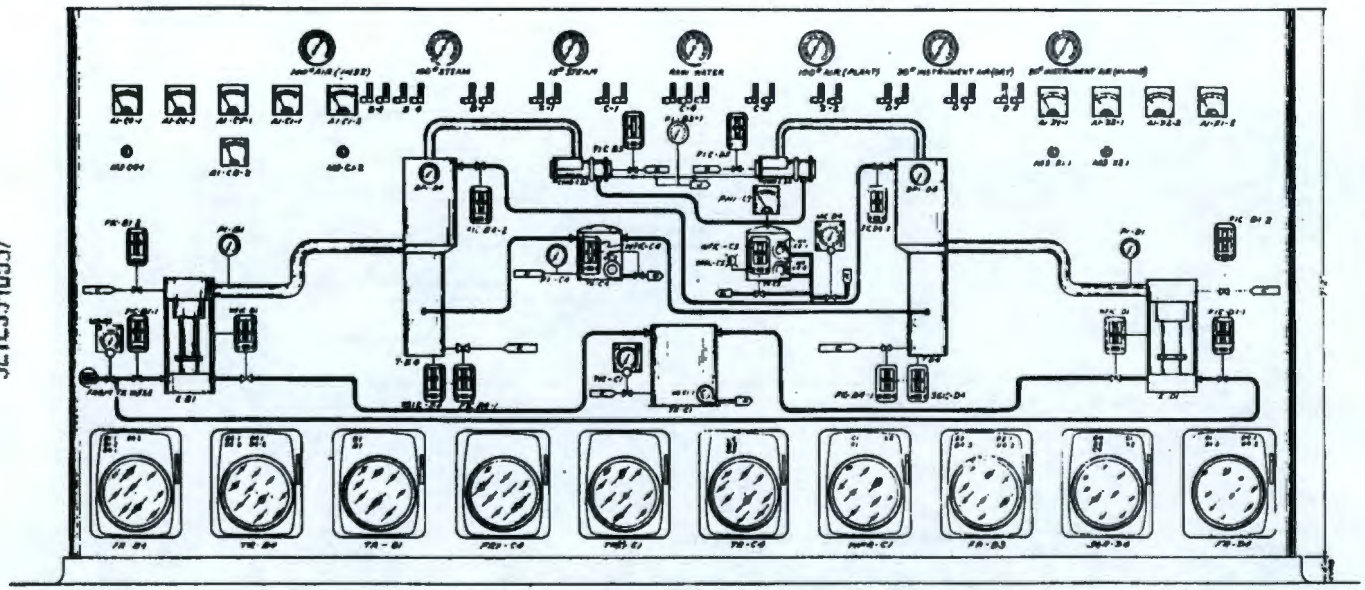

FRONT ELEVATION

-LEGEND-

- MANUAL AUTOMATIC PNEUMATIC INDICATING CONTROLLER
- AMMETER INDICATOR/pH INDICATOR
- PRESSURE INDICATORS/FLOW INDICATORS
- PUMP MOTOR STARTER WITH LIGHTED STARTER BUTTON
- MANUAL AUTOMATIC PNEUMATIC INDICATING CONTROLLER
- AIR OPERATED VALVE
- MOTOR STARTER BUTTON
- "C" CLAMP PURGE ROTAMETER
- JEWEL SIGNAL LIGHT

WFR - WEIGHT FACTOR RECORDER
SGR - SPECIFIC GRAVITY RECORDER
TR - TEMPERATURE RECORDER
FR - FLOW RECORDER
WFIC - WEIGHT FACTOR INDICATING CONTROLLER
TIC - TEMPERATURE INDICATING CONTROLLER
FI - FLOW INDICATOR
PI - PRESSURE INDICATOR
DPI - DIFFERENTIAL PRESSURE INDICATOR
SGIC - SPECIFIC GRAVITY INDICATING CONTROLLER
WFAL - WEIGHT FACTOR ALARM LIGHT
AI - AMMETER
MS - MOTOR SWITCH
MC - MANUAL CONTROLLER
pHI - pH INDICATOR
FRR - FLOW RECORDING INTEGRATOR
TRR - TEMPERATURE RECORDER WITH PNEUMATIC CONVERTER OUTPUT TO SUPPLEMENTARY INDICATOR

REFERENCE PLATES

DESIGNATION	QUANTITY	DESCRIPTION
C	1	100# STEAM
D	1	RAW WATER
E	1	TO 241-WR PADS
H	1	TO U.S. POT & PH-CE
J	1	TO LOCAL STEAM
K	1	DEMINERALIZED WATER

Figure XIX-12

INSTRUMENT PANEL BOARD

GRAPHIC PANEL "D"

(From Dwg. H-2-40373)

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PART IV: PROCESS CONTROL, continued

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CHAPTER XX. ANALYTICAL METHODS

A. INTRODUCTION

1. General

This chapter briefly outlines the principal analytical methods now available (September, 1951) for use in analyzing the various components normally expected in Uranium Recovery Process streams. The limitations of each method are presented as an aid to operating personnel so that they can intelligently interpret laboratory results and can request determinations which will produce meaningful data. For each analytical method the precision, accuracy, sample size, time required for analysis, and impurities known to affect the method (if any) have been listed together with a brief description of the method.

As time passes, many of the methods described may be improved or replaced with new and better methods. Therefore, if the outlined method does not meet a particular process requirement the Analytical Laboratory should be consulted.

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2. Definition of Terms

2.1 Time required per determination indicates, unless otherwise noted, the total elapsed analysis time required for a single determination. It includes any method delays such as digestion, cooling, or agitation, but does not include the time required to get the sample from the operating building to the laboratory.

2.2 Accuracy as presented in this chapter is stated in terms of the percentage disagreement of the average analysis from the absolute or "true" analysis. This disagreement is termed the "systematic error."

2.3 Recovery. In radiochemical determinations a portion of the radioactive element concentration being determined is generally lost and not counted. To determine the percentage of the radioactive element lost, a large quantity of an inactive isotope (large in comparison with the radioactive element concentration) is added and its chemical yield (recovery) is calculated.

2.4 Precision is an indication of the reproducibility of the method. In this chapter the precision figures represent 99% limits. In other words, in ninety-nine out of one hundred determinations statistical studies have shown the reported value does not vary from the mean value by more than the stated precision.

2.5 Sample size is the volume of sample actually required by the analytical method for a single determination. For most Redox samples duplicate determinations will be made for each requested analysis so the total volume required for a requested analysis will be twice the volume shown on the method tabulations.

For many of the radiochemical methods the sample volume required is dependent upon the precision required of the method and the concentration of the radioactive element. Statistical studies have shown that the following counting precision may be expected from the ASP (Alpha-Simpson Proportional) and BGO (Beta-Gamma-Offner) counters:

Precision (99% Limits)	Total No. of Counts*
± 1%	66,000
± 2%	18,000
± 5%	2,600
± 10%	700
± 20%	170

*Note: This is the total number of counts counted for the determination -- irrespective of whether they were counted in a short time for a sample of high radioactivity, or a longer time for a sample of lower radioactivity.

The specific activity for one microgram of plutonium is approximately 1.48×10^5 disintegrations per minute (approximately 74,000 alpha counts per minute on a 50% geometry ASP counter). Therefore, if a five-minute count is to be made and one per cent counting precision is desired, the sample aliquot used for a determination should contain approximately 0.2 microgram of Pu. Similarly, for a five minute counting period and 20 per cent counting precision the sample should contain approximately 0.0005 microgram of Pu. If insufficient sample is available to obtain the counting precision desired during a short counting period the counting precision may be increased by lengthening the counting period.

The sample sizes stipulated for the various fission product determinations are based on the assumption that the plant is processing a 2-year-aged waste.

B. PHYSICAL PROPERTIES

1. Crystallization Point

Application: The method may be used for all uranium recovery process solutions, but it has been developed for use primarily with "hot" solutions such as concentrated RAW.

Description: The crystallization temperature is obtained as a plateau on a cooling curve for the sample. The temperature in the freezing

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point tube is measured by an iron-constantan thermocouple enclosed in a glass sleeve, and is recorded on a Brown Recording Potentiometer (Model 153 XIIV-X-27.)

Liquids which supercool tend to give low results. The supercooling effect may be overcome by running several cooling curves on the same sample, thereby establishing a crystal "memory" on the walls of the freezing point tube.

Time required per determination: 90 minutes. (It is expected that with additional experience with the method the time required may be reduced to less than one hour with a probable decrease in the precision attained.)

Systematic error: Dependent upon the accuracy of calibration of the measuring and recording system. In the range of crystallization temperatures expected (0 to 100°C.) the systematic error is between -0.1 and +0.1°C.

Precision (99% limits): Between -0.2 and +0.2°C.

Sample size: Samples as small as 1 ml. may be used. Since the composition of the sample is not altered during the determination, it may be used later for other analyses.

2. Completeness of Solution

Application: This method is used to determine the effectiveness of slurry dissolution at the various tank farm process vaults (e.g., Blend Tank samples). In those cases where dissolution has not been complete the approximate amount of nitric acid required for complete uranium dissolution is reported.

Description: The sample is placed in a 3-milliliter glass centrifuge cone and centrifuged in an International Clinical Centrifuge. Any undissolved uranium salts appear, upon visual examination, as a yellow sediment in the tip of the centrifuge cone. If undissolved uranium salts are present, the sample is titrated with 60% nitric acid until the sample appears clear, and then recentrifuged. When uranium sediment is no longer present, the sample is reported as "clear" and the sample is stored for six days to determine whether precipite forms on standing.

Insoluble uranium salts may be differentiated from other nitric acid insoluble materials (e.g., sand, glass) by the characteristic yellow color of the uranium salts.

Time required per determination: To determine absence of solids--15 minutes; for titration procedure--60 minutes.

Systematic error: For samples containing insoluble uranium salts, the systematic error of the method is considered to be negligible in comparison with the error which might be introduced in obtaining a representative sample.

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Precision (99% limits): Dependent upon the limit of detection of solids, probably less than 0.1% of sample volume.

Sample size: 1 ml.

3. Disengagement Time

Application: The method is used as an emperical test to determine the emulsification tendencies of TBP process solvent-extraction column feed solutions. It may be used in its present form to determine the emulsification characteristics of a slightly radioactive recycled or treated solvent by using a "cold" standard solution prepared to simulate the approximate aqueous phase composition in an RA Column along with the solvent. Since a large amount of aqueous phase is required by the method in its present form the method cannot be used to evaluate the emulsification characteristics of "hot" RAF solution, though modifications of the method rendering it suitable for "hot" solutions could probably be developed.

Description: Approximately 50 ml. of solvent and standard aqueous solution at 25°C. are placed in a stoppered, 50-ml. graduated cylinder and rotated 20 times at one rev./sec. At the completion of the rotating period the time required for the emulsion to break (i.e., the two-phase zone becomes less than 0.1 ml.) is measured and reported as the disengaging time.

The ratio of aqueous to organic solution in the cylinder is specified by the person requesting the determination. (Normally the relative volumes are those of the flowsheet being run through the solvent-extraction columns.)

Time required per determination: Aproximately 15 minutes.

Precision (99% limits): Unknown. (Estimated at about ± 10 to ± 25% of the disengaging time.)

Sample size: A total of approximately 50 ml. of aqueous plus organic is used for each determination. At HW No. 4 Flowsheet conditions the organic to aqueous ratio is approximately 5:3.

4. Distribution Ratio Test

Application: This method may be used to detect solvent unsuitable for recycling in the solvent-extraction battery.

Description: One volume of sample is successively contacted (shaken vigorously, allowed to settle, and separated) with one-half volume of standard RAF plus RAS (RAF/RAS = 2) solution, three one-volume portions of standard RCX solution, and one volume of standard UNH stock solution containing approximately 0.8 g.UNH/l. The solutions from the final contact are analyzed by the fluorophotometer for UNH and the distribution ratio, E_A^o, is calculated and compared with the value obtained using standard RAX instead of the organic sample. The standard "cold" solutions

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used are prepared from C.P. chemicals with the RAX, RAF, RAS, and RCX compositions corresponding to those of the HW No. 4 Flowsheet shown in Chapter I.

Time required for determination: Elapsed time -- 90 minutes; operator time -- 45 minutes.

Systematic error: The fluorophotometer results may "drift" over extended operating periods. This effect is eventually detected and the instrument reset so that there is very close to zero systematic error. It is felt that the drifting may be detected and corrected by the time it has amounted to a 10-per cent discrepancy.

Precision (99% limits): Mainly dependent upon the precision of the fluorimeter method--approximately ± 30%.

Sample size: 2 to 5 ml.

5. Flash Point--Tag Closed Cup Method (A.S.T.M. D56-36)

Application: The A.S.T.M. Tag Closed Cup flash point test is used as a measurement of the flammability of the diluent purchased for use in the extractants of the Uranium Recovery Plant. Purchase specifications(1) have stated that the diluent closed cup flash point should not be less than 140°F.

Description: The procedure and equipment used in the determination conform to those specified in the standard A.S.T.M. method. Briefly, the temperature of a closed cup of diluent is gradually increased (1°C. per min.) until a distinct flash is produced in the cup when a carefully regulated test flame is introduced.

Time required for determination: 30 minutes.

Systematic error: Dependent upon the calibration of the thermometers used in the determination. (Usually approximately ± 0.2°F.)

Precision (99% limits): ± 1° Fahrenheit.

Sample size: 50 ml. per analysis.

6. Specific Gravity by Falling Drop

Application: Since such a small volume of sample is required the method is well suited to determining the specific gravity of radioactive aqueous streams such as RAF and RAW.

Description: Specific gravity is determined by measuring, at a carefully controlled temperature, the length of time required for a carefully formed small drop of sample to fall (or rise) through a fixed distance in an immiscible liquid. Changes in composition of the immiscible liquid are detected by making periodic determinations with standard samples.

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Time required per determination: 20 minutes.

Systematic error: Minus 0.02 to plus 0.02% (i.e., 0.0002 g./ml.).

Precision (99% limits): Better than ±0.2% (±0.002 g./ml.) for average of 5 drops.

Sample size: As little as one drop (0.005 ml. from a special device which makes small drops) may be used. However, greater precision can be obtained by making several determinations. (3 to 5 drops generally used.)

7. Specific Gravity by Pycnometer

Application: The specific gravity of "cold" or slightly radioactive organic and aqueous samples is determined by this method. For samples such as RAF and RAW which contain appreciable amounts of fission products the Falling Drop method should be used.

Description: The weight of a known volume of sample at 25°C. is compared with the weight of an equal volume of water at 4°C.

Time required per determination: 25 minutes.

Systematic error: Minus 0.02 to plus 0.02% (i.e., 0.0002 g./ml.).

Precision (99% limits): ±0.05% for aqueous samples (approx. 0.0005 g./ml.),
±0.1% for organic samples (approx. 0.001 g./ml.).

Sample size: "Cold" samples, 5 ml.
Slightly radioactive samples, 2 ml.

C. CHEMICAL DETERMINATIONS

1. Aromatics and Olefins (A.S.T.M. D875-46T)

Application: This method is used for the determination of the sum of the olefin and aromatic concentrations in diluent purchased for use in the Uranium Recovery Plant. The allowable sum of the olefin and aromatic concentrations in the purchased diluent[1] is 2% by volume or less.

Description: The procedure, solutions, and equipment used in the determination conform to those specified in the aromatic portion of A.S.T.M. Method D875-46T. Briefly, an accurately measured sample is sulfonated at a carefully controlled temperature using a 70% H_2SO_4 - 30% P_2O_5 solution. The volume of olefins and aromatics present is calculated by subtracting the volume of sample remaining after sulfonation (paraffins) plus the volume of sample soluble in the aqueous phase (assumed) from the original sample volume.

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