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STRONTIUM-90 - RECOVERY AND LAG STORAGE INTERIM PROGRAM

AUTHOR

S. J. Beard

W. H. Swift

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STRONTIUM-90 - RECOVERY AND LAG STORAGE
INTERIM PROGRAM

by

S. J. Beard
Advance Process Development

and

W. H. Swift
Purex Technology

Research and Engineering Operation
CHEMICAL PROCESSING DEPARTMENT

August 2, 1960

HANFORD ATOMIC PRODUCTS OPERATION
RICHLAND, WASHINGTON

Work performed under Contract #AT(45-1)-1350
between the Atomic Energy Commission and the General Electric Company.

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STRONTIUM-90 - RECOVERY AND LAG STORAGE
INTERIM PROGRAM

I. INTRODUCTION

Recent increased interest[1] in the civilian, space, and military applications of isotopic power has prompted a study by which the Chemical Processing Department can provide the interim strontium-90 requirements on a schedule considerably accelerated from that previously proposed[2]. This document summarizes a study of the technical and operational feasibility and hazards involved in:

1. Recovery of semi-refined megacurie quantities of Sr^{90} from current Purex waste.

2. Lag storage of the Sr^{90} fraction in the 244 CR Process Vault for Sr^{89} decay.

3. Subsequent reconcentration and refinement to a bulk product suitable for isolation and packaging by Hanford Laboratories Operation and Oak Ridge National Laboratory.

II. SUMMARY

The feasibility of using the Purex Fission Product Recovery Test Plant and the 244 CR Process Vault for early interim recovery and lag storage of strontium-90 semi-refined fractions has been established. Approximately 80,000 curies of Sr^{90} can be recovered per Purex run with a 5-day time cycle. Initial recovery will be from waste solution (IWW) aged approximately 7.5 months on October 1, 1960.

Transfer of strontium fractions to storage in the 244 CR Process Vault Tanks 002 and 003 can be accomplished through existing spare piping and diversion boxes. The 244 CR Process Vault provides storage capability for approximately 1.5 megacuries of Sr^{90} with a high degree of containment and minimum hazards. Transfer of the stored material to the Hot Semiworks or return to 202-A Building for further processing is practicable.

Recovery and storage of strontium fractions is currently scheduled to start in October, 1960.

(1) Letter: B.F. Judson to E.R. Irish, "Trip Report - Strontium Program", dated July 12, 1960.

(2) Judson, B.F. Hanford Fission Product Program. HW-64105. 3-10-60. (SECRET)

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III. DISCUSSION

A. Strontium-90 Requirements

Sr^{90} requirements[1] during the next 12 to 14 months are currently set at 700,000 curies, with a minimum age of 10 months from reactor discharge. Of the total, 400,000 curies are scheduled for processing to a pure bulk compound by Hanford Laboratories Operation. The remaining 300,000 curies are to be shipped to Oak Ridge National Laboratory as a semi-refined bulk compound.

B. Strontium-90 Availability

Purex high activity waste is currently concentrated to approximately 30 gallons per ton of uranium processed, and thus should have the strontium isotopic content as shown in Table I. Actual isotopic analyses[3] are also shown for a recent sample.

TABLE I

STRONTIUM ISOTOPIC CONTENT OF PUREX WASTE
Basis: 600 MWD/T, 8 MW/T, 120-day Cooled

Isotope	Curies/Gallon (Theoretical)	Atomic Percent (Analyzed)	Atomic Percent (Theoretical)
Sr^{86}	stable	0.93 ± 0.13	-
Sr^{87}	stable	0.68 ± 0.11	-
Sr^{88}	stable	42.2 ± 1.2	-
Sr^{89}	44000	-	-
Sr^{90}	2050	56.1 ± 1.2	61.4

A Sr^{88} content slightly higher than theoretical is to be expected from impurities in essential materials and the uranium metal. The fission product strontium content of irradiated uranium is on the order of 25 - 35 ppm.

Aside from stable Sr^{88} contamination, the ratio of Sr^{89} to Sr^{90} is the most important factor governing its use. Both Sr^{89} and Sr^{90} are strong beta heat generators, and Sr^{89} also emits 0.92 mev gamma radiation with a 0.02 percent abundance. Due to the short half life of Sr^{89} (54 days), lag storage of strontium fractions eliminates the undesirable variation in heat generation with time. Figure I shows the heat generation characteristics of fission product strontium as a function of time since irradiation.

(3) Personal Communication, F. P. Roberts. July 22, 1960

[redacted]

[redacted]

Table II below indicates the approximate gamma radiation intensities to be expected from a one-curie Sr^{90} source, plus its attendant Sr^{89} as a function of time (neglecting Bremsstrahlung).

TABLE II

GAMMA RADIATION FROM FISSION PRODUCT STRONTIUM AT ONE FOOT

1 Curie Sr^{90}

Days From Reactor Discharge	Curies Sr^{89}/Sr^{90}	Mr/Hr.
120	21	23
172	11	12
224	5.3	6
276	2.6	3
328	1.3	1.4
380	0.65	0.7
432	0.32	0.4

In order to produce an aged strontium fraction as soon as possible, plans have been made to reserve a block of irradiated uranium. This currently aging metal will be scheduled for the Purex Plant and subsequent strontium recovery when the lag storage equipment has been completed.

C. Strontium Fraction Recovery

Laboratory work indicates that a semi-refined strontium fraction suitable for storage and subsequent purification can be recovered from current Purex waste using the existing Purex Fission Product Recovery Test Plant (Figure II). The chemical flowsheet as shown in Figure III includes a lead carrier sulfate precipitation followed by an oxalate precipitation to isolate the strontium from cerium and the trivalent rare earths.[4] The proposed flowsheet has been evaluated through tracer-scale laboratory tests and is currently undergoing full activity level laboratory evaluation.

Processing in the Purex Plant would be carried out on 1500-gallon batches of 1WW (equivalent to 50 tons of uranium). Each batch would involve a five-day operation cycle. Assuming Purex operation at a 3.2 capacity factor, approximately 40 percent of the Purex 1WW can be processed. An estimated 80 percent strontium recovery

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(4) Personal Communication, L. A. Bray, May 1960.

is anticipated. Product batch size to storage would be 700 gallons including a 200-gallon transfer line flush and would contain approximately 80,000 curies of Sr^{90}. At the present time, no data are available on the purity of semi-refined fraction. Every effort will be made to hold calcium and barium contamination to a minimum; an attempt will also be made to minimize product acidity.

It is expected that test runs will be completed during September, 1960, with production runs starting in October, 1960.

D. Transfer to Storage

The storage area proposed is the 244 CR Process Vault - Tanks 002 and 003 as discussed below. Transfer to these vessels will be by jet from TK-E1 in the Purex Plant through Diversion Boxes 241-A-151 and 241-A-152 using a spare interdiversion box encased line (V005) and a direct buried cathodically protected stainless steel line (V051) from Diversion Box 241-A-152 to the 244 CR Vault. The inter area transfer line involves approximately 4000 feet of 3-inch line which, if full, would hold approximately 1500 gallons of solution; however, the entire transfer line slopes at a rate of 0.92 to 1.0 percent to the 244 CR Vault. Due to existing nozzle deviations in the 244 CR Vault and the 241-CR-151 Diversion Box, certain jumpers in this area will be trapped. The transfer technique would consist of jetting the acidic product batch (approx. 500 gallons - necessitated by agitation and sampling requirements in TK-E1) followed by a water flush of approximately 200 gallons.

E. Storage

1. Description of Facilities

The 244 CR Process Vault (Figure IV) located within the C Tank Farm, as shown in Figure V, is available for interim storage of semi-refined fission product fractions. This facility was formerly used in waste metal recovery and in-tank farm supernate scavenging operations. Supporting facilities associated with the vault are the 271 CR Control House, the 241-CR-151 Master Diversion Box, and the 291 CR Exhaust Ventilation System as well as the 200-E Area Diversion Box System.

As indicated in Figure IV, the 244 CR Vault is a two-level concrete structure. The upper level is divided into a series of pump pits (one for each tank) housing jumpers, process piping, pump and agitator motors, and a series of sampler pits (one for each tank) housing sampling equipment and instrument shafts. The lower level houses four tanks: two 15,000-gallon

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stainless steel tanks (TK-002 and TK-003, each 14 ft.-0 in. in diameter x 17 ft.-4 in. in height); one 50,000-gallon stainless steel tank (TK-011, 20 ft.-0 in. in diameter x 24 ft. in height); and one 50,000-gallon mild steel tank (TK-001, 20 ft.-0 in. in diameter x 19 ft.-2 in. in height). In addition, an 8200-gallon stainless steel tank (TK-004, 10 ft.-0 in. in diameter x 14 ft.-0 in. in height) is located above ground for chemical addition to TK-002 and TK-003 in the vault.

The vault tanks are equipped with temperature and weight factor - specific gravity instrumentation. The tanks have manholes for agitators and pumps. Presently the 002 and 003 and 011 tanks are equipped with pumps, and the 002, 003 and 001 tanks are equipped with agitators. Two of the tanks (002 and 003) contain cooling coils. The instruments and electrical switchgear for the vault are located in the 271 CR Control House.

The ventilation and air conditioning system (evaporative cooling tower and preheat coils) feeds approximately 3900 CFM of air to the vaults at the pump pit levels. Air flows downward to the vessel chambers and is exhausted through a buried, encased asbestos cement duct to the 291 CR Figerglas filter. The filter is a multiple layer of Fiberglas (18 in. 115K at 1.5 lb/cu.ft., 12 in. 115K at 3 lb/cu.ft., 12 in. 115K at 5 lb/cu.ft., and 2 in. AA at 1.2 lb/cu.ft.) 145 square foot in area with a design pressure drop of 6.0 to 6.5 inches water with a calculated efficiency of > 99.99 percent. Air motivation is provided by either of two 4200 CFM dampered blowers mounted in parallel and discharging to an 18-inch diameter 50-foot high stack.

2. <u>Equipment Utilization and Reactivation</u>

a. Due to the need for cooling coils, TK-002 and TK-003 will be used for storage of the strontium fractions. TK-011 will be used as an emergency cooling water catch tank in the event of coil failure in TK-002 or TK-003. The use of TK-001 is not contemplated. TK-004 may be required initially and intermittently for chemical flushing of the vault vessels. TK-002, TK-003, and TK-011 should be acid flushed prior to use. Storage scheduling will be arranged such that only one-half of the available storage volume is utilized.

Prior to the initial addition of strontium fractions to TK-002 or TK-003, 1500 gallons of dilute nitric acid must be added so the coil and agitator paddles will be covered.

b. Ventilation System

The existing ventilation system blowers and stack, although constructed of mild steel, are in excellent condition as indicated by metal coupon samples. Differential pressure tests of its filter, however, have shown that the filter has at least partially failed. It appears likely that the final 2 in. AA Fiberglas layer has been damaged. Inspection of the filter will be required to determine if the filter must be completely repacked or if just the AA layer needs replacement.

Although acidic storage is contemplated and nitrogen oxide vapors are expected in the off-gas, it is recommended that the existing system be used and replaced at a later date if necessary. Only one of the blowers will normally be used, maintaining the second on standby in case of failure of the first. Continued use of the 244 CR Vault will ultimately necessitate replacement of the aboveground exhaust ventilation system with stainless steel, polyvinyl chloride, or cement asbestos ducts, fans and stack. Underground exhaust ventilation is constructed of cement asbestos and is regarded as satisfactory.

Based on past experience, use of the cooling tower and preheat coils on the supply air is not required.

c. Instrumentation

The following instrumentation will require reactivation:

1. Air compressor.

2. Electrodryer.

3. Weight Factor, Specific Gravity, and Temperature Recorders on TK-002, 003, 001, and 011.

4. Weight Factor Indicators on all sumps.

5. Differential Pressure on Fiberglas filter.

Existing and required new alarm systems are summarized in Table III:

TABLE III

244 CR ALARM SYSTEMS

(1) Existing

Radiation		-	High	Level			
Sump	001	-	High	Level	Wt.	Fac.	
"	002	-	"	"	"	"	
"	003	-	"	"	"	"	
"	011	-	"	"	"	"	
TK -	001	-	"	"	"	"	
"	002	-	"	"	"	"	& Agitator Failure
"	003	-	"	"	"	"	" " "
"	011	-	"	"	"	"	
"	001	-	Low	"	"	"	
"	002	-	"	"	"	"	
"	003	-	"	"	"	"	

(2) New Required

Cooling water radiation.
Low cooling coil pressure.
Weight Factor rise TK-002, TK-003.
High Temperature TK-002, TK-003.
Stack Blower, on-off.

Presuming that 24-hour operational coverage will not be maintained in the vault area, all the above alarms should be connected to trip a "scram" system signaling the 202-A Building Dispatcher's Office.

Cooling water flow measurement devices will be required on the TK-002 and TK-003 coils. A low coil pressure activated air pressurization system should be provided on each coil to protect against simultaneous cooling water failure and coil leaks. The same coil pressure system should provide for closing of the coil backpressure-discharge valves.

d. Samplers

Samplers on TK-002 and TK-003 should be reactivated. Gamma radiation from Sr^{89} and Sr^{90} is shown in Table II, and it is expected that fission product impurities and Bremsstrahlung will contribute the major fraction. The exact magnitude of this radiation source is difficult to estimate, and it is recommended that the existing bayonet samplers be used until the need for revisions can be shown.

A proportional sampler should be provided on the cooling water exit lines from TK-002 and TK-003.

e. Rotating Equipment

The following equipment will be required:

(1) Agitators: TK-002, TK-003.

(2) Pumps: TK-002, TK-003, TK-011.

Spares for these equipment items are available.

f. Cooling Water System

Cooling water is currently provided at 90 psig to the TK-002 and TK-003 coils through manual valves. Water flow control is maintained by separate air-operated valves on the coil discharges.

Cooling water from TK-002 and TK-003 is currently routed via the 8712-6 in. (UD) utility drain header to the C Farm ditch. In order to insure containment of radioactivity in the event of coil failure in TK-002 or TK-003, it is recommended that provision be made for emergency storage of cooling water discharge (ca. 20 gpm) in TK-011. This will provide adequate time for transfer of the stored strontium solution from the failed vessel to the alternate storage tank or to the 202-A Building. Special alarm and sampling requirements on the cooling water system have been described above.

g. Other Utilities

Other utilities requiring reactivation are electrical, steam, process air, and raw water.

h. Underground Lines

The direct buried line from 241-A-152 Diversion Box to 244 CR should be pressure tested prior to use.

i. Jumper Requirements

Jumper requirements are summarized in Table IV. In addition, two jumpers will be required for return of stored material to the Purex Building. One of these jumpers is required in the 241-A-151 Diversion Box and the other in E-Cell of the Purex Building for reprocessing and concentration.

[redacted]

[redacted]

TABLE IV

244 CR REACTIVATION
JUMPER REQUIREMENTS

Building	Location	Function	Print No.	Remarks
202A	E1-G to E-T54	TK-E1 to 241-A-151	New	(Remove E1
	E-G101-E1	Steam to Jet	New	(Recirc. Jet H-2-53829
241-A-151	U24 to L21	202A to 152-DB	New	
241-A-152	U8 to L8	151-DB to 244 CR	Old	Do not trap
244-CR-31 (011)	U1 to U2	152-DB to CR-151-DB	New	Do not trap
241-CR-151	L5 to L6	to TK-002	New	Do not trap
	L5 to L4	to TK-003	New	" " "
244-CR-22 (002)	U1 to L7	to TK-002	Mod.H-2-42011 New	Check for S.St. Elim. Branch (Used also in 23)
	L1(22 to L7(23)	002 to 003	New	
	L1 to U1, L7	TK-002,003, to 202A	New	
	U8 to L1, U1,L7	Inst. Air	New	
	U3 to L2	Pump Power	H-2-42008 Old	
	U4 to L3	Lub. to Agit.	H-2-42480 Old	
	U5 to L4	" " "	H-2-42009 Old	
	U7 to L5	Agit. Power	H-2-42010 Old	
244-CR-23 (003)	U4 to L3	Lub. to Agit.	H-2-42480 Old	
	U5 to L4	" " "	H-2-42009 Old	
	U7 to L5	Agit. Power	H-2-42010 Old	
	L1(23)to L7(22)	TK-003 to TK-002	New	
	U3 to L2	Pump Power	H-2-42008 Old	

New Design: 11
Mod. Design: 1
Reclaim: 8
Fabricate: 11

Figure VI is a sketch of the jumper layout in the 244 CR Vault and the 241-CR-151 Diversion Box.

[redacted]

F. Special Problems

1. Heat Dissipation

Heat dissipation requirements are typified by Figure VII in which the heat duty is presented for the case of accumulating 1 megacurie of Sr^{90} from material aged approximately 120 days. It is of interest to note that specific heat generation of the Sr^{90} fraction at time of processing is sufficient to cause an adiabatic heating rate of approximately 6 °F/hour. Assuming a peak heat generation of approximately 300,000 BTU/hour (1.5-fold above theoretical) and storage at 60 °C, approximately 10 gpm cooling water flow will be adequate. The TK-002 and TK-003 coils were initially sized to dissipate 1,200,000 BTU/hour.

2. Radiolytic Decomposition

Due to the extremely high radiation field in the stored solution (ca. 1 watt/liter), appreciable quantities of nitrogen dioxide will be produced by radiolysis of the nitric acid. Using published(5) G values and assuming no reabsorption of the NO_2, it is predicted that the exit ventilation air will contain a maximum of 200 to 300 ppm NO_2 at 4000 CFM total air flow.

The maximum hydrogen evolution rate is expected to be less than 0.11 CFM assuming no recombination. This rate of evolution would result in 0.03 volume percent H_2 in the vessel vent system, a factor of 100 below the lower explosive limit.

G. Hazards and Containment Evaluation

1. Strontium-90 Recovery in the 202-A Building

Strontium-90 fractions will be recovered from Purex high-level waste by precipitation and centrifugation type flowsheets. Purex Plant head-end equipment formerly used for dissolver solution clarification is available for this service and has been designated as the Purex Fission Product Recovery Test Plant (Figure II). Strontium recovery can be carried out in this equipment with the same safety and containment assurance as normal Purex processing since although this equipment is isolated from the Purex process, it is still an integral part of the Purex Plant with all canyon services retained. No unusual process chemicals or reactions are employed.

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(5) Mahlman, H. A. Radiation Induced Nitrite Formation From Concentrated Nitrate Solution. ORNL-2208. 12-3-60. (UNCLASSIFIED)

2. <u>Inter-Area Transfer</u>

Strontium-90 fractions will be transferred from the Purex canyon to the 244 CR Vault through existing underground piping. The portion of the line between the 241-A-151 Diversion Box and the 241-A-152 Diversion Box adjacent to A Tank Farm is stainless steel encased line exactly similar to the line used for lWW transfers to the A Farm tanks. Since the Sr^{90} concentration in lWW and the proposed Sr^{90} fractions is approximately equal, the transfer is consistent with current plant practices.

The line from 241-A-152 Diversion Box to the 244 CR Vault is direct buried cathodically protected stainless steel line. This line will be pressure tested for integrity before use and used for an interim period of approximately two years. The entire line slopes from the Purex 202-A Building to the 244 CR Vault and thus should drain after each transfer. Inventory measurements of receipts versus shipments should allow detection of any gross leak. Small leaks could possibly go undetected, but are not considered serious since only small volumes of solution would be involved on a very infrequent basis over a two-year period. The specific retention of the soil adjacent to the pipe lines will insure containment of small leaks.

3. <u>Storage</u>

The strontium-90 fractions will be stored in vessels considerably more elaborate than the typical waste storage tanks. Consequently, the hazards associated with Sr^{90} storage are all concerned with equipment or service failures.

a. <u>Vessel Failure</u>

In the event the integrity of a vessel is lost, it will drain into a sump. An alarm system on the sump and/or on the tank weight factor will sound in the Purex 202-A Building. Steps can then be taken to transfer the sump and tank contents to the adjacent vessel (TK-002 to TK-003 or TK-003 to TK-002). Storage schedules are to be arranged such that only one-half the available storage will be utilized at any given time. These routings will be available before the tanks are placed in service.

b. <u>Coil Failure</u>

Flow through the cooling coils in the storage vessels is controlled by DOV valves on the coil discharge lines. Thus, the coils are always under pressure except in the event of a raw water failure discussed below. In the event a coil starts to leak, it will most likely be detected by an increase in the storage vessel weight factor which alarms in the Purex 202-A Building. Transfer of the tank contents to the other tank can then be made, if necessary.

In the event activity enters the coil, it will be detected by a proportional sampler and/or a Beckman chamber located adjacent to the coil discharge DOV's. The Beckman also alarms in the Purex Building. Contaminated cooling water can be valved to the 011 Tank for storage while the vessel is emptied to the opposite vessel (TK-002 to TK-003 or TK-003 to TK-002).

c. Ventilation Failure

Off-gas ventilation is provided by two blowers mounted in parallel, either of which handles the entire load. In the event of blower failure, the spare blower is placed in service. Failure of both blowers is not considered serious since no processing steps are performed in the vault tanks. However, sample equipment, agitators, jets, and pumps should not be operated until ventilation is restored.

d. Utility Failure

(1) Cooling Water

Cooling water failure would result in a loss in coil pressure which would sound an alarm in the Purex 202-A Building, activate a coil air pressurization system, and close the cooling coil discharge DOV's, thus protecting the coil from internal contamination from small coil leaks. The heating rate of the solution would allow approximately 12 hours to restore flow before reaching boiling.

If the tanks reached boiling, containment is not expected to be a problem; however, some damage to the filters or blowers could result.

(2) Electrical

An electrical failure would result in loss of ventilation described above and loss of some instruments immediately and all instruments eventually as instrument air was depleted. The cooling coil flow fails safe and would increase to a maximum. No unusual problems would be encountered unless an equipment failure occurred during the electrical failure, in which case the failure would probably not be detected until instrument service was restored. The possibility of a serious equipment failure coinciding with an electrical failure is considered remote.

(3) Instrument Air

Loss of instruments that permit detection of equipment failure is the primary concern. As mentioned above, this possibility of an instrument air failure coinciding with an equipment failure is considered remote.

e. Emergency Routings

As mentioned above, emergency routings will be available for diverting contaminated cooling water to TK-011 and for transferring storage vessel contents to the opposite vessel (TK-002 to TK-003 or TK-003 to TK-002). In addition, jumpers will be available for transferring TK-002 or TK-003 to the Purex Building for disposal to A Tank Farm, if necessary.

H. Removal from Storage

After suitable decay period (5 to 7 months), the strontium fractions in TK-002 and TK-003 can be pumped via the 241-CR-151, 241-C-151, and 241-C-252 diversion boxes to Hot Semiworks. Alternatively, the solution can be returned to Purex by pumping through the 241-CR-151, 241-A-152, and 241-A-151 diversion boxes to the centrifuge feed tank (TK-E3) in the 202-A Building. Due to the large line volumes, it will be necessary to add water to TK-002 and TK-003 as the last material is being transferred from the tank. This water will displace the remaining strontium fraction from the inter-area line.

Material returned to Purex will be processed through suitable precipitation steps for concentration and further purification prior to removal through the Export Station.

The direct buried, wrapped line from the 241-C-252 Diversion Box is currently being tested and will be cathodically protected before use.

I. Schedules

Full-scale strontium recovery test runs are scheduled to start in early September, 1960. Beneficial use of the 244 CR Vault is expected by September 15. Production recovery runs are to start in early October, 1960.

Initial runs will be made from waste resulting from processing metal of the greatest cooling time since reactor discharge. It is expected that metal aged approximately 7.5 months will be available October 1.

[redacted] [redacted]

APPENDIX A

MASTER DRAWING LIST

244 CR PROCESS VAULT

Architectural & Structural

Index	Title	Print No.
0900	Struct. Conc. - Proc. Tk. Vault	H-2-41888
	" " - Misc. Dets.	H-2-41890
	" " - Reinforcing Struct.	H-2-41891
0901	Bolt & Pipe Sleeve Schedule	H-2-41388
	Struct. Conc. Plans, Sect., Dets., Covers Schedules, Etc.	H-2-41530
	Struct. Conc. Det. - Proc. Tk. Vault Sh. 1	H-2-41889
	" " " - " " " Sh. 2	H-2-41892
	" " " - " " " Sh. 2	H-2-41982
	" " " - Reinforcing Sect. P.T.V. Sh. 3	H-2-41983

Mechanical

Index	Title	Print No.
2500	Vessel Ass'y. & Det. - TK-CR-001	H-2-41088
	" " " " - TK-CR-002, CR-003	H-2-41089
	" Details, 14' x 12' Tank	H-2-41090
	" Ass'y. & Det. - Redesign Ext. TK-CR-004	H-2-41107
	" " " " - TK-CR-011	H-2-41108
	Pit Floor Flange for Agitator	H-2-41121
	" " " " "	H-2-41122
	" " " " P-CR-002, 003	H-2-41123
	" " " " P-CR-001	H-2-41124
	Process Feed Pump, Ass'y. Details	H-2-41399
	Pit Floor Flange for P-CR-011	H-2-41429
	Vessel Dets., Jet Conn. Flange & Piping for TK-CR-001	H-2-41438
	Vessel Ass'y. Dets. TK-CR-001	H-2-41688
	Recirc. Line for TK-CR-011	H-2-42257
	Piping Kerosene Seal Vessel Location, Dets.	H-2-42259
	Dets. pH Elements & Housings for Tk's.	H-2-42313
	Mod. Bracing Mounting & Lagging Dets., Strain Gages	H-2-42831
	Scope Spray Ring	SK-2-17694
2600	TK-CR-002, 003 Revised Pump & Jet Ass'y.	SK-2-17695
	Nitric Acid Pump	H-2-40134
	Equip. Arrangement, Plan & Sections	H-2-40388
	Piping & Arrg't. Waste Removal Phase II	H-2-40451
	Slurry Accumulator Agitator	H-2-41209
	Blend Tank Agitator	H-2-41211
	Lube Exhaust Cont'n'r. for Vert. Agitators	H-2-41212
	Blend Tank Pump	H-2-41224
	Process Feed Pump	H-2-41398
	Gen'l. Arr'g't. Proc. Pump Arrgt.	H-2-41400

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Mechanical - Cont'd.

Index	Title	Print No.
2800	As Built Dimen. Nozz. Inst.	H-2-41582
	" " " " " - Proc. Pump Pits Sh. 1	H-2-42399
	" " " " " - " " " Sh. 2	H-2-42792
	" " " " " - " " " Sh. 4	H-2-42797
4501	Std. 1-1/4" Dia. Stud & Free Nut.	H-2-41365
	Det. Short, Dowel	H-2-41366
	Det. Long Dowel	H-2-41367
4600	Det. Solution Sampler	H-2-41817
	Sol'n. Sampler Pit & Inst.	H-2-41818
	Ass'y. Sol'n. Sampler Pit & Inst.	H-2-42634
	Dets. Solution Sampler	H-2-42635

Instrumentation

Index	Title	Print No.
590023	Inst. Engr. Flow Diag. pH Monitor	H-2-3009
5901	Instr. Piping Arr'g't. Sects., Details	H-2-3011
	Instr. Fab. & Inst. Det. Conductivity Elem.	H-2-41436
	Special Thermowell	H-2-41762
	Conduit & Bracket Arrgt. Instr. Encl.	H-2-41881
	Instr. Location, Dets. - Pipe Inserts	H-2-41882
	Instr. Pipe Jumper - Fig. 4 - 3	H-2-42006
	" " " - Fig. 4 - 2	H-2-42012
	Conduit & Bracket Arrgts. Instr. Encl.	H-2-42264
	Dets. pH Elements & Housings for Tanks	H-2-42313
	Details - Dip Pipes	H-2-42599
	Ass'y. Solution Sampler Pit & Inst.	H-2-42634
	Details - Solution Sampler	H-2-42635
	" - Turbidity Sensing Element	H-2-42809
5902	Instr. Piping Arrg't. Pnl. Bds. CA, CB, CE	H-2-41822
5903	Instr. Cable Rtg., Bds. CA, CB, CE to Eq'pt.	H-2-41437
	Interconnection Diag. Pnl. Bds. to Equip't.	H-2-41928
	" " " " " "	H-2-41929
	" " " " " "	H-2-41930
590123	Modified Sol'n. Sampler	H-2-3010

Flow Diagrams

Index	Title	Print No.
7000	Engrs. Flow Sketch	H-2-40247
	Engr. Flow Diag. Cesium Rec. Plant	SK-02-17692
7001	Engr. Sketch Stored - TBP Waste Scavenging	SK-02-1818

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Electrical

Index	Title	Print No.
7301	Elec. Cond. & Grnd. - Proc. Tk. Vault	H-2-41485
	" " " " - " " "	H-2-41536
	Pipe Jumper Assm. Det. - Fig. 6 - 4	H-2-42002
	" " " " - Fig. 6 - 1	H-2-42004
	" " " " - Fig. 6 - 5	H-2-42005
	" " " " - Fig. 6 - 2	H-2-42008
	" " " " - Fig. 6 - 3	H-2-42010
	" " " " - Fig. 6 - 9	H-2-42483
	" " " " - Fig. 6 - 10	H-2-42642

Piping

Index	Title	Print No.
8403	Utility Pipe Jumper Assm. Det. - Fig. 2 - 2	H-2-41996
8404	Piping Arrg't., Proc. Tk. Vault Sh. 1	H-2-41496
	" " " " " Sh. 2	H-2-41497
		H-2-41498
		H-2-41499
	Piping Arrg't. Sect's. Details	H-2-41500
	" " " " - Sh. 4	H-2-41656
	Piping Location of Sleeves, Proc. Tk. Vault	H-2-41824
8405	Lube Jumper Pit #31 Upper Nozz. 6 to Nozz. 8	H-2-3036
	Elec. Jumper Upper Nozz. 4 to Lower Nozz. 6	H-2-3137
	Utility Pipe Jumper Assm. Dets. - Fig. 2 - 1	H-2-41997
	Piping Process Jumper - Fig. 1 - 33	H-2-41998
	" " " - Fig. 32	H-2-41999
	Lube Jumper - Fig. 3 - 2	H-2-42000
	" " - Fig. 3 - 3	H-2-42001
	Elec. Jumper - Fig. 6 - 4	H-2-42002
	Proc. Pipe Jumper - Fig. 1 - 42	H-2-42003
	Elec. Jumper - Fig. 6 - 1	H-2-42004
	" " - Fig. 6 - 5	H-2-42005
	Instr. Jumper - Fig. 4 - 3	H-2-42006
	Proc. Pipe Jumper - Fig. 1 - 34	H-2-42007
	Elec. Pipe Jumper - Fig. 6 - 2	H-2-42008
	Lube " " - Fig. 3 - 1	H-2-42009
	Elec. " " - Fig. 6 - 3	H-2-42010
	Proc. " " - Fig. 1 - 39	H-2-42011
	Instr. " " - Fig. 4 - 2	H-2-42012
	Lube " " - Fig. 3 - 5	H-2-42479
	" " " - Fig. 3 - 6	H-2-42480
	Proc. " " - Fig. 1 - 48	H-2-42481
	Lube " " - Fig. 3 - 7	H-2-42482
	Elec. " " - Fig. 6 - 9	H-2-42483
	Proc. " " - Fig. 1 - 49	H-2-42495
	Lube " " - Fig. 3 - 8	H-2-42641
	Elec. " " - Fig. 6 - 10	H-2-42642
	Proc. " " - Fig. 1 - 50	H-2-42643
	" " " - Fig. 1 - 51	H-2-42644

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Piping - Cont'd.

Index	Title	Print No.
8407	As Built Dim. Nozz. Inst. Proc. Pump Pits, Sh. 1	H-2-42399
8510	Arrgt. Outside Utility Lines, Sh. 2	H-2-41847

Ventilation

Index	Title	Print No.
8900	H & V Proc. Tk. Vault	H-2-41788
	H & V Sections Process	H-2-41789
	H & V Sects. Dets. Evap. Cooling Tower Steam & Water Piping	H-2-41790
	H & V Plan. Sect. Evap. Cooling Tower	H-2-41791
9000	Plans, Elev. Evap. Cooling Tower	H-2-41809

271 CR CONTROL HOUSE

Architectural & Structural

Index	Title	Print No.
0800	Arch. Plans, Sects., Elev. & Dets.	H-2-41093
0801	Arch. Sections & Dets.	H-2-41094
0900	Struct. Concrete, Floor, Slab, Foundation	H-2-41654

Instrumentation

Index	Title	Print No.
5901	Instr. Conduit Arrg't. Pnl. Bds. CA, CB, CE	H-2-41181
	Inst. Piping Detail	H-2-41760
	Inst. Elec. Conn. Diag. Panel Boards	H-2-41796
	" " " " " "	H-2-41797
590117	H & V Steam & Water Piping	H-2-41740
	Instr. Piping Arrg't.	H-2-41822
	Pnl. Brd. Terminal Boxes & Troughs	H-2-41851
	Conn. Diag. Rear Elev. Pnl. Bds.	H-2-42759
5902	Master Cutout Det. Pnl. Bds.	H-2-41119
	Instr. Pnl. Brd. Arrg't. - CA, CB, CE	H-2-41120
	Instr. Piping Arrg't. - CA, CB, CE	H-2-41153
	Brackets, Det. Rear Elev. Pnl. Bds.	H-2-41154
	Det. of Pnls. Control Houses	H-2-41433
	Ass'y. Inst. Pnl. Bd. for Control Hse.	H-2-41761
	Instr. Piping Arrg't. - CA, CB, CE	H-2-41822
5903	Instr. Cable Routing - CA, CB, CE to Equipt.	H-2-41437
	Interconn. Diag. Pnl. Bds. to Equipt.	H-2-41928
	" " " " " "	H-2-41929
	" " " " " "	H-2-41930

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Electrical

Index	Title	Print No.
7301	Elec. Conduit & Grounding Plan	H-2-41251
7302	Interconn. Diag. Motor Ctrs.	H-2-41362
	Elec. Wiring Diag.	H-2-41363
		H-2-41392
7303	Elec. Wiring Diag.	H-2-40363
Piping		
8408	Plumbing - Plan, Sects., Sewage Disposal	H-2-41106
8510	Plumbing - Plan & Riser Diag.	H-2-41105
	Compressor Equipt. & Piping	H-2-41415
8900	H & V Layout of Ducts & Equipt.	H-2-41640
	Ductwork & Equipt. Det. & Supports - Control Hse.	H-2-41739
	H & V Steam & Water Piping	H-2-41740
	Vent. Control System - Control Hse.	H-2-41758

271 CR VENTILATION SYSTEM

7301	Elec. Cond. & Grounding, Floodlight & Stack	H-2-41486
7401	Elec. Cond. & Grounding, Floodlight & Stack	H-2-41486
8900	H & V Stack Gas Filter	H-2-41743
		H-2-41744
	H & V Plan, Ductwork to Filter & Stack	H-2-41745
		H-2-41746
	H & V Stack Exhaust Fans, Platform	H-2-41781

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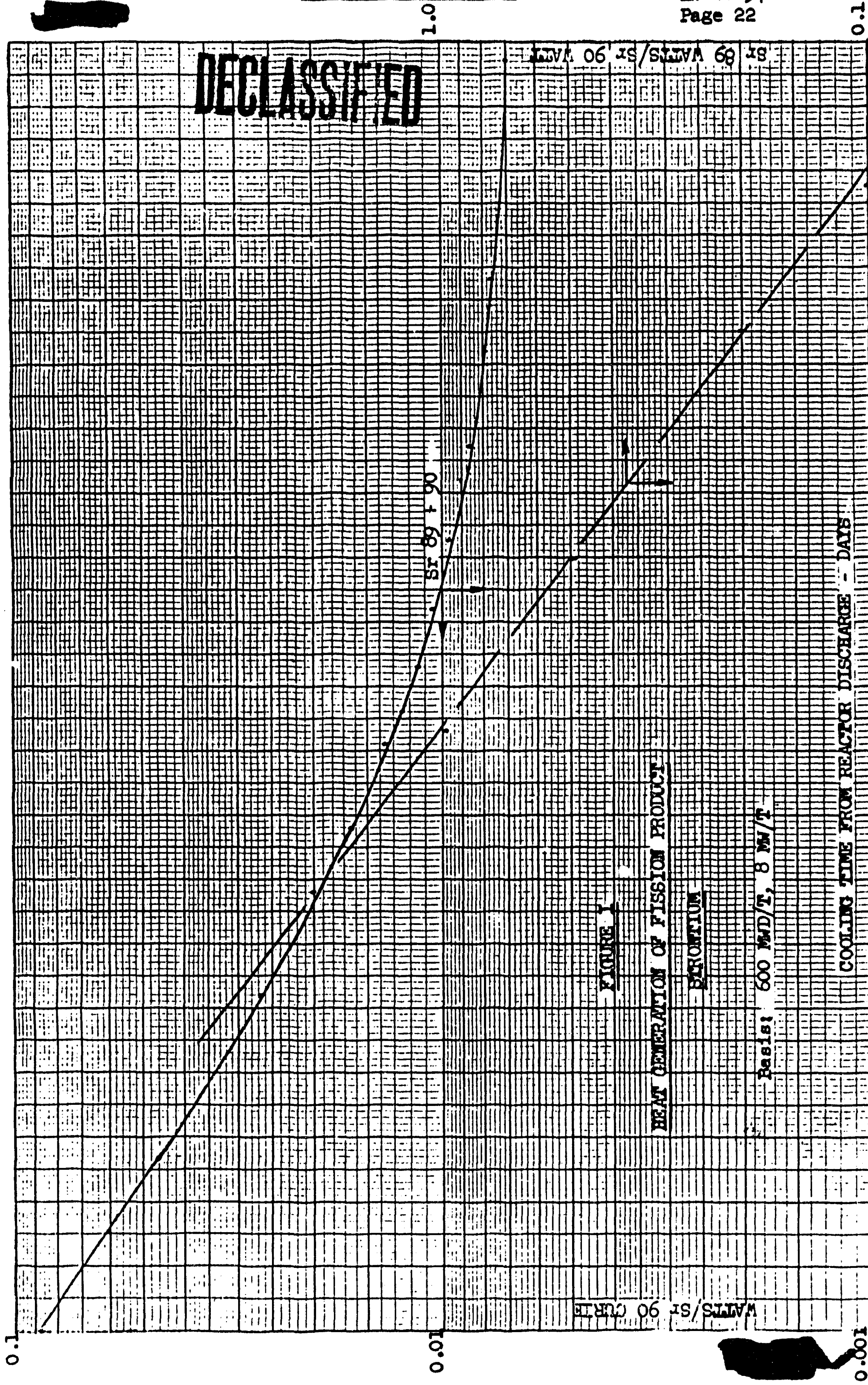

FIGURE I
HEAT GENERATION OF FISSION PRODUCT
STRONTIUM
Basis: 600 MWD/T, 8 MW/T

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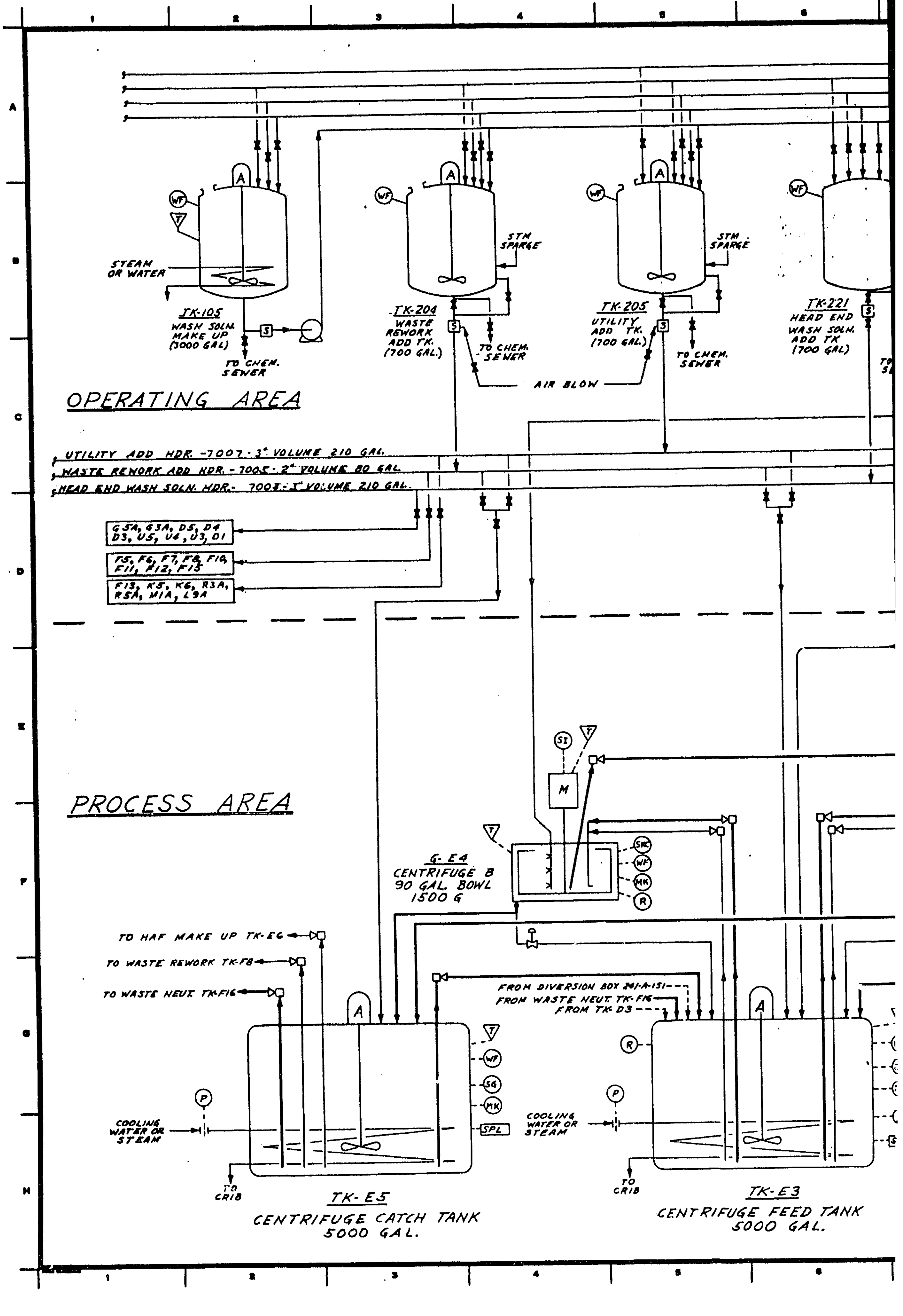
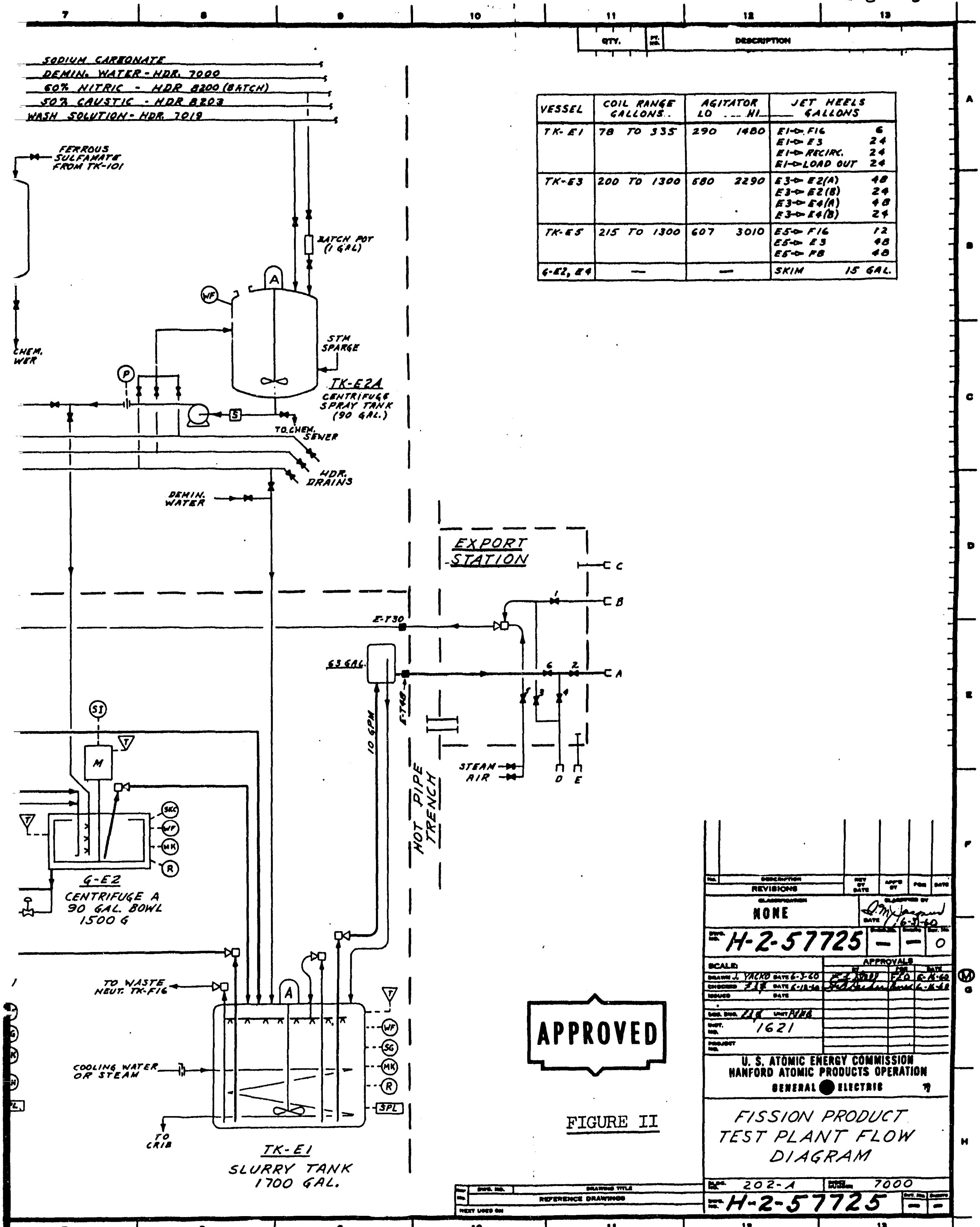


OPERATING AREA
TK-105
WASH SOLN. MAKE UP (3000 GAL)
STEAM OR WATER
TO CHEM. SEWER
TK-204
WASTE REWORK ADD TK. (700 GAL.)
STM SPARGE
TO CHEM. SEWER
TK-205
UTILITY ADD TK. (700 GAL.)
STM SPARGE
TO CHEM. SEWER
AIR BLOW
TK-221
HEAD END WASH SOLN. ADD TK (700 GAL)
UTILITY ADD HDR. -7007 - 3" VOLUME 210 GAL.
WASTE REWORK ADD HDR. - 7005 - 2" VOLUME 80 GAL.
HEAD END WASH SOLN. HDR. - 7003 - 3" VOLUME 210 GAL.
G5A, G3A, D5, D4 D3, U5, U4, U3, D1
F5, F6, F7, F8, F10, F11, F12, F15
F13, K5, K6, R3A, R5A, M1A, L9A
PROCESS AREA
G-E4
CENTRIFUGE B 90 GAL. BOWL 1500 G
TO HAF MAKE UP TK-E6
TO WASTE REWORK TK-F8
TO WASTE NEUT. TK-F16
FROM DIVERSION BOX 241-A-151
FROM WASTE NEUT. TK-F16
FROM TK-D3
COOLING WATER OR STEAM
TO CRIB
TK-E5
CENTRIFUGE CATCH TANK 5000 GAL.
COOLING WATER OR STEAM
TO CRIB
TK-E3
CENTRIFUGE FEED TANK 5000 GAL.



VESSEL	COIL RANGE GALLONS	AGITATOR LO	AGITATOR HI	JET HEELS GALLONS	
TK-E1	78 TO 335	290	1480	E1→F16	6
				E1→E3	24
				E1→RECIRC.	24
				E1→LOAD OUT	24
TK-E3	200 TO 1300	580	2290	E3→E2(A)	48
				E3→E2(B)	24
				E3→E4(A)	48
				E3→E4(B)	24
TK-E5	215 TO 1300	607	3010	E5→F16	12
				E5→E3	48
				E5→F8	48
G-E2, E4	—	—		SKIM	15 GAL.

CLASSIFICATION: NONE

DWG. NO. H-2-57725 — — 0

DRAWN J. YACKO DATE 6-3-60

BLDG. 202-A

U. S. ATOMIC ENERGY COMMISSION
HANFORD ATOMIC PRODUCTS OPERATION
GENERAL ELECTRIC

FISSION PRODUCT TEST PLANT FLOW DIAGRAM

SYSTEM 7000

DWG. NO. H-2-57725

FIGURE II

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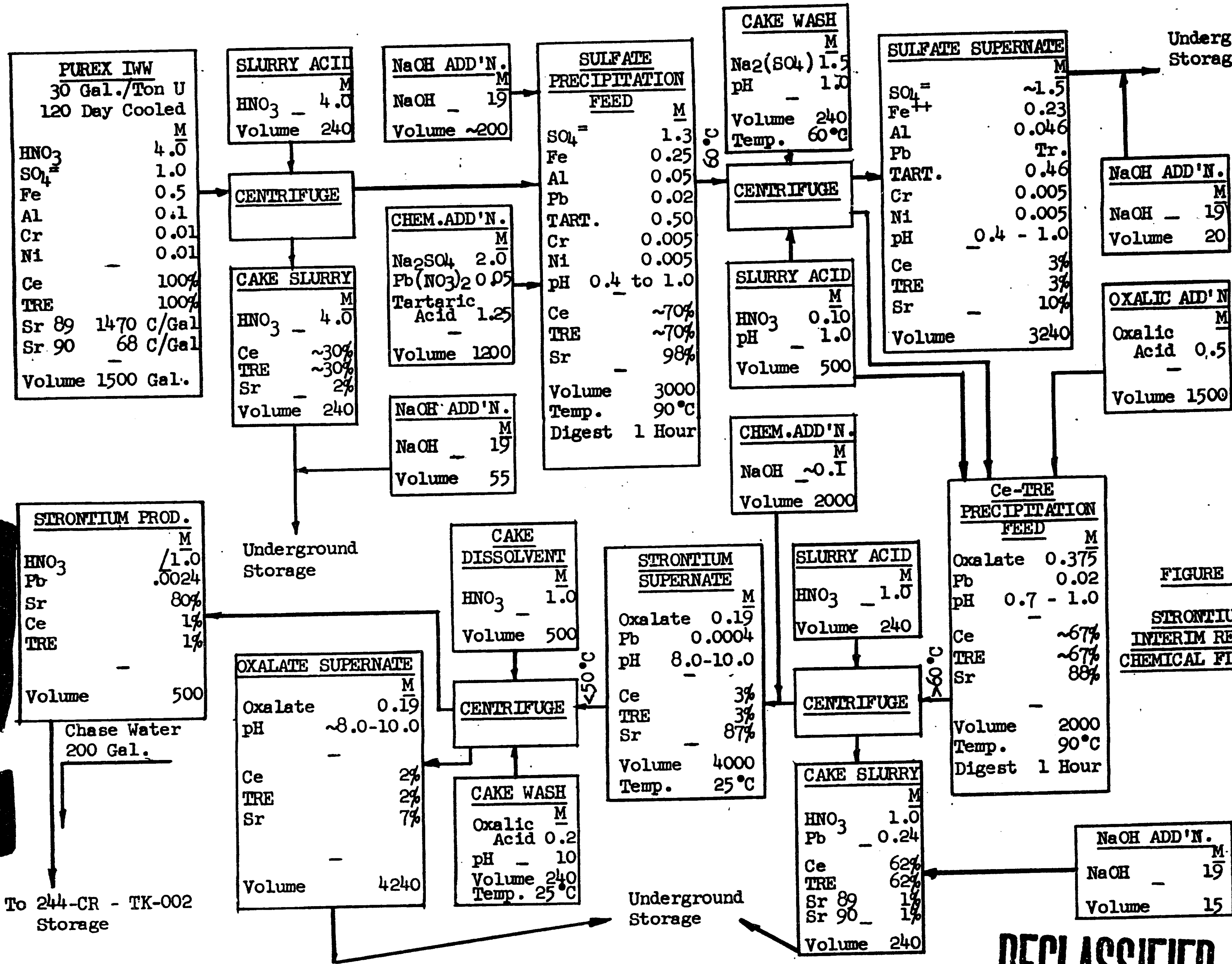

FIGURE III

STRONTIUM-90
INTERIM RECOVERY
CHEMICAL FLOWSHEET

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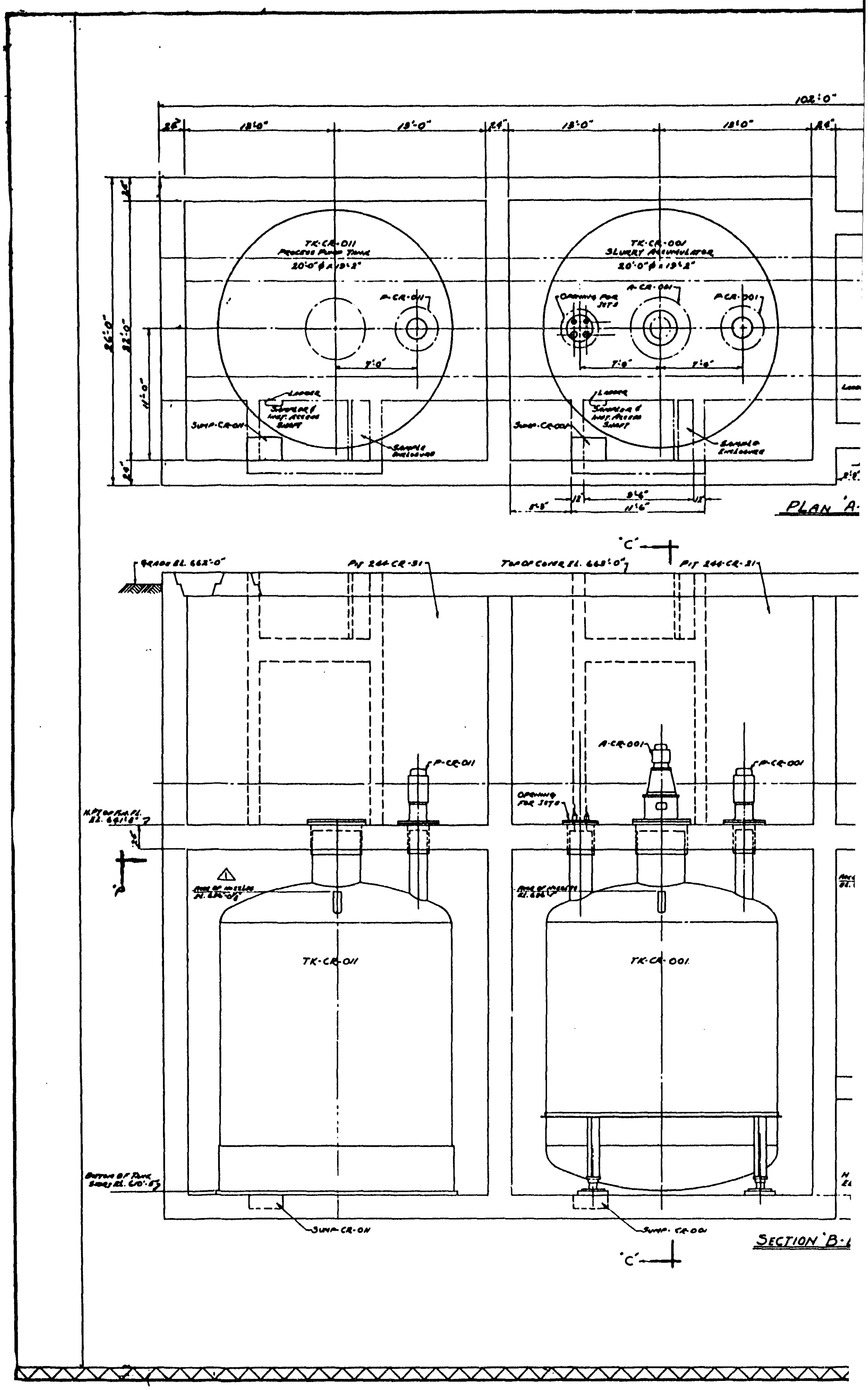

TK-CR-011
PROCESS PUMP TANK
20'-0"ø x 19'-2"
TK-CR-001
SLURRY ACCUMULATOR
20'-0"ø x 19'-2"
PLAN 'A-
TK-CR-011
TK-CR-001
SECTION 'B-

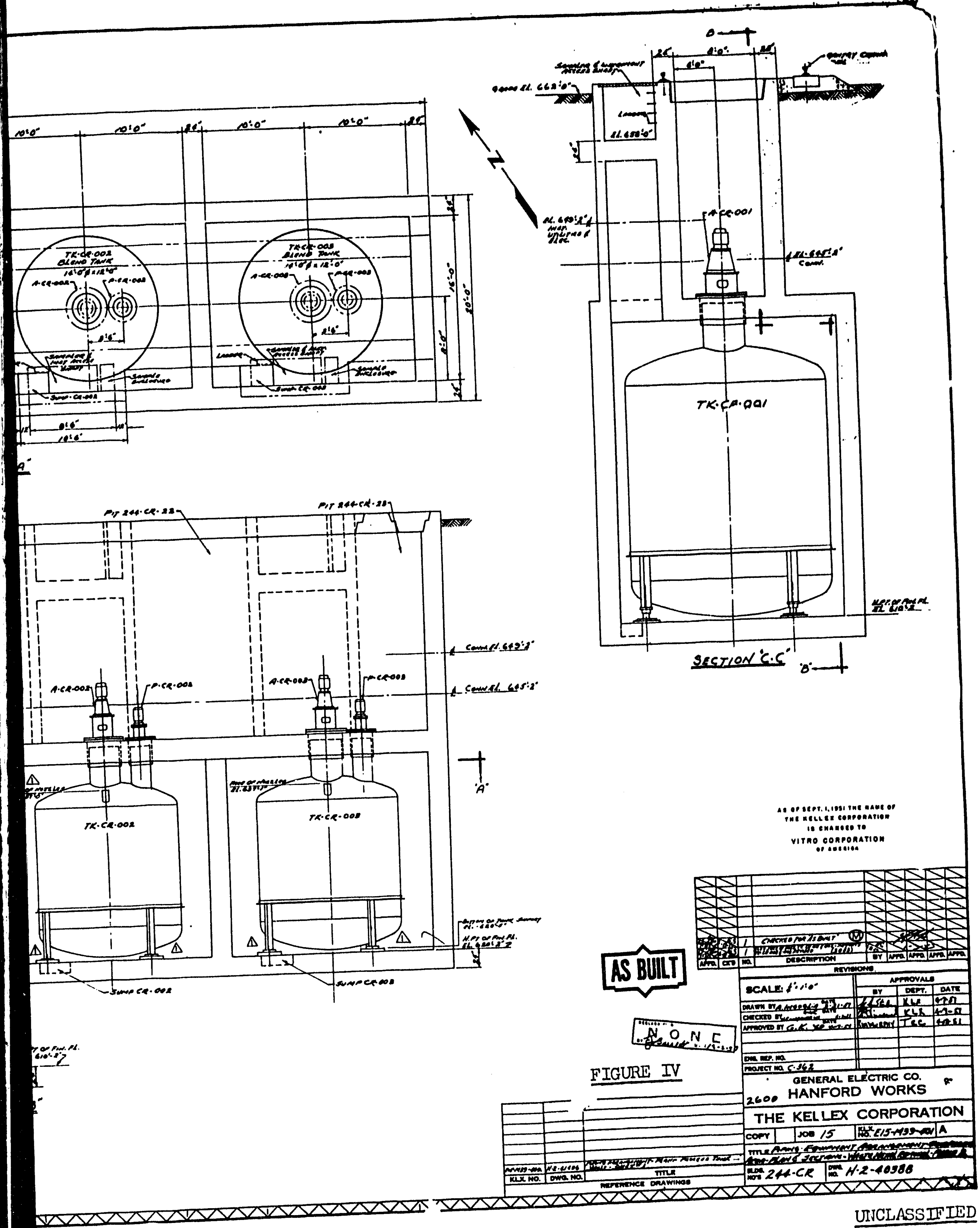
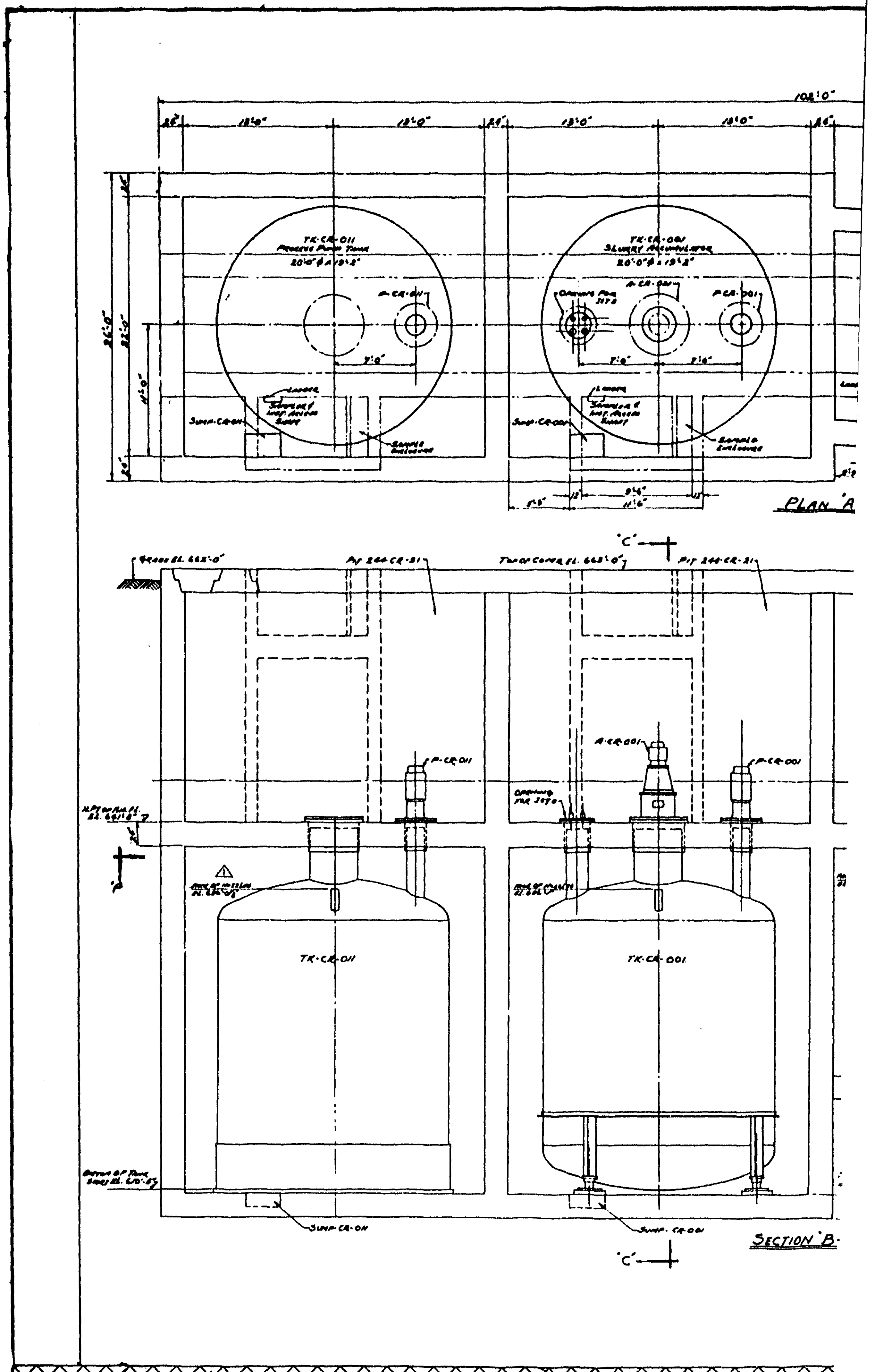


FIGURE IV

UNCLASSIFIED

UNCLASSIFIED



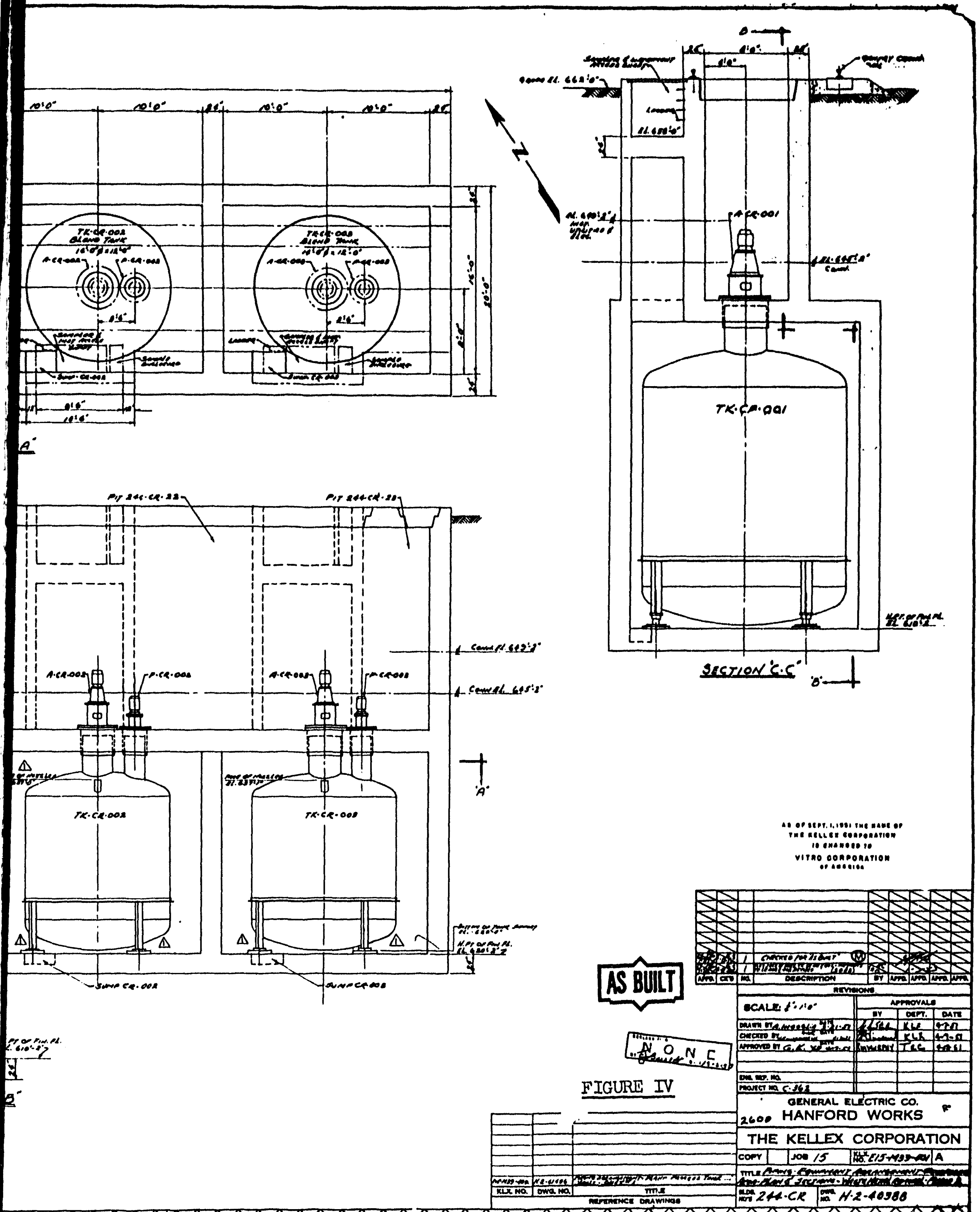


FIGURE IV

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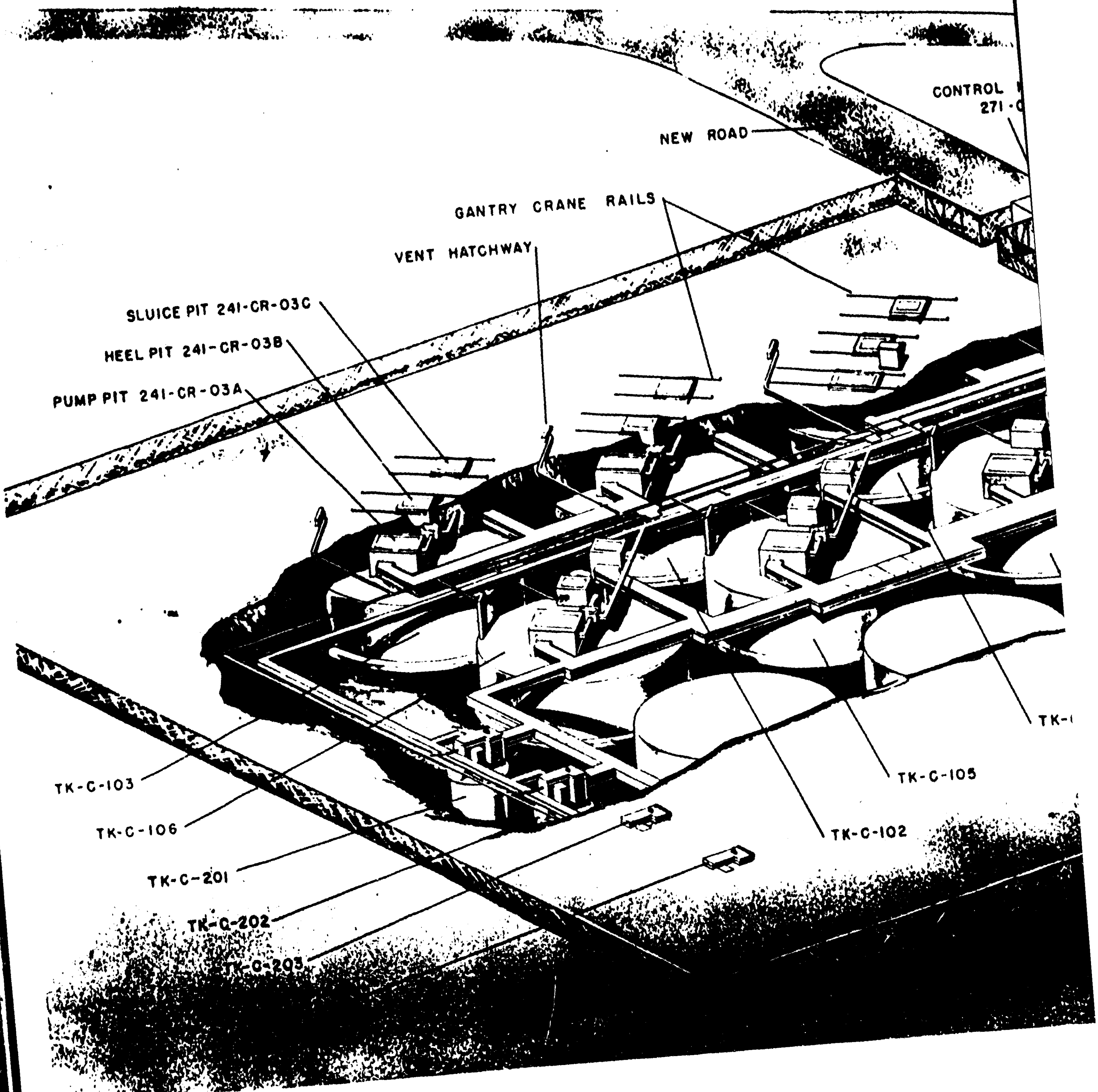
CONTROL
271-
NEW ROAD
GANTRY CRANE RAILS
VENT HATCHWAY
SLUICE PIT 241-CR-03C
HEEL PIT 241-CR-03B
PUMP PIT 241-CR-03A
TK-C-103
TK-C-106
TK-C-201
TK-C-202
TK-C-203
TK-C-102
TK-C-105
TK-

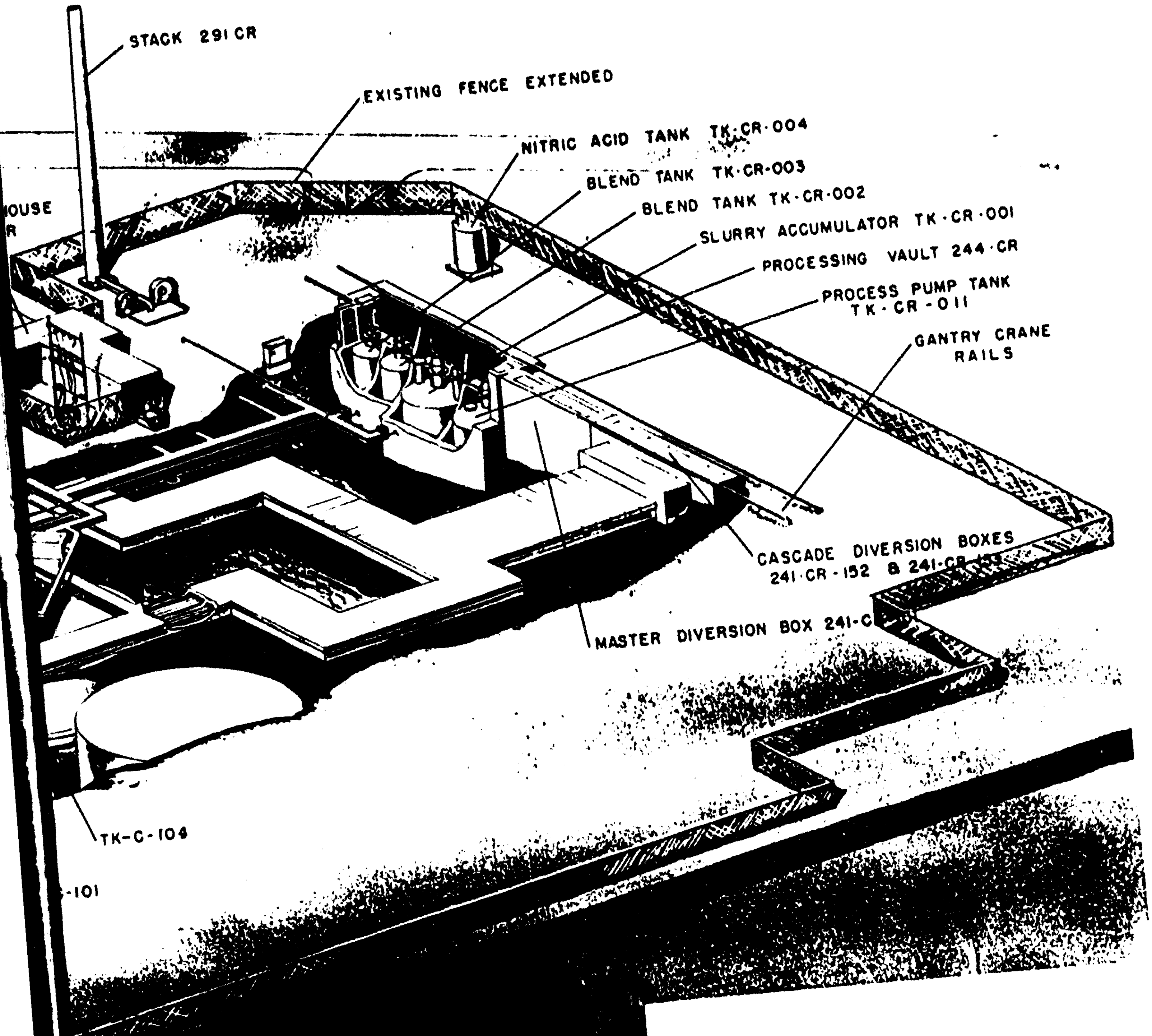

FIGURE V
CUTAWAY VIEW, 241-C TANK FARM
(FROM KLX. DWG. E15-TR-414)

UNCLASSIFIED

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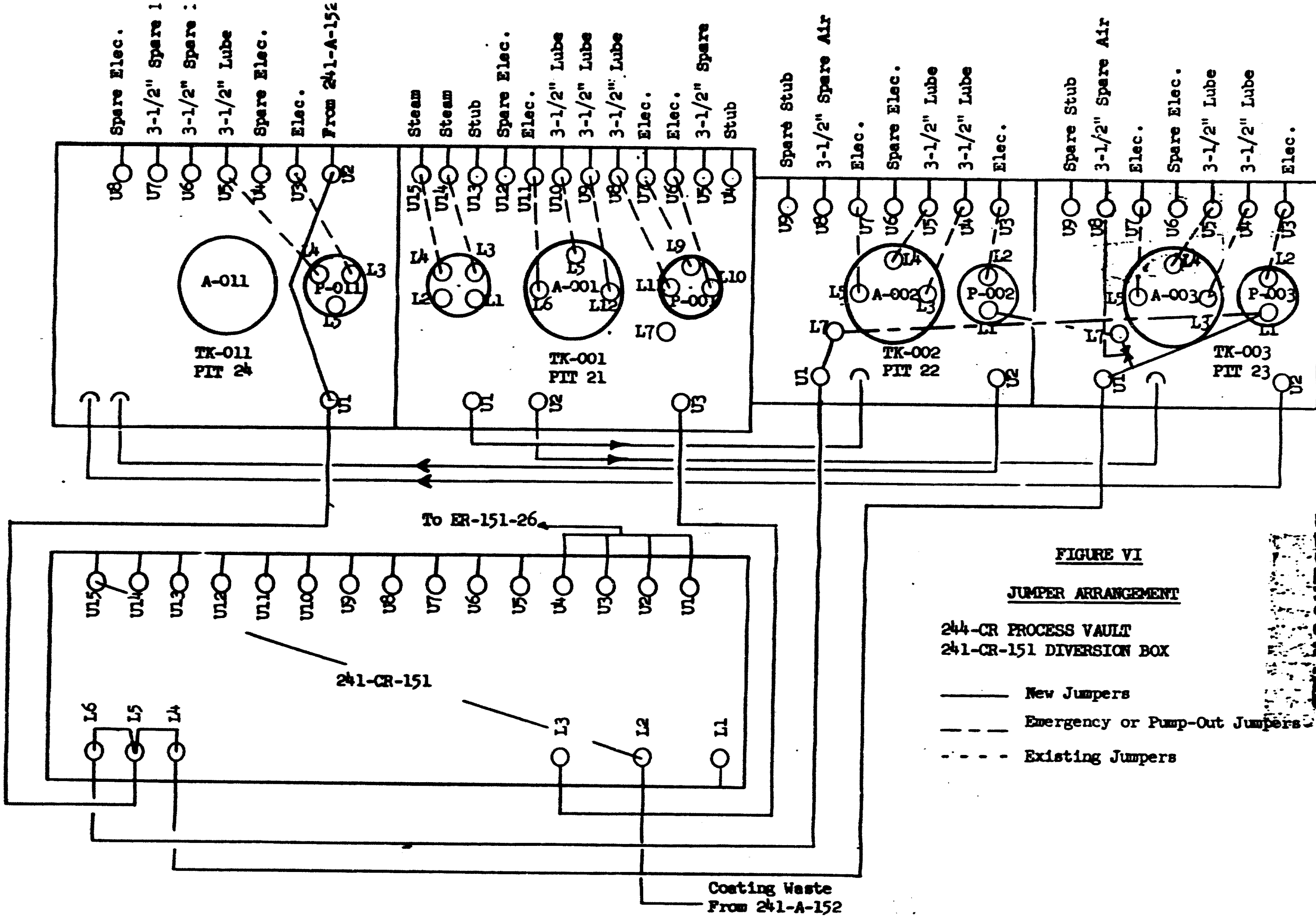

FIGURE VI

JUMPER ARRANGEMENT

244-CR PROCESS VAULT
241-CR-151 DIVERSION BOX

——— New Jumpers

— — — Emergency or Pump-Out Jumpers

- · - - Existing Jumpers

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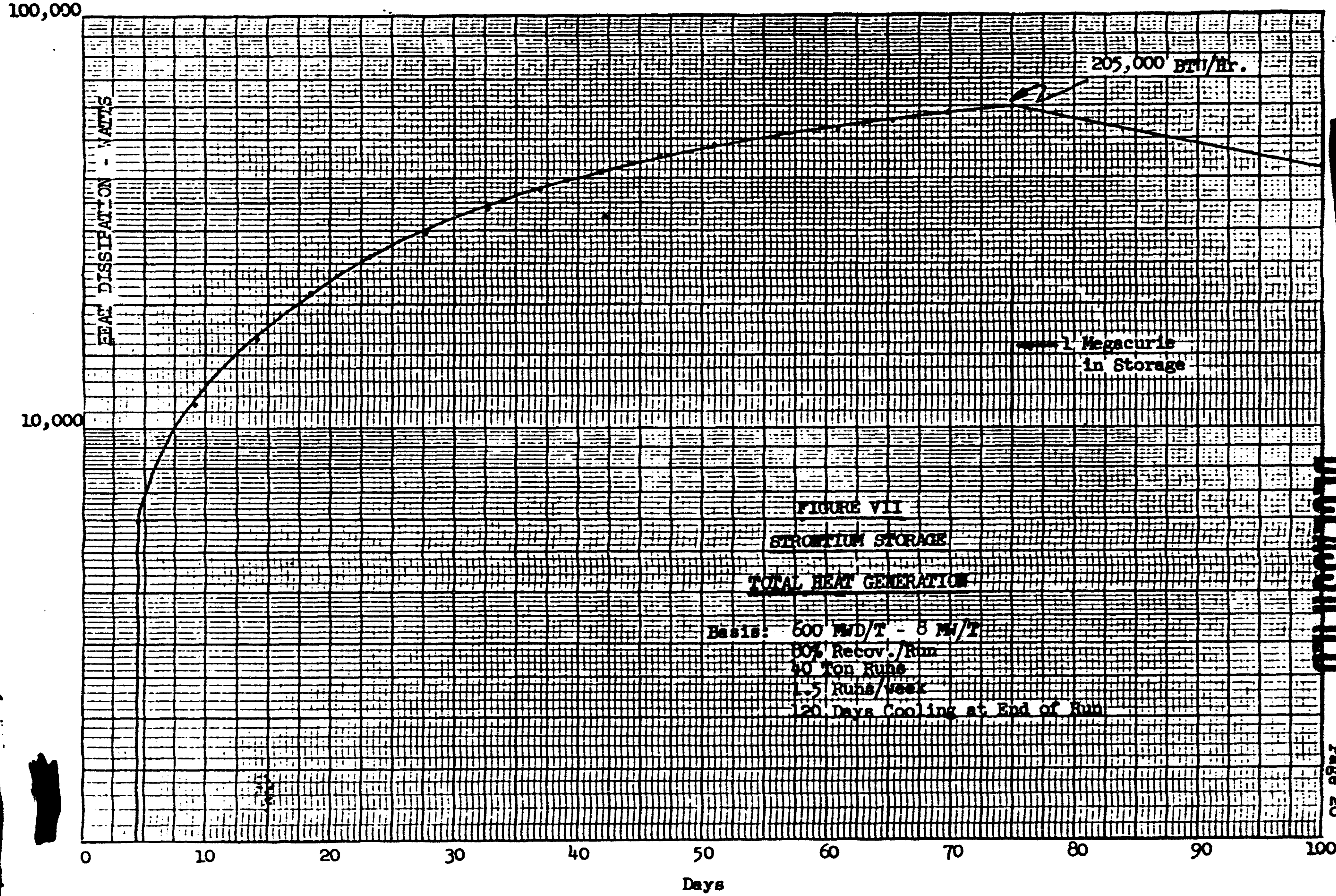

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