CLL-01462 DEL:

5/1/91

[redacted]

HISTORY OF OPERATIONS 1/JANUARY/1944 to 20/MARCH/1945
Book 4

CLASSIFICATION REVIEW FOR DECLASSIFICATION BUT LEFT UNCHANGED
H. Mahmurry
73-553
U.S. AEC Division of Classification

716547

REPOSITORY PNL
COLLECTION General Human Subjects
BOX No. N/A
FOLDER N/A

CONTENTS

Classification Cancelled (Change to
DECLASSIFIED W/DELETIONS)
By Authority of RLO-CG-4/CG-PR-2
D.L. SAMPLES/WHC-CO
By Chris Mason 5/16/91
PA Thurman
5/16/91

☐ DECLASSIFY
OR
☒ REVIEW

(DATE OR EVENT)

[redacted] DECLASSIFIED WITH DELETIONS

THIS DOCUMENT IS PUBLICLY AVAILABLE

1101478

[redacted]

LIST OF PHOTOGRAPHS, MAPS AND DRAWINGS

Photographs:

[redacted]

[redacted]

LIST OF PHOTOGRAPHS, MAPS AND DRAWINGS (CONTINUED)

[redacted]
DECLASSIFIED WITH DELETIONS
[redacted]

1101480

[redacted]

LIST OF PHOTOGRAPHS, MAPS AND DRAWINGS (CONTINUED)

[redacted]
DECLASSIFIED WITH DELETIONS
[redacted]

[redacted]

SECTION I

OBJECTIVES OF HANFORD OPERATIONS

[redacted]

Book 4

7

SECTION I

OBJECTIVES OF HANFORD OPERATIONS

production of

The objectives of Hanford operations are the ~~manufacture and delivery to the Corps of Engineers of the Army~~ sufficient quantities of plutonium and secondary products in time to meet adequately military requirements at the lowest cost of manpower, money, and materials commensurate with the maximum degree of certainty in attaining the objectives.

A secondary accomplishment will be to make sufficient quantities of plutonium, together with accumulated operating knowledge, available to the Government for assuring future national security and the conservation of the limited supply of vital raw materials.

All efforts of the responsible organizations have been well coordinated and have been directed toward the full attainment of these objectives and accomplishments. The responsible organizations are as follows: The E. I. du Pont de Nemours & Co., the Prime Contractor; the University of Chicago Metallurgical Project, Consultants; and the Corps of Engineers of the Army directly representing the Government of the United States. The Office of Scientific Research and Development has furnished invaluable scientific guidance in the process development, although it is not directly involved in plant operation.

[redacted]

DECLASSIFIED WITH DELETIONS

1101483

[redacted]

SECTION II

ELEMENTARY FACTS ABOUT PRODUCTION OF PLUTONIUM AND SECONDARY PRODUCTS

[redacted]

[redacted]

SECTION II

ELEMENTARY FACTS ABOUT PRODUCTION OF PLUTONIUM AND SECONDARY PRODUCTS

The processes developed to produce plutonium, and practiced at Hanford, are described elsewhere in the historical, research, and development documents of the Manhattan District. The following summary, however, is included here to make available readily the elementary facts which apply specifically to plant operations.

Plutonium.--Plutonium is the name given to a newly discovered chemical element of atomic number 94 which is obtained by transmutation of uranium of atomic number 92. Uranium was the heaviest element known and continues to be the heaviest element known to occur in nature.

Uranium.--Uranium occurs naturally in three different forms called isotopes. In the Hanford process, advantage is taken of the properties of two of these isotopes possessing atomic masses of 235 and 238. Uranium-235 possesses the properties which are desirable from a military standpoint or for the production of power. However, for these purposes, the uranium-235 must be separated from the other isotopes and this separation cannot be made by previously established production methods. Uranium-235 is vital to the Hanford process and its function is described below. Uranium-238, in the Hanford process, is transmuted to plutonium-239 which does possess the desirable military and power producing properties of uranium-235 and which, because it is a specific and distinct chemical element, can be separated from other chemical elements by difficult, though feasible, chemical methods.

Hanford Process.--Briefly and very generally, the facts of the Hanford process for the manufacture of plutonium-239 are as follows:

(1) Metallic uranium is surrounded by graphite;

(2) Present at random in the system and emitted continually from the uranium are atomic particles called neutrons;

(3) The structure is such that these neutrons must pass through the graphite which reduces them to a velocity which permits their absorption by both the uranium-238 and uranium-235 producing:

(4) The new chemical element plutonium-239,

(5) The destruction of the uranium-235 accompanied by the formation of some 25 highly radioactive by-product chemical elements,

[redacted]

[redacted]

(6) The emission of neutrons slightly greater in quantity than those absorbed, and

(7) Large quantities of heat approximately equivalent to the burning of 3,000,000 pounds (1500 tons) of coal for each pound of plutonium formed.

<u>Chain Reaction</u>.--The slight gain, or multiplication, in neutrons which accompanies the destruction of uranium-235 is the primary factor which makes the Hanford process possible. This process of neutron multiplication and use is what is commonly called a chain reaction. The quantity of these neutrons present in the graphite-uranium structure at any instant must be controlled. If an excess of neutrons are absorbed other than in the uranium-235 such as the formation of an excess of plutonium, capture by any of the large number of chemical elements present or leakage from the structure, the chain will be broken and the reactions will cease. If, on the other hand, the multiplication of neutrons is permitted to proceed without limit, the heat released by the destruction of an excess of uranium-235 could not be dissipated with sufficient rapidity to prevent a condition of serious damage or hazard and, perhaps catastrophe. The pile is so constructed that an excess of neutrons are always available. This excess is regulated by neutron absorbing rods, called control rods, which are inserted into, or withdrawn from, the pile so that the number of neutrons available are always precisely limited to meet the requirements.

<u>Heat Removal</u>.--Thus, it is seen that the graphite-uranium structure, called a pile, is a heat producing unit. The heat developed determines the rate at which the reactions and, consequently, the rate of plutonium manufacture may proceed. This great amount of heat must be dissipated and, in the Hanford piles, this is accomplished by a water cooling system the capacity of which is the limiting factor in determining the rate of plutonium manufacture.

<u>Pile Capacity</u>.--Since the rate of heat removal is proportional to the rate of plutonium manufacture, each of the three Hanford piles is rated in terms of heat removal or power units and the megawatt (one thousand kilowatts) was chosen. The rated capacity of each pile is 250 megawatts which rate of operation is approximately equivalent to the burning of 850 tons of coal per day.

<u>Radioactivity and Protection</u>.--The radioactivity associated with the operation of the Hanford piles and in subsequent processing is great. The energy of radiation within each pile at rated capacity is roughly equivalent to that which would emanate from 3,000,000 pounds of radium. The total amount of radium isolated prior to the outbreak of the war was less than one millionth of this amount. It is of the utmost importance that these very penetrating radiations be confined adequately so that operating personnel may work safely. Thus, the piles and all other processing apparatus in which these radiations are present are pro-

[redacted]

[redacted]

[redacted]

vided with massive shielding of various materials such as special masonite, iron, steel, concrete, water, and lead depending upon the specific requirements to be met.

Detection of Radioactivity.--The magnitude of these radiations and the serious consequences with respect to persons exposed to them make it also of the utmost importance that adequate precautions are taken to determine the presence and to maintain records of stray radiations and the degree to which persons have been exposed to them. This is necessary for the protection of all personnel in the manufacturing areas as well as all inhabitants within a radius of some fifty miles. Monitoring stations have been located at appropriate locations within the required area to provide records of such stray radiations and which records can be produced as evidence in any possible future legal actions against the Government. These precautions require a staff of highly trained technicians equipped with special instruments for detecting, measuring, and recording the intensities of the various radiations.

Secondary Products.--In addition to plutonium, a quantity of radioactive polonium is manufactured at Hanford. This is accomplished by exposing metallic bismuth to the neutrons in the pile. The polonium resulting from this exposure possesses properties which are required for other Manhattan District work. After the required period of irradiation, the bismuth slugs enriched with polonium are discharged from the pile and transferred to the Army ~~for delivery to another site~~.

[redacted]

SECTION III

SUMMARY OF MANUFACTURING OPERATIONS

[redacted]

SECTION III

SUMMARY OF MANUFACTURING OPERATIONS

The primary manufacturing facilities at Hanford are located in the 300, 100, and 200 Areas.

300 Area.—Metallic uranium is received in the 300 Area where it is fabricated into individual pieces, called slugs, and bonded into aluminum cans.

100 Area.—The canned slugs are transferred to the 100 Areas where they are placed into the 2004 water cooling tubes which pierce each of the three graphite piles. The rate of plutonium manufacture varies within the piles and, at rated capacity, the most highly enriched uranium will contain about 225 grams, or one half pound, of plutonium per ton of uranium at the end of about four months or about one quarter of a pound per ton at the end of two months. After the desired amount of enrichment has been obtained, those slugs containing this amount are discharged from the pile and replaced by freshly canned slugs. It is expected that about 30 tons of slugs will be discharged by remote handling methods and replaced each month at each pile.

200-N Area.— The discharged slugs require about sixty days of storage under water for decay of the radioactive fission by-product elements to a safe level for handling; this is accomplished in the 200-N storage area. This is required even though massive shielding is provided for the subsequent processing. This time lag also permits the substantial completion of the formation of plutonium from the intermediate element neptunium of atomic number 93.

200 Areas.—The slugs are then ready for shipment to the 200 Area Separation Plants in specially designed, lead-lined casks. In the 200 Areas, the aluminum jackets are dissolved from the slugs after which the plutonium is separated from the uranium and some 25 fission by-product elements. This is accomplished by a multiplicity of intricate chemical processes most of which are carried out behind massive concrete shielding by methods of remote control, operation, and maintenance.

Final Product.—The final product is in the form of a paste of plutonium nitrate of about 98% purity and almost entirely free of radioactivity except that emanating from the plutonium. The radiations from the plutonium, however, are so serious that sub-microscopic particles taken internally are fatal. The plutonium nitrate is then placed in specially designed containers and transferred to the Army for shipment to another site for further processing.

[redacted]

Manufacturing Time.--This summary indicates the time requirements for plutonium production. More than six months are consumed with operations at rated capacity from the time uranium is charged in a pile before quantity production of isolated plutonium is available for transfer to the Army for shipment to another site for further processing.

[redacted]

SECTION IV

300 AREA OPERATIONS AND FACILITIES

[redacted]

SECTION IV

300 AREA OPERATIONS AND FACILITIES

Metallic uranium, in the form of billets about $4\frac{1}{2}$ inches in diameter and 12 to 20 inches long, is received from suppliers under the jurisdiction of the Madison Square Area of the Manhattan District.

Extrusion.--The billets are heated in a furnace, in an inert gas (argon) atmosphere, to a working temperature of about 1700 degrees Fahrenheit. They are then extruded into rods about $1\frac{1}{2}$ inches in diameter and an average of about 12 feet in length by pressing, by means of a high powered hydraulic press, through a die.

Outgassing.--The rods receive a preliminary straightening manually, are quenched in water, and are then outgassed. The outgassing is performed to remove hydrogen from the metal to prevent formation of gas pockets or a bulky chemical compound of uranium and hydrogen either of which might result in serious difficulties in pile operation.

Straightening.--After outgassing, the rods receive a final straightening in a mechanical device and are then ready for machining.

Machining.--The rods are then machined in turret lathes into pieces, called slugs, each 1.359 inches in diameter and 8 inches long. After inspection to assure that there are no serious defects which would adversely affect pile operations and to make certain that the slugs are within the dimensional limits of tolerance, they are given an acid bath for removal of scale and a treatment for removal of any grease which may be on the surfaces.

[redacted]

away by the cooling water with resulting serious radioactive contamination of the pile area and the Columbia River.

[redacted]

Final Machining.--Following canning, the ends are machined to marks made under a fluoroscope which assures an equal amount of aluminum at each end for heat transfer and a minimum of aluminum to prevent excess neutron absorption.

Welding.--After degreasing, the top cap is then welded to the can by means of an argon shielded arc to assure maximum freedom from leaks.

Inspection and Testing.--The inspections and testing of each canned slug are performed to assure acceptance only of those which meet the specifications for surface defects, dimensions and warpage, penetration of aluminum-silicon through the aluminum can, and bonding of the uranium slug to the can.

Autoclave Testing.--One final, drastic test is applied to each slug. This consists of exposure to steam at a pressure of about 100 pounds per square inch for forty hours. Canning quality has been such that less than one failure occurs for each 2000 slugs surviving previous inspections and tests. As of 14 March 1945, a series of 25,000 slugs have passed the above autoclave test without a single failure.

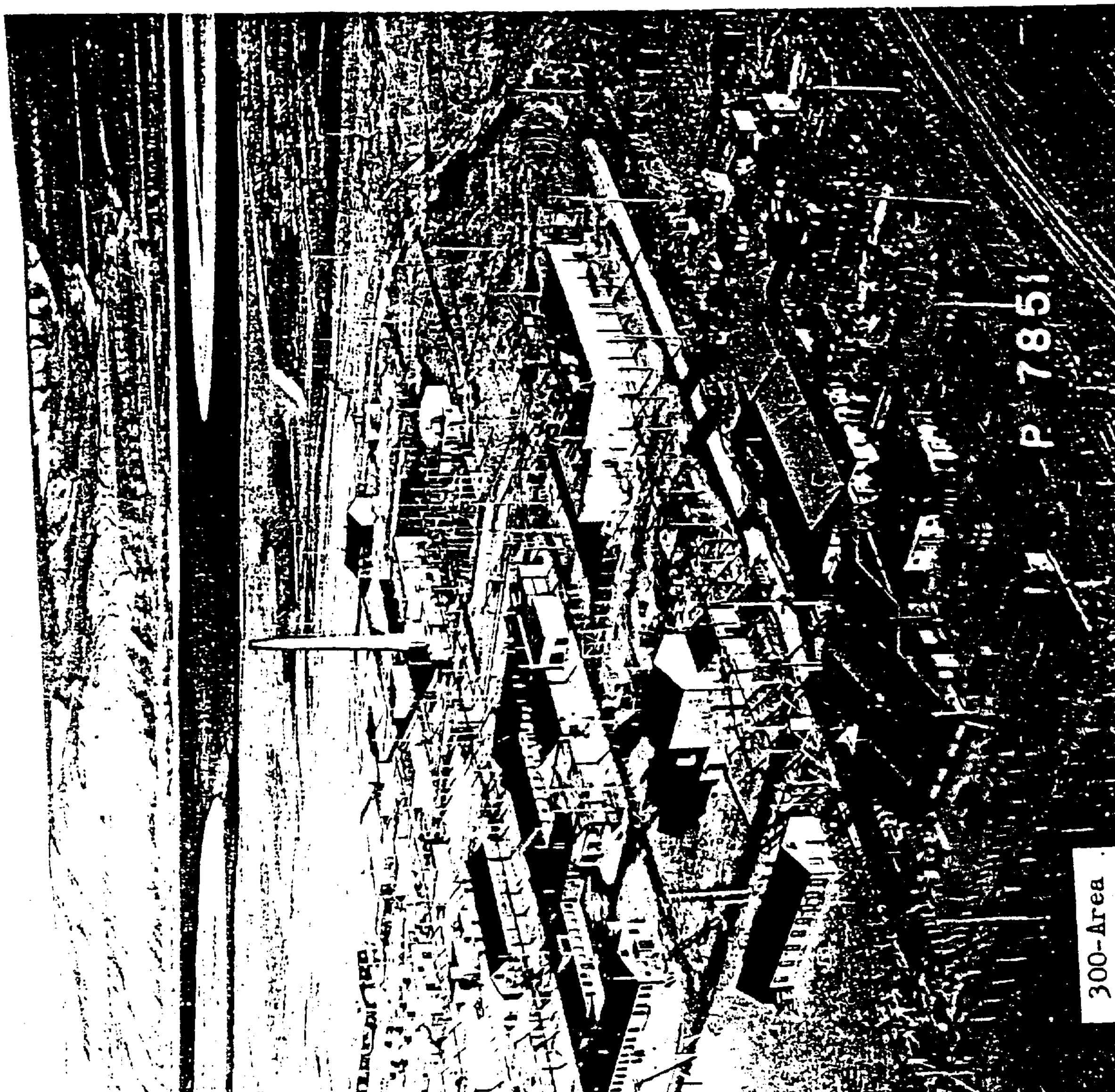
Quantity Requirements.--The magnitude of the uranium fabrication and canning processes is indicated by the following approximate requirements: (1) more than 1250 tons of billets were required for the initial charging of the three piles; (2) more than 130 tons of billets are required for normal replacement each month after equilibrium conditions have been reached in pile operation; (3) more than 210,000 canned slugs were required for the three initial charges; (4) more than 23,000 canned slugs will be required each month after routine operations have been established.

Slug Recovery.--Slugs rejected from the canning process are sent to the Recovery Operations for reclaiming of the uranium for recanning. In this process the cans and bonding layers are removed by

[redacted]

dissolving in a mixture of caustic soda and sodium nitrate followed by immersion in hydrofluoric acid.

Other 300-Area Facilities.--The 300 Area also includes the following facilities: (1) offices, library, and laboratories for scientific and technical personnel engaged in furnishing necessary assistance for all phases of Hanford operations; (2) a test pile for determining the neutron absorption or emission properties of all materials such as graphite and uranium used in the construction or operation of the manufacturing piles; (3) semi-works for investigating problems arising in the separation and isolation of plutonium from the uranium and fission by-product elements; (4) special shops and facilities for manufacturing, repairing, modifying, and calibrating the many types of electronics and other instruments required in the manufacturing processes and safety surveys; (5) a standards building for storage and use of the radium and radium-beryllium sources required for calibration of the special instruments and which also houses a small, special pile for calibration purposes; and (6) miscellaneous service facilities such as boiler plant and water supply.



DECLASSIFIED WITH DELETIONS

1101495

[redacted]

SECTION V

100 AREA FACILITIES AND OPERATIONS

[redacted]

SECTION V

100 AREA FACILITIES AND OPERATIONS

<u>General</u>.--There are three pile areas for manufacturing plutonium designated respectively as 100-B, 100-D, and 100-F. In each of these areas, the pile is the focal point toward which all other activities and auxiliary processes are directed. The auxiliary manufacturing facilities of these areas include several main features the most important of which is an unfailing supply of extremely pure and precisely treated water in large quantities. The three areas are identical in design except for differences in the water purification and refrigeration systems.

<u>Water</u>.--In each pile area, a river pump house supplies water from the Columbia River to two storage reservoirs totalling 25,000,000 gallons capacity. It is then treated to meet the rigid requirements of the process which demand almost complete freedom from corrosion and film formation in the water cooling tubes and the canned uranium slugs in the pile. The facilities for water treatment include filtration plants, demineralization equipment (for 100-D only) deaerators and chemical addition. Refrigeration facilities for a part of the water are provided in the 100-D and 100-F areas to increase the power capacity of the piles during the warm months when the river temperature rises. Following this treatment, the water is pumped to the piles. After passing through the piles, the water is held up in retention basins to allow decay of certain short-lived radioactivity before the water is discharged back into the river.

<u>Helium</u>.--In addition to the water, helium is circulated through the pile. A helium storage, purification and circulating system are is provided for each pile.

<u>Auxiliary Facilities</u>.--Steam power, high voltage electrical power, shops, storerooms, laboratories, and offices are also included in the facilities for each pile area.

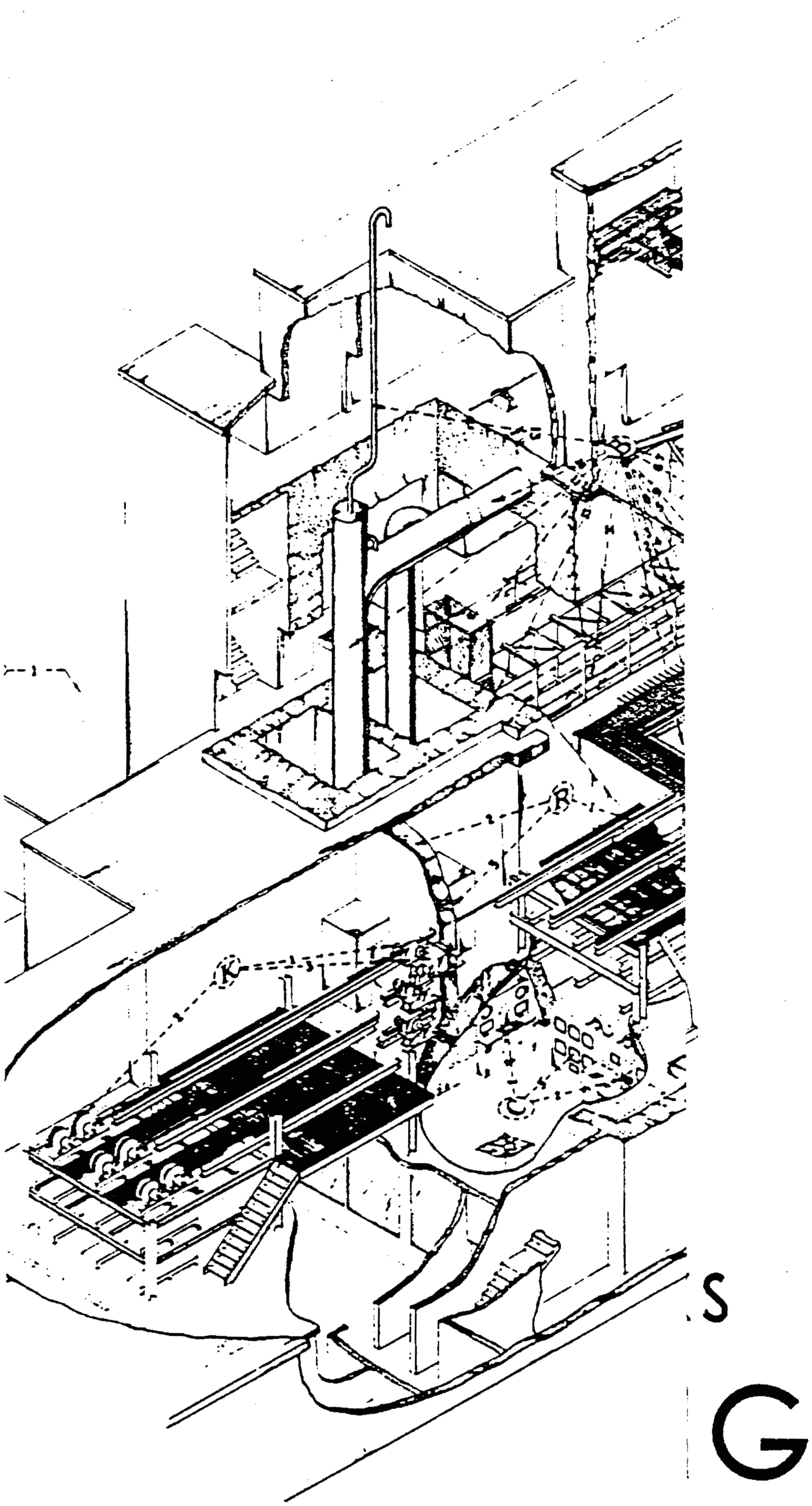
<u>Size of Area</u>.--Each of the 100 Areas occupies about 685 acres of land.

\- - - - -

With emphasis on operations, these facilities are described in somewhat greater detail as follows:

<u>Pile Structures</u>.--Each pile is a heat producing unit designed to liberate the heat equivalent of 250 megawatts or approximately that which would be released from the burning of 850 tons of coal per day.

7-1401



CHARGE PREPARATION

U-1 HANDLING OF URANIUM SLUGS PREPARATORY TO LOADING THEM IN PILE

FACE OF PILE

P-1 SHIELD COMPOSED OF LAMINATIONS OF STEEL AND MASONITE.
P-2 2004 TUBES PROJECT THROUGH SHIELD AND PILE
P-3 HEADERS CARRY WATER TO TUBES. FLOW CONTROLLED BY SEPARATE ORIFICE IN EACH TUBE.
P-4 RISERS FEED HEADERS. TWO RISERS MAKE IT POSSIBLE TO FEED MOST ACTIVE TUBES WITH REFRIGERATED WATER, LESS ACTIVE TUBES WITH WATER AT NORMAL RIVER TEMPERATURE. ENTER THROUGH TUNNEL.
P-5 VALVE ON EACH HEADER
P-6 TUBES FOR COOLING OF SHIELD OF PILE
P-7 AUXILIARY PIPING SYSTEM MAKES POSSIBLE DRAINING OF ANY SELECTED HEADER AT TIME OF LOADING PILE
P-8 ELEVATOR PLATFORM FOR USE IN LOADING TUBES AND FOR ANY WORK ON PILE FACE. CAN BE WITHDRAWN INTO ELEVATOR PIT BELOW
P-9 WORK AREA. LENGTH DETERMINED BY POSSIBILITY OF HAVING TO REMOVE ALUMINUM TUBE FROM PILE. DUCT LEADS IN AIR FOR VENTILATION AND REMOVAL OF RADIOACTIVE EMANATIONS.
P-10 CANVAS CURTAIN FORCES VENTILATION TO SWEEP OVER WHOLE FACE OF PILE.

FAN HOUSE

F-1 EQUIPMENT FOR CIRCULATING AIR THROUGH PILE BUILDING TO REMOVE RADIOACTIVE GASES.

VALVE ROOM

V-1 VALVES FOR CONTROL OF FLOW OF WATER IN INLET PIPES

X-RAY VIEW FROM BALCONY

B-1 GRAPHITE BLOCKS IN PILE LAID UP IN CRISS-CROSS ARRAY
B-2 THERMAL SHIELD CONSTRUCTED OF IRON TO REMOVE MAJOR PART OF HEAT OF EMERGENT NEUTRONS AND GAMMA RAYS
B-3 GAP FOR ENTRANCE OF HELIUM INTO PILE; DISPLACES NITROGEN, NEUTRON ABSORBING COMPONENT OF AIR
B-4 LAMINATED SHIELD TO LOWER INTENSITY OF RADIATIONS TO LEVEL SAFE FOR PERSONNEL.
B-5 SAFETY RODS CONSTRUCTED OF NEUTRON ABSORBING MATERIAL DROPPED INTO PILE IN CASE OF EMERGENCY TO BRING NEUTRON CHAIN REACTION TO QUICK HALT
B-6 CABLES ATTACHED TO RODS LEAD TO OVERHEAD WINCHES.
B-7 SPRING BUFFERS TO BREAK SHOCK OF FALL IF WINCH BRAKES FAIL.
B-8 RODS USED FOR CONTROL OF REACTION UNDER NORMAL OPERATING CONDITIONS.
B-9 ALUMINUM TUBES LEAD WARMED WATER FROM PILE TO HORIZONTAL HEADERS (NOT SHOWN).
B-10 HORIZONTAL CONNECTOR COMBINES WATER FROM BOTH EXIT RISERS.
B-11 DOWNCOMER CARRIES RADIOACTIVE DISCHARGED WATER TO SHIELDED CANAL WHICH LEADS TO HOLDING BASIN AND RIVER.
B-12 CONCRETE WALLS SHIELD OPERATORS FROM PENETRATING RADIATIONS COMING FROM RADIOACTIVE WATER.
B-13 VENT PIPE PREVENTS FORMATION OF VACUUM. IT IS IMPORTANT THAT WATER SHOULD NOT BE SUCKED OUT OF PILE IN CASE THE INLET PUMPS FAIL.
B-14 ELEVATOR PLATFORM ALLOWS OPERATOR TO UNSCREW CAPS AT ENDS OF TUBES AT TIMES OF DISCHARGE OF IRRADIATED URANIUM
B-15 BALCONY FOR INSPECTION OF REAR FACE OF PILE AND WATER BASIN BELOW INTO WHICH SLUGS FALL.

ROD ROOM

R-1 NINE RODS OF WHICH SEVEN MAY BE USED FOR COMPENSATION OF MAJOR PART OF UNUSED MARGIN OF MULTIPLICATION FACTOR AND TWO FOR THE MINUTE-TO-MINUTE CONTROL OF THE CONSTANCY OF THE POWER OUTPUT.
R-2 LEAD-CONCRETE WALL PROTECTS OPERATORS OUTSIDE AGAINST ACTIVITY INDUCED IN CONTROL RODS WHILE THEY ARE IN PILE.
R-3 LABYRINTH PREVENTS ESCAPE OF RADIATION FROM RODS BUT MAKES POSSIBLE ENTRANCE TO ROD ROOM AFTER DECAY OF ACTIVITY.

RACK ROOM

K-1 RACK AND PINION DRIVE OF CONTROL ROD
K-2 FLEXIBLE HOSES UNWOUND FROM REELS CARRY COOLING WATER TO ROD AND LEAD HEATED WATER AWAY FROM ROD.
K-3 SELSYN MOTOR TRANSMITS TO CONTROL ROOM INDICATION OF POSITION OF CONTROL ROD.

CONTROL ROOM

C-1 LIGHTS ON CONTROL PANEL GIVE INDICATION IF TEMPERATURE OF EXIT WATER IN ANY TUBE EXCEEDS PERMISSIBLE VALUE. SIMILAR PANEL FACING THIS ON OPPOSITE SIDE OF ROOM GIVES INDICATION IF PRESSURE AT INLET OF ANY TUBE EXCEEDS OR FALLS BELOW PERMISSIBLE RANGE.
C-2 CONTROL PANEL PROVIDES INDICATION OF POSITION OF RODS AND OF OTHER OPERATING CONDITIONS. OPERATOR ADJUSTS POWER LEVEL BY ALTERING POSITION OF RODS BY REMOTE CONTROL.
C-3 POWER OUTPUT INDICATED ON PANEL. METER WORKS ON BASIS OF READINGS OF WATER FLOW AND INLET AND OUTLET TEMPERATURES.

STORAGE AND TRANSFER

S-1 BASIN FOR TEMPORARY UNDERWATER STORAGE OF IRRADIATED URANIUM SLUGS. EQUIPMENT FOR TRANSFER OF SLUGS TO CARS WHICH CARRY THEM TO STORAGE AREA.

[redacted]

[redacted]

The pile consists essentially of a block of exceptionally pure graphite about 36 feet by 36 feet by 28 feet. From front to rear this block is pierced by 2004 holes in which are located aluminum water cooling tubes. The canned uranium slugs are charged into the aluminum tubes and rest upon two ribs located at the bottom of the tubes. This design permits the cooling water to pass through the annular space between the slugs and the tubes.

The graphite block rests upon a massive concrete foundation and is surrounded on the four sides and the top by shielding approximately six feet in thickness comprising about one foot of water cooled cast iron and five feet of steel and special masonite arranged in alternate layers.

The shielding at the front and rear faces is pierced by holes which match up with those in the graphite for the cooling tubes which protrude through the shields and are connected to an intricate system of piping which, in turn, is connected to the water supply and discharge systems. The connections are such that refrigerated water can be passed through the central, or hottest, zone and unrefrigerated water through the outer zone.

The sides and top of the graphite and shielding contain additional holes for insertion or withdrawal of the neutron absorbing control and safety rods and for special test purposes.

Discharging Operations.—As previously described, plutonium is continuously manufactured and the amount present is dependent upon the amount of heat developed (the power level at which the pile is operated), the length of time the uranium slugs are in the pile and, for any specific slug, its location within the pile.

The pile is taken out of service when slugs enriched with plutonium are to be discharged. Discharging and charging are performed simultaneously; as the new canned uranium slugs are charged, or pushed, into an aluminum cooling tube, the enriched slugs are forced out at the other end falling freely onto a neoprene mattress and, thence, into the water of the discharge storage basin. The discharge face of the pile is evacuated of all personnel during these operations because of the intense radioactivity.

The water in the basin is sufficiently deep to shield the working area above the surface from any radioactivity which emanates from the discharged slugs. After discharging, the slugs are sorted under water manually by the use of long tongs, placed in special buckets suspended from an overhead monorail system, and weighed. The buckets are then placed, by means of specially designed apparatus, into a lead-lined, water cooled cask and transferred to the 200-North Area on a special railroad car.

[redacted]

Plutonium Accountability.--It has been stated that the total amount of plutonium manufactured is determined by the power level, time of irradiation, and location within the pile. The history of each of the approximately 70,000 slugs in each pile relative to these statistics is kept by means of automatic card indexing machines. This permits ready selection for discharging of those tubes which contain the most desirable amount of plutonium.

Helium System.--It is necessary that all voids within the pile structure be filled with some gas which will neither affect the process adversely nor present a serious health hazard in the event of leakage from the pile. Air cannot be used because its nitrogen absorbs neutrons effectively and its argon becomes intensely radioactive presenting a potentially serious health hazard. Helium does meet these requirements perfectly and, in addition, possesses the desirable quality of conducting heat to the cooling tubes at a satisfactory rate. Only the impurities which may be present in the helium present a serious problem. Thus, helium circulation and purification systems are provided so that impurities may be removed. Moisture is removed by circulation through silica gel which is regenerated as required; other impurities are removed by compressing the helium to extremely high pressures and refrigerating to extremely low temperatures followed by circulation through activated carbon. The activated carbon is regenerated by application of an extremely high vacuum. All of these operations are carried on behind massive concrete walls and by remote operation of the equipment because of the intense radioactivity of the impurities. High pressure helium storage tanks are provided to permit ready replacement of that helium which is normally lost from the system.

Control and Safety Rods.--As previously mentioned, the quantity of neutrons present in the pile at any instant must be precisely controlled and this is done by inserting, or withdrawing, rods which contain the element boron which possesses the property of absorbing neutrons effectively.

Nine horizontal hydraulically operated, water cooled control rods are provided for each pile and enter the graphite from the side. These rods are used, in whatever quantity is required, for regulating the process from moment to moment. In the event of loss of electric power, reduction of process water pressure, or a number of other predetermined conditions, these rods are driven into the pile automatically to stop the reactions. These rods are designed with sufficient capacity to absorb excess neutrons resulting from any condition except loss of water from the cooling tubes.

In addition to the nine horizontal control rods, 29 vertical safety rods are provided which are not water cooled and which are normally suspended above the top of the pile. The vertical rods are released automatically to drop by gravity into the pile upon the occurrence

[redacted]

of any of a number of predetermined events more serious than those which insert the horizontal rods only.

Instrumentation and Control Systems.--The pile process is of such nature that operation would be impossible without instruments which measure accurately conditions which exist at points within the pile and at other remote and inaccessible locations.

All pile control operations are conducted from a central control room. The operator is seated in front of the main control panel where he may observe readily those instruments which keep him constantly informed of power level, minute deviations from operating power level, control rod positions, and the identification of any of 28 conditions which have either automatically inserted the control or safety rods into the pile or which require investigation. The operator also has immediately at hand the switches for adjustment of control rod positions and for emergency manual insertion of the control and safety rods.

Four additional instrument panels are provided in each pile control room furnishing important information relative to some 5000 individual conditions of the pile or the contributing auxiliary processes. For example, the water pressure at the inlet of each of the 2004 pile cooling tubes is indicated on one panel and these instruments are so constructed and connected that a previously determined deviation above or below the standard pressure causes the nine control rods to be driven instantaneously into the pile stopping the reaction. The exit water temperature of each of the 2004 tubes may be measured automatically at sufficiently frequent intervals to assure safe operation. Other panels furnish information relative to total water flow, water supply pressures, the functioning of the helium system, radioactivity in various parts of the building, and many other important conditions.

Other important instrument and control centers are located within each 100 Area in the boiler houses, and at various points in the water supply, distribution, and treatment systems.

Removal of Heat.--More than 90% of the heat developed is in the uranium and is transferred through the slug jacket directly into the cooling water raising its temperature. Most of the remainder of the heat developed is from the bombardment of the graphite by neutrons; a small amount is developed in the shields. Normally, more heat is developed and more plutonium manufactured in the central tube of the pile than in any other; the central tube is approximately twice as effective in heat and plutonium production as the average tube; the outer tubes are less effective. If an abundance of neutrons are available, this distribution of heat can be adjusted somewhat by a process known as poisoning in which neutron absorbing slugs are interspersed within the pile so

[redacted]

[redacted]

[redacted]

as to reduce the heat developed in the central tubes and permit more to be developed in the outer tubes. This is desirable because the exit water temperature of the hottest tube is limited to approximately 65° Centigrade for a number of reasons including a factor of safety below the boiling point of water and because serious corrosion of the aluminum surfaces takes place at higher temperatures.

The cooling water system is so designed and operated that 30,000 gallons per minute are pumped through the tubes and around the uranium slugs of the pile. This quantity is more than would be required if each tube of the pile generated the same amount of heat and if a higher exit water temperature could be tolerated. The total amount of water pumped through the three manufacturing piles is more than would normally be required for a city of 1,000,000 population.

Because ordinary water absorbs neutrons quite readily, the total amount of water which may be present in the pile at any instant is limited to that which will permit sufficient neutrons to avoid capture and continue the chain reaction required by the process. This amount of water, in turn, limits the size of the annular passage through which the water must flow in passing through the pile and this annular passage is somewhat more than 1/16 inch in thickness. This fact has resulted in the most severe heat transfer problem ever encountered and demands almost complete freedom from film formation on the cooling surfaces; this is distinct from the requirement of freedom from corrosion to prevent contact of water with the uranium.

<u>Water Supply</u>.--The previously described control and safety rods function to stop the reaction within the pile within approximately 2½ seconds. However, the pile will continue to generate heat indefinitely at a gradually reduced rate after shutdown due to the radiations emanating from the fission by-product elements. At the end of the approximate 2½ second period, the heat developed will have been reduced to about 1/5 of the operating value and this amount will slowly diminish. Thus, it is vital that the water supply be unfailing. Probably the worst condition resulting from stoppage of the water supply would be a steam explosion requiring complete abandonment of the pile area unless it should be of such violence that the radioactive uranium slugs were scattered over a wide area making a much larger amount of territory untenable.

The design, construction, operation, and maintenance of the water supply system have been predicated upon this requirement of complete dependability. The requirements are reflected in water storage, distribution, pumping, and control systems and in the duplication of electric and steam power in many instances.

In addition to the primary process requirements, water is required for condensing the steam exhausted from the many steam turbines driving pumps and other equipment; for cooling water for the extremely large refrigeration plants; for boiler feeding; for fire and sanitary requirements; and other purposes. The magnitude of the operations is indicated by the fact that the combined rated capacity of the 40 river pumps is 377,500 gallons per minute or approximately the amount required for a city of 5,000,000 population. The following tabulation is a partial list of water pumping facilities for the three pile areas:

Service	Number of Pumps	Approximate Total Capacity Gallons per Minute
River Pumps	40	377,500
Reservoir Pumps	85	360,000
Filter Plant Pumps	44	175,000
Main Process Pumps	72	108,000

The water treating equipment differs slightly in the three areas. Only 100-D has a demineralization system. Only 100-D and 100-F are provided with refrigeration equipment. In other respects the facilities in each of the three 100 Areas are identical.

River Pumps and Reservoir.--Water is pumped from the river by means of 10,000 gallon per minute motor driven vertical pumps. In addition, steam turbine driven pumps are provided for stand-by service. In each area the water is delivered from the river pumps to a 15,000,000 gallon reservoir from which it overflows into an adjacent 10,000,000 gallon raw water reservoir. From this reservoir it is pumped to a filter plant. The 15,000,000 gallon reservoir is called the emergency reservoir and is kept full at all times.

Filter Plant.--The 36,000 gallon per minute filter plant for each 100 Area consists of chemical feeding equipment, mechanical mixing and flocculating chambers, subsidence basins, gravity filters, and two 5,000,000 gallon clear wells for storage of filtered water. In the filter plant, the suspended material present in the water is removed by treatment with suitable chemicals followed by a sedimentation period and then filtration through a bed of specially treated anthracite coal, sand, and gravel. Provision is also made for chlorination of water before and after the filters and for individual chlorination of the sanitary water supply.

Demineralization.--A 30,000 gallon per minute demineralization plant is provided in 100-D to assure distilled water purity if necessary and space has been left for similar installations in the other areas. The demineralization plant is designed to remove dissolved calcium, magnesium, and sodium salts by passing the water through sulfonated coal.

In the process, these salts are converted to their corresponding acids. The acids, except for the carbonic acid which is formed, are removed by passing the acidic water through a special material called De-Acidite.

Deaeration.--Deaerating equipment is provided in each pile area to remove dissolved gases from 30,000 gallons per minute of water. The demands are especially great in 100-D where the demineralized water contains large quantities of dissolved carbon dioxide. In all areas, the deaerators can remove dissolved oxygen from the water. Deaeration (degassification) is obtained by passing the water in a finally divided state through towers in which a vacuum is maintained by means of steam jets. Acid feeding equipment is provided at these units for adjusting the acid content of the exit water in controlling corrosion. Equipment for feeding other chemicals such as sodium dichromate and sodium silicate are also provided for corrosion control.

Refrigeration.--Provision has been made in 100-D and 100-F for supplying chilled water to the central portion of the piles. Approximately 14,000 tons of refrigeration has been provided in 100-D and 10,000 tons in 100-F. One ton of refrigeration represents the equivalent amount of heat required to freeze one ton of water per day at 32 degrees Fahrenheit.

Process Water Storage.--All process water is stored in specially designed tanks with floating roofs to prevent reabsorption of oxygen. There are four such process water tanks in each pile area. Each tank has a capacity of 1,750,000 gallons and two tanks are normally connected to the chilled water system and the other two to the unchilled system.

Process Water Pumps.--The process water tanks feed by gravity to the suction of the Process Water Pumps which force the 30,000 gallons per minute of water through the cooling tubes of each pile. These pumps are arranged in sets of two in series. Each set consists of one 3,000 gallon per minute electric pump and one 3,000 gallon per minute steam turbine driven pump. The motor driven pumps are provided with flywheels so that they will continue to pump for a number of seconds after an electric power failure. The time element provided by the flywheels is to assure a positive flow of water through the pile while the control and safety rods are being inserted to stop the pile reaction and to permit the automatic control systems for the boiler plant and steam turbine driven process water pumps to act to accelerate steam generation and water pumping by the steam pumps.

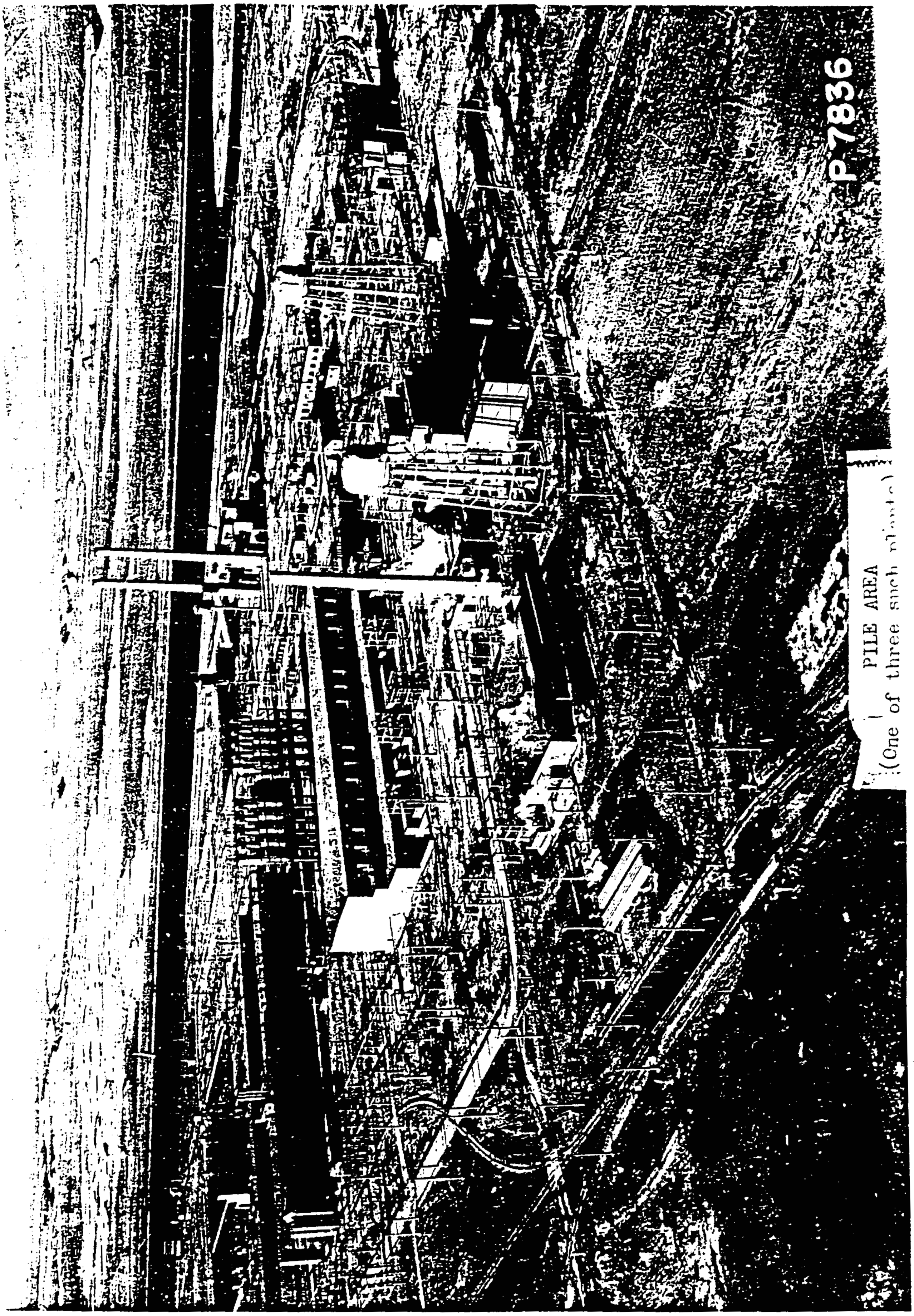
Emergency Water Tanks.--Two 300,000 gallon emergency water storage tanks are connected into the water system to the pile. In the event of failure of both steam and electric power systems, the water pressure to the pile will be reduced to the extent that water will flow from these emergency tanks through the pile. This assures an adequate flow of water through the pile for a short period while steps are being taken to reestablish the normal flow.

Power Supply

Electric.--The primary power requirements for water pumping and other services are supplied by a 230,000 volt electrical transmission system connected to the Bonneville and Grand Coulee system. The total connected load of the three 100 Areas is 84,350 kilowatts of which more than 60,000 kilowatts result from motor driven water pumps.

Steam.--A boiler plant is provided in each 100 Area to furnish an independent source of power in the event of failure of the main electric supply. However, the amount of steam generating capacity and number of steam turbines do not duplicate the electric power capacity; they are limited to those requirements where less than complete dependability would be disastrous. The combined capacity of the steam generating equipment of the three pile areas is 1,200,000 pounds per hour or about that required to produce electric power at the rate of 120,000 kilowatts.

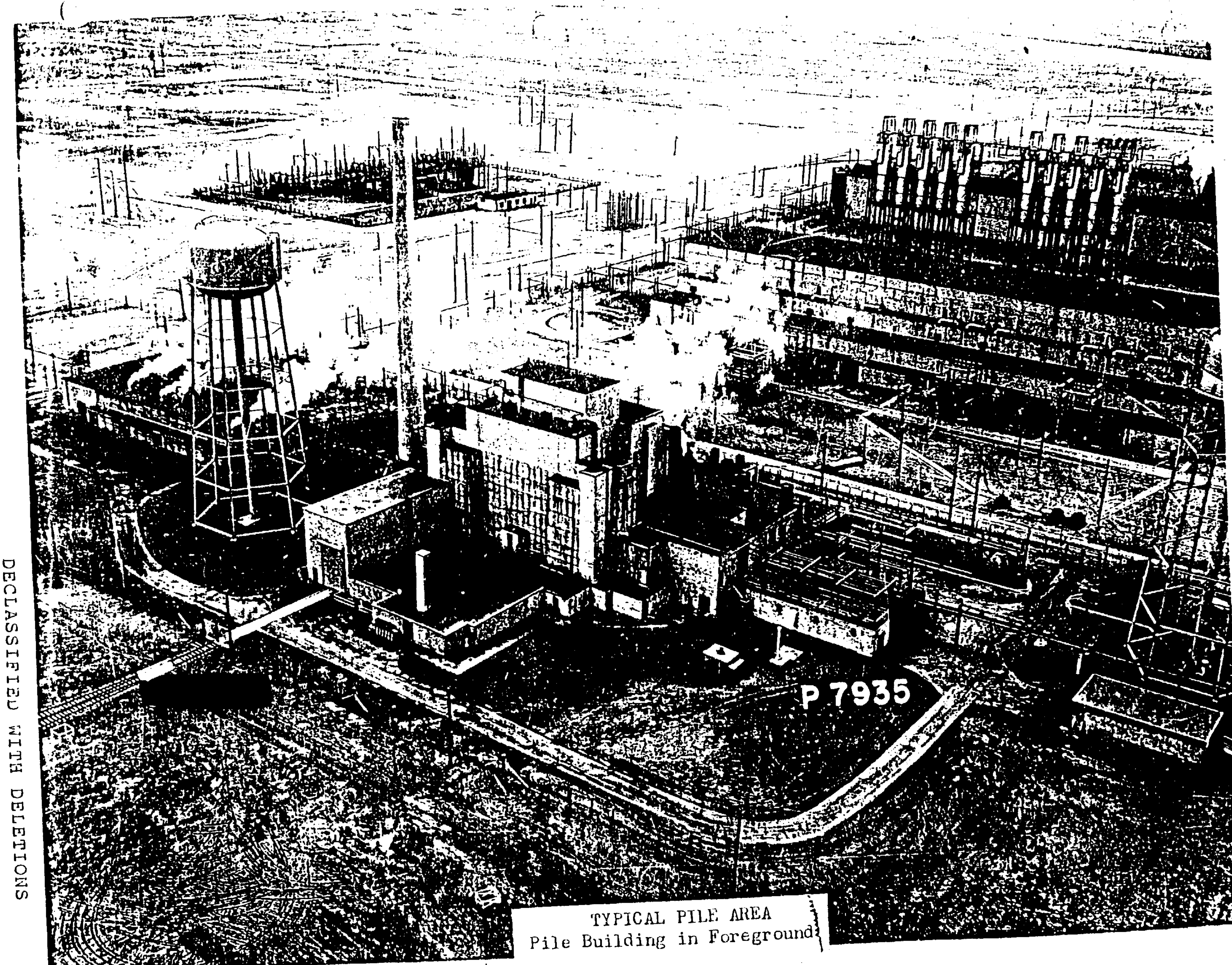
Note:--Of the above described facilities, the demineralization and deaeration plants are not being used. These facilities were incorporated in design and construction on the basis of the best knowledge and judgment available at the time. Subsequent research and development relative to film formation and corrosion provided more satisfactory and lower cost methods for limiting these conditions than do the demineralization facilities. Subsequent knowledge with respect to dissolved oxygen in the pile cooling water has reversed the earlier beliefs so that deaeration is now considered undesirable. It is possible that accumulated operating knowledge will indicate a future need for the demineralization and deaeration facilities.



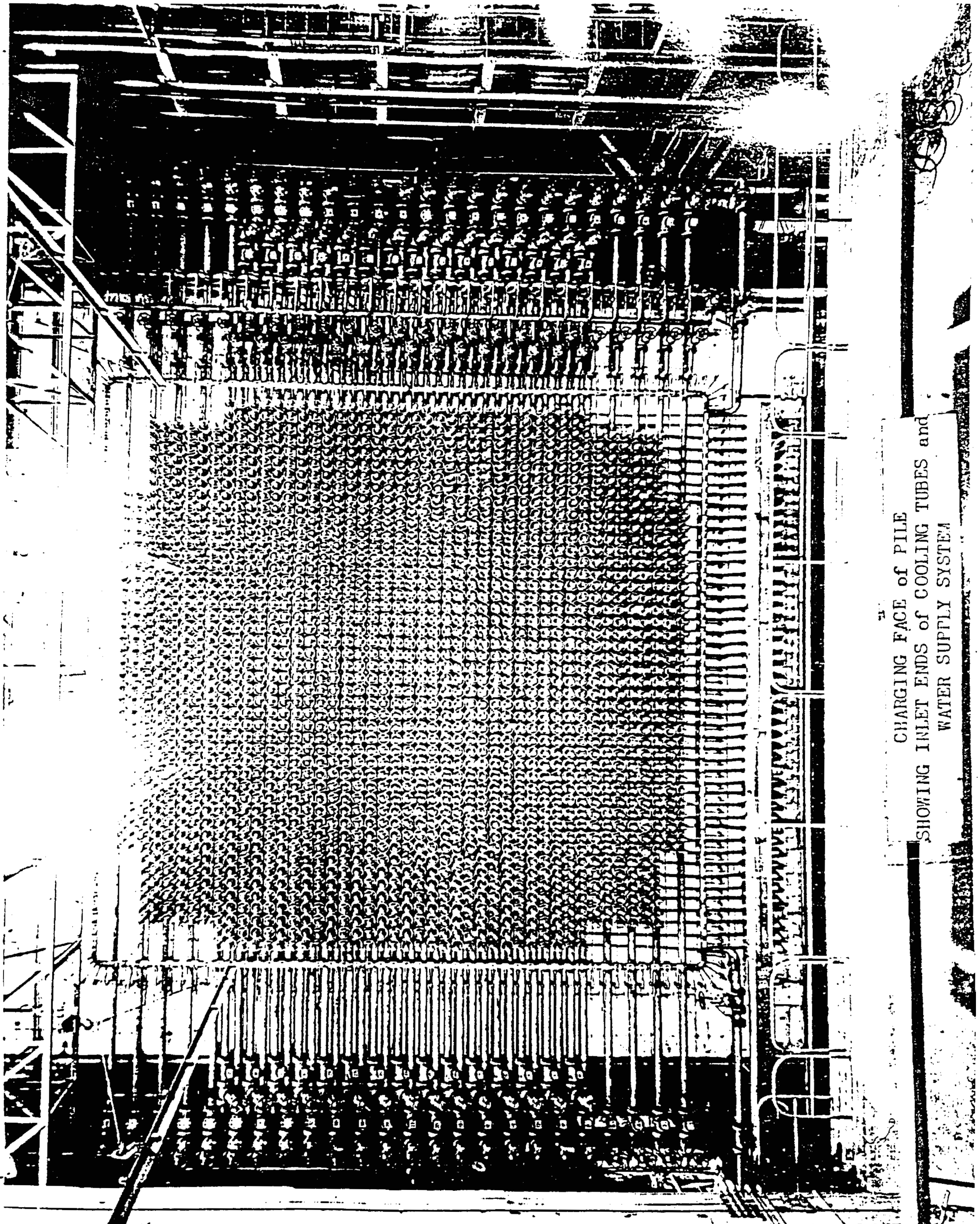
PILE AREA
(One of three such plants)

DECLASSIFIED WITH DELETIONS

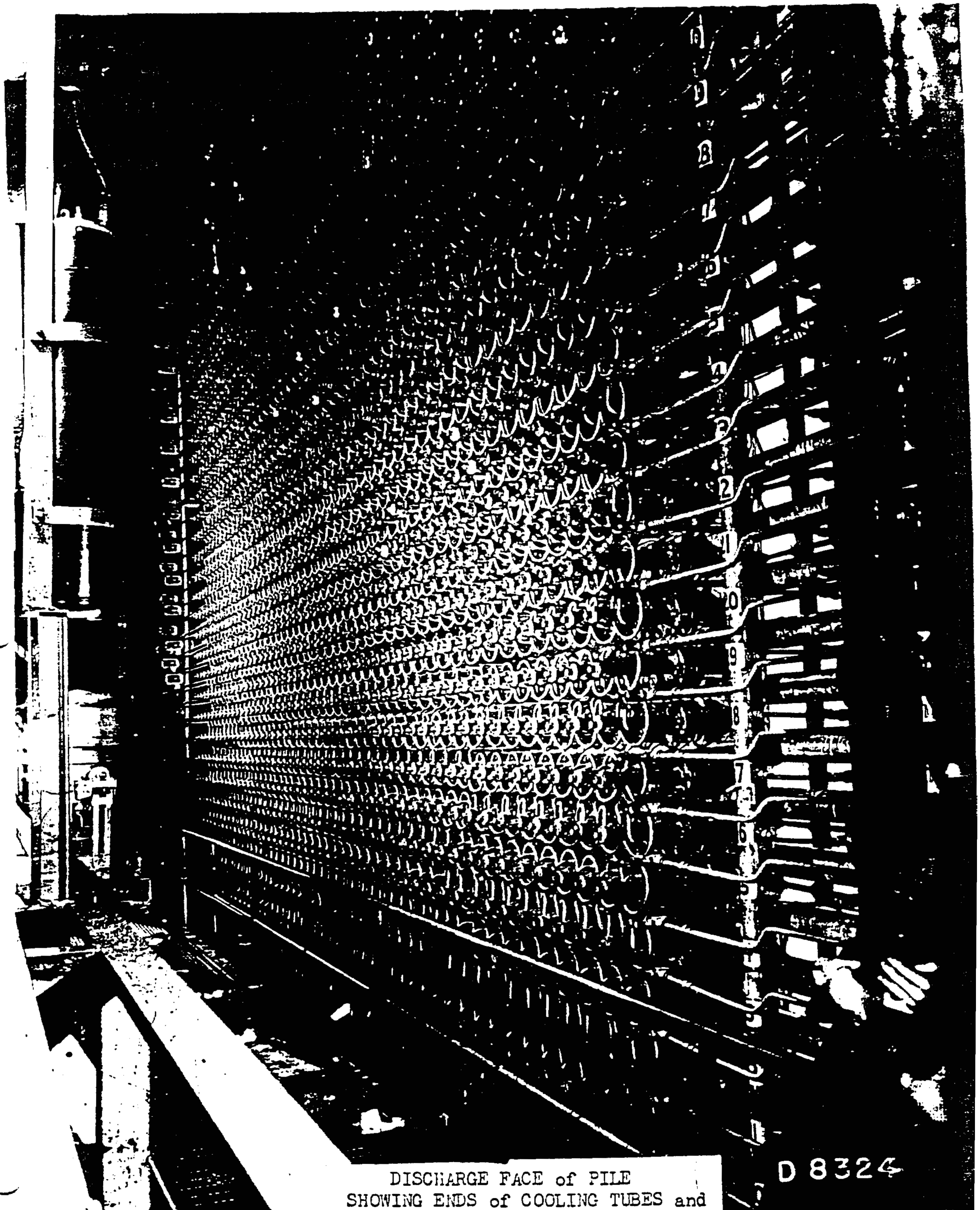
1101506



TYPICAL PILE AREA
Pile Building in Foreground



CHARGING FACE of PILE
SHOWING INLET ENDS of COOLING TUBES and
WATER SUPPLY SYSTEM



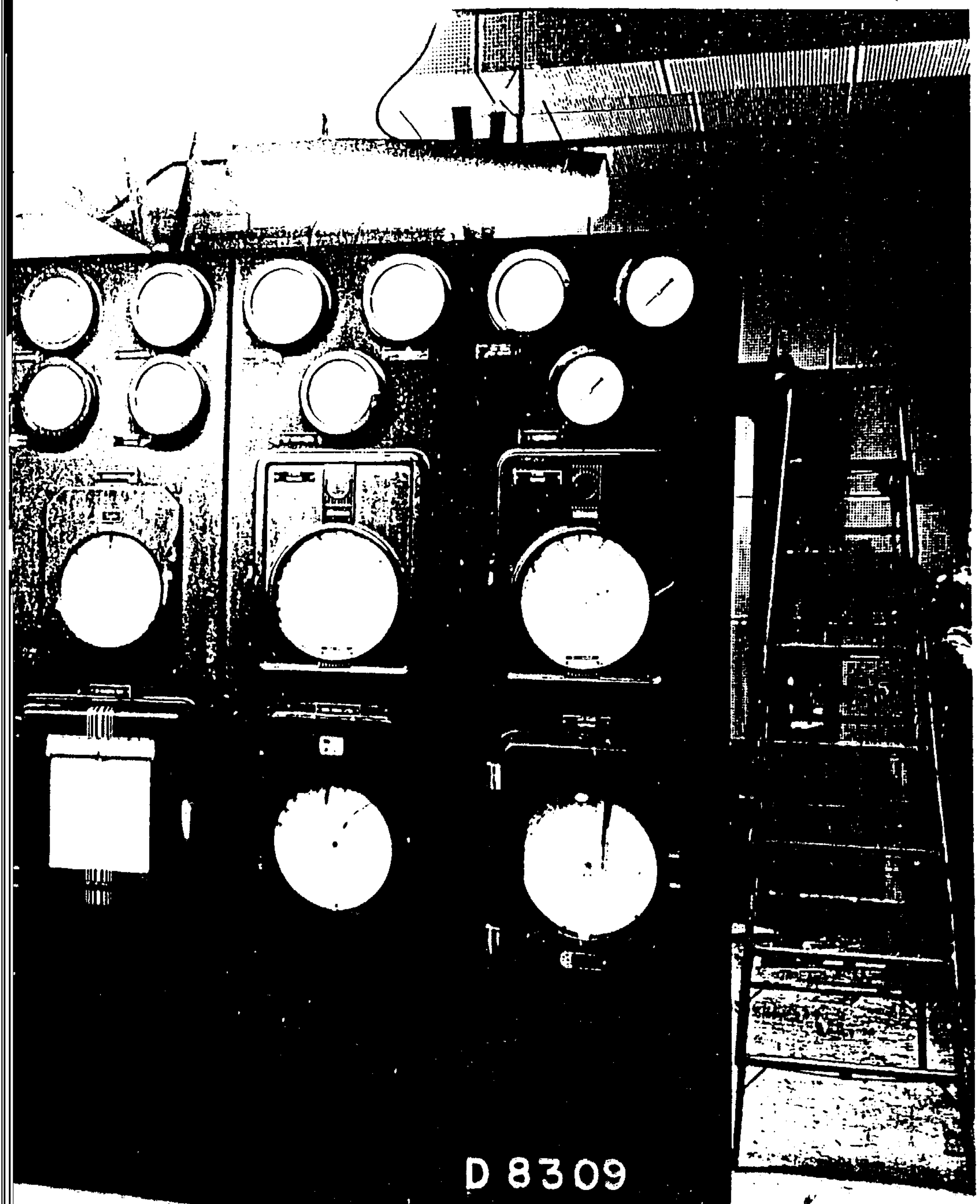
DISCHARGE FACE of PILE
SHOWING ENDS of COOLING TUBES and
WATER COLLECTION SYSTEM

1101509

PILE BUILDING--CONTROL ROOM
MAIN OPERATING PANEL BOARD

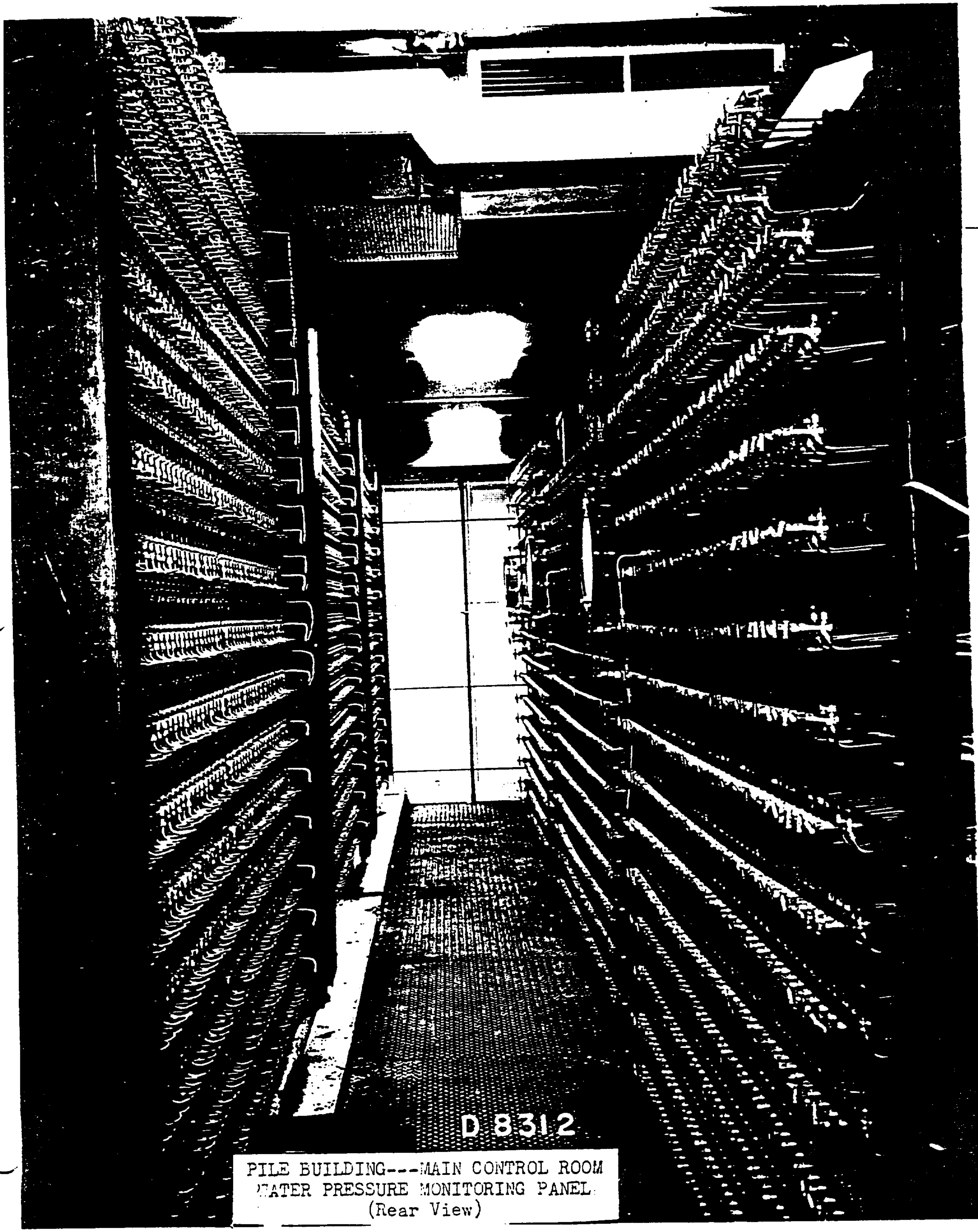
DECLASSIFIED WITH DELETIONS

1101510

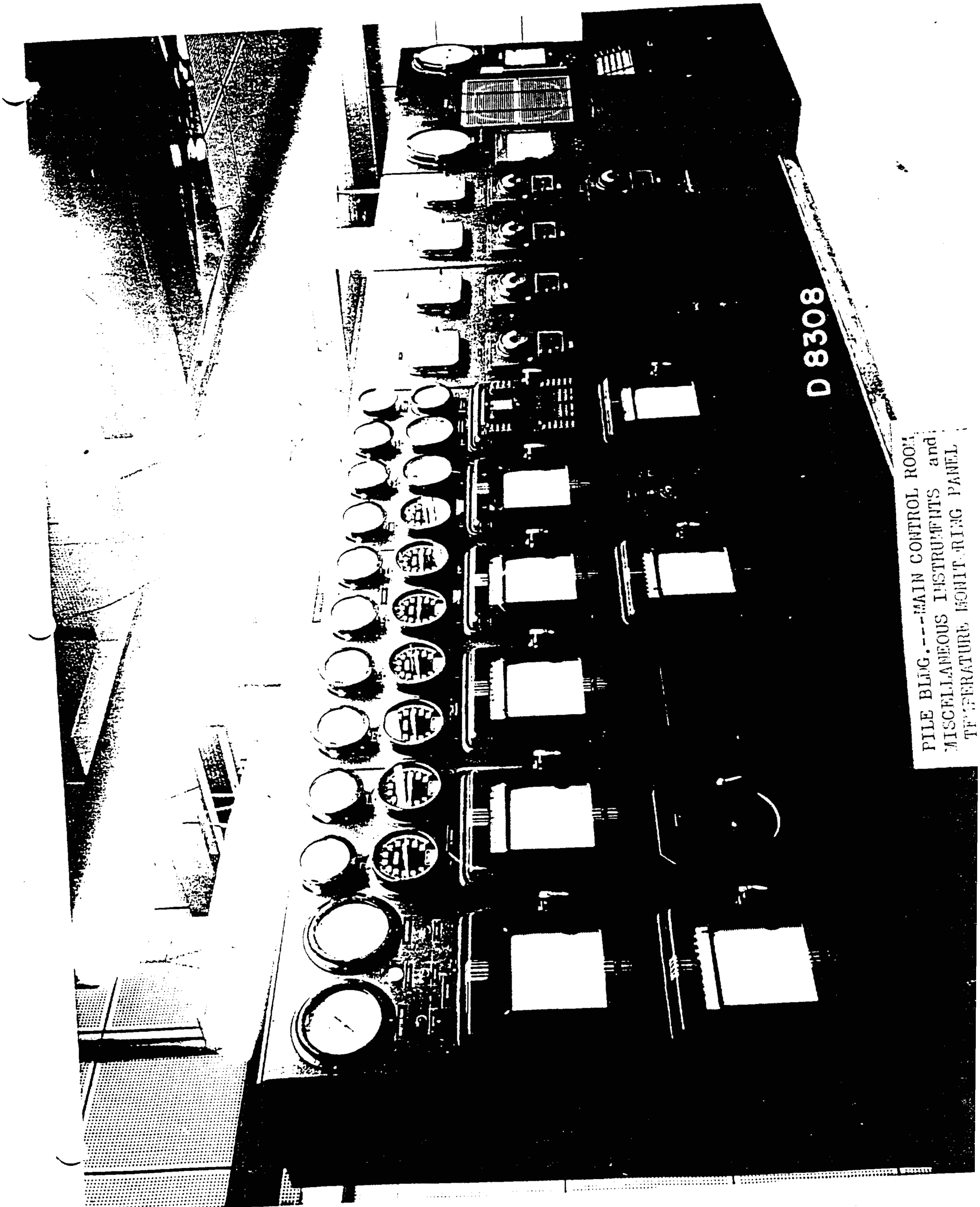


E BUILDING---MAIN CONTROL ROOM
INLET WATER PANEL

PILE BUILDING---MAIN CONTROL ROOM
WATER PRESSURE MONITORING PANEL
(for Individual Cooling Tubes)



PILE BUILDING---MAIN CONTROL ROOM
WATER PRESSURE MONITORING PANEL
(Rear View)



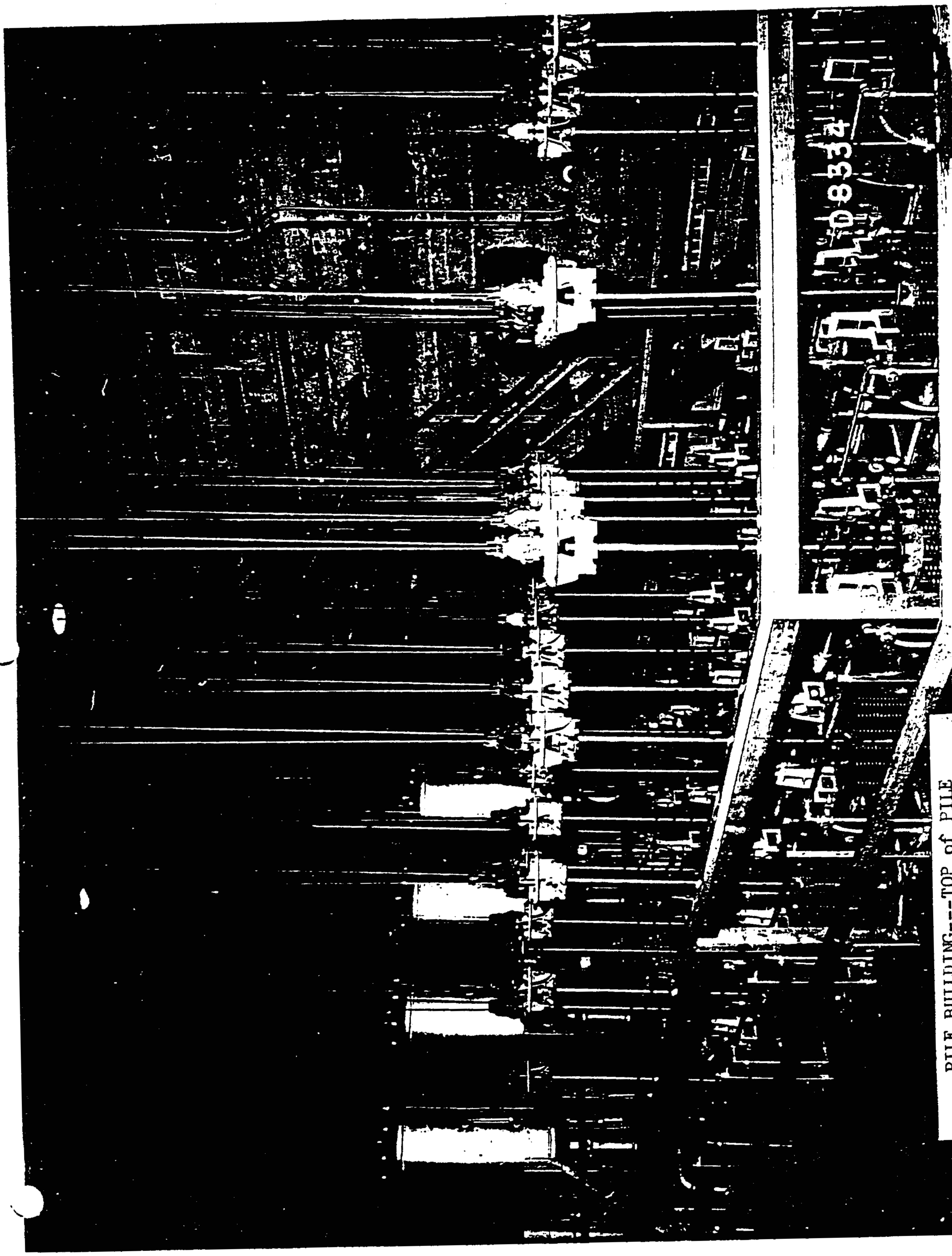
PILE BLDG.---MAIN CONTROL ROOM
MISCELLANEOUS INSTRUMENTS and
TEMPERATURE MONITORING PANEL

DECLASSIFIED WITH DELETIONS

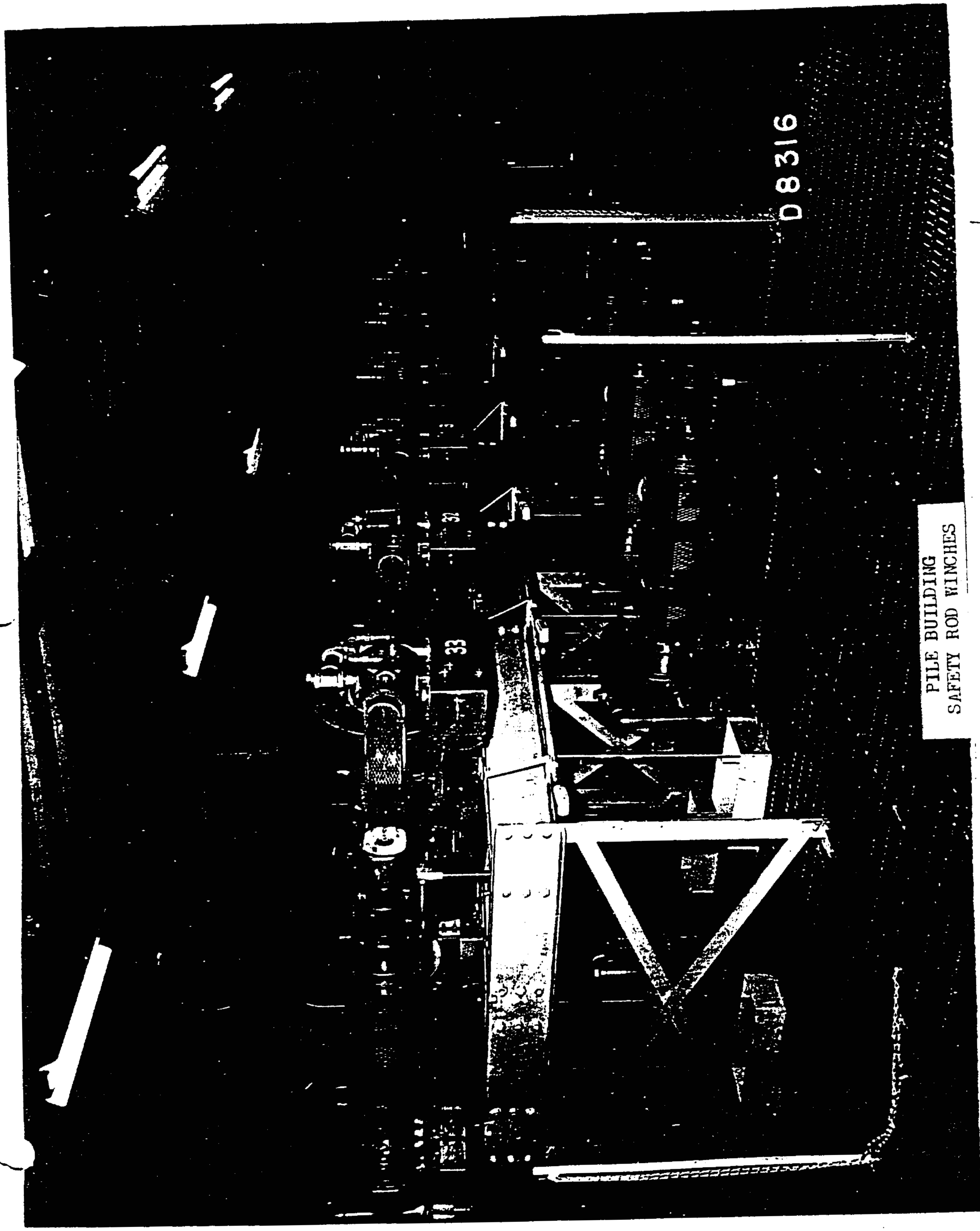
1101514

PILE BUILDING
CONTROL RODS

1101515



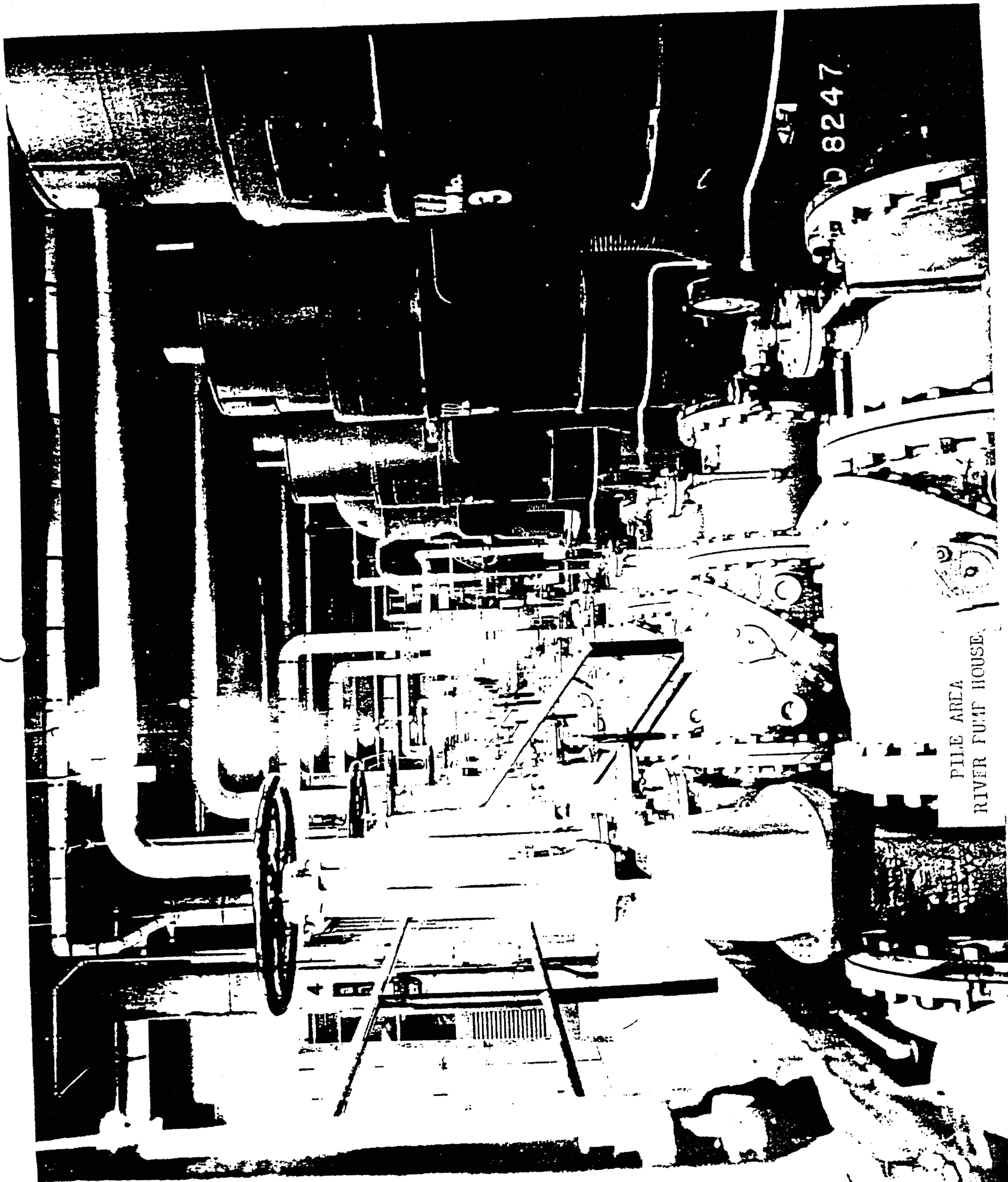
PILE BUILDING--TOP of PILE
(Showing Partly Raised Safety Rods)



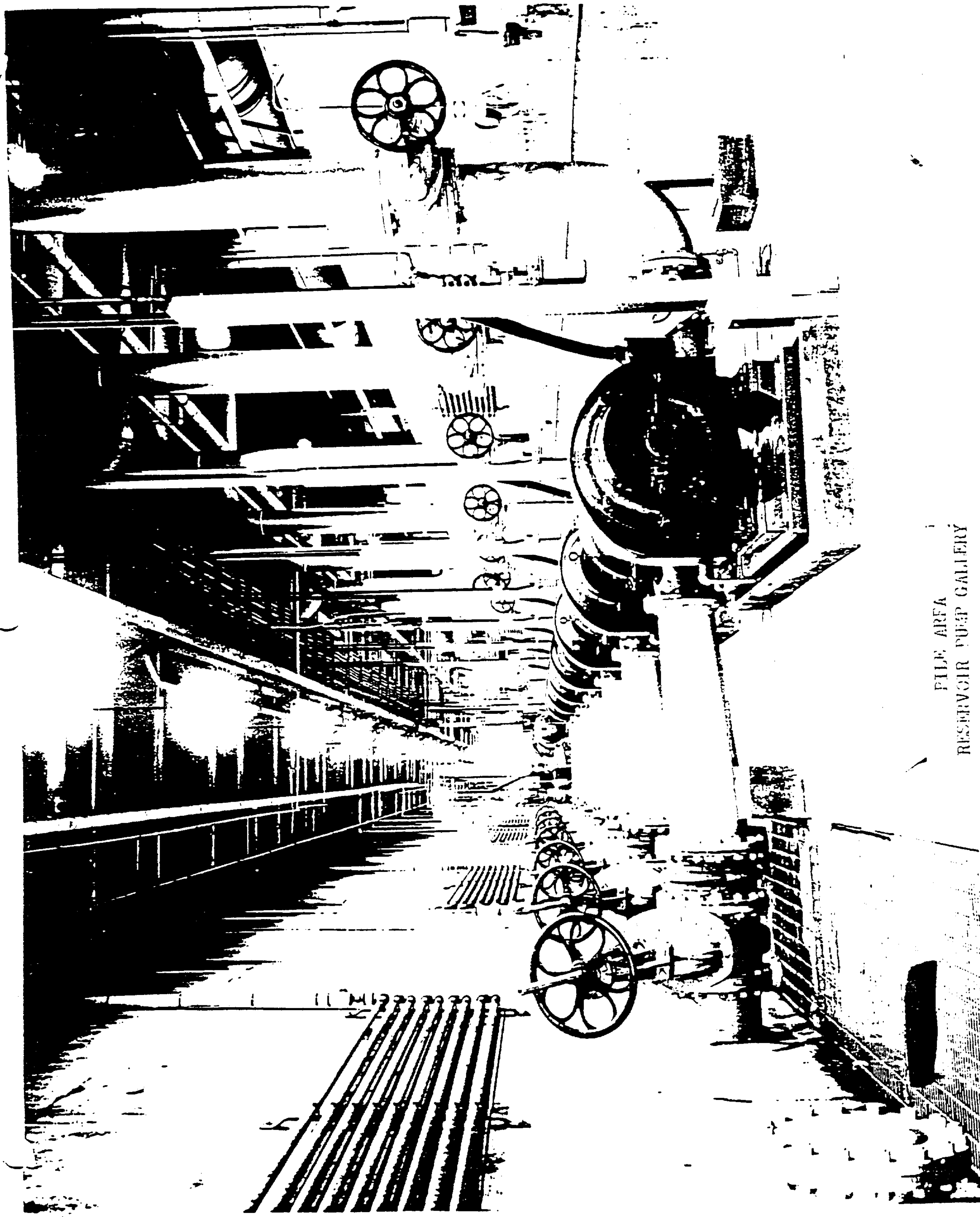
PILE BUILDING
SAFETY ROD WINCHES

1101517

DECLASSIFIED WITH DELETIONS



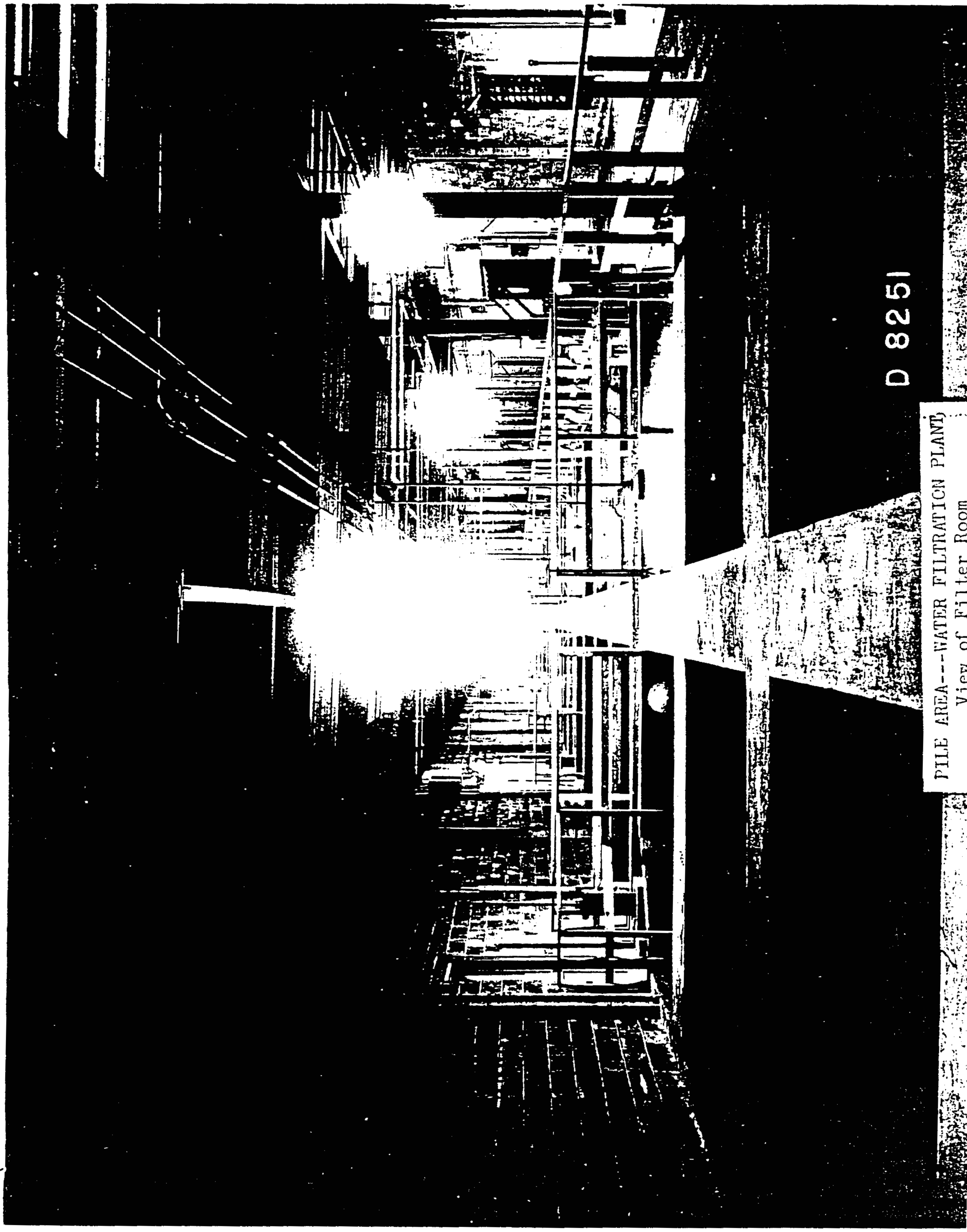
PILE AREA
RIVER PUMP HOUSE



PILE AREA
RESERVOIR PUMP GALLERY

1101519

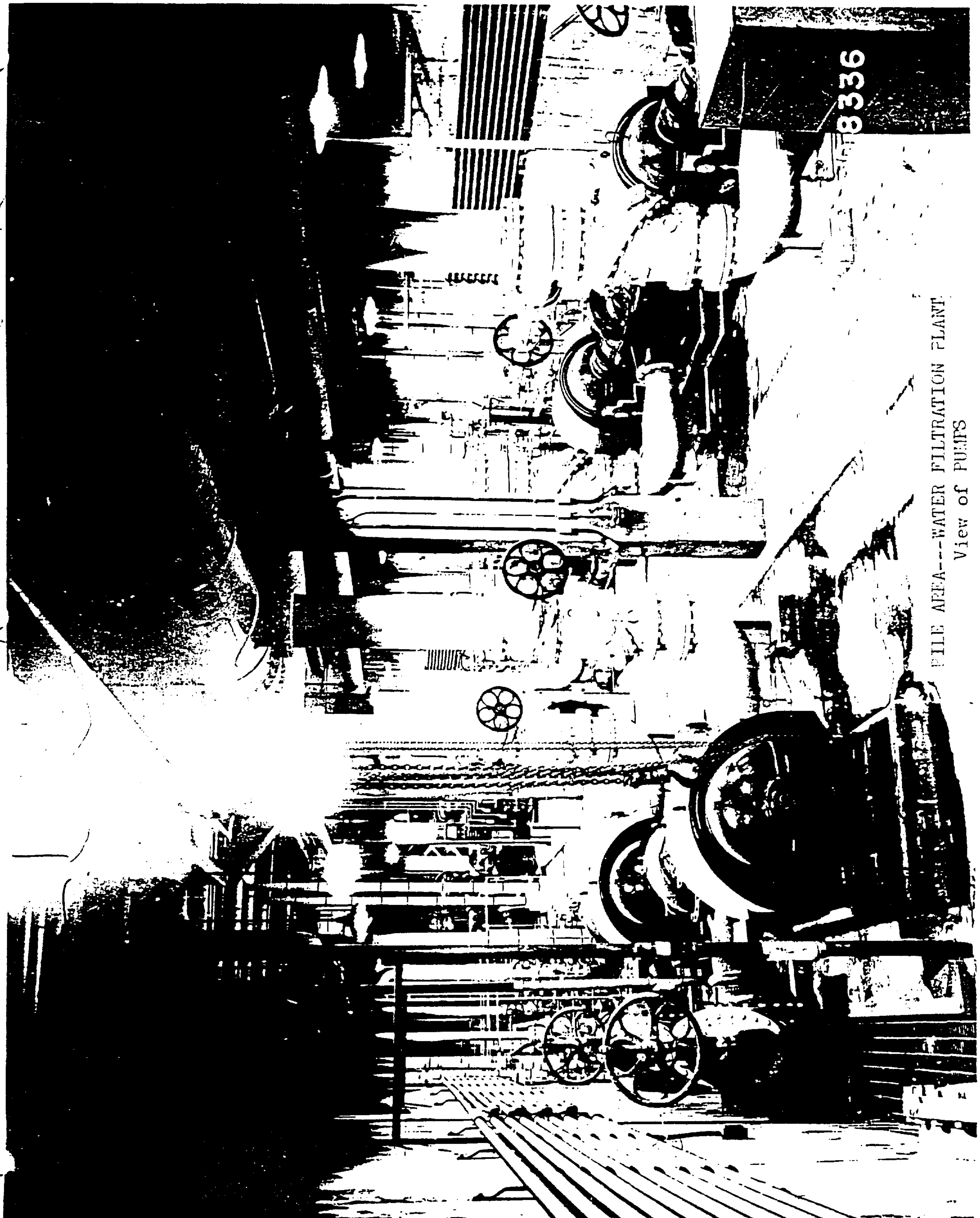
DECLASSIFIED WITH DELETIONS



PILE AREA--WATER FILTRATION PLANT
View of Filter Room

1101520

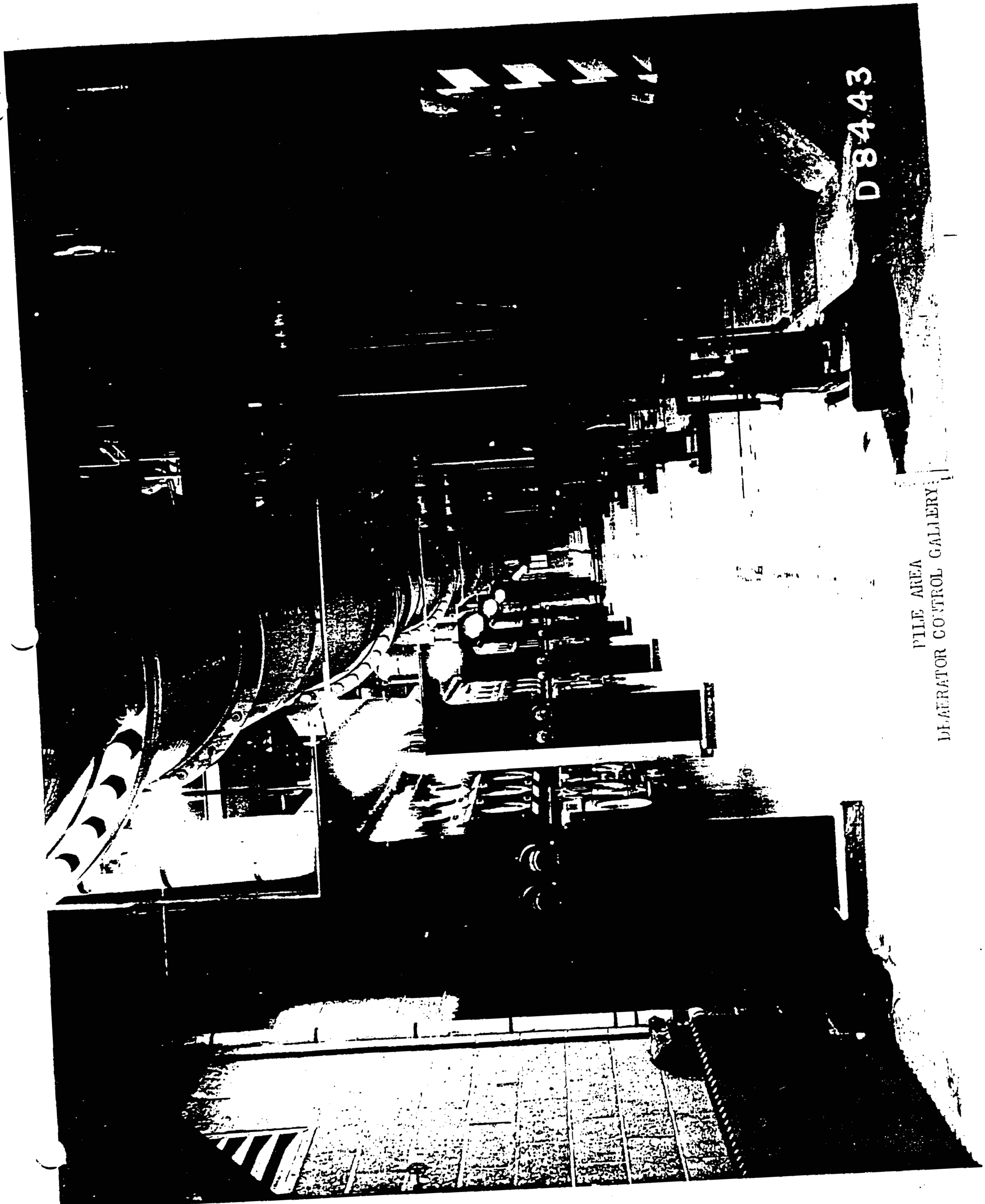
DECLASSIFIED WITH DELETIONS



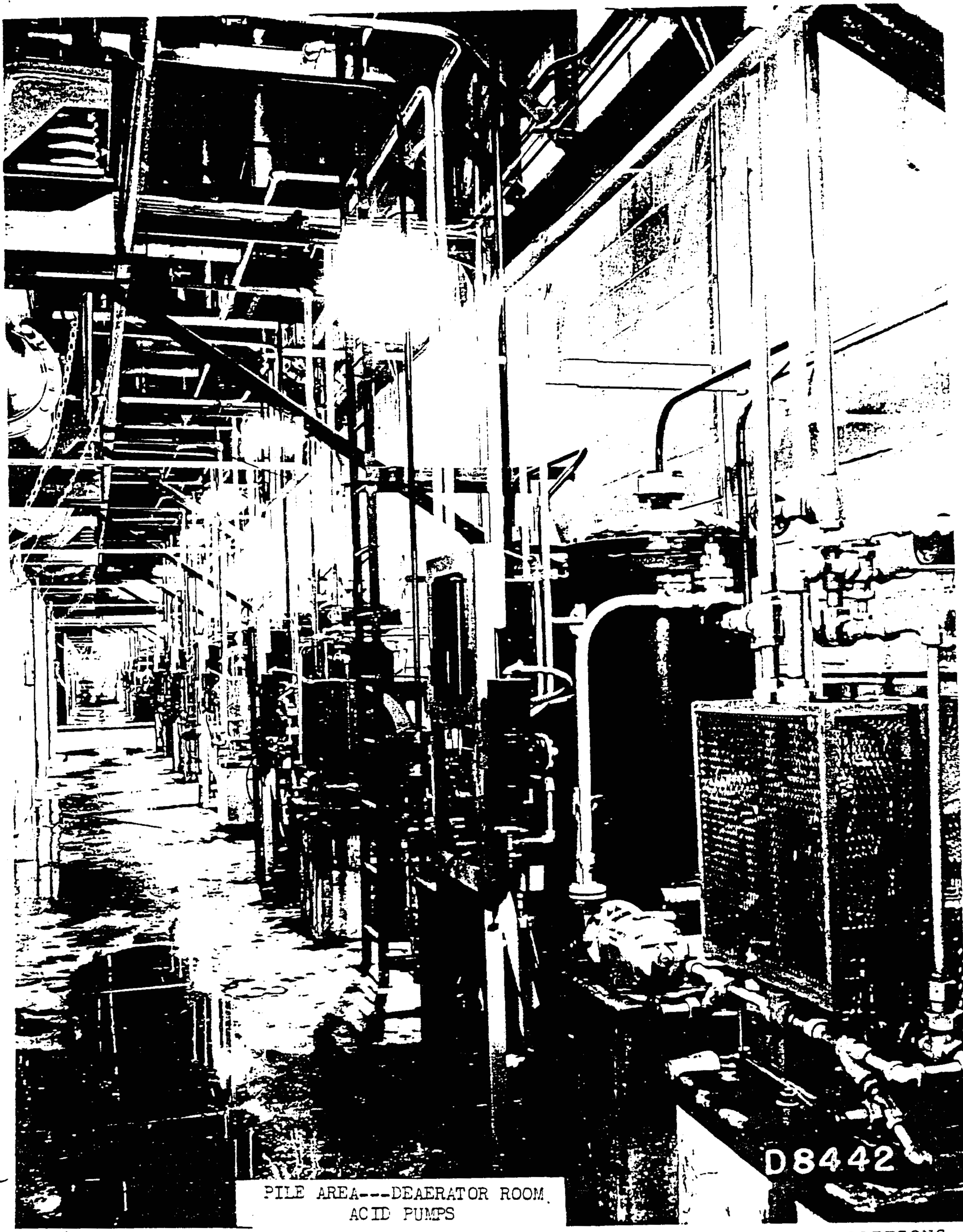
FILE AREA--WATER FILTRATION PLANT
View of PUMPS

DECLASSIFIED WITH DELETIONS

H01521



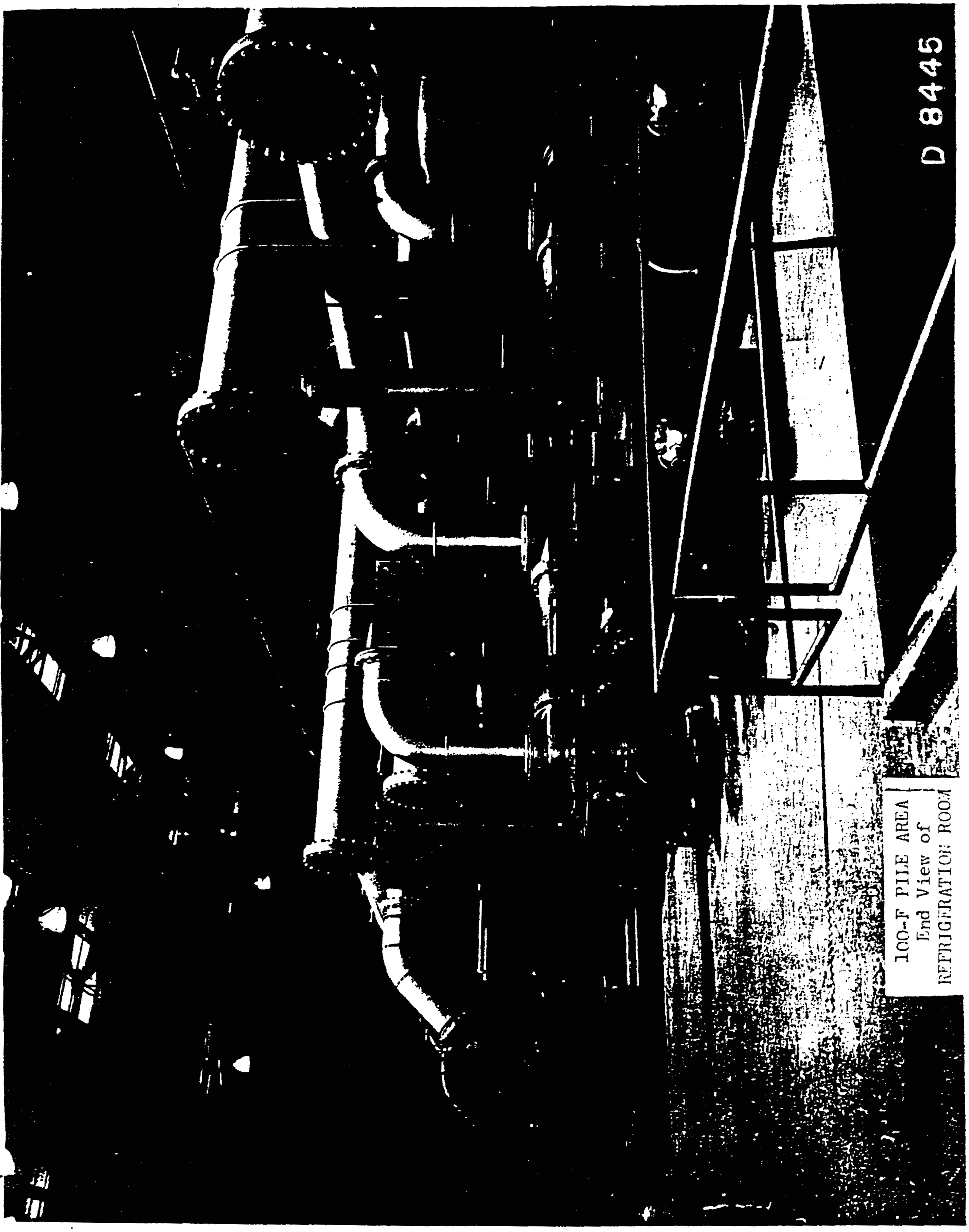
PILE AREA
DEAERATOR CONTROL GALLERY

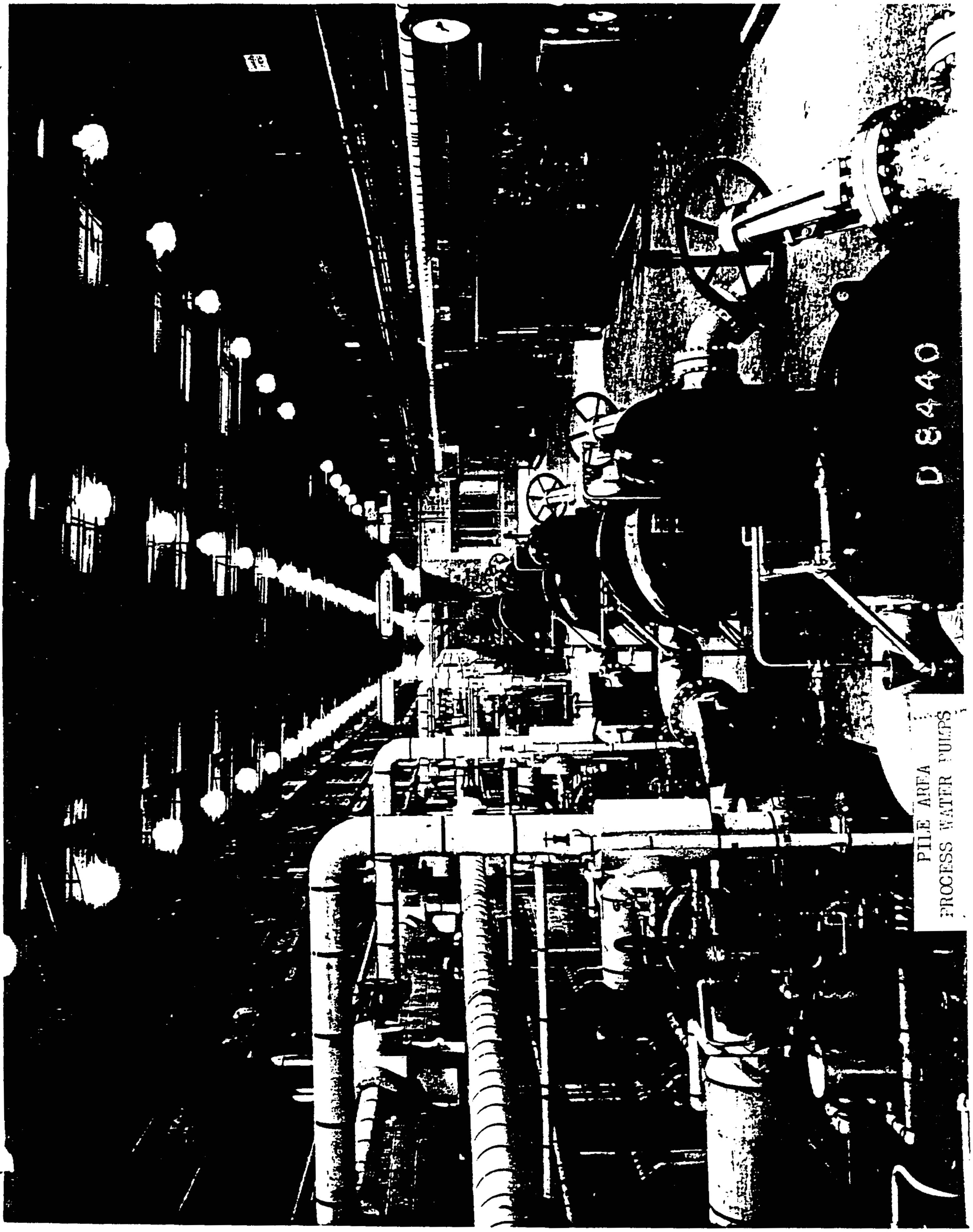


PILE AREA---DEAERATOR ROOM
ACID PUMPS

DECLASSIFIED WITH DELETIONS

1101523

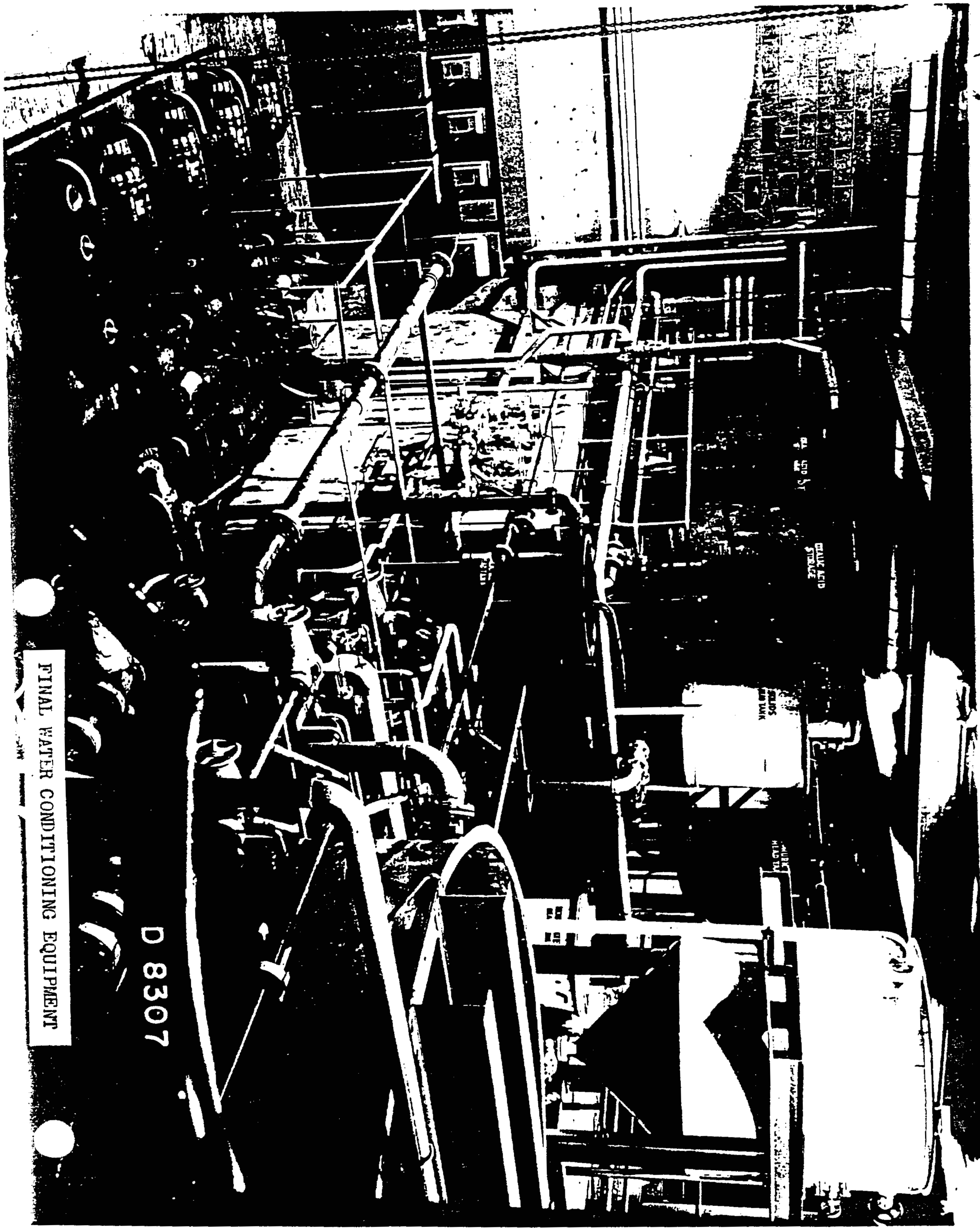

D 8445
100-F PILE AREA
End View of
REFRIGERATION ROOM



DECLASSIFIED WITH DELETIONS

1101525


PILE AREA
PROCESS WATER TANK
D 8438



FINAL WATER CONDITIONING EQUIPMENT

1101527

[redacted]

SECTION VI

200 AREA FACILITIES AND OPERATIONS

[redacted] DECLASSIFIED WITH DELETIONS

[redacted]

SECTION VI

200 AREA FACILITIES AND OPERATIONS

Decay Storage.--After discharge from the piles, the uranium slugs enriched with plutonium are transferred to an intermediate storage area, the 200-N Area, where they are held for forty-five to sixty days of underwater storage. During this storage period much of the intense radioactivity is reduced through decay, and formation of plutonium is substantially completed. The 200-N Area consists of three separated storage basins equipped with mechanical facilities for handling the slugs while under water.

Separations Plants.--After the necessary period in underwater storage, the slugs are transferred in their original buckets, using specially constructed and shielded railroad cars, to one of the three Separations Plants of the 200 Area. Each of these plants, designated as 200-T, 200-U, and 200-B, is capable of processing uranium slugs at a normal rate of thirty tons a month, or a total of ninety tons a month for the entire 200 Area. The major steps in the separation and concentration of plutonium are accomplished in these plants; final isolation in the form of a pure product is carried out in a separate small building, the 231-W Building, which serves all three Separations Plants.

Difficulties of Plutonium Separation.--The fact that plutonium is a new and specific chemical element makes it possible to effect a separation from uranium, and from some twenty-five fission by-products of the pile operation, by use of a chemical process. Operation of such a process is complicated by (1) the extremely small amounts of product which must be isolated from gross quantities of the parent uranium, and (2) the intense radioactivity of the by-products present. The relative proportion of plutonium is so small that in many steps of the process, the amount present in the solutions is actually less than the normal hardness of the water used in preparing these solutions. Because of the radioactivity and its hazard to operating personnel, a major part of equipment must be operated and maintained by remote control behind massive concrete shielding. Because of these factors the separations process, while not especially complex in principle, has presented a number of unique problems which have had to be met by radical departures from the ordinary standards of chemical plant practice.

Possible Separations Processes.--A number of processes were developed for accomplishing plutonium separation; and when the above mentioned difficulties are realized, together with the fact that a large portion of the research and development work was conducted with amounts of plutonium far below the power of the eye to see even when aided by

[redacted]

[redacted]

the most powerful microscopes, the results have been truly remarkable. The process chosen for Hanford Operations is called the Bismuth Phosphate Process and this, together with the other possible processes, is described in detail in the recorded history of Manhattan District research and development.

Bismuth Phosphate Process.--The Bismuth Phosphate Process is a wet precipitation method in which the insoluble compound bismuth phosphate is used as a carrier medium in separating small quantities of plutonium from large amounts of solution. The principle is analogous to that used in the isolation of radium from its ores, where the amount of key material is likewise so small that it cannot be precipitated directly but must be thrown out of solution in combination with much larger amounts of a "carrier" substance. After the slugs have been dissolved, a single precipitation is sufficient to separate plutonium cleanly from the uranium, but an extensive series of further steps is needed to eliminate the associated fission by-products for reduction of the radioactivity to one ten millionth of the starting value. This large reduction in radioactivity is required before the product can be handled safely without shielding. This series of steps comprises several bismuth phosphate precipitations, with the plutonium alternately in its soluble and insoluble form, which is controlled by adjusting its valence state through appropriate chemical treatment. During this processing, the one-half pound of plutonium formed in a normal charge of 2000 pounds of uranium must be handled in as much as 4000 gallons of solution. These large volumes are reduced in the final steps of the process by shifting to a more efficient carrier medium, lanthanum fluoride. The use of this carrier in smaller amounts makes it possible to dissolve the final, purified plutonium-carrier residue in about eight gallons of solution. In this form the material is subjected to a final isolation treatment in which the plutonium is separated from carrier, precipitated from the solution as an essentially pure (over 98%) product, separated, and prepared for shipment as a concentrated solution equivalent to about eight ounces for each starting ton of enriched uranium slugs.

Basic Operations.--From the standpoint of equipment requirements and operating techniques, the separations process may be considered as made up of six basic operations which are performed consecutively.

(1) Slug Dissolving.--In this operation the aluminum cans and bonding coatings which envelope the slugs are first dissolved and separated, after which the uranium with its fractional per cent of plutonium and fission by-products is dissolved in a strong acid.

(2) Extraction.--In this operation, the plutonium is precipitated (with bismuth phosphate carrier) from the solution of uranium slugs and is thus separated from the uranium and also from a large proportion of the fission by-product elements.

[redacted]

[redacted]

(3) Decontamination.--This is a series of steps which is carried out to reduce the fission by-product elements by a factor of 100,000 fold and thus permit further processing to be carried on without the use of massive shielding. This is accomplished by four successive bismuth phosphate precipitations, with the plutonium alternately in the soluble and insoluble states, and from which the plutonium emerges in combination with approximately one hundred times its weight of bismuth phosphate carrier.

(4) Concentration.--This operation serves a double purpose of further decontamination (by 100 fold) and reduction in bulk by substituting an insoluble lanthanum compound for bismuth phosphate as a carrier medium.

(5) Isolation.--In this step plutonium is separated from lanthanum by precipitation as the insoluble plutonium peroxide. This compound is converted to plutonium nitrate, the solution of this pure salt dried to a paste and the concentrate transferred to the Army for shipment to another site for further processing.

(6) Waste Disposal.--In the several steps above, large volumes of liquid waste are accumulated which, because of the value or health hazard of the constituents, cannot be disposed of by ordinary means. During dissolving of the slugs a large amount of gas also is evolved which must be vented to the outside air. These waste products are enumerated as follows:

a. Uranium.--The uranium has been partially depleted of its power producing isotope of atomic mass 235. However, national security and economy demand that the uranium be stored for future recovery and reuse when time can be devoted to the work.

b. Fission by-product elements.--Many of the radioactive fission by-product elements are so long-lived and so hazardous that disposal into the sandy soil of Hanford or into the Columbia River is impracticable because of its possible effect on water supply and fishing industries.

c. Gaseous by-products.--Certain of the fission by-product elements are in the form of gas so radioactive that dilution with atmospheric air of the order of one cubic foot of the gas to one cubic mile of air is required for safety. These gases are partially diluted before release and are then discharged from

[redacted] DECLASSIFIED WITH DELETIONS

[redacted]

tall stacks to assure adequate dispersal.

Quantity of Waste Products.--To meet these requirements, the liquid waste products, which amount to about 15,000 gallons per one-half pound of plutonium, are placed in large underground storage tanks which will permit appropriate action to be taken at a later date. There are a total forty-eight of these tanks for the three Separations Plants of the 200 Area.

Separations Plant Facilities.--The 6 basic operations described above are performed in each of the Separations Areas, namely, 200-B, 200-T, and 200-U. Each of these areas contains the following process buildings: 221 - Cell Building; 224 - Concentration Building; 241 - Waste Disposal Tanks; 291 - Ventilation Building and Stack. The following process service buildings are also provided for each Separations Area: 211 - Tank Farm; 271 - Chemical Preparation and Services; 222 - Control Laboratories. In addition, building 231 - Isolations is provided to handle the output from the three Separations Areas. Auxiliary facilities are provided for the Separations Areas and include: Area Shops, Laundry, Boiler Houses, Water Reservoirs, Filter Plants, First Aid, Administration Building, Fire Department, and large scale Heat Treating facilities. The most important of the facilities are described as follows with emphasis on operation and maintenance:

221 - Cell Building.--The basic operations of Slug Dissolving, Extraction, and the major part of Decontamination are carried out in Building 221, frequently called the canyon.

The building is a concrete structure approximately 800 feet long by 60 feet wide by 80 feet high. Four essential operating considerations are incorporated in its design: (a) adequate protection of operating personnel from intense radioactivity; (b) remote operation of the process equipment; (c) maintenance of process equipment in the presence of intense radioactivity; and (d) flexibility of arrangement to permit a wide range of process operations without major alterations.

Protection of personnel from the radioactivity is obtained by the use of massive concrete walls which confine the process equipment within cells and separate the cells from operating personnel.

Remote control of the process equipment is obtained by the use of panel board instruments, switches, and operating devices which keep the operators informed of process conditions and permit adjustment of the conditions from the operating gallery.

The many process vessels and connecting piping are de-

[redacted]

signed for removal and replacement by means of a specially developed crane. The crane operator is located in a heavily shielded cab and views the crane operations through a periscope and a television screen. The pipe connections and the nuts which hold down the equipment are specially designed for removal and replacement by means of an electrical impact wrench operated from within the crane cab. The piping is made up in standard prefabricated units which can be dropped in place by the crane and then made up with the special automatic connectors. The crane is also required for remote handling of the uranium slugs in transferring them from the special railroad car and cask into the dissolving equipment.

An important consideration in the design of the Cell Building is the flexibility of arrangement. At the time design was begun, the process was largely undeveloped. This required the incorporation of sufficient flexibility to permit minor changes and also fundamental alterations in the equipment arrangement and process flow. To accomplish this, the Cell building was designed, as far as possible, as a group of standard units in which different types of process vessels, pipe connections, and instrument connections can be installed without requiring structural modification.

A group of standard units consists of four pieces of equipment: (a) precipitator; (b) catch tank; (c) centrifuge; and (d) solution tank. Most of the Cell Building operations can be carried out in this standard grouping. For example, in an oxidation and by-product step, the fission by-product elements are formed as solids in the precipitator while the plutonium remains in solution. The plutonium solution and by-product solids are then transferred to the centrifuge where the solids are separated and sent to the solution tank. The plutonium solution is sent to the catch tank for transfer to the next operation.

The Cell Building contains 40 cells arranged side by side for the 800-foot length of the building. In addition to the above mentioned standard cells, the following requirements are served: (a) storage of discarded radioactive equipment; (b) railroad tunnel for receiving slugs from the 200-N Area; (c) underwater storage of slugs with fractured coatings; (d) jacket removal and slug dissolving; (e) storage of enriched uranium solutions prior to extraction; (f) sewage disposal; (g) neutralization of wastes prior to transfer to waste disposal tanks; and (h) unequipped spare cells. The cells are provided with massive concrete covers for shielding. Process solutions are transferred from one cell and from one vessel to another by means of steam jets which have no moving parts.

<u>224 - Concentration Building</u>.--As soon as the decontamination steps have reduced the radioactivity to a reasonably safe level, it is

[redacted]

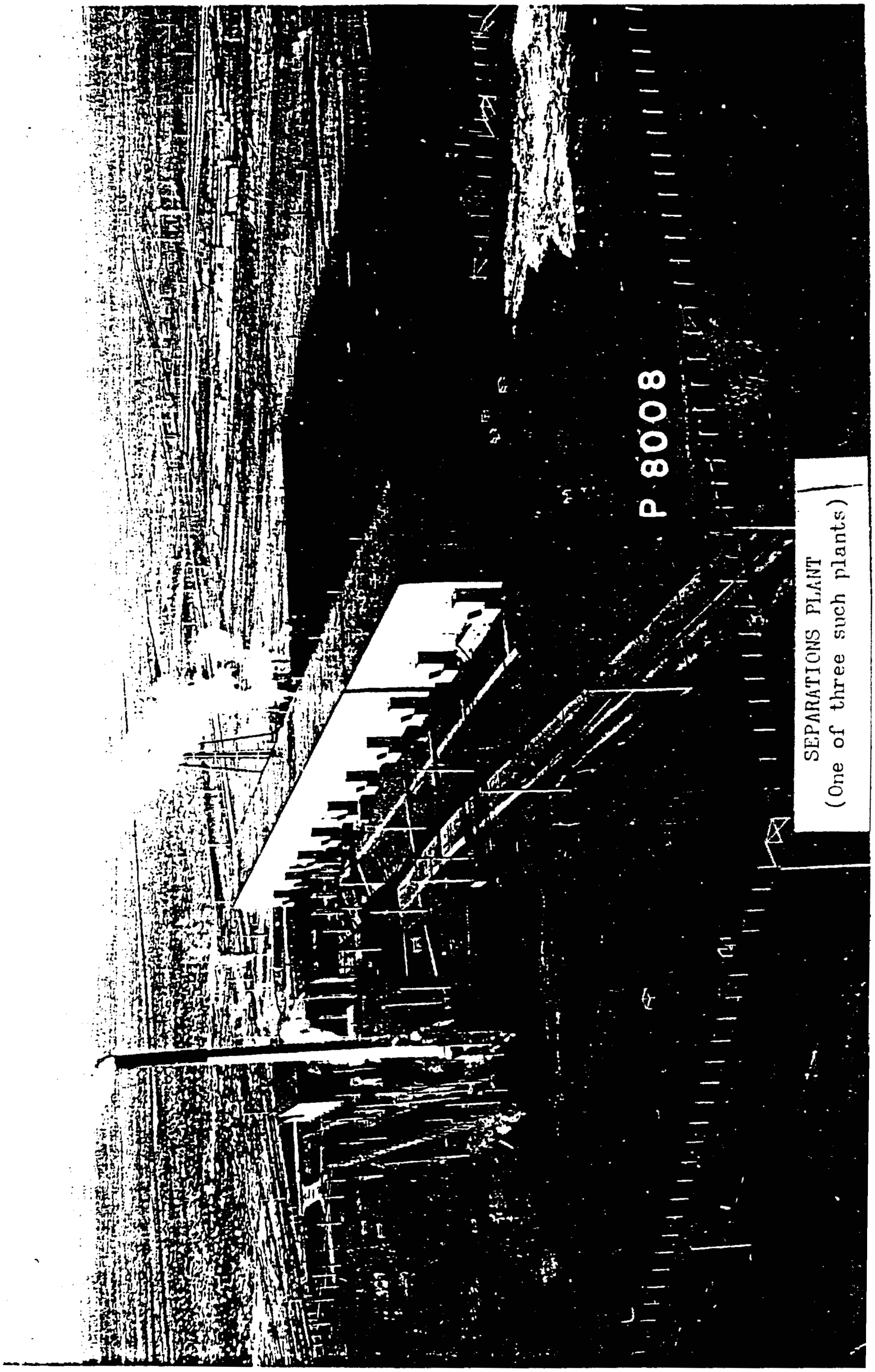
ing operations, once started, may be carried to completion without creating hazardous conditions.

Climatic conditions at the Hanford site were not known adequately but it was believed to be possible that this basin, almost entirely surrounded by ranges of mountains, might conceivably present dead calms or slow wind drifts during some seasons resulting in entirely inadequate dilution. It was believed possible that slow drifts following the Columbia River could create hazardous conditions along its course.

Meteorological research was started early in 1943 to provide information relative to atmospheric conditions at the Hanford site. The preliminary work consisted of inspections of the site and careful analysis of existing Weather Bureau statistics from those stations closest to Hanford. This work indicated that an elaborate research program was required. This program was undertaken and a vast amount of data collected and analyzed at the 200 Areas at Hanford by a force of expert meteorologists. By November 1944, statistics had been prepared for a full year and subsequent work has been devoted largely to verification of information obtained to that time and to routine forecasting of atmospheric conditions for control of plant operations.

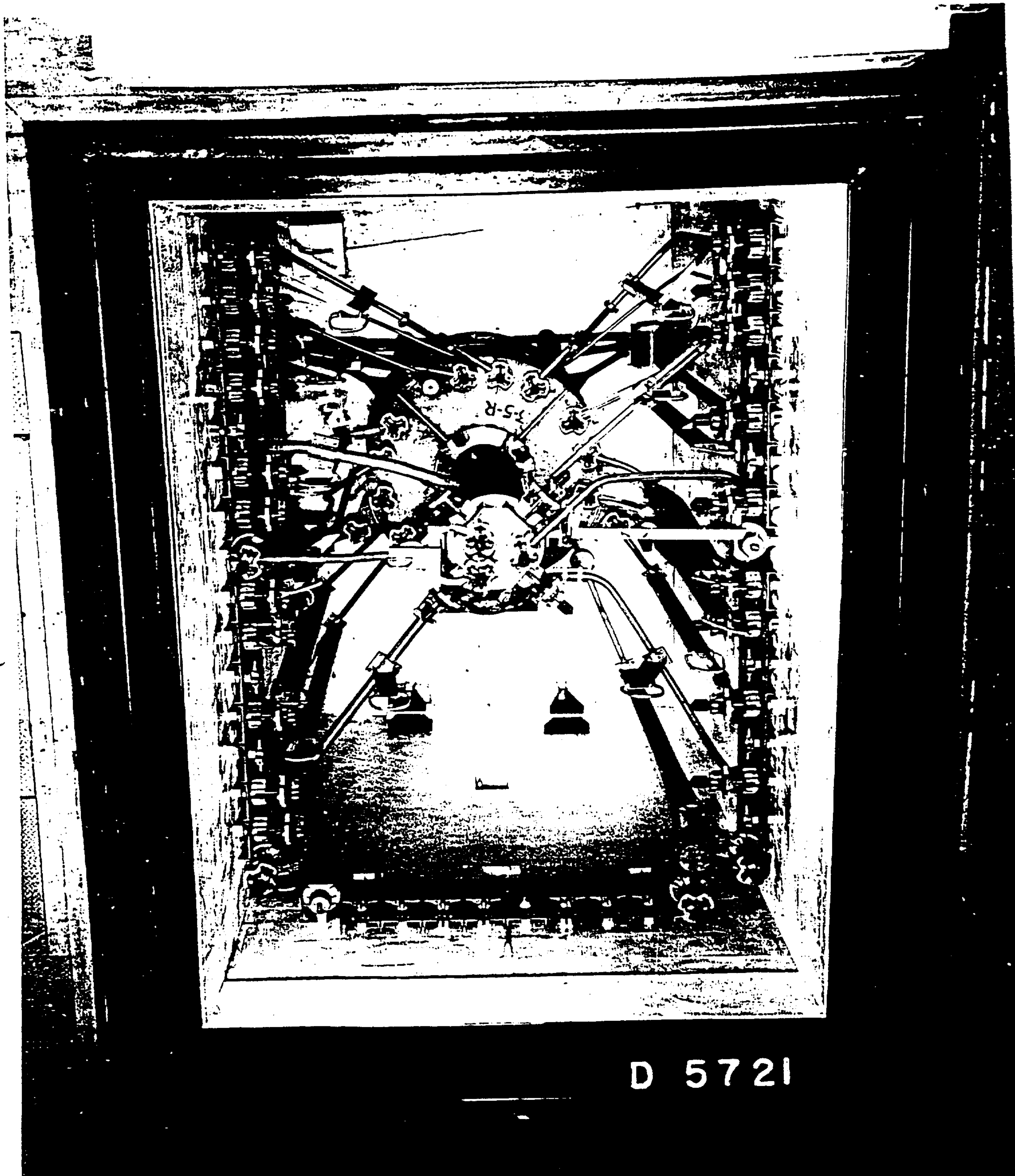
The entire meteorological research program has been directed toward the end that the knowledge obtained will be correlated so that expert meteorological personnel will be required only for a limited time. It is expected that routine weather observations will be made by regular operations personnel and that the scheduling of plant operations will be accomplished from these observations.

[redacted]



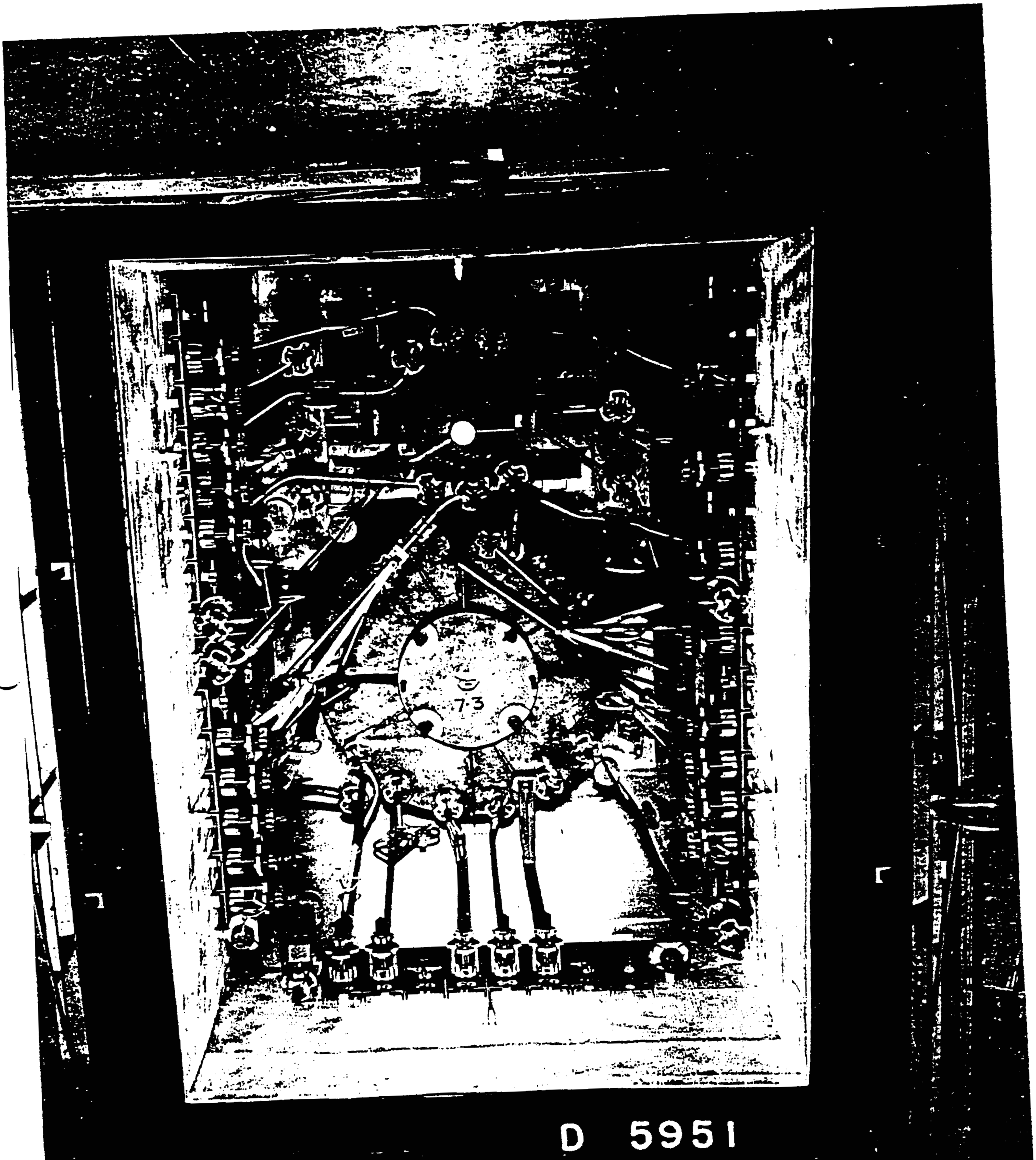
SEPARATIONS PLANT
(One of three such plants)

SEPARATIONS PLANT---CELL BLDG.221
OPERATING GALLERY

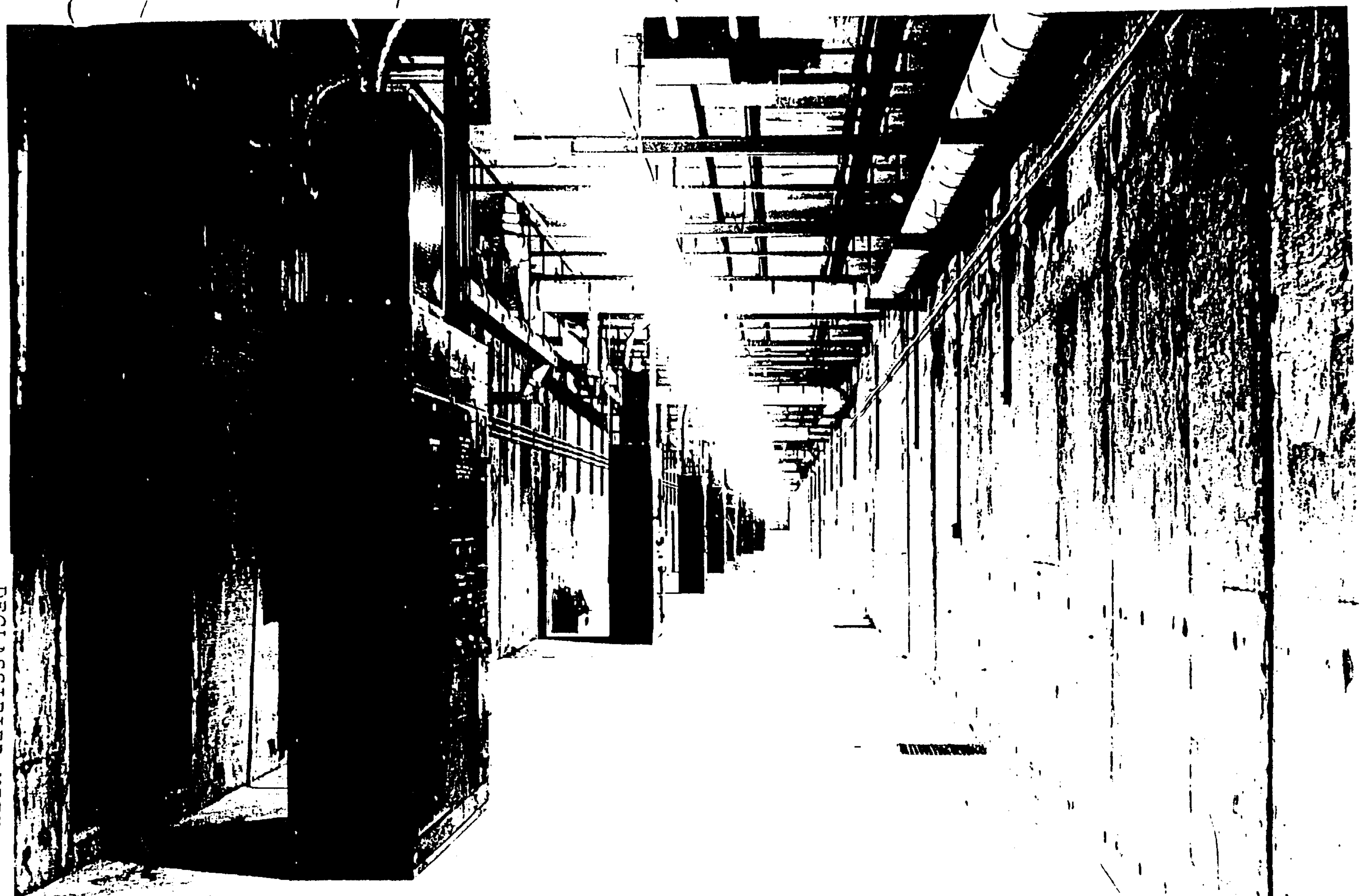


SEPARATIONS PLANT---CELL BUILDING 221
TYPICAL DISSOLVER LOOKING DOWNWARD
FROM CANYON FLOOR

SEPARATIONS PLANT---CELL BUILDING 221
Downward View from Canyon Floor Showing
Typical Arrangement of
PRECIPITATOR and SOLUTION TANK



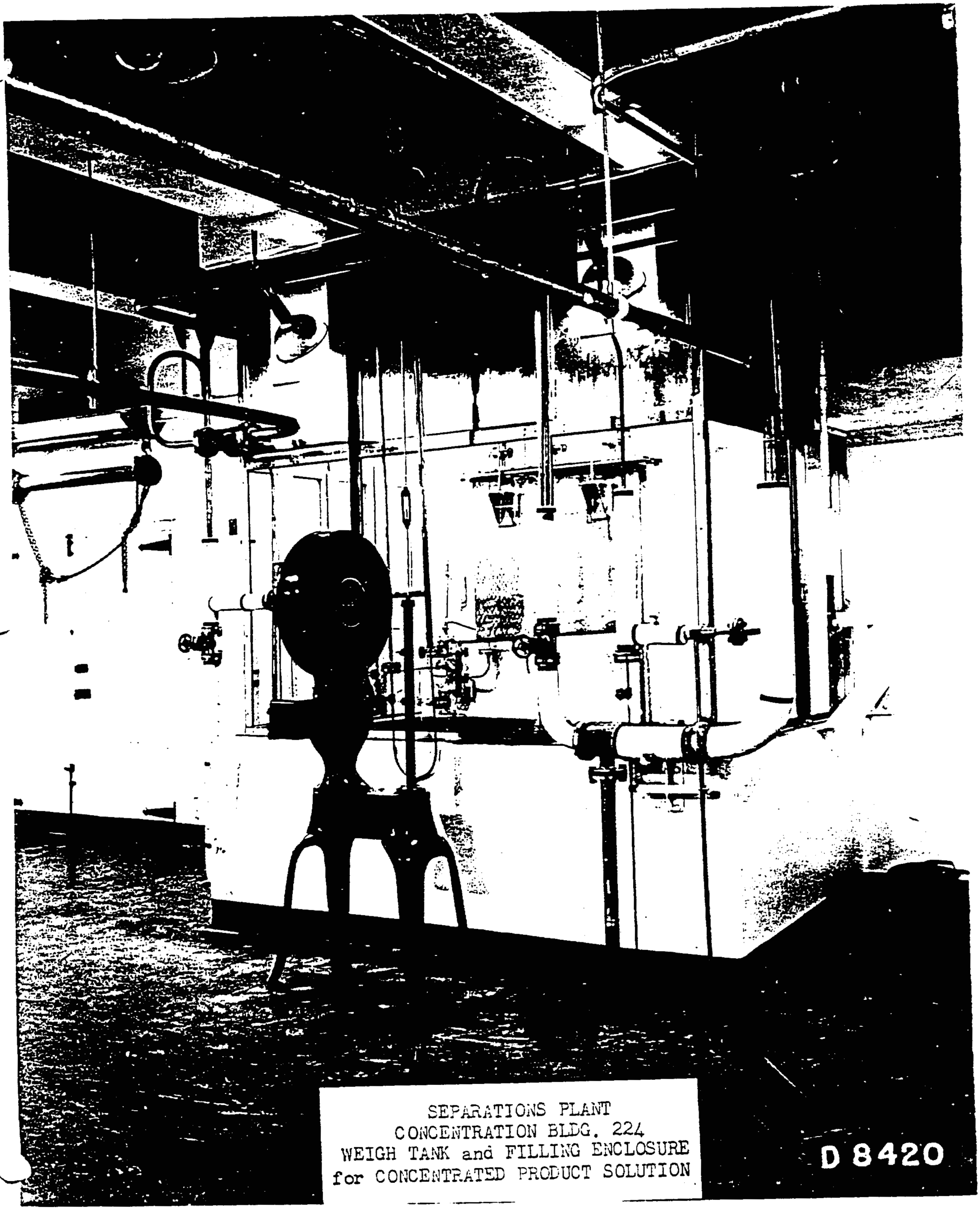
SEPARATIONS PLANT——CELL BUILDING 221
Downward View from Canyon Floor Showing
Typical Arrangement of
CENTRIFUGE and CATCH TANK



SEPARATIONS PLANT---CELL BLDG. 221
ELECTRICAL GALLERY

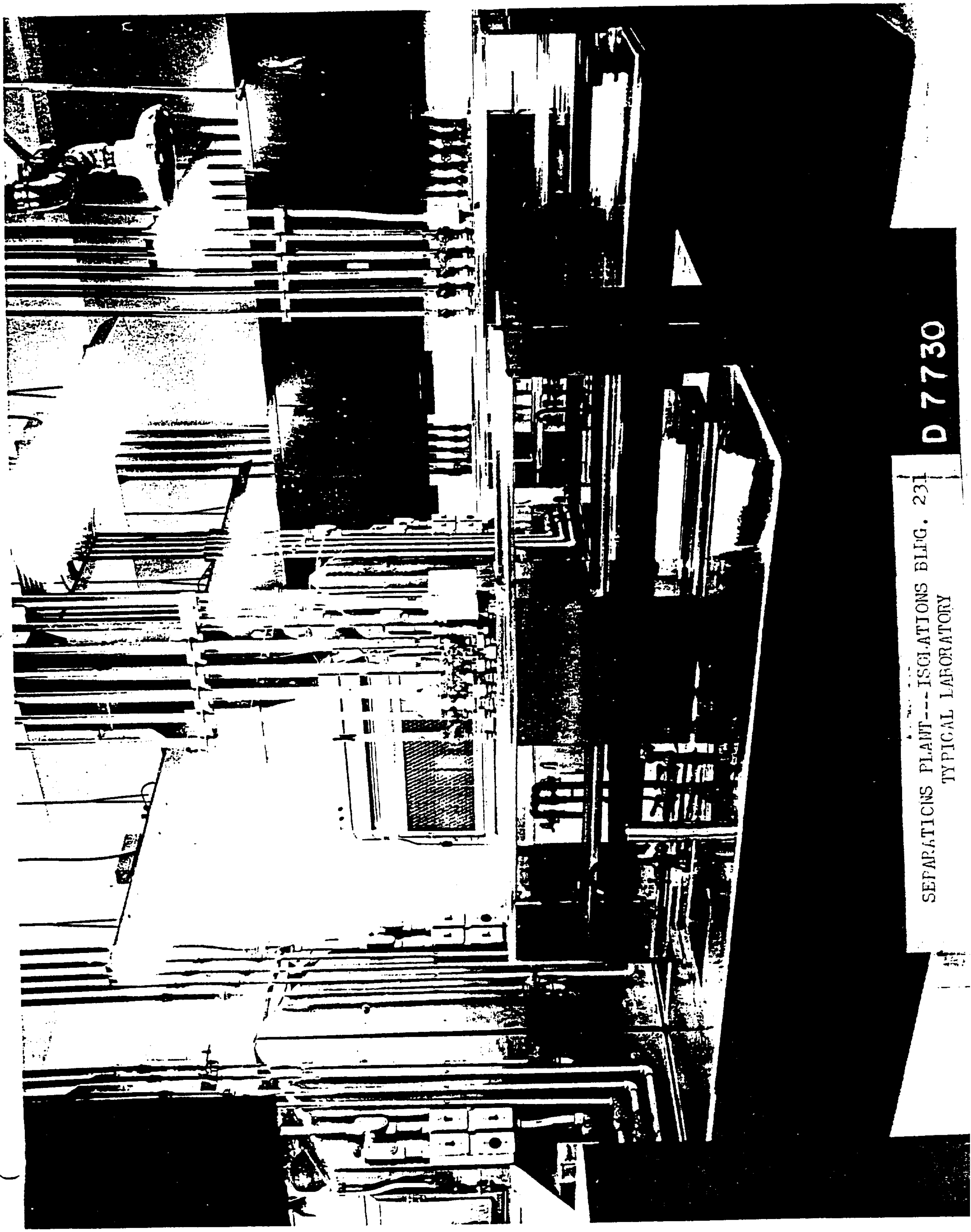
SEPARATIONS PLANT
CONCENTRATION BLDG. 224
OPERATING GALLERY

SEPARATIONS PLANT
CONCENTRATION BLDG. 224
View Across Top of Cells


SEPARATIONS PLANT
CONCENTRATION BLDG. 224
WEIGH TANK and FILLING ENCLOSURE
for CONCENTRATED PRODUCT SOLUTION
D 8420

SEPARATIONS PLANT---ISOLATIONS BLDG. 231
TYPICAL PROCESS CELL

1101544



D 7730

SEPARATIONS PLANT---ISOLATIONS BLDG. 231
TYPICAL LABORATORY

1101545

SECTION VII

SELECTION OF OPERATIONS CONTRACTOR

[redacted]

SECTION VII

SELECTION OF OPERATIONS CONTRACTOR

From the foregoing description of primary and auxiliary operations at Hanford, it is seen that they present innumerable hazardous and previously unexplored elements in combination with a wide variety of other work requiring high standards of industrial practices.

It may be said further that no possible contractor, or group of contractors, possessed adequate knowledge and experience to assure beyond doubt the complete fulfillment of the objectives of the Hanford Engineer Works.

An unprecedented high standard of industrial organization was required to assure the close cooperation of every individual associated with design, construction, and operation. This undeviating requirement, coupled with the extreme demands of military security, indicated the selection of a single contractor in preference to a group of contractors.

It was demanded that the contractor be able to adapt his organization to the unknown fields of applied nuclear physics and radiations chemistry without sacrifice of the other requirements and to do so without loss of time, the most important factor.

It was believed, and subsequent events have proved, that the selection of the E. I. du Pont de Nemours and Company as the Operations Contractor was well conceived.

[redacted]

SECTION VIII

DISCUSSION OF CONTRACT

[redacted]

SECTION VIII

DISCUSSION OF CONTRACT

The United States Government, represented by the War Department, Corps of Engineers, has entered into a Cost-Plus-Fixed-Fee Contract with the E. I. du Pont de Nemours and Company, Wilmington, Delaware for the design, engineering, construction, equipping, training personnel and operation of the plant designated as the Hanford Engineer Works under Contract No. W-7412 eng-1. The fixed-fee for the work is $1.00.

The Contract provisions, in general, follow the pattern of the standard Cost-Plus-Fixed-Fee Construction Contract, modified to embrace the training of personnel and plant operations. The work covered under design, engineering, construction, equipping the plant is covered elsewhere and this discussion will deal only with the operations phase of the work.

The reasons the Contractor was selected to perform this work are covered under Section VII.

The essential provisions in the operation of the plant clauses are briefly summarized as follows:

(1) Contractor is to notify Contracting Officer as each unit is completed for operation.

(2) Contractor is to make every reasonable effort to produce product but make no guarantee that any product will be produced.

(3) First period of operation is one year from the time that first unit is completed for operation. Second period of operation begins at the end of the first period of operation, after notifying the Contractor in writing one half year after the first unit is completed for operation that such continued operation is desired. The second period of operation continues for such period as may be desired by the Government, but not to exceed the duration of hostilities with the Axis Powers plus nine months.

(4) Contractor is to be in position to transfer plant to another contractor after the second period of operation or to place the plant in stand-by condition.

DECLASSIFIED WITH DELETIONS

[redacted]

[redacted]

(5) Specification of final product is to be as mutually agreed upon between the Contractor and the Government but Contractor makes no guarantee that said specifications will be met. Tentative specification is covered under Section X.

(6) The Government takes delivery and title to product at the Plant.

(7) The Government furnishes the Contractor with the principal raw material.

(8) Patents covering inventions made by the Contractor will lie solely in the United States.

In addition to and part of the Contract, there exist several other documents, which explain the reasons and circumstances lying behind the contract and must be considered for a thorough appreciation of the problems, hazards, and feasibility of the process. These documents are enumerated below and no further comments thereon will be made.

(1) The secret letter dated 6 November 1943 and Supplement No. 1 dated 31 March 1944.

(2) Preliminary Negotiations.

(3) Administrative Negotiations.

(4) Memorandum Covering Technical Basis for Work under the Contract.

[redacted]

DECLASSIFIED WITH DELETIONS

[redacted]

SECTION IX

DEPARTMENTAL ORGANIZATION OF OPERATIONS CONTRACTOR

[redacted]
DECLASSIFIED WITH DELETIONS
[redacted]

[redacted]

SECTION IX.

DEPARTMENTAL ORGANIZATION OF OPERATIONS CONTRACTOR

The various departments of the operating organization together represent the usual coverage of production, technical, engineering, services, and accounting. The unusual nature and size of the plant facilities, and the inclusion of Richland Village have necessitated special coverage in some departments such as Technical, Medical, Instrument, Maintenance, Protection, and Village Administration. The duties of each of the present departments are summarized briefly below:

P Department.--The P Department is one of the two primary production departments and is directly responsible for operation of the piles and pile auxiliaries in all three 100 Areas. Specifically, this direct responsibility involves metal storage, pile building, retention basin, and helium purification. The P department also supervises directly all operations in the 300 Area; namely, metal fabrication and canning and the Test Pile in Building 305. This department also has an over-all responsibility for all operations within the 100 Areas, insofar as they relate to operation of the piles, and has a similar responsibility for the receipt of metal and its handling through fabrication and pile processing to the point of final delivery to the metal storage basins in the 200-N Area.

S Department.--This department has direct responsibility for the receipt of processed metal from the P Department into storage at the 200-N Area; and for all subsequent processing and separation of plutonium through the 200 Area buildings (notably Bldgs. 221, 224, and 231) ~~to the~~ point of final isolation and delivery to the Army at Building 231. This involves all the 200 Area production facilities as well as the very extensive provisions for safe disposal of the metal wastes. Paralleling the P Department position in the 100 Areas, the S Department has the over-all responsibility for all operations in the 200 Areas. The department also operates directly the very special meteorological facilities installed at Building 622, adjacent to the 200-W Area (200-T and 200-U Separations Plants).

Technical Department.--This department has the responsibility for all process technology. Adequate coverage of unusually extensive technological requirements of operations at the Hanford Engineer Works has required sub-division of departmental responsibility along the following lines:

(1) 100 Area Technical, covering the physics, water and corrosion, and other technical engineering phases of the work in all 100 Areas.

[redacted]

DECLASSIFIED WITH DELETIONS

1101552

[redacted]

(2) Separations Engineering, responsible for 200 Area process technology as well as the use of the semi-works process investigation facilities in the head end addition of Building 221-T and the similar facility for low activity solutions in Building 321 (300 Area).

(3) Laboratories Division, which operates all of the control and general laboratories in the 100, 200, and 300 Areas; a special Statistical Section is included in this division.

(4) Metallurgical Section, which is responsible for all metal fabrication technology and the processes employed.

As part of its over-all process responsibility, this department maintains the Hanford Technical Manual, the Operating Standards, and issues regular reports of technical progress.

Power Department.--This department is responsible for all steam and water facilities in the 100, 200, 300 Areas and Richland Village. This responsibility is particularly great in the 100 Areas where both dependability and quality of water supplied the piles is vital. The facilities involved are river pumps, reservoirs and reservoir pumps, filter plant and pumps, process water storage, and final process pumps. The refrigeration, deaeration, and demineralization facilities are also power department responsibilities. Plant water responsibility includes the supply to the 200 Areas as well as the highly important inter-connections between the 100 Areas. Steam facilities operated include the 184 and 284 Power Houses and the heating plants at the 300 Area and Richland Village (Buildings 384 and 784). This department also operates the water supply system and the sewage disposal facilities at Richland.

Maintenance Department.--This department handles all maintenance of Plant and Village facilities except automotive and railroad equipment. This involves the required shop facilities in each of the plant areas, and includes all of the special facilities for the remote maintenance required in the 200 Areas. Also included is the Central Shops in Building 272 of the 200-W Area. The department has a Project Engineering Section which handles the design and supervision of equipment revisions and additions as well as the projects and appropriation requests involved.

Electrical Department.--The electrical department has the following twofold responsibility: (1) operation and maintenance of all electrical distribution facilities for the plant areas and the Richland Village including the 230,000-volt loop originating at Midway sub-station; and (2) the maintenance of all plant electrical equipment. The department also handles certain contacts with BPA and performs liaison work with the Signal Corps for all telephone maintenance.

[redacted]

Instrument Department.--This department is responsible for the maintenance of all instruments and process control equipment in the plant areas and Richland Village. In addition to normal interpretation of these duties, the department services all analytical laboratory test equipment, much of which is of special electronic nature (counters, scalers, etc.,). Also, considerable new fabrication of special instruments peculiar to this project is performed. The department necessarily conducts engineering and improvement of these instruments and currently is concluding the instrument development work formerly done by a special section of the Technical Department.

Protection Department.--This department combines three protective activities which have special importance at the Hanford Engineer Works; namely, Investigations, Security, and Patrol. The highly classified nature of the plant work has necessitated careful checking and special clearance procedures for all personnel. The Security Section administers the pass and badge system for controlling access to restricted areas and is responsible for over-all safeguarding classified information. Patrol limits operations area entry to authorized personnel, guards all vital plant areas, controls road traffic, and polices the Richland Village.

Service Department.--The duties of this department may be defined by its principal sub-divisions:

(1) Employment, which is responsible for procurement of non-exempt personnel as well as their transfer between departments. All terminations clear through this section for exit interviews, security cautioning, and the processing of termination papers.

(2) Industrial Relations and Training, affording a general employee service with respect to field consultation, Company plans, income tax, occupational gasoline, etc. The Training Group assists the other departments with development of supervision, operator training programs, safety meeting conduction, etc.

(3) Selective Service, administering the deferment program so essential to the Hanford Engineer Works.

(4) Safety and Fire Protection, operating the paid force of fire protection personnel in the plant areas and the Richland Village with coordination of auxiliary fire brigades in the plant areas. A regular fire inspection service is maintained. The safety activity centers in inspection with cooperation and advice to operating supervision to the end that the usual high Company standards are maintained.

[redacted]

(5) General Division, which operates the Plant Laundry in the 200-W Area, the dormitory and Administration Area laundry at Richland (Building 723) and is responsible for all janitor service in the plant areas and Richland Village except those assumed by commercial operators, schools, and churches.

(6) Central Files, located in the 300 and 700 Areas which include the centralized Classified Files with responsibility for control of all classified written information.

<u>Village Administration</u>.--This department is responsible for all phases of village operation. The Housing Section administers all of the new residences plus the few remaining original village houses and the outlying tract houses. In addition, room rentals for the dormitories are handled. Village Administration also has procured the commercial facility operators and is responsible for the contracts and relationships with these concerns. The latter involves principally structural maintenance, price control, and sanitation (in the case of food handling establishments). The department also administers the church leases, and clears all structural maintenance of these and other community facilities. Community activities are afforded the necessary assistance and coordination.

<u>Transportation Department</u>.--This department operates and maintains all automotive equipment in the plant areas and the Richland Village. This includes all passenger buses, motor freight services, and car pools as well as motor fuel distribution. In addition, this department operates the main Labor Division, some primary duties of which are: (1) Village services, such as coal handling, garbage collection, and ground maintenance; (2) all unloading of materials on the plant and in Richland; (3) operation of burning grounds and disposal pits; and (4) all maintenance of roads and streets on the plant and in Richland.

<u>Traffic Department</u>.--This department operates and maintains the Plant railroad system including Riverland Yard and handles all normal traffic matters such as pre-audit of freight bills, tracing and expediting, conversion to Government bills of lading, passenger reservations and ticket orders. This department also handles all movements of household effects to and from Richland Village including packing, loading, and crating for shipping.

<u>Medical Department</u>.--The Medical Department operates all facilities provided for meeting the normal and special medical needs of both plant and village. The normal requirements are met by standard Industrial and Village medical facilities and staff including field First Aid Stations and full plant and village hospital facilities centered at Richland. Included also is operation of the Medical and Dental Building adjacent to the Kadlec Hospital, and a full Public Health Section. Also under Medical is the Health Instrument Section which is responsible for control of the special process hazards peculiar to Hanford operations. This work in-

[redacted]

volves hazard survey staffs in all plant areas working very closely with production and maintenance supervision. The Health Instruments group also handles the pencil and badge meters for monitoring exposure of personnel to radioactivity and maintains Site Survey and Special Studies branches.

Accounting Department.--This department is responsible for all accounting and related activities essential to the operation of the Hanford Engineer Works and Richland Village under the terms of the prime contract. The principal sub-divisions of the department are: (1) Accounts Payable; (2) Accounts Receivable; (3) Cashier; (4) Property; (5) Purchasing; (6) Stores and Receiving; (7) Billing; (8) Insurance and War Bonds; (9) Costs and Essential Materials; (10) Time Office (non-exempt weekly salary roll; and (11) Salary Unit (exempt monthly salary roll). In addition, this department administers the Main Office Building, all office equipment, and all clerical personnel in the plant areas and Richland. It also operates the telephone switchboards, mail rooms, and correspondence reproduction facilities.

Force Report.--On the following page is the Hanford Engineer Works Force Report showing the growth of the various departments by months. The peak of anticipated employment has been reached as of 28 February 1945. In subsequent months, it is expected that reductions will be made in the Technical, Power, Maintenance, Protection, and Accounting Departments.

The successful accomplishment of Hanford objectives requires the best talent available. This applies to the exempt and non-exempt personnel. Even in normally minor positions, the skill and ability of the employee has an important bearing on the success of the work.

Because of the secret nature of the work undertaken, each person selected for quality and ability was subjected to a rigid personal investigation before employment. This investigation was made by established agencies and entered into every phase of the applicant's past history.

Positive influences such as satisfactory industrial relations policies had to be emphasized to hold labor turnover to a minimum. Because of the importance of the project and because of the security regulations with which it is surrounded, satisfied employees on the project are a vital necessity.

H. E. W. FORCE REPORT

DEPARTMENT	4/1/44	5/31/44	6/30/44	7/31/44	8/31/44	9/30/44	10/31/44	11/30/44	12/31/44	1/31/45	2/28/[illegible]
Management	5	6	6	7	7	7	7	7	7	7	
P	195	297	326	356	357	342	326	307	343	365	3[illegible]
S	27	64	70	79	78	98	137	171	174	231	3[illegible]
Technical	66	144	163	197	245	329	369	367	372	399	4[illegible]
Power	30	51	55	214	294	352	396	441	484	562	6[illegible]
Maintenance	38	92	123	190	321	429	482	666	769	861	8[illegible]
Electrical	16	27	32	38	82	120	137	155	175	196	2[illegible]
Instrument	35	57	69	136	193	219	225	223	227	237	2[illegible]
Service	70	81	78	90	84	101	128	145	175	225	2[illegible]
Transportation	2	7	11	11	16	52	155	328	480	600	[redacted]
Traffic	4	4	4	4	4	4	6	15	30	35	[redacted]
Medical	8	14	48	73	142	187	243	265	278	311	[redacted]
Accounting	267	328	393	486	575	626	703	714	718	738	[redacted]
Training	4	6	6	5	3	-	-	-	-	-	-
Village Engineering	-	-	-	-	19	40	81	-	-	-	-
Protection	-	-	-	-	972	1058	1157	1101	1035	944	8[illegible]
Village Administration	-	-	-	-	21	19	24	21	22	20	[illegible]
TOTAL	767	1178	1384	1886	3413	3983	4576	4926	5289	5731	61[illegible]

DECLASSIFIED WITH DELETIONS

1101557

6

The operation of the various processes present many exceptional and unusual hazards. In addition to those already known, there are indications of others about which information will be obtained only by trial and experience. These hazards carry the potentialities of occupational disease and permanent disabilities and will endanger all those who work in or around the manufacturing areas.

The plant is located in a desert section of the country away from towns and cities. Those who work on the plant have had to be imported from other regions and have had to sacrifice normal economic and social standards in accepting employment.

Despite all of the above real obstacles, the contractor managed to man adequately the work; to train the personnel; and to get into full scale operation in a remarkably short time.

SECTION X

SPECIFICATIONS FOR FINAL PRODUCT

[redacted]

SECTION X

SPECIFICATIONS FOR FINAL PRODUCT

Contract Requirements.--The prime contract states that the Contractor shall use all reasonable efforts to produce plutonium which conforms to specifications mutually agreed upon by the District Engineer (as representative of the Consumer) and the Contractor. The extreme difficulties and uncertainties relating to the manufacture and use of plutonium prohibited the incorporation of a rigid specification in the contract or a guarantee that a specification, after being established, could be met implicitly.

Tentative Specification.--The first tentative specification was furnished by the District Engineer in a letter dated 26 December 1944. This was done as a guide to establish generally the requirements of plutonium for the processing steps of the Hanford consumer and to provide early information directed toward elimination of delays which might result from the need for altering processes or equipment.

First Specification Conference.--The first conference relative to plutonium specifications was held at Hanford during the period 18 to 20 February 1945. The following offices were represented: the Consumer, the Contractor, the Metallurgical Project, the District Engineer, and the Hanford Area Engineer. It was reported that the first plutonium received by the Consumer had redissolved readily and had been assayed at about 99% purity. All impurities were well within the tentatively established limits except for chromium, nickel, and suspended solids. Since it was determined that the amounts of chromium and nickel present were not harmful, the tentative limits for these elements were increased. It was suspected that the suspended solids were largely silica which would normally be expected to decrease as Hanford operations became established. It was agreed that a second conference would be held in April 1945 at which time accumulated knowledge should permit a more firmly established appraisal to be made.

Second Specification Conference.--A second conference was held in Chicago on 27 April 1945. The Consumer, the Contractor, the Metallurgical Project, and the Hanford Area Engineer were represented. Briefly, the following points were established:

1. Quality.--It was reported by representatives of the Consumer that plutonium quality to this time had been excellent except for the presence of suspended solids.

2. Suspended Solids.--The suspended solids have created filtering difficulties in initial processing and also in subsequent chemical operations at the plant of the Consumer. It was agreed that a research study would be conducted at Hanford directed toward a determination of the origin of the suspended solids and elimination of these objectionable im-

[redacted]

purities or their effects. The process step in which the most difficulty has been experienced by the consumer was established primarily to remove zirconium and columbium. Since these elements, together with uranium, are almost completely removed at Hanford, it was suggested that this step might possibly be eliminated without affecting the final processing and use of the plutonium.

3. Batch Size for Shipment.--It was agreed that the batch size for shipment from Hanford would be increased from 80 to 160 grams of plutonium per shipping container. This change was effected early in May.

4. Plutonium Assay.--For accounting purposes, it was agreed that the plutonium assay would be determined by radiations counting methods for the time being. It is the consensus, however, that a chemical method offers the most reliable determination ultimately and work on the development of such a method has been progressing and will continue at Hanford and at the plant of the Consumer.

5. Plutonium Purity.--It was agreed that plutonium of purity less than 95% would not be shipped.

6. Specific Impurities.--It was agreed that no formal specifications for specific impurities would be established at present although a tabulation of the normal expectancy of 27 elements was prepared to serve as a guide. It was also agreed that no changes would be made in Hanford processing which might result in deviation from this tabulation without notifying the Consumer. The tabulation of expected specific impurities will be reviewed from time to time as additional information is obtained.

7. Batch Histories.--It was agreed that the Consumer would be furnished pertinent historical data relative to each batch of plutonium received. This information will include the time and the amount of radiations to which the uranium was exposed in the piles, the concentration of plutonium in the uranium discharged from the piles, and the percentage of distribution of the various pile discharges in each batch shipped.

8. Analytical Methods.--It was agreed to interchange information between Hanford and the Consumer on matters of mutual concern, particularly spectographic methods for specific impurities and chemical and radio chemical assay methods, to establish standard methods at the two sites.

Future.--As knowledge is accumulated, the subject of plutonium specifications will be reviewed from time to time. This section of the History of Operations will be revised as frequently as significant developments occur.

[redacted]

The tolerances as set forth above were arbitrary as the consumer had not tested the effect of all the elements present in the process nor did they have the final metallurgical specifications at that writing.

An early meeting was arranged with the consumer to discuss and to determine a final specification to be mutually agreed upon. Toward this end a meeting was held at Hanford Engineer Works on 19 February 1945 to obtain the consumer's preliminary report on the first can shipped and to reach certain conclusions with respect to purity and tolerance levels of the impurities. In general, the meeting bore out that the first material substantially met the original specification and was satisfactory with the exception of an objectionable feature of high silica content. Metal was prepared from the first shipment and its properties in general were analagous to those of metal obtained from the product from Clinton Laboratories. It was agreed that in future shipments the consumer would advise the Hanford Engineer Works at once of any unusual characteristics of the product so that proper adjustment of its processing operations at Hanford can be made to correct objectionable characteristics of product if at all possible. It was further agreed that the final specifications of the product would not be established until about five shipments had been made to the consumer. Operations here will have reached a stable state by that time and a meeting of the same group was set tentatively for early in April for the drafting of final specifications.

[redacted]

[redacted]

SECTION XI

OPERATIONS RECORD

[redacted]

[redacted]

SECTION XI

OPERATIONS RECORD

A. Preparations for Placing Plant in Operation

The Manufacturing Division has been engaged in all phases of the Hanford Engineer Works and those activities, prior to the start of production operations, are enumerated as follows:

1. Liaison work between the University of Chicago Metallurgical Project and the Engineering Design Division at Wilmington, Delaware.

2. Consulting service to the Engineering Division followed by review and approval of plans, specifications, and procurement of all primary and auxiliary manufacturing facilities.

3. Consulting, testing, and statistical service to the Construction Division relative to all field construction requiring knowledge of the manufacturing processes including the 300-Area Test Pile service for assuring adequate purity of the pile construction materials such as graphite.

4. Conducting, partly with the aid of the Construction Division, the final preparations for placing each manufacturing area in operation. This work included the following: checking, testing, calibrating, and adjusting all instruments and equipment; flushing and cleaning piping, tanks, and cooling tubes; charging the piles with uranium slugs; and final system tests to assure the adequacy of all design and construction.

5. Establishing personnel requirements for preliminary preparations and for all aspects of plant operation and maintenance.

6. Developing and establishing the plant organization and standard procedures, methods, and limits for all phases of plant operation and maintenance.

7. Preparation of the Hanford Technical Manual as a guide to all manufacturing processes.

8. Conducting the necessary training courses for em-

[redacted]

[redacted]

ployees, particularly in those branches of the work representing new art.

9. Developing and establishing procedures for accountability of all money and materials.

10. Developing and designing printed forms for assuring appropriate records of all phases of the work.

B. Early Operating Problems and Solutions

The problems encountered during the periods when each manufacturing area was placed in operation were fewer than would normally have been expected in any large industrial plant.

This exceptional degree of success may be attributed almost entirely to the high calibre and close cooperation of those persons representing the several responsible organizations in management, scientific advancements, and engineering. The operating problems have been few because the potentially serious possibilities were foreseen and adequate provisions incorporated in the plant design to counteract them.

Three important problems, however, are worthy of mention. These are the canning of metallic uranium; the formation of xenon of atomic mass 135 as a fission by-product of the pile reaction (xenon-135 is by far the most effective neutron absorber yet discovered); and the development of methods for controlling film formation and corrosion of the cooling surfaces of the pile tubes.

<u>Canning of metallic uranium slugs</u>.--The early research and development work relative to a jacket or coating which would unfailingly withstand the severe conditions of exposure within an operating pile is recorded elsewhere in the Manhattan District literature. This work effectively determined the approximate conditions and choice of materials for the Hanford process and for substitute processes. However, only the application of mass production methods could establish precisely the permissible limits to which the numerous conditions must be held to assure the minimum possibility of an operating failure. The Hanford process for canning is described briefly under the heading <u>300-Area Processes and Facilities</u>.

The following conditions each have a material effect upon the quality of the canned slug and it was of the utmost importance that the optimum for each be determined and established on a mass production basis:

(1) The dimensions and surface condition of the uranium slugs and aluminum cans;

[redacted]

(2) The dimensions, surface conditions, and shape of the aluminum top cap;

(3) The temperature and purity of the bronze, tin, and aluminum-silicon baths;

(4) The time of immersion of the slug in each of the three baths and in the centrifuge;

(5) The time element in transferring the slug from one step in the process to the next; and

(6) The dimensions, surface condition, and design of the steel sleeve in which the aluminum can is held while the slug is inserted.

Although no delays were encountered in placing the manufacturing piles in operation due to a shortage of canned uranium slugs for charging, several factors combined to create delay in placing the canning operation on a production basis and these factors were as follows:

(1) The late date on which the elements of a suitable canning process were formulated caused considerable lost time in completing design, procurement, construction, and in getting canning production operations started:

(2) The hydraulic presses used to drive the uranium slug into the aluminum can after the final dip in aluminum-silicon were unsatisfactory and interruptions to production caused by press maintenance prevented early knowledge of the limits of the various other conditions; and

(3) The lack of a positive method of testing the canned slugs to assure conformity with the requirements prevented early knowledge of the quality of those canned.

Effort was concentrated on improvement of the presses with the result that sufficiently continuous performance was obtained to permit the optimum limits for the many conditions to be established. For example, it was learned that a reduction of 50 degrees Fahrenheit in the bath temperatures resulted in an increase of the cans classed in the highest grade from 5% to 75%. The cause for this remarkable improvement could not be determined with assurance until it was possible to hold all other conditions constant. This improvement was made on 14 August 1944 and resulted in the decision to reject all prior canning production. On 27 September 1944, the canning presses were abandoned entirely and a modification to the process substituted. In this modification, the slug, can, and cap are assembled

[redacted]

manually below the surface of the aluminum-silicon bath with the following advantages:

(1) Assembly of the parts under closer temperature control;

(2) Improved seating of the top cap;

(3) Simplification of the operation assuring improved operator performance;

(4) A production rate approximately three times that of a production line using the presses;

(5) Elimination of press maintenance; and

(6) Reduction in the cost of canning.

With this and other gradual improvements to the process, almost 90% of the total number of slugs canned are classed in the highest grade which is the only grade accepted for use.

It was decided that the importance of eliminating the possibility of any slug failure within an operating pile required a positive method of testing every slug. The autoclave method of exposing each slug, after canning, to steam at about 100 pounds per square inch pressure for 40 hours was decided upon. The steam penetrates through the most minute hole and reacts with the uranium resulting in a burst can. Comparative tests have proved that exposure to the steam is much more severe than exposure to hot water at a much higher pressure. In July 1944 the autoclave equipment was ready and the first tests indicated over 2% slug failures. With the production improvements previously enumerated, autoclave failures are now about 1/50 of the earlier amount.

Formation of Xenon-135.--Production operations were started in the 100-B pile at 10:48 p.m. on 26 September 1944 with 901 of the 2004 tubes of the pile charged with uranium slugs. After making the necessary preliminary measurements at practically zero power level, the pile power was increased to 9 megawatts or 3.6% of rated power level. Shortly thereafter, it became apparent that neutrons were being absorbed somewhere in the pile at a rate greater than they were being created by the fission of uranium-235. After about 18 hours of operation at the 9 megawatt power level, the reactions had diminished to the extent that operations could not proceed and the pile was taken out of service.

After being out of service for six hours, the measurements indicated that neutrons were again beginning to multiply slowly and the pile power was again raised to 9 megawatts after which it became apparent again that the neutrons were being absorbed at a greater

[redacted]

[redacted]

rate than they were being created and the earlier events were substantially repeated.

There were numerous possible causes of the parasitic neutron absorption but there was no immediate concrete evidence which adequately explained any of the possibilities. In order to evaluate the various possibilities, the pile was again started and the power held at about 2.5 megawatts for 6 hours followed by a longer run at 1.7 megawatts. It was determined that continuous operation could be maintained at a power of about 3 megawatts with the pile charged with 901 tubes. From the data collected at this time, and during operations at 90 megawatts in November, the physicists made substantially the following analysis and predictions which have proved to be remarkably accurate:

(1) The parasitic neutron absorption resulted from the formation of xenon-135 as a fission by-product element. With the time expressed as half-lives (the time required for one half of the amount present to decay to the next element), this is part of the decay chain of: tellurium (15 minutes) to iodine (6.6 hour) to xenon (9.4 hour) to cesium (25 year) to stable barium. In this chain, only xenon capacity is about 50 times greater than that of any previously known element.

(2) It was predicted that the pile would be able to operate at the following power levels when the indicated number of tubes were charged with uranium slugs: 14 megawatts at 1000 tubes; 59 megawatts at 1300 tubes; 94 megawatts at 1500 tubes; and 216 megawatts at 2004 tubes.

(3) It was predicted that higher power levels than those above would gradually be attained as boron and other impurities with high neutron absorption characteristics were gradually transmuted during pile operation to less objectionable elements; and as plutonium formed in the pile and some of it fissioned to produce additional neutrons. This prediction was based on knowledge of some other fission by-product elements which would absorb neutrons and thus retard the pile reaction.

(4) It was also pointed out that additional power could be obtained by placing up to 38 instead of the planned number of 32 uranium slugs in each tube of the pile; by making certain that a minimum of aluminum is present at the ends of the slugs to be charged into the other two piles; by carefully zoning slugs in the piles so that the heavier slugs are in the central portion.

[redacted]

In the early analyses of the possibilities of the Hanford process for the manufacture of plutonium, it was recognized that serious neutron absorption might occur among the fission by-product elements. In all subsequent studies, effort was concentrated on evaluating the various possibilities with the greatest accuracy permissible with the then undeveloped state of knowledge. Thus, even though the effect of xenon-135 was unknown, the possibility of the formation of some element of similar properties was foreseen. If the neutron absorption capacity of xenon-135 were greater than it is, it appears reasonable to believe that it would have been discovered during the operation of the experimental piles at Argonne and the Clinton Laboratories. In that event, adequate provisions would have been made in the Hanford piles to counteract it on the basis of accurate knowledge.

Through what has subsequently proved to have been good judgment, two very important factors were incorporated in the original design of the Hanford piles which have permitted the charging of sufficient uranium slugs to provide a source of neutrons adequate for saturation of the xenon poisoning and operation of the piles at, or above, rated power level. The first is the fact that the piles are constructed with 2004 cooling tubes rather than the 1500 which were indicated theoretically as being adequate. The second is the fact that 9 control rods were designed into each pile instead of about three which were indicated as being required.

The additional control rod capacity is essential in absorbing sufficient neutrons to hold the pile safely when starting for the first time or after a shutdown when the xenon has decayed to less absorptive elements. On these occasions, the piles have a far greater ability to accelerate in power than was ever contemplated and are consequently much more hazardous. However, during normal operation the excess neutron producing capacity is absorbed by the xenon and operations are much less hazardous than had been predicted.

Film Formation and Corrosion.--Concurrently with the design and construction of the Hanford Engineer Works a great deal of work was done in developing a means of limiting film formation and corrosion with respect to the pile cooling surfaces and for periodically removing any film which might form. A part of these investigations were conducted by the Metallurgical Project and the remainder by the Technical Division at Hanford. Without the successful attainment of these objectives, the Hanford piles could not operate. The test laboratory at Hanford, called CMX, was built originally to investigate corrosion only under simulated pile operating conditions. However, the formation of film was discovered promptly and became the dominating condition to be controlled.

As a result of this work, practicable operating standards were established prior to the beginning of operations for the performance of the various water treatment processes and for the final chemical conditioning of the process water through the addition of sodium dichromate and sodium silicate. Positive methods were also established for removing the very thin film which does form on the cooling surfaces through the addition of diatomaceous earth as a scouring agent to the process water flowing through the pile.

During the early operations of the 100-B pile, film formation was kept within the limits which had been established. After 4 months of operation, film had gradually formed to the extent that the pressure drop through the cooling tubes had increased by about 20 to 25 pounds per square inch. The first operating demonstration of the effectiveness of the diatomaceous earth purge was made on 26 January at which time film was removed successfully from approximately one half of the pile tubes. At that time the purge was limited to those tubes connected to the chilled water system.

C. Chronology of Significant Developments

Significant Dates

13 September 1944 -- Charging of 100-B pile started.

26 September 1944 -- 100-B pile placed in operation followed immediately by discovery of xenon poisoning.

28 November 1944 --- First discharge of enriched uranium slugs from 100-B pile completed.

4 December 1944 --- First enriched slugs received in 200-N Area.

5 December 1944 --- Charging of 100-D pile started.

17 December 1944 --- 100-D pile placed in operation.

26 December 1944 --- First Hanford enriched slugs dissolved in Building 221-T.

17 January 1945 ---- Isolation of first Hanford plutonium started in Building 231.

2 February 1945 --- First plutonium resulting from Hanford operations transferred to Army, thus establishing Hanford process from raw material to finished product.

4 February 1945 --- 100-B pile reached rated power level of 250 megawatts

[redacted]

5 February 1945 --- First Hanford plutonium transferred to representative of Hanford customer

11 February 1945 --- 100-D pile reached rated power level of 250 megawatts.

15 February 1945 --- Charging of 100-F pile started.

25 February 1945 --- 100-F pile placed in operation.

8 March 1945 ------ 100-F pile reached rated power of 250 megawatts for about 24 hours after which it was reduced to 240 megawatts.

15 March 1945 ------ First discharge of enriched uranium slugs from 100-D pile.

\- - - - -

The following chronological history describes briefly the most important developments in the operations history of the Hanford Engineer Works beginning with the first quarter of 1944 and ending on 20 March 1945:

<u>1944 -- January, February, March</u>

<u>General</u>.--For the first quarter of 1944, the work of the Manufacturing Division was devoted to:

(1) Organization;

(2) Preparation of personnel specifications;

(3) Personnel procurement;

(4) Training of personnel at Hanford and elsewhere;

(5) Consulting service to the Construction Division for the 100 and 200 Areas;

(6) Machining uranium slugs from extruded rods in the 300-Area;

(7) Testing graphite and other pile construction materials in the 300-Area Test Pile;

(8) Investigating methods of water treatment in pre-

[redacted] DECLASSIFIED, WITH DELETIONS

[redacted]

venting corrosion and film formation on the surfaces of the slug coatings and pile cooling tubes;

(9) Development of procedures for protective security;

(10) Development of procedures for accounting;

(11) Procurement of essential materials; and

(12) Operation of the Richland Village.

Most of these activities have continued and no further mention of them will be made in this chronology except where special significance is involved.

Canning of Metallic Uranium Slugs.--In March, it was believed that a practicable process had been made available for the mass production of canned slugs although it was expected that continued research and practice would be required to produce ultimate improvements. Sufficient equipment was on hand to initiate a training and development program and some production. The frost test was made available for determining the areas on the surface of the canned slug which are not completely bonded.

1944 -- April

Canning of Metallic Uranium Slugs.--By April it was realized that the problem of fully developing a suitable process for canning slugs was extremely complex; that the time element for converging design, procurement, construction, and operator training had been reduced to the minimum which it was expected would meet production requirements. Extensive changes were made in the personnel organization to the end that the most experienced talent available was assigned to a relatively narrow field.

Testing of Pile Construction Materials.--The testing of graphite which had been contaminated with boron during manufacture received special emphasis in the Test Pile and it was generally established that there would be no delays in the construction of the manufacturing piles because of the contamination.

1944 -- May

Organization.--With one or two exceptions, all key personnel of the Manufacturing Division had arrived on the project.

Canned Uranium Slugs.--A test of 2,000 canned slugs in the Test Pile indicated that the neutron production and absorption properties were about as predicted.

[redacted]

[redacted]

Exhaustive studies were started to evaluate all of the numerous factors influencing the quality of canned slugs. All canned slugs were subjected to examination with respect to dimensions, surface defects, penetration of aluminum-silicon through the can wall, and for bonding as determined by the frost test. The first method for statistically classifying individual slugs for quality was initiated.

Recovery of Rejected Canned Slugs.--A method of dissolving the aluminum can and aluminum-silicon bond of rejected slugs as a means of reclaiming the uranium for recanning was developed. The method employs a caustic soda bath followed by a nitric acid bath.

1944 -- June

Canned Uranium Slugs.--The first heavy bottomed cans were received toward the end of the month. This type of can eliminates the need for inserting an aluminum cap in the bottom to provide the required thickness and which was a source of trouble in the canning process.

100-B Pile.--The following work was performed in preparation for operations:

(1) Group training for pile operations consisting of lectures, study of written information, observation of construction, and review of various departmental functions;

(2) Started regular weekly meetings of top supervisory personnel assigned to the various departments within the area;

(3) Preparation of test procedures for acceptance of plant and equipment;

(4) Concentrated study of pile operation relative to a possible accelerated schedule of plutonium delivery;

(5) The Power Department conducted preliminary tests of boilers;

(6) Preliminary operation of the river pumps and filling of the reservoirs.

[redacted]

1944 -- July

Scientific and Specialized Personnel.--During the month a number of scientists and specialists arrived from the Metallurgical Project and from the Contractor's Wilmington office to be present during all preliminary preparations and for the start of 100-B pile operations.

Special Plutonium Production Study.--A study was substantially completed to determine the earliest date on which 2 kilograms of plutonium could be manufactured and delivered and to evaluate the effect of such a program on future production. It was indicated that this amount could have been delivered by the first of January 1945 at the sacrifice of later production.

100-B Area.--During the month the Manufacturing Division accepted responsibility for all facilities in the area except the Pile Building, Chemical Building for special water conditioning, Helium Purification System, Deaerators, Process Water Pumps, and the Emergency Water Tanks.

Performance and capacity tests were completed on all electric and steam pumps except the Process Water Pumps. Testing and flushing of the water systems including the supply line to the 200-W (comprising 200-T and 200-U) Area were substantially completed.

The following auxiliary facilities were placed in continuous operation: River Pump House, Reservoirs and Reservoir Pump House, Filter Plant and Pump House, and the Boiler Plant and Steam Distribution System.

200-Areas.--In addition to the continued furnishing of consulting service to the Construction Division, the work of the Manufacturing Division was accelerated to some extent preparatory to the start of operations. Some 27 men had arrived and were engaged in study of the separations plant design and operation and in observing the work of construction.

300-Area.--

Canned Uranium Slugs.--With gradual improvement in the quality of canned slugs, a sufficient quantity had been completed by July 1944 to charge the 100-B pile. For 8000 slugs autoclaved 160 failures were reported.

1944 -- August

Abandonment of Accelerated Production.--At the direction of

[redacted]

the District Engineer, the accelerated schedule for producing an early 2 kilograms of plutonium was abandoned in favor of the original longer range plan which assures a greater quantity over an extended period.

100-B Area.

Acceptance by the Manufacturing Division.--The 100-B Area was accepted by the Manufacturing Division in August except for certain work remaining to be done by the Construction Division and scheduled for the period from 28 August to 4 September and about 15 September to 22 September.

Testing, Inspections, and Preparations.--All testing, inspections, and preparations were completed in the pile except for that which could only be done after charging the pile.

Operating Standards.--Substantially all operating standards were completed during the month covering the work from charging of the pile with canned uranium slugs to discharging and including the water and helium systems.

300-Area.

Canned Uranium Slugs.--On 14 August the temperatures of the canning baths were reduced about 50 degrees Fahrenheit. This resulted in such a marked improvement in the quality of canned slugs that it was decided to charge into the 100-B pile only slugs canned after this date and to hold prior production until the required number were assured from current production.

Testing of Pile Construction Materials.--By the end of August, the testing of pile graphite in the Test Pile was completed.

200-Area.--Manufacturing Division personnel assisted the Construction Division in the supervision of the following work: inspection, testing, flushing, and cleaning of process and waste lines; inspection, testing, and identification of process vessels, equipment, and instruments. In addition, studies and preparations were carried out for testing all facilities in Building 221-T under simulated operating conditions.

1944 -- September

100-B Area.

Charging of the Pile.--The charging of canned uranium slugs was started at 5:50 p.m. on 13 September.

Dry Critical.--The dry critical condition is obtained

[redacted]

when a sufficient amount of uranium has been charged into the pile to start a multiplication of neutrons, called a chain reaction, when the cooling tubes are free of water. This condition was reached with 400 tubes charged with 32 uranium slugs each at 2:30 a.m. on 15 September.

Wet Critical.--The wet critical condition is obtained when sufficient uranium has been charged into the pile to create a chain reaction with water flowing through the cooling tubes. This condition was obtained with about 834 tubes charged on 18 September. The exact condition was passed and the number 834 determined by calculation.

Charging for Operations.--Charging was continued until 5:00 a.m. on 19 September when a total of 903 tubes of 32 slugs each was reached. Subsequently, two tubes were unloaded because of excessively high water pressure loss. This left 901 tubes charged at the start of operations.

Measurements.--At intervals during, and after, the charging of the pile, the necessary measurements were taken to determine operating characteristics including the following: effectiveness and calibration of the control and safety rods; effect of the graphite reflector (this is 2-foot border of graphite which surrounds the main body of graphite in the pile); ratio of fast to slow neutrons; traverse of neutron flux; pile temperature coefficient; water flow and pressure.

System Tests.--Following the charging of the pile, and concurrently with some of the measurements, final tests were conducted on the steam and electric power, pumping, and emergency water tank systems together with the simulation of various faults. This work determined the speed of response of the several interconnected control systems and equipment. In general, the results proved that the installations fulfill satisfactorily the conditions imposed by the rigid operating and safety requirements of the process.

Production Operations.--Production operations for the manufacture of plutonium were started at 10:48 p.m. on 26 September. The early history of the problems encountered due to the formation of xenon-135 as a fission product is briefly recorded under Early Operating Problems and Solutions.

300-Area.

Canned Uranium Slugs.--In September 1944, the canning process was modified to eliminate the hydraulic presses with substantial improvements in the quality of the canned slugs. This

[redacted]

is briefly described under Early Operating Problems and Solutions.

Outgassing and Straightening.--During September, the Manufacturing Division accepted responsibility for the outgassing and straightening equipment in the 300-Area. The processes are described briefly under Description of 300-Area Processes and Facilities.

200 Areas.

Tracer Slugs.--96 irradiated uranium slugs from the Clinton Laboratories pile were received at Hanford and placed in the 200-N Storage Area. These slugs were obtained for enrichment of fresh uranium slugs in checking the performance of 221-T Building processing equipment.

1944 -- October

100-B Area.

Pile Operations.--During October, pile operations were conducted at the following power levels with the indicated number of tubes charged with uranium slugs: 1.6 megawatts at 901 tubes; 17 megawatts at 1003 tubes; 30 megawatts at 1128 tubes; 60 megawatts at 1300 tubes; and 90 megawatts at 1500 tubes.

Pile Studies.--The discovery of the xenon poisoning resulted in a great concentration of effort at Hanford, the Metallurgical Project, and at the Clinton Laboratories to determine the requirements for attaining full pile power capacity in the shortest possible time and assurance of adequate control and safety rod capacity to hold the pile safely at times when the xenon poisoning had decayed. A great deal of this work was done during October.

100-D Area.

Auxiliary Facilities.--During October, the Manufacturing Division accepted from the Construction Division the following 100-D Area facilities: Boiler House; River Pump House; Reservoirs and Reservoir Pump House.

200-T Area.

Acceptance.--The Manufacturing Division accepted full responsibility for the 200-T Area on 9 October.

1944 -- November

General

[redacted]

Production Schedule.--On 21 November a formal schedule of production was submitted for approval covering the period from 1 December 1944 to 1 January 1946.

100-B Area.

Pile Operations.--The pile power, during the major portion of November, was held at 90 megawatts with 1500 tubes charged with uranium slugs. Toward the end of the month charging was continued to 1595 tubes and the power level attained a new high of 125 megawatts on 30 November.

Discharging Operations.--The first enriched slugs were discharged from the 100-B pile, this work being completed on 28 November.

Film Formation and Corrosion.--Careful examination of slugs which had been exposed to the most severe conditions in the pile indicated that film formation and corrosion on the aluminum surfaces had been held to limits appreciably less than had been estimated.

100-D Area

Pile Building.--The Manufacturing Division accepted full responsibility for the pile building on 27 November and immediately began final inspections, testing, and preparation of all facilities for initial charging of the pile.

200-N Area.--The Manufacturing Division accepted full responsibility for this area which was made ready for the arrival of the first enriched uranium from the 100-B Area.

200-T Area.

Operating Preparations.--The work of the Manufacturing Division in the 200-T Area was devoted to the final testing, calibration, and adjusting of processing facilities. Trial operations included the checking of the performance of processing equipment with water in preparation for chemical runs.

1944 -- December

General

Production Studies.--On 11 December, an independent study of plutonium manufacture was prepared by the office of the Area

[redacted]

Engineer to illustrate the effect of the quantity of uranium used on the time and cost of delivering specific quantities of plutonium. On 23 December, a similar study was prepared by the Contractor. The two studies were in substantial agreement.

100-B Area.

Pile Operations.--With 1595 tubes charged with uranium slugs, the pile power was varied between 115 and 130 megawatts during the first 20 days of the month. During this period, the pile was out of service for a total of 36 hours for various reasons including an attempt at film removal by an oxalic acid purge of the cooling tubes and for prearranged tests on the Bonneville electrical transmission system. After 20 December, the pile was taken out of service to complete charging to the full 2004 tubes and a power level of 150 megawatts was attained on 29 December.

Discharging Operations.--On 28 December the second discharge of enriched uranium slugs was accomplished.

100-D Area.

Acceptance.--The 100-D Area was accepted by the Manufacturing Division on 5 December and charging of the pile started immediately.

Charging of the Pile.--The full 2004 tubes of the pile were charged with 35 uranium slugs each by 10 December. Four tubes were subsequently discharged and replaced with poisoned slugs to supplement the holding capacity of the control rods.

Production Operations.--After completion of all required preparatory work, production operations were started at 11:11 a.m. on 17 December. On 21 December, the pile power had reached 150 megawatts and by 27 December it had reached 180 megawatts. 14 hours of production time were lost on 23 December to permit discharging 2 of 4 poisoned tubes previously charged to assure holding the pile prior to formation of the xenon poisoning.

200-N Area.

Storage of Enriched Slugs.--The first enriched slugs from 100-B Area operations were received in the 200-N Area for decay storage on 4 December.

200-T Area.

Operating Preparations.--The 200-T Area was placed in operating condition during the month of December with the completion

[redacted]

[redacted]

[redacted]

of chemical and inactive uranium runs through the process steps. Tracer runs using enriched slugs from the Clinton pile were started.

Production Operations.—The first enriched uranium slugs from 100-B Area operations were dissolved in the 221-T Building on 26 December.

Operating Standards.—A complete set of Operating Standards for the 221, 224, and 231 Buildings have been prepared and were approved by Metallurgical Project representatives on 15 December.

200-U Area.

Acceptance.—On 18 December, the entire 200-West Area including 200-U and the 231 Building were accepted by the Manufacturing Division.

Operating Preparations.—The work of testing and calibrating processing equipment in the 200-U Area was in progress during December.

231 Building.

Acceptance and Alterations.—This building was taken over by the Manufacturing Division on 18 December. Two major jobs remained to be done by the Maintenance Department. This work consisted of covering and venting the process vessels and installation of emergency ventilating equipment in case of failure of electric power. This work necessitated extensive piping and assembly.

1945 — January

General.

Establishment of Entire Process.—By the end of January 1945, the entire Hanford process for the manufacture of plutonium had been proved from raw material to finished product. Although a considerable number of improvements and refinements remained to be made in the many process steps and in the sampling and analytical procedures, the results to this time were noteworthy.

100-B Area.

Pile Operations.—The power level of the pile was gradually raised during the month reaching a new high of 240 megawatts on 27 January.

[redacted]

[redacted]

<u>Pile Power Capacity</u>.--The gains in pile power producing capacity predicted for continued operation and mentioned in <u>Early Operating Problems and Solutions</u> were especially evident during the month of January.

<u>Film Formation and Corrosion</u>.--During 100-B pile operations, the pressure drop across the cooling tubes gradually increased to significant amounts due to formation of film. On 26 January, a trial purge of the film was conducted using diatomaceous earth added to the water supply to about one half of the tubes of the pile. This purge was successful and established the fact that a satisfactory method of removing film is available.

<u>Discharging Operations</u>.--The third discharge of enriched uranium slugs from the 100-B pile was accomplished on 18 January.

<u>100-D Area</u>.

<u>Pile Operations</u>.--The power level of the 100-D pile was gradually increased during the month reaching a new high of 230 megawatts on 27 January.

<u>200-T Area</u>.

<u>Processing Capacity</u>.--Processing of the first enriched uranium slugs from the 100-B Area has established the fact that, with only minor alterations, the production capacity of the 221 and 224 Buildings is at least equal to the rated capacity.

<u>Plutonium Yields</u>.--Incomplete data from the various processing operations indicated that the loss of plutonium was well within the limits established by the operating standards.

<u>Decontamination Factors</u>.--Incomplete data from the various processing operations also indicated that the reduction of radioactivity better than the requirements of the operating standards.

<u>200-U Area</u>.

<u>Operating Preparations</u>.--The final checking of instruments and equipment was completed during January so that the water, chemical, and other preparatory process runs could begin in February.

<u>231 Building</u>.

<u>Production Operations</u>.--The first concentrated plutonium

was received from the 224-T Building on 16 January and Isolations processing started on the following day.

were disputed!

Acceptance of Product.--Arrangements were made during January for the Army to accept delivery of plutonium in the shipping containers at the Isolations Building, 231, and relieve the contractor of all subsequent responsibility for security, handling, storage, and shipment.

300-Area.

Extrusion Operations.--The Manufacturing Division accepted from the Construction Division the facilities for extruding uranium billets into rods. Production operations were on a development basis until the latter part of the month due to difficulties with the furnace, extrusion press, and appurtenances. This work was done previously by the Revere Copper and Brass Company at Detroit until 26 November at which time operations at that location were discontinued.

1945 -- February

General.

Production Schedules.--On 19 and 20 February, conferences relative to possible schedules for delivery of specific quantities of plutonium by the earliest possible dates were held. These conferences were attended by representatives of the District Engineer, Metallurgical Project, Operations Contractor, and the Area Engineer.

Plutonium Delivery.--On 2 February, the first plutonium resulting from Hanford operations was transferred to the Area Engineer by the Contractor. On 5 February, it was transferred by the Area Engineer to the representative of the site at which further processing will be done. No mention will be made in this history of subsequent shipments.

Plutonium Specifications.--Conferences relative to plutonium specifications were held during the period 18 to 20 February with representatives of the receiving site where further processing will be performed. It was reported that the first batch of material was satisfactory and within the tentatively established limits for impurities except for silicon in the form of suspended solids, chromium, and nickel. Silicon will be materially reduced as Hanford operations proceed. Since the amounts of chromium and nickel are not harmful, the limits for these impurities were increased.

[redacted]

<u>Secondary Product Manufacture</u>.--Conferences were also held during the period 18 to 20 February relative to schedules for manufacturing the secondary Hanford product, polonium.

<u>Pile Operations</u>.--The policy was formulated of operating the piles at the rated capacity of 250 megawatts for an indefinite period until early manufacturing requirements have been met. A discussion of this policy is included as paragraph <u>8</u>., page 3 of the Monthly Operations Report for February 1945.

<u>100-B Area</u>.

<u>Pile Operations</u>.--The 100-B pile attained the rated power level of 250 megawatts on 4 February.

<u>Discharging Operations</u>.--The fourth discharge of enriched uranium slugs from the 100-B pile was accomplished on 22 February.

<u>100-D Area</u>.

<u>Pile Operations</u>.--The 100-D pile reached the rated power level of 250 megawatts on 11 February.

<u>100-F Area</u>.

<u>Acceptance</u>.--The 100-F Area was accepted by the Manufacturing Division on 10 February and final preparations started immediately.

<u>Charging of the Pile</u>.--Charging of the pile was started on 15 February and the full 2004 tubes had been charged with 35 slugs each on 19 February. Subsequently, 10 tubes were discharged of which 7 were recharged with poisoned slugs for improved power distribution and 3 were recharged temporarily with poisoned slugs to supplement the control rods until the formation of sufficient xenon-135 in the pile permitted replacing again with uranium slugs.

<u>Production Operations</u>.--After completion of all required preparatory work, production operations were started at 12:47 p.m. on 25 February. By the end of the month the pile power level had reached 175 megawatts.

<u>200-B Area</u>.

<u>Acceptance</u>.--The 200-B Area of the 200-East Area was

[redacted]

[redacted]

[redacted]

accepted by the Manufacturing Division on 11 February. With the acceptance of this area, all manufacturing facilities at the Hanford Engineer Works have been completed by the Construction Division. The Waste Storage Tanks of the abandoned 200-C Area, however, are not yet connected to the 200-B system. Because of the additional waste storage capacity it was planned to use the 200-B Area as the second Separations Unit rather than the 200-U Area.

200-T Area.

Plutonium Yields.--More complete figures made available during February indicate that the overall yield through 200-T was 74.4%. The measured loss of plutonium through the processing was about 12% leaving an unaccounted for balance of about 13%. Part of this discrepancy was due to sampling and analytical difficulties and part due to holdup of plutonium in the many parts of the system. Incomplete data for additional processing indicates that the actual yield is increasing and should approach 90%.

Separations Plant Capacity.--Studies of time cycles for the 221 and 224 Buildings processing steps indicates that all can be performed in less than 24 hours except one operation which requires 26 hours. The Production and Technical Departments were concentrating on means to reduce the time for this one operation so that full rated separations capacity can be reached and which requires that all operations be performed within 24 hours.

Waste Storage.--Calculations of 200-T waste storage capacity during February indicate that approximately 11 months storage remains available at full rated plant production capacity.

1945 -- March

100-B Area.

Discharging Operations.--The fifth discharge of enriched uranium slugs from the 100-B pile was accomplished on 8 March.

100-D Area.

Discharging Operations.--The first discharge of enriched uranium slugs from the 100-D pile was accomplished on 15 March.

100-F Area.

Pile Operations.--On 1 March, the pile power level was raised from 175 to 190 megawatts. On 6 March, the pile was taken out of service for rearrangement of poisoned tubes to permit at-

[redacted]

tainment of higher power levels. On 7 March the power was raised to 225 megawatts. On 8 March the power was raised to the rated capacity of 250 megawatts at 2:00 p.m. This level could not be sustained, however, and at 1:30 p.m. on 9 March it was reduced to 240 megawatts. There has been no change to 16 March.

[redacted]

SECTION XII

ESSENTIAL MATERIALS

[redacted]

SECTION XII

ESSENTIAL MATERIALS

The following pages of tabulations of essential materials for Hanford Engineer Works operations indicate the magnitude and diversification of the primary and auxiliary processes in the 300, 100 and 200 Areas.

[redacted]

ESTIMATED CONSUMPTION OF ESSENTIAL MATERIALS

300 AREA

MATERIAL	MONTHLY CONSUMPTION	YEARLY CONSUMPTION
Aluminum Cans	40,000	480,000
Aluminum Caps (Boss) (ea.)	30,000	360,000
Argon Gas 99.6 (Cyl.)	500	6,000
" " 99.8 (Cyl.)	50	600
Aluminum Silicon	33,000	396,000
Copper	2,500	30,000
Perm-A-Clor (Degreasing Solvent) (Gal.)	250	3,000
Duponal (Degreasing Solvent)	60	720
Hydrofluoric Acid 60%	875	10,500
Nitric Acid	17,000	204,000
Phosphoric Acid 85%	1,360	16,320
Sodium Hydroxide	15,000	180,000
Tin	17,000	204,000
Potassium Chloride	900	10,800
Steel Sleeves	1,600	19,200
Barium Chloride	1,500	18,000
Sodium Nitrate	3,500	42,000
Aluminum	2,200	26,400
Sodium Chloride	600	7,200
Tetra Sodium Phosphate	60	720
Hydrofluorosilicic Acid	60	720

All items unless otherwise specified are in pounds

DECLASSIFIED WITH DELETIONS

[redacted]

ESTIMATED CONSUMPTION OF ESSENTIAL MATERIALS

POWER DEPARTMENT 100 AREA

MATERIAL	AREA	MONTHLY CONSUMPTION	YEARLY CONSUMPTION	TOTAL CONSUMPTION
Sodium Hexametaphosphate (Calgon)	100 B	150	1,800	
	100 D	150	1,800	
	100 F	150	1,800	5,400
Chlorine (Unit - tons)	100 B	12,000	144,000	
	100 D	12,000	144,000	
	100 F	12,000	144,000	432,000
Disodium Phosphate	100 B	500	6,000	
	100 D	500	6,000	
	100 F	500	6,000	18,000
Ferric Sulphate	100 B	300,000	3,600,000	
	100 D	300,000	3,600,000	
	100 F	300,000	3,600,000	10,800,000
Lime	100 B	80,000	960,000	
	100 D	80,000	960,000	
	100 F	80,000	960,000	2,880,000
Sodium Sulphite	100 B	500	6,000	
	100 D	500	6,000	
	100 F	500	6,000	18,000
Salt (Bulk)	100 B	30,000	360,000	
	100 D	30,000	360,000	
	100 F	30,000	360,000	1,080,000
Sodium Silicate	100 B	300,000	3,600,000	
	100 D	300,000	3,600,000	
	100 F	300,000	3,600,000	10,800,000
Coal (unit - tons)	100 B	6,450	77,400	
	100 D	6,750	81,000	
	100 F	6,400	76,800	234,200
Sodium Dichromate	100 B	30,000	360,000	
	100 D	25,000	300,000	
	100 F	25,000	300,000	960,000

All units unless otherwise specified are in pounds

DECLASSIFIED WITH DELETIONS

[redacted]

ESTIMATED CONSUMPTION OF ESSENTIAL MATERIALS

100 AREA

MATERIAL	AREA	* MONTHLY CONSUMPTION	* YEARLY CONSUMPTION	* TOTAL CONSUMPTION
Carbon Dioxide (50# cyl.)	100 B	50	600	
	100 D	40	480	
	100 F	40	480	1,760
Helium (cu. ft.)	100 B	115,000	1,380,000	
	100 D	55,000	660,000	
	100 F	55,000	660,000	2,700,000
Aluminum Dummies (ea.)	All Areas	8,500	102,000	102,000

* All units unless otherwise specified are in pounds.

[redacted]

DECLASSIFIED WITH DELETIONS

1101590

[redacted]

ESTIMATED CONSUMPTION OF ESSENTIAL MATERIALS

200 AREA

MATERIAL	MONTHLY CONSUMPTION	YEARLY CONSUMPTION
Anhydrous Hydrogen Fluoride	26,550	618,600
Nitric Acid (tons)	409	5,148
Phosphoric Acid	422,640	5,071,680
Sodium Carbonate	399,600	4,795,200
Sodium Hydroxide	1,121,400	13,366,800
Sulphuric Acid	84,150	1,009,800
Ammonium Silicofluoride	39,780	477,360
Ammonium Sulphate	99	1,188
Bismuth Subnitrate	20,970	251,640
Ceric Ammonium Nitrate	720	8,640
Ferrous Ammonium Sulphate	70,200	842,400
Hydrogen Peroxide	4,410	52,920
Lanthanum Ammonium Nitrate	2,880	34,560
Oxalic Acid	19,980	239,760
Potassium Carbonate	Process alteration eliminated use.	
Potassium Hydroxide	36,360	436,320
Potassium Permanganate	2,880	34,560
Sodium Bismuthate	4,770	57,240
Sodium Dichromate	2,430	29,160
Sodium Nitrate	30,060	360,720
Sodium Nitrite	15,930	191,170
Super Cel Hyflo	90	1,080
Zirconium Carbonate Gel	1,530	18,360

All items unless otherwise specified are in pounds.

[redacted]

[redacted]

ESTIMATED CONSUMPTION OF ESSENTIAL MATERIALS

POWER DEPT. ALL AREAS

MATERIAL	AREA	MONTHLY CONSUMPTION	YEARLY CONSUMPTION	TOTAL CONSUMPTION
Sodium Hexametaphosphate	100B	150	1,800	
	100D	150	1,800	
	100F	150	1,800	5,400
Chlorine (150# Cyls.)	300	150	1,800	1,800
	700	150	1,800	1,800
	1100	8,700	104,800	104,800
Chlorine (1 Ton)	100B	12,000	144,000	
	100D	12,000	144,000	
	100F	12,000	144,000	432,000
Disodium Phosphate	100B	500	6,000	
	100D	500	6,000	
	100F	500	6,000	18,000
	200W	500	6,000	6,000
Ferric Sulphate	100B	300,000	3,600,000	
	100D	300,000	3,600,000	
	100F	300,000	3,600,000	10,800,000
Lime	100B	80,000	960,000	
	100D	80,000	960,000	
	100F	80,000	960,000	2,880,000
Sodium Sulphite	100B	500	6,000	
	100D	500	6,000	
	100F	500	6,000	18,000
Salt (Bulk)	100B	30,000	360,000	
	100D	30,000	360,000	
	100F	30,000	360,000	1,080,000
	200E	10,000	120,000	
	200W	15,000	180,000	300,000
Salt (Bags)	700	6,000	72,000	72,000
	300	3,000	36,000	36,000
Sodium Silicate	100B	300,000	3,600,000	
	100D	300,000	3,600,000	
	100F	300,000	3,600,000	10,800,000

DECLASSIFIED WITH DELETIONS

All units unless othe[redacted] specified are in pounds.

1101592

[redacted]

ESTIMATED CONSUMPTION OF ESSENTIAL MATERIALS

POWER DEPT. ALL AREAS (Cont'd.)

MATERIAL	AREA	MONTHLY CONSUMPTION	YEARLY CONSUMPTION	TOTAL CONSUMPTION
Coal (Tons)	100B	6,450	77,400	
	100D	6,750	81,000	
	100F	6,400	76,800	234,200
	200E	1,000	12,000	
	200W	2,750	33,000	45,000
	300	400	4,800	4,800
	700	1,000	12,000	12,000

All units unless otherwise specified are in pounds.

[redacted]

ESTIMATED CONSUMPTION OF ESSENTIAL MATERIALS

POWER DEPARTMENT 200 AREA

MATERIAL	AREA	MONTHLY CONSUMPTION	YEARLY CONSUMPTION	TOTAL CONSUMPTION
Disodium Phosphate	200 W	500	6,000	6,000
Salt (Bulk)	200 E	10,000	120,000	
	200 W	15,000	180,000	180,000
Coal	200 E	1,000	12,000	
	200 W	2,750	23,000	45,000 ?

POWER DEPARTMENT 300 AREA

Chlorine		150	1,800	1,800
Salt (Bags)		3,000	36,000	36,000
Coal		400	4,800	4,800

RICHLAND ADMINISTRATIVE AREA
POWER DEPARTMENT 700 AREA

Chlorine		150	1,800	1,800
Salt (Bags)		6,000	72,000	72,000
Coal		1,000	12,000	12,000

POWER DEPARTMENT 1100 AREA - RICHLAND VILLAGE

Chlorine		8,700	104,800	104,800

DECLASSIFIED WITH DELETIONS

All units unless other[redacted] specified are in pounds.

SECTION XIII

RICHLAND VILLAGE

[redacted]

SECTION XIII

RICHLAND VILLAGE

General.--The conditions leading to the selection, design, and construction of the Richland Village and the facilities included to care for operating personnel and families are described in the historical accounts of the design and construction of the Hanford Engineer Works. In general, adequate facilities have been furnished to provide for the essential minimum requirements of a population of about 16,000 with respect to food, housing, clothing, health, schools, churches, recreation, transportation, and police and fire protection.

Population.--The most recent census indicates that the population of Richland as of 31 March 1945 is 15,401. This is distributed as follows:

Total number of women in dormitories	672
Total number of men in dormitories	377
Other adults over age 18	8883
Total children ages 14 to 18	676
Total children ages 6 to 14	2020
Total children under age 6	2773

Village Management.--Evaluation of all the factors entering into the management of the Richland Village indicated the desirability of placing this responsibility with the Contractor. This has proved advantageous to the Government through the elimination of duplication of effort in many instances by combining a considerable number of village operations requirements with existing plant management and services. As with plant operation, the Richland Village is under the general administrative and supervisory control of the Government as represented by the Corps of Engineers of the United States Army.

Normal Services.--Normal services for the entire village are performed by the departmental organization of the Contractor. Included in such normal services are the following: maintenance of buildings, houses, facilities, roads, and walks; furnishing of electricity, water, fuel and heat; collection and disposal of sewage, garbage, and ashes; furnishing of police, fire, and sanitary protection; billing, collecting, leasing, and accounting relative to rentals for housing and commercial establishments. The cost of all such normal services is included in the rental agreements established.

Housing.--All houses in Richland have been used to capacity as rapidly as they were completed. Present indications are that the peak population will be reached in the spring of 1945 with a considerable drop in population during the summer resulting from completion of the last phases of construction and from a reduction in operating forces as operations are gradually stabilized.

[redacted]

A total of 4304 houses were built comprising 2500 permanent and 1804 prefabricated temporary dwellings. Of the latter, 500 were included to assure adequate housing of key personnel during the unusually prolonged peak period when both construction and operations forces created extremely heavy demands. 35 existing houses from the original Richland Village are occupied.

Health.--The Medical Department is organized to provide a close check on business establishments and schools to assure the highest possible sanitary standards. Periodic inspections of all food dispensing establishments are made in schools and business houses with reports forwarded to those Department Heads who are responsible for the maintenance of sanitary facilities. Copies of the reports are also sent to the respective schools and business operators. Rechecks are made to determine that recommendations of health inspectors are carried out.

Medical, Hospital, and Dental Service.--Medical, hospital, and dental services are available to all residents of the village at reasonable cost at the hospital located in Richland. While this hospital and medical center was provided to take care of the industrial requirements of the plant, adequate facilities were included to serve the essential needs of the village. It is indicated that the revenue from these public services, as of March 1945, will be approximately $380,000 per year.

Schools.--The schools are operated entirely under the laws of the State of Washington and under the jurisdiction of the County Superintendent of Schools. Because of the great expansion of school population, however, it has been necessary to rely heavily on Federal funds made available under the Lanham Act.

For the school year 1944-45, State and County funds in the amount of $90,000 were available to the Richland Schools. In addition, it was necessary to use $278,292 of Lanham Act funds for school facilities and $47,224 of Lanham Act funds for the Nursery. The Nursery was established to care for children of mothers who are working for the Government or for the Contractor.

Representatives of the Government and the Contractor attend each meeting of the school board in order to keep in close touch with the operation of the schools.

Churches.--Nearly all religious denominations are represented in Richland. Fifteen of the Protestant groups are combined in the Council of Churches and Christian Education for Washington and Northern Idaho.

Two church buildings were constructed: one Catholic and the other for the United Protestant Branch of the Council of Churches. Two denominations of the Protestant groups, Episcopalian and Lutheran, are making use of old church buildings which were in the original town of Richland. School auditoriums are also made available for certain denominations which are not represented in the Council of Churches.

[redacted]

[redacted]

Recreation.--With the completion of the Recreation Hall, and with numerous groups organized for various special activities, facilities for adult recreation in Richland are believed to be adequate. Recreation for teen age children, however, has presented a serious problem. Federal funds under the Lanham Act have not been available for a recreation program. It has been necessary, therefore, that various Richland civic organizations and the schools combine and coordinate their efforts to provide essential recreation for the teen age groups.

Transportation.--Scheduled, routed, and Government owned bus transportation is provided under the direction of the Transportation Officer throughout the village and to the plant areas only for the essential requirements of project employees. Bus fare is five cents per ride with free transfers to connecting local buses. This fare was established on the basis of that charged in other communities of similar size in the State of Washington. Projecting the bus service for March 1945 indicates that approximately 4,000,000 passengers will use the buses per year providing a total revenue of about $200,000.

Police and Fire Protection.--Police and Fire Departments are a part of the departmental organization of the Contractor. The police are deputized by the Sheriff and are also auxiliary Military Police.

Special attention has been given to fire protection and the record to date has been excellent.

Commercial Establishments.--All normal essential living requirements such as food, drugs, clothing, miscellaneous supplies, entertainment, and similar needs are provided by commercial establishments selected through competitive bidding. This arrangement has proved to be very satisfactory as indicated by the freedom from complaints by the residents of the village. The commercial operators maintain as complete stocks of quality merchandise as conditions permit. Prices are checked and maintained at the prevailing levels of those in the nearest towns. O.P.A. regulations are the controlling factor in all prices where they apply.

In evaluating the bids of prospective commercial operators, consideration has been given to past successful experience, financial responsibility, and procurement capacity under existing difficult conditions. Only two of the original Richland business operators were considered as meeting these requirements and both declined to enter bids.

Commercial Rentals.--Considerable thought was given to the establishment of a basis for rental of facilities to the various commercial operators. Uncertainties in the volume of business and the duration of operation introduced difficulties in arriving at equitable arrangements. Consequently, it was decided that rental would be determined as a percentage of gross income from the business and that each prospective commercial operator would include his percentage as a part of his bid to be evaluated in combination with the other considerations in selecting the successful bidder. This method has been followed in the great majority of cases and has proved to be advantageous to the Government. Present rental revenues indicate a probably rental return of about $250,000 per year.

[redacted]

Housing Rentals.--On the following page is a tabulation of the types of housing provided for residents of the village, the unit costs of construction, and the established rental prices furnished and unfurnished.

Existing Buildings.--An existing building was made available to the County Auditor for the issue of vehicle licenses to village residents, and for the conducting of other local business of the office. Othes existing buildings have been made available to the local Ration Board, the United States Employment Service, and to Villagers, Inc. The latter body is a civic non-profit organization which sponsors a weekly newspaper, a circulating library, and a wide variety of recreation and social activities.

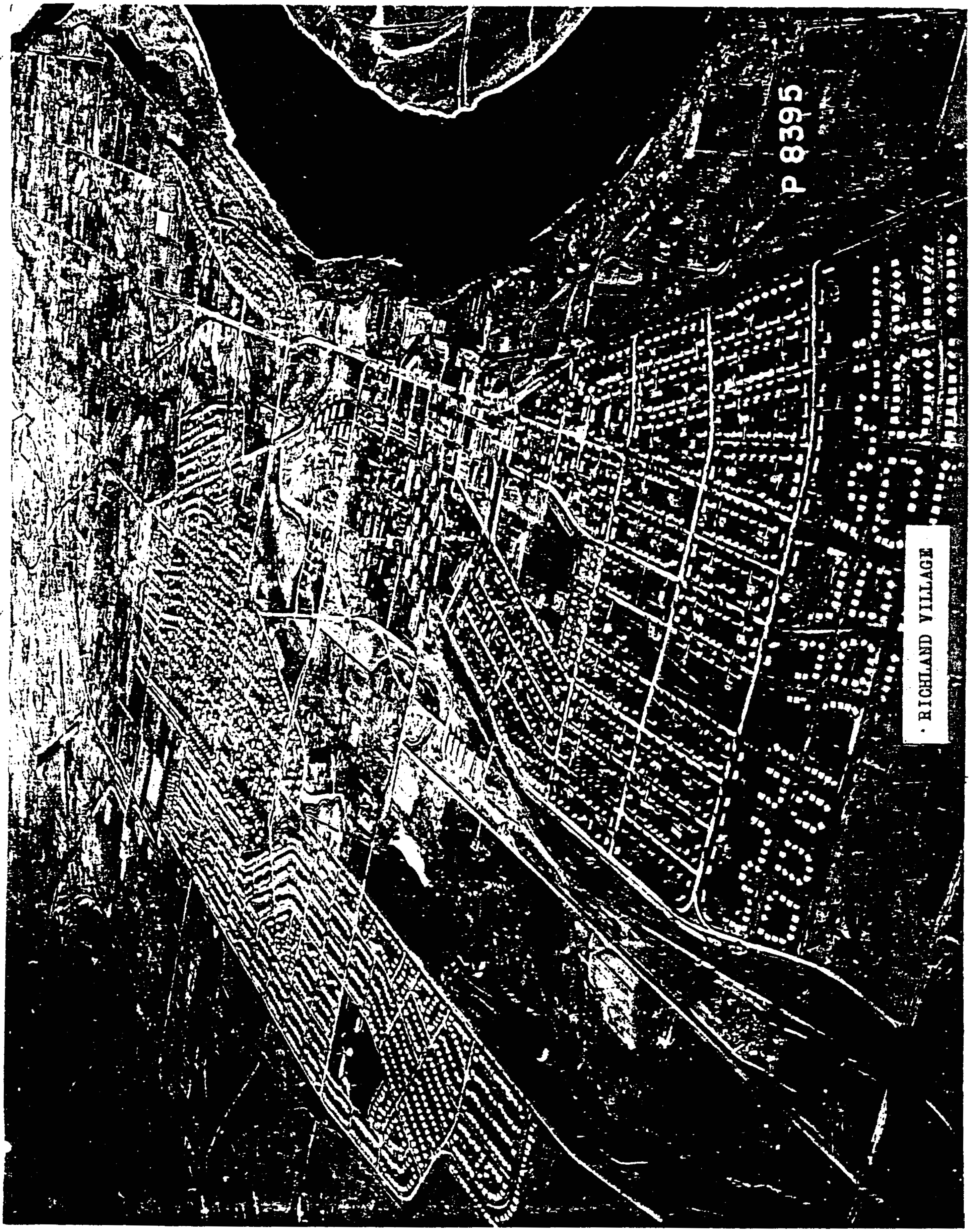
[redacted]

	Number Units	Number Bedrooms	Type	Unit Cost*	Monthly Rent (Includes Utilities) Unfurnished	Monthly Rent (Includes Utilities) Furnished
Regular						
A	816	3	2 Story - Duplex	$3,950.00	$37.50	$47.00
B	1040	2	1 Story - Duplex	3,770.00	33.50	42.00
D	8	4	2 Story - Single	6,025.00	67.50	84.50
E	84	3	1 Story - Single	5,325.00	62.50	78.00
F	250	3	2 Story - Single	4,820.00	50.00	62.50
G	8	4	2 Story - Single	6,030.00	67.50	84.50
H	250	3	1 Story - Single	4,700.00	50.00	62.50
L	44	4	2 Story - Single	6,580.00	62.50	80.00
Sub-Total	2500					
Prefabs						
A	402	1	1 Story - Single	2,199.00		27.50
B	802 **	2	1 Story - Single	3,088.00		35.00
C	600	3	1 Story - Single	3,895.00		42.50
Sub-Total	1804 **					
Grand Total	4304 **					

* Includes only modifications and revisions which have been approved and processed as of 27 March 1945. These unit costs probably will be revised upward by a few dollars when final costs are determined.

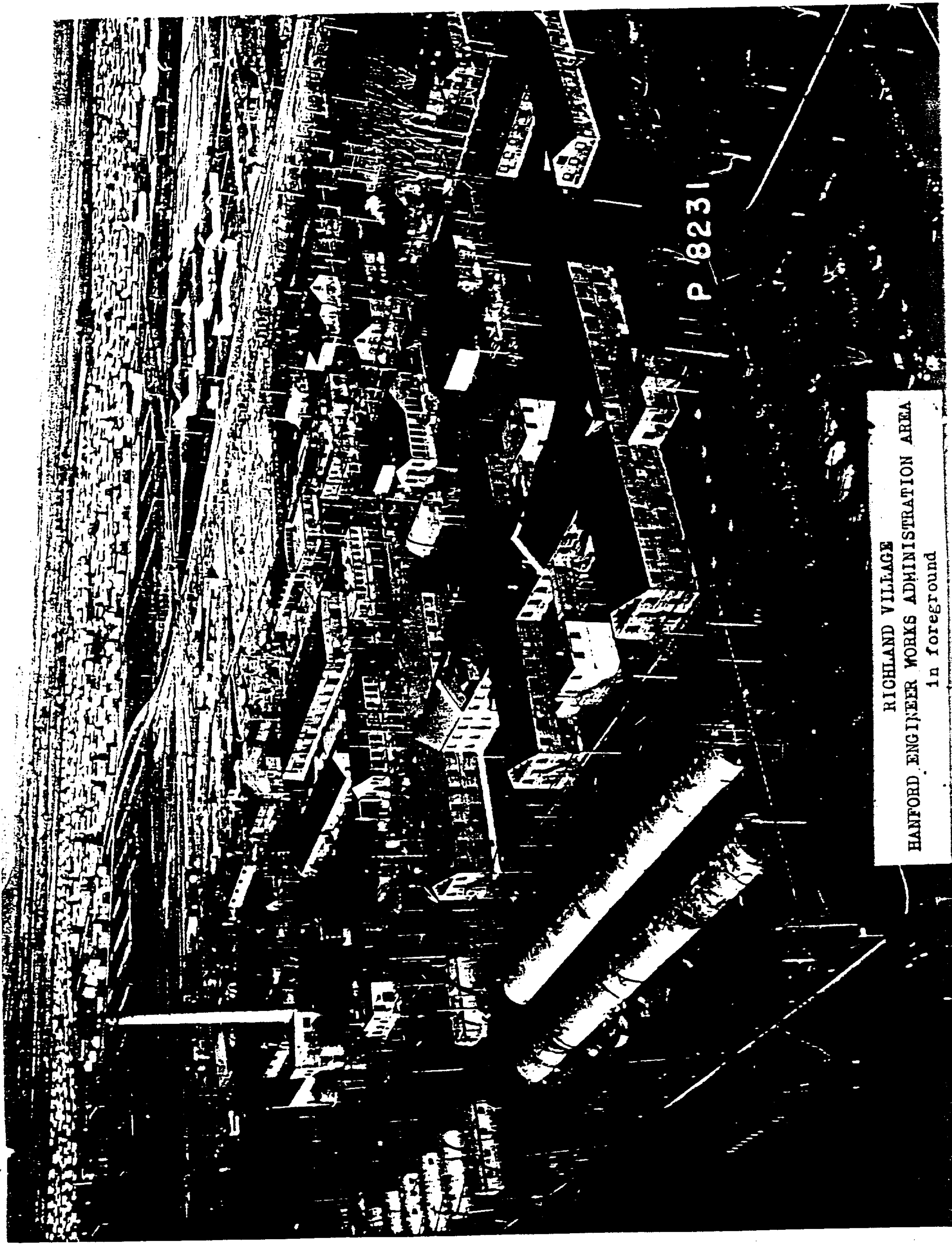
** Includes one house which was destroyed by fire after acceptance for payment, but before acceptance for occupancy.

[redacted]
DECLASSIFIED WITH DELETIONS
[redacted]



DECLASSIFIED WITH DELETIONS

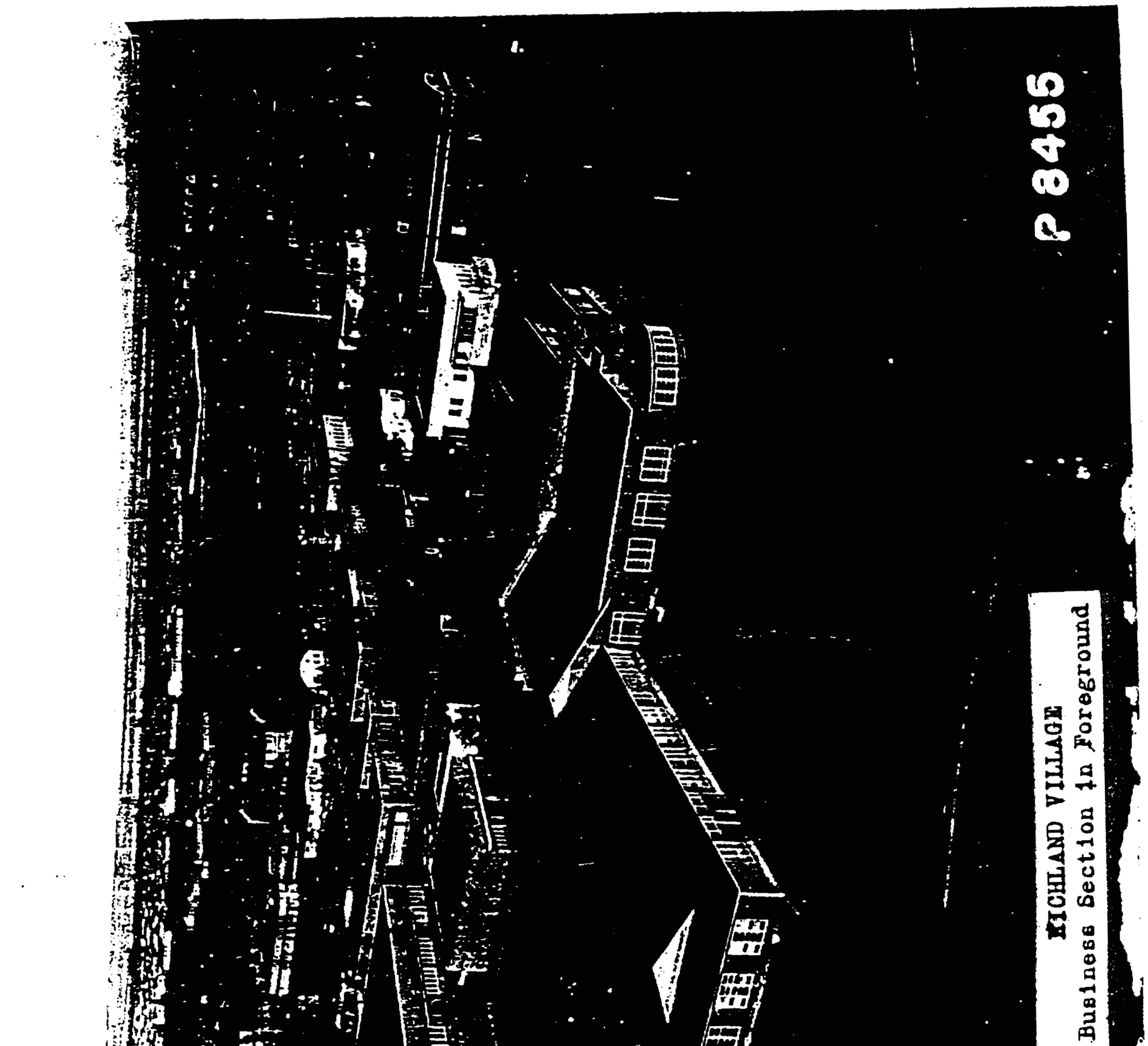
1101601



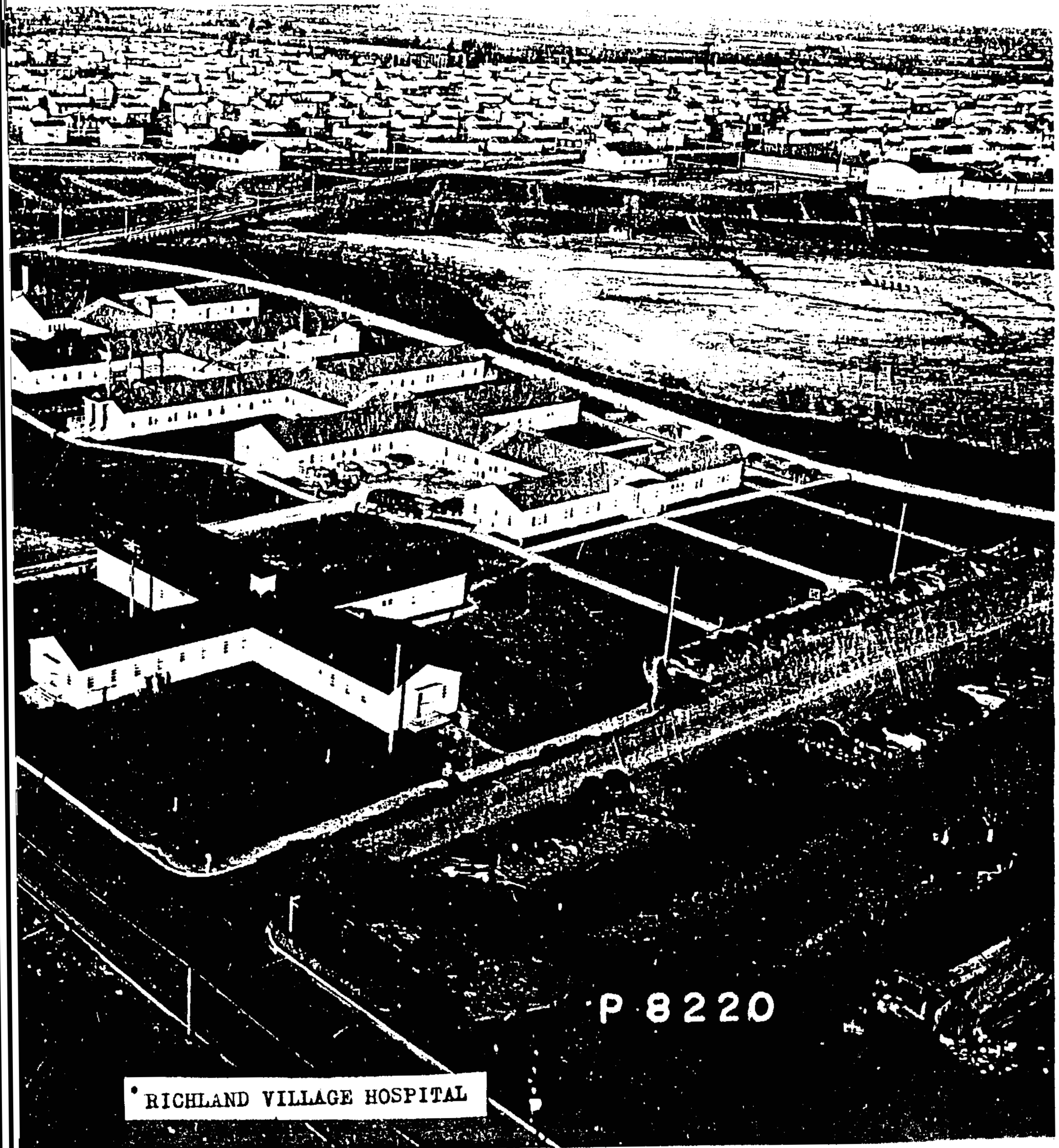
RICHLAND VILLAGE
HANFORD ENGINEER WORKS ADMINISTRATION AREA
in foreground

DECLASSIFIED WITH DELETIONS

1101602



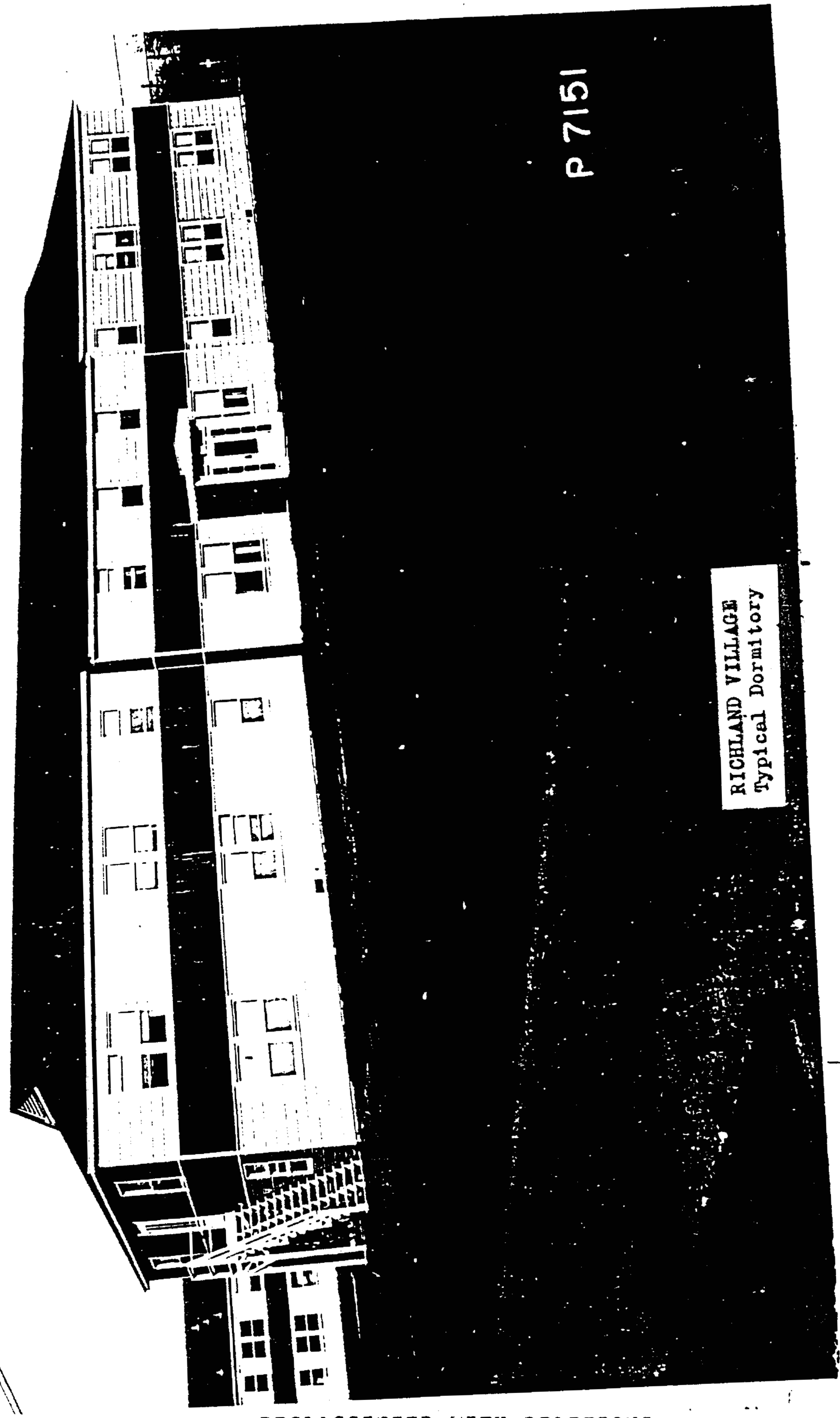
1101603


P 8220
RICHLAND VILLAGE HOSPITAL

RICHLAND VILLAGE TRANSIENT QUARTERS

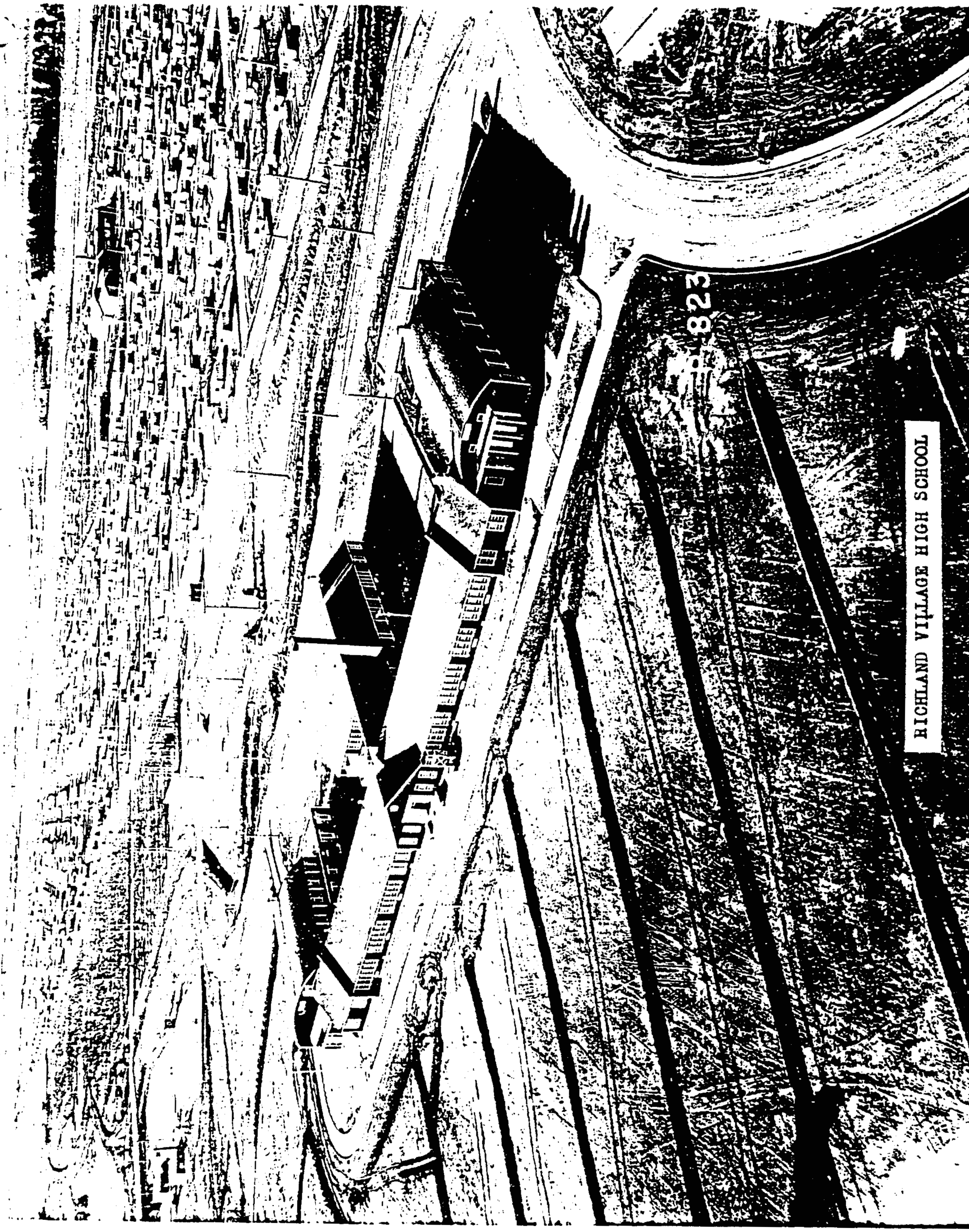
DECLASSIFIED WITH DELETIONS

1101605



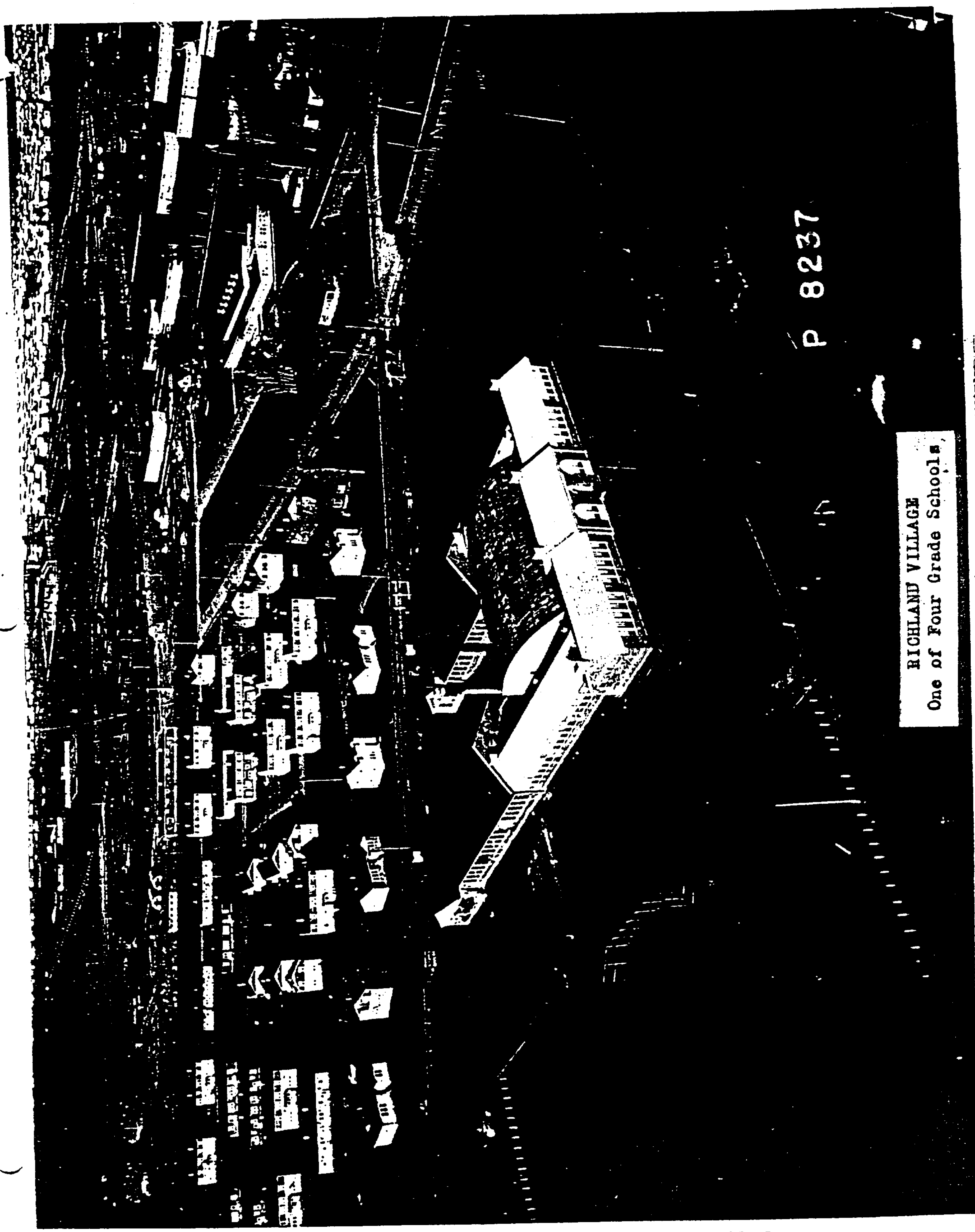
DECLASSIFIED WITH DELETIONS

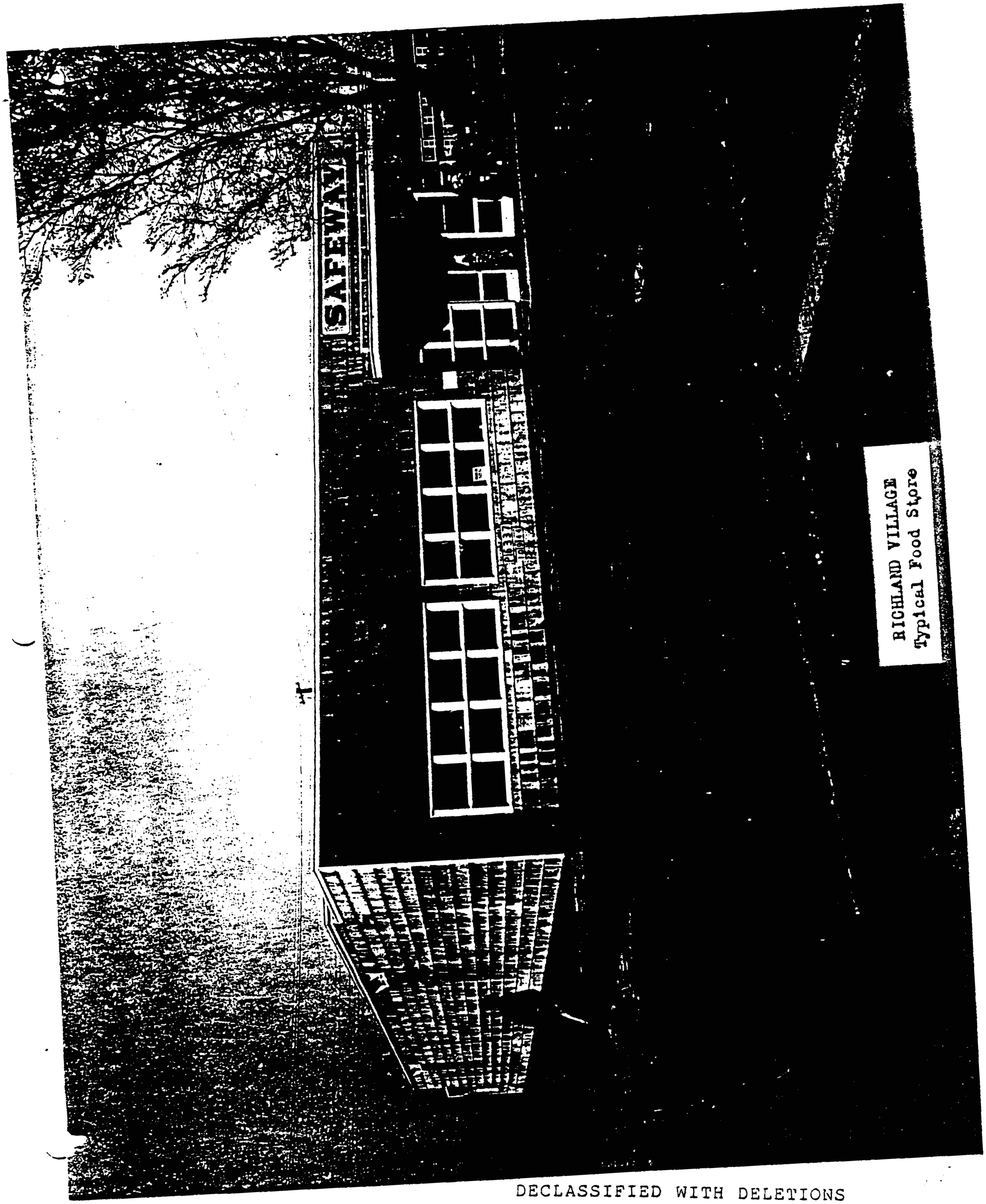
1101606



DECLASSIFIED WITH DELETIONS

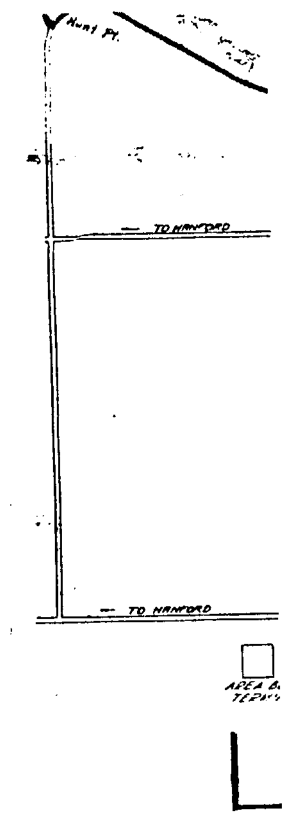
1101607


P 8237
RICHLAND VILLAGE
One of Four Grade Schools



DECLASSIFIED WITH DELETIONS

1101609



LEGEND

AREA SHUTTL
AUTHORIZED !

114

1101610

[redacted]

SECTION XIII

RICHLAND VILLAGE

At the time the town of Richland was taken over by the government, in April 1943, it was a small farm community of about 350 population. It had the usual small mercantile facilities needed to serve such a community.

In order to house the thousands of families required for construction and operation of the Hanford plant, it was necessary to build an entire new town from the ground up. Acting under an Order of Possession granted by the Federal Court, under the War Powers Act, the government required that residents vacate an area of approximately two square miles, including the town of Richland. Various houses and a few business buildings thus made available were occupied temporarily by construction personnel, who paid rent to the government for all dwellings.

Construction of houses started on April 29, 1943. The first house was occupied on July 28, 1943. A total of 4300 housing units were constructed. This includes 1800 prefabricated one, two and three bedroom houses. All of the prefabricated houses were completely furnished, and about one-half of the remaining units were furnished. As of 28 February 1945, all houses are occupied or in process of assignment.

To supply the needs of the community, the minimum mercantile requirements were determined, and facility buildings were constructed to meet these needs. These facilities are listed on the following page.

As these buildings were completed, invitations to bid for operation of each facility were circulated to potential operators. Careful financial investigations were made on each bidder, and the business experience of the bidder and his proposed key personnel was checked.

Bids were submitted on a basis of payment of a percentage of monthly gross income as the rental payment. The method followed for selection of operators resulted in bringing excellent merchandising organizations to the town, with rentals from the business buildings totalling approximately $250,000 per year.

There were inquiries and applications by operators of various other types of businesses, but these were turned down. These businesses included bakeries, jewellers, gift shops and others that are desirable in a community of this size, but the fact remained that they were not essential. Therefore, no buildings were provided for them.

The volume of business done by each of the facilities in the town has been ample evidence of the necessity for their being set up in Richland. The town is isolated from large marketing centers, Pasco and Kennewick being the closest. The population of Richland, however, is greater than Pasco and Kennewick combined.

[redacted]

Cla

these emergency tanks through the pile. This assures an adequate flow of water through the pile for a short period while steps are being taken to reestablish the normal flow.

Power Supply

Electric.--The primary power requirements for water pumping and other services are supplied by a 230,000 volt electrical transmission system connected to the Bonneville and Grand Coulee system. The total connected load of the three 100 Areas is 84,850 kilowatts of which more than 60,000 kilowatts result from motor driven water pumps.

Steam.--A boiler plant is provided in each 100 Area to furnish an independent source of power in the event of failure of the main electric supply. However, the amount of steam generating capacity and number of steam turbines do not duplicate the electric power capacity; they are limited to those requirements where less than complete dependability would be disastrous. The combined capacity of the steam generating equipment of the three pile areas is 1,200,000 pounds per hour or about that required to produce electric power at the rate of 120,000 kilowatts.

[redacted]

pld

advantageous to transfer operations from the massive shielding of Building 221 into a more normal type of structure.

There are six working areas, or cells, in the Concentration Building. Four of the cells are identical and contain the same standard units as in the Cell Building. No provisions are made for remote maintenance although operation and control of process steps is accomplished from the central operating panels. A fifth cell contains equipment and vessels for transferring process solutions between buildings 221 and 224. The sixth cell contains the equipment for the final plutonium concentration before transfer to Building 231.

<u>231 -- Isolation Building</u>.--Upon arrival at the Isolations Building, the plutonium which was originally associated with a ton of uranium in the form of slugs has been concentrated to an 8-gallon solution. Consequently, the equipment for final preparation is greatly reduced in size from that required in earlier processing.

Vaults are provided in the Isolations Building for receiving process solution from the 224 Building and for storing finished plutonium until transferred to the Army. Five cells are provided in which the processing steps are performed in stainless steel vessels behind glass. The remainder of the building houses laboratories, offices, ventilation equipment, stockrooms, and other necessary facilities.

Throughout the Isolations Building cleanliness and safety are emphasized because of the extreme toxicity of plutonium. Every conceivable precaution is taken to avoid personal contact with the pro-

[redacted]

DECLASSIFIED WITH DELETIONS

[redacted]

1101613

[redacted] *ela*

rate than they were being created and the earlier events were substantially repeated.

There were numerous possible causes of the parasitic neutron absorption but there was no immediate concrete evidence which adequately explained any of the possibilities. In order to evaluate the various possibilities, the pile was again started and the power held at about 2.5 megawatts for 6 hours followed by a longer run at 1.7 megawatts. It was determined that continuous operation could be maintained at a power of about 3 megawatts with the pile charged with 901 tubes. From the data collected at this time, the physicists made substantially the following analysis and predictions before 2 October and all of which have proved to be remarkably accurate:

(1) The parasitic neutron absorption resulted from the formation of xenon-135 as a fission by-product element. With the time expressed as half-lives (the time required for one half of the amount present to decay to the next element), this is part of the decay chain of: tellurium (15 minutes) to iodine (6.6 hour) to xenon (9.4 hour) to cesium (25 year) to stable barium. In this chain, only xenon has a high capacity for absorbing neutrons and the xenon capacity is about 50 times greater than that of any previously known element.

(2) It was predicted that the pile would be able to operate at the following power levels when the indicated number of tubes were charged with uranium slugs: 14 megawatts at 1000 tubes; 59 megawatts at 1300 tubes; 94 megawatts at 1500 tubes; and 216 megawatts at 2004 tubes.

(3) It was predicted that higher power levels than those above would gradually be attained as boron and other impurities with high neutron absorption characteristics were gradually transmuted during pile operation to less objectionable elements; and as plutonium formed in the pile and some of it fissioned to produce additional neutrons. This prediction was based on knowledge of some other fission by-product elements which would absorb neutrons and thus retard the pile reaction.

(4) It was also pointed out that additional power could be obtained by placing up to 38 instead of the planned number of 32 uranium slugs in each tube of the pile; by making certain that a minimum of aluminum is present at the ends of the slugs to be charged into the other two piles; by carefully zoning slugs in the piles so that the heavier slugs are in the central portion.

[redacted]

[redacted]

j-l-o

[redacted]

In the early analyses of the possibilities of the Hanford process for the manufacture of plutonium, it was recognized that serious neutron absorption might occur among the fission by-product elements. In all subsequent studies, effort was concentrated on evaluating the various possibilities with the greatest accuracy permissible with the then undeveloped state of knowledge. Thus, even though the effect of xenon-135 was unknown, the possibility of the formation of some element of similar properties was foreseen. If the neutron absorption capacity of xenon-135 were greater than it is, it appears reasonable to believe that it would have been discovered during the operation of the experimental piles at Argonne and the Clinton Laboratories. In that event, adequate provisions would have been made in the Hanford piles to counteract it on the basis of accurate knowledge.

Through what has subsequently proved to have been good judgment, two very important factors were incorporated in the original design of the Hanford piles which have permitted the charging of sufficient uranium slugs to provide a source of neutrons adequate for saturation of the xenon poisoning and operation of the piles at, or above, rated power level. The first is the fact that the piles are constructed with 2004 cooling tubes rather than the 1500 which were indicated theoretically as being adequate. The second is the fact that 9 control rods were designed into each pile instead of about three which were indicated as being required.

The additional control rod capacity is essential in absorbing sufficient neutrons to hold the pile safely when starting for the first time or after a shutdown when the xenon has decayed to less absorptive elements. On these occasions, the piles have a far greater ability to accelerate in power than was ever contemplated and are consequently much more hazardous. However, during normal operation the excess neutron producing capacity is absorbed by the xenon and operations are much less hazardous than had been predicted.

Film Formation and Corrosion.--Concurrently with the design and construction of the Hanford Engineer Works a great deal of work was done in developing a means of limiting film formation and corrosion with respect to the pile cooling surfaces and for periodically removing any film which might form. A part of these investigations were conducted by the Metallurgical Project and the remainder by the Technical Division at Hanford. Without the successful attainment of these objectives, the Hanford piles could not operate.

As a result of this work, practicable operating standards were established prior to the beginning of operations for the performance of the various water treatment processes and for the final chemical conditioning of the process water through the addition of sodium dichromate and sodium silicate. Positive methods were also established for re-

[redacted]

[redacted]

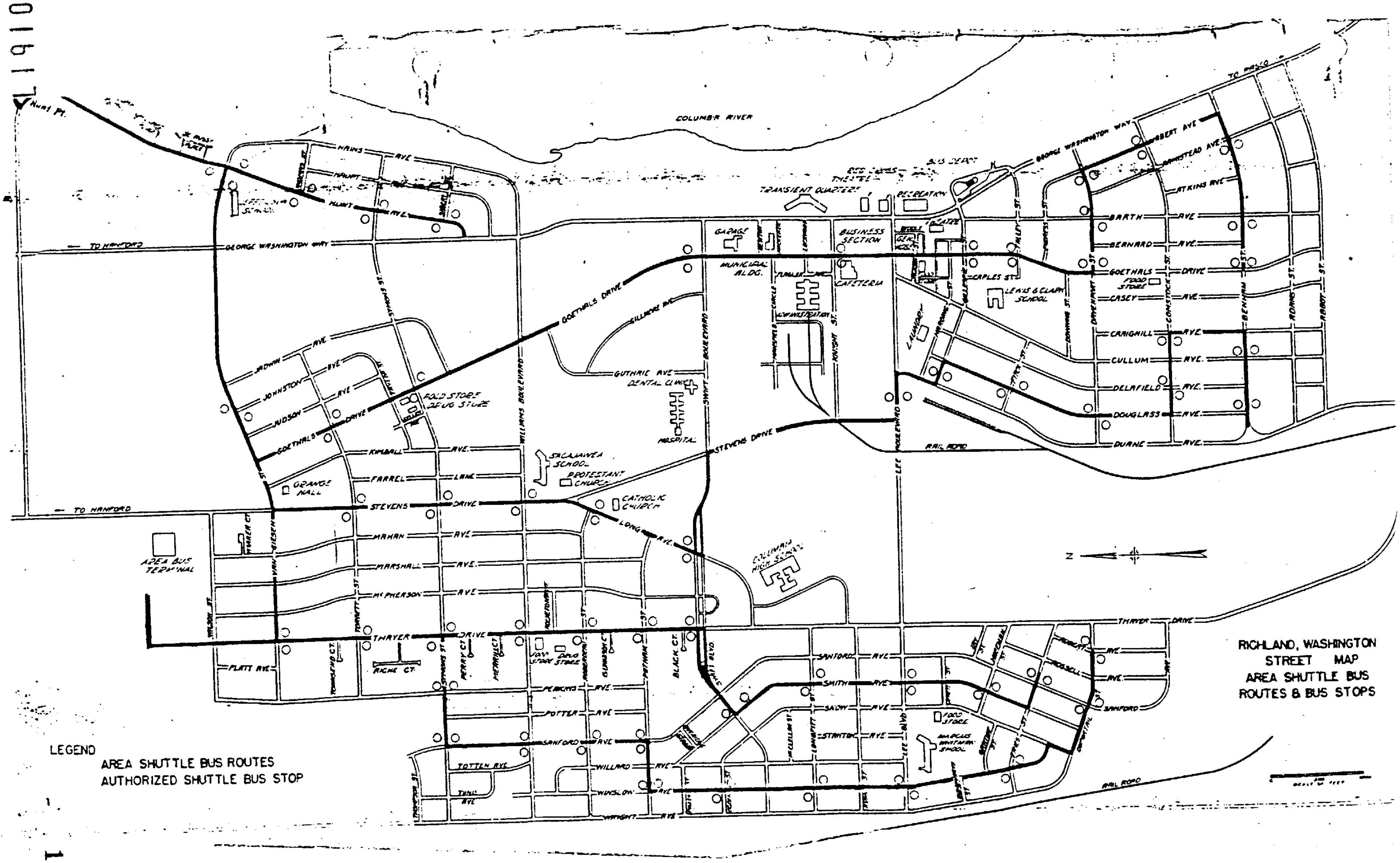
RICHLAND VILLAGE

SERVICES AND FACILITIES

Item	Quantity
High School	1
Grade Schools	4
Churches	3
Grocery Stores	4
Drug Stores	3
Hotel (Transient Quarters)	1
Theaters	2
Red Cross Headquarters	1
Bus Depot	1
Service Stations (Automotive)	4
Bank	1
Post Office	1
Garage (Automotive Repairs)	1
Fire Stations	2
Recreation Building	1
Hanford Engineer Works Administration Area	1
Cafeteria	1
Hardware Store	1
Optical Shop	1
Western Union	1
Railway Express	1
Barber Shop	1
Beauty Shop	1
General Merchandise	1
Men's Furnishings	1
Women's Apparel	1
Shoe Store	1
Shoe Repair Shop	1
Hospital and Medical Center	1
Laundry	1
Milk Store	1
Nursery (Children)	1

[redacted]

DECLASSIFIED WITH DELETIONS



RICHLAND, WASHINGTON
STREET MAP
AREA SHUTTLE BUS
ROUTES & BUS STOPS

LEGEND
AREA SHUTTLE BUS ROUTES
AUTHORIZED SHUTTLE BUS STOP

[redacted]

SECTION XIII

RICHLAND VILLAGE

At the time the town of Richland was taken over by the government, in April 1943, it was a small farm community of about 350 population. It had the usual small mercantile facilities needed to serve such a community.

In order to house the thousands of families required for construction and operation of the Hanford plant, it was necessary to build an entire new town from the ground up. Acting under an Order of Possession granted by the Federal Court, under the War Powers Act, the government required that residents vacate an area of approximately two square miles, including the town of Richland. Various houses and a few business buildings thus made available were occupied temporarily by construction personnel, who paid rent to the government for all dwellings.

Construction of houses started on April 29, 1943. The first house was occupied on July 28, 1943. A total of 4300 housing units were constructed. This includes 1800 prefabricated one, two and three bedroom houses. All of the prefabricated houses were completely furnished, and about one-half of the remaining units were furnished. As of 28 February 1945, all houses are occupied or in process of assignment.

To supply the needs of the community, the minimum mercantile requirements were determined, and facility buildings were constructed to meet these needs. These facilities are listed on the following page.

As these buildings were completed, invitations to bid for operation of each facility were circulated to potential operators. Careful financial investigations were made on each bidder, and the business experience of the bidder and his proposed key personnel was checked.

Bids were submitted on a basis of payment of a percentage of monthly gross income as the rental payment. The method followed for selection of operators resulted in bringing excellent merchandising organizations to the town, with rentals from the business buildings totalling approximately $250,000 per year.

There were inquiries and applications by operators of various other types of businesses, but these were turned down. These businesses included bakeries, jewellers, gift shops and others that are desirable in a community of this size, but the fact remained that they were not essential. Therefore, no buildings were provided for them.

The volume of business done by each of the facilities in the town has been ample evidence of the necessity for their being set up in Richland. The town is isolated from large marketing centers, Pasco and Kennewick being the closest. The population of Richland, however, is greater than Pasco and Kennewick combined.

[redacted]

Clu

these emergency tanks through the pile. This assures an adequate flow of water through the pile for a short period while steps are being taken to reestablish the normal flow.

Power Supply

Electric.--The primary power requirements for water pumping and other services are supplied by a 230,000 volt electrical transmission system connected to the Bonneville and Grand Coulee system. The total connected load of the three 100 Areas is 84,850 kilowatts of which more than 60,000 kilowatts result from motor driven water pumps.

Steam.--A boiler plant is provided in each 100 Area to furnish an independent source of power in the event of failure of the main electric supply. However, the amount of steam generating capacity and number of steam turbines do not duplicate the electric power capacity; they are limited to those requirements where less than complete dependability would be disastrous. The combined capacity of the steam generating equipment of the three pile areas is 1,200,000 pounds per hour or about that required to produce electric power at the rate of 120,000 kilowatts.

[redacted] fld

advantageous to transfer operations from the massive shielding of Building 221 into a more normal type of structure.

There are six working areas, or cells, in the Concentration Building. Four of the cells are identical and contain the same standard units as in the Cell Building. No provisions are made for remote maintenance although operation and control of process steps is accomplished from the central operating panels. A fifth cell contains equipment and vessels for transferring process solutions between buildings 221 and 224. The sixth cell contains the equipment for the final plutonium concentration before transfer to Building 231.

<u>231 -- Isolation Building</u>.--Upon arrival at the Isolations Building, the plutonium which was originally associated with a ton of uranium in the form of slugs has been concentrated to an 8-gallon solution. Consequently, the equipment for final preparation is greatly reduced in size from that required in earlier processing.

Vaults are provided in the Isolations Building for receiving process solution from the 224 Building and for storing finished plutonium until transferred to the Army. Five cells are provided in which the processing steps are performed in stainless steel vessels behind glass. The remainder of the building houses laboratories, offices, ventilation equipment, stockrooms, and other necessary facilities.

Throughout the Isolations Building cleanliness and safety are emphasized because of the extreme toxicity of plutonium. Every conceivable precaution is taken to avoid personal contact with the product.

[redacted] ela

rate than they were being created and the earlier events were substantially repeated.

There were numerous possible causes of the parasitic neutron absorption but there was no immediate concrete evidence which adequately explained any of the possibilities. In order to evaluate the various possibilities, the pile was again started and the power held at about 2.5 megawatts for 6 hours followed by a longer run at 1.7 megawatts. It was determined that continuous operation could be maintained at a power of about 3 megawatts with the pile charged with 901 tubes. From the data collected at this time, the physicists made substantially the following analysis and predictions before 2 October and all of which have proved to be remarkably accurate:

(1) The parasitic neutron absorption resulted from the formation of xenon-135 as a fission by-product element. With the time expressed as half-lives (the time required for one half of the amount present to decay to the next element), this is part of the decay chain of: tellurium (15 minutes) to iodine (6.6 hour) to xenon (9.4 hour) to cesium (25 year) to stable barium. In this chain, only xenon has a high capacity for absorbing neutrons and the xenon capacity is about 50 times greater than that of any previously known element.

(2) It was predicted that the pile would be able to operate at the following power levels when the indicated number of tubes were charged with uranium slugs: 14 megawatts at 1000 tubes; 59 megawatts at 1300 tubes; 94 megawatts at 1500 tubes; and 216 megawatts at 2004 tubes.

(3) It was predicted that higher power levels than those above would gradually be attained as boron and other impurities with high neutron absorption characteristics were gradually transmuted during pile operation to less objectionable elements; and as plutonium formed in the pile and some of it fissioned to produce additional neutrons. This prediction was based on knowledge of some other fission by-product elements which would absorb neutrons and thus retard the pile reaction.

(4) It was also pointed out that additional power could be obtained by placing up to 38 instead of the planned number of 32 uranium slugs in each tube of the pile; by making certain that a minimum of aluminum is present at the ends of the slugs to be charged into the other two piles; by carefully zoning slugs in the piles so that the heavier slugs are in the central portion.

[redacted]

In the early analyses of the possibilities of the Hanford process for the manufacture of plutonium, it was recognized that serious neutron absorption might occur among the fission by-product elements. In all subsequent studies, effort was concentrated on evaluating the various possibilities with the greatest accuracy permissible with the then undeveloped state of knowledge. Thus, even though the effect of xenon-135 was unknown, the possibility of the formation of some element of similar properties was foreseen. If the neutron absorption capacity of xenon-135 were greater than it is, it appears reasonable to believe that it would have been discovered during the operation of the experimental piles at Argonne and the Clinton Laboratories. In that event, adequate provisions would have been made in the Hanford piles to counteract it on the basis of accurate knowledge.

Through what has subsequently proved to have been good judgment, two very important factors were incorporated in the original design of the Hanford piles which have permitted the charging of sufficient uranium slugs to provide a source of neutrons adequate for saturation of the xenon poisoning and operation of the piles at, or above, rated power level. The first is the fact that the piles are constructed with 2004 cooling tubes rather than the 1500 which were indicated theoretically as being adequate. The second is the fact that 9 control rods were designed into each pile instead of about three which were indicated as being required.

The additional control rod capacity is essential in absorbing sufficient neutrons to hold the pile safely when starting for the first time or after a shutdown when the xenon has decayed to less absorptive elements. On these occasions, the piles have a far greater ability to accelerate in power than was ever contemplated and are consequently much more hazardous. However, during normal operation the excess neutron producing capacity is absorbed by the xenon and operations are much less hazardous than had been predicted.

Film Formation and Corrosion.--Concurrently with the design and construction of the Hanford Engineer Works a great deal of work was done in developing a means of limiting film formation and corrosion with respect to the pile cooling surfaces and for periodically removing any film which might form. A part of these investigations were conducted by the Metallurgical Project and the remainder by the Technical Division at Hanford. Without the successful attainment of these objectives, the Hanford piles could not operate.

As a result of this work, practicable operating standards were established prior to the beginning of operations for the performance of the various water treatment processes and for the final chemical conditioning of the process water through the addition of sodium dichromate and sodium silicate. Positive methods were also established for re-

[redacted]

[redacted]

RICHLAND VILLAGE

SERVICES AND FACILITIES

Item	Quantity
High School	1
Grade Schools	4
Churches	3
Grocery Stores	4
Drug Stores	3
Hotel (Transient Quarters)	1
Theaters	2
Red Cross Headquarters	1
Bus Depot	1
Service Stations (Automotive)	4
Bank	1
Post Office	1
Garage (Automotive Repairs)	1
Fire Stations	2
Recreation Building	1
Hanford Engineer Works Administration Area	1
Cafeteria	1
Hardware Store	1
Optical Shop	1
Western Union	1
Railway Express	1
Barber Shop	1
Beauty Shop	1
General Merchandise	1
Men's Furnishings	1
Women's Apparel	1
Shoe Store	1
Shoe Repair Shop	1
Hospital and Medical Center	1
Laundry	1
Milk Store	1
Nursery (Children)	1

[redacted]