

THE HANDLING OF RADIOACTIVE-CONTAMINATED AIR
AT OAK RIDGE NATIONAL LABORATORY*

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1. Introduction

Air contaminated with radioisotopes constitutes the greatest volume of radioactive waste created by the operation of nuclear reactors and associated chemical processes. It is part of the most costly single item in a modern radiochemical process - Waste Disposal.

Waste disposal accounted for 20 per cent of the total construction budget of a recently constructed radiochemical plant. This 20 per cent exceeds the total amount of estimated capital expenditure (E. P. Wigner and Associates) that can be allowed for a fuel recovery plant in connection with a power reactor if the reactor is to compare favorably with the present methods for producing power. This clearly indicates the importance of proper and economical disposal of radioactive waste and the importance that should be attached to it in design.

This presentation is to discuss the systems in use at Oak Ridge National Laboratory for decontamination of radioactive-contaminated air and its final disposal.

In 1948, at the start of the present air-cleaning program at Oak Ridge National Laboratory, the major source of the particulate contamination in the air was expected to be the air-cooled nuclear reactor, and work was immediately initiated on the design of a system for cleaning this air. At the same time, a survey was undertaken to evaluate the contribution of all the potential sources in the Laboratory to this problem of particulate contamination. The results

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of this study indicated that the large-scale chemical processing units at the Laboratory contributed more to the general area contamination than did the operation of the nuclear reactor. In addition, it was found that the amount of radioactivity contributed to the general atmospheric contamination from Laboratory hoods was relatively insignificant.

2. Air-Cleaning Facilities for ORNL Graphite Reactor

As a result of a literature search and consultation with companies concerned with problems of cleaning air, filtration was selected as the procedure to be used for cleaning the air from the nuclear reactor. Among the other techniques that were considered for this application were cyclone separators and electrostatic precipitators.

The ORNL graphite reactor filter house was designed to filter 120,000 cfm of air at a temperature of 215°F and a negative pressure of 50 inches water gage. The expected dust load was less than 900 grams per day of particles with a maximum diameter of 600 microns, a large number of them being in the submicron range. The designed efficiency of this house was 99.9 per cent or better for particles down to 0.1 micron in size.

To remove much of the estimated atmospheric dust load of 0.3 grain per 1000 cubic feet (280 grams per day), the cooling air is filtered before it enters the pile with American Air Filter Company Airmat Type PL-24 filter units loaded with 3/32-inch type G Airmat filter medium.

The filter house is a large reinforced concrete structure composed of four identical cells, each containing a roughing filter and a polishing filter. The capital investment was of the order of \$400,000. This is estimated to be approximately 25 per cent above normal costs owing to the crash program of two 10-hour shifts during construction, which was warranted because of the

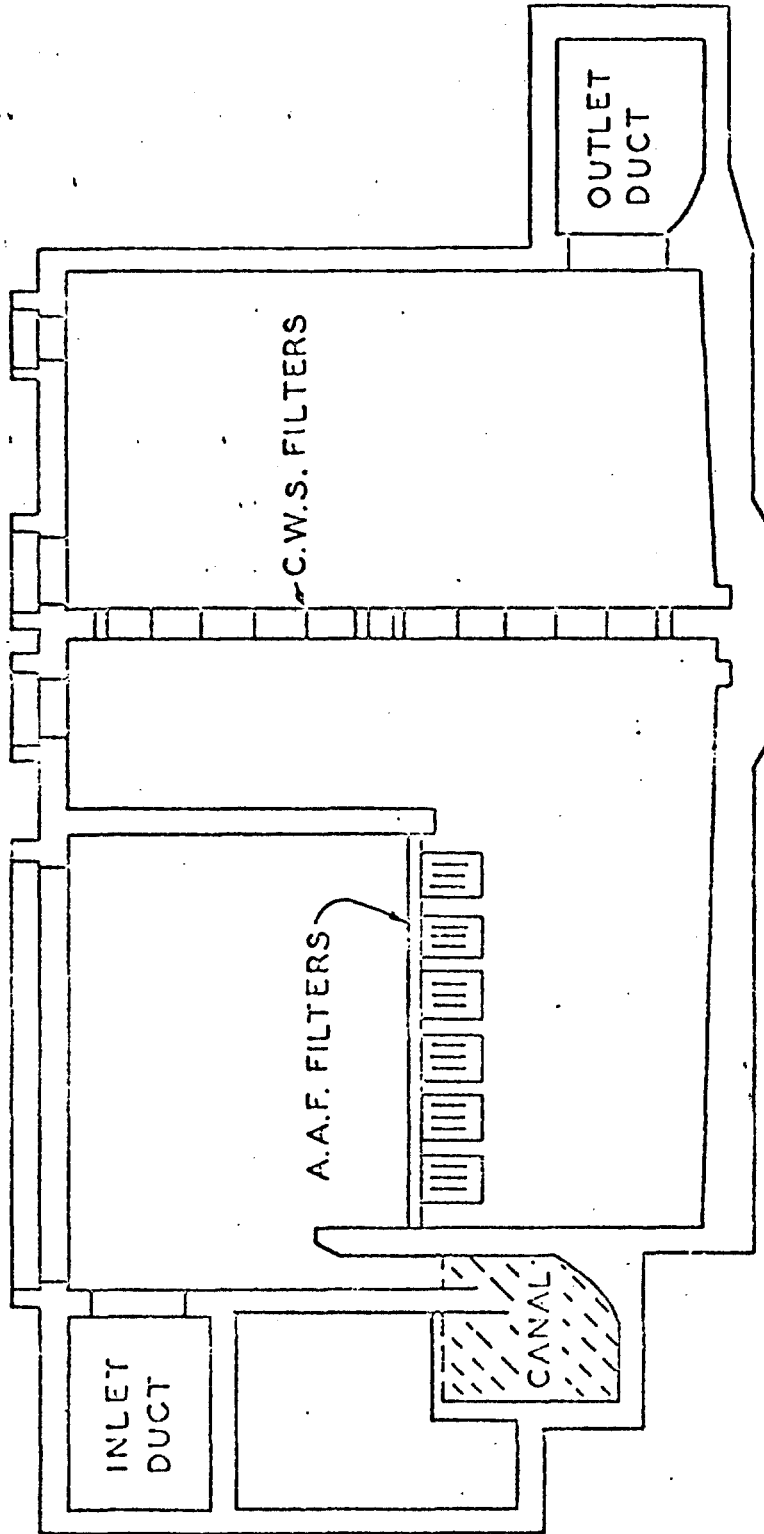


FIGURE 1

PILE FILTER HOUSE

serious atmospheric contamination at that time. A cross section of the filter house is shown in Fig. 1.

The air enters the top of the filter house, passes downward through the roughing filter, then horizontally through the polishing filter into the exit air duct. A canal located across the front of the filter house provides a water seal between the roughing filter area and the atmosphere and is a safe receptacle for the dust-laden filters when the filter medium is being renewed.

Precautions are taken to seal all filters in place in structural steel frames to ensure against leaks and bypassing of the filters. All access to the filters is through removable roof slabs which provide a method for remote maintenance.

The roughing filters are standard A.A.F. Co. deep-pocket filters, each pocket containing two layers of filter medium - first a 1/2-inch layer of FG-25 and then a 1/2-inch layer of FG-50. The polishing or finishing filters are CWS No. 6 or AEC No. 1 units 2 feet by 2 feet by 11-1/2 inches in plywood frames.

Maintenance of the filter house is practically nonexistent except for the periodic renewal of the filter medium. The average life of the roughing filters is two years and of the polishing filters two and one-half years.

The roughing filters are changed one cell at a time at approximately six-month intervals when the pressure drop across the filter house approaches or exceeds 8 inches water gage. The filters are washed down, removed, and stored in the canal. The medium is removed from the pockets and buried, and the pockets are reloaded for the next change.

The polishing filters are all changed at the same time when the pressure drop across them reaches or approaches 5 inches water gage. Both sides of these are sprayed with strip coating before they are removed from the building for burial. The manpower required for changing filters is as follows: (1)

Roughing Filters⁽¹⁾

	<u>Man-days nor Coll</u>
Loading and gasketing filter pockets	
Millwrights	6
Laborers	2
Changing filters	
Operation	4
Riggers	2
Utility mechanics	1
Health physics surveyors	1
Unloading and cleaning pockets	
Operators	10
	<hr/>
Total	26

Polishing Filters

Manufacture and loading of frames	
Carpenters	10
Changing filters	
Riggers	10
Painters	3
Truck drivers	2
Health physics surveyors	2
	<hr/>
Total	27

The cost of operation of the filter house is low except during filter changes. Normal operation of the house requires less than 1 manhour per day. The following is a breakdown of the cost of a complete filter change:⁽¹⁾

Roughing filters		
Material	\$ 3,800	
Labor and Equipment	3,400	
	<hr/>	
Subtotal	\$ 7,200	\$ 7,200
Polishing filters		
Material	\$10,000	
Labor and Equipment	4,500	
	<hr/>	
Subtotal	\$14,500	\$14,500
		<hr/>
Total		\$21,700

With one roughing filter change every two years and one polishing filter change every two and one-half years, the annual maintenance cost would be \$9,400.

(1) Data taken from letter to W. R. Page, BNL, May 21, 1952 by J. A. Cox, CRNL.

3. Air Cleaning Facilities for Laboratories and Chemical Plants

During the recent construction program at Oak Ridge National Laboratory to replace temporary facilities, it was necessary to develop new basic procedures for the ventilation of the working areas and the control of radioactive contamination in air. It was proposed to reduce to a minimum the amount of air that is certain to or has a possibility of becoming contaminated, and to classify radioactive contaminated air according to the degree of contamination and to prevent its dilution by less radioactive streams before treatment. The areas considered in this program were offices, laboratories, hoods, cells, and radiochemical processing equipment. These procedures are briefly summarized as follows:

Office Air: six changes of air per hour, without treatment.

Laboratory Air: minimum of ten changes of air per hour, without treatment.

Laboratory Hood Air: minimum of 50 feet per minute face velocity with provisions for the installation of the filter when demonstrated necessary.

In addition, each hood will have two vacuum systems: the first system with 10 inches of water vacuum to draw the gases off vessels containing high levels of radioactivity and the second system with 20 inches of mercury vacuum to be used for solution transfers and other applications where high vacuum is required. The air from both these vacuum systems will be cleaned before being discharged to the atmosphere.

Cell Air: held at reduced pressure (1 inch of water) when contamination is anticipated; air flow limited to about 250 cubic feet per minute, which will require the air to be cleaned. When cell air contamination is not probable, 20 changes of air per hour without treatment is permitted.

Radiochemical Process Vessel Off-Gas: a system with a vacuum of 40 inches of water to be used for the dissolver and process vessel off-gas line and one with a vacuum of 28 inches of mercury to be used for solution transfers and high-vacuum applications. The air from both vacuum systems will be treated.

A central facility has been established at Oak Ridge National Laboratory to clean the radioactive contaminated air from the chemical processing areas and to dispose of it to the atmosphere. The air from the off-gas systems is cleaned by passing it through a Cottrell electrostatic precipitator followed by an A. A. F. Co. FG-25-50 combination filter identical in performance with those described in Sect. 2. This system has a capacity of 2000 cubic feet of air per minute and collects gas from all radioisotope production vessels, off-gas from hoods, and ventilation air from dry boxes.

The second air-cleaning facility in this area is on the ventilation systems from radiochemical processing areas. This facility consists of a bank of FG-25-50 combination A. A. F. Co. backed by CWS No. 6 paper filters, and is essentially a miniature of the graphite reactor filter house described earlier.

The third system consists of central collection ducts from laboratory hoods in the area and experimental cells when, by the nature of the work, the possibility of contamination is slight. This volume of air is discharged to the atmosphere via a 250-foot-high stack without preliminary cleanup. The discharge from the two previously mentioned systems also empties into this stack.

Figure 2 is a schematic drawing of the central air-cleaning facility. Figure 3 is a photograph of the area as constructed. To the left behind the concrete barricade is the filter bank on the ventilation systems. To the right foreground are the main exhaust fans. Figure 4 is a photograph of the same area showing the top of the Cottrell precipitator and the stainless steel discharge line to the stack. Figure 5 is a photograph of the precipitator during construction.

The Cottrell precipitator is of the exposed-tube type, containing twenty-three 8-inch-diameter tubes 12 feet in length, fabricated of No. 14 gage stainless steel. Those parts of the precipitator that come in contact with the gases to be cleaned which may be corrosive are constructed of type 347 stainless steel. Figure 6 is a cross-section drawing of the precipitator.

The discharge electrode system is stainless steel wire longitudinally centered through each collecting electrode, suspended from porcelain insulators, and held taut by porcelain weights at the bottom.

The precipitator is equipped with a continuous water-flush system. Nozzles are provided at the top of each tube in such a manner that a continuous film of water is maintained on the inner surface of the tube. In addition, a water-spray system is located in the extreme top to facilitate washdowns. The water which is collected in a catch tank is recirculated to the precipitator. When the activity level or the acid content (NO and NO_2 are present in the off-gas) becomes high, the water is discharged to its proper location in the liquid-waste-disposal system of the plant.

The precipitator is designed to operate at a maximum temperature of 200°F and a negative pressure of 60 inches water at a flow of 2000 cubic feet per minute. The water flush system operates at 3 to 6 gallons per minute per tube.

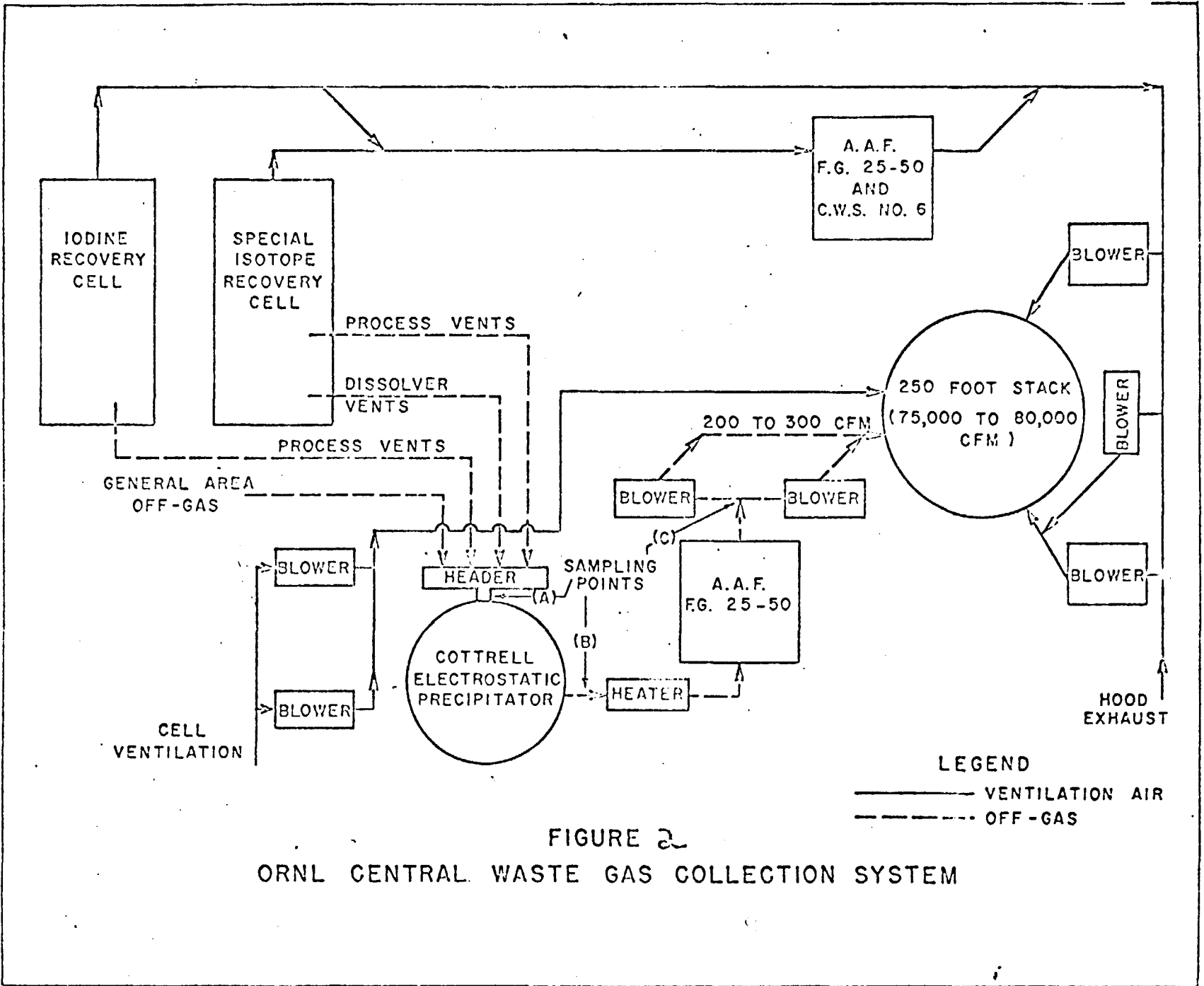


FIGURE 2
 ORNL CENTRAL WASTE GAS COLLECTION SYSTEM

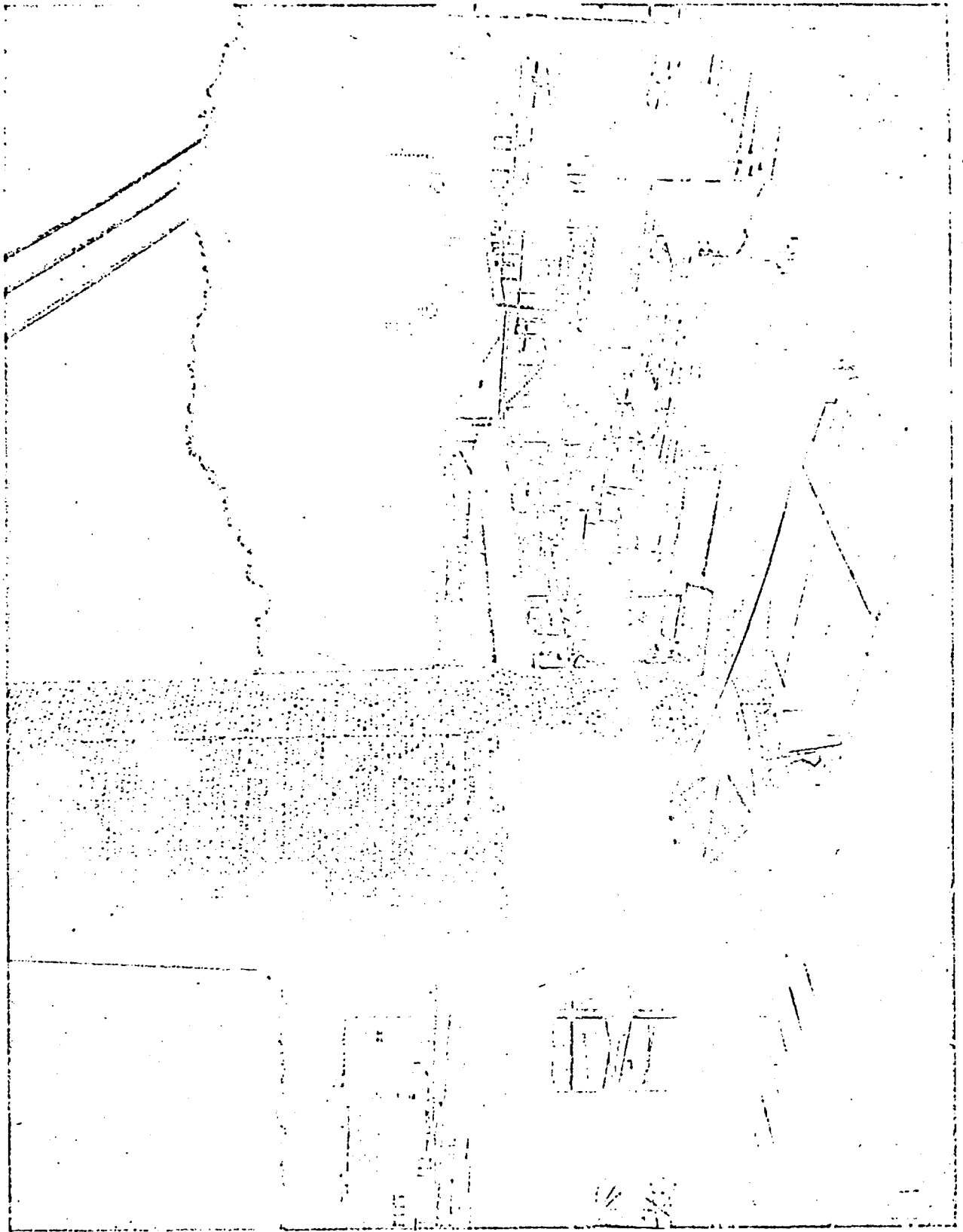


Figure 3

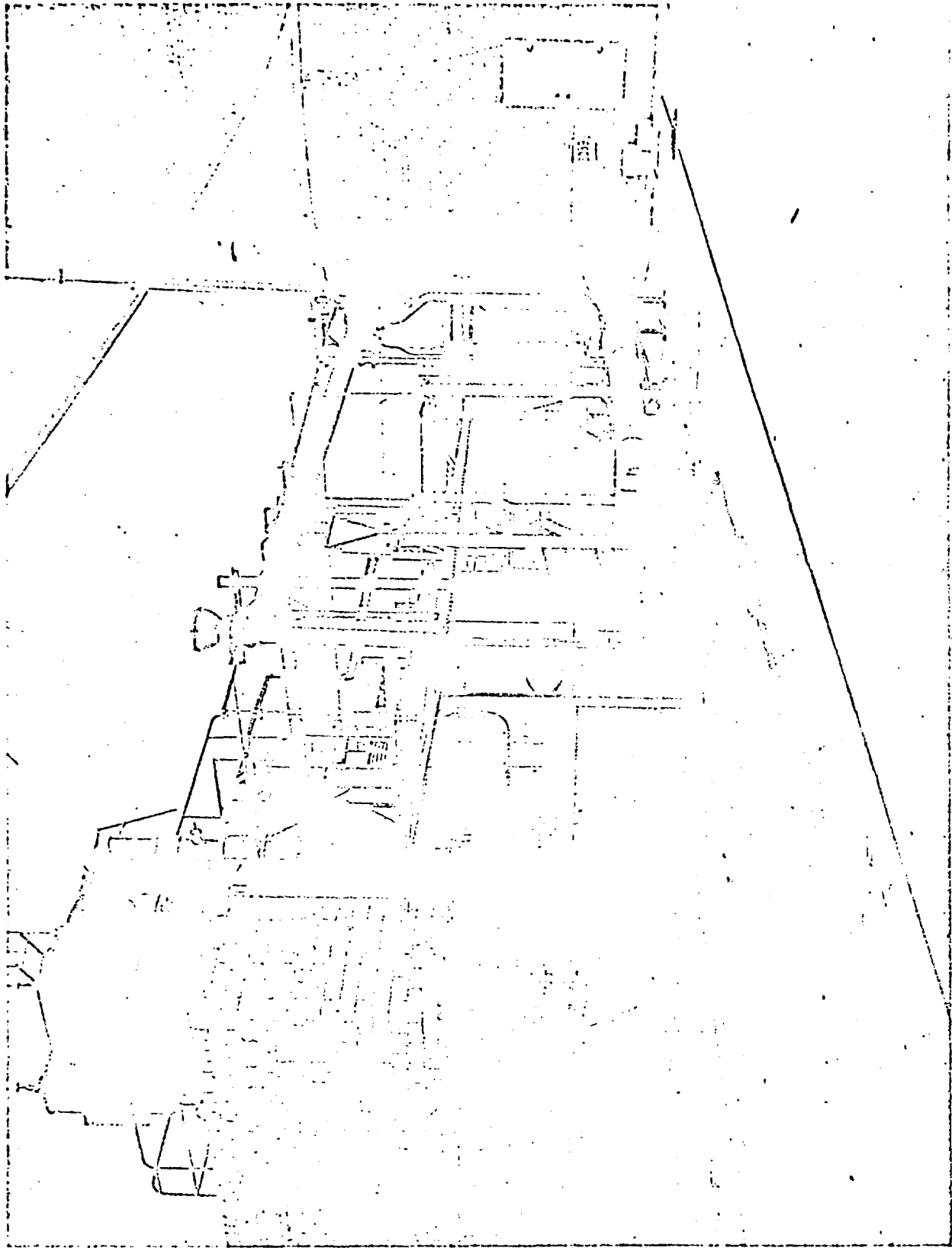
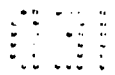


Figure 4



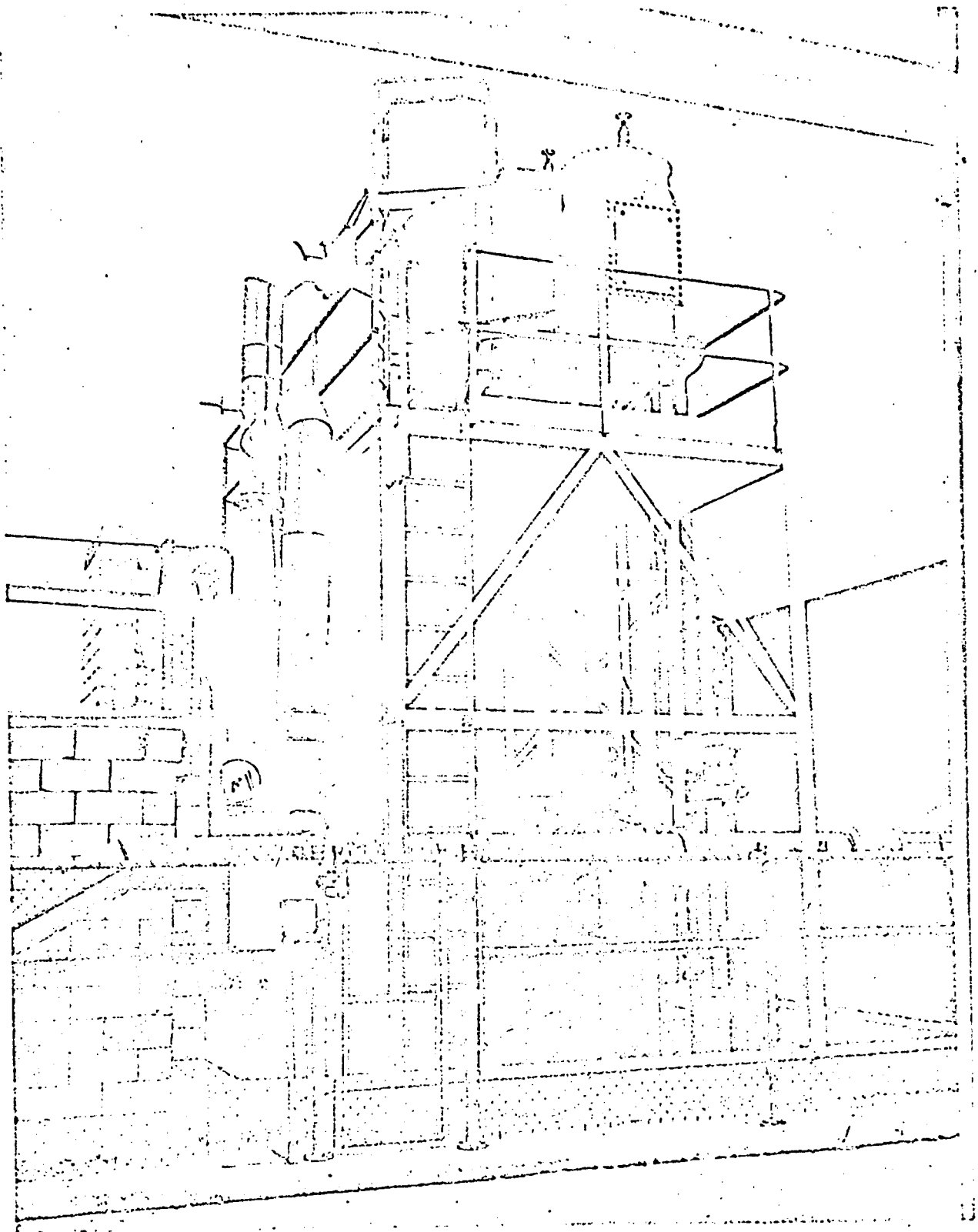


Figure 5

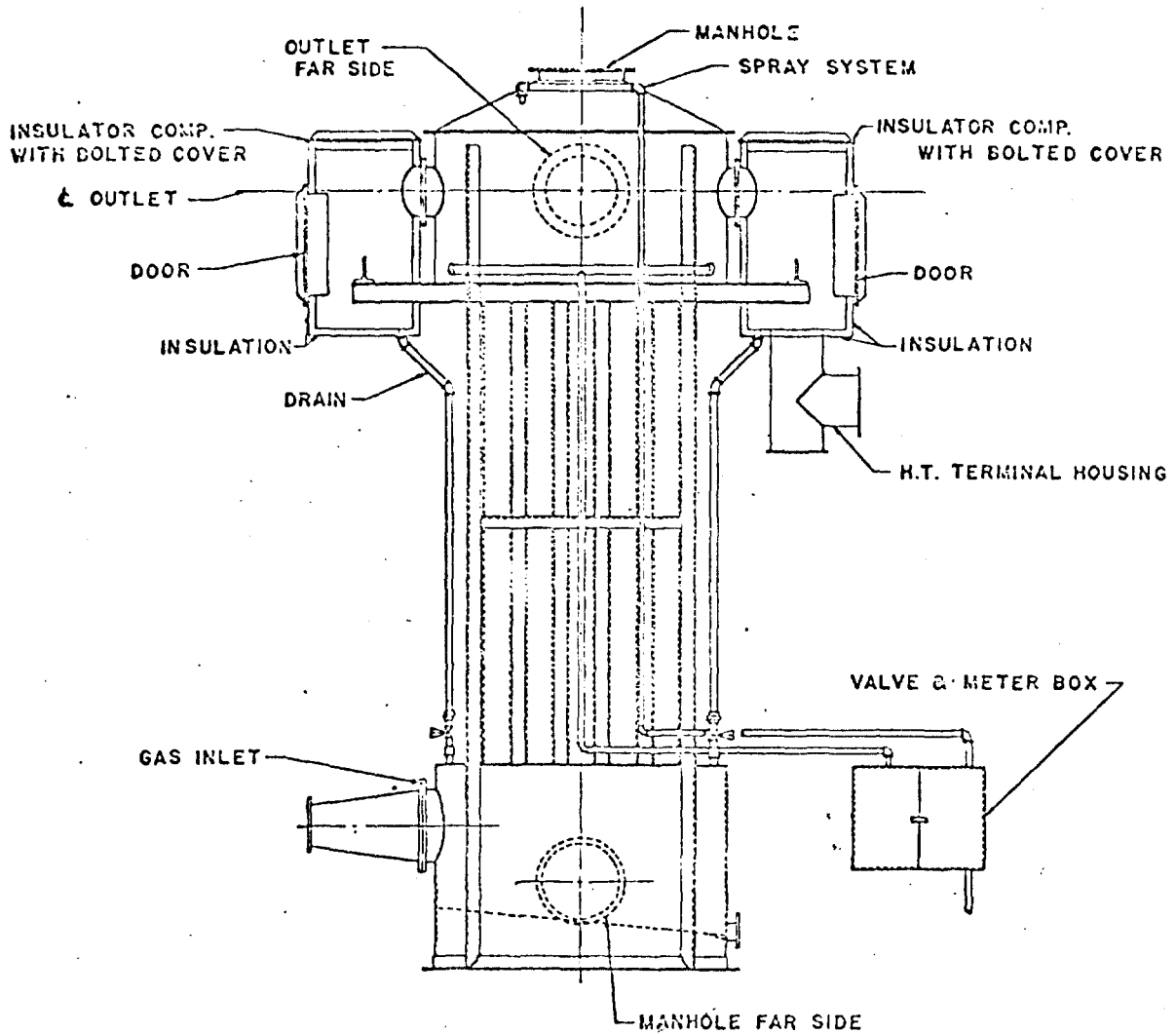


Figure 6
COTTRELL PRECIPITATOR TYPE "A"

The electrical design voltage is 75,000 volts, 25 kilovolt-amperes and operates on 440-volts 3-phase 60-cycle current to the power pack. In actual practice the precipitator is operating with 52,000 volts and a current of 130 milliamperes.

The capital investment of the entire system is \$100,000.

In addition to the main central facility, several small air-cleaning filters are located at isolated experimental radiochemical installations. These are miniature replicas of the graphite reactor filter installation except for one unit in which a graded filter-fibre unit developed at Hanford is used.

5. Homogenous Reactor Experiment Air-Cleaning System

A charcoal system was constructed for the Homogenous Reactor Experiment. Its purpose is to absorb the fission gases present in the effluent gas stream, and thereby hold up the active gases until they have had time to decay to a safe level before being discharged to the atmosphere. This system consisted of a pipe coil 328 feet in length and containing 13.94 cubic feet of Columbia activated coconut charcoal (gage 9, 8 to 14 mesh granular) and was designed to operate at atmospheric temperature and pressure with a flow rate of 24 standard cubic feet per day. Here, the air cleaning facilities were to be used only for the relatively short time during which the experiments are to be carried out.