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VENTILATION DESIGN MODIFICATIONS AT LOS ALAMOS SCIFNTIFIC LABORATORY MAJOR PLUTONIUM OPERATIONAL AREAS*

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Abstract

Major ventilation design modifications in plutonium operational areas at Los Alamos have occurred during the past two years. An additional stage of HEPA filters has been added to DP West glovebox process exhaust resulting in significant effluent reductions. The additional stage of HEPA filters is unique in that each filter may be individually DOP tested. Radiological filter efficiencies of each process exhaust stage is presented. DP West room air ventilation systems have been modified to incorporate a single stage of HEPA filters in contrast to a previous American Air Filter PL-24 filtration system. Plutonium effluent reductions of 10^2 to 10^3 have resulted in these new systems. Modified DOP testing procedures for room air filtration systems are discussed.

Major plutonium areas of the CMR Building utilizing Aerosolve 95 process exhaust filtration systems have been upgraded with two stages of HEPA filters. Significant reductions in effluent are evident. A unique method of DOP testing each bank of HEPA filters is discussed. Radiological efficiencies of both single and two-stage filters are discussed.

I. Introduction

There are presently two major plutonium Research and Development facilities at Los Alamos Scientific Laboratory (LASL), DP West and CMR laboratories. DP West facilities involve glovebox operations with kilogram quantities of ^{239}Pu and multi-one hundred gram quantities of ^{238}Pu. The CMR Building also involves glovebox operations with ^{238}Pu and ^{239}Pu; however, these operations are generally with gram to 100 gram quantities of both isotopes.

The present DP West plutonium facilities were derived from the original D Building at the LASL Technical Area where the first plutonium metal was produced in quantity. It became apparent in the early 1940's that handling of large quantities of plutonium would require design and construction of more extensive facilities to ensure safe operations. The core of the present DP facilities was constructed in 1944-45 by moving in and modifying army warehouse buildings and installing equipment needed for continual operations (1). Since 1945 there have been numerous revisions and upgrading

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of ventilation systems to improve safety, operability, and to reduce radioactive effluents.

The CMR Building construction was completed in 1952. This building is a three-story concrete structure with a full attic and basement which are auxilary to the main floor containing the research and development laboratory modules. It is a winged structure with laboratory wings, each approximately 260 ft long, branching off a 650-ft-long spinal corridor. Research and development activities at the CMR Building include analytical chemistry, physical chemistry, inorganic chemistry, physical metallurgy, and irradiated material examination and handling. As with the DP facilities, there have been considerable ventilation revisions and additions to improve safety and operability; however, since the Rocky Flats Plant fire in 1969, a review of the AEC supported Plutonium facilities indicated that a considerable upgrading program was needed to provide not only the level of fire protection desired, but also ventilation upgrading to protect the environment during normal and postulated accident type conditions. As a result, an extensive program at the LASL was initiated to improve both the DP West and the CMR Building ventilation exhaust system.

Ventilation Systems and Effluent Data

From 1944 to 1959 numerous modifications of the process (glovebox) ventilation systems occurred at DP West. Prior to 1959, the process and room exhaust were combined, and the only filtration was one stage of PL-24 filter media at Building 12. In 1959, the process exhaust was separated from the room exhaust and a combined central process exhaust system installed. High efficiency particulate air filters (HEPA) were installed on each glovebox, either within the glovebox or immediately adjacent in an in-line configuration. During this same modification, a bank of HEPA filters was installed on the combined process exhaust system. Building 12 was then used only as the room air exhaust filter system.

The new process exhaust filter system was designed to handle an air flow of 21,000 cfm and to allow the filters to be changed without disrupting process operations. Since the system was handling air containing radioactive particles and acid fumes, it was necessary that all parts of the system exposed to the exhaust air be stainless steel and all joints and openings be sealed to prevent escape of any air. Figure 1 illustrates the filter system which consists of a filter wheel and housing, a loading dry box, a transfer dry box, and a recovery dry box. Figure 2 shows the filter wheel, which is approximately 7 ft in diameter and 7-1/2 ft long, and is constructed of 1/4-in. thick cold rolled type 304 stainless steel. Figure 3 shows an end view of the filter wheel and the recovery dry boxes. The wheel has twenty-four openings sized to hold the standard 24-in. square HEPA filters. It rotates on two 48-in. diam sleeve bearings which are located at the end of the wheel which is sealed with Garlock seals. The filter wheel assembly is housed in a stainless steel plenum chamber which was shown in the first slide. Twenty-one of the filters are in use at any one time;

the other three being in stand-by position at the transfer box location. The wheel is rotated every 6 to 8 weeks to change location of the filters in the plenum. A complete change of filters is done every year. Contaminated filters are removed from the wheel and moved to the recovery box where they are bagged for recovery. In operation, the contaminated air flows radially in through the filters and the cleaned air flows axially out the center of the wheel to the blowers and exhaust stack. DOP testing of the entire system was done by introducing air jet generated DOP well upstream of the filters and measuring the intake and exhaust concentrations on each side of the filters.

In early 1973, an additional bank of HEPA filters was installed in the process exhaust system. Figure 4 shows Building 324 which houses this final stage of process exhaust at DP West. A duct connects the final filter stage of process from Building 146 (housing the rotary drum) to this final stage of filtration, containing 20-2' x 2' x 1' HEPA filters. This Figure illustrates the intakes and the exhaust ducts with perpendicular flange fitted HEPA filters. Shutoff valves are incorporated on each side of the filter to enhance easy removal and valving off for DOP testing. DOP testing is accomplished by introducing the aerosol at a port in Building 146 and measuring the upstream and downstream concentrations as indicated by the sample probes in the Figure. After initial installation, each filter was individually tested; and finally, the entire system was tested and found to have an overall efficiency of 99.994%.

In late 1972 and early 1973 new room air exhaust systems were installed which is shown in Figure 5. This system contains roughing filters and one bank of HEPA filters. Efficiency testing was accomplished by valving off the intake plenum and introducing DOP through an opening in the plenum airlock. A description of the exact method of DOP testing is better illustrated by Figures shown later in this paper.

Table 1 illustrates the total discharge in curies from 1948 to present(2). From 1948-1958 both room air and process exhausts were combined. In 1959, Building 146 was constructed to incorporate one stage of HEPA filtered process exhaust. At this time, room and process exhaust were separated. Residual contamination in the previous combined room and process exhaust system (Building 12) led to high room air identified effluent. In 1973 new HEPA filtered room air exhaust systems were installed, and a second stage of HEPA filters was also installed on the process exhaust. Reductions in measured effluent are quite evident. An attempt has been made to estimate the process exhaust first stage radiometric filter efficiency; however, since the intake concentration has previously been used only for operational purposes, and has been taken in an undesirable sampling location, we are reluctant to present this data. Changing bimodal particle size distributions make it difficult to evaluate total system efficiency; however, we are presently trying to quantitate this information.

During the 1950's, the exhaust system of the CMR Building consisted primarily of capillary air washers incorporating coarse glass filaments set at an angle to the air stream. Water from spray heads, oriented in the direction of the air stream, was sprayed over the glass filaments. The air washer served as efficient removers of corrosive fumes, acid mists, and chemical vapors(3). Water eliminator plates followed the capillaries to protect the downstream dry filter pads against water saturation. The sequence of filtration after the water elimination plates was dry glass fiber filter pads, another wet cell, and a final bank of commercial glass fiber mat filters. The overall radiometric efficiency of this system was considered in excess of 90%.

Over the years, four principal developments have evolved which have led to present determination that a number of the building exhaust systems are inadequate. These are (1) improvements in state-of-the-art filtration methods and materials; (2) programmatic changes resulting in significantly increased research and development efforts involving plutonium; (3) conversion of several general-purpose basement areas to laboratories to meet new or growing programmatic commitments; and (4) increased concern on the part of both the public and the AEC in the control and reduction of potentially harmful effluents to the environment. This latter area is of concern since not only effluents resulting from normal operations but those associated with accidental releases must be considered. Maintenance of the air washers in the early system proved to be a continuing and expensive problem due to high evaporation rates, scaling, and nozzle failure. A program was initiated to replace the unsatisfactory air washers with single banks of Aerosolve 95 filters, which had an efficiency of 80-85% for the removal of 0.3 micron DOP particles. Testing throughout their use indicated that the Aerosolve 95 filters were, in fact, functioning at their specified efficiency. It became apparent that the major wings of the CMR Building where there was work involving plutonium and where the greatest effluent concentrations occurred were Wings 2, 5, and 7. It was also apparent that the effluent concentrations were increasing annually and funds expended to reduce plutonium effluents from these three wings would be most significant for the CMR Building. In early 1972, engineering efforts were begun to design a new ventilation cleanup system for these three wings. Design consisted of roughing filters and two banks of HEPA filters, new plenums, airlocks, and blowers. These new systems became operable in late 1973 and early 1974. Each system consists of two filter banks in series and each bank contains 60-24" x 24" x 12" HEPA filters. A fire screen was installed upstream of the first filter bank and was constructed of wire mesh 2" thick on galvanized steel frames with a pressure drop of 0.15 in H_2O.

All banks of HEPA filters were leak tested after installation. Although leak probing of each filter does not determine the overall efficiency of a system, it is beneficial to locate leaks in the filter housing, filter mounting frames, gasket compression, and other related components before overall system efficiency is measured. Leaks were determined by blowing DOP aerosol between the filters and on welded joints on the upstream side of the filter bank. Penetration of aerosol downstream was measured with a forward light scattering photometer with a 30 ft portable probe and meter.

Figure 6 shows a leak probe test operation where two men introduce the aerosol on the upstream side of the filter and two men scan the downstream penetration. Initially, leaks were found on the joints of the filter housing, frames, and poor filter gasket compression areas. All leaks were repaired, and scanning continued until all leaks were eliminated.

The procedure used for in-place testing of filter system consists of discharging a polydisperse DOP aerosol into a convenient air intake, upstream from the filter bank. For the initial testing, a temporary 30-inch round duct approximately 20' long was used(4).

Figure 7 shows the aerosol generators used for this test which are of the same design that was developed by the Naval Research Laboratory(5). A total of 6 nozzle type high capacity compressed air aerosol generators were used. A generator operated at 25 psig delivers approximately 24 cfm with a DOP aerosol having a count median diameter of the aerosol of 0.7 micrometer and 95% of its particles less than 1.5 micormeters in diameter(7). In testing the first filter bank, the 30" duct was positioned in the filter housing air lock shown in Figure 8. The concentration of the unfiltered smoke was determined by drawing a sample from the 30" duct.

The concentration of DOP was measured with a linear readout forward light scattering photometer(6). Figure 9 depicts the method of testing the first bank of filters. Aerosol is introduced through a sealed opening in the airlock and measured by a sample probe in the introduction duct. Four filters from the second bank are removed and the filtered aerosol is then measured from a sample withdrawn downstream from the first filter bank on the discharge side of the fan. Traverses indicated that the test aerosol was uniformly mixed in the duct. The filtration efficiency of the system was then calculated from the upstream and downstream concentration values. After replacing the four filters in the second bank it was tested in the same manner as the first bank, except that the test aerosol was introduced between the two banks, as shown in Figure 10. The three new systems showed efficiencies greater than 99.97%.

Table 2 illustrates the stack effluent concentrations in curies from 1953 to 1974. There is an apparent increase in effluent concentrations up to 1974.

Table 3 expands the 1973 and 1974 effluent data for all three wings. The asterisks show when the new two bank HEPA filter system was installed. In all cases, we have seen significant reductions.

Table 1

Plutonium in Gaseous Effluent from DP Operation

Year	Room Air Discharge, Ci	Process Air Discharge, Ci	Total Discharge, Ci
1948-9			0.31
1950			0.19
1951			0.027
1952			0.057
1953			0.035
1954			0.022
1955			0.088
1956			0.076
1957			0.074
1958			0.080
1959	0.1750	0.0050	0.18
1960	0.0430	0.0010	0.044
1961	0.0043	0.0030	0.0073
1962	0.0022	0.0020	0.0042
1963	0.0064	0.0008	0.0072
1964	0.0011	0.0010	0.0021
1965	0.0022	0.0003	0.0025
1966	0.0022	0.0003	0.0025
1967	0.0075	0.0003	0.0073
1968	0.0010	0.0008	0.0011
1969	0.0121	0.0009	0.013
1970	0.0030	0.0006	0.0036
1971	0.0125	0.0005	0.0130
1972	0.0550	0.0003	0.0550
1973	0.000001	0.000013	0.000014
1974 (4 months)	0.000001	0.00000008	0.0000011

Controlled soluble	2×10^{-12} µCi/cm^3
Uncontrolled soluble	6×10^{-14} µCi/cm^3

Table 2

CMR Building Gross Alpha Effluent in Curies

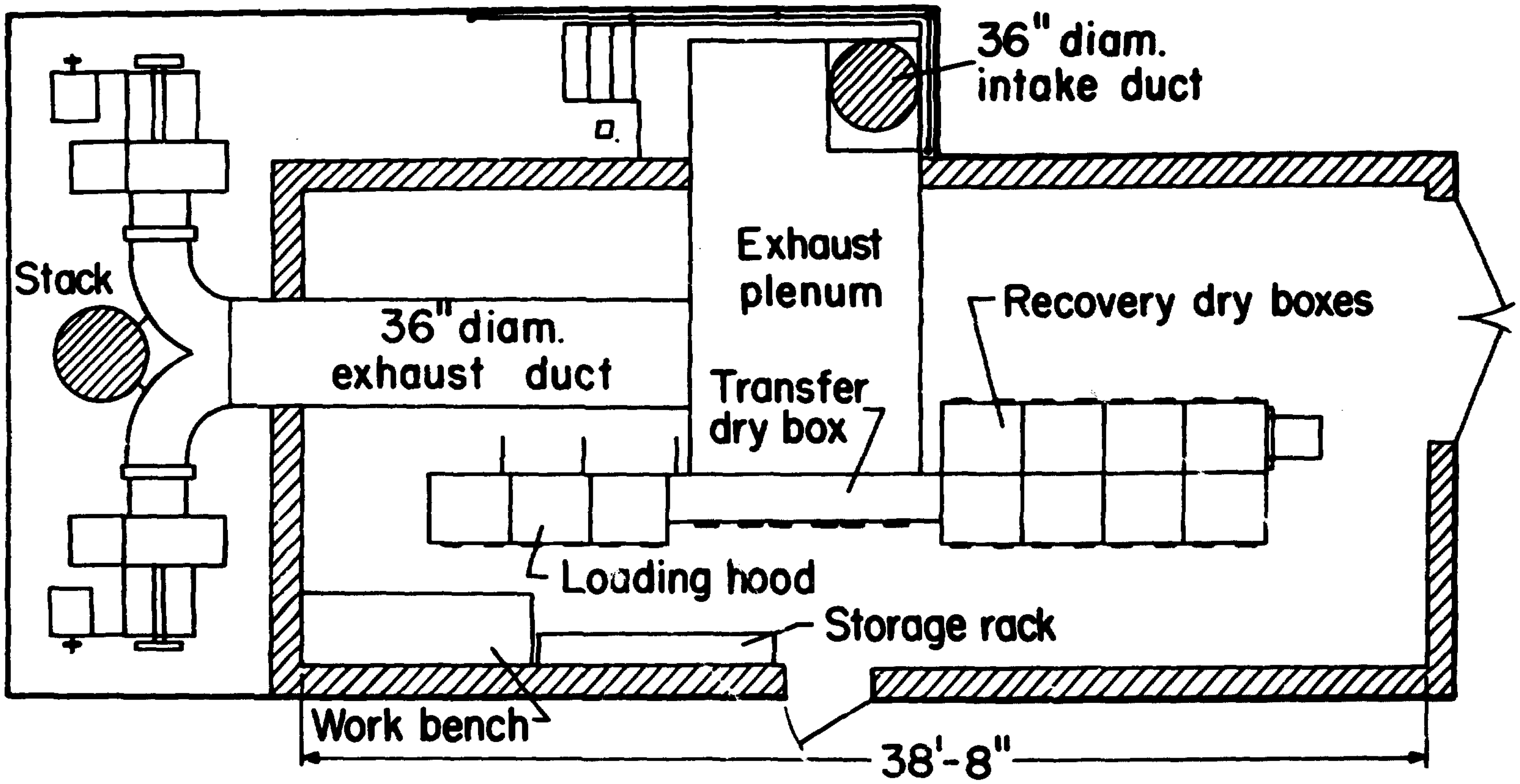
Year	Wing 7	Wing 5	Wing 2
1953	———	———	.000024
1954	.000426	.000337	.000352
1955	.000397	.000374	.000984
1956	.000374	.001151	.000361
1957	.000315	.000183	.000297
1958	.002062	.000316	.000435
1959	.000323	.000151	.000139
1960	.000499	.000953	.000207
1961	.000574	.000400	.000241
1962	.000544	.000139	.000037
1963	.000347	.000042	.000156
1964	.000305	———	.000258
1965	.001053	.000139	.000244
1966	.000627	.000042	.000136
1967	.002992	.000109	.000578
1968	.003201	.000722	.001597
1969	.005251	.003960	.001259
1970	.004100	.003900	.005200
1971	.005300	.002000	.006650
1972	.003290	.001400	.003030
1973	.003698	.001371	.003101
1974	.000017	.000135	.000003

Table 3

1973 and 1974 CMR Building Gross Alpha Effluent in Curies

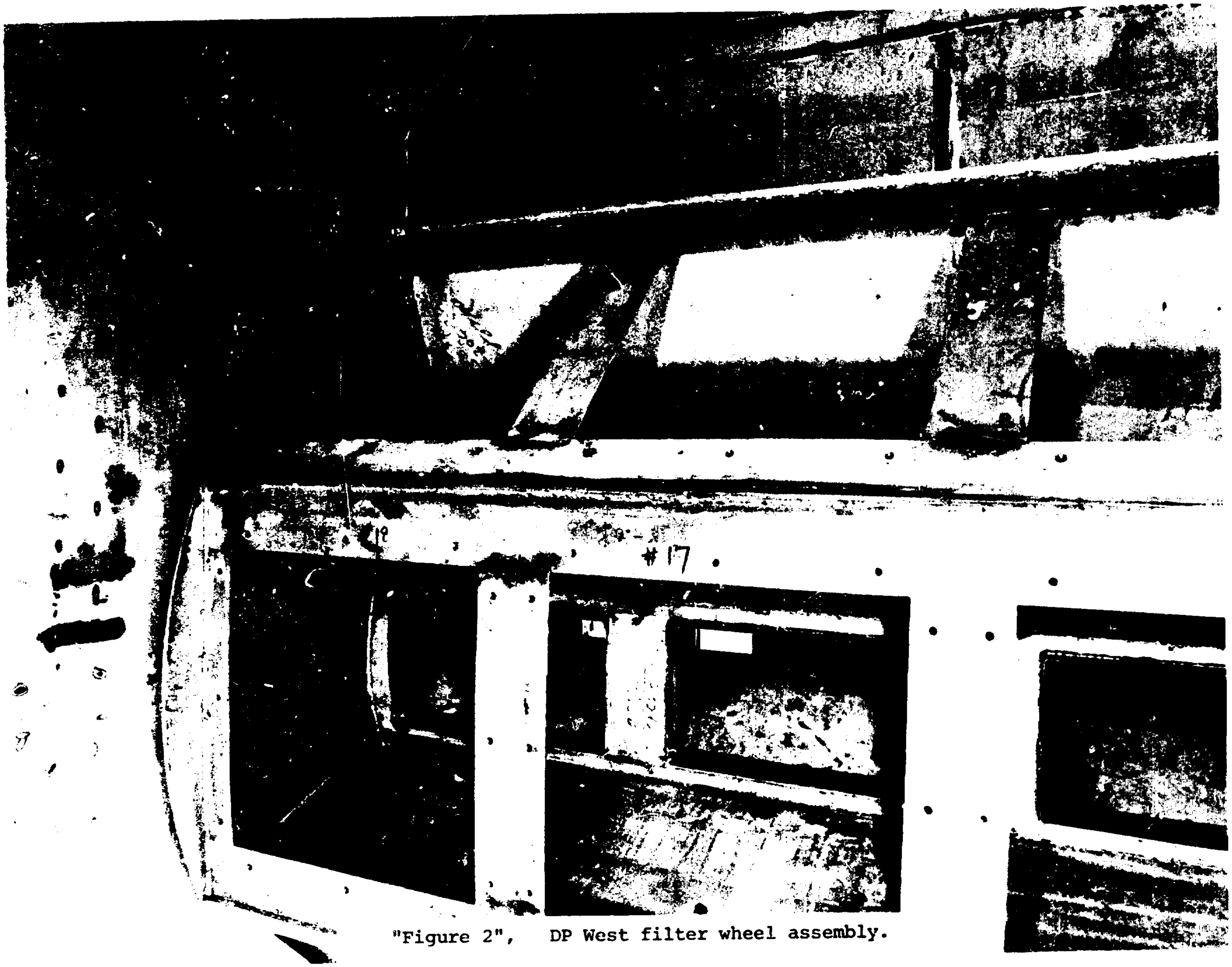
Month	Wing 2	Wing 5	Wing 7
1/73	.000133	.000041	.000521
2/73	.000433	.000273	.000282
3/73	.000108	.000125	.000061
4/73	.000049	.000039	.000338
5/73	.002053	.000279	.000422
6/73	.000029	.000056	.000281
7/73	.000158	.000148	.000080
8/73	.000070	.000068	.000378
9/73	.000049	.000030	.000435
10/73	.000019	.000179	.000379
11/73	.00000009*	.000062	.000416
12/73	.00000000	.000071	.000105
1/74	.00000090	.000134	.000012
2/74	.00000004	.00000010*	.00000040*
3/74	.00000010	.00000007	.00000003
4/74	.00000100	.00000020	.00000003
5/74	.00000043	.00000036	.00000190
6/74	.00000051	.00000046	.00000240

*HEPA Filters Installed.

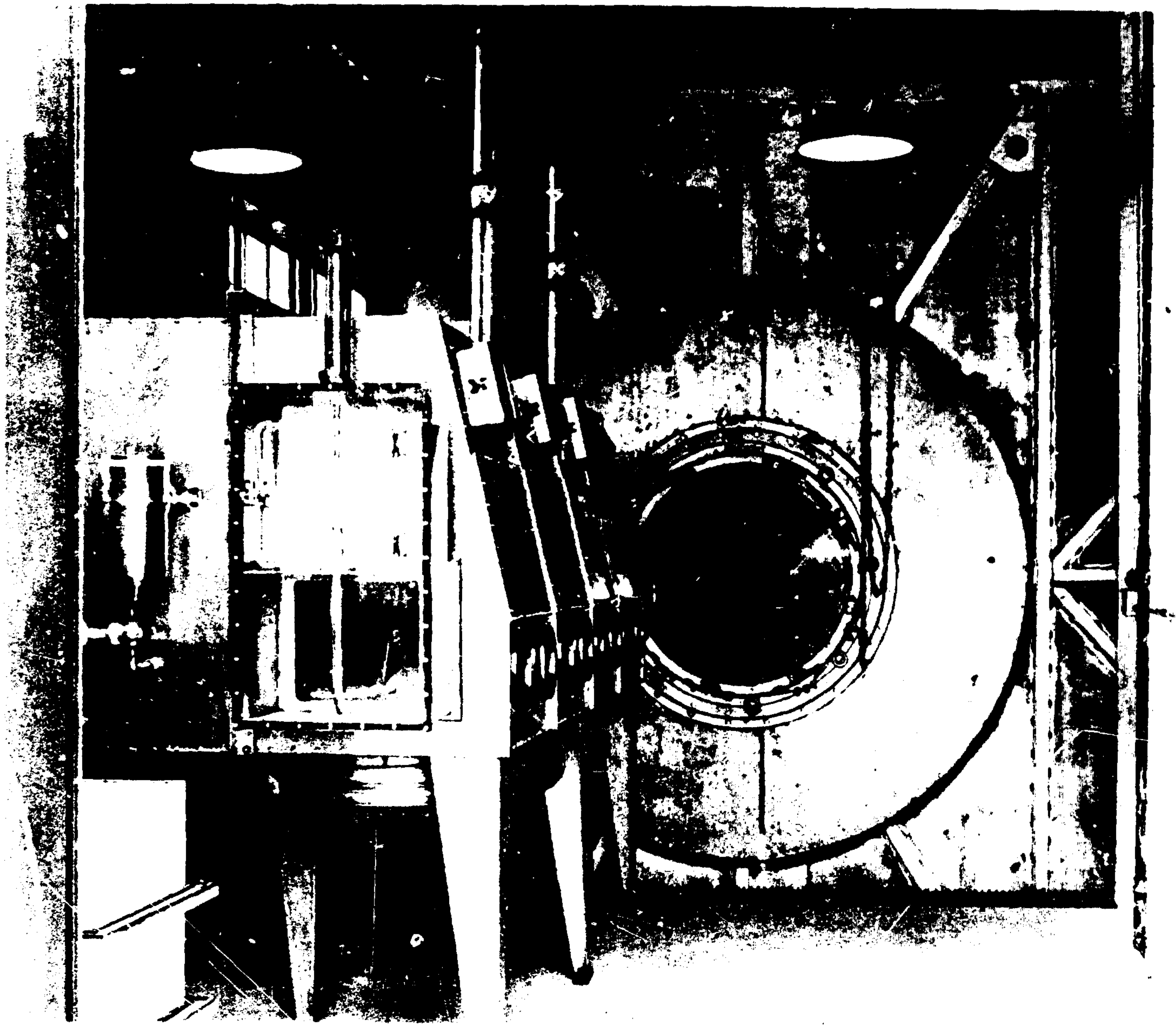


Filter house layout

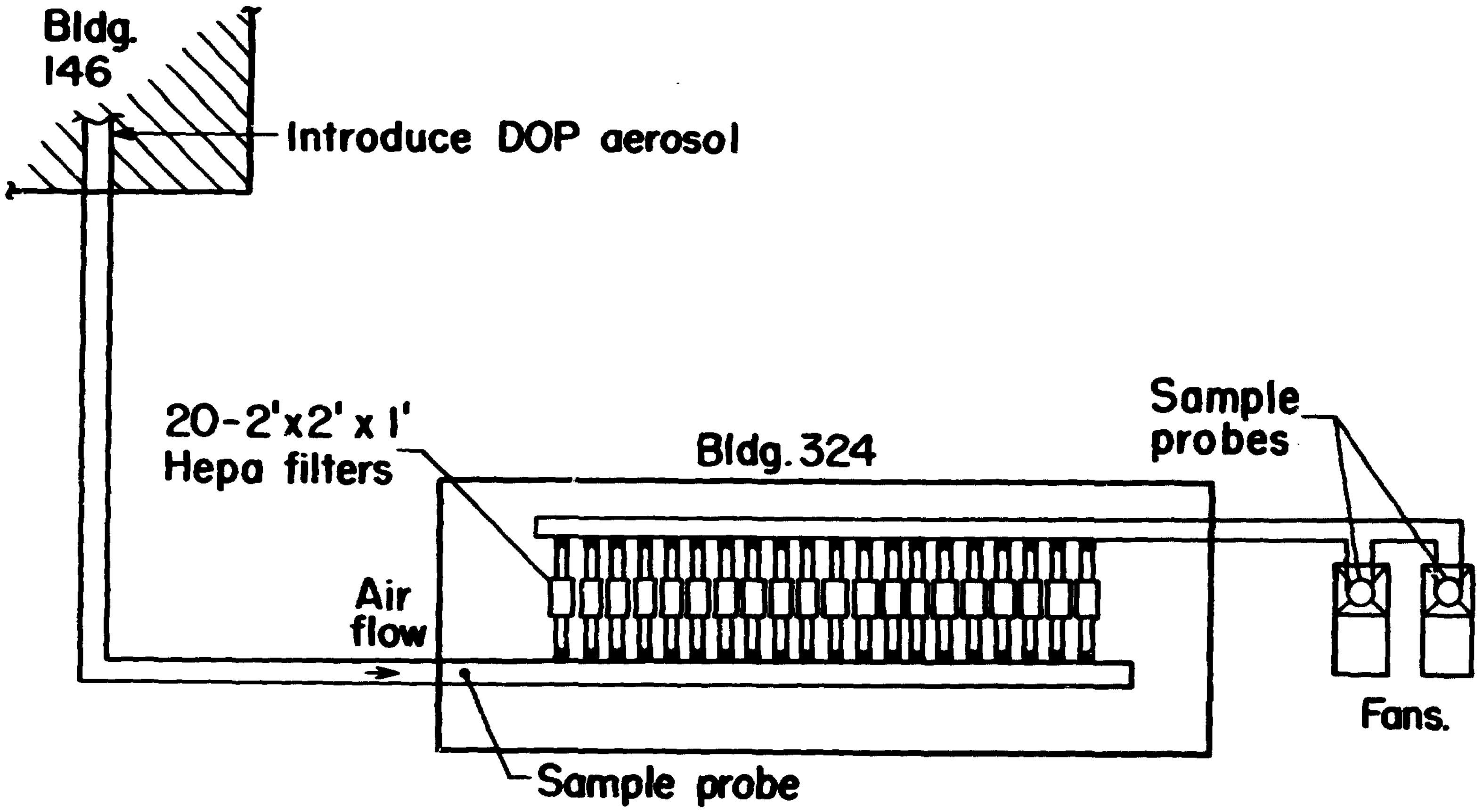
"Figure 1", DP West process exhaust (stage 1).



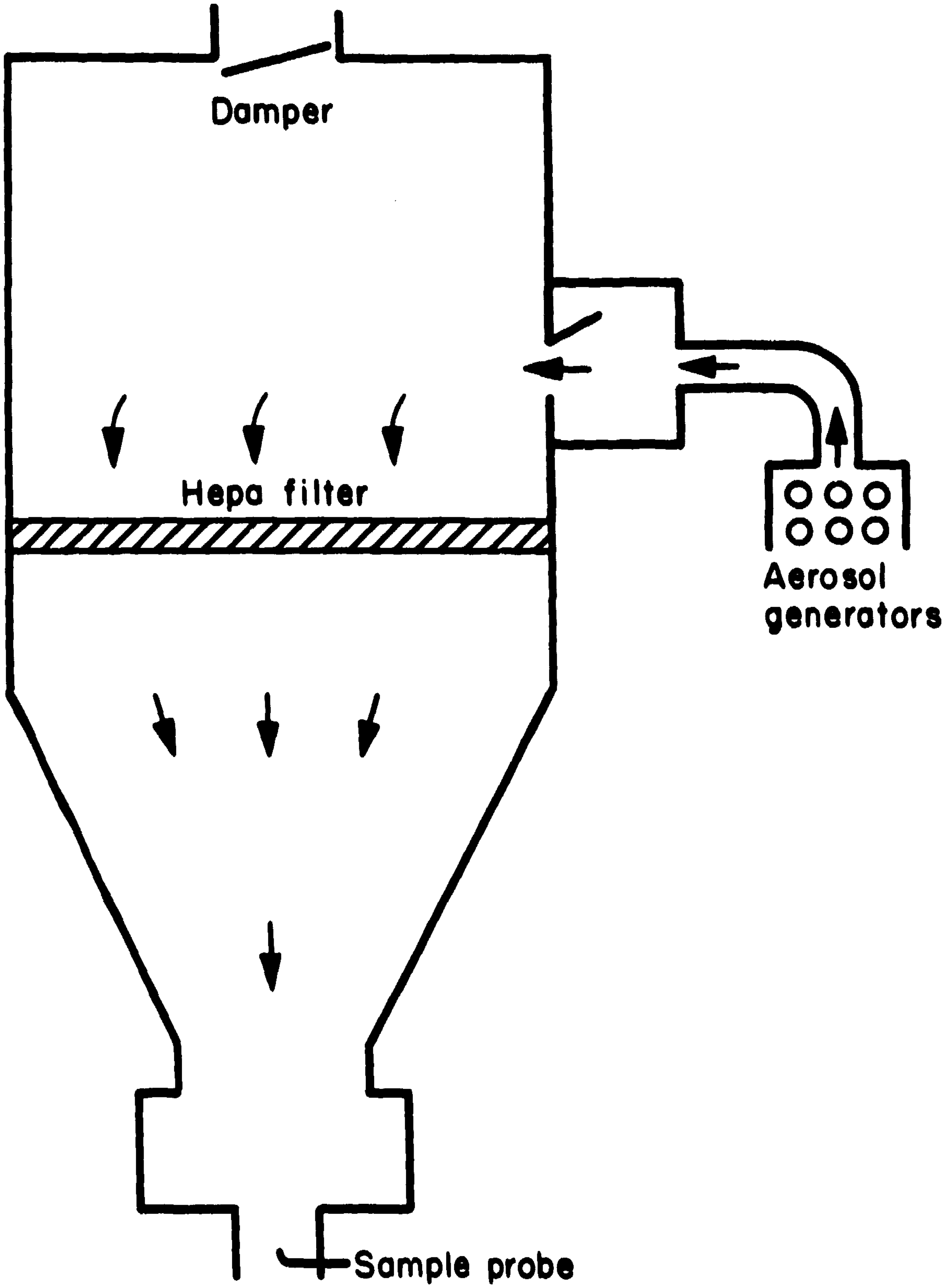
"Figure 2", DP West filter wheel assembly.



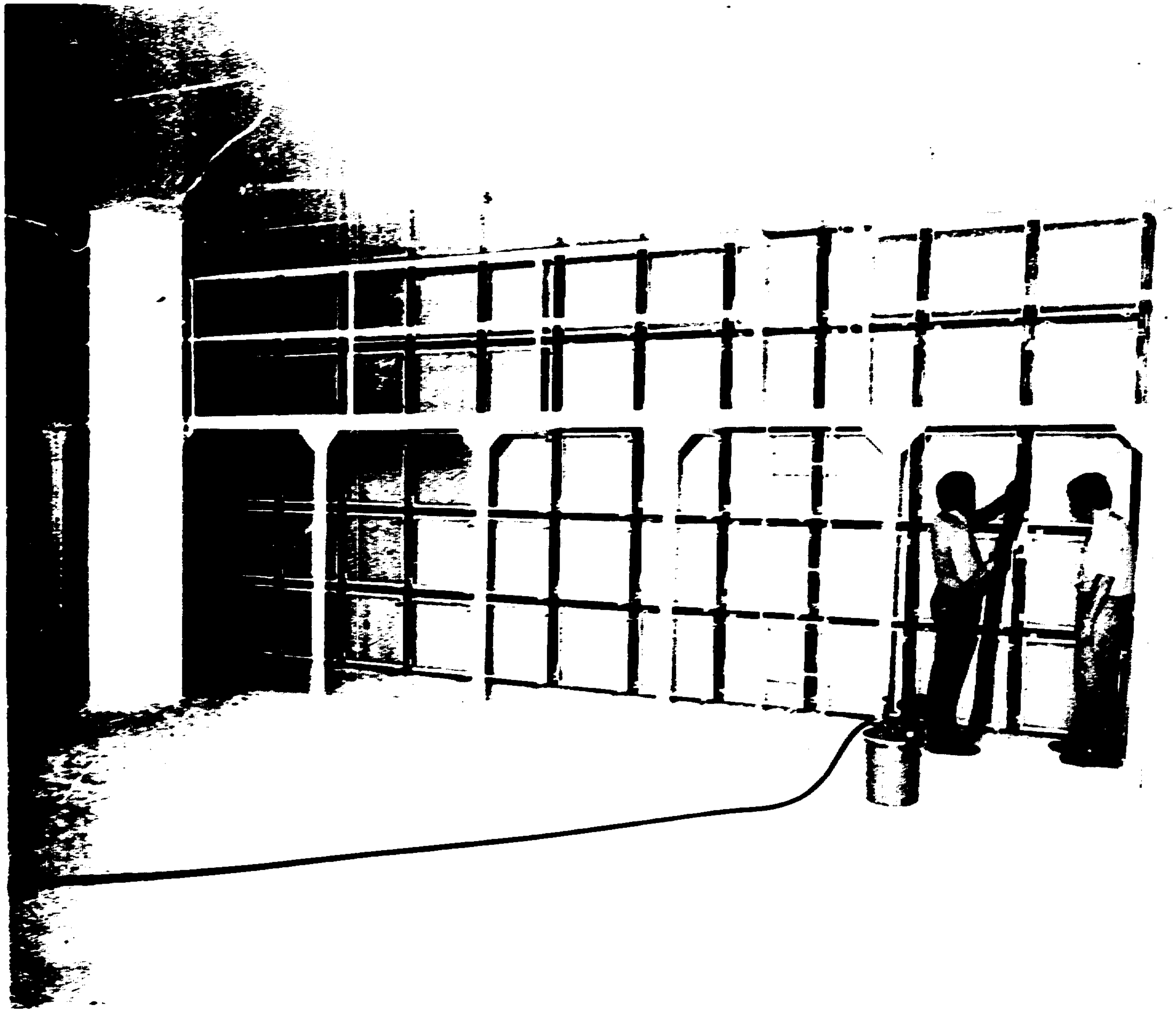
"Figure 3", DP West filter wheel assembly (end view).



"Figure 4", DP West process exhaust (final stage).



"Figure 5", DP West room air exhaust system.



"Figure 6", CMR Building filter leak probe test.

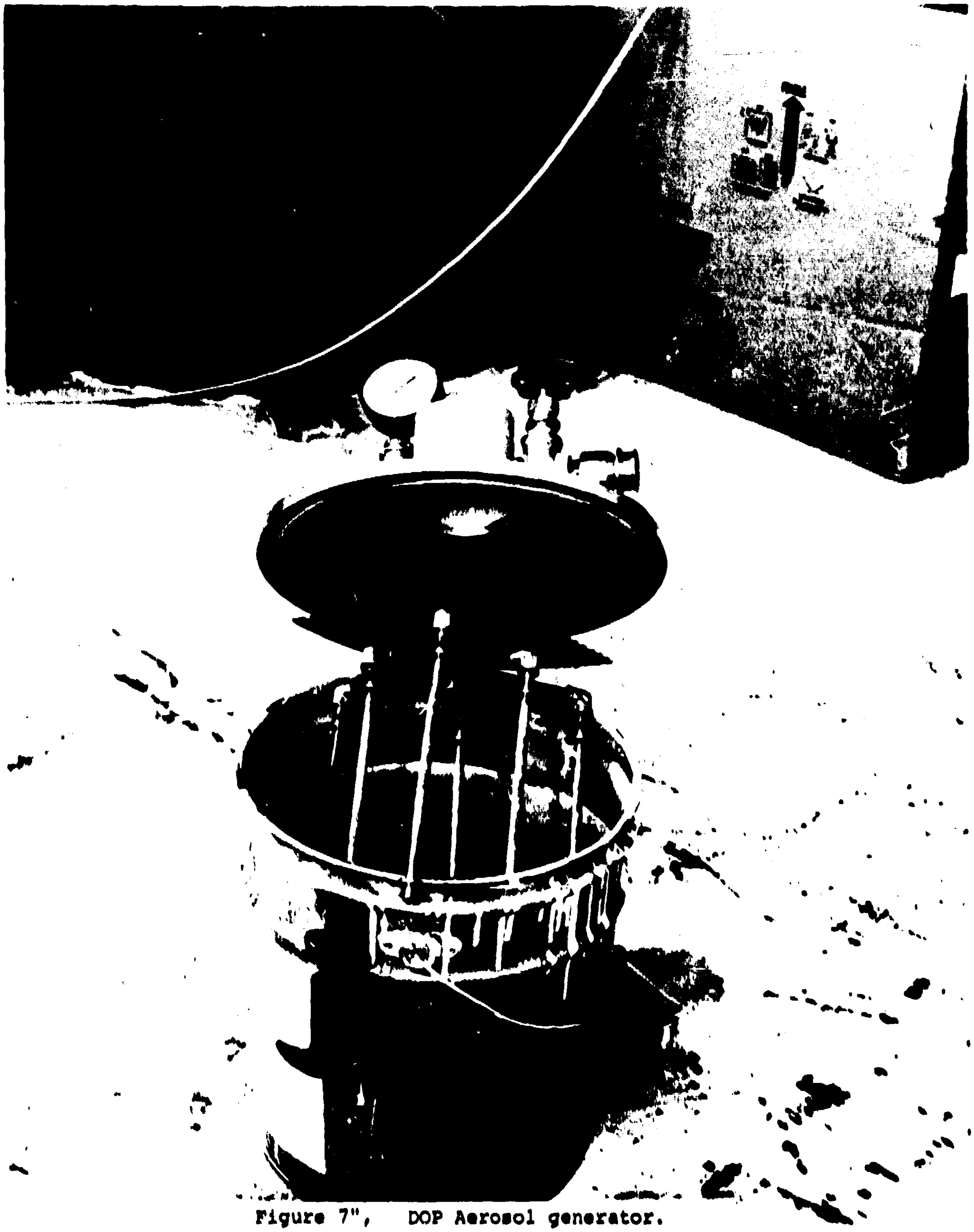
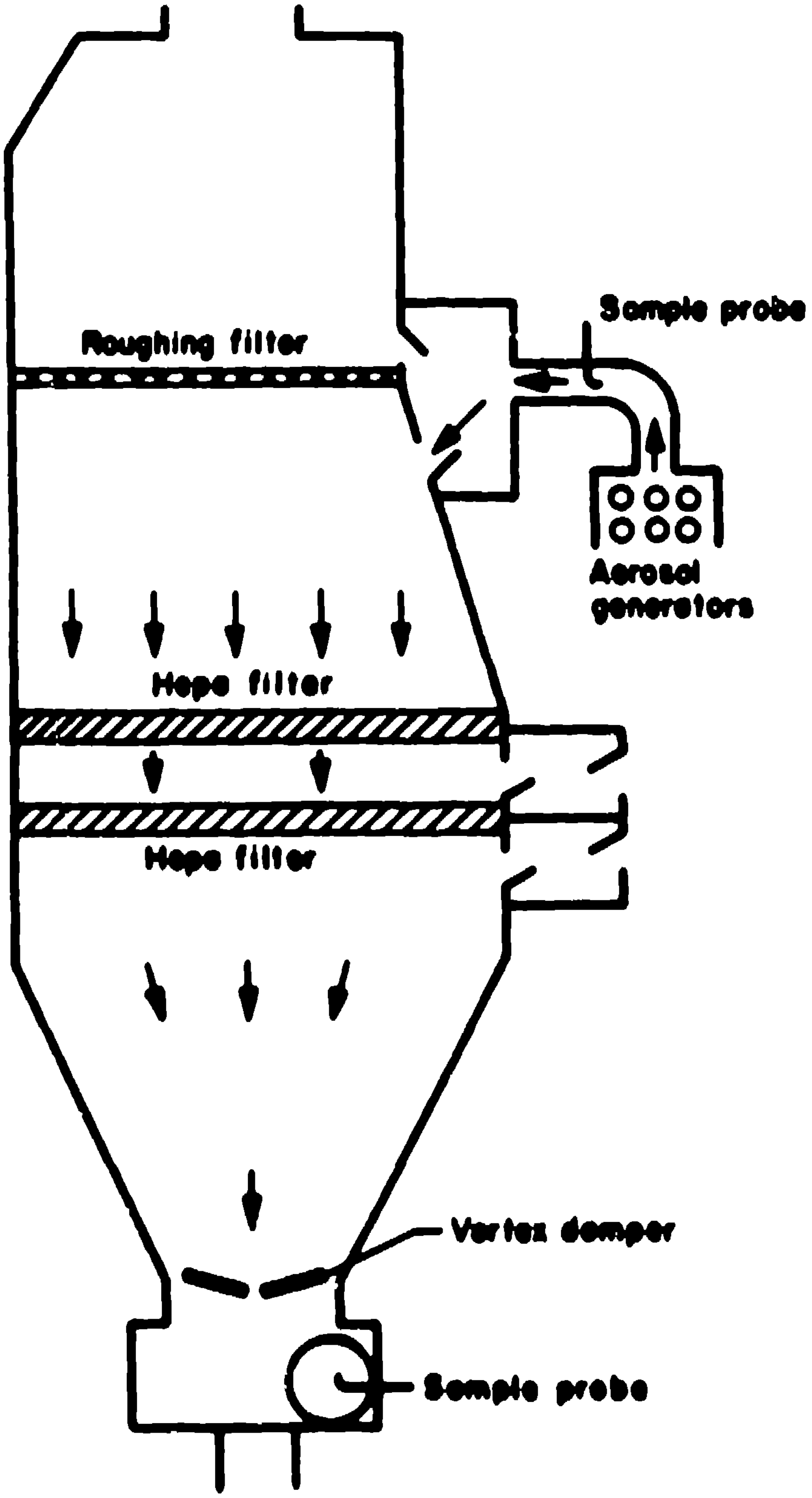
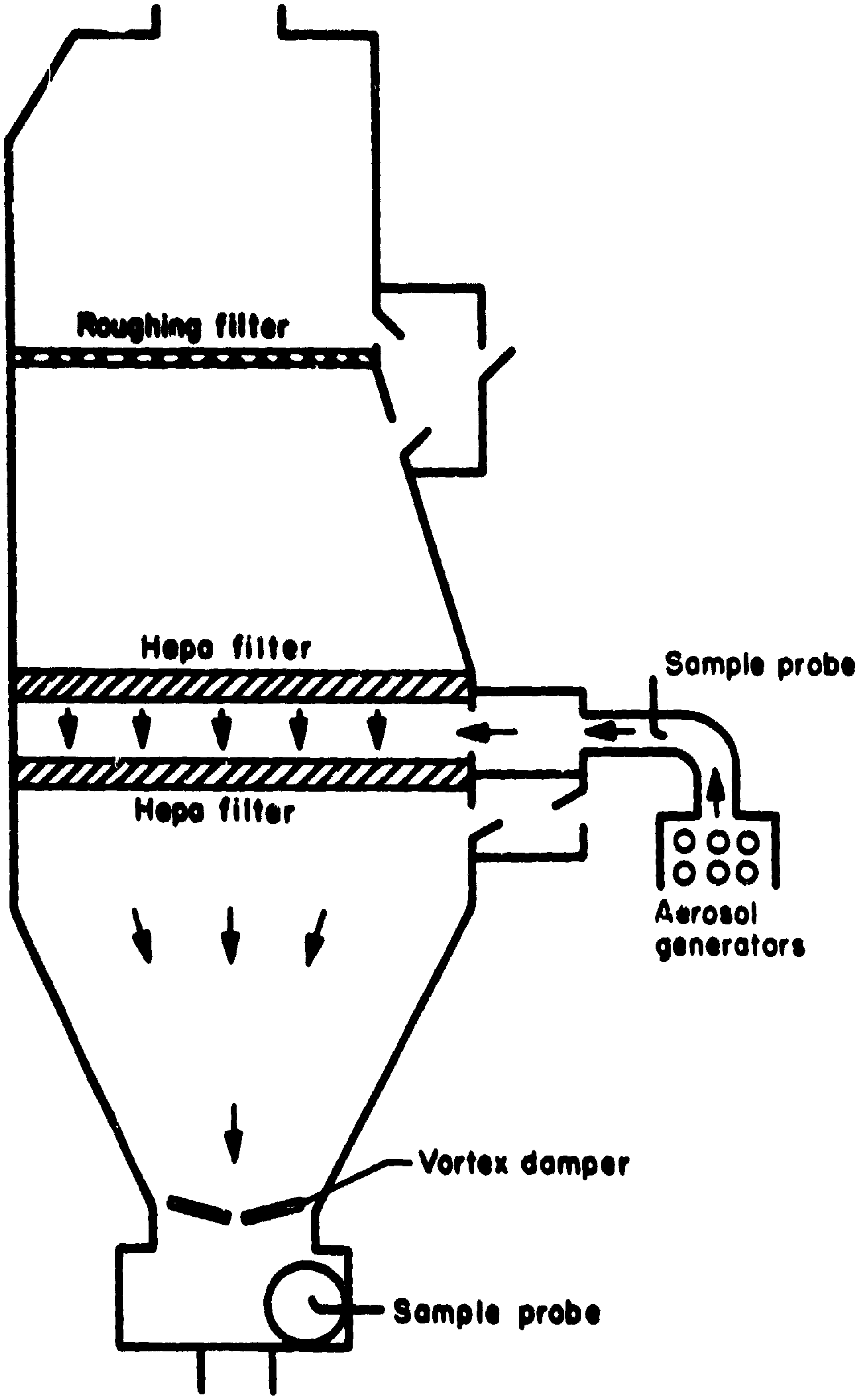


Figure 7", DOP Aerosol generator.

"Figure 8". DOP Aerosol introduction system.



"Figure 9", DOP Testing of the first stage of filters.



"Figure 10". DOP Testing of the second stage of filter.

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