UCN-2383
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CENTRAL FILES NUMBER
CF-61-3-11

DATE: March 3, 1961

COPY NO. 36

SUBJECT: GC-ORR Loop II Filter Tests

TO: Distribution

FROM: F. A. Flint and R. E. MacPherson

ABSTRACT

Tests of Flander's Airpure filters, stock number 6G31R-C, size C, specified for use in the GC-ORR Loop No. 2 as full-flow, primary coolant filters have demonstrated that this equipment is unsatisfactory for the intended application. D.O.P. (dioctylphthalate) efficiency tests were carried out on two filters in the "as received" condition and after typical thermal cycles. Only one unit met the design criteria of 99.9% efficiency for removal of 0.6 micron particles in the "as received" conditions, and this unit was subsequently damaged by thermal cycling.

Introduction

The helium coolant of the GC-ORR No. 2 in-pile loop is to be filtered through a full-flow high-efficiency filter to remove solids which might damage the coolant compressor impeller and gas bearings. It is also hoped that the filter will be effective in limiting the spread of particulate radioactive material. Tests have been conducted in existing experimental facilities of the Reactor Division to determine the adequacy of a proposed filter design. Filter efficiency was measured in the "as received" condition and again, following typical thermal cycling of the units.

Test Specimens

The filters tested were Flander's Airpure, stock number 6G31R-C, size C. They were cylindrically shaped, 12 inches in diameter by 8-3/4 inches long (note Fig. 1). The filtering element was made up of a glass filter paper (F-600) and corrugated separators arranged in a series of folds parallel to the flowstream (note Fig. 2). Each fold contained a corrugated separator. The passages formed by the corrugations of the separators in the upstream folds directed the flow stream to the filter paper, while the passages formed by the corrugations in the separators of the downstream folds served as escape routes (note Figures 2 and 3). The filtering element was attached to a stainless steel cylindrical shell with a silicate adhesive* (a mixture of silica soda, ground silicate, fireclay and asbestos fibers).

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* Made by United Gilsonite Laboratories, Scranton, Pa.

Test Equipment

1. 125 HP centrifugal blower with necessary valving to permit air flows to 5000 cfm at a head of 98 inches of water.

2. Orifice run and necessary valves and instrumentation to measure air flow rate and pressure drop across the test piece.

3. Flander's Airpure filter size C (pre-filter).

4. Filter mount with upstream plenum and upstream and downstream probe holes for conducting D.O.P.* (dioctylphthalate) filter efficiency tests.

5. Aerosol contaminant equipment, upstream and downstream probes, and filter efficiency measuring equipment.**

6. Electrically heated furnace, control panel and associated equipment for thermal cycling tests.

Efficiency Test Procedure

1. Filter unit was installed in the test equipment, as shown in Figures 4 and 5.

2. The blower was started with the throttling valve closed.

3. The air flow through the filter was gradually brought to approximately the desired rate by gradually opening the throttling valve. The filters were tested at an air flow rate equivalent to a helium flow rate of 1000 lb/hr at 314 psia, and 700°F.

4. The equipment was operated until thermal equilibrium was attained before the final flow adjustments were made.

5. Flow data were taken.

6. Contaminant was introduced at the plenum, and filter efficiency data were taken. ***

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* Particle size, .6 micron

** Test equipment furnished by Naval Research Laboratory

*** Efficiency data taken by Naval Research Lab. personnel, Mr. Young and Mr. Echolls

Efficiency Test Results

Unit	Flow Rate	Δ P (in. H_2O) Across Filter	Air Temperature	Air Pressure	Filter Efficiency Percentage
			Before Thermal Cycling		
* 2	522 lb/hr 133 cfm	______	132°F	ATM	99.995
1	572 lb/hr 145 cfm	______	130°F	ATM	86.00
			After Thermal Cycling		
2	287 lb/hr 71 cfm	.75	125°F	ATM	86.00
2	405 lb/hr 101 cfm	1.3	125°F	ATM	____
2	576 lb/hr 146 cfm	2.4	127°F	ATM	83.00

Thermal Cycling Tests

Filter Unit 2 was evacuated to 120 microns, and filled with argon at approximately 10 psig. Difficulty was experienced in evacuating the unit, due to the small size of the evacuation line (1/4-in. o.d. tubing). The filter was brought to a temperature of 700°F in three hours, held at that temperature for a half hour, and then cooled to a temperature of 150°F in three hours. This cycle was repeated three times. Visual inspection, following thermal cycling, revealed the presence of moisture in the filter container. This was corroborated by visual inspection of the vacuum pump, which showed that there had been considerable moisture in the filter or filter container at the time it was pumped down prior to thermal cycling.

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* In order tested

Filter Unit 1 had an efficiency too low to be acceptable (86.00 percent, prior to thermal cyling). However, it was evacuated through a cold trap and thermal cycled to check for the presence of moisture. In order to obtain a better vacuum than had been obtained in Unit 2, Unit 1 was equipped with rubber gaskets, and 1/2-in. o.d. evacuation tube. It was also equipped with a vacuum gage on the end of the filter opposite that to which the vacuum pump was connected. The filter was evacuated to 13 microns on the pump gage and minus 28.25 inches of mercury on the filter container gage. The filter was returned to atmospheric pressure, unflanged, and visually inspected. No evidence of moisture was found in the filter, the cold trap, or the vacuum pump. The filter was then equipped with asbestos gaskets, evacuated to 1300 microns, purged with argon, filled with argon at approximately 10 psig, and heated to a temperature of 700°F in three hours. While at this temperature, the vent valve was opened momentarily and steam escaped. The filter was subsequently cooled, unflanged, and visually inspected. No evidence of moisture was found; however, the gas system was not completely tight and some loss of moisture may have occurred during the thermal cycling period.

Internal Visual Inspection

The pressure vessel of Filter Unit 2 was cut open, and the filter cartridge was visually inspected. The filtering material had a scorched appearance, as compared with the creamy-white appearance of the filtering material in a spare unmounted cartridge (compare Figures 2 and 6). This may have been due to the charring of D.O.P. picked up during the filter efficiency test. No fractures or tears were visible in the filtering material. The mastic, sealing the filtering material to the metal of the cylindrical wall, was cracked in several places (note Fig. 6). However, the bonding mastic of the spare, unmounted cartridge was also cracked in several places (note Fig. 2).

Conclusicns

1. Out of two filter units tested, only one unit demonstrated satisfactory filtering in the as-delivered condition. This may have been due to quality control during fabrication or to damage during delivery and assembly. Reasonable care was taken to avoid mechanical shock during assembly.

2. The filter which demonstrated acceptable efficiency in the as-delivered condition was damaged by moderate thermal cycling or by the handling procedures associated with this test. Again, reasonable care was taken to avoid mechanical shock.

3. Water vapor was outgassed from both filters during thermal cycling. This could have been adsorbed moisture and/or water of hydration in the filter constituents and/or the mounting mastic.

4. Filter units of the type tested are not suited to the intended application without further testing to determine the reason for failure and to demonstrate satisfactory design modifications.

Recommendations

1. If there is a continuing interest in the use of this filter type, the following steps are necessary:

   a. Determine the reason for failure of Filter Unit #1 in the as-delivered condition and take steps to correct.

   b. Determine source of water vapor noted in thermal cycling tests.

   c. Determine whether thermal cycling, per se, is responsible for filter damage.

   d. Determine mechanical shock sensitivity of filter in as-delivered and post-heat condition.

2. Investigate other filters which may satisfy design criteria and conduct a proof-test program on the most promising.

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Fig. 1. Oblique View of Unmounted Filter Cartridge.

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Fig. 2. View of Upstream End, Unmounted Filter Cartridge.

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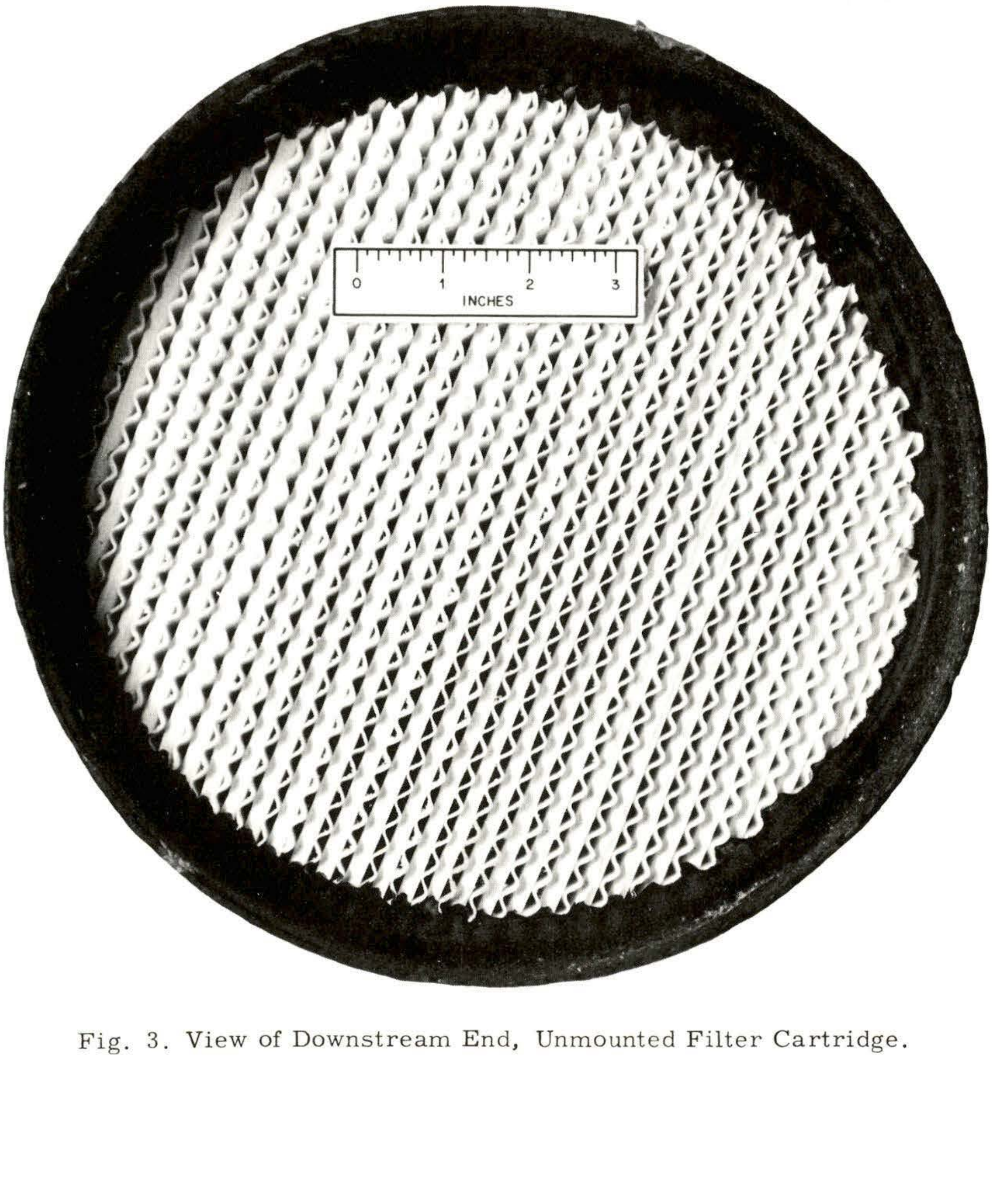

Fig. 3. View of Downstream End, Unmounted Filter Cartridge.

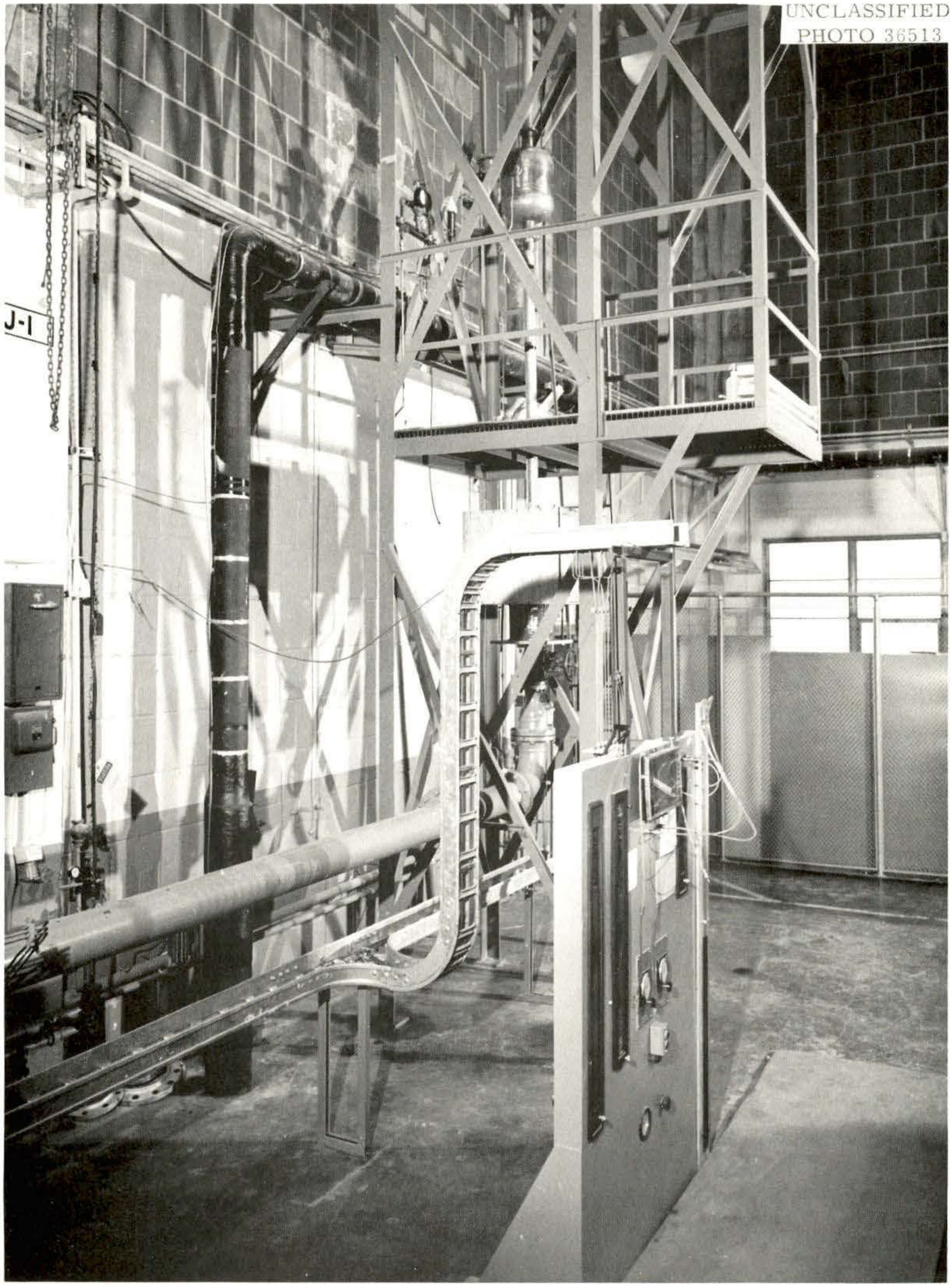

Fig. 4. View of Filter Installed in Test Rig.

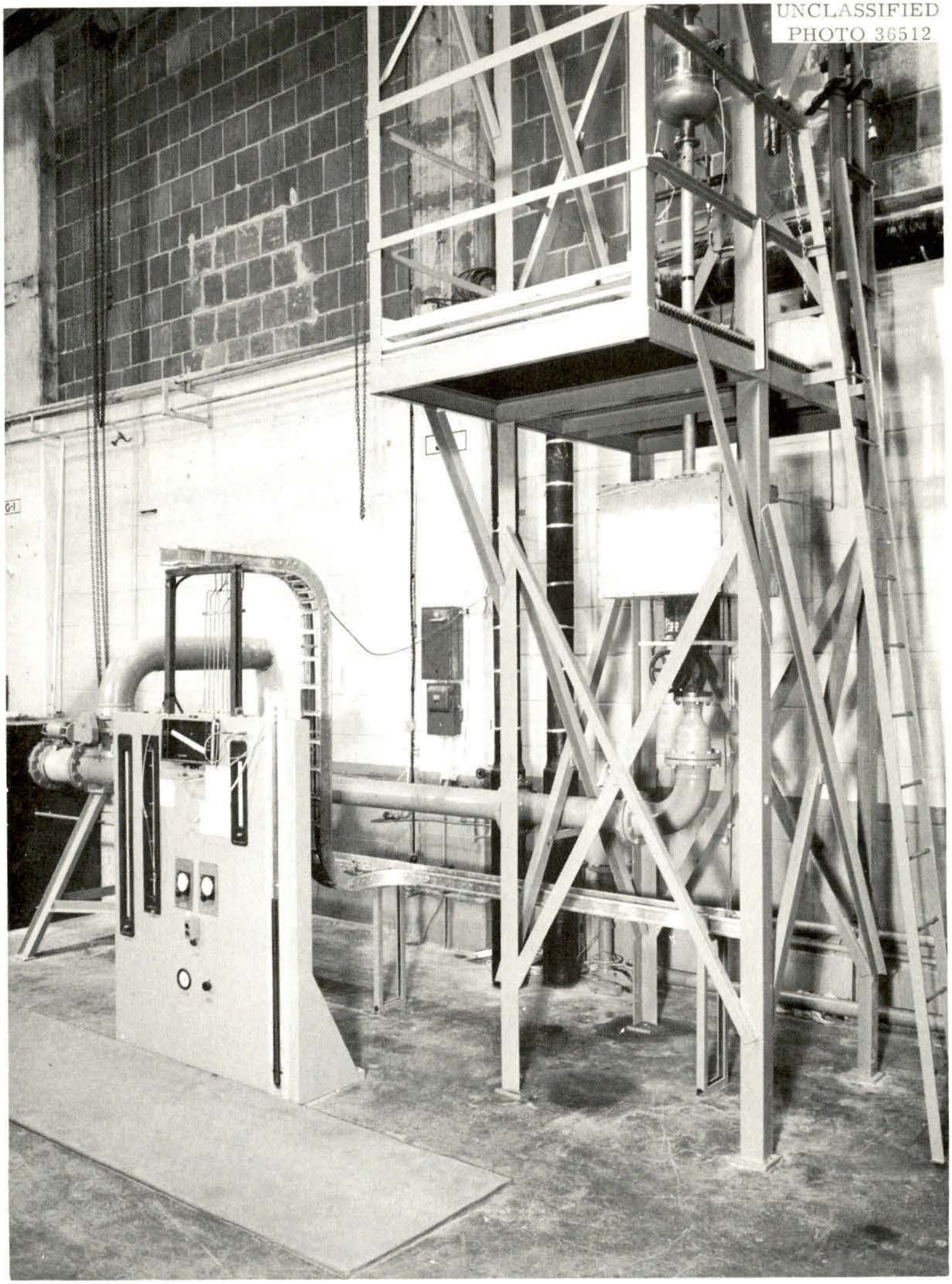

Fig. 5. Alternate View of Filter Installed in Test Rig.

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Fig. 6. Cutaway View of Filter Unit 2.

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Fig. 7. Oblique Cutaway View of Filter Unit 2.

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