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NATIONAL BUREAU OF STANDARDS REPORT

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PERFORMANCE TEST OF THE ROLL-O-TRON
ELECTRONIC AIR CLEANER, MODEL #3-50HV

manufactured by
American Air Filter Company
Louisville, Kentucky

by

Carl W. Coblentz and Paul R. Achenbach

Report to

Public Buildings Service
General Services Administration
Washington, D. C.

U. S. DEPARTMENT OF COMMERCE
NATIONAL BUREAU OF STANDARDS

THE NATIONAL BUREAU OF STANDARDS

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NBS PROJECT **NBS REPORT**

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Mechanical Systems Section
Building Research Division

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U. S. DEPARTMENT OF COMMERCE
NATIONAL BUREAU OF STANDARDS

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1. INTRODUCTION

At the request of the General Services Administration, Public Buildings Service, the performance characteristics of the Roll-O-Tron electronic air cleaner, Model #3-50HV, were determined. The scope of this examination included the determination of the arrestance of the particulate matter in the laboratory air and the pressure drop of the unit, the electrical characteristics of the agglomerator and the dust-holding capacity of the collector at a face velocity of 500 ft/min.

2. DESCRIPTION OF TEST SPECIMEN

The test specimen was manufactured and supplied for test purposes by the American Air Filter Company of Louisville, Kentucky, and was identified as their Roll-O-Tron, Model #3-50HV. The equipment was a combination of an electrostatic precipitator and an automatic renewable media air filter, designed to be used in series. By operating the electrostatic precipitator without adhesive on the collection plates, only a small dust load could accumulate on them. It operated on the principle that the electrostatic precipitator collected small air borne dust particles and agglomerated them on the collector plates. Then, after dust had been deposited to a certain thickness, it is blown off the collector plates by the air stream and drawn into the automatic renewable filter downstream of the precipitator, where the rather large agglomerations are arrested in the glass fiber mat in a much higher proportion than the individual dust particles would have been.

The test specimen was designed for an air flow rate of 5,000 cfm at a face velocity of 500 ft/min. By reducing the open area to 24 x 24 in. to match the cross section of the test duct while maintaining the 500 ft/in. face velocity the performance characteristics of the device were not significantly altered while the air flow rate of 2,000 cfm was commensurate with the capacity of the NBS test apparatus.

The two identical agglomerator units comprising the electrostatic precipitator were installed one above the other in the same housing used for the automatic renewable filter. The individual agglomerator units as well as the renewable glass fiber medium were essentially the same design as those of the Electrocell and Roll-O-Matic units, respectively, manufactured by the American Air Filter Company and previously described in NBS Reports 6952 and 6947 . The type SG-5V power pack used a full-wave voltage-doubler rectifier circuit for the ionizer supply and a half-wave rectifier for the plate supply.

3. TEST METHOD AND PROCEDURE

The arrestance determinations of the test specimen were made with the particulate matter in the laboratory air as the aerosol using the NBS Dust Spot Method as described in a paper by R. S. Dill entitled "A Test Method for Air Filters" (ASHVE Transactions, Vol. 44, p. 379, 1938).

The device was installed in the test apparatus and carefully sealed to prevent bypass of air or inward leakage into the test apparatus except through the measuring orifice. Samples of air were drawn from the center points of the test duct 2 feet upstream and 8 feet downstream of the filter at equal rates and passed through equal areas of Whatman No. 41 filter paper. The light transmission of each sampling paper was measured before and after each arrestance determination on the same area of the papers. The two papers used for any one arrestance determination were selected to have the same light transmission when clean. A similar increase of the opacity of

the two sampling papers was obtained by passing the sampling air through the upstream paper only part of the time while operating the downstream sampler continuously. This was accomplished by installing one solenoid valve in the upstream sampling line and another one in a line bypassing the sampler. The solenoid valves were operated by an electric timer and a relay so that one was open while the other one was closed during any desired percentage of the 5-minute timer cycle, reversing the position of the two valves during the remainder of the cycle. The arrestance, A (in percent), was then determined with the formula:

$$A = 100 - T \times \frac{\Delta D}{\Delta U}$$

where T is the percentage of time during which air was drawn through the upstream sampler, and ΔU and ΔD are the observed changes in the opacity of the upstream and downstream sampling paper, respectively.

Arrestance determinations were made at the beginning and at the end of the test and at several intermediate loading conditions. The filter was loaded with Cottrell precipitate to which cotton linters were added in a ratio of 4 parts to every 96 parts of Cottrell precipitate. The Cottrell precipitate had been previously sifted through a 100-mesh screen and was injected into the air stream at a ratio of 1 gram per 1,000 cu. ft. of air. The lint was prepared by grinding No. 7 cotton linters through a Wiley mill with a 4-millimeter screen.

The pressure drop across the device was recorded at the beginning of the test, after the introduction of each 20-gram increment of Cottrell precipitate into the test duct, and after each arrestance determination.

The power pack was connected to the laboratory electric supply line through a variable voltage transformer and the inoizer and plate voltages were measured with the input voltage adjusted to 115 volts. While the input voltage to the power pack was allowed to drift with the line voltage between readings, it was adjusted to its original value before subsequent readings of the D.C. potentials, which were taken with an electrostatic kilovoltmeter. With the input voltage

to the power pack adjusted to 115 volts transformer taps were selected that furnished an ionizer potential of 13,300 volts and a plate voltage of 5,400 volts.

A number of arrestance determinations were made during the early part of the test which indicated an average value of 88 percent. In order to improve the arrestance of the unit the factory representative, who attended the test, changed the ionizer wires to a smaller size and placed a metal strip, about 1 inch wide between the two agglomerator sections to close an air gap between them. These modifications were made to improve the ionization without increasing the potential and also to prevent the flow of un-ionized aerosol between the two sections of the agglomerator.

4. TEST RESULTS

Table 1 shows the performance of the device during the second half of the test. While 1376g of dust, i.e. 688g/ft. width, were introduced into the test apparatus the media advanced 27 in. in 6 increments ranging from 3 1/2 in. to 5 1/2 in. Seven arrestance determinations made during this time showed values ranging from 89.7 percent to 91.2 percent, averaging 90.7 percent.

The medium was then advanced approximately 3 ft. and another arrestance determination was made using a clean portion of the media as the collector. The arrestance was 90.9 percent, then, indicating that the loading condition did not measurably affect the arrestance of the device. When the metal strip that had been placed between the two agglomerator sections to close an air gap was removed, the arrestance decreased to 88.7 percent. This indicates that un-ionized aerosol leaking between the two agglomerator sections had reduced the arrestance significantly. Though not experimentally proven, it appears that the installation of this metal strip had a larger effect in improving the arrestance than the increase in size of the ionizing wires.

The pressure drop across the complete device ranged from 0.352 to 0.460 in. W.G. during the test. The average pressure drop at the beginning of the media advance cycle was 0.458 in. W.G. and at the end of the advance cycle was 0.370 in. W.G., corresponding to an average pressure differential of 0.088 in. W.G.

The "Dust-Holding Capacity" of the filter media, i.e. the dust load received per unit area, was computed from Figure 1. This figure shows the cumulative advance values plotted against the cumulative dust load and the straight line that best fitted the individual points of the observation. The slope of this line expressed the dust-holding capacity of the mat. According to the graph, while the media advanced 26 in., from the 20-inch position to the 46-inch position, the dust load increased from 967g/ft. width to 1637g/ft. width or by 670g/ft. width. The dust-holding capacity, D, was therefore:

$$D = 670 \times \frac{12}{26} = 309\text{g/sq.ft.}$$

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TABLE 1

Performance of Roll-O-Tron Electronic Air Cleaner

Model #3-50HV

Dust Load g/ft. width	Mat Travel, In. Advance	Total	Pressure Drop, in. W.G. Start	End	Arrestance %
937	--	19 1/2	0.360	0.360	90.9
937	--	19 1/2	0.360	0.360	91.2
1062	3 1/2	23	0.458	0.388	--
1166	5 1/2	28 1/2	0.460	0.352	--
1312	4	32 1/2	0.458	0.370	--
1427	5	36 1/2	0.459	0.380	--
1438	--	36 1/2	0.398	0.398	89.8
1438	--	36 1/2	0.398	0.398	89.7
1520	5	41 1/2	0.458	0.370	--
1608	--	41 1/2	0.439	0.439	91.1
1625	5	46 1/2	0.454	0.360	--
1625	--	46 1/2	0.360	0.360	90.7
1625	--	46 1/2	0.360	0.360	91.2

MAT TRAVEL V/S DUST LOAD

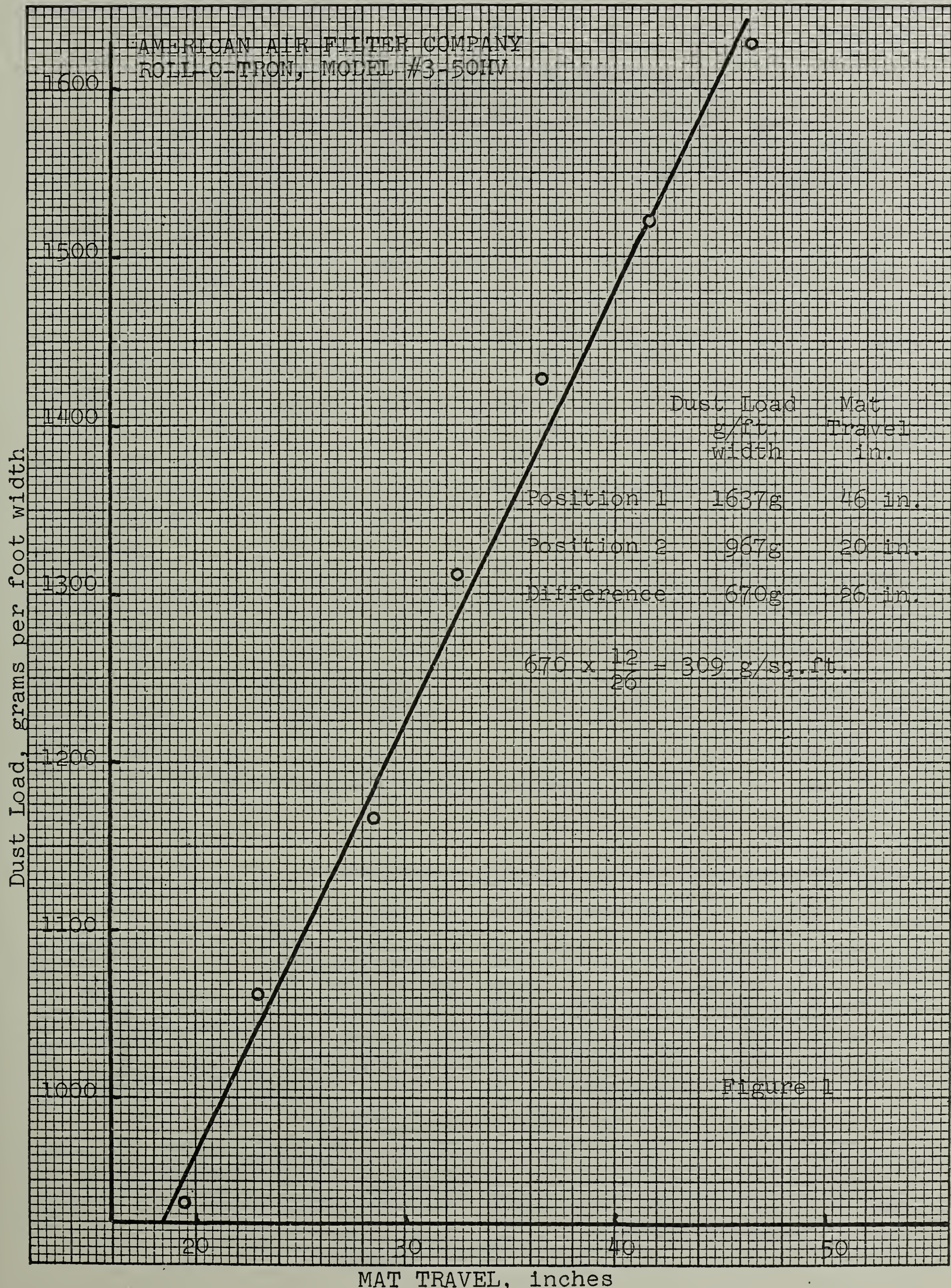

Figure 1

U. S. DEPARTMENT OF COMMERCE
Luther H. Hodges, *Secretary*

NATIONAL BUREAU OF STANDARDS
A. V. Astin, *Director*

THE NATIONAL BUREAU OF STANDARDS

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WASHINGTON, D. C.

Electricity. Resistance and Reactance. Electrochemistry. Electrical Instruments. Magnetic Measurements. Dielectrics. High Voltage.

Metrology. Photometry and Colorimetry. Refractometry. Photographic Research. Length. Engineering Metrology. Mass and Scale. Volumetry and Densimetry.

Heat. Temperature Physics. Heat Measurements. Cryogenic Physics. Equation of State. Statistical Physics.

Radiation Physics. X-ray. Radioactivity. Radiation Theory. High Energy Radiation. Radiological Equipment. Nucleonic Instrumentation. Neutron Physics.

Analytical and Inorganic Chemistry. Pure Substances. Spectrochemistry. Solution Chemistry. Standard Reference Materials. Applied Analytical Research. Crystal Chemistry.

Mechanics. Sound. Pressure and Vacuum. Fluid Mechanics. Engineering Mechanics. Rheology. Combustion Controls.

Polymers. Macromolecules: Synthesis and Structure. Polymer Chemistry. Polymer Physics. Polymer Characterization. Polymer Evaluation and Testing. Applied Polymer Standards and Research. Dental Research.

Metallurgy. Engineering Metallurgy. Microscopy and Diffraction. Metal Reactions. Metal Physics. Electrolysis and Metal Deposition.

Inorganic Solids. Engineering Ceramics. Glass. Solid State Chemistry. Crystal Growth. Physical Properties. Crystallography.

Building Research. Structural Engineering. Fire Research. Mechanical Systems. Organic Building Materials. Codes and Safety Standards. Heat Transfer. Inorganic Building Materials. Metallic Building Materials.

Applied Mathematics. Numerical Analysis. Computation. Statistical Engineering. Mathematical Physics. Operations Research.

Data Processing Systems. Components and Techniques. Computer Technology. Measurements Automation. Engineering Applications. Systems Analysis.

Atomic Physics. Spectroscopy. Infrared Spectroscopy. Far Ultraviolet Physics. Solid State Physics. Electron Physics. Atomic Physics. Plasma Spectroscopy.

Instrumentation. Engineering Electronics. Electron Devices. Electronic Instrumentation. Mechanical Instruments. Basic Instrumentation.

Physical Chemistry. Thermochemistry. Surface Chemistry. Organic Chemistry. Molecular Spectroscopy. Elementary Processes. Mass Spectrometry. Photochemistry and Radiation Chemistry.

Office of Weights and Measures.

BOULDER, COLO.

Cryogenic Engineering Laboratory. Cryogenic Equipment. Cryogenic Processes. Properties of Materials. Cryogenic Technical Services.

CENTRAL RADIO PROPAGATION LABORATORY

Ionosphere Research and Propagation. Low Frequency and Very Low Frequency Research. Ionosphere Research. Prediction Services. Sun-Earth Relationships. Field Engineering. Radio Warning Services. Vertical Soundings Research.

Radio Propagation Engineering. Data Reduction Instrumentation. Radio Noise. Tropospheric Measurements. Tropospheric Analysis. Propagation-Terrain Effects. Radio-Meteorology. Lower Atmosphere Physics.

Radio Systems. Applied Electromagnetic Theory. High Frequency and Very High Frequency Research. Frequency Utilization. Modulation Research. Antenna Research. Radiodetermination.

Upper Atmosphere and Space Physics. Upper Atmosphere and Plasma Physics. High Latitude Ionosphere Physics. Ionosphere and Exosphere Scatter. Airglow and Aurora. Ionospheric Radio Astronomy.

RADIO STANDARDS LABORATORY

Radio Physics. Radio Broadcast Service. Radio and Microwave Materials. Atomic Frequency and Time-Interval Standards. Radio Plasma. Millimeter-Wave Research.

Circuit Standards. High Frequency Electrical Standards. High Frequency Calibration Services. High Frequency Impedance Standards. Microwave Calibration Services. Microwave Circuit Standards. Low Frequency Calibration Services.

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