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NATIONAL BUREAU OF STANDARDS REPORT

7892

PERFORMANCE TEST OF A WESTINGHOUSE ELECTROSTATIC AIR CLEANER, PRECIPITRON VB-012

manufactured by
Westinghouse Electric Corporation
Staunton, Virginia

by

Carl W. Coblentz and Paul R. Achenbach

Report to

General Services Administration
Public Buildings Service
Washington 25, D.C.

NBS

U. S. DEPARTMENT OF COMMERCE
NATIONAL BUREAU OF STANDARDS

THE NATIONAL BUREAU OF STANDARDS

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Carl W. Coblentz and Paul R. Achenbach
Mechanical Systems Section
Building Research Division

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PERFORMANCE TEST OF A WESTINGHOUSE ELECTROSTATIC AIR CLEANER, PRECIPITRON VB-012

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1. INTRODUCTION

At the request of the Public Buildings Service, General Services Administration, the performance characteristics of an electrostatic air cleaner, Precipitron VB-012, manufactured by the Westinghouse Electric Corporation, Staunton, Virginia, were determined. The scope of this examination included the determination of the arrestance of the particulate matter in the laboratory air at different face velocities and at different ionizer potentials, as well as the determination of the pressure drop of the device and its electric current requirements.

2. DESCRIPTION OF THE TEST SPECIMEN

The test specimen was supplied by the Air Conditioning Division of Westinghouse Electric Corporation, Staunton, Virginia. It was a redesign of this company's commercial electrostatic precipitator which was described in NBS Report 6498, dated August 5, 1959. The device was designed for use in residences with forced hot air heating systems where a higher degree of air purification is desired than can be obtained with the conventional type of furnace filters.

The outside dimensions of the filter were 28 x 22 1/2 x 18 1/2 in., the air inlet measured 24 x 18 1/4 in., and the outlet measured 16 3/16 x 14 1/4 in. The air flowed first through the pre-filter which consisted of two identical pleated foam filters, installed side by side, each about 15 3/4 x 10 3/4 1 3/4 in. with a total media area of about 3.4 sq. ft. The medium was made of plastic foam approximately

45 pores per square inch and 1/8 in. thick. Each of the two ionizer and collector sections had a face area of 13 1/4 x 10 3/4 in., i.e., 2 sq. ft. total face area for the two sections. There were 7 ionizer wires in each section. The 31 collector plates in each section were 10 3/4 in. long and spaced 0.34 in. center-to-center, with a total plate area of approximately 65 sq. ft. The pre-filters as well as the ionizer and collector sections could be removed individually from the housing for the purpose of cleaning.

The frames of the ionizer and collector sections were grounded to the housing, while the ionizer wires and the charged plates were connected to the positive side of the power pack by means of insulated contact springs mounted inside the panel door. The power pack was installed inside the housing and was equipped with a rheostat in series with the primary winding of the transformer to adjust the ionizer voltage according to the operating conditions. The transformer output was rectified by means of a conventional half-wave doubler arrangement. Both ionizer wires and collector plates were operated at the same D.C. potential.

After completion of the test, it was noted that the performance determined with the test specimen did not agree with the values observed in the factory laboratories. It was then found that the outlet area should have been enlarged to permit free passage of the effluent air over the full width of the collector sections. The housing was designed for devices with different air flow rates and had an original outlet opening commensurate with a single ionizer - collector set. It was to be cut out when installed to match the existing duct system, but it should not be smaller than the collector area. The outlet area was enlarged from 16 3/16 x 14 1/8 in. to 22 1/2 x 14 1/8 in., i.e., from approximately 0.8 to 1.2 times the face area.

3. TEST METHOD AND PROCEDURE

The arrestance determinations were made in accordance with the NBS Dust Spot Method described in a paper by R. S. Dill entitled "A Test Method for Air Filters" (ASHVE Transactions, Vol. 44, p. 379, 1938). After the device was installed in the air filter test apparatus, it was carefully sealed to prevent inward leakage through cracks. 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 paper. 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 drawn through the upstream sampler, and ΔU and ΔD are the observed changes in the opacity of the upstream and downstream sampling paper, respectively.

The power pack was connected to the laboratory electric supply line through a variable transformer and the performance of the device was determined at four different input voltages to the power pack ranging from 90 volts to 120 volts with a fixed medium setting of the series rheostat. The ionizer potential was measured with an electrostatic kilovoltmeter. The input current was also observed. Arrestance measurements were conducted at six air flow rates ranging from 600 cfm to 1600 cfm in 200 cfm steps, i.e., at face velocities of 300 ft/min. to 800 ft/min. corresponding to the 2 sq. ft. free area of the inoizer and collector sections.

After a series of arrestance determinations had been made with the particulate matter in the laboratory air as the aerosol, it was planned to determine the dust-holding capacity of the device by introducing Cottrell precipitate at a rate of 1 gram per 1000 cu. ft. of air. This test had to be discontinued when it was noticed that the feeding of Cottrell precipitate produced an excessive arcing of the device and that the arcing decreased only to approximately one discharge per second when the potential was lowered to 7,200 volts.

4. TEST RESULTS

The arrestance values determined at different face velocities and ionizer voltages with the original outlet area of 16 3/16 x 14 1/4 in. are shown in Table 1.

TABLE 1

Observed Arrestance Values at Different Face Velocities and Ionizer Voltages

Voltage		Face Velocity, ft/min.					
Supply	Ionizer	300	400	500	600	700	800
90	7,450	93.5	--	--	76.8	69.5	--
100	7,850	--	--	86.5	80.6	--	69.0
110	8,200	--	--	88.8	--	--	--
120	8,550	95.0	94.2	90.6	86.8	--	79.4

By plotting the arrestance values and ionizer voltages in Figure 1, a family of smooth curves could be drawn that show with acceptable accuracy the arrestance at each of the six face velocities at varying ionizer voltages. It will be noted that the highest arrestance values of 95.0 percent was observed at the lowest face velocity of 300 ft/min. and the lowest arrestance of 69 percent was determined at 800 ft/min. face velocity. The effect of the ionizer voltage became increasingly greater with higher face velocity, whereas the difference of arrestance between the lowest recommended ionizer voltage of 7,500 volts and the highest of 8,500 volts was only about 1.4 percent (93.6 - 95.0 percent) at 300 ft/min. face velocity, the difference at 800 ft/min. face velocity was approximately 16.7 percent (63.0 - 79.7 percent).

The dashed curves in Figure 2 were obtained by cross-plotting from Figure 1 the values of arrestance and face velocity for three selected ionizer voltages. The convergence of these curves at the lowest observed face velocity indicated a small difference in arrestance resulting from changes of the ionizer voltage, as revealed by an almost flat curve in Figure 1. Also shown in Figure 2 are three arrestance values observed after the outlet area was increased from 16 3/16 x 14 1/8 in. to 22 1/2 x 14 1/8 in., and a family of three solid lines was drawn analogous to the dashed lines to present a close approximation to the performance that could be expected for a range of face velocities and ionizer voltages when the device was operated with the correct outlet area. Values taken from Figure 2 are shown in Table 2.

TABLE 2

Arrestance Values at Different Face Velocities and Ionizer Voltages

(Extrapolated from Fig. 2, for Enlarged Outlet Area)

Ionizer	Face Veclcity, ft/min.					
Voltage	300	400	500	600	700	800
7,500	94.0	90.9	86.2	81.0	75.5	70.0*
8,000	94.8	92.7	89.4	85.7	81.8	77.9
8,500	95.6	94.7	92.7*	90.2	87.5	84.7*

*Observed values

The above values, though determined by a graphical similarity procedure, are believed to correspond to the arrestance of the device when operated at the design outlet area within about ±1/2 percent.

The overall performance of the power pack is shown in Table 3, indicating the effect of the supply voltage on the ionizer voltage, the maximum and minimum values obtained by means of the adjustable series rheostat, and the values of the supply current demand.

TABLE 3

Performance of Power Pack

AC SUPPLY CHARACTERISTICS			IONIZER VOLT. RANGE		TEST VALUES	
	Current	Amp.			DC	AC
Volts	Min.	Max.	Min.	Max.	Voltage	Amp.
90	0.22	0.33	7,000	7,900	7,450	0.26
100	0.26	0.40	7,300	8,350	7,850	0.32
110	0.30	0.47	7,650	8,750	8,200	0.37
120	0.34	0.55	7,950	9,100	8,550	0.42

It will be noted that an increase of 30 percent in the ionizer voltage, from 7,000 volts to 9,100 volts, produced a supply current increase from 0.22 amp. to 0.55 amp., i.e., 150 percent. However, no change of the ionizer voltage nor the supply current was observed as an effect of a change in the air flow rate.

No discharges in the ionizer or collector were noticed when the device was operated with laboratory air. When Cottrell precipitate was added to the air stream, the arcing produced drops of the ionizer voltage to about half its operating value with a noticeable increase in the supply current.

The pressure drop across the test specimen is shown in Table 4 at different face velocities and with the original outlet area of 16 3/16 x 14 1/4 in. and also after the outlet area was enlarged to 22 1/2 x 14 1/4 in.

TABLE 4

Pressure Drop across Filter

Face Velocity ft/min.	Pressure Drop, in. W.G. Orig. Outlet	Enlarged Outlet
300	0.058	0.055
400	0.093	0.080
500	0.140	0.115
600	0.193	0.161
700	0.255	0.210
800	0.320	0.265

The values presented in this table are plotted as smooth curves in Figure 3 showing that the decrease in pressure drop resulting from enlarging the outlet area was insignificant when the device was operated at low air flow rates, but becomes quite considerable at the higher flow rates.

Arrestance v/s Plate Voltage at Different Face Velocities

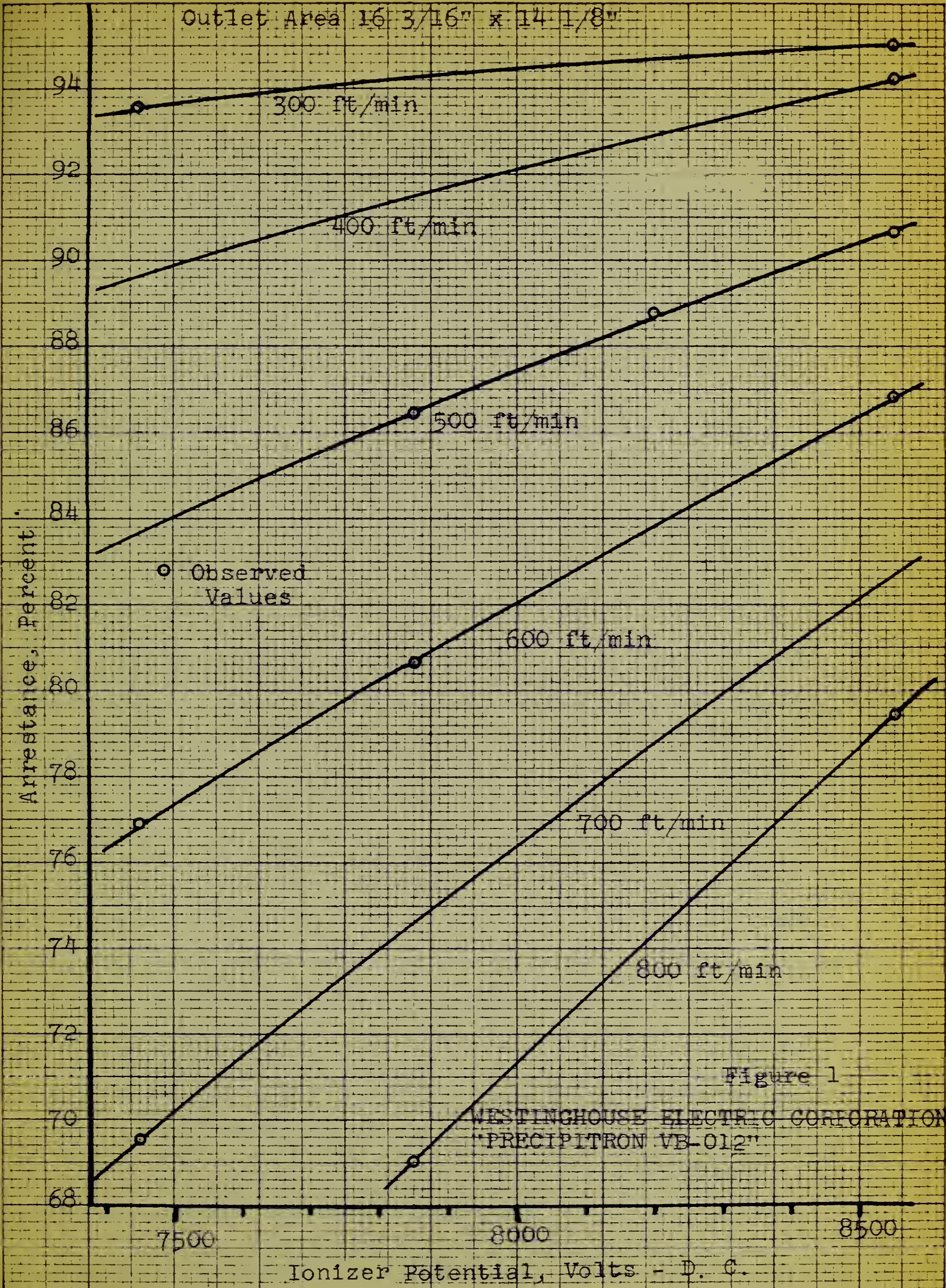


Figure 1

WESTINGHOUSE ELECTRIC CORPORATION
"PRECIPITRON VB-012"

Arrestance v/s Face Velocity at Different Inoizer Voltages

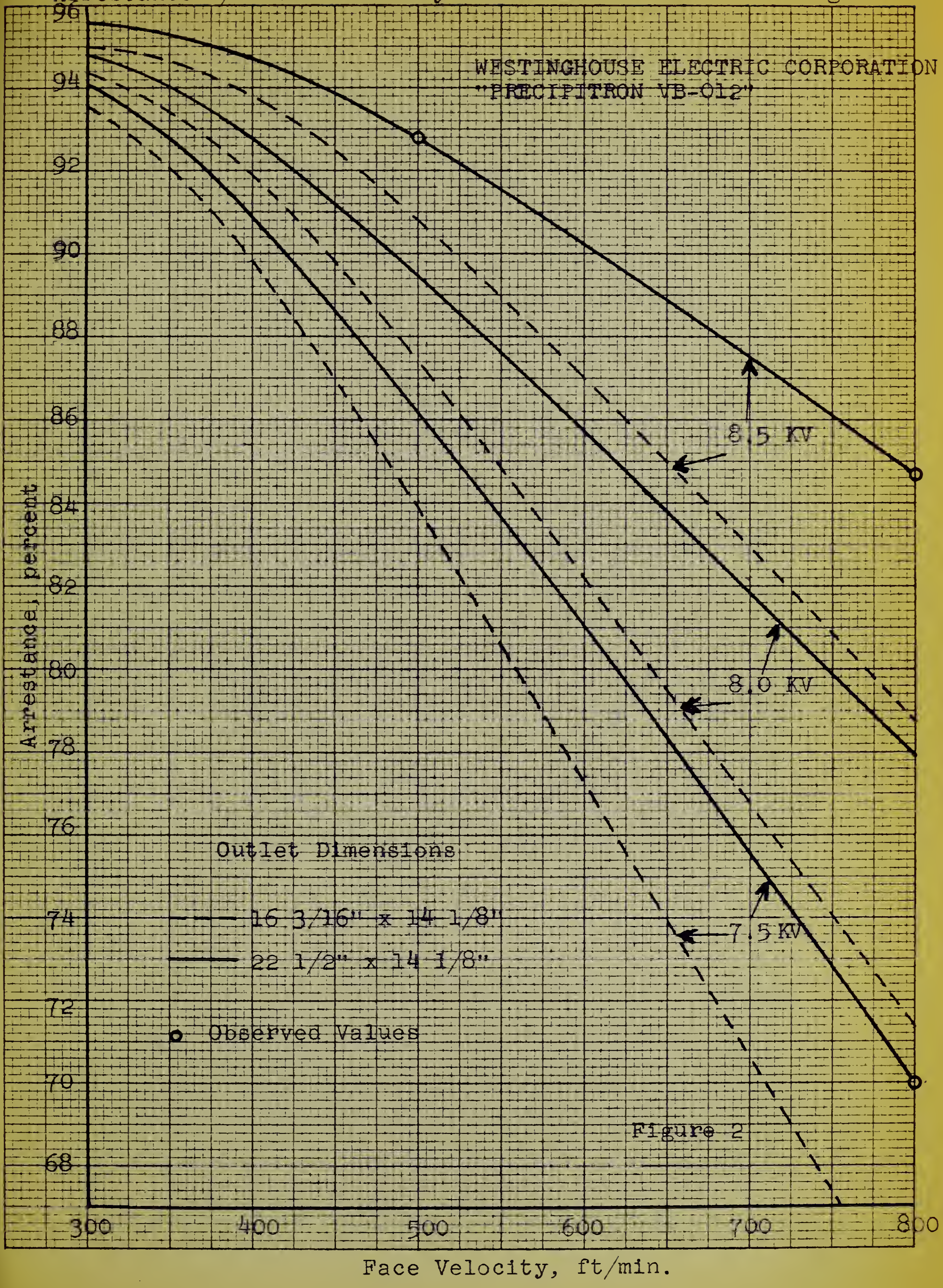
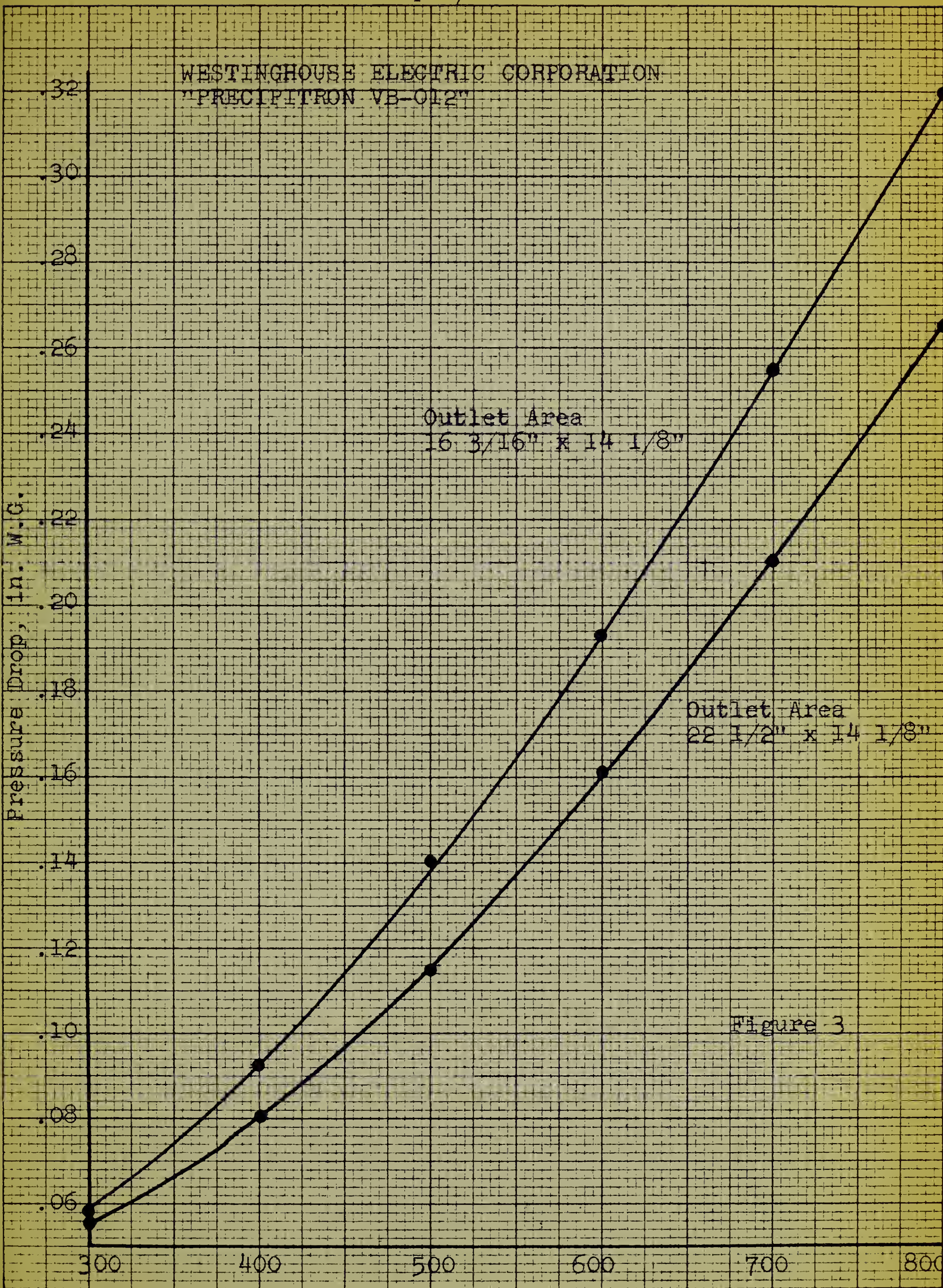


Figure 2

Pressure Drop v/s Air Flow Rate



Face Velocity ft/min.

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BOULDER, COLO.

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

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Joint Institute for Laboratory Astrophysics-NBS Group (Univ. of Colo.).

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