NATIONAL BUREAU OF STANDARDS REPORT

6250

PERFORMANCE TESTS OF AN AUTOMATIC RENEWABLE MEDIA AIR FILTER WITH TWO FILTER MEDIA, CONOMATIC, MODEL 3-C90

MANUFACTURED BY
CONTINENTAL AIR FILTERS, INC.
LOUISVILLE, KENTUCKY

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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NBS PROJECT
1000-30-4830

NBS REPORT
6250

December 23, 1958

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1. Introduction

At the request of the Public Buildings Service, General Services Administration, the performance characteristics of a Conomatic, automatically-renewable media type air filter were determined with a glass fiber and with a plastic fiber filter media. The scope of this investigation included the determination of arrestance of atmospheric dust and Cottrell precipitate, the dust holding capacity per unit area of filter media and the characteristics of the automatic movement of the filter media.

2. Description of Test Specimen

The test specimen was manufactured and supplied for test by Continental Air Filters, Inc., of Louisville, Kentucky, and was identified as their type "Conomatic 3-C90". It was modified for installation in the NBS test apparatus by building a sheet metal housing around it and providing upstream and downstream transition sections, 24 in. square inside, to fit the test duct. This modification was necessary for the adaptation of the filter and did not affect the performance of the equipment.

The "Conomatic" filter was designed to move a long blanket or mat of filter medium across the air flow opening in the housing by intermittent feed under automatic control. A roll of the clean medium was held at the top of the housing from which it was unrolled as needed by a spool at the bottom of the housing. The lower spool was driven by a 1/6 HP electric motor and a reduction gear which was connected to a sprocket wheel by a standard gear chain. This sprocket wheel was directly coupled to the empty spool at the bottom of the housing on which the soiled filter media was rolled up. In passing from the clean roll at the top to the bottom roll the media was backed up by a stationary vertical grid that prevented the media from being stretched by the air flow as it passed across the air stream.

The movement of the blanket was controlled by a differential pressure switch built by the Republic Auto Gas Corporation. This control started the electric motor when the pressure drop across the medium had risen to a preselected value and stopped it when the pressure drop was reduced by an increment of almost 0.05 in. W.G. by feeding some clean media into the air stream. The speed of the lower spool while moving the media was about 1 RPM. Depending on how much media had been wound up on the lower spool the rate of feed of the filter media during these periods varied from about 1 ft/min to 3 ft/min.

Two different filter media were furnished with the unit. One was a 2-inch thick Fiberglas mat for general use and the other one consisted of a 1/2-inch thick light plastic felt for use in food processing plants or where the user wanted to guard against the possible contamination of the air with glass fiber particles. The media width was 32 in. for both materials.

3. Test Method and Procedure

Arrestance determinations were made with the NBS "Dust Spot Method" using the following aerosols: (a) air drawn from the laboratory without addition of other dust or contaminant and (b) Cottrell precipitate. The test method is described in the paper "A Test Method for Air Filters" by R. S. Dill (ASHVE Transactions, Vol. 44, p. 379, 1938).

For this test, the unit was installed in the test duct and carefully sealed to prevent inleakage of air except through the measuring orifice. The desired rate of air flow through the filter was established and samples of air were drawn from the center points of the test duct one foot upstream and eight feet downstream of the test specimen at equal rates and passed through known areas of Whatman No. 41 filter paper. The ratios of the upstream and downstream filter paper areas were selected to obtain a similar increase of opacity, and with air drawn through both samplers for the full period, the arrestance was computed by the following formula:

$$A = 100 - \left[\frac{A_D}{A_U} x \frac{\Delta D}{\Delta U} \right] x\ 100$$

where A_D and A_U are the downstream and upstream filter paper areas and ΔD and ΔU the respective changes in opacity of the samplers.

Each test with atmospheric dust required from one to two hours and, in order to make the increase of opacity of the two samplers more nearly equal, the upstream sampling air was drawn through the sampler for only part of the time. If "T" is the percentage of the time during which air was drawn through the upstream sampler while air through the downstream sampler was drawn continuously, the formula for computing arrestance would be:

$$A = 100 - \left[T \times \frac{A_D}{A_U} \times \frac{\Delta D}{\Delta U} \right] \times 100$$

The two filter papers used for each test were selected to have the same opacity readings when clean.

During operation, the pressure drop of an automatic self-cleaning air filter of this type increases due to the accumulating dust load until it reaches the value at which the pressure switch is set to operate the roller mechanism. As clean media is then moved into the air stream, the pressure drop decreases until the pressure switch stops the roller drive. The filter then operates repetitively in the on-off range of the pressure switch, the differential controlling the amount of clean media that is moved into the air stream and the rate of dust accumulation determining the frequency of the cycles. Since the operation of this type of filter at a high pressure drop increases the dust load per unit area of filter media it reduces the consumption of the material but the increased blower power tends to offset the saving on filter material. For this test, the pressure switch was adjusted to start the roller mechanism at about 0.50 in. W.G. and stop it at about 0.45 in. W.G. which was in line with common operating practice for self-cleaning air filters at a face velocity of 500 ft/min.

The following procedure was used for determining the performance of the test specimen: The unit was installed between the upstream and downstream sections of the test apparatus and carefully sealed against extraneous leakage of air.

With the clean filter media in the air stream the pressure drop was measured at the rated face velocity of 500 ft/min and also at 400 and 600 ft/min. The arrestance of the filter at the rated face velocity was determined first with only the particulate matter in the laboratory air as the aerosol and thereafter with Cottrell precipitate. The loading of the filter was performed with a mixture of 96 parts by weight of Cottrell precipitate to 4 parts of cotton lint in a concentration of one gram per 1000 cu ft of air. The Cottrell precipitate and the lint were dispersed separately into the air stream. The lint used for this purpose was No. 7 cotton linters previously ground in a Wiley mill with a 4-millimeter screen. It was dispersed into the air stream through an aspirator operating at approximately 35 psi inlet air pressure. At intervals, the arrestance determinations with Cottrell precipitate and with the particulate matter in the laboratory air as the aerosol were repeated.

Markers were fastened to the filter media which could be observed through a glass window in the test duct to determine the amounts of clean media fed into the air stream at each roller operation. A pilot light was connected in parallel with the roller motor which lighted when the motor was operating the shift mechanism. This arrangement enabled the operator to record the pressure drop at the beginning and at the end of each advance of the filter media and also provided information on the consumption of filter media.

Each of the two filter mats was tested as follows. A total of 10 arrestance values were made of the fiber glass mat until it had advanced a total of 40 inches during 12 roller cycles. The Dycon mat was tested during 21 roller cycles with a total advance of 46.5 inches and 12 arrestance determinations were made on this material. In both cases, the test was continued until the arrestance values became steady indicating that repetitive conditions existed during each roller cycle.

4. Test Results

The results of the tests are shown in four tables. Tables 1 and 2 summarize for the two different filter media the arrestance values determined with both the particulate matter in the laboratory air and Cottrell precipitate. They also give the accumulated dust loads in grams per 1 ft width of the filter media, the total media travel and the pressure drop of the filter at the

Table 1

Summary of Arrestance Tests
Conomatic, Model 3-C90
With Fiberglas Filter Mat

Dust Load g/ft	Total Mat Travel in.	Pressure Drop in. W.G.	Arrestance %	Aerosol**
0	0	0.233	17*	A
10	0	0.245	80*	C
109	0	0.477	85	C
135	7-1/2	0.451	20	A
291	29	0.418	20	A
301	29	0.432	84	C
368	37-1/2	0.488	84	C
383	40	0.437	20	A

* Average of two tests

** Aerosol A- Particulate matter in the laboratory air.

Aerosol B- Cottrell precipitate in the laboratory air.

Table 2

Summary of Arrestance Tests
Conomatic, Model 3-C90, With Dycon Filter Mat

Dust Load g/ft	Total Mat Travel in.	Pressure Drop in. W.G.	Arrestance %	Aerosol**
0	0	0.206	9*	A
10	0	0.217	67*	C
130	3-1/2	0.494	74	C
337	25-1/2	0.464	78	C
342	25-1/2	0.483	18	A
430	35-1/2	0.458	74*	C
436	35-1/2	0.470	17	A
498	44-1/2	0.434	20	A
524	46-1/2	0.475	20	A

* Average of two tests

** Aerosol A- Particulate matter in the laboratory air.

Aerosol C- Cottrell precipitate in the laboratory air.

end of each arrestance measurement. The average initial arrestance of the Fiberglas media with atmospheric dust was 17 percent and with Cottrell precipitate was 80 percent. As the test continued, these values increased and they leveled out at 20 percent and 84 percent, respectively. The initial arrestance of the Dycon mat was found to be 9 percent and 67 percent, respectively. However, the steady state value for particulate matter in the laboratory air was also 20 percent, the same as determined for the Fiberglas mat, and the arrestance of Cottrell precipitate was 74 percent.

Tables 3 and 4 present a summary of the mat travel of the two media during each shift and also cumulatively. The values for the dust loads reported in these tables were interpolated between the 20 g loaded into the feeder hopper at one time and are correct to within ± 3 g. It will be noted that the increments of advance of the filter mat during individual roller cycles, varied from 1-1/2 in. to 3 in. with the exception of the two first advances of the Dycon mat, which were 4 and 3-1/2 inches, respectively. The values shown for the travel of the mat are correct to ± 1/2 in.

The differential pressure started the roller drive mechanism at 0.494 in. W.G. at the beginning of the test with the Dycon mat, whereas at the end of this test the cut-in pressure had decreased to 0.480 in. W.G. and further decreased during the test of the Fiberglas mat to 0.470 in. W.G. This condition was not noticed during the test. It may have been caused by not properly securing the adjustment screw of the pressure switch. The differential pressure remained practically steady during the whole test at slightly below 0.05 in. W.G.

Fig 1 and 2 are graphs of the arrestance determinations and of the mat travel values plotted against the dust load for the two filter media.

The amount of Cottrell precipitate collected on a unit area of filter media during the steady state operation of the unit provides some measure of the consumption of filter media during actual use. Disregarding the relatively small amounts of particulate matter collected during the tests in which the arrestance of the filter was determined with laboratory air, the slope of the straight portion of the lower curves in Fig 1 and 2 (during the steady state condition) indicates the unit dust-holding capacity of the filter media.

Table 3

Dust Load, Mat Travel and Pressure Drop Characteristics
Conomatic, Model 3-C90 With Fiberglas Filter Mat

Dust Load g/ft	Mat Travel, in. Advance	Total	Pressure Drop, in. W. G. Before Advance	After Advance
0	0	0	0.233	-
110	4	4	0.480	0.431
116	3-1/2	7-1/2	0.480	0.429
140	3	10-1/2	0.478	0.424
165	3	13-1/2	0.478	0.424
182	2-1/2	16	0.475	0.428
200	2-1/2	18-1/2	0.478	0.424
222	2-1/2	21	0.474	0.424
246	2-1/2	23-1/2	0.470	0.420
268	2-1/2	26	0.471	0.420
290	3	29	0.470	0.418
314	3	32	0.470	0.421
336	2-1/2	34-1/2	-	0.420
360	3	37-1/2	0.470	0.419
384	2-1/2	40	0.470	0.422

Table 4

Dust Load, Mat Travel and Pressure Drop Characteristics
Conomatic, Model 3-C90 With Dycon Filter Mat

Dust Load	Travel of Mat, in.		Pressure Drop, in. W. G.	
g/ft	Advance	Total	Before Advance	After Advance
0	0	0	0.206	-
130	3-1/2	3-1/2	0.494	0.438
145	2-1/2	6	0.490	0.444
165	3	9	0.494	0.445
190	2-1/2	11-1/2	0.495	0.446
209	2	13-1/2	0.494	0.450
230	2-1/2	16	0.493	0.446
252	2	18	0.490	0.444
270	1-1/2	19-1/2	0.490	0.443
282	2	21-1/2	0.490	0.442
299	2	23-1/2	0.488	0.444
320	2	25-1/2	0.490	0.443
340	2	27-1/2	0.490	0.440
360	2-1/2	30	0.488	0.430
376	1-1/2	31-1/2	0.480	0.436
397	2	33-1/2	0.481	0.430
410	2	35-1/2	0.480	0.432
429	2	37-1/2	0.480	0.436
446	2-1/2	40	0.480	0.432
470	2	42	0.480	0.430
492	2-1/2	44-1/2	0.480	0.431
512	2	46-1/2	-	0.430

According to Fig 1, the Fiberglas mat traveling from position 16 inch to 40 inch, a distance 2 ft, was fed dust in the amount of 207 g/ft width, indicating a dust-holding capacity 103.5 g/sq ft. Correspondingly, from Fig 2, the Dycon mat traveling from position 20 inch to 44 inch, a distance of 2 ft, was fed dust in the amount of 214 g/ft width, indicating a dust-holding capacity of 107 g/sq ft.

A summary of the performance of both filter media is presented in Table 5 below.

Table 5

Summary of Test Results
Conomatic Automatic Renewable Media Air Filter

	Fiberglas Mat	Dycon Mat
Face Velocity, ft/min	500	500
Pressure Drop, clean, in. W.G.	0.233	0.206
Average Operating Pressure Drop Range, in. W.G.	0.475 to 0.425	0.487 to 0.438
Arrestance, %		
Mat Clean: Laboratory Air	17	9
Mat Clean: Cottrell Precipitate	80	67
Steady State: Laboratory Air	20	20
Steady State: Cottrell Precipitate	84	74
Dust-Holding Capacity, g/sq ft	103.5	107.0
Pressure Drop of Clean Filter, in. W.G.		
at 400 ft/min Face Velocity	0.169	0.148
at 600 ft/min Face Velocity	0.305	0.270

CONOMATIC WITH FIBERGLAS FILTER MAT

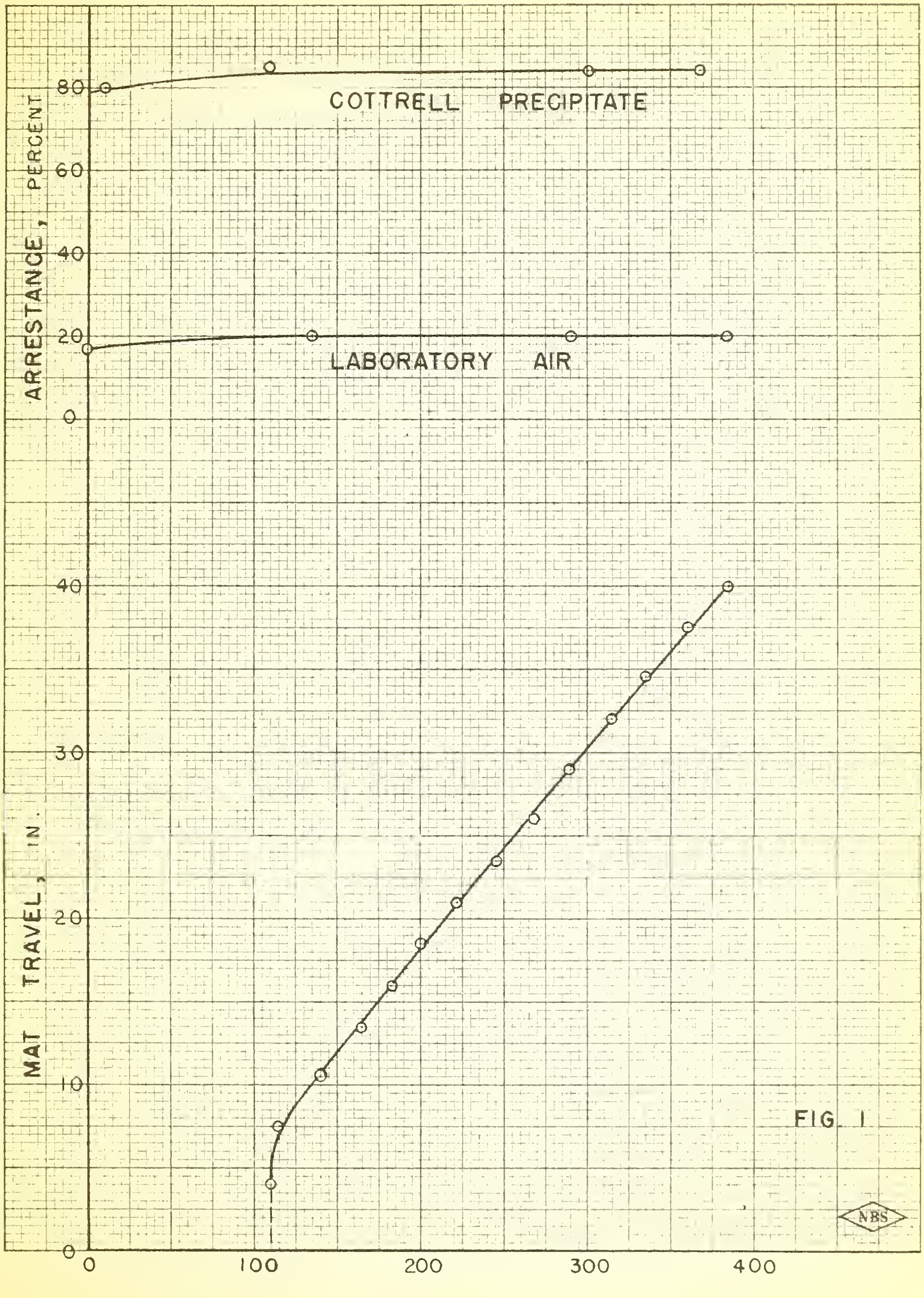

FIG. 1

DUST LOAD, G. / FT. WIDTH

CONOMATIC WITH DYCON FILTER MAT

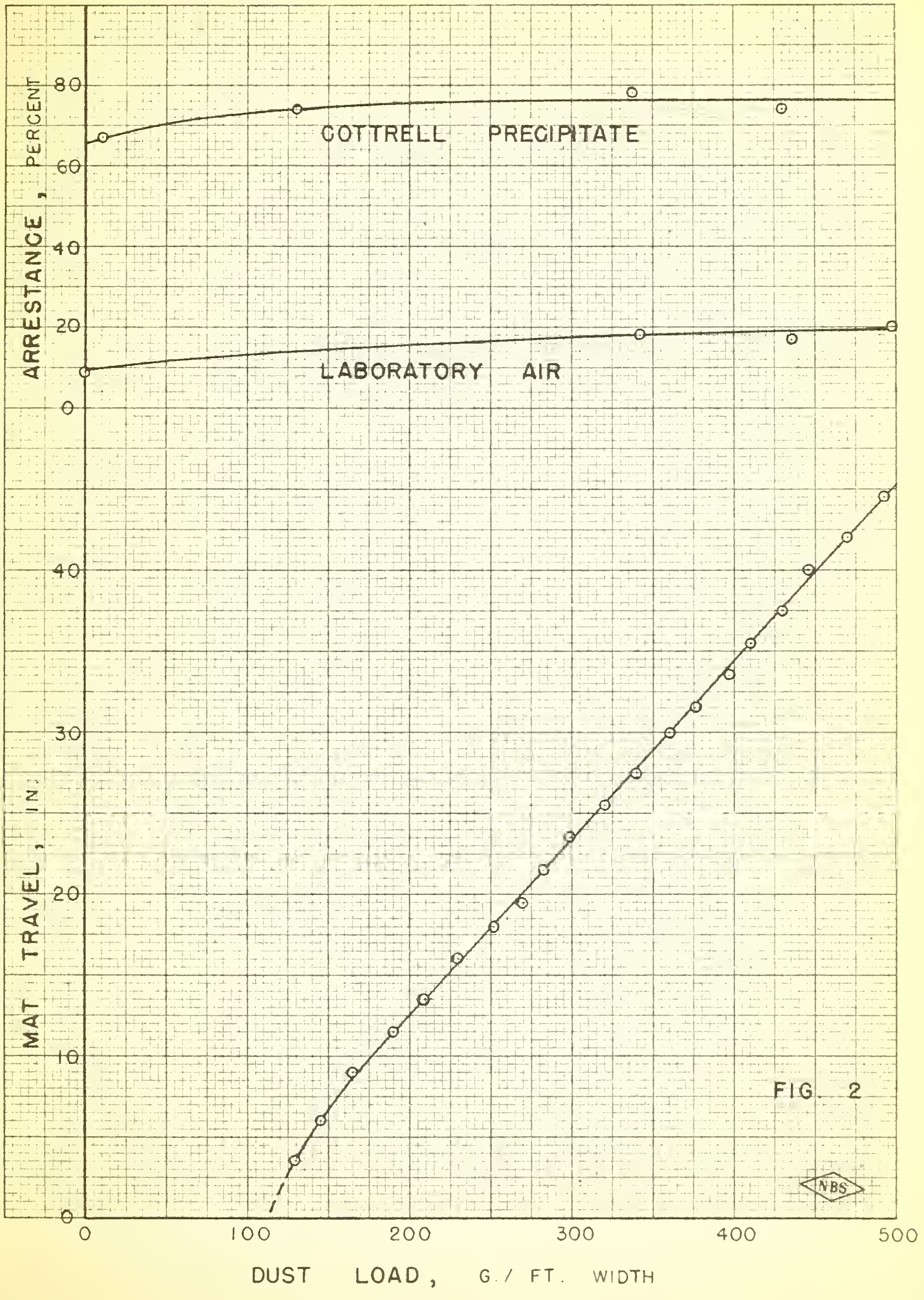

FIG. 2

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