NATIONAL BUREAU OF STANDARDS REPORT

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PERFORMANCE TESTS OF TWO "DYCON" DRY-TYPE AIR FILTERS

by

Henry E. Robinson
Thomas W. Watson

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

NBS

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1. INTRODUCTION*

At the request of the Public Buildings Service, General Services Administration, the performance characteristics of dry-type air filters were determined to provide information to assist in the preparation of new air filter specifications.

The test results presented herein were obtained on specimen dry-type air filters submitted by the manufacturer at the request of the Public Buildings Service and included determinations of dust arresting efficiency with two aerosols (atmospheric air and Cottrell precipitate), pressure drop and dirt load.

2. DESCRIPTION OF THE FILTER SPECIMENS

The two filters submitted were manufactured by Continental Air Filters, Inc. of Louisville, Kentucky, and were dry-type air filters, 24x24x8 3/4 inches in nominal size. They were identified by the manufacturer as Model CA-24 with Type A blanket and Model CA-24 with Type AX blanket as the filtering media.

The model CA-24 (Type A) air filter cell had overall dimensions of 23 1/2 x 23 1/2 x 7 5/8 inches. The filtering media consisted of an un-oiled blanket of wool-like synthetic fibers, held together by a bonding agent. The blanket was arranged in vee-folds approximately 7 inches deep, between retainers of 2-mesh wire on the upstream and downstream faces. The net face area of the filter was 3.36 sq. ft. and the area of blanket effective for filtering was approximately 11.75 sq. ft. The filter cell weighed 14.5 pounds when clean.

The filter model CA-24 (Type AX) was identical in size and design except that two sheets of blanket (Type A and Type X) were laid in contact in vee-folds with the finer media (Type X) on the downstream side. The filter cell weighed 15.1 pounds when clean.

*This report is submitted for information only, and is not released for use in connection with advertising or sales promotion.

The manufacturer recommends that for best results and highest economy, the Dycon CA-24 cell can be cleaned by vacuum cleaning with a special nozzle, and occasionally by washing the media in place with cold water from a hose nozzle. It is stated that such washing can be repeated up to about 10 times before the Dycon blanket media needs replacement.

3. TEST METHOD AND PROCEDURE

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

For these tests, the filter was installed in the apparatus and the desired rate of air flow through the cleaner was established. Samples of air were drawn from the center of the test duct, at points one foot upstream and eight feet downstream of the filter and passed through known areas of Whatman No. 41 filter paper. The areas of the filter paper used upstream and downstream and the times during which the air was sampled upstream and downstream were selected experimentally so that the change in transmission of light through the two filter paper spots would be about the same. The filter efficiency was calculated by means of the formula

$$\text{Efficiency, percent} = 100\left[1 - \frac{A_2}{A_1} \cdot \frac{O_2}{O_1} \cdot \frac{T_1}{T_2}\right]$$

where A represents the dust spot area, O the change in light transmittance of the filter paper as measured before and after the deposition of dust, and T the time during which the air sample was drawn. Subscripts 1 and 2 refer to the upstream and downstream positions, respectively.

Three efficiency-measuring techniques, or modifications based on the above formula, were used, depending on the apparent efficiency of the filter with the different aerosols. For the tests made, techniques L, M and N were used, as indicated in Table 2.

All light transmission measurements were made with the photometer illumination at a constant intensity as determined by measurement on a reference of constant transmission characteristics. The filter papers used upstream and downstream were selected to have equal light transmissions when clean.

The efficiency of the filter in arresting particulate matter in atmospheric air was determined by means of two tests of the L and M types, as described in Table 2, with the filter clean. Following these, the efficiency of the filter in arresting Cottrell precipitate was measured by means of two N-type tests, after which was begun the process of loading the filter with a mixture of four percent of cotton lint and 96 percent of Cottrell precipitate, by weight, separately dispersed in 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. At suitable periods as the loading progressed, the efficiency of the filter was determined using Cottrell precipitate in outdoor air. Pressure drops were recorded at intervals during the test. The dirt-loading was continued until the pressure drop increased to approximately 0.50 inch W.G. The efficiency was again determined with Cottrell precipitate and then with atmospheric air as the aerosols.

The filter was then removed from the test duct and the blanket was cleaned in the filter cell by means of a stream of cold water from a high-pressure hose nozzle directed at and into the filter media beginning with the downstream face. After drying, the filter was re-installed in the test apparatus for measurement of its initial pressure drop after the cleaning process, and for subsequent tests.

4. TEST RESULTS

Table 1 presents data as to the pressure drops of the clean filters at several rates of air flow and also the pressure drops at rated air flow of the same filters after one cleaning operation with water.

The performance of the filters at 1000 cfm is summarized in Table 2, for both aerosols A and C. The performance of the filters in regard to aerosol C (Cottrell precipitate in atmospheric air) is also shown graphically in Figures 1 and 2. The efficiency of the filters in

arresting aerosol A (atmospheric particulate matter), both initially, and after their resistance had been increased to 0.5 inch W.G., is indicated in Table 2.

Observation of the filters at the end of the dirt-loading tests revealed that the greater part of the arrested lint was found on the upstream faces (heavier in the bottoms of the vee-folds) and had not penetrated the media to any noticeable degree. The downstream faces of the media were uniformly darkened by dust. No lint was visible on the downstream face of either filter.

After the filters had been removed from the test duct, the section of the duct five feet long downstream of the unit, and upstream of a 3/4-inch wood strip fastened flat across the bottom of the test duct, was carefully swept out with a fine brush. The amount of material obtained from the duct by this sweeping was 21.0 grams or 1.8 percent for the Type A media, and eight grams or 0.8 percent for the Type AX media, of the dust load reaching the filter. This material consisted for the most part of large dust particles, and constituted the fall-out in the first five feet of the duct from the air passed through the filter.

Cellophane tapes, stretched across the test duct downstream of the filter with the adhesive side facing upstream, indicated upon visual and microscopic examination after exposure to the air stream that some particles of sizes up to approximately 125 microns had passed through the Type A media and particles up to 100 microns in size had passed through the Type AX media during the dirt-loading tests. Particles smaller than five microns were observed in quantity by microscopic examination of the downstream filter papers obtained in tests on the two filters with each of the aerosols. No lint was observed on the tapes downstream of either filter during these tests.

At the conclusion of the dirt-loading tests, cellophane tapes also indicated that in the case of the CA 24 Type A filter (see Table 2) there was some release or escape of Cottrell precipitate from the filter media during the efficiency tests with atmospheric air as the aerosol. This is also reflected in the low efficiency values (negative in one case) and the pressure drop decrease from 0.512 to 0.496 inches W.G. as noted in Table 2.

There was no evidence of release or escape of Cottrell precipitate from the CA-24 Type AX filter media during the corresponding tests with the atmospheric aerosol.

After the loading tests, the filters were removed from the test duct and subjected to the cleaning process described under Test Method and Procedure. Complete apparent cleaning was accomplished with moderate time and care. However, upon subsequent measurements of pressure drop after the cleaning and drying operation, it was found, as noted in Table 1, that the initial pressure drops were slightly higher than those of the clean as-received filters, in the case of both the Type A and Type AX filters. The efficiency values for the two filters after the cleaning procedure were substantially the same as the values obtained with the clean as-received filters, for both aerosols.

It is believed that a thorough washing with cold water restores these filters to substantially their original initial efficiency, with perhaps a slight increase in initial pressure drop for each successive washing. It is felt that cleaning may be facilitated by using a vacuum cleaner on the upstream surfaces of the media to remove loose dust and lint before washing with water is undertaken.

TABLE 1

PRESSURE DROP OF CLEAN FILTERS

Air Flow cfm	Face Velocity fpm	Pressure Drop (1) inch W.G.	Pressure Drop (2) inch W.G.
		CA-24 (Type A Media)	
1200	102	0.120	-
1000	85	.092	0.100
800	68	.064	-
600	51	.040	-
		CA-24 (Type AX Media)	
1200	102	0.242	-
1000	85	.188	0.200
800	68	.136	-
600	51	.092	-

(1) Initial values for the clean filters
(2) Values for the filters after dirt-loading and cleaning with water.

TABLE 2

PERFORMANCE OF FILTERS AT 1000 CFM

Filter	Aerosol(1)	Total Dirt Load(2)	Pressure Drop	Eff. Meas. Technique(3)	Efficiency
		grams	inch W.G.		percent
CA-24 (Type A)	A	-	0.092	M	12
		-	.092	L	15
	C	9	.093	N	73
		17	.094	N	72
		28	.096	N	74
		203	.123	-	-
		406	.150	N	78
		590	.202	N	85
		706	.253	N	85
		957	.378	N	83
		977	.384	N	84
		1189	.512	N	84
"	A	1189	.500	M	-6 (4)
		1189	.496	M	7
			After Cleaning and Drying		
"	A	-	0.100	M	14
	C	9	.101	N	73

TABLE 2 - Cont'd

Filter	Aerosol(1)	Total Dirt Load(2)	Pressure Drop	Eff. Meas. Technique(3)	Efficiency
		grams	inch W.G.		percent
CA-24	A	-	0.188	M	15
(Type AX)		-	.188	L	20
	C	9	.190	N	78
"		17	.192	N	85
		278	.248	N	87
		413	.286	-	-
		556	.316	N	88
		710	.363	N	90
		894	.430	-	-
		1057	.504	N	91
"	A	1057	.504	M	29
		After Cleaning and Drying			
"	A	-	0.200	M	15
	C	9	.202	N	79

(1) Aerosol A: Particulate matter in atmospheric air at NBS.
Aerosol C: Cottrell precipitate in atmospheric air (1 gram per 1000 cf).

(2) Average mixture: 4.0 percent lint, 96.0 percent Cottrell precipitate by weight.

(3) Efficiency measuring technique:

L: Air sampled at equal rates through equal areas; upstream sampling time selected to yield approximately equal dust-spot opacities of the upstream and downstream filter papers.

TABLE 2 - Cont'd

(3) Efficiency measuring technique:

M: Air sampled at equal rates through equal areas for equal times.

N: Air sampled at equal rates for equal times; downstream areas selected to yield approximately equal dust-spot opacities of the upstream and downstream filter papers.

(4) Cellophane tapes downstream indicated that Cottrell precipitate was escaping from the filter media during this measurement.

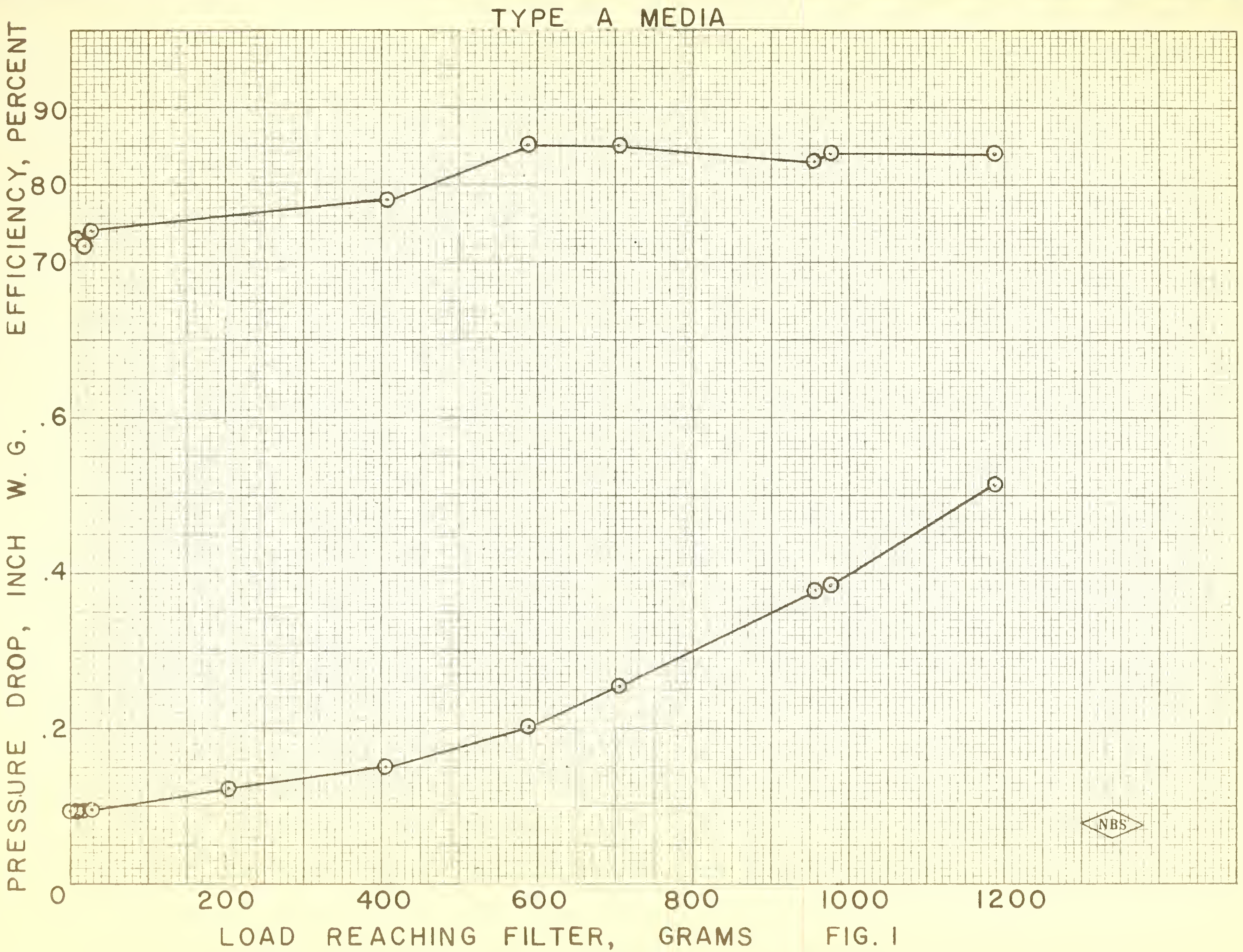
TYPE A MEDIA
EFFICIENCY, PERCENT
90
80
70
PRESSURE DROP, INCH W. G.
.6
.4
.2
0
200
400
600
800
1000
1200
LOAD REACHING FILTER, GRAMS
NBS

FIG. 1

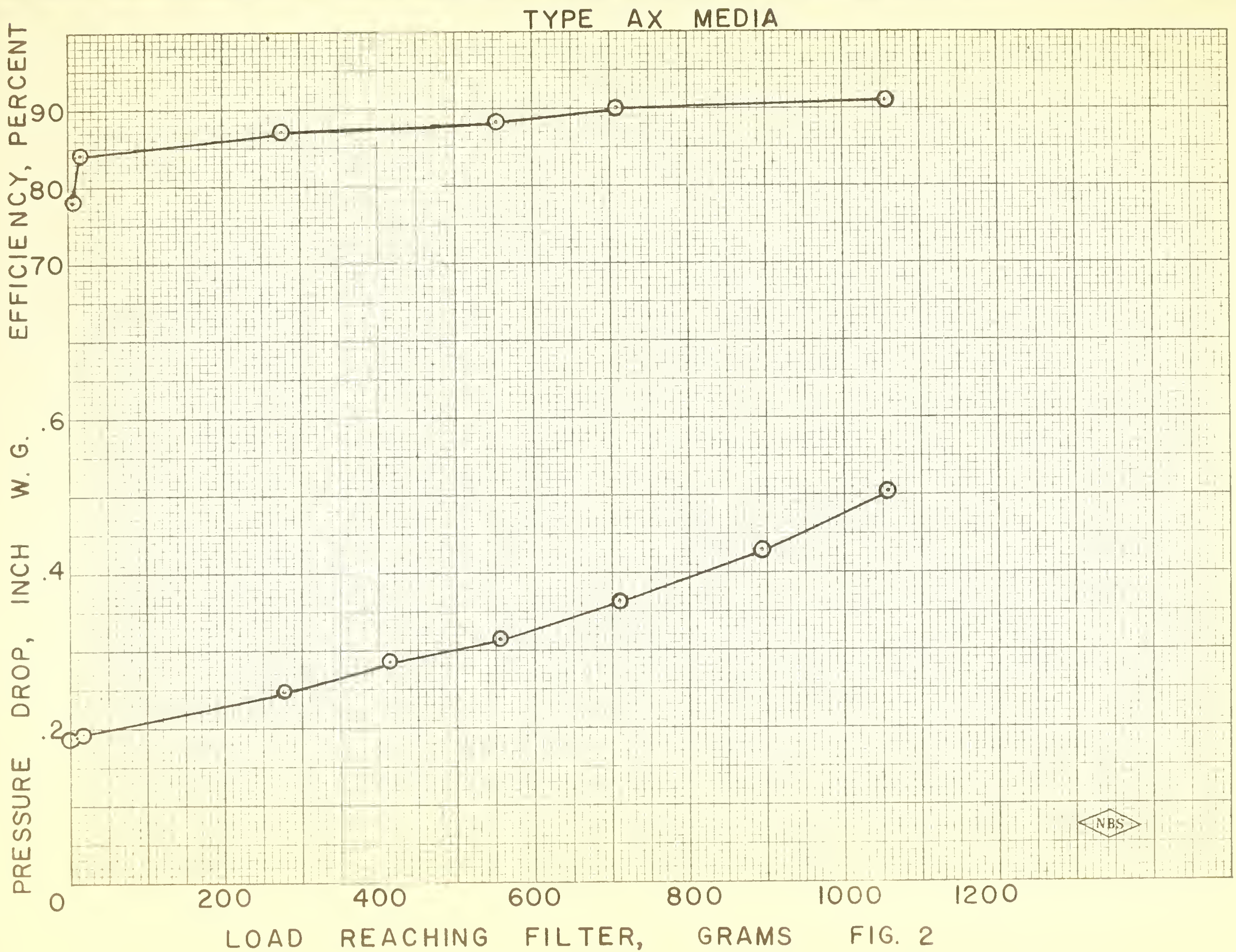
TYPE AX MEDIA
EFFICIENCY, PERCENT
90
80
70
PRESSURE DROP, INCH W. G.
.6
.4
.2
0
200
400
600
800
1000
1200
LOAD REACHING FILTER, GRAMS
NBS

FIG. 2

THE NATIONAL BUREAU OF STANDARDS

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The functions of the National Bureau of Standards are set forth in the Act of Congress, March 3, 1901, as amended by Congress in Public Law 619, 1950. These include the development and maintenance of the national standards of measurement and the provision of means and methods for making measurements consistent with these standards; the determination of physical constants and properties of materials; the development of methods and instruments for testing materials, devices, and structures; advisory services to Government Agencies on scientific and technical problems; invention and development of devices to serve special needs of the Government; and the development of standard practices, codes, and specifications. The work includes basic and applied research, development, engineering, instrumentation, testing, evaluation, calibration services, and various consultation and information services. A major portion of the Bureau's work is performed for other Government Agencies, particularly the Department of Defense and the Atomic Energy Commission. The scope of activities is suggested by the listing of divisions and sections on the inside of the front cover.

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Information on the Bureau's publications can be found in NBS Circular 460, Publications of the National Bureau of Standards ($1.25) and its Supplement ($0.75), available from the Superintendent of Documents, Government Printing Office. Inquiries regarding the Bureau's reports and publications should be addressed to the Office of Scientific Publications, National Bureau of Standards, Washington 25, D. C.

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