# NATIONAL BUREAU OF STANDARDS REPORT

5991

PERFORMANCE TESTS OF TWO CLEANABLE IMPINGEMENT TYPE
AIR FILTERS
AIRSAN TYPES AF1-30 AND AF2-30

MANUFACTURED BY
AIR FILTER CORPORATION
MILWAUKEE, WISCONSIN

by

Carl W. Coblentz
and
Paul R. Achenbach

Report to
Bureau of Yards and Docks
Office of the Chief of Engineers
Headquarters, U. S. Air Force
Washington, D. C.


U. S. DEPARTMENT OF COMMERCE

NATIONAL BUREAU OF STANDARDS

## THE NATIONAL BUREAU OF STANDARDS

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Carl W. Coblentz
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Air Conditioning, Heating, and Refrigeration Section
Building Technology Division

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# PERFORMANCE TESTS OF TWO CLEANABLE IMPINGEMENT TYPE AIR FILTERS AIRSAN TYPES AF1-30 AND AF2-30

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## 1. Introduction

The performance characteristics of a group of cleanable viscous impingement air filters were measured to provide information for evaluating the relative economy of cleanable versus throw-away types of filters. This investigation was requested by the Defense Department through the Tri-Service program of research and development at the National Bureau of Standards to obtain the required data for the preparation of new air filter specifications.

The test results presented herein were obtained on two new "Airsan" filters and include determination of the arrestance and pressure drop as a function of specific dirt load and information on cleanability for face velocities of 360 and 540 ft/min.

## 2. Description of Test Specimens

The two test specimens were of the cleanable viscous impingement type and were manufactured and supplied by the Air Filter Corporation of Milwaukee, Wisconsin. They were their models Airsan AF1-30 and Airsan AF2-30 with nominal sizes of 20 x 20 x 1 in. and 20 x 20 x 2 in., respectively; the actual outside dimensions were 19 1/2 x 19 1/2 x 15/16 in. and 19 3/8 x 19 3/8 x 1 7/8, respectively. The inside opening of the frames of both filters was 18 x 18 in. providing a net filter area of 2.25 sq ft.

Both filters had a galvanized steel frame and grilles made of expanded galvanized steel sheet on the front and back side to hold the filter elements made of 16-mesh wire screen. The two-inch thick filter contained six layers of pleated screen with 5/8-in. pleats running alternately vertical and horizontal and a flat screen between the downstream grille and the last pleated screen. The one-inch thick filter was built symmetrically and had no mark to indicate the direction of the air flow. It contained five layers of screening. A flat screen in the center was sandwiched between two 3/8-inch pleated screens which in turn were placed between two screens with 5/8-inch pleats which ran at a 90-degree angle to the 3/8-inch pleats.

The adhesive used was supplied by the manufacturer, bearing the trade mark "Film Cor."

## 3. Test Method and Procedure

The performance of the filters was determined at 360 ft/min and 540 ft/min face velocity, i.e., at an air flow rate of 810 cfm and 1215 cfm, respectively. The clean filters were immersed in the adhesive and left to dry in the laboratory at least 16 hours before being weighed and installed in the test apparatus. The initial pressure drop at each air velocity was measured and then the initial arrestance at the air velocity desired for that test was determined with the NBS "Dust Spot Method" as described in the paper, "A Test Method for Air Filters," by R. S. Dill (ASHVE Transactions, Vol. 44, p. 379, 1938).

The aerosol used for the arrestance determinations was Cottrell precipitate which had been sifted through a 100-mesh wire screen. In order to simulate actual operating conditions when loading the filters, four percent by weight of #7 cotton linters, previously ground in a Wiley mill with a four-millimeter screen, was fed simultaneously with the Cottrell precipitate. The pressure drop of the filters was recorded after each increment of 20 g of dust introduced into the apparatus. Whereas the arrestance measurements were made with 100 percent Cottrell precipitate, cotton linters were added to retain a ratio of four parts by weight to every 96 parts of Cottrell precipitate, including that amount used for the arrestance measurements. Arrestance determinations were made at the beginning and at the end of the loading period for each filter and at several intermediate load conditions. The filters were loaded with a dust concentration of approximately 1 g dust in 1000 cu ft of air until the pressure drop reached 0.5 in. W.G. in 360 ft/min face velocity test and 0.8 in. W.G. in the tests with 540 ft/min face velocity.

After the filters had been loaded to capacity, they were cleaned with water and allowed to dry; then, oiled again as previously described, weighed and installed in the test apparatus for determining any change in pressure drop and in some cases for a new performance test.

## 4. Test Results

The performance observed on the two filters is shown in Tables 1 to 7.

Table 1

Performance of Airsan Filter AF2-30 (2" thick) at 360 ft/min Face Velocity

| Load g/sq ft | Pressure Drop in. W.G. | Arrestance % |
|---|---|---|
| 0 | 0.080 | 54 |
| 7 | 0.081 | 55 |
| 26 | 0.110 | 56 |
| 48 | 0.145 | 59 |
| 70 | 0.203 | 60 |
| 92 | 0.325 | 66 |
| 111 | 0.525 | 77 |

Table 2

Performance of Airsan Filter AF2-30 (2" thick) at 540 ft/min Face Velocity

| Load g/sq ft | Pressure Drop in. W.G. | Arrestance % |
|---|---|---|
| 0 | 0.225 | 64 |
| 31 | 0.275 | 64 |
| 49 | 0.345 | -- |
| 68 | 0.455 | 65 |
| 86 | 0.695 | -- |
| 99 | 0.960 | 72 |

Table 3

Performance of Airsan Filter AF1-30 (1" thick) at 360 ft/min Face Velocity

| Load g/sq ft | Pressure Drop in. W.G. | Arrestance % |
|---|---|---|
| 0 | 0.075 | 51 |
| 22 | 0.100 | 55 |
| 44 | 0.141 | 61 |
| 66 | 0.250 | 62 |
| 73 | 0.325 | -- |
| 88 | 0.568 | 70 |

Table 4

Performance of Airsan Filter AF1-30 (1" thick) at 540 ft/min Face Velocity

| Load g/sq ft | Pressure Drop in. W.G. | Arrestance % |
|---|---|---|
| 0 | 0.155 | 64 |
| 22 | 0.190 | 64 |
| 50 | 0.320 | 66 |
| 64 | 0.517 | -- |
| 77 | 0.775 | 73 |
| 86 | 1.000 | 78 |

Tables 1 to 4 show the relation of the pressure drop and arrestance to specific dirt load for the two filters at face velocities of 360 ft/min and 540 ft/min. Fig. 1 presents a graph of the values observed with the two-inch thick media and fig. 2 those of the one-inch thick media. The values of the dust holding capacity taken from the curves in figs. 1 and 2 for pressure drops of 0.5 in. W.G. at the 360 ft/min air velocity and 0.8 in. W.G. at 540 ft/min air velocity are given in table 5. Also shown in the table are the mean arrestance values for each filter and each face velocity during the period in which the capacity dust load was being deposited.

Table 5

Dust Holding Capacity and Mean Arrestance (Determined from Figs. 1 and 2)

| Thickness of Filter Media | 1" | | 2" | |
|---|---|---|---|---|
| Face Velocity, ft/min | 360 | 540 | 360 | 540 |
| Final Pressure Drop, in. W.G. | 0.5 | 0.8 | 0.5 | 0.8 |
| Dust Holding Capacity, grams/sq ft | 85 | 78 | 110 | 92 |
| Mean Arrestance, percent | 60 | 67 | 61 | 65 |

Table 6

Cleanability of Airsan Filter AF2-30 (2" thick)

| Condition of Filter | Weight of Filter grams | Pressure Drop, in. W.G. 360 ft/min | 540 ft/min |
|---|---|---|---|
| New | 2910 | 0.080 | -- |
| After 1 loading & cleaning | 2995 | 0.115 | 0.237 |
| After 2 loadings & cleanings | 2995 | 0.110 | 0.225 |
| " 3 " " " | 3011 | 0.119 | 0.235 |
| " 4 " " " | 3025 | 0.120 | 0.225 |

Table 7

Cleanability of Airsan Filter AF1-30 (1" thick)

| Condition of Filter | Weight of Filter grams | Pressure Drop, in. W.G. 360 ft/min | 540 ft/min |
|---|---|---|---|
| New | 2318 | 0.075 | 0.160 |
| After 1 loading & cleaning | 2312 | 0.077 | 0.155 |
| After 2 loadings & cleanings | 2320 | 0.075 | 0.160 |

Tables 6 and 7 show comparative data of the cleanability of the filters. Unfortunately, no pressure drop measurement was made of the new two-inch thick filter at the 540 ft/min air velocity. But the weight increase after the first loading and cleaning as well as lower dust holding capacities observed in subsequent tests confirmed that in the first run this filter accumulated a basic load that could not be cleaned out later. The weight and pressure drop of the one-inch thick filter, as shown in table 7, remained practically unchanged after two loading and cleaning processes.

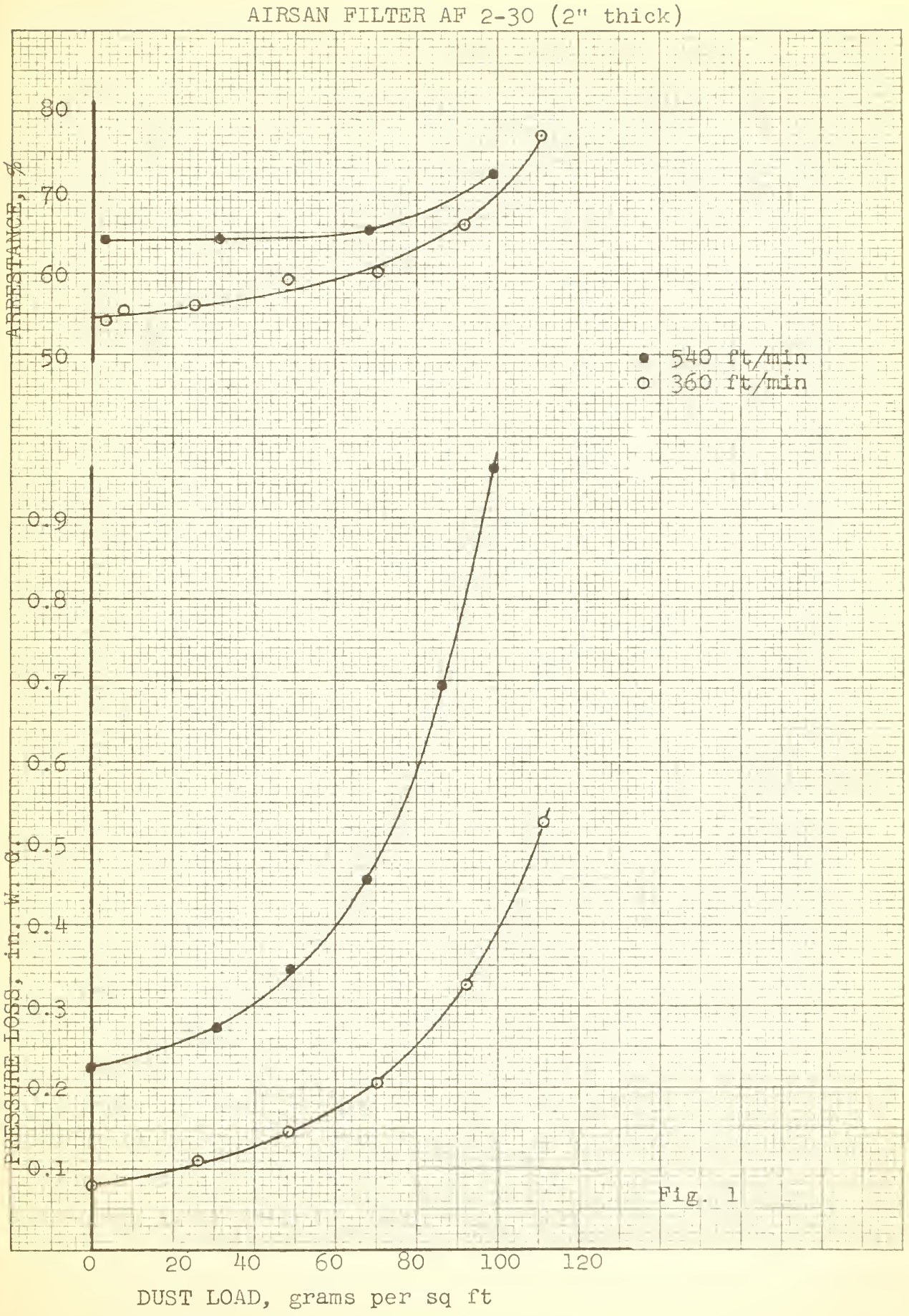
AIRSAN FILTER AF 2-30 (2" thick)
ARRESTANCE, %
80
70
60
50
540 ft/min
360 ft/min
PRESSURE LOSS, in. W. G.
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
20
40
60
80
100
120
DUST LOAD, grams per sq ft

Fig. 1

AIRSAN FILTER AF 1-30 (1" thick)

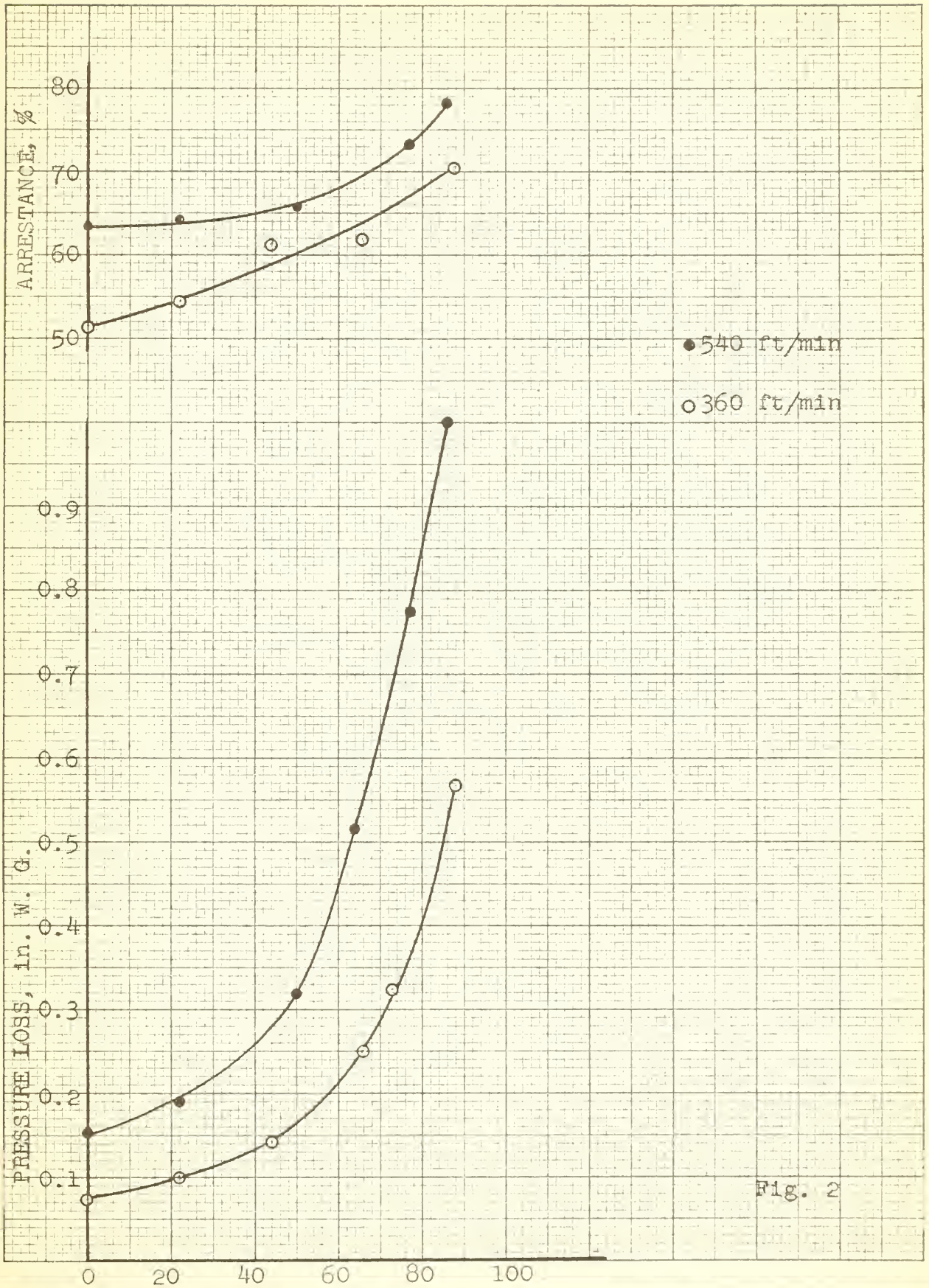


Fig. 2

U. S. DEPARTMENT OF COMMERCE
Sinclair Weeks, *Secretary*

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

## THE NATIONAL BUREAU OF STANDARDS

The scope of activities of the National Bureau of Standards at its headquarters in Washington, D. C., and its major laboratories in Boulder, Colo., is suggested in the following listing of the divisions and sections engaged in technical work. In general, each section carries out specialized research, development, and engineering in the field indicated by its title. A brief description of the activities, and of the resultant publications, appears on the inside front cover.

### WASHINGTON, D. C.

**Electricity and Electronics.** Resistance and Reactance. Electron Devices. Electrical Instruments. Magnetic Measurements. Dielectrics. Engineering Electronics. Electronic Instrumentation. Electrochemistry.

**Optics and Metrology.** Photometry and Colorimetry. Optical Instruments. Photographic Technology. Length. Engineering Metrology.

**Heat.** Temperature Physics. Thermodynamics. Cryogenic Physics. Rheology. Engine Fuels. Free Radicals Research.

**Atomic and Radiation Physics.** Spectroscopy. Radiometry. Mass Spectrometry. Solid State Physics. Electron Physics. Atomic Physics. Neutron Physics. Nuclear Physics. Radioactivity. X-rays. Betatron. Nucleonic Instrumentation. Radiological Equipment.

**Chemistry.** Organic Coatings. Surface Chemistry. Organic Chemistry. Analytical Chemistry. Inorganic Chemistry. Electrodeposition. Molecular Structure and Properties of Gases. Physical Chemistry. Thermochemistry. Spectrochemistry. Pure Substances.

**Mechanics.** Sound. Mechanical Instruments. Fluid Mechanics. Engineering Mechanics. Mass and Scale. Capacity, Density, and Fluid Meters. Combustion Controls.

**Organic and Fibrous Materials.** Rubber. Textiles. Paper. Leather. Testing and Specifications. Polymer Structure. Plastics. Dental Research.

**Metallurgy.** Thermal Metallurgy. Chemical Metallurgy. Mechanical Metallurgy. Corrosion. Metal Physics.

**Mineral Products.** Engineering Ceramics. Glass. Refractories. Enameled Metals. Concreting Materials. Constitution and Microstructure.

**Building Technology.** Structural Engineering. Fire Protection. Air Conditioning, Heating, and Refrigeration. Floor, Roof, and Wall Coverings. Codes and Safety Standards. Heat Transfer.

**Applied Mathematics.** Numerical Analysis. Computation. Statistical Engineering. Mathematical Physics.

**Data Processing Systems.** SEAC Engineering Group. Components and Techniques. Digital Circuitry. Digital Systems. Analog Systems. Application Engineering.

• Office of Basic Instrumentation.

• Office of Weights and Measures.

### BOULDER, COLORADO

**Cryogenic Engineering.** Cryogenic Equipment. Cryogenic Processes. Properties of Materials. Gas Liquefaction.

**Radio Propagation Physics.** Upper Atmosphere Research. Ionospheric Research. Regular Propagation Services. Sun-Earth Relationships. VHF Research.

**Radio Propagation Engineering.** Data Reduction Instrumentation. Modulation Systems. Navigation Systems. Radio Noise. Tropospheric Measurements. Tropospheric Analysis. Radio Systems Application Engineering. Radio Meteorology.

**Radio Standards.** High Frequency Electrical Standards. Radio Broadcast Service. High Frequency Impedance Standards. Calibration Center. Microwave Physics. Microwave Circuit Standards.


NBS