NATIONAL BUREAU OF STANDARDS REPORT

7504

PERFORMANCE TESTS OF FARR REPLACEABLE CARTRIDGE FILTERS
TYPES HP 100 AND HP 200

Manufactured by
Farr Company
Los Angeles, California

by

Carl W. Coblentz and Paul R. Achenbach

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

U. S. DEPARTMENT OF COMMERCE
NATIONAL BUREAU OF STANDARDS

THE NATIONAL BUREAU OF STANDARDS

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Mechanical Systems Section
Building Research Division

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1. Introduction

At the request of the Public Buildings Service, General Services Administration, the performance characteristics of the Farr HP 100 and HP 200 replaceable cartridge air filters were determined. The scope of this examination included the determination of the arrestance of particulate matter in the laboratory air, the pressure drop, and the dust holding capacity of the specimens at the rated air flow rate of 1,000 cfm.

2. Description of Test Specimens

The filters were manufactured and supplied for test purposes by the Farr Company of Los Angeles, California. The devices consisted of a replaceable media or cartridge, a retainer made of steel wire and shaped to support the pleats of the filter medium, a holding frame, and a sealer frame. The holding frame was made of sheet steel and a number of these frames could be bolted together to form a filter bank. The retainers were fastened in the holding frame by means of spring steel clips. When the filter cartridge had been installed in the retainer the sealer frame pressed the media against the holding frame to prevent air from leaking past the filter medium.

The HP 100 and the HP 200 cartridges could both be fitted into the same frame. The cartridges were approximately 12 in. deep and each had an effective filter area of about 42 sq ft. The rated air flow for either specimen was 1,000 cfm, corresponding to a face velocity of 250 ft/min. at the 2 ft square holding frame of the filter and about 24 ft/min face velocity at the filter media.

The filter cartridges were supplied folded and could be fitted into the retainer when unfolded. The filter media were made of a dry glass fiber felt, approximately 1/8 inch thick.

3. Test Method and Procedure

The filters were tested at the rated air flow rate of 1,000 cfm. The arrestance determinations were made using the NBS Dust Spot Method described in a paper by R. S. Dill entitled "A Test Method for Air Filters", (ASHVE Transactions, Vol. 44, pp. 379, 1938). The filter under test was installed in the test apparatus and carefully sealed to prevent any by-pass of air or inward leakage into the test apparatus, except through the measuring orifice. After establishing the correct air flow rate through the filter, samples of air were drawn from the center points of the test duct 2 feet upstream and 8 feet downstream of the test specimen at equal rates and passed through known areas of Whatman No. 41 filter paper. The arrestance determinations were made with the particulate matter in the laboratory air as the aerosol except for one measurement on the HP 200 filter using Cottrell precipitate.

The light transmission of the sampling papers was measured for the same area of each paper before and after the test and the two sampling papers used for any one arrestance determination were selected to have the same light transmission when clean.

For determining the arrestance of the particulate matter in the laboratory air equal sampling areas were used in the upstream and downstream samplers. A similar increase of the opacity of the two sampling papers was obtained by passing the sampled air through the upstream paper only a 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 by-passing 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 papers, respectively.

For determining the arrestance of the filter with Cottrell precipitate as the test dust, different size areas of sampling paper were used upstream and downstream of the filter in order to obtain a similar increase of opacity on both sampling papers. The arrestance was then calculated by the formula:

$$A = (1 - \frac{S_D}{S_U} \times \frac{\Delta D}{\Delta U}) \times 100$$

where the symbols A, ΔU, and ΔD are the same as indicated above and S_U and S_D are the upstream and downstream sampling areas, respectively.

Arrestance determinations were made at the beginning and at the end of the test, and at several intermediate values of dust loading. The filters were loaded with a mixture of Cottrell precipitate and cotton linters in a ratio of 4 parts of cotton linters to every 96 parts of Cottrell precipitate by weight. The Cottrell precipitate had been previously sifted through a 100-mesh screen and the lint was prepared by grinding No. 7 cotton linters through a Wiley mill with a 4 millimeter screen.

The pressure drop across the filter under test was recorded at the beginning of the test of each specimen, after each arrestance determination, and after every 20-gram increment of Cottrell precipitate had been introduced into the test duct. The tests were terminated when the pressure drop across the HP 100 type reached 0.7 in. W.G. and across the HP 200 type, 0.9 in. W.G.

4. Test Results

Whereas only one specimen of the HP 200 type filter was tested and was found to perform as claimed by the manufacturer, four specimens of the HP 100 type filter were installed in the test apparatus, of which two were loaded to capacity whereas the other two were removed after initial arrestance determinations showed that they would probably not perform as expected. Several cartridges were damaged during installation in the retainer and had to be discarded.

A summary of the results obtained during the tests of the two specimen HP 100 filters is presented in Table 1 and the results for the model HP 200 filter are shown in Table 2.

The "Dust Load" shown in these tables is the amount of Cottrell precipitate and lint received by the filters. It is the weight of dust introduced into the test apparatus diminished by the percentage of dust fallout upstream of the filter. The dust fallout was determined, at the conclusion of the test

TABLE 1

PERFORMANCE OF FARR MODEL HP 100 AIR FILTER
AT 1000 CFM AIR FLOW RATE

Dust Load g	Pressure Drop in. W.G.	Arrestance** %
	SPECIMEN NO. 1	
0	0.185	65.7*
201	0.219	80.3*
403	0.244	73.5*
604	0.285	71.4*
806	0.344	75.4*
1002	0.407	78.9*
1248	0.570	---
1370	0.693	86.6*
	SPECIMEN NO. 2	
0	0.190	72.5*
143	0.210	89.2*
285	0.234	90.9
468	0.264	94.7*
671	0.330	95.5
915	0.464	84.3*
1099	0.679	91.7

*Average of two or three arrestance determinations.
**Particulate matter in the laboratory air used as aerosol.

TABLE 2

PERFORMANCE OF FARR MODEL HP 200 AIR FILTER
AT 1000 CFM AIR FLOW RATE

Dust Load g	Pressure Drop in. W.G.	Arrestance %
0	0.405	88.0*
12	0.410	98.5**
112	0.439	89.4*
265	0.475	91.3
427	0.510	91.7
548	0.549	93.3*
650	0.608	93.3
792	0.728	94.1
938	0.906	94.2

*Average of two tests.
**The aerosol in this test was Cottrell precipitate, all other arrestance values were determined with the particulate matter in the laboratory air.

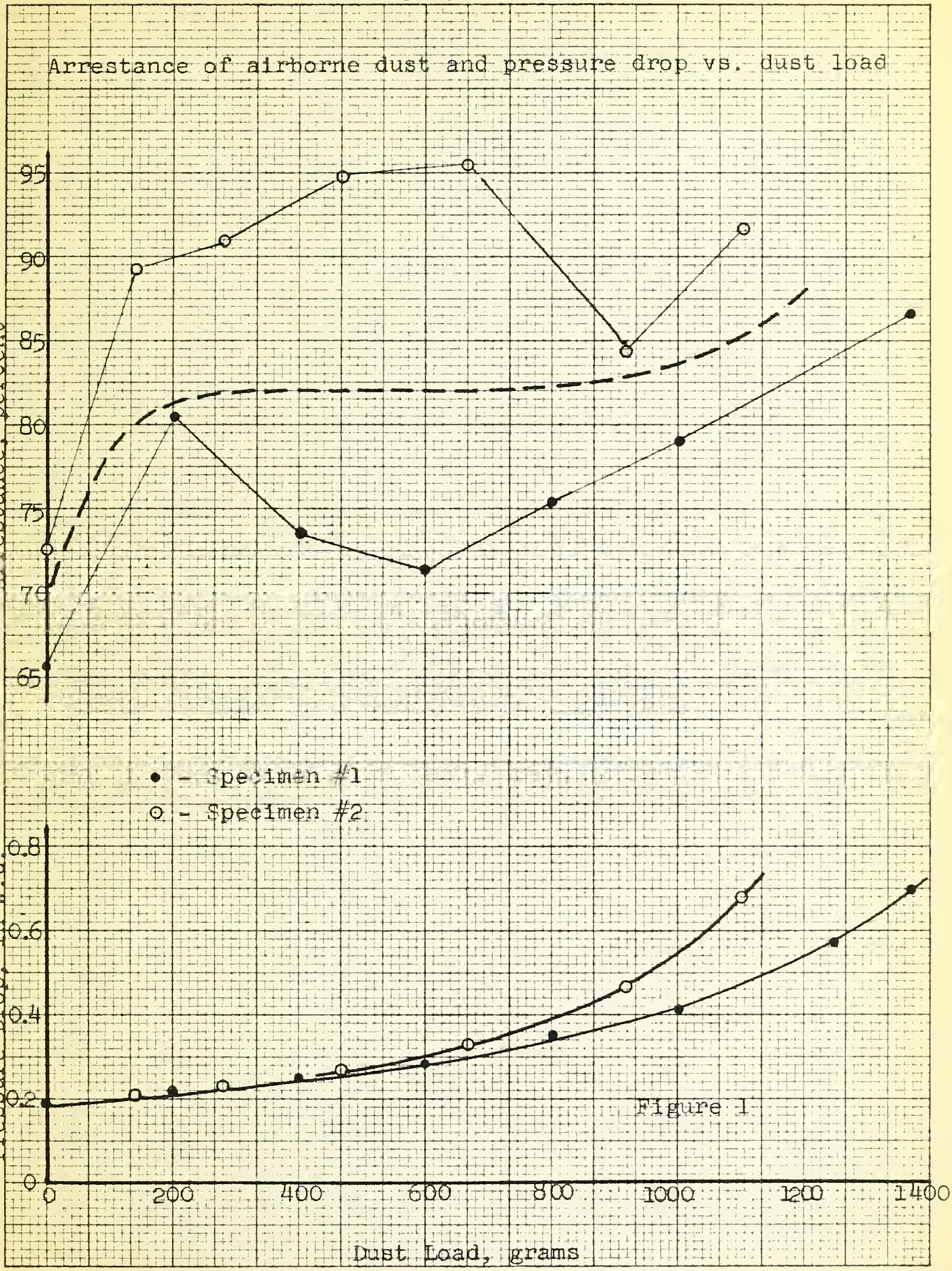
by sweeping out the test duct upstream of the test specimen and calculating the ratio of fallout to the total dust introduced.

Table 1 indicates that the arrestance of the particulate matter in the atmospheric air for the first specimen of the HP 100 type filter increased from 65.7 percent to 86.6 percent while the pressure drop increased from 0.185 in. W.G. to 0.693 in. W.G. due to a dust load of 1370 grams of Cottrell precipitate and lint. The average arrestance of the second specimen of this type was appreciably higher than that of the first one, starting at 72.5 percent with a clean filter and a pressure drop of 0.190 in. W.G. The arrestance of the second specimen increased to 95.5 percent at a pressure drop of 0.330 in. W.G., then dropped sharply to 84.3 percent at 0.464 in. W.G. but recovered at the end of the test to 91.7 percent. The dust load of this filter was 1099 grams and the final pressure drop, 0.679 in. W.G.

Figure 1 is a graph of the values shown in Table 1. The upper section shows the observed arrestance values for the two specimens connected by straight lines and a dotted smooth curve which approximates the average arrestance values of the two specimens. This latter curve indicates an average arrestance of approximately 83 percent based on the observations made on the two specimens. It will be noted that the pressure drop of the first specimen, having the higher arrestance of the two, increased faster than that of the other filter.

Table 2 summarizes the test results obtained with the HP-200 model air filter. The arrestance of the particulate matter in the laboratory air by this filter was initially 88.0 percent at a pressure drop of 0.405 in. W.G. An arrestance determination with Cottrell precipitate following the initial arrestance determination with airborne particulate matter in the laboratory air as the aerosol showed 98.5 percent. Thereafter, the arrestance of the particulate matter in the laboratory increased steadily as the dust load was increased to final values of 94.2 percent arrestance and coincident dust load and pressure drop values of 938 grams and 0.906 in. W.G., respectively as shown in Figure 2. Assuming that this filter was operated until its pressure drop at the rated air flow rate had increased by 0.5 in. W.G., the approximate average arrestance would be 92 percent.

Farr Company, Type HP-100



Farr Company, Type HP-200

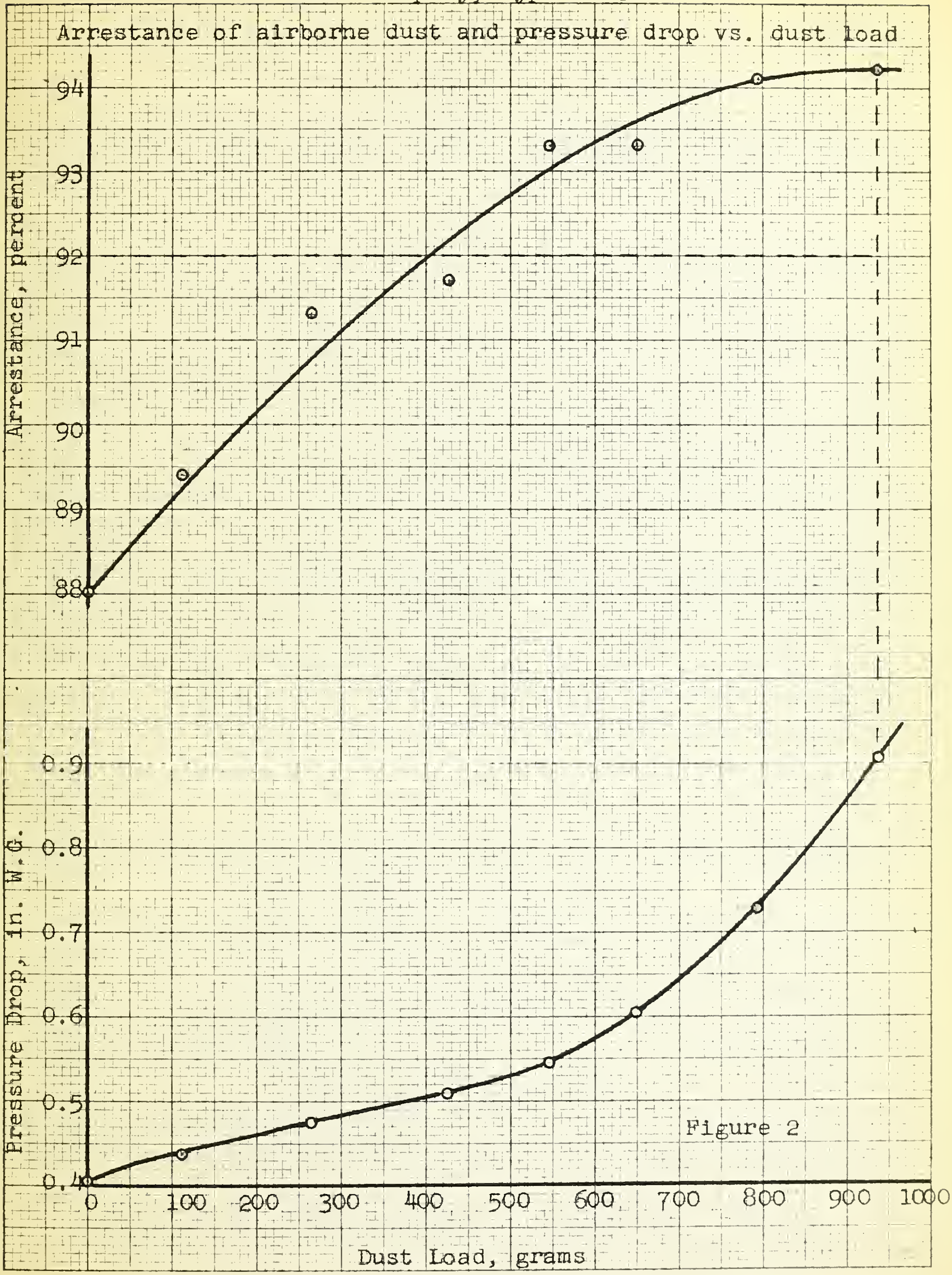


Figure 2

U. S. DEPARTMENT OF COMMERCE
Luther H. Hodges, *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 major laboratories in Washington, D.C., and Boulder, Colorado, 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 of the front cover.

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. Solid State Physics. Electron Physics. Atomic Physics.

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

Physical Chemistry. Thermochemistry. Surface Chemistry. Organic Chemistry. Molecular Spectroscopy. Molecular Kinetics. Mass Spectrometry.

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. Modulation Research. Antenna Research. Navigation Systems.

Upper Atmosphere and Space Physics. Upper Atmosphere and Plasma 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. Millimeter-Wave Research.

Circuit Standards. High Frequency Electrical Standards. Microwave Circuit Standards. Electronic Calibration Center.

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