was recommended to take its place. The subject of air cleaning is under investigation in cooperative research now being conducted at the *University of Minnesota.*

At the *National Bureau of Standards* a test method was developed for interested Government agencies, under which measured samples of the uncleaned air and of the air cleaned by a device under test are passed through filter papers.[65] The ratio of the flow rates through the two filter papers is adjusted during successive tests, until the resulting dust spots approach equality in density as shown by a photometer. The ratio of the flow rates is then indicative of the effectiveness of the cleaner in arresting dust. A statement of an air cleaner's efficiency by any test method, is meaningless unless the test dust is specified. Other instruments for determining gaseous and particulate air contaminants are described in industrial hygiene literature.[62, 66, 67, 68]

SOUND AND VIBRATION MEASUREMENTS

Approximate measurements of sound intensity can be made by aural methods. The ear is used to compare the measured noise with sounds of known strength.

Electrical devices, in which the ear plays no part, furnish the most satisfactory means of measuring noise intensities. The sound meter consists essentially of a microphone coupled to an amplifier designed with an ear-like response. The output of the microphone is read on a sensitive direct current milliammeter graduated to read directly in decibels. Instruments of this type, if connected with suitable band pass filters, can be used to study the intensity of the sound over its entire range of frequencies.

Electrical instruments are available for measuring the frequency, amplitude and acceleration of a vibrating mass. They are usually more convenient and accurate than the vibrating reed tachometer, the seismic type displacement meters or the accelerometers which can also be used for this purpose. Sound level meters are discussed in several text books[69, 70] and standards.[71]

REFERENCES

[1] Standard Code for Testing and Rating Steam Unit Heaters (adopted jointly by THE AMERICAN SOCIETY OF HEATING AND VENTILATING ENGINEERS and the *Industrial Unit Heater Association*, January 1950, second edition).

[2] A.S.H.V.E. Standard Code for Testing and Rating Steam Unit Ventilators (A.S.H.V.E. TRANSACTIONS, Vol. 38, 1932, p. 25), adopted June, 1932.

[3] A.S.R.E. Standard Methods of Rating and Testing Air Conditioning Equipment, A.S.R.E. Circular No. 13.

[4] A Survey of Testing Methods and Rating Limits for Domestic Heating Devices, by R. S. Dill (A.S.H.V.E. TRANSACTIONS, Vol. 51, 1945, p. 185).

[5] For a comprehensive treatment of temperature measurement the reader is referred to Temperature, Its Measurement and Control in Science and Industry, a symposium sponsored by the *American Institute of Physics* and published by Reinhold Publishing Corp.

[6] *Temperature Measurement in Engineering*, by H. D. Baker, E. A. Ryder, and N. H. Baker (John Wiley and Sons, New York).

[7] Temperature Measurement (*A.S.M.E.* Power Test Code, Part 3).

[8] Errors in the Measurement of the Temperature of Flue Gases, by P. Nicholls and W. E. Rice (A.S.H.V.E. TRANSACTIONS, Vol. 35, 1929, p. 473).

[9] Investigation of Warm Air Furnaces and Heating Systems, by A. C. Willard, A. P. Krats and V. S. Day (*Illinois Engineering Experiment Station, Bulletin* No. 120).

[10] Measuring Heat Transmission in Building Structures and a Heat Transmission Meter, by P. Nicholls (A.S.H.V.E. TRANSACTIONS, Vol. 30, 1924, p. 94).

[11] Parallel-connected Thermocouples for the Testing of Gas Appliances, by Walter B. Kirk and George J. Pacanovsky (*Gas*, September, 1939, p. 51).

[12] American Standard for Indicating Pressure and Vacuum Gages, Round Dial Type, with Elastic Pressure Chamber. B. 40.1–1939–(*American Standards Association*).

[13] Standard Test Code for Centrifugal and Axial Fans, 1938 (*A.S.H.V.E.* and *N.A.F.M.*) published by N.A.F.M. as Bulletin No. 110.

[14] Fan Engineering, Buffalo Forge Company, 5th Edition, p. 165.

[15] Illinois Micromanometer (*University of Illinois, Engineering Experiment Station Bulletin* No. 120, p. 91).

[16] The Weathertightness of Rolled Steel Windows, by J. E. Emswiler and W. C. Randall (A.S.H.V.E TRANSACTIONS, Vol. 34, 1928, p. 527).

[17] Pressure Measurement (*A.S.M.E.* Power Test Code 1936, Part 2, Chapter 2).

[18] The Measurement of Static Pressure, by C. J. Fechheimer (*Mechanical Engineering*, August, 1927).

[19] Psychrometric Tables for Vapor Pressure, Relative Humidity and Temperatures of the Dew-Point (*U. S. Department of Agriculture*, Weather Bureau, Washington, D. C.).

[20] For technical data refer to Fluid Meter Reports, Parts 1—1937, 2—1931, and 3—1933 (*American Society of Mechanical Engineers*).

[21] Technical Notes No. 546 (*National Advisory Committee for Aeronautics*, November, 1935).

[22] The Characteristics of Double Pitot Tubes, by F. R. Ingram, E. Diez-Canseco and L. Silverman (A.S.H.V.E. JOURNAL SECTION, *Heating, Piping and Air Conditioning*, November, 1942, p. 708).

[23] Discharge Coefficients of Square Edged Orifices for Measuring the Flow of Air, by H. S. Bean, E. Buckingham and P. S. Murphy (*Bureau of Standards Journal of Research*, Vol. 2, 1929, p. 561).

[24] Flow Measurement by Nozzles and Orifice Plates (*A.S.M.E.* Power Test Codes, Chapter 4 of Part 5, 1940).

[25] Air Flow Measurement in the Laboratory, by D. D. Wile (*Refrigerating Engineering*, June, 1947, p. 515).

[26] A.S.H.V.E. RESEARCH REPORT No. 1204—Entrainment and Jet-Pump Action of Air Streams, by G. L. Tube, G. B. Priester and D. K. Wright, Jr. (A.S.H.V.E. TRANSACTIONS, Vol. 48, 1942, p. 241).

[27] A.S.H.V.E. RESEARCH REPORTS Nos. 857, 911 and 966—Measurement of the Flow of Air Through Registers and Grilles, by L. E. Davies (A.S.H.V.E. TRANSACTIONS, Vol. 36, 1930, p. 201, Vol. 37, 1931, p. 619, and Vol. 39, 1933, p. 373).

[28] A.S.H.V.E. RESEARCH REPORT No. 1162—Air Flow Measurements at Intake and Discharge Openings and Grilles, by G. L. Tuve and D. K. Wright, Jr. (A.S.H.V.E. TRANSACTIONS, Vol. 46, 1940, p. 313).

[29] A.S.H.V.E. RESEARCH REPORT No. 1092—The Flow of Air Through Exhaust Grilles, by A. M. Greene, Jr. and M. H. Dean (A.S.H.V.E. TRANSACTIONS, Vol. 44, 1938, p. 387).

[30] A.S.H.V.E. RESEARCH REPORT No. 936—Investigation of Air Outlets in Class Room Ventilation, by G. L. Larson, D. W. Nelson and R. W. Kubasta (A.S.H.V.E. TRANSACTIONS, Vol. 38, 1932, p. 463).

[31] A.S.H.V.E. RESEARCH REPORT No. 1076—Air Distribution From Side Wall Outlets, by D. W. Nelson and D. J. Stewart (A.S.H.V.E. TRANSACTIONS, Vol. 44, 1938, p. 77).

[32] Measuring Air Flow, by G. L. Tuve (*Heating, Piping and Air Conditioning*, December, 1941).

[33] A.S.H.V.E. RESEARCH REPORT No. 1140—The Use of Air Velocity Meters, by G. L. Tuve, D. K. Wright, Jr. and L. J. Siegel (A.S.H.V.E. TRANSACTIONS, Vol. 45, 1939, p. 545).

[34] Temperature, Humidity and Air Motion Effects in Ventilation, by O. W. Armspach and Margaret Ingels (A.S.H.V.E. TRANSACTIONS, Vol. 28, 1922, p. 103).

[35] A.S.H.V.E. RESEARCH REPORT No. 1165—Development of Instruments for the Study of Air Distribution in Rooms, by A. P. Kratz, A. E. Hershey and R. B. Engdahl (A.S.H.V.E. TRANSACTIONS, Vol. 46, 1940, p. 351).

[36] Development of Testing Apparatus for Thermostats, by D. D. Wile (A.S.H.V.E. TRANSACTIONS, Vol. 42, 1936, p. 349).

[37] The Heated Thermometer Anemometer, by C. P. Yaglou (*Journal Industrial Hygiene and Toxicology*, Vol. 20, October, 1938, No. 8).

[38] A Simple Heated-Thermocouple Anemometer, by H. B. Nottage (A.S.H.V.E. TRANSACTIONS, Vol. 56, 1950, p. 431).

[39] Measurement of Ventilation Using Tracer Gas Technique, by J. B. Dick (A.S.H.V.E. JOURNAL SECTION, *Heating, Piping and Air Conditioning*, May, 1950, p. 131).

[40] The Temperature of Evaporation, by Willis H. Carrier (A.S.H.V.E. TRANSACTIONS, Vol. 24, 1918, p. 25).

[41] A Review of Existing Psychrometric Data in Relation to Practical Engineering Problems, by W. H. Carrier and C. O. Mackey (*A.S.M.E. Transactions*, January, 1937, p. 33; Discussion *A.S.M.E. Transactions*, August, 1937, p. 528).

[42] Divided Flow Low Temperature Humidity Test Apparatus, by Arnold Wexler (*National Bureau of Standards*, Research Paper No. 1894).

[43] Gas Analysis by Measurement of Thermal Conductivity, by H. A. Daynes (*Cambridge Press*, 1933).

[44] Standard Method of Test for Thermal Conductivity of Materials by Means of the Guarded Hot Plate adopted July, 1942, by A.S.H.V.E. (*A.S.T.M. Designation* C177 - 45).