eral instruments have been devised to evaluate the comfort or warmth of rooms, taking radiant as well as convective effects into account. Prominent among these are the eupatheoscope, the globe thermometer, the thermal integrator and the heated globe.[54, 55] Descriptions are contained in the references, and are omitted here because these devices are not widely used in America for several reasons, among which is the fact that radiant heating with high temperature sources is not a chief method of comfort heating in this country.

COMBUSTION ANALYSIS

There are two approaches to the problem of measuring the capacities of fuel burning devices, such as boilers and furnaces. The direct or calorimetric test consists in measuring the change in enthalpy or heat content of the fluid, air or water, heated by the device and multiplying by the flow rate in pounds per hour to arrive at the capacity in Btu per hour.[56] The indirect test consists in determining the heat lost in the flue gases and deducting it from the heat evolved by combustion of the fuel.[57] A heat balance consists in the simultaneous application of both tests to the same device. The indirect test almost invariably indicates the greater capacity, and the difference is credited to radiation from the boiler or furnace casing and *unaccounted for loss*.

In the case of some small equipment, the expense of the direct test is not considered justifiable, and the indirect test is relied upon with an arbitrary *radiation and unaccounted for* factor.[57]

Flue Gas Analysis

The Orsat apparatus is commonly used for analyzing flue gases. In its ordinary form, it consists of three pipettes and a means for isolating a sample of flue gas in a graduate. After measuring, the sample is expelled from the graduate into the first pipette where the carbon dioxide is extracted by potassium hydroxide. The sample is then remeasured and successively passed into the second and third pipettes, where the oxygen and the carbon monoxide are respectively extracted by potassium pyrogallate and cuprous chloride.

For field testing and burner adjustment, simpler portable devices are available for carbon dioxide determination only. From curves, based on typical hydrogen content of several common fuels, efficiencies may be estimated from the carbon dioxide value obtained. More elaborate laboratory equipment is sometimes provided for precise determination of carbon monoxide content by burning the carbon monoxide to carbon dioxide in presence of a catalyst.[58, 59] In large plants, carbon dioxide recorders are used to obtain a continuous indication of the plant's efficiency.[60]

SMOKE DENSITY MEASUREMENTS

Ringelmann charts are widely used for evaluating the density of smoke discharged from chimneys or stacks, and smoke ordinances are based on them in some cities. Each chart is composed of a series of crossed black lines on white paper which, at a distance of about 50 ft, is visually compared with the smoke under observation. Four charts are used with different degrees of blackness as shown in Table 1. The smoke density is specified by Ringelmann numbers from 1 to 4.

The photoelectric cell is used in some apparatus developed for smoke density recording in large plants. The same device is included in the testing equipment for domestic oil burners described in *National Bureau of Standards*, Commercial Standard CS75-42.[61] Under *Laboratory Tests* this publication contains the following section: "Smoke Determination.—After combustion has reached equilibrium, the amount of smoke in the flue gases, when viewed lengthwise through 4 feet of the smoke pipe in accordance with the *Underwriters' Laboratories, Inc.*, Standard for Domestic Oil Burners (Subject 296), March 1934 and subsequent revisions, shall not reduce the output of a standard photoelectric cell from 9 microamperes, with a clear smoke pipe, to less than 8 microamperes." The Commercial Standard also requires that during a test after installation, the burner shall operate without visible smoke at the chimney top.

A method of evaluating smoke produced by pot type oil burners was developed for the *Institute of Cooking and Heating Appliance Manufacturers* by R. N. St. John. A glass rod is interposed between a light source and a photo-sensitive cell, both before and after being exposed to the flue gases from a heating device. The diminution of the light transmitted by the rod, due to the deposit of soot on its surface, causes a reduction in the cell emf which is taken as an index of the concentration of smoke in the flue gases. A description of the method is contained in National Bureau of Standards Commercial Standard CS104-46.[57]

TABLE 1. RINGELMANN SMOKE CHART SPACINGS

NUMBER OF CARD	THICKNESS OF LINES, MM	DISTANCE IN CLEAR BETWEEN LINES, MM
1	1.0	9.0
2	2.3	7.7
3	3.7	6.3
4	5.5	4.5

DETERMINATION OF AIR CONTAMINANTS

Two measures of air dustiness are in use: particles per unit volume of air, and weight per unit volume of air. A comparative method consists in drawing known samples of air through a known area of filter cloth or paper, and comparing the density of the resulting spots with blackness charts or with spots from other sources.

For counting, particles are captured in a device such as the Smith-Greenburg impinger, the Owens jet dust counter, or in an electrostatic or a thermal precipitation device designed for the purpose.[62] Counting is done with a microscope, and the method yields important results when the nature or constituents of the dust are of interest.

For a weight determination, a known volume of air is drawn through a porous crucible or thimble, and the weight gained by the thimble during the operation is the weight of the dust captured from the air sample.[63] For precise work, the thimble must be dried in a desiccating chamber before weighing each time.

A test method based on weight determination was used in the A.S.H.V.E Code for Testing and Rating Air Cleaning Devices Used in General Ventilation Work.[64] This code was withdrawn by the Society in 1955 when it was evident that no manufacturer of filters was using equipment such as that specified in the code. This withdrawal was accompanied by a statement that it did not imply that any other code