At the National Bureau of Standards, sampling tubes are used upstream and downstream of an air cleaner under test whereby samples of air can be drawn through filter papers to afford an evaluation of the comparative effectiveness of the cleaner in arresting dust [43].

Other instruments for evaluating dust, including the konimeter, are described by Drinker and Hatch [44].

HEAT TRANSFER THROUGH BUILDING MATERIALS

The A.S.H.V.E. Standard Test Code for Heat Transmission Through Walls [45] describes the construction and use of the guarded hot box for determining over-all heat transmission coefficients of built-up sections including surface resistances. This apparatus consists of inner and outer insulated boxes, each having one open side which is sealed tightly against the wall specimen to be tested. The outer box serves as a guard and a zero temperature difference is maintained between the inner box and the air space separating it from the outer box. Electric heaters are provided to maintain any desired temperature within the boxes while at the same time the outer surface of the wall specimen is subjected to a low temperature. A common method of applying this low temperature is to fit the specimen into an opening in the wall of a refrigerated room. The air temperature difference between the two sides of the specimen, and the rate of heat input to the guarded hot box are measured. From these data an over-all heat flow coefficient can be calculated.

The Nicholls heat meter is very useful for determining the heat flow through walls of buildings [46]. This apparatus consists of a guarded plate on both sides of which are mounted a series of thermocouples. The plate is calibrated so that the rate of heat flow through it can be determined by observing the temperature difference between the two surfaces. In use, the meter is clamped tightly against the surface of the wall in question, and readings of heat flow of accuracy sufficient for many test purposes may be obtained.

In June 1942, the A.S.H.V.E. adopted a standard test procedure for determining the conductivity of materials by use of the guarded hot plate [47]. This method is adapted to homogeneous materials, and conductivities obtained do not include surface coefficients. The method involved is one in which two identical samples are arranged one on each side of a heated plate having a guard and a central test section. The resulting sandwich is placed between cold plates. In operation the same temperature is maintained in the guard section and test section of the heated plate and a lower temperature is maintained in each of the cold plates from a common source of cold water. Thermal conductivity is determined by measuring the amount of heat supplied to the center or guarded portion of the hot plate, the temperatures at the hot and cold surfaces and the thickness of the specimen. The apparatus requires careful, precise construction and its operation requires care and skill. The actual design of basic types of hot plates is described in an *A.S.T.M.* publication [48].

MEASUREMENT OF HEAT EXCHANGE FOR COMFORT CONDITIONS

Several instruments have been devised to measure the effect of various factors as they relate to the comfort of the body [49]. The principal ones are

the Kata-thermometer, Dufton's eupatheoscope, Vernon's globe thermometer, Winslow and Greenburg's thermo-integrator, and Yaglou's heated globe [50, 51]. These instruments were designed to obtain a quantitative measurement of the thermal exchange between the human body and its environment.

COMBUSTION ANALYSIS

The analysis of flue gases to determine completeness and efficiency of combustion is usually made chemically with an Orsat apparatus. This consists of a measuring burette, a leveling bottle, and three pipettes. Carbon dioxide is absorbed in the first pipette by potassium hydroxide, oxygen in the second by potassium pyrogallate, and carbon monoxide in the third by cuprous chloride. A known volume of gas is drawn in, and after each of the three absorptions the reduced volume is again measured in the burette. Pressure and temperature of the gas sample are kept constant while measuring. Several passes are made through each pipette which contains tubes or glass beads to increase the wetted surface. It is essential that each reaction be completed before the next reaction is started. Since the life of the reagents is limited, it is well to keep a record of the number of samples tested. Care is needed in operation to prevent the pulling of reagents out of the pipettes into the capillary tubing and burette. Many types of recording gas analyzers are available and are usually found in the larger boiler plants.

The concentration of carbon dioxide is a measure of the excess air in a plant's flue gases and this is an important factor which concerns the efficiency of fuel utilization. In larger boiler plants carbon dioxide recorders are installed which operate in several ways. The basic principles involved are chemical absorption, thermal conductivity and difference in density between the flue gas and the atmosphere. Thermal conductivity apparatus for either indicating or recording carbon dioxide concentration in flue gas are available on the market. Instruments of this type have advantages of convenience and, under some circumstances, of accuracy compared to the better known Orsat apparatus. Methods of sampling flue gases for test purposes as well as of approximating their average temperature are contained in the $I=B=R$ Codes [52].

Carbon Monoxide Measurement

The Orsat apparatus may be used for determining amounts of carbon monoxide of 2/10 of 1 per cent or more. For very low concentration of carbon monoxide, indicators and recorders depend on measurement of the heating effect of combustion of carbon monoxide to dioxide in the presence of a catalyst. The temperature rise is measured by a thermopile, the junctions of which are buried in the catalyst [53]. Such instruments are used to determine the presence of carbon monoxide in quantities as low as 1/100 of 1 per cent.

For indicating low ranges of CO as for combustion products from gas appliances discharged into occupied spaces the colorimetric method developed at the National Bureau of Standards is satisfactory [54, 55].

SMOKE DENSITY MEASUREMENTS

Smoke density may be judged by assigning to it the number of the Ringelmann Smoke Chart which appears to have the same color when