to fan pressure or chimney pull, an increase in the discharge of soot and fly ash from the combustion chamber will result.

Measurement of the Efficiency of Combustion

As efficient combustion is based upon a certain percentage of excess air, it is possible to determine the results by analysis of the gases formed by the combustion process. An Orsat apparatus can be used to determine the percentage (by volume) of the carbon dioxide (CO_2), oxygen (O_2) and carbon monoxide (CO) in the flue gases. Due to variations in the fuel bed and rate of burning of stoker-fired solid fuels it is not sufficient to analyze a *grab* sample. A continuous gas sample drawn at a constant rate throughout an operating period of reasonably long duration should be used.

A CO_2 reading of 12.5 to 14 per cent indicates that the excess air supplied is in the range of 30 to 50 per cent. The presence of CO indicates a loss due to improper mixing of the air and the gases of combustion. As an increase in excess air maintained during *on* periods will decrease the tendency toward smoke in the *off* periods of intermittently operated bituminous coal stokers, care should be taken that the delivery of air by the fan is great enough to avoid smoke.

Controls

The industry developed by stokers in Classes 1, 2, 3 and 4 has been due as much to the application of proper controls as to the stoker itself. This is especially true of Class 1 stokers because of their application to residential heating, a field wherein the majority of owners and users are not familiar with control problems or stoker operation.

The usual controls applied are as follows:

a. Thermostats (plain and clock).
b. Limit Controls (steam, vapor, vacuum, hot water, or air).
c. Stack Temperature or Time Controls (for actuating fires periodically).
d. Relay (for low voltage controls).
e. Safety or Overload Cutout (for protection against overload).
f. Low Water Cutout (steam, vapor and vacuum).

DOMESTIC OIL BURNERS

An oil burner is a mechanical device for producing heat automatically and safely from liquid fuels. This heat is produced in the furnace or firepot of hot water or steam boilers or warm air furnaces and is absorbed by the boiler, and thus made available for distribution to the house through the heating system.

The number of combinations of the characteristic elements of domestic oil burners is rather large and accounts for the variety of burners found in actual practice. Domestic oil burners may be classified as follows:

1. AIR SUPPLY FOR COMBUSTION
   a. Atmospheric—by natural chimney draft.
   b. Mechanical—electric-motor-driven fan or blower.
   c. Combination of (a) and (b)—primary air supply by fan or blower and secondary air supply by natural chimney draft.

2. METHOD OF OIL PREPARATION
   a. Vaporizing—oil distills on hot surface or in hot cracking chamber.
   b. Atomizing—oil broken up into minute globules.
      (1) Centrifugal—by means of rotating cup or disc.
      (2) Pressure—by means of forcing oil under pressure through a small nozzle or orifice.
      (3) Air or steam—by high velocity air or steam jet in a special type of nozzle.
      (4) Combination air and pressure—by air entrained with oil under pressure and forced through a nozzle.
   c. Combination of (a) and (b).

3. TYPE OF FLAME
   a. Luminous—a relatively bright flame. An orange-colored flame is usually best if no smoke is present.
   b. Non-luminous—Bunsen-type flame (*i.e.*, blue flame).

4. METHODS OF IGNITION
   a. Electric.
      (1) Spark—by transformer producing high-voltage sparks. Usually shielded to avoid radio interference. May take place continuously while the burner is operating or just at the beginning of operation.
      (2) Resistance—by means of hot wires or plates.
   b. Gas.
      (1) Continuous—pilot light of constant size.
      (2) Expanding—size of pilot light expanded temporarily at the beginning of burner operation.
   c. Combination—electric sparks light the gas and the gas flame ignites the oil.
   d. Manual—by manually-operated gas torch for continuously operating burners.

5. MANNER OF OPERATION
   a. On and off—burner operates only a portion of the time (intermittent).
   b. High and low—burner operates continuously but varies from a high to a low flame.
   c. Graduated—burner operates continuously but flame is graduated according to needs by regulating both air and oil supply.

A trade classification of oil burners consists of the following general types: (*a*) gun or pressure atomizing, (*b*) rotary and (*c*) pot or vaporizing.

The gun type, illustrated in Fig. 10 is characterized by an air tube, usually horizontal, with oil supply pipe centrally located in the tube and arranged so that a spray of atomized oil is introduced and mixed in the combustion chamber with the air stream emerging from the air tube. A variety of patented shapes are employed at the end of the air tube to influence the direction and speed of the air and thus the effectiveness of the mixing process.

The most distinguishing feature of vertical rotary burners is the principle of flame application. These burners are of two general types; the center flame and wall flame. In the former type, (Fig. 11) the oil is atomized by being thrown from the rim of a revolving disc or cup and the flame burns in suspension with a characteristic yellow color. Combustion is supported by means of a bowl-shaped chamber or hearth. The wall flame burner (Fig. 12) differs in that combustion takes place in a ring of