lowest workable minimum. Laboratory tests frequently show 25 per cent to 50 per cent more air than is required for combustion, yet field tests indicate that the average burner operates with from 50 per cent to 125 per cent excess air, with a corresponding reduction in the efficiency of the burner. Many domestic burners are extremes of simplicity, the only moving parts being the motor armature with a shaft and direct-connected fan and pump set.

Type of Flame, Ignition

If the vaporizing of the atomized oil and the combustion are concurrent events, a luminous flame will usually result. If vaporization and mixing are accomplished before combustion, a non-luminous flame will result. Some burners may produce either type of flame according to the adjustment made.

A limited comparison of these two types of flame shows no inherent superiority of one over the other so far as thermal efficiencies are concerned. This is definitely true when the burners are placed in boilers having ample indirect surface, and is probably true in general. The moot question of radiation has not been conclusively settled. There are indications that the radiation of luminous and non-luminous flames in boiler furnaces are practically the same. More information is needed upon this subject.

It is true, however, that a non-luminous flame may show low excess air and the presence of carbon monoxide, but no smoke. Low excess air with a luminous flame will usually show little or no carbon monoxide, but will be unmistakably smoky. Visual indications, especially with a blue flame, may therefore be quite unreliable.

When a burner is operating intermittently under the control of a thermostat, some positive form of ignition is required to function every time there is a call for heat.

The necessity for certain ignition under adverse conditions, when the line voltage is low or the oil is cold is paramount, and this phase of burner design and operation has been given the closest attention, as faulty ignition is more to be feared than improper operation once the flame is established.

The effect of the air and oil setting is important, since it may be necessary in some instances to adjust for greater excess air than is otherwise required in order to get a mixture suitable for certainty of ignition.

Recent research[1] at Yale University, conducted in coöperation with the A.S.H.V.E. Research Laboratory and the *American Oil Burner Association*, reveals that the various methods of operation (*i.e.*, on and off, high and low, and graduated) all have potential advantages and disadvantages and that a choice in any case requires a consideration of the heat-absorbing characteristics of the boiler in which the burner is to operate. From the standpoint of efficiency of operation it seems that there is little choice if at the maximum setting of all burners the boiler efficiency were at its maximum value. If, on the other hand, the boiler were operating beyond its point of maximum efficiency, then it appears that the graduated type

[1]Intermittent Operation of Oil Burners, by L. E. Seeley and J. H. Powers (A.S.H.V.E. TRANSACTIONS, Vol. 38, 1932).

might show better results. The following additional factors should be considered:

1. The intermittent type by having only one setting might be set for efficient combustion at that point.

2. An intermittent burner should be set for a higher total heat output than either of the other two types in order to get the acceleration necessary when heat is required. This may in some cases give less economical performance due to the increased boiler load.

3. An interruption in electric current might in some instances be troublesome with continuously operating burners where manual ignition is employed.

4. The continuously operating burners must have a minimum fuel setting low enough to prevent overheating in mild weather or during the summer if the boiler is used for domestic hot water.

5. Electrical operating costs must be considered, but must be based upon known power requirements. The power requirements of some burners will be several times as high as others so any generalization on operating costs is futile.

6. Evenness of heat supply will have some influence on uniformity of temperature.

7. Number and cost of controls which reflect in the manufacturing costs.

This entire subject, therefore, is likely to be somewhat perplexing because of the necessity of knowing, and the difficulty in determining, the efficiency characteristics of many heating boilers. Selections of oil burners on the basis of their manner of operation will probably be largely a matter of preference. The advent of special boilers for oil burning will provide the engineer with the opportunity for greater discrimination.

Temperature Control, Protective Devices

Domestic oil burners are controlled directly from the change in temperature of a designated control room (usually the living room, dining room or hall), and by temperature or pressure variations in the boiler. Oil-burner installations put in only a few years ago were simplified to the extent of having a single control element—the room thermostat—that started and stopped the burner. The modern installation provides, in addition, electrical devices inter-wired with the control system to insure against poor operation and to guard against troubles brought on by the characteristics of the heating plant.

One control system provides an instrument actuated by two temperature bulbs, one placed in the outdoor air and the other in a designated part of the heating system. The control is actuated by both bulbs and is designed to maintain the heating medium at a temperature to suit the variations in outdoor temperature, the lower the outdoor temperature the higher the temperature of the heating medium. Other devices have been developed to maintain a certain minimum temperature that will effectively prevent the downward window currents of cold air from reaching and traveling across the floor, regardless of the room thermostat.

Owing to the comparative intensity of heat production with a burner, a boiler with limited water storage above the crown sheet might pass steam to the radiator system so rapidly, at starting, that the sheet would be uncovered, with probable damage to the boiler structure. A low-water safety can be so wired into the system that the burner will be stopped before the water level is reduced to the danger point, or a boiler feed can