

and thus the effectiveness of the mixing process. The most distinguishing feature of the rotary type is that the oil is discharged to the furnace or fire-pot by a rotating element of special design. The pot type can be identified by the presence of a metal structure, called a pot, in which combustion takes place. While fire brick linings in the boiler are necessary with the gun and rotary type, they are not needed with the pot type.

The oil burners are operated by a small electric motor which pumps the oil and some or all of the air required. The smallest sizes can generally burn not much less than $1\frac{1}{2}$ gal of oil per hour. The grade of oil burned ranges from No. 1 to No. 4 (see pg. 479 to 481). No. 4 oil is the heaviest and most viscous of the various grades mentioned. An oil burner satisfactory for No. 4 oil can burn any of the lighter grades easily but an oil burner recommended for No. 2 oil should never be supplied with the heavier grades. It has been found that while the heavier grades of oil have a smaller heat value per pound, they have, due to greater density, a larger heat value per gallon. The relative economy of the various grades must be based upon price and the amount of excess air required for clean and efficient combustion.

The Combustion Process

Efficient combustion as previously indicated must produce a clean flame and must use relatively small excess of air (*i.e.*, between 25 and 50 per cent). This can be done only by vaporizing the oil quickly, completely, and mixing it vigorously with air in a firepot hot enough to support the combustion. A vaporizing burner (*i.e.*, pot type) prepares the oil vapor before it mixes with air to any extent. If air and oil vapor temperatures are high and the firepot hot, a clear blue flame is produced. There may be a deficiency of air as shown by the presence of carbon monoxide (CO) or an excessive supply of air, depending upon burner adjustment, without altering the clean, blue appearance of the flame. An atomizing burner (*i.e.*, gun and rotary types) is so named because the oil in one way or another is mechanically separated into very fine particles so the surface exposure of the liquid to the radiant heat of the firepot is vastly increased and vaporization proceeds quickly. Since the air enters the firepot with the liquid fuel particles, it follows that mixing, vaporization and burning are all occurring at once in the same space. This produces a luminous instead of a blue or non-luminous flame. In this case a deficient amount of air is indicated by a dull red or dark orange flame with smoky flame tips.

An excessive supply of air may produce a brilliant white flame in some cases or, in others, a short ragged flame with incandescent sparks flashing through the combustion space. While extreme cases may be easily detected, it is generally not possible to distinguish, by the eye alone, the finer adjustments which competent installation requires.

Certain tests indicate that there is no difference in economy between a blue flame and a luminous flame if the position, shape and the per cent of excess air of both flames are about the same.

Furnace or Firepot Design

It is evident that the atomizing burner is dependent upon the surrounding heated refractory or firebrick surfaces to vaporize the oil and

support combustion. While the importance of the firepot is obvious, its design has been troublesome. Unsatisfactory combustion may be due to inadequate atomization and mixing. A firepot can only compensate for these things to a limited extent. If liquid fuel continually reaches some part of the firebrick surface, a carbon deposit will result. Fundamentally, the firepot should enclose a space having a shape similar to the flame but large enough to avoid flame contact. The nearest approach in practice is to have the bottom of the firepot flat but far enough below the nozzle to avoid flame contact; the sides tapering from the air tube at the same angle as the nozzle spray and the back wall rounded. A plan view of the firepot thus resembles in shape the outline of the flame. In this way as much firebrick as possible is close to the flame so it may be kept quite hot. This insures quick vaporization, rapid combustion and better mixing by eliminating dead or inactive spaces in the firepot. An overhanging arch at the back of the firepot is sometimes used to increase the flame travel and give more time for mixing and burning and sometimes to prevent the gases from going too directly into the boiler flues. When good atomization and vigorous mixing are achieved by the burner, firepot design becomes a less critical matter. Where secondary air is used, firepot design is quite important. Manufacturers generally provide careful directions and in some instances provide special firebrick shapes suited to their burners.

Oil and Air Adjustments

Where adjustments of oil and air have been made which give efficient combustion, the problem of maintaining the adjustments constant becomes an important one. Particularly is this true when the change causes the per cent of excess air to decrease below allowable limits of the burner. A decrease in air supply while the oil delivery remains constant or an increase in oil delivery while the air supply remains constant will make the mixture of oil and air too rich for clean combustion. The more efficient the adjustment (*i.e.*, 25 per cent excess air) the more critical it will be of variations. The oil and air supply rates must remain constant.

The following factors may influence the oil delivery rate: (a) changes in oil viscosity due to temperature change or variations in grade of oil delivered, (b) erosion of atomizing nozzle, (c) fluctuations in by-pass relief pressures and (d) possible variations in methods 2b (3) and 2b (4) listed in the previous classification table. Note that any change due to partial stoppage of oil delivery will increase the proportion of excess air. This will result in less heat, reduced economy and possibly a complete interruption of service but usually no soot will form.

The following factors may influence the air supply: (a) changes in firepot draft due to a variety of causes (*i.e.*, changes in chimney draft because of weather changes, seasonal changes, back drafts, failure or inadequacy of automatic draft regulator, use of chimney for other purposes, possible stoppage of the chimney and changes in draft resistance of boiler due to partial stoppage of the flues), (b) changes in air inlet adjustments to the fan—collection of lint and dirt on the inlet grille may be enough in some cases.