hydeous combustion theory since most investigators who have studied the former have observed that the formation of aldehydes is one of the steps in the combustion process. It has been well established that fuel oils must be gasified before combustion can occur, and that molecules of a hydrocarbon and oxygen do not combine directly with each other to form carbon dioxide and water vapor, but pass through intermediate reactions in the process.

Lewis and von Elbe,[5] Pease, and others[6] have advanced the theory that the reactions between hydrocarbons and oxygen are probably chain reactions. This theory postulates that a great many different reactions take place simultaneously or progressively between molecules, atoms, and radicals in a mixture of hydrocarbons and oxygen. Some of these reactions

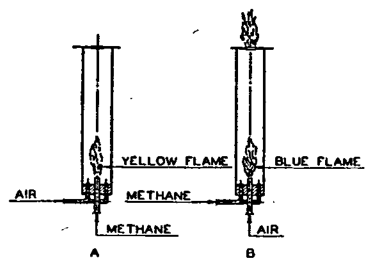

FIG. 3. ILLUSTRATION OF BLUE AND YELLOW FLAME COMBUSTION

produce particles or substances that tend to accelerate the reactions while others tend to slow down the process. Also, temperature, pressure, light and certain catalytic agents all may affect the speed and nature of these processes. The kind of intermediate products formed before combustion is complete depends on the physical conditions mentioned, as well as the molecular structure of the particular hydrocarbon participating in the reaction. Aldehydes, methyl and ethyl alcohols, formic acid, and other substances, have all been identified as intermediate products in certain reactions. The chain reaction theory, in reality embraces and elaborates on the aldehydeous combustion theory.

Oil Burning Indexes

A number of indexes have been used, or proposed, as an indication of the burning qualities of fuel oils based on one or more physical measurements made on the oil. These may be summarized as follows:

A. Indexes based on a single physical test: (1) *API* gravity[7], (2) Aniline point[8], (3) *Institute of Petroleum* smoke test, (4) Carbon-Hydrogen ratio based on flue gas analysis or ultimate analysis, and (5) Percent aromatics determined by sulfuric acid absorption tests[8].

B. Indexes based on two or more physical tests: (1) Diesel index[9] based on *API* gravity and aniline point, (2) *Institute of Petroleum* cetane number [10] based on the *API* gravity and 50 percent distillation point, (3) *Universal Oil Products* characterization factor[11] based on specific gravity and average boiling point, (4) Burning index[12] based on *API* gravity and 50 percent distillation point, and (5) Estimated Carbon-Hydrogen ratio[13] based on *API* gravity aniline point, and boiling point.

Various investigators have shown correlation between one or more of these indexes and the performance of fuel oils in oil burners. Experiments

conducted with the *Oil Heat Institute* Reference Test Unit[14] indicated good correlation between the smoking tendency of fuel oils and *API* gravity, burning index, Diesel index, and hydrogen-carbon ratio for a limited number of oils in laboratory apparatus simulating a pressure-atomizing burner. These results are shown graphically in Fig. 4. Smoking tendency is given here in terms of smoke spot reflectance, the light reflectance of a smoke-soiled filter paper. A high reflectance, relative to a clean filter paper, indicates low smoking tendency. CO_2/U is the observed CO_2 divided by the ultimate or maximum theoretical CO_2 expressed as a percentage. Reid and Hersberger[12] have related burning qualities and burning index for various oils in a wall-flame burner. Cauley and Delgass[13] cite test results

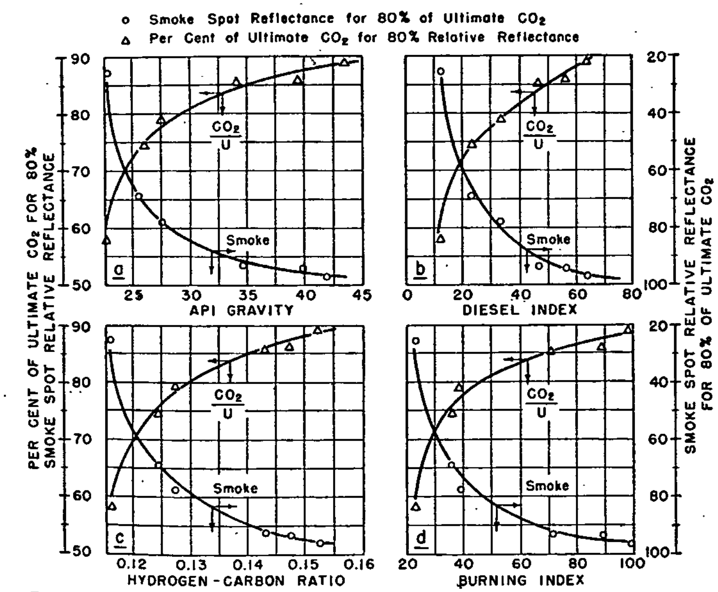

FIG. 4. CORRELATION OF BURNING QUALITIES OF FUEL OILS WITH FOUR COMBUSTION INDEXES

on combustion indexes obtained with vaporizing burners. The present experimental data are probably too meager as yet to correlate adequately any one of these indexes with burning qualities of oil fuel for all types of burners. Few attempts have been made to suggest limits for any of these fuel oil indexes for particular applications, even though correlations between them and burning qualities have been observed. In other words, none of the above mentioned indexes has yet gained sufficiently wide usage to replace the grading of oils by *Commercial Standard* CS12-48.

Experiments have shown that thermal decomposition or cracking of hydrocarbons begins at a temperature of approximately 680 F at atmospheric pressure, although the temperature of cracking varies somewhat above and below this value. Thus pure distillate fuel oils, whose end point does not exceed this temperature, can usually be completely evaporated in vaporizing-type oil burners at atmospheric pressure without leaving a residue or without cracking of the hydrocarbons. Fuel oils that cannot