SCIENCE

Acoustical Oscillations of Flames

THE pulsation and oscillation of flames in burners have acquired scientific and economic significance for combustion technologists, engineers in power plants, and designers of aircraft and missiles, because the phenomenon may cause many types of trouble. Or, conversely, it can be harnessed to accomplish desired ends. Two widely separated developments have brought flame oscillation to the forefront of scientific investigation: the increased popularity of basementless, ranch-type homes, and the technological evolution of pulse-jet, jet-turbine, ram-jet, and rocket engines. Problems within power plants have also heightened the interest.

Residential furnace manufacturers have received complaints from builders and homeowners about the noise and vibration caused by their equipment. Flame pulsation in burners located in utility rooms of basementless houses has produced disagreeable noises and has caused adjacent walls to vibrate. In certain instances homeowners have experienced an "uncomfortable feeling" during the operative phase of the burner cycle, apparently caused by inaudible pulsations.

In large burning systems, such as in power plants, oscillations from flames sometimes cause vibrations violent enough to threaten damage to structures, and costly changes have been tried to blanket or reduce such vibrations. Acoustical oscillations in the afterburners of jet turbines and in ram-jet and rocket engines have caused difficulties ranging from noises intolerable to the human ear to vibratory destruction of engine parts. Oscillations in certain rockets and missiles, on the other hand, are believed to increase combustion efficiency.

Both industry and military are cognizant of the need to know more about flame oscillations and are sponsoring research on the subject. Fundamental studies are being conducted at Battelle Institute for the Flight Research Laboratory, Wright-Patterson Air Force Base. In addition, Battelle has been the site of research sponsored by several manufacturers of industrial and home-heating equipment. Four lines of investigation have been followed. Attempts have been made to (1) determine the various types of oscillations that may occur in combustion systems; (2) explain the mechanism, or sequence of events, responsible for causing each type of oscillation; (3) determine the effect of oscillations on other components of the system; and (4) develop means for either suppressing or amplifying a particular oscillation.

Some burners emit sound consisting of relatively pure tones, of the same type as produced by a pipe organ. Oscillations from these burners have been explained by elementary acoustical considerations. In some instances, an analysis of the system has been used to predict the occurrence of oscillations and to determine what steps can be taken to suppress or amplify them. Effective suppression of the organ-pipe type has been attained with quarter-wave tubes and Helmholtz resonators of the proper size.

Burners may also produce tones that are not immediately recognized as of the organ-pipe type because they are so close to the low Helmholtz frequencies. The predicted frequency may be as much as eight times greater than the observed frequency. High-speed motion pictures in such a burner show drastic, periodic changes in flame shape. Oscillations that often cause trouble in large combustion systems, such as oil-fired locomotives or industrial furnaces, may not be primarily of acoustical origin. Here the flame may act as an amplifier, raising the intensity of pressure fluctuations to an intolerable level.

In their studies of oscillations in burners, Battelle scientists have used microphone systems, tape recorders, sonic analyzers, sound-level meters, and motion picture cameras. It seems probable that research will provide the information needed to eliminate most of the troubles caused by flame oscillations. The deliberate use of the phenomena in certain types of burners to improve combustion efficiency is another probable positive gain that will come from the research.

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