Obviously, spark ignition timing is an important factor controlling the initial rise of pressure in the combustion chamber. The ignition of the fuel mixture must begin at the proper time to allow flame front propagation and the release of heat to build up peak pressure for the power stroke.

The speed of flame front propagation is a major factor affecting the power output of the reciprocating engine since this factor controls the rate of heat release and rate of pressure rise in the combustion chamber. For this reason, dual ignition is necessary for powerplants of high specific power output. Obviously, normal combustion can be accomplished more rapidly with the propagation of two flame fronts rather than one. The two sources of ignition are able to accomplish the combustion heat release and pressure rise in a shorter period of time. Fuel-air ratio is another factor affecting the flame propagation speed in the combustion chamber. The maximum flame propagation speed occurs near a fuel-air ratio of 0.08 and, thus, maximum power output for a given airflow will tend to occur at this value rather than the stoichiometric value.

Two aberrations of the combustion process are preignition and detonation. Preignition is simply a premature ignition and flame front propagation due to hot spots in the combustion chamber. Various lead and carbon deposits and feathered edges on metal surfaces can supply a glow ignition spot and begin a flame propagation prior to normal spark ignition. As shown on the graph of figure 2.16, preignition causes a premature rise of pressure during the piston travel. As a result, preignition combustion pressures and temperatures will exceed normal combustion values and are very likely to cause engine damage. Because of the premature rise of pressure toward the end of the compression stroke, the net work of the operating cycle is reduced. Preignition is evidenced by a rise in cylinder head temperature and drop in *BMEP* or torque pressure.

Denotation offers the possibility of immediate destruction of the powerplant. The normal combustion process is initiated by the spark and beginning of flame front propagation. As the flame front is propagated, the combustion chamber pressure and temperature begin to rise. Under certain conditions of high combustion pressure and temperature, the mixture ahead of the advancing flame front may suddenly explode with considerable violence and send strong detonation waves through the combustion chamber. The result is depicted by the graph of figure 2.16, where a sharp, explosive increase in pressure takes place with a subsequent reduction of the mean pressure during the power stroke. Detonation produces sharp explosive pressure peaks many times greater than normal combustion. Also, the exploding gases radiate considerable heat and cause excessive temperatures for many local parts of the engine. The effects of heavy detonation are so severe that structural damage is the immediate result. Rapid rise of cylinder head temperature, rapid drop in *BMEP*, and loud, expensive noises are evidence of detonation.

Detonation is not necessarily confined to a period after the beginning of normal flame front propagation. With extremely low grades of fuel, detonation can occur before normal ignition. In addition, the high temperatures and pressure caused by preignition will mean that detonation is usually a corollary of preignition. Detonation results from a sudden, unstable decomposition of fuel at some critical combination of high temperature and pressure. Thus, detonation is most likely to occur at any operating condition which produces high combustion pressures and temperatures. Generally, high engine airflow and fuel-air ratios for maximum heat release will produce the critical conditions. High engine airflow is common to high *MAP* and RPM and the engine is most sensitive to *CAT* and fuel-air ratio in this region.