Combustion chamber

The combustion chamber is that turbo-engine component which fuel, supplied by feeding nozzles, is mixed with air flow coming from the compressor and burns releasing heat to obtain a gas stream to a temperature as much as possible uniform in condition requested form turbine.
This task must be carried out with the possible minimum of pressure leaks and with the maximum possible release of heat respect the limited space available.

The amount of fuel supplied to the air depends by requested temperature raising.
However the maximum temperature is limited in 850 - 1700 C interval, depending by characteristics of materials of which turbine vanes and blades are constituted and by cooling system of same blades and vanes. The air enters in combustion chamber with temperature comprised between 200 and 550 °C because of the heating caused by compression, so the required temperature raising in the combustion chamber is 650-1150 °C.
The combustion chamber must also be able to maintain a stable and efficient combustion in a wide radius of engine operating conditions.
An efficient combustion has become more and more important during last few years because of rapid increment of the commercial air traffic and consequent increase of atmospheric pollution in exhaust smokes form.

The air coming from the compressor enters in the combustion chamber with speed that can reach 150 m/s. This speed is too much high for combustion, so first tha must happen in a combustor is a spread, that is a deceleration of air with a consequent increase of the static pressure.
The kerosene burning speed to the normal mixing rate air-fuel is of little meters/second, any flame obtained in these conditions would be blown away.
Therefore a low speed axial region must be created in the chamber so that the flame remains ignited and anchored in all conditions of engine operation.

In normal conditions, the total air-fuel rate in a combustion chamber can vary between 45:1 and 130:1. The kerosene only burns in efficient way to rate near 15:1, thus the fuel must be burnt only with a part of entering air in that which primary zone is called. This is obtained by a flame tube that has several accesses that regulate the air distribution along combustor.

Approximately 20% of the air capacity enters in combustion chamber through the snout.
Immediately downstream to the snout there are swirl vanes and a perforated plate through which the air passes in the primary zone of combustor. The air that comes from the swirlers induces a motion of recirculation in the primary zone.
The remaining part of the air passes through the annulus, interspace that is between the flame tube and the outer case of combustor (see fig. 1)

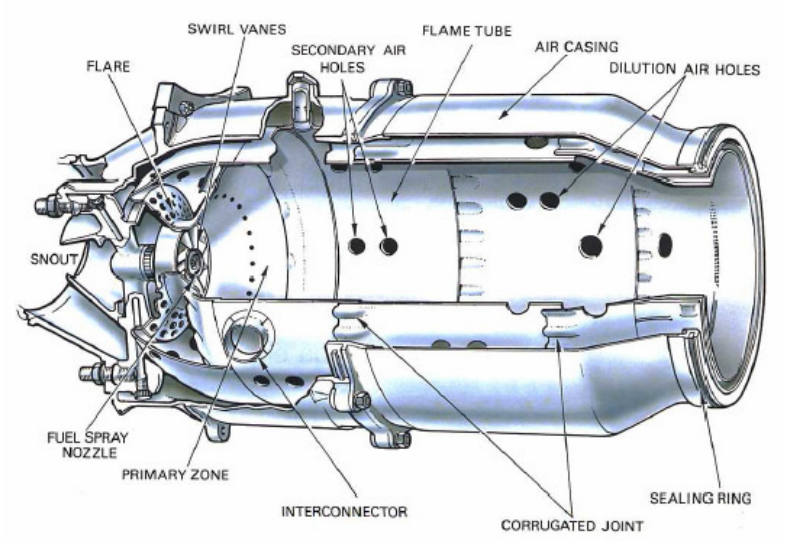

Fig. 1

Through the tube flame wall, adjacent to the combustion zone, they are present some secondary holes through which ulterior 20% of the total air enters in the primary combustion zone.
The air that passes through these holes and that through the swirler interacts so as to form a recirculation zone. This takes a toroidal form that has the effect to stabilize flame. The gas that recirculate facilitate the combustion of injected fuel quickly raising it to the temperature facilitating the ignition.

The fuel is injected by the sprayers in centre of recirculation zone and enters in the combustor along an hollow cone surface. The interaction between air and fuel, together with the high turbulence level present in the primary zone, it facilitates the atomization of fuel drops, the mixing with air and combustion.

The temperature of gas produced by combustion is approximately 1800-2000 °C, that is by far too much high to enter in turbine.
The not used air for combustion, that amounts to approximately 60% of total, is introduced progressively in the flame tube. Approximately a third part of it is used to reduce the gas temperature in the zone of dilution and rest is used for walls combustor cooling. This is obtained by air flows that flow along the internal surface of flame tube isolating it from combustion gases

Systems of advanced cooling (Effusion cooling) are constituted by a series of small diameter holes that cross the combustor wall. The air flow, from a part drains heat crossing the wall, from the other, forms an air film on the hot zone protect it from the action of warm gases.

The combustion must finish before zone of dilution holes, otherwise the flame is cooled with result of an incomplete combustion.

The combustion generally starts from the spark emitted from a ignition plug after that the flame is self supported.
The fuel is fed in the combustor in two different ways . The way more usual and more traditional is to directly inject it in the primary zone by sprayers or vaporizers.

Another way is to supply it pre-vaporized before entering in the combustion chamber by some opportune mixing ducts.

Kind of combustion chambers.

There are 3 kinds of combustion chambers used on turbo-engines:

a) **tubular combustion chambers:** In this case some tubular flame tubes are arranged aound engine center line. Every flame tube is contained in an outer case. The several flame tubes are interconnected so as to operate in the same conditions of
pressure

b) **combustion chamber tube-annular:** it consists of several flame tubes that are fitted in a single casing. The air flow is similar to the tubular chambers This configuration joins the advantage of maintenance easiness of the tubular chambers with the compactness of annular chambers (fig. 2).

c) **annular combustion chambers:** this type of combustor consists of a single flame tube with annulus form that is contained in a inner and an outer casings.
The main advantage of this combustion chamber is that on same performances it is shorter than a tubular chamber or tube-annular with a remarkable saving of weight and cost of the losses of Production. The pressure leaks in this combustion chamber are lower
with respect regarding the previous one with remarkable benefits on the engine thermodynamic cycle (fig. 3).

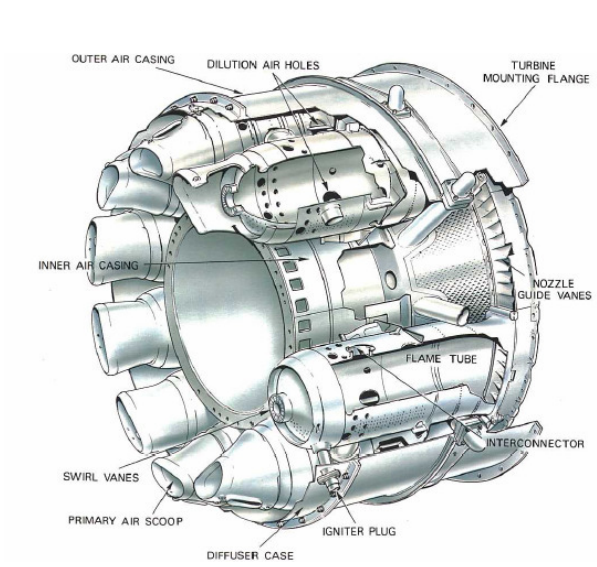

Fig.2

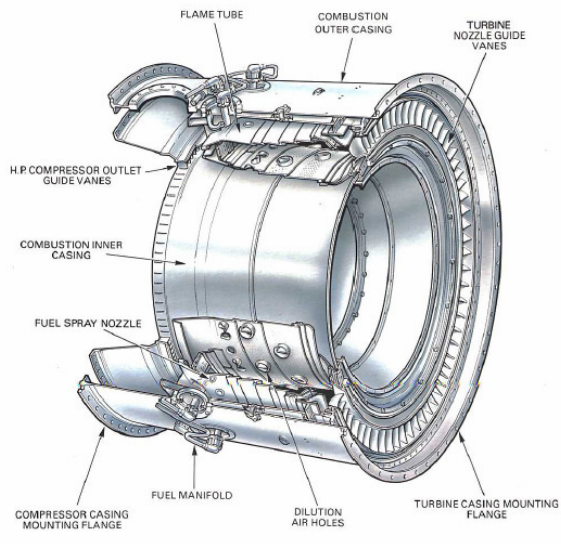

Fig. 3