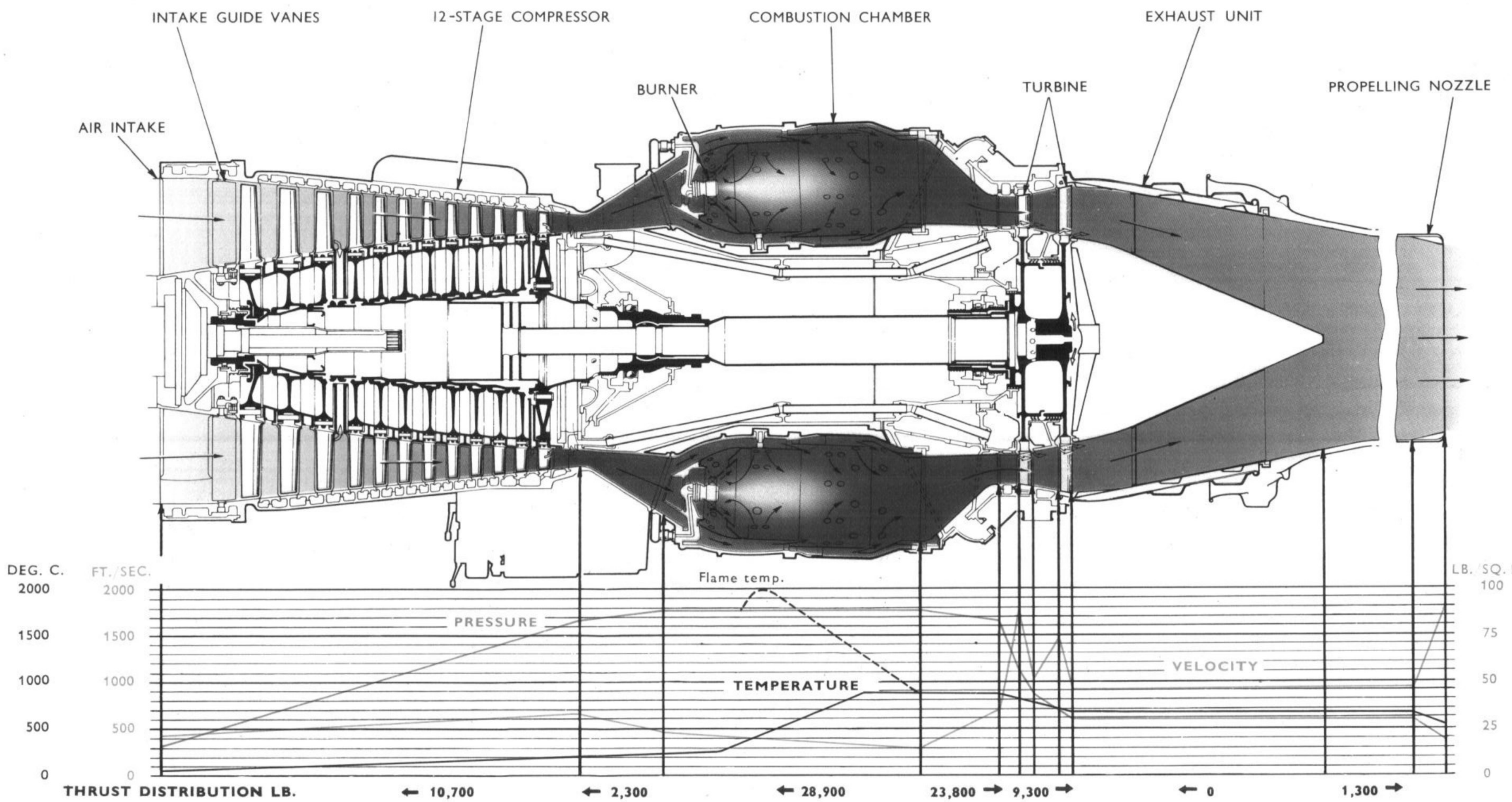
AERO ENGINE SCHOOL
COURSE NOTE
Nº TAV.164



← EFFECTIVE FORWARD THRUST 7,500 LB.

TYPICAL GAS FLOW - AVON

1.9.55

AVON.

INTERNAL GAS FLOW.

The following is a survey of the physical changes occurring in the Gas Flow throughout the working cycle.

This cycle is a continuous process of compression, combustion, expansion and exhaust applied to air, which is the working fluid, and is known as the constant pressure cycle, since combustion takes place at a constant pressure.

The physical changes occurring in the gas flow, indicated by the change of pressure, temperature and velocity, are shown on the curves for the main points, e.g. before and after compression, before and after combustion, at entry and discharge from the turbine and at exit from the jet pipe.

Compressor.

The rotation of the compressor induces the air to flow down the intake and via the intake guide vanes into the first stage. Here it encounters the aerofoil section rotating blades at the correct angle of attack, as ensured by the intake guide vanes, to obtain a smooth flow over the blade section.

The rotating blades now do work upon the air causing an increase in pressure energy and kinetic energy, the latter appearing as a whirl velocity at the blade outlet.

The whirl velocity is removed as the air passes through the stator blade passages and by a process of diffusion the pressure is further increased.

This sequence of change in energy is repeated through the subsequent stages to achieve the desired outlet pressure at a corresponding rise in temperature.

Combustion Chambers.

On leaving the compressor, the air flows to the combustion chambers via divergent ducts formed in the compressor outlet casing, thus by diffusion the velocity of the air is decreased.

This is essential as the velocity of burning kerosine is comparatively low.

Efficient combustion also depends upon a correct fuel/air mixture in the combustion zone, and this is arranged by the scoop and flame tube design.

Approximately 15% of the air is metered by the scoop and passed into the primary zone via the swirlers, whilst a further quantity is metered by drillings in the wall of the scoop to enter the zone via the flare.

The resultant flow pattern creates a local area of flow reversal in order to maintain flame stability.

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At the forward end of the flame tube is a chosen number of primary air holes through which some of the air from the annular space between the flame tube and air casing penetrates the combustion zone to help complete combustion, and approx. one third of the engine total air consumption is burnt.

The temperature of the combustion gases is unacceptable to the nozzle guide vanes and turbines, being at a maximum of 2000°C approx. Dilution air is therefore admitted via further holes towards the rear of the flame tube to reduce the temperature to a figure acceptable to the turbine assembly. The gas has now acquired its maximum head of energy in the form of pressure, temperature and velocity.

Nozzle Box and Turbine.

The flow of gas from the individual combustion chambers enters the nozzle box where large nozzles first convert the flow into annular form and direct it into the convergent spaces between the first stage nozzle guide vanes, which are at an angle relative to the plane of turbine rotation.

These guide vanes impart a high angular velocity to the gas with a consequent drop in pressure and temperature. The flow is in the form of a free vortex i.e. a constant angular momentum at all radii, and in consequence will perform equal work at all radii.

This implies that the physical condition of the gas varies over the annulus width, i.e. at the smallest annulus diameter the angular velocity is at its highest value and the pressure at the lowest, and at the largest annulus diameter the velocity is at a reduced value and the pressure at its highest.

To exploit this energy in its varying form requires a changing turbine blade section and an increasing amount of blade twist from root to tip.

The turbine design is a combination of two basic types and is known as an "impulse/reaction" turbine.

Impulse Turbine.

The gas enters the turbine as a low pressure, high velocity spiral flow. In its passage over the curved surfaces of the blades its velocity is reduced and it emerges parallel to the turbine shaft. The change in momentum of the gas produces a force to rotate the turbine wheel. The gas passages between the blades are of constant section and there is no drop in gas pressure.

Reaction Turbine.

The gas enters the turbine as a high pressure, low velocity spiral flow and passes through convergent passages between the blades. These cause an increase in velocity and a drop in pressure. This acceleration of the gas causes a reaction on the blades to rotate the turbine wheel.

The amount of energy expended in driving the turbine is reflected in the reduced temperature and pressure of the gas.

In passing through the second stage nozzle guide vanes and turbine blades there is a repetition of the sequence of events in the first stage, and the increasing annulus area from front to rear of the assembly accommodates the increasing expansion of the gas.

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Exhaust Unit. AVON 200 SERIES ONLY.

From the turbine the gases are discharged into the exhaust unit where its velocity is increased due to the reducing area. This increase in velocity, accompanied by a slight decrease in pressure and temperature, produces the ideal velocity conditions in the jet pipe to reduce losses.* AVON Mk200 Series only

AVON Mk100 SERIES IS A PARALLEL DUCT.

The exhaust cone blends the annular area of the turbine outlet into a suitable circular form to prevent turbulence in the stream flow and protects the rear face of the turbine disc from contact with the hot combustion gases.

Jet Pipe.

The flow now continues into the jet pipe and expands to atmosphere via the propulsion nozzle, which forms a convergent section to change the energy in the stream and produce a high velocity jet.