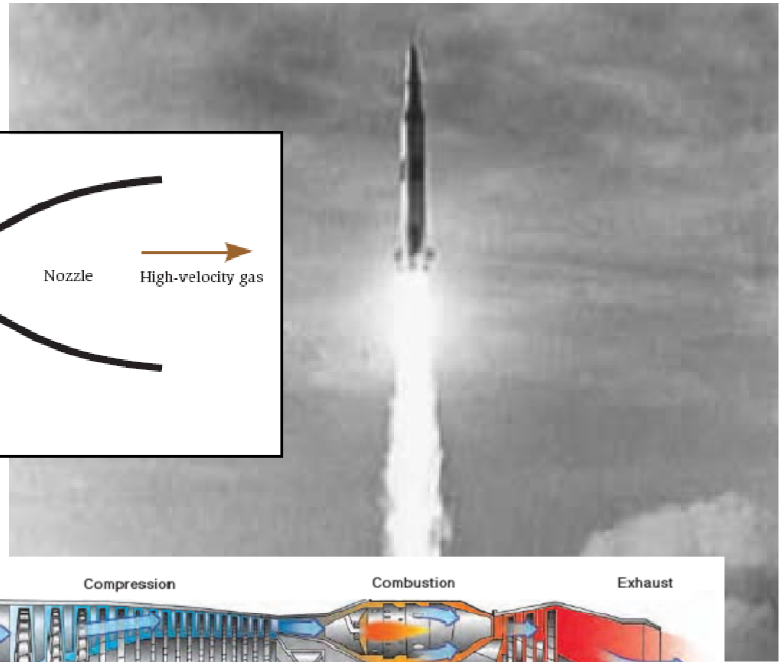
Cap.6 – Caratteristiche propulsive

- Razzi (Rockets)
- Ramjet
- Turbojet
- Turbofan
- Turboprop
- Motoelica



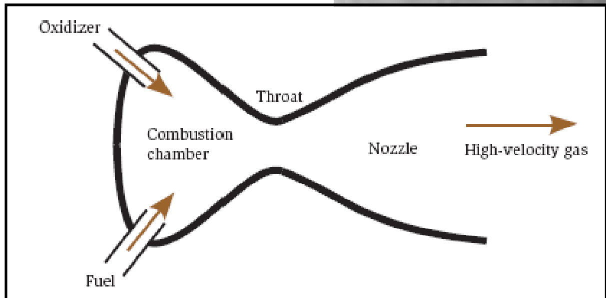
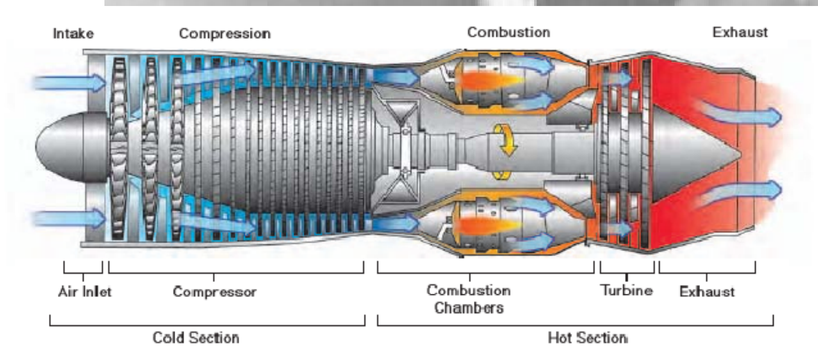
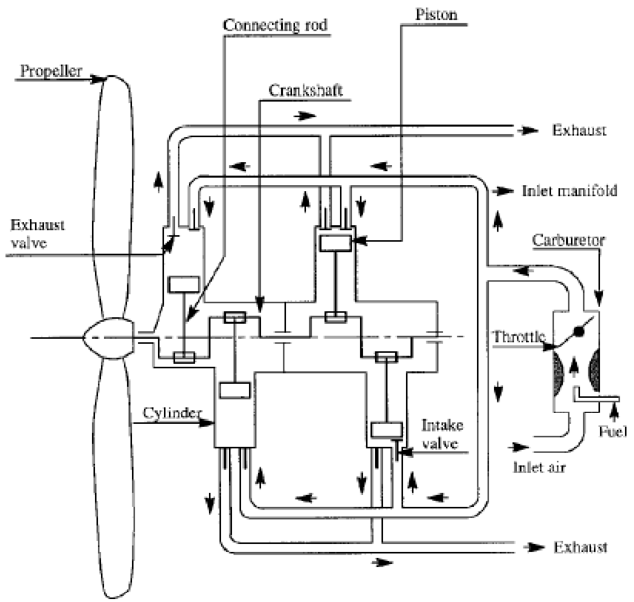


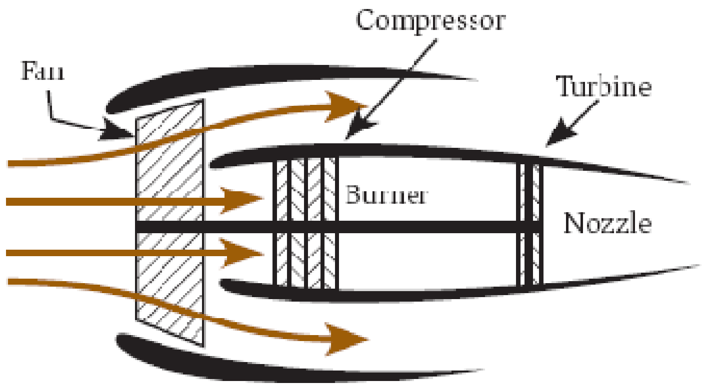
Fig. 5.1. Schematic of a rocket engine.





Note: modern engines tend to use fuel injection rather than carburetors

Figure 6.6 Typical Cross–section of a Four–cylinder Piston Engine



Cap.6 – Caratteristiche propulsive

- Razzi (Rockets) (o anche Endoreattori)

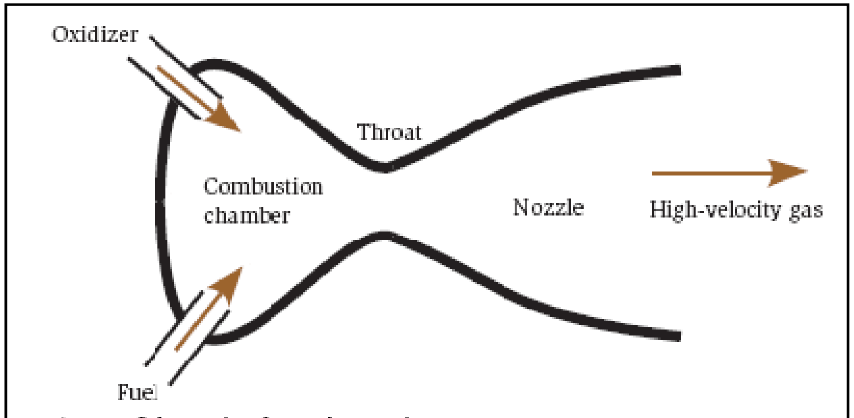
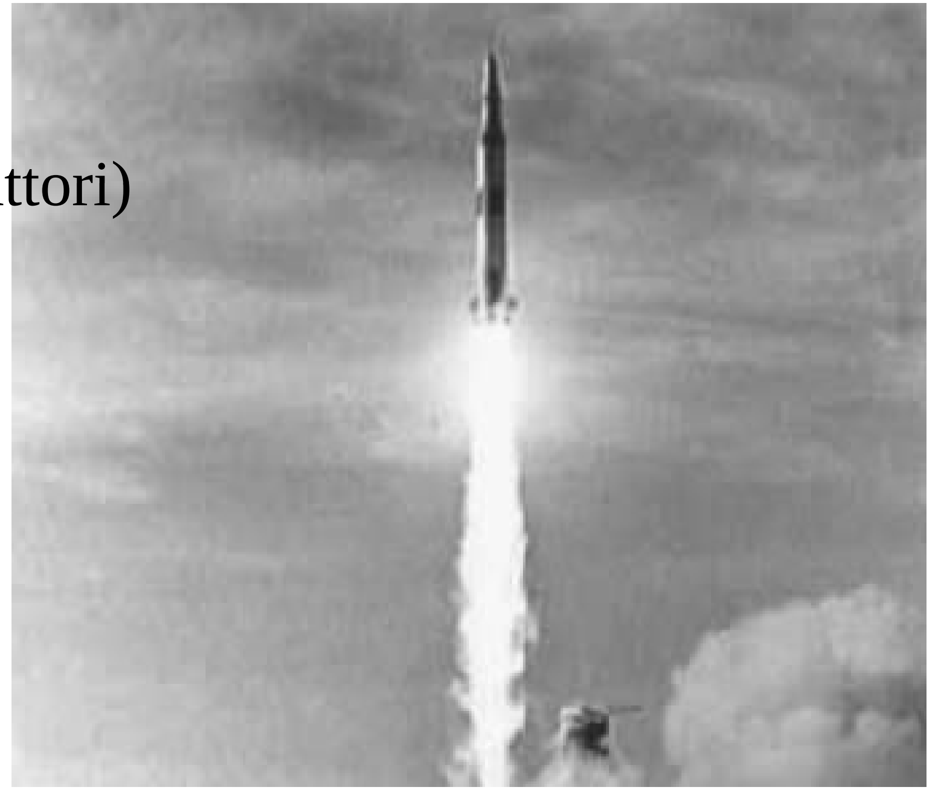
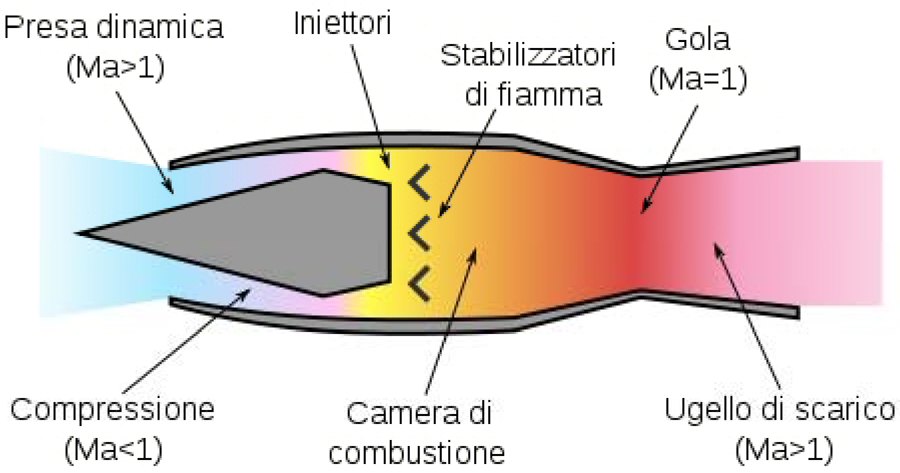


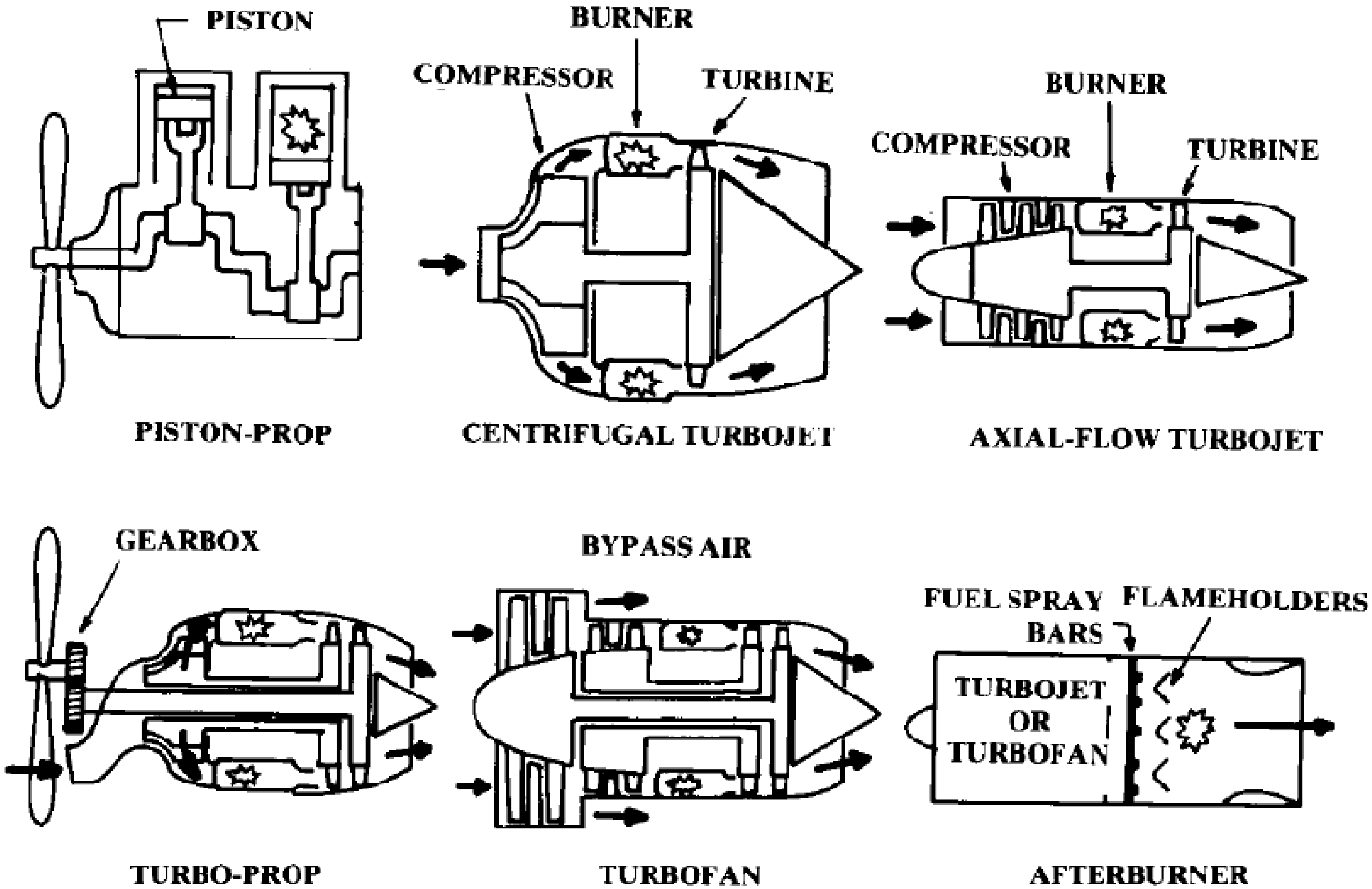
Fig. 5.1. Schematic of a rocket engine.



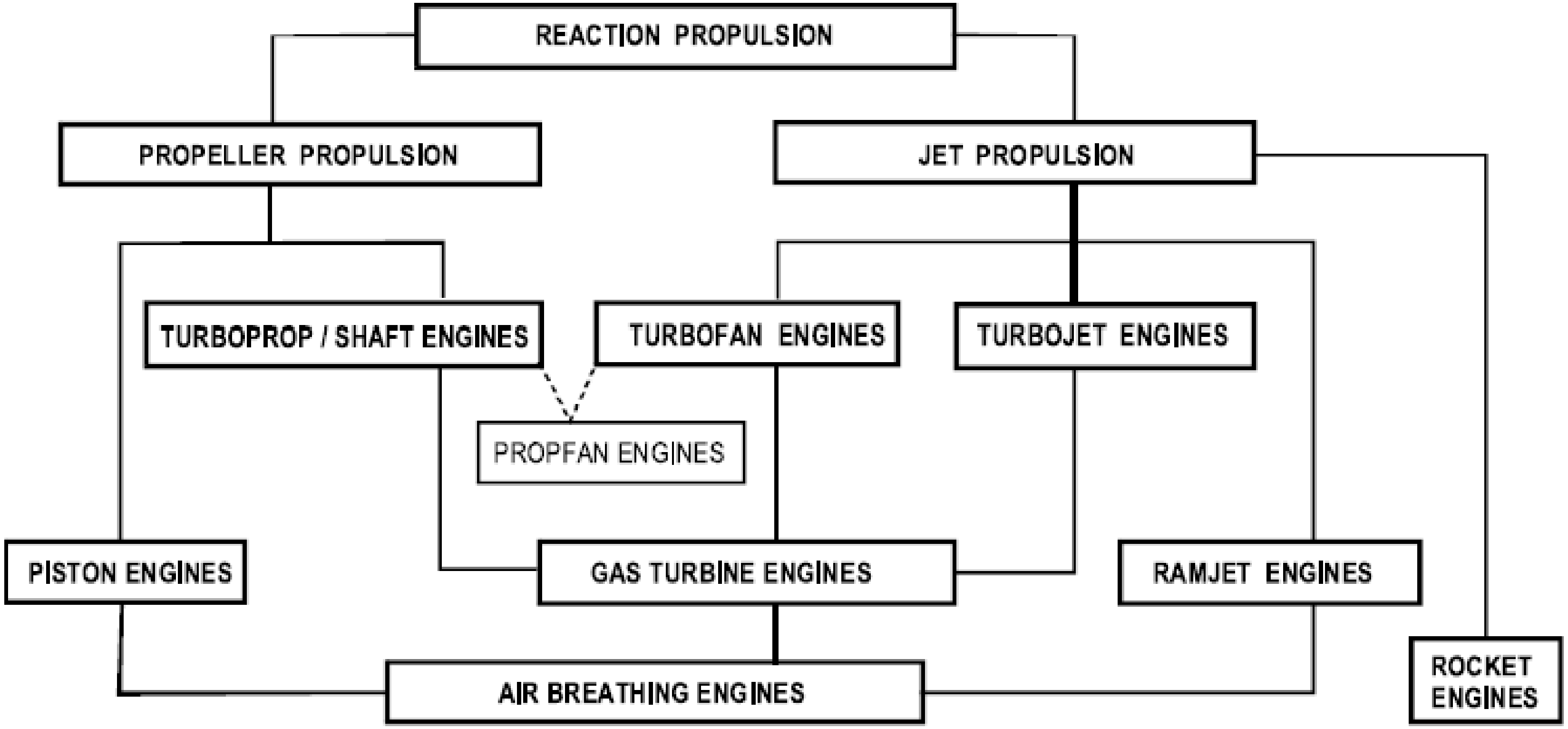
- Ramjet



Cap.6 – Caratteristiche propulsive

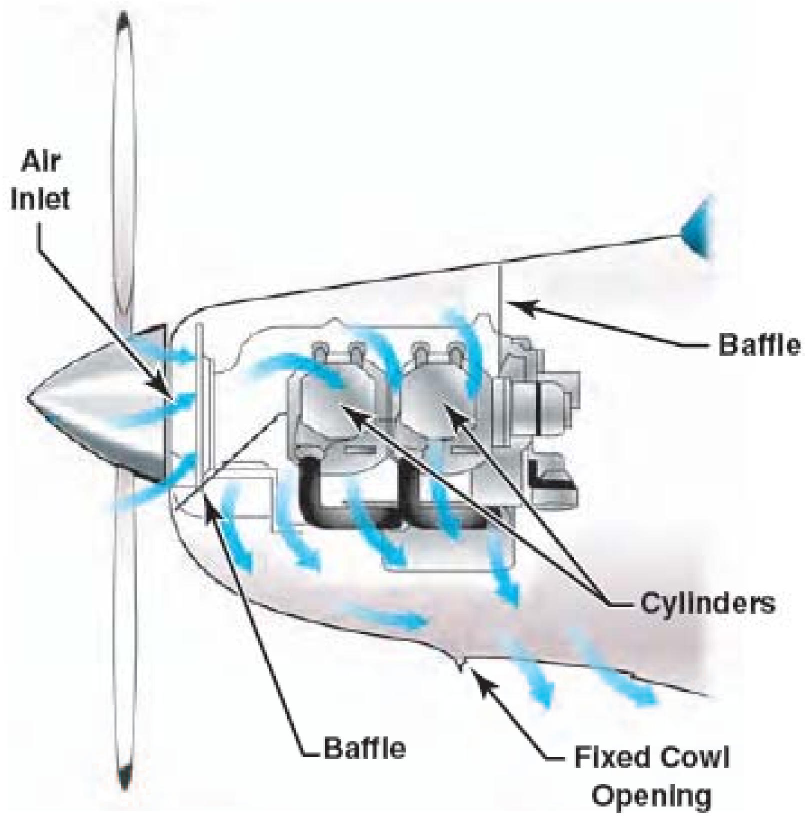


Cap.6 – Caratteristiche propulsive



Cap.6 – Caratteristiche propulsive

Motoelica



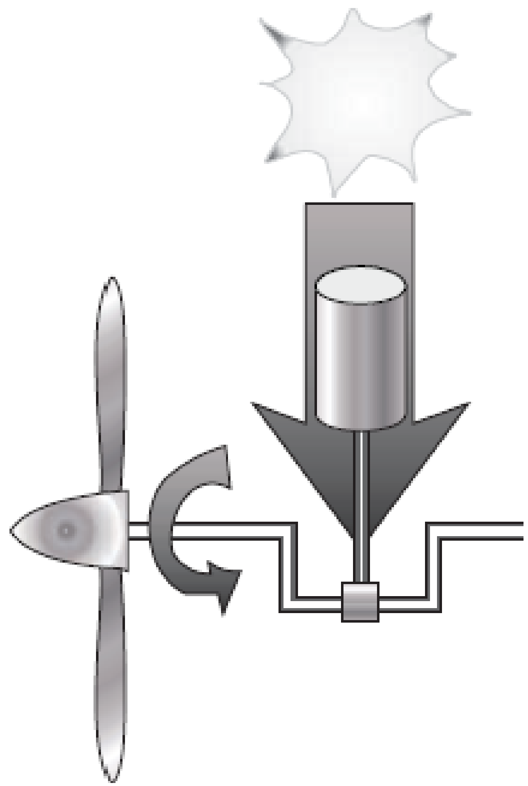


Fig. 5.7. How a piston engine converts chemical energy to propeller rotation.

Cap.6 – Caratteristiche propulsive

Motoelica

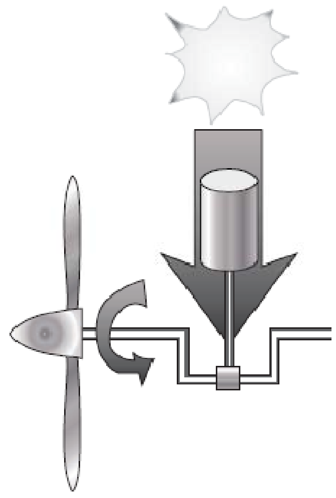
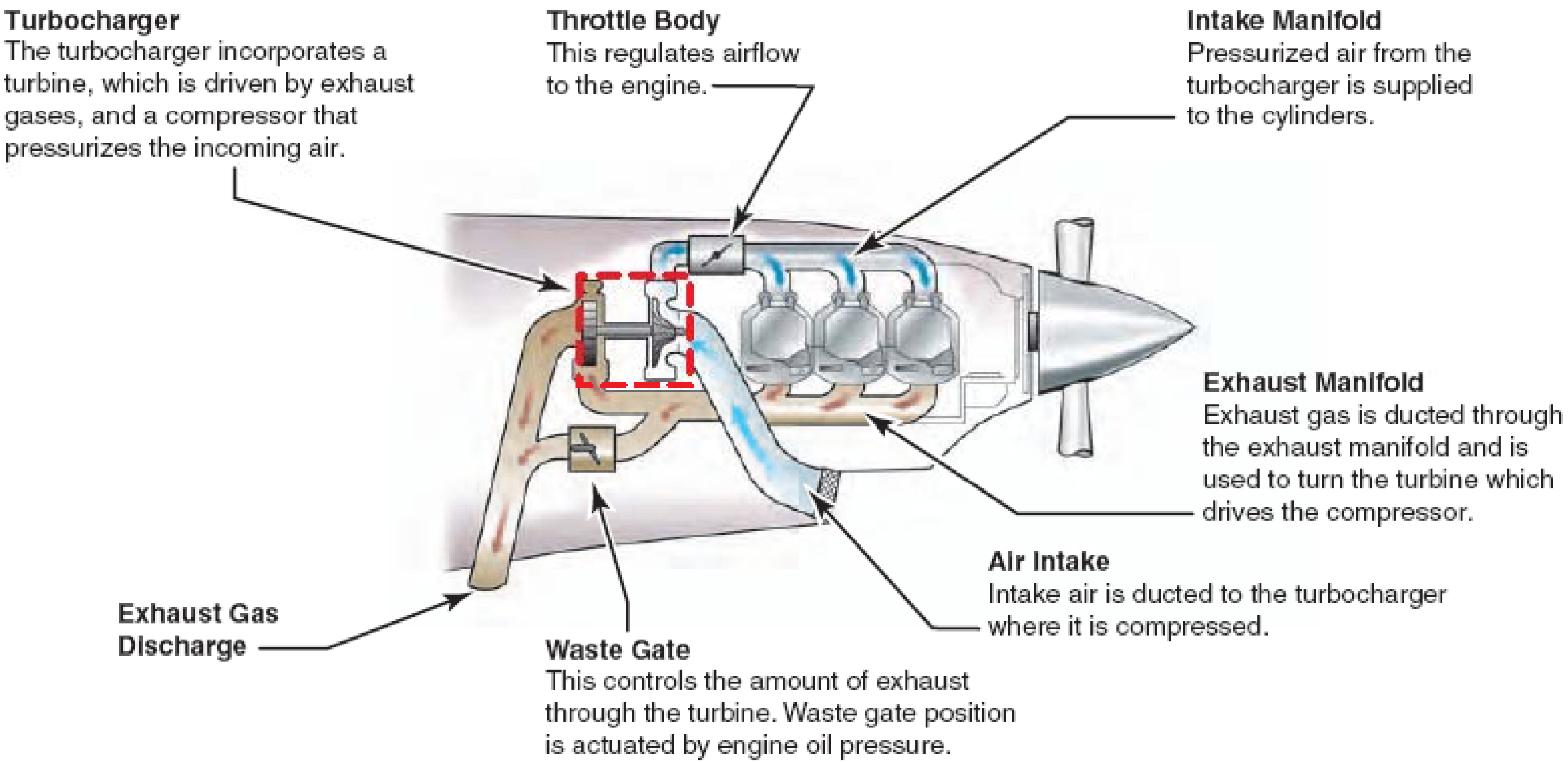
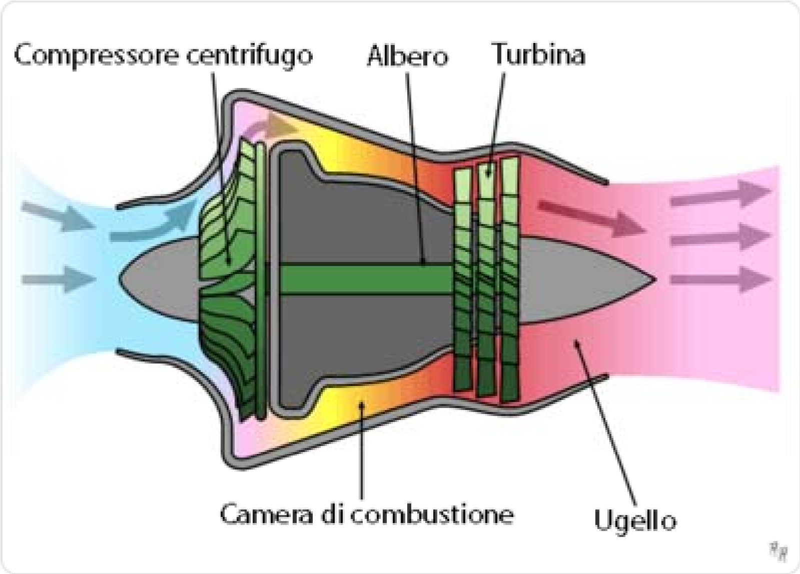


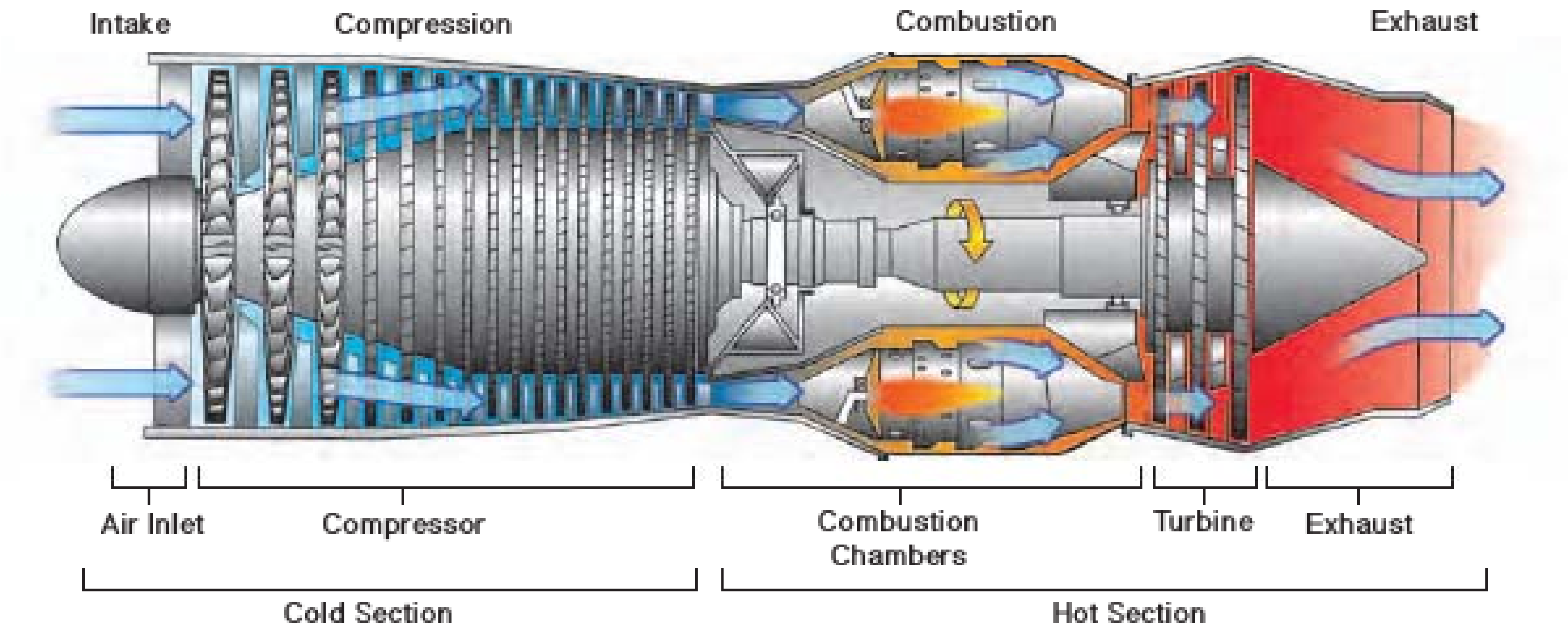
Fig. 5.7. How a piston engine converts chemical energy to propeller rotation.



Cap.6 – Caratteristiche propulsive

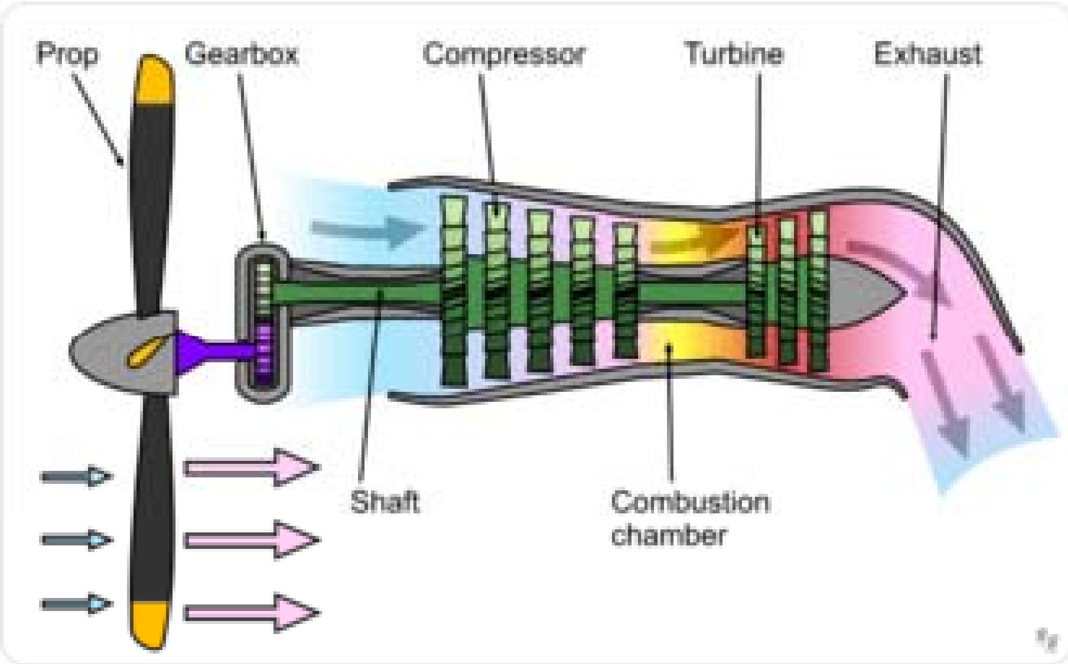
Turbogetto

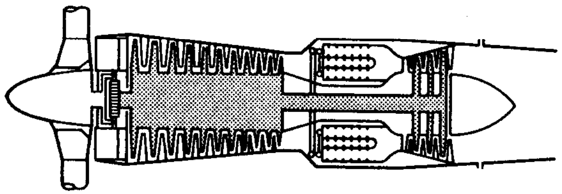




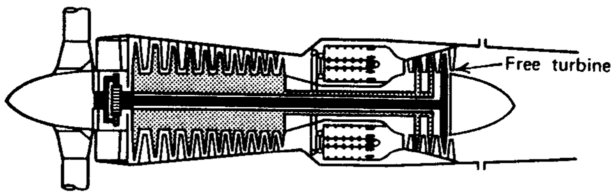
Cap.6 – Caratteristiche propulsive

Turboprop (tipo ATR42)





(d)

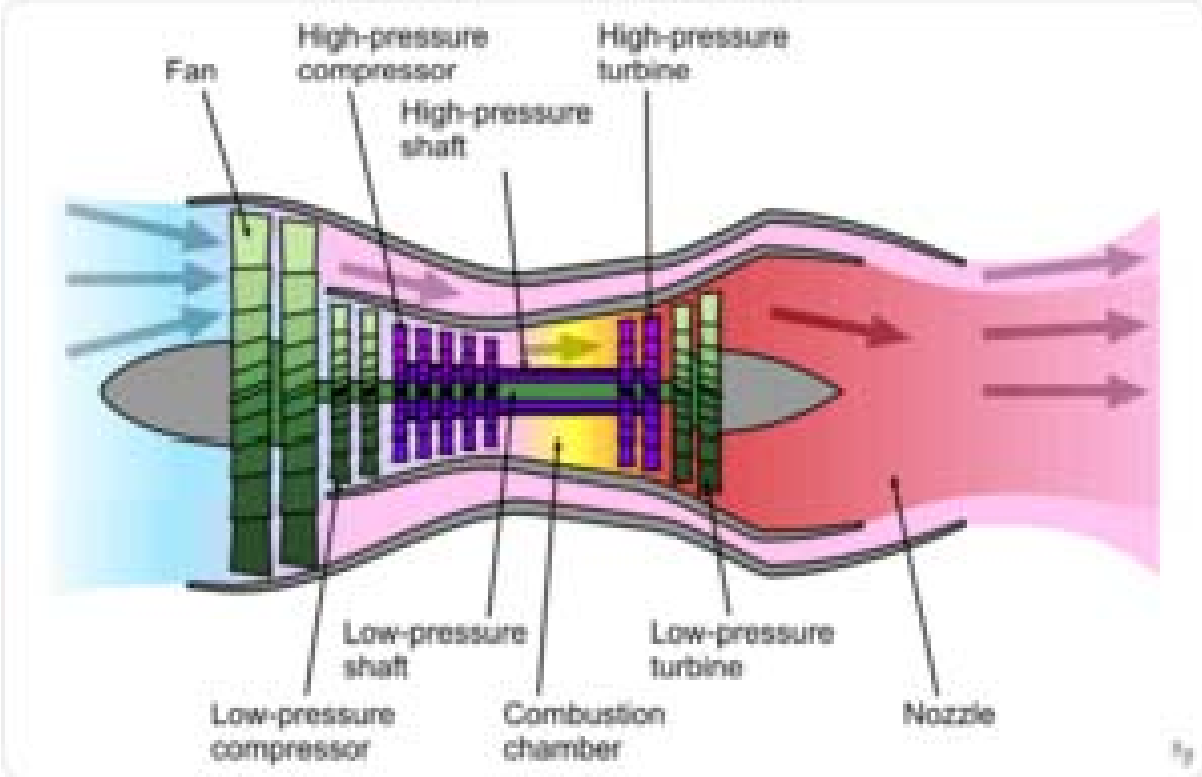


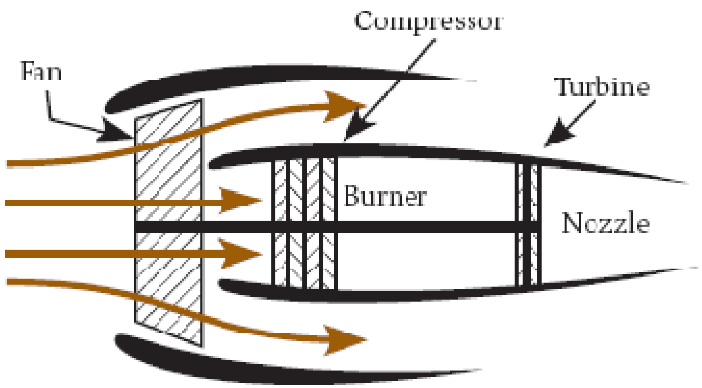
(e)

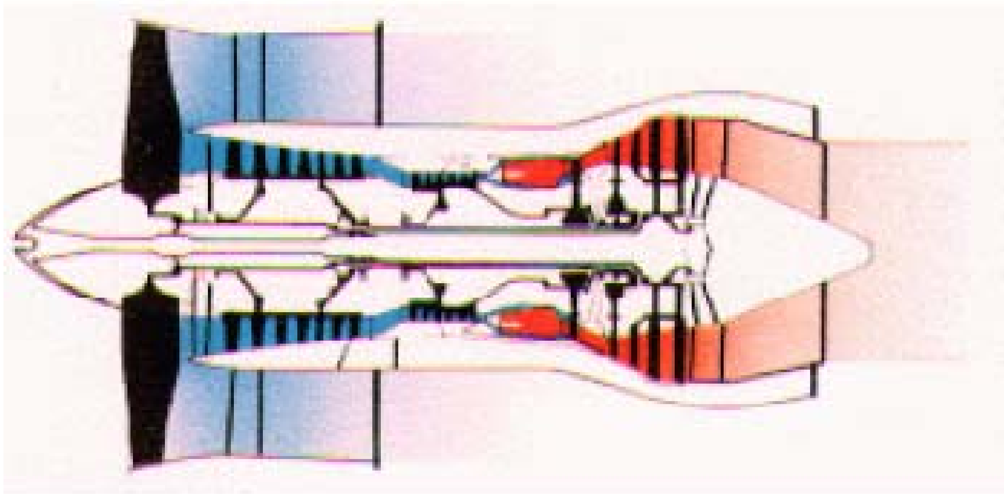
Cap.6 – Caratteristiche propulsive

Turbofan

BPR (By-Pass Ratio)



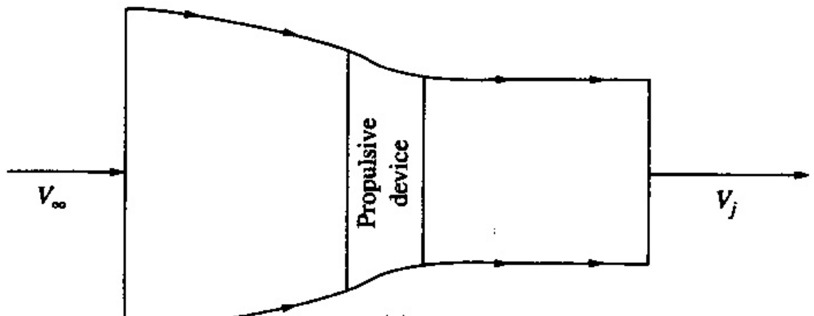




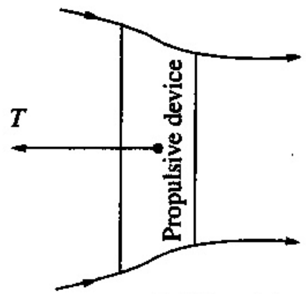
Cap.6 – Caratteristiche propulsive

Principio di funzionamento

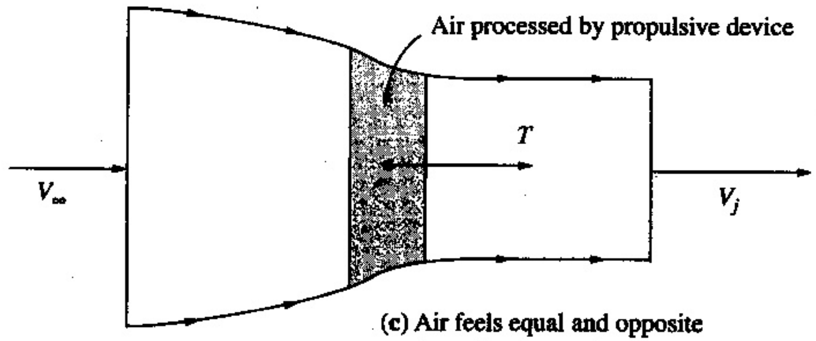
$$T = \dot{m}(V_j - V_\infty)$$



(a)



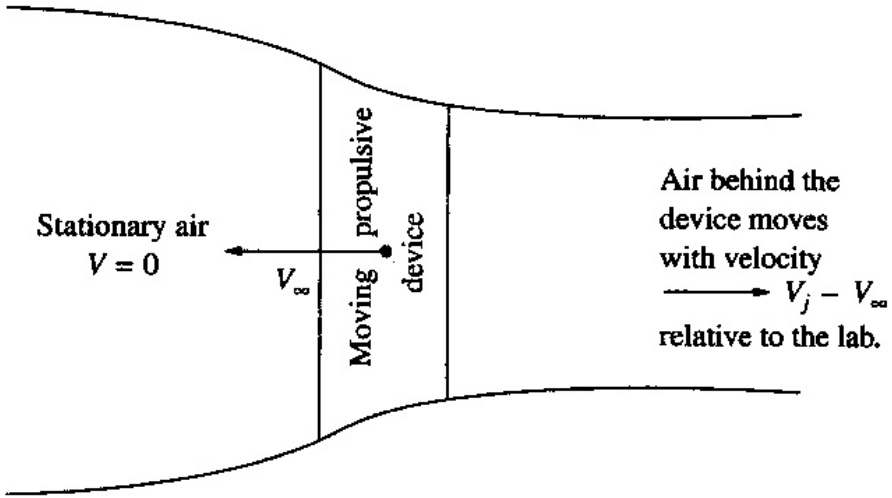
(b) Propulsive device produces thrust T acting to the left.



(c) Air feels equal and opposite force T acting to the right.

Cap.6 – Caratteristiche propulsive

Principio di funzionamento



Aria si muove a vel.

$$V_j - V_\infty$$

Energia cinetica per unità di massa

$$\frac{1}{2}(V_j - V_\infty)^2$$

Quest'energia cinetica è interamente dissipata

$$Potenza = forza \times velocità$$

Cap.6 – Caratteristiche propulsive

La *potenza utile*, chiamata *potenza disponibile*

$$\Pi_d = TV_\infty$$

Ma c'è anche una quantità di potenza dissipata (aria in uscita)

$$\frac{1}{2}\dot{m}(V_j - V_\infty)^2$$

=> *Potenza totale prodotta dal congegno propulsivo*

$$= TV_\infty + \frac{1}{2}\dot{m}(V_j - V_\infty)^2$$

$$\eta_j = \frac{potenza disponibile}{potenza totale prodotta}$$

Cap.6 – Caratteristiche propulsive

$$\eta_j = \frac{TV_\infty}{TV_\infty + \frac{1}{2}\dot{m}(V_j - V_\infty)^2}$$

$$\eta_j = \frac{\dot{m}(V_j - V_\infty)V_\infty}{\dot{m}(V_j - V_\infty)V_\infty + \frac{1}{2}\dot{m}(V_j - V_\infty)^2}$$

Dividendo num e denom. per $\dot{m}(V_j - V_\infty)V_\infty$

$$\eta_j = \frac{1}{1 + \frac{1}{2}(V_j - V_\infty)/V_\infty} = \frac{1}{\frac{1}{2}(1 + \frac{V_j}{V_\infty})}$$

$$\eta_j = \frac{2}{1 + \frac{V_j}{V_\infty}}$$

EFFICIENZA PROPULSIVA (Froude Efficiency)

Cap.6 – Caratteristiche propulsive

Possiamo definire anche la spinta specifica:

$$\frac{T}{\dot m} = \left(V_j - V_\infty\right)$$

Spinta prodotta per unità di portata di massa [N/(kg/sec)] o anche dimensione di una vel. [m/s]

$$\eta_j = \frac{2}{2 + (V_j - V_\infty)/V_\infty} = \frac{2}{2 + \frac{T}{\dot m}V_\infty} = \frac{2}{2 + C_j}$$

Abbiamo introdotto il "jet velocity coeff."

$$C_j = \frac{T}{\dot m}V_\infty = \frac{V_j}{V_\infty} - 1$$

$$\eta_j = \frac{2}{1 + \frac{V_j}{V_\infty}}$$

$$\eta_j = \frac{2}{2 + C_j}$$

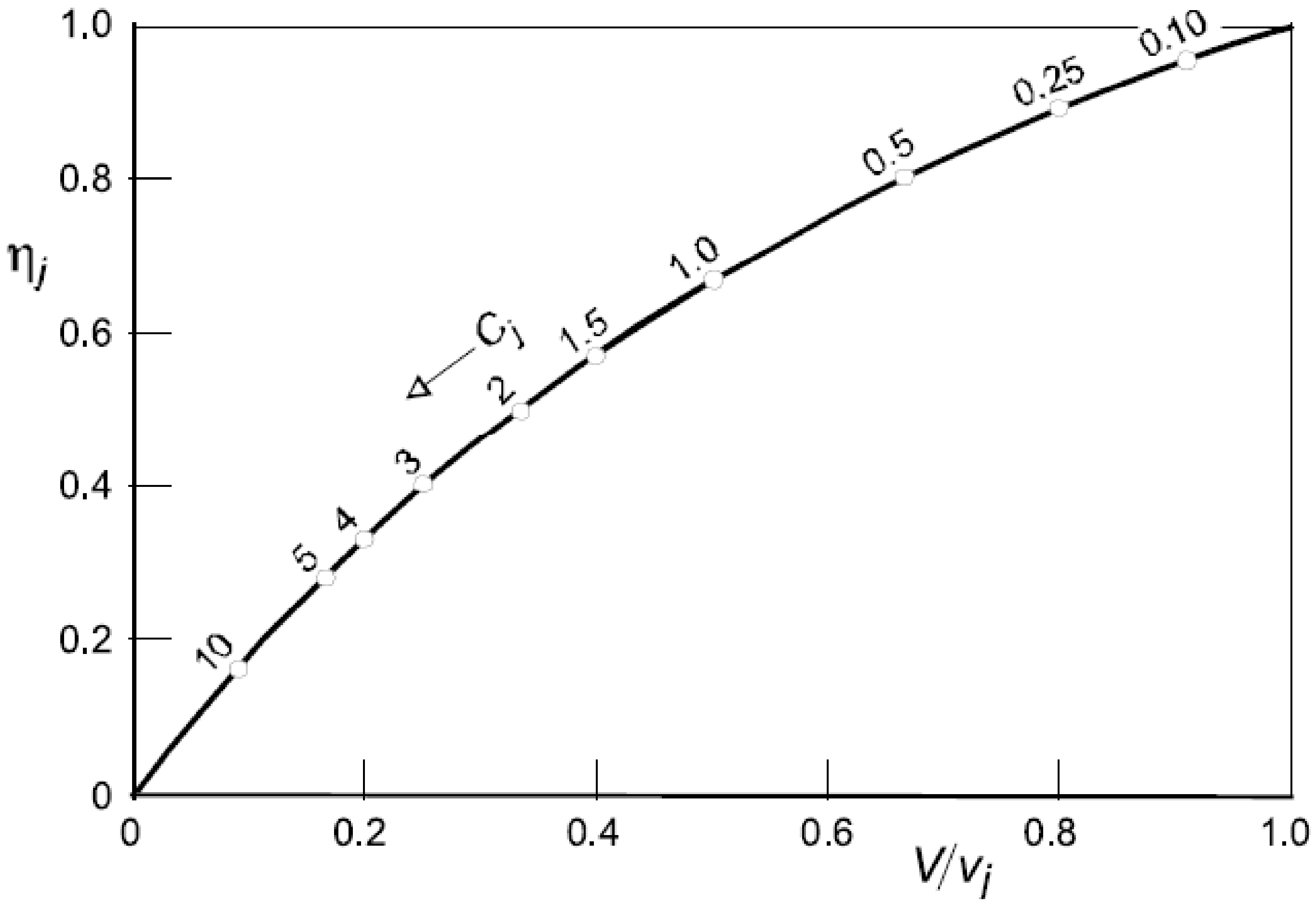
Cap.6 – Caratteristiche propulsive

$$C_j = \frac{T}{\dot{m}}V_\infty = \frac{V_j}{V_\infty} - 1$$ *jet velocity coeff.*

$$\eta_j = \frac{2}{1 + \frac{V_j}{V_\infty}}$$

$$\eta_j = \frac{2}{2 + C_j}$$

Propulsive efficiency



Cap.6 – Caratteristiche propulsive

Table 5.1 Example of *propulsive efficiency* data.

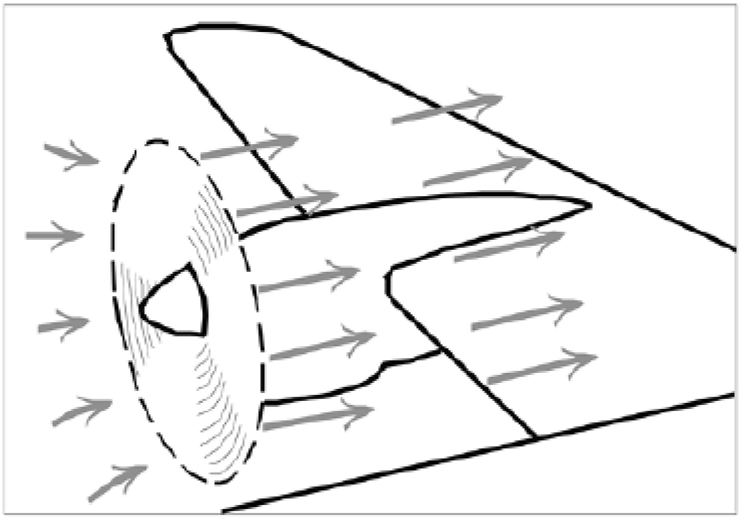
Type of propulsion	*Altitude* km	*Flight speed* V, m/s (Mach no.)	*Jet velocity* v_j, m/s	*Speed ratio* v_j/V	*Specific thrust* $T/\dot{m}_a$, m/s	*Jet coefficient* C_j	*Propulsive efficiency* η_j
propeller	6	150	160 (0.47)	1.07	10	0.067	0.97
subsonic jet engine	9	250 (0.82)	750	3.00	500	2.00	0.50
low BPR turbofan	9	250 (0.82)	582*	2.33	332	1.33	0.60
high BPR turbofan	9	250 (0.82)	418*	1.67	168	0.67	0.75
supersonic jet engine	16	600 (2.03)	1,000	1.67	400	0.67	0.75

* weighted average of primary and secondary airflow

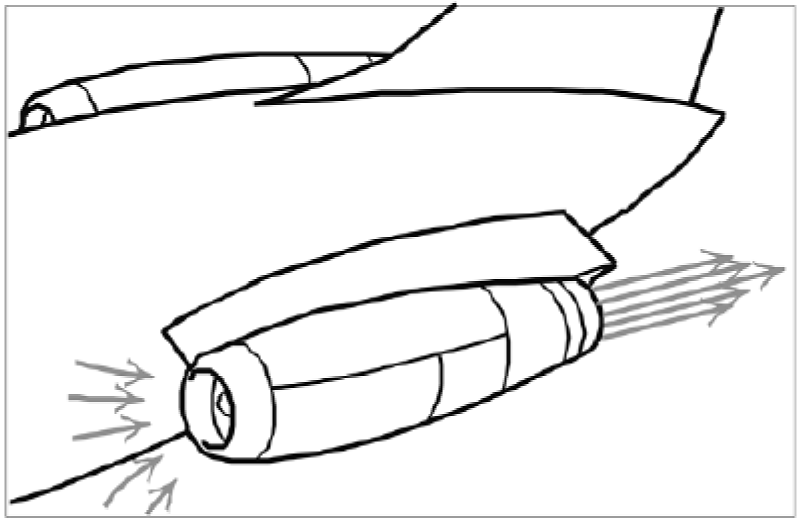
Cap.6 – Caratteristiche propulsive

L'efficienza propulsiva dell'elica è maggiore di quella del getto.

- Elica: piccolo incremento di velocità ad una grossa massa aria
- Jet: grande incremento di velocità ad una piccola quantità di aria



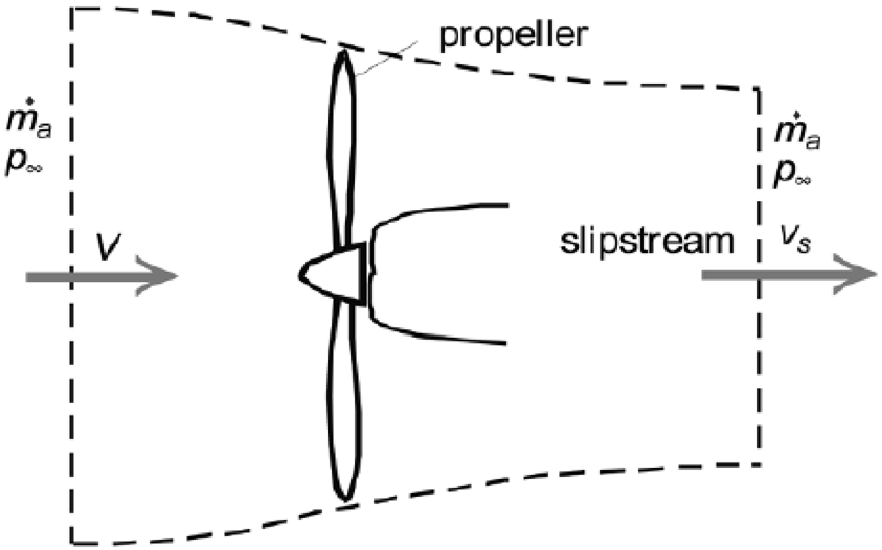
(a) A propeller imparts a small velocity increment to a large mass of air



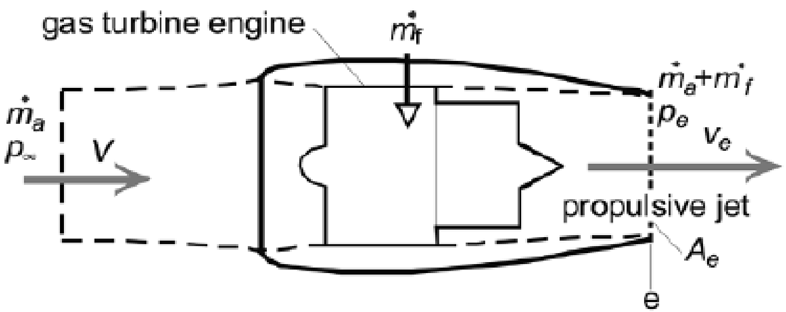
(b) A turbojet engine imparts a large velocity increment to a (relatively) small amount of air

Cap.6 – Caratteristiche propulsive

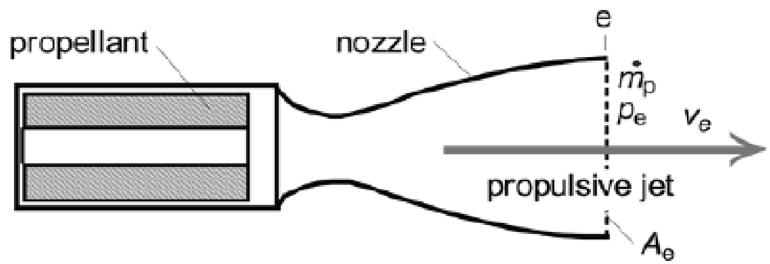
Principio di funzionamento



(a) Airflow through a propeller



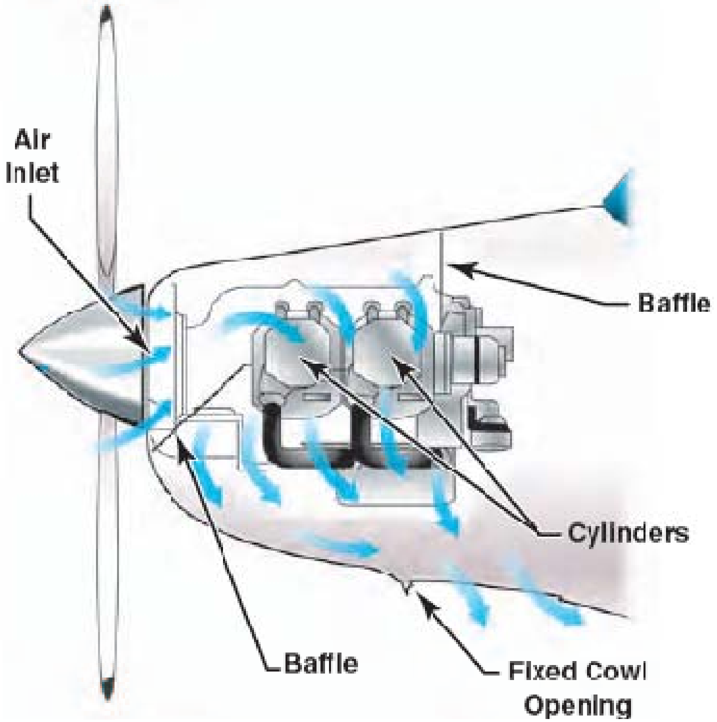
(b) Airflow through a jet engine

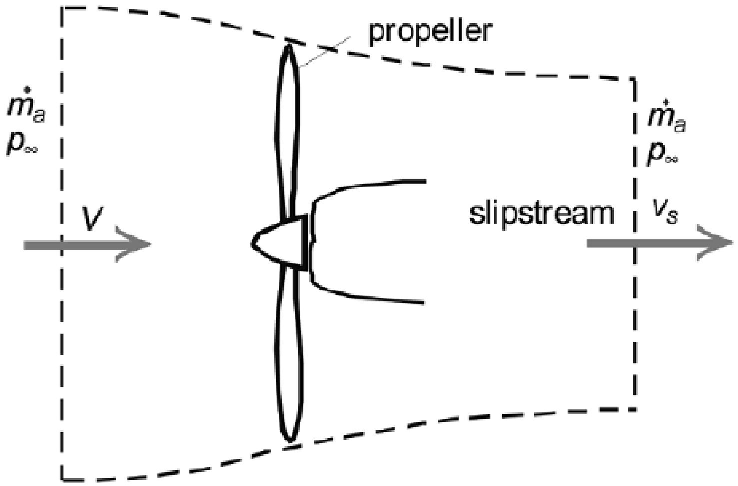


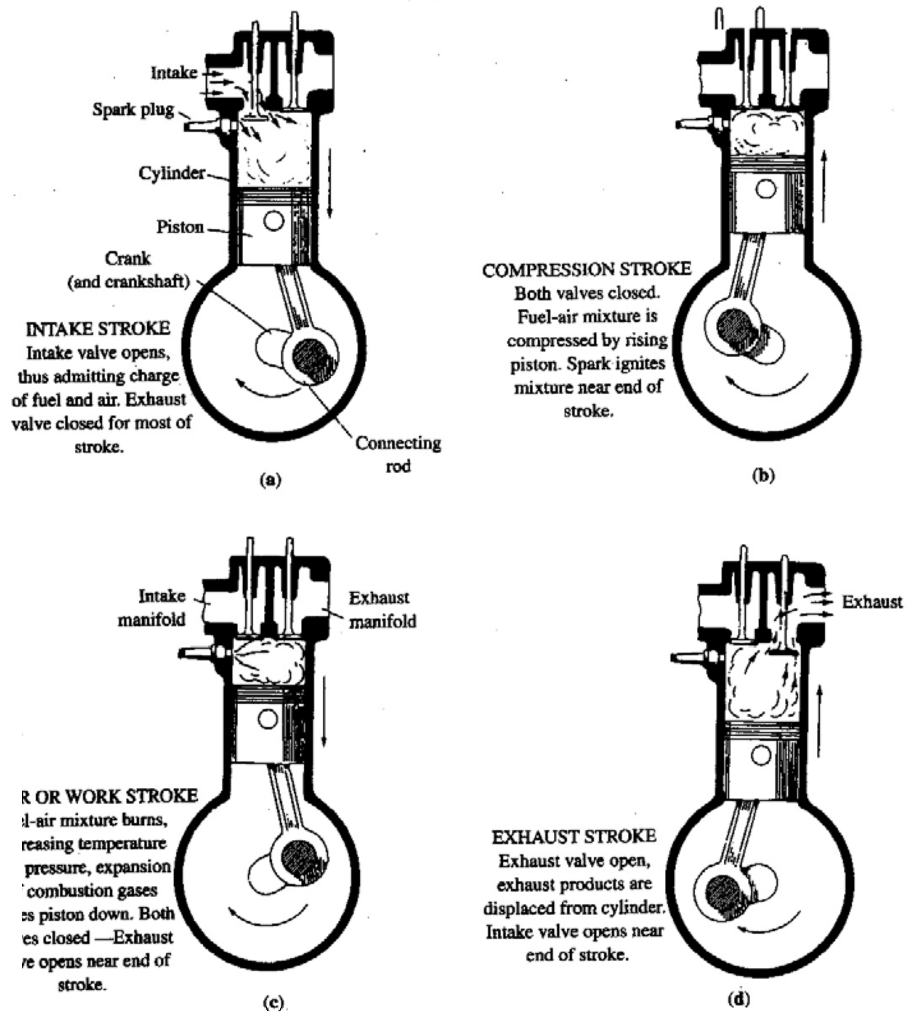
(c) Principle of a solid rocket engine

Cap.6 – Caratteristiche propulsive

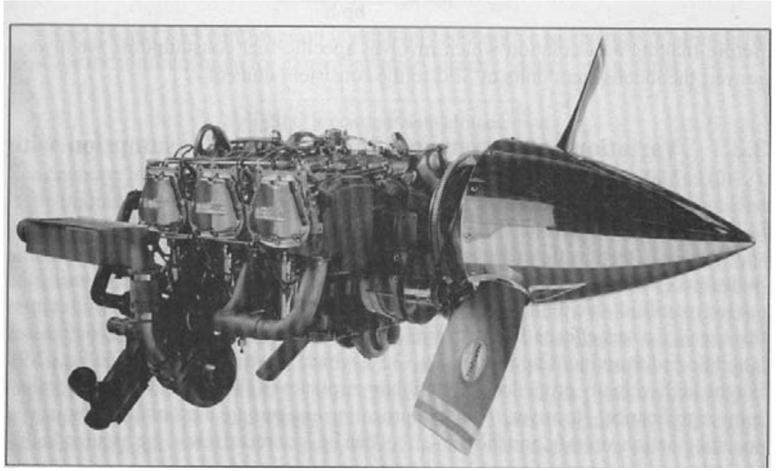
MOTOELICA







Cap.6 – Caratteristiche propulsive MOTOELICA



$$\Pi_a \propto d \cdot p_e \cdot RPM$$

- la cilindrata con *d* (dall'inglese *displacement*)
- *pressione media efficace* p_e

Consumo specifico

$$c = \frac{pesodicombustibileconsumatoperdatoincrementoditempo}{(potenzasviluppata)(incrementoditempo)}$$

$$[c] = \frac{lb}{(ft \cdot lb/s)(s)} \qquad [c] = \frac{N}{W \cdot s}$$

$$SFC = \frac{lb}{hp \cdot h}$$

Unità ingegneristiche

valore tipico 0.40-0.50 [lb/(hp h)].

Il che vuol dire che un motore da 100 hp in funzionamento al massimo della potenza per un’ora di volo consuma circa 50 lb di combustibile (cioè circa 25 Kg di combustibile). Teniamo anche presente che il peso specifico del combustibile è circa 0.70 Kg/l , quindi un serbatoio da 100 l di combustibile è capace di trasportare 70 Kg di combustibile.

Cap.6 – Caratteristiche propulsive MOTOELICA

Variazione di potenza e SFC con vel e quota

- Π_a è ragionevolmente costante con la velocità
- SFC è ragionevolmente costante con la velocità

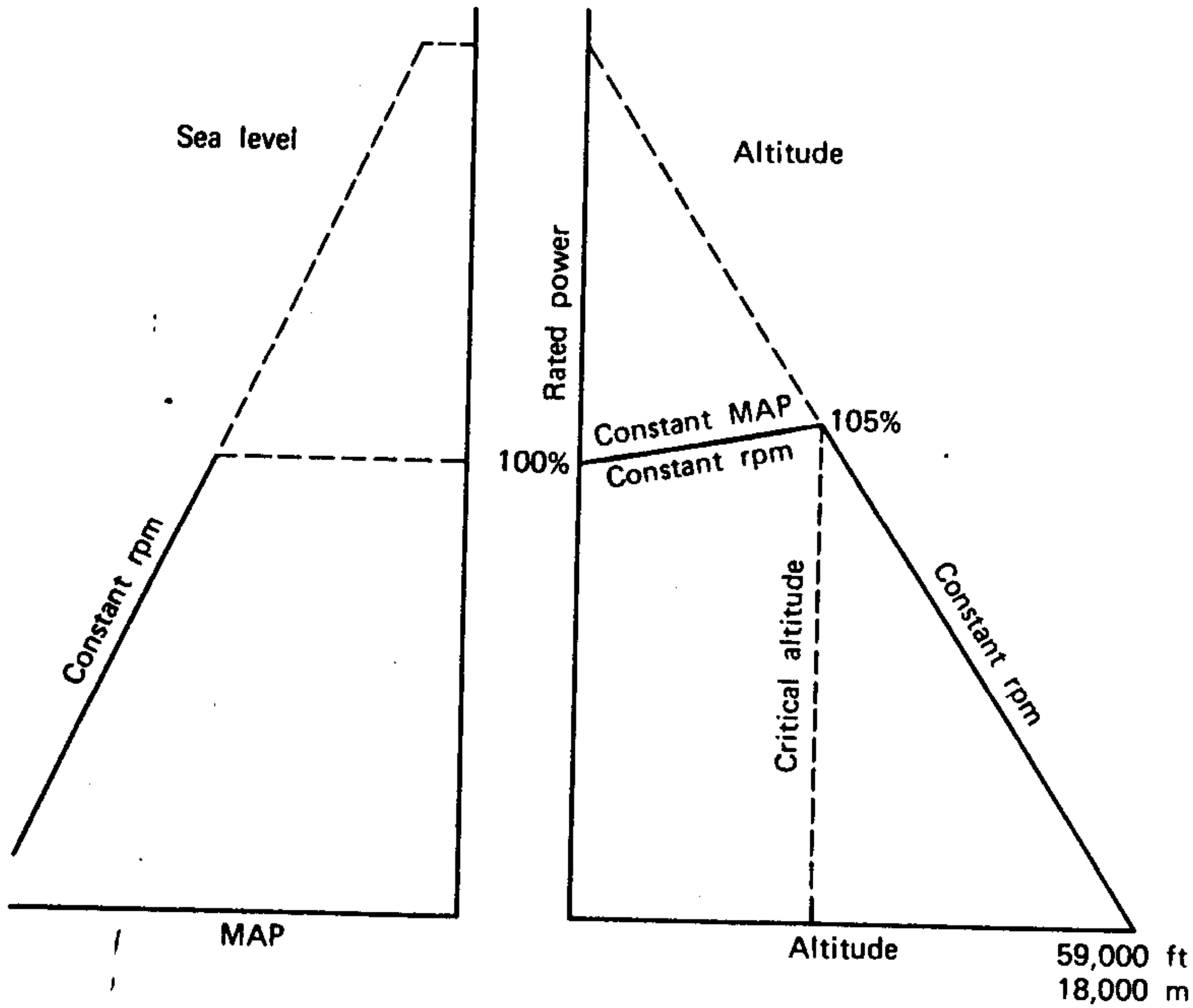
Negli Stati Uniti i due principali produttori di motori alternativi aerei sono Teledyne Continental e Textron Lycoming. I cavalli vapore a livello del mare per questi motori generalmente variano da 75 a 300 hp. Per questi motori un tipico valore di SFC è 0.4lb di carburante consumate per cavallo vapore per ora.

<u>Effetto quota</u>

$$\frac{\Pi_a}{\Pi_{a0}} = \frac{\rho}{\rho_0} \qquad \text{oppure} \qquad \frac{\Pi_a}{\Pi_{a0}} = 1.132\frac{\rho}{\rho_0} - 0.132$$

Cap.6 – Caratteristiche propulsive MOTOELICA

Motori Supercharged (turbocompressi)



Cap.6 – Caratteristiche propulsive MOTOELICA

$\Pi a = \Pi a_o \, \sigma \, \varphi$

Quindi effetto della quota e del grado di ammissione

Cap.6 – Caratteristiche propulsive ELICHE

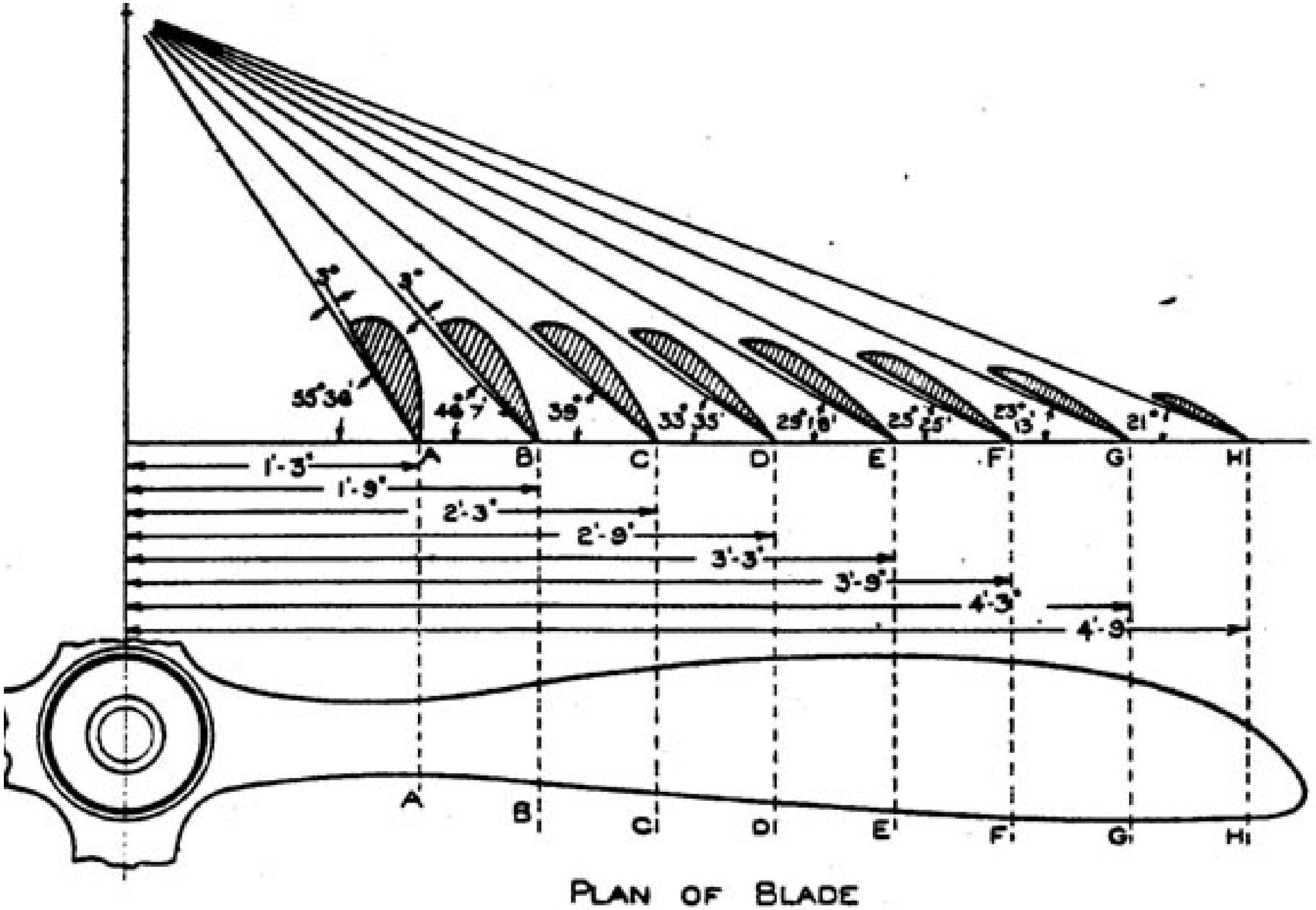
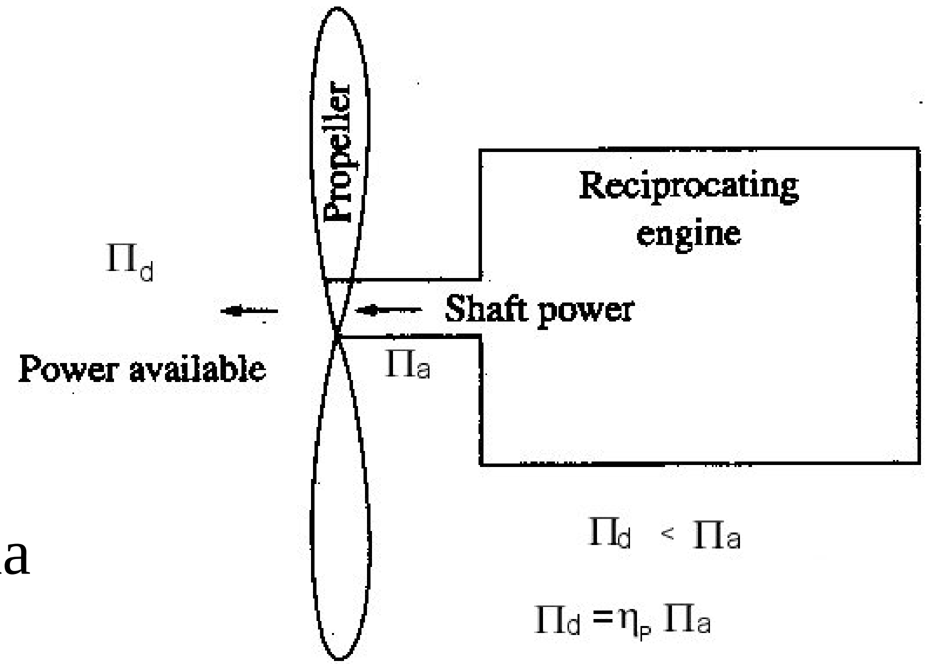


Fig. 219.—Lay-out of an Airscrew.

Cap.6 – Caratteristiche propulsive ELICHE

$$\Pi_d = \eta_{pr} \Pi_a$$



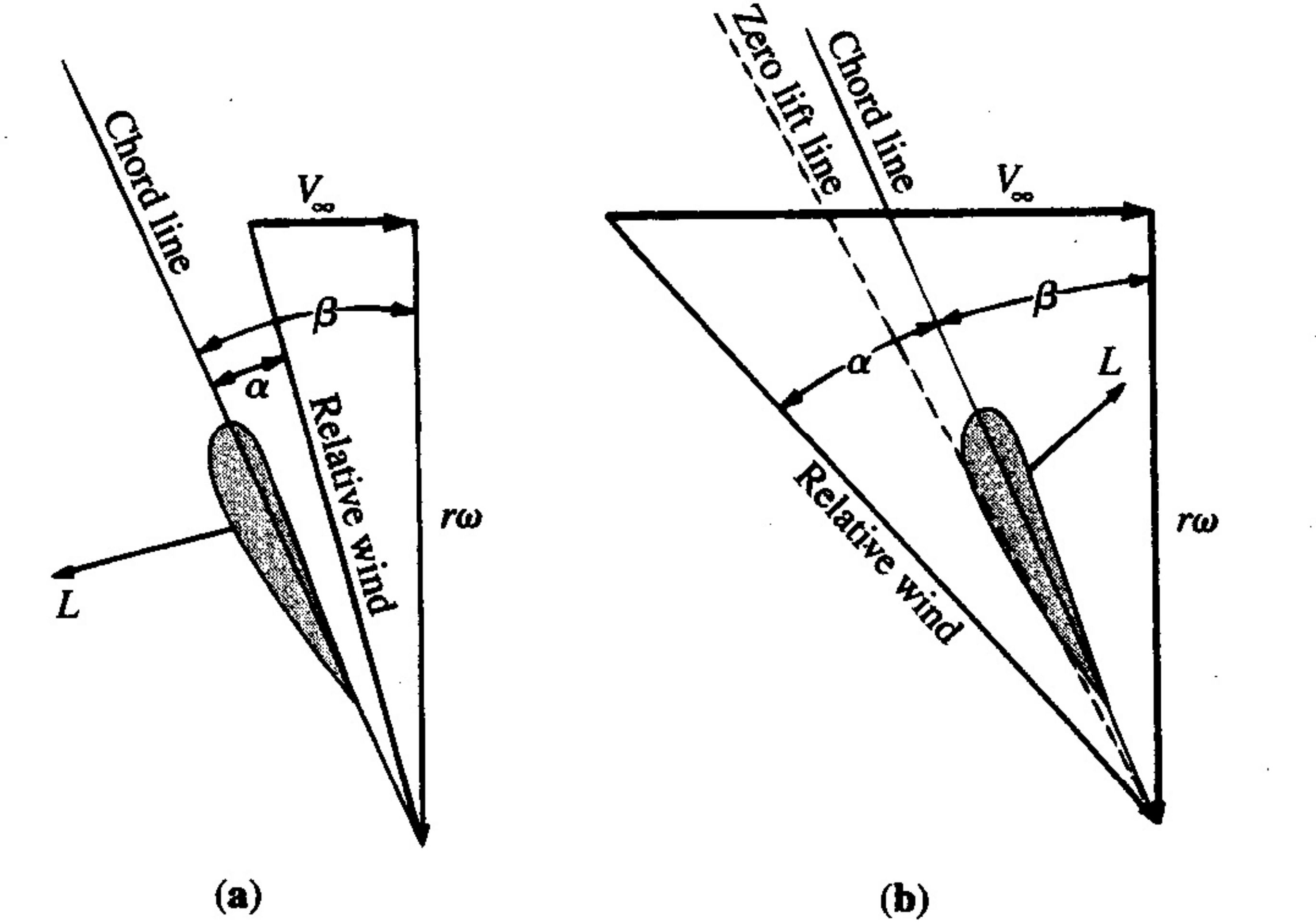
Il rendimento dell'elica è una funzione del *rapporto di avanzamento J* definito come

$$J = \frac{V_\infty}{ND}$$

Cap.6 – Caratteristiche propulsive ELICHE

$$(r\omega)_{tip} = \pi ND$$

$$\frac{V_\infty}{r\omega} = \frac{V_\infty}{r(2\pi N)} \quad \text{(angolo vel locale)} \quad \left(\frac{V_\infty}{r\omega}\right)_{tip} = \frac{V_\infty}{(D/2)(2\pi N)} = \frac{V_\infty}{\pi ND} = \frac{J}{\pi}$$



Cap.6 – Caratteristiche propulsive ELICHE

$$(r\omega)_{tip} = \pi ND$$

$$\frac{V_\infty}{r\omega} = \frac{V_\infty}{r(2\pi N)} \quad \text{(angolo vel locale)} \quad \left(\frac{V_\infty}{r\omega}\right)_{tip} = \frac{V_\infty}{(D/2)(2\pi N)} = \frac{V_\infty}{\pi ND} = \frac{J}{\pi}$$

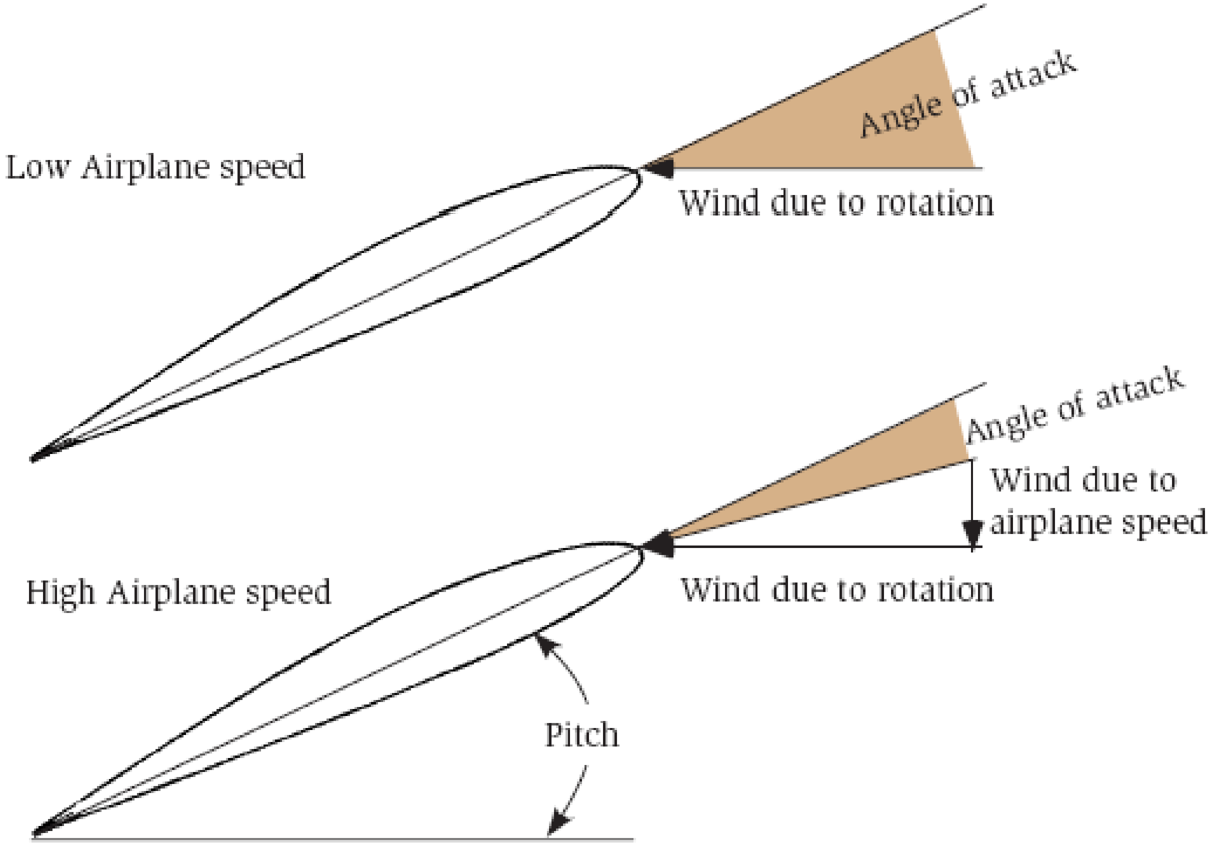
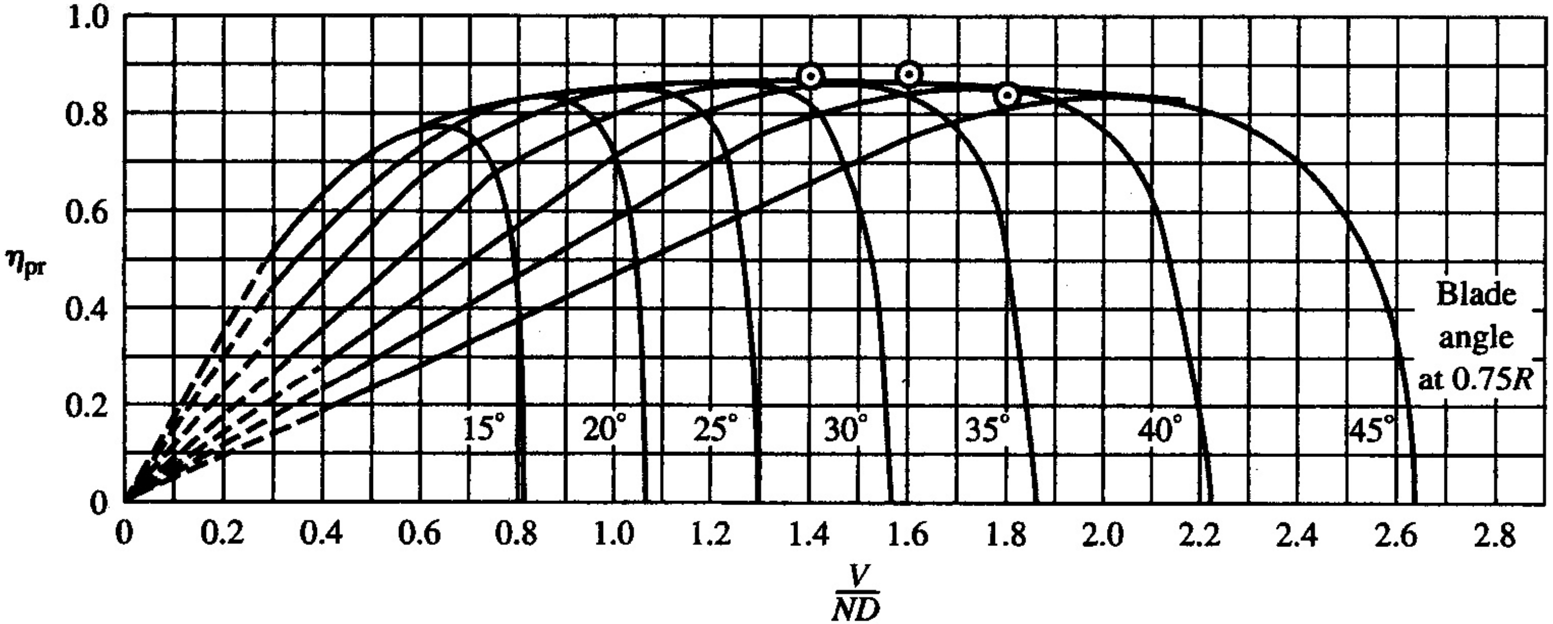
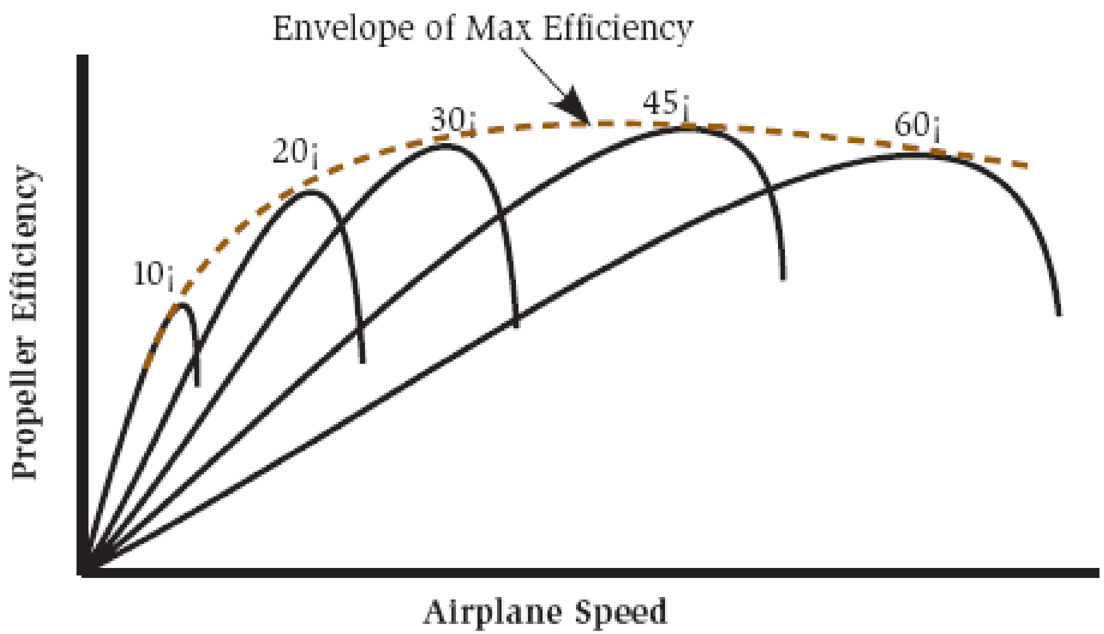


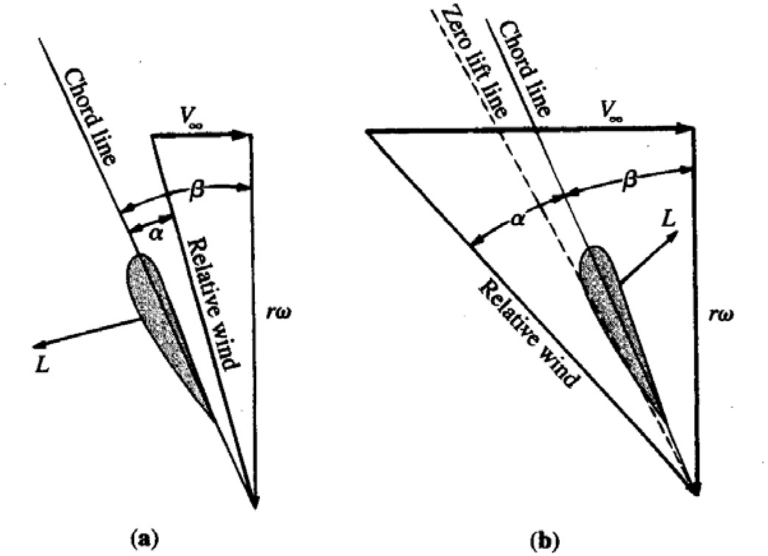
Fig. 5.5. Angle of attack of a rotating propeller.

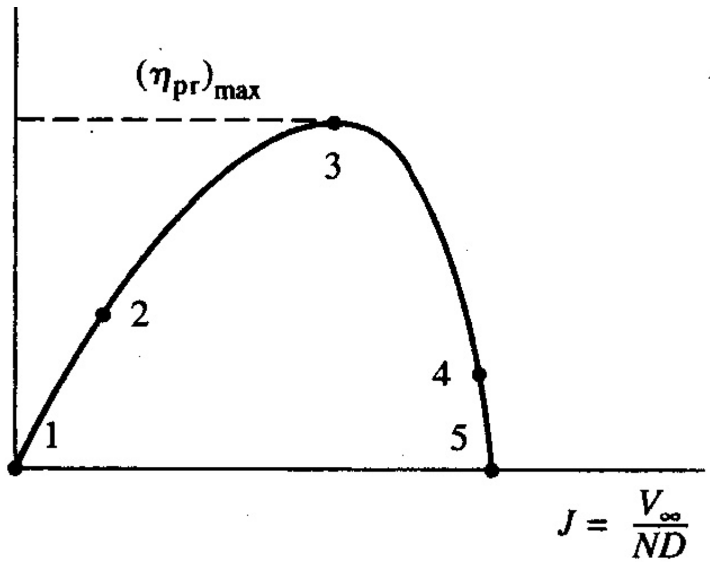
Cap.6 – Caratteristiche propulsive ELICHE



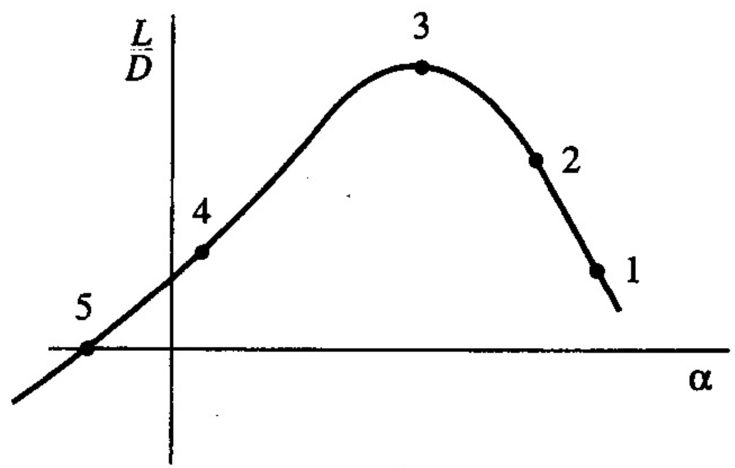


Cap.6 – Caratteristiche propulsive ELICHE



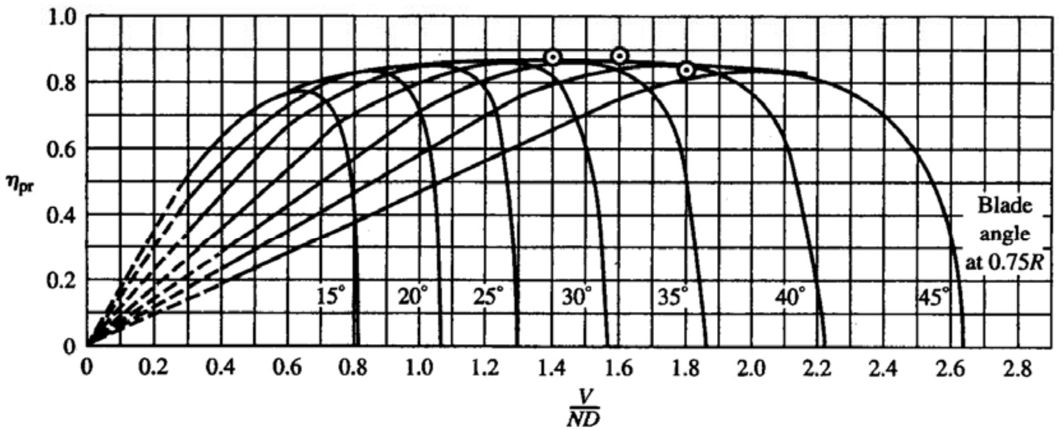


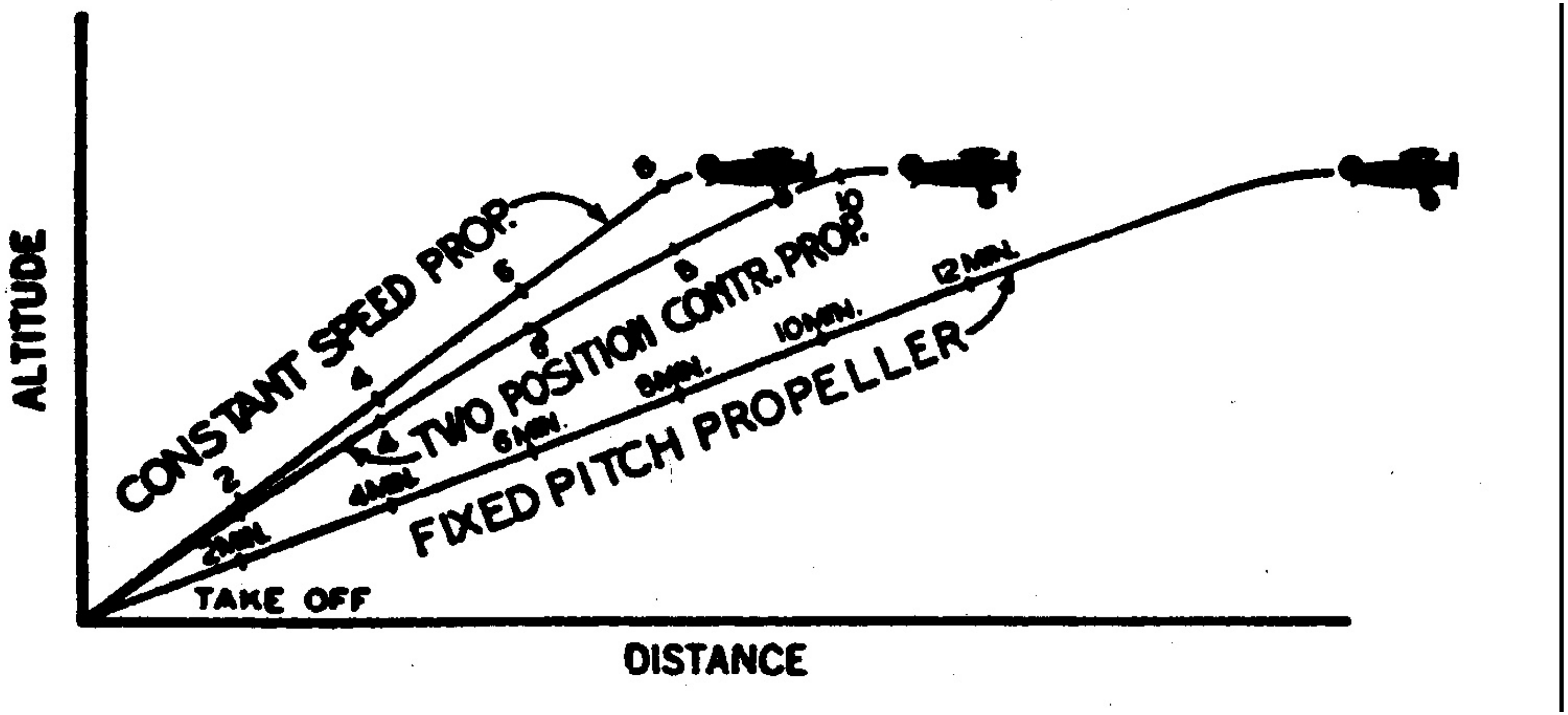
(a) Propeller efficiency



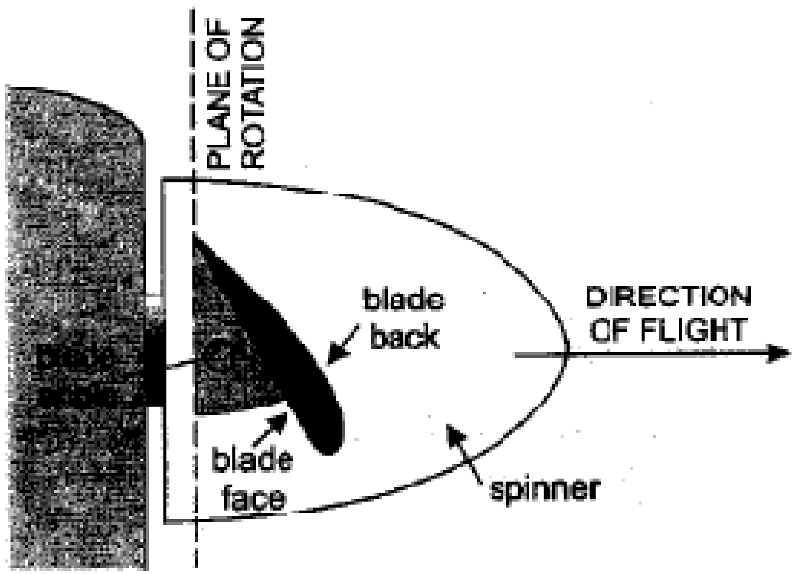
(b) Lift-to-drag ratio of a given propeller airfoil cross-section

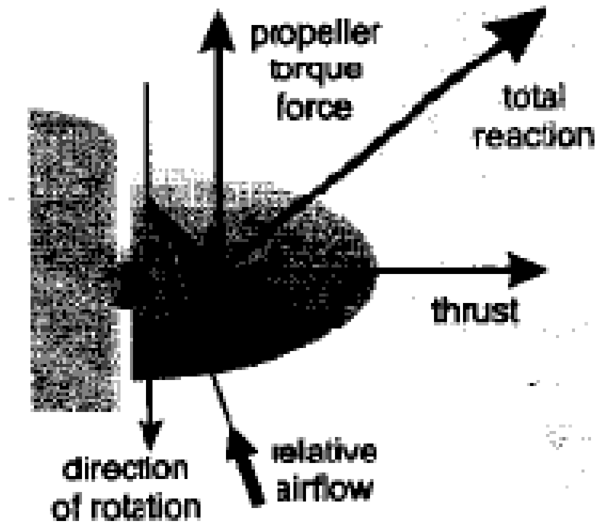
- Elica a passo variabile
- Elica a giri costanti

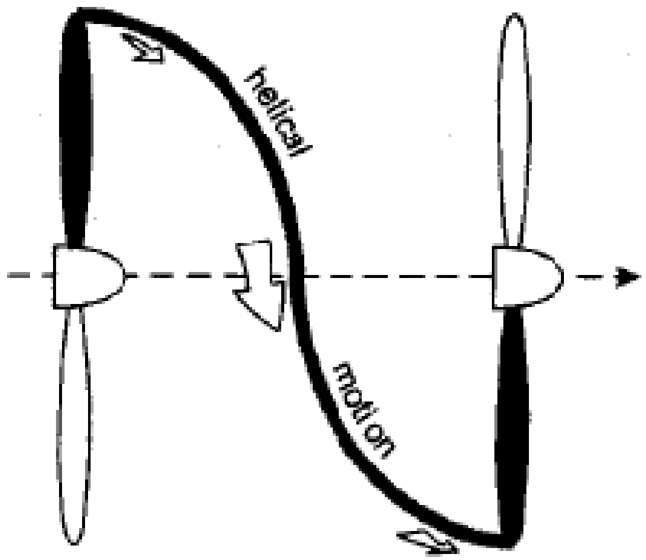


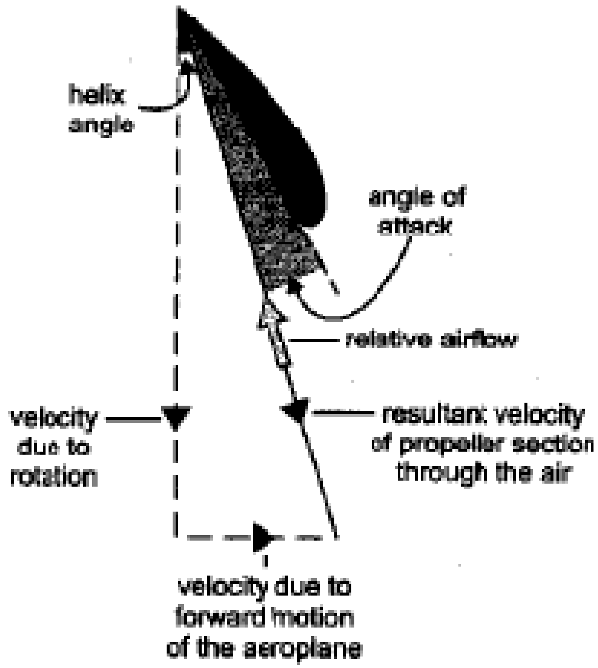


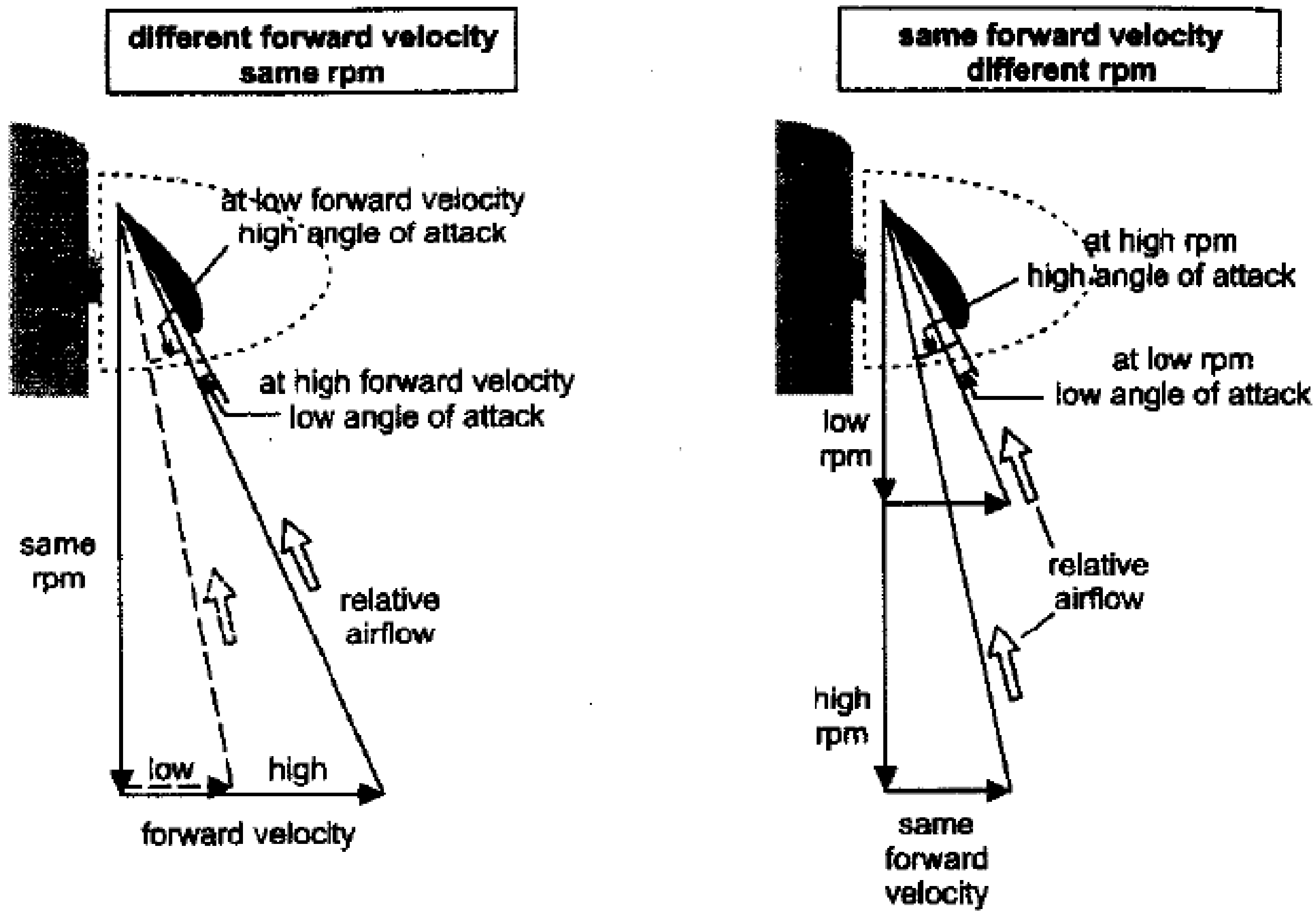
Cap.6 – Caratteristiche propulsive ELICHE



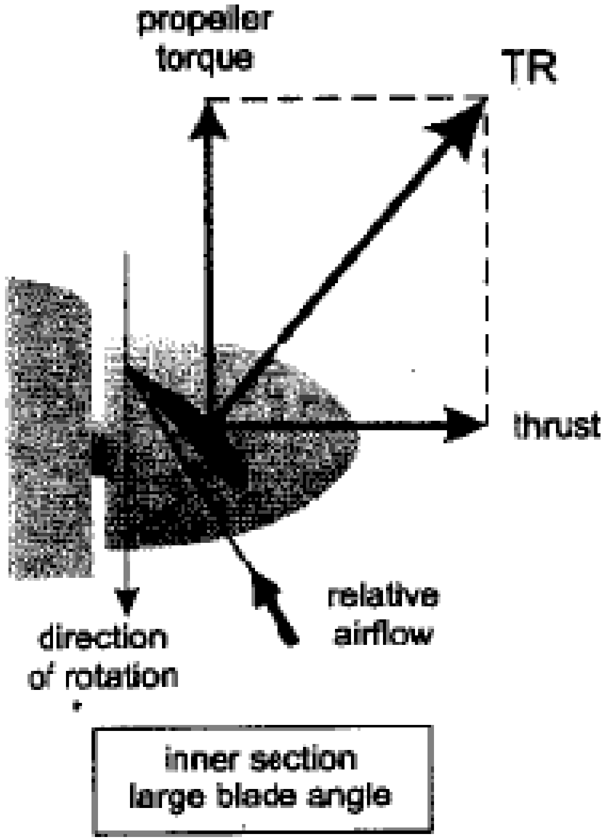


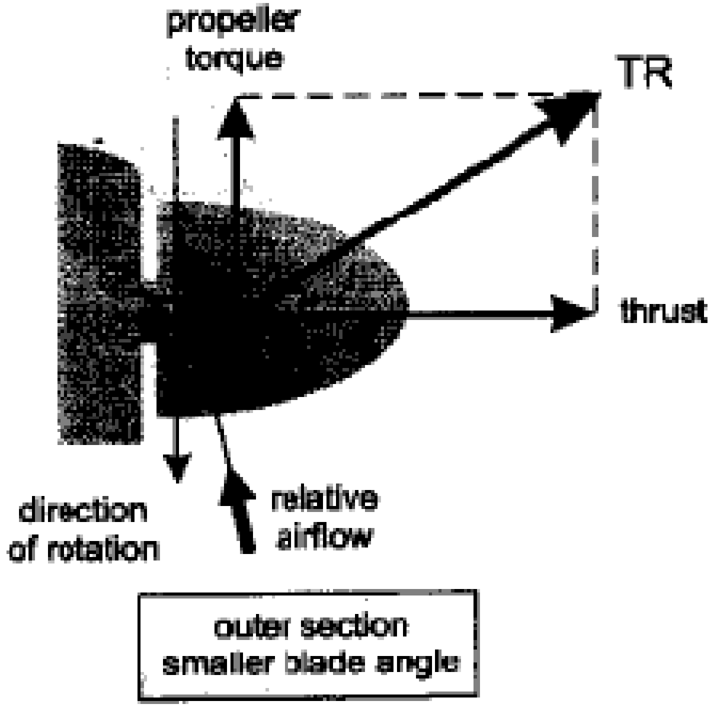




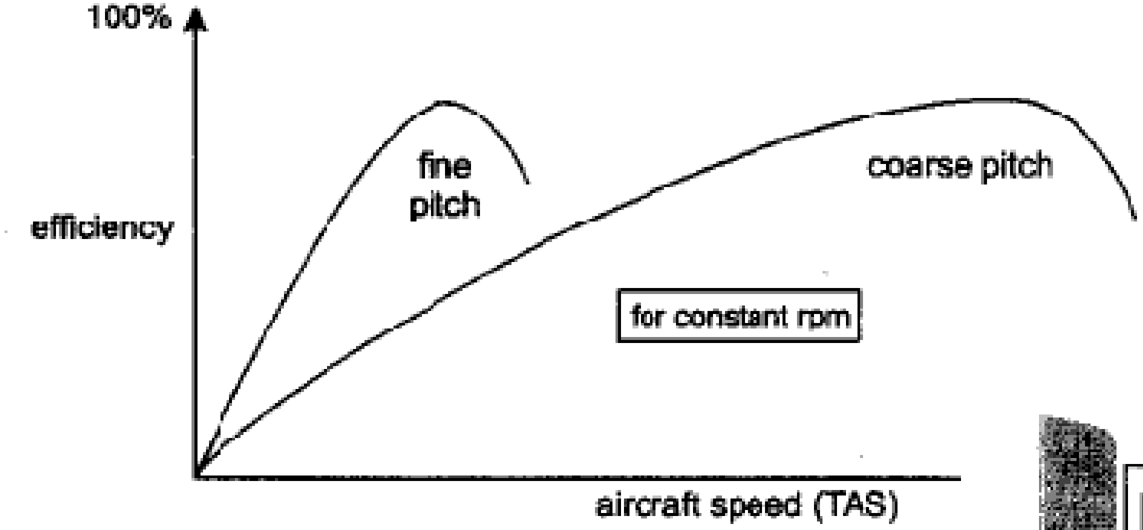

different forward velocity
same rpm
at low forward velocity
high angle of attack
at high forward velocity
low angle of attack
same
rpm
relative
airflow
low
high
forward velocity
same forward velocity
different rpm
at high rpm
high angle of attack
at low rpm
low angle of attack
low
rpm
relative
airflow
high
rpm
same
forward
velocity

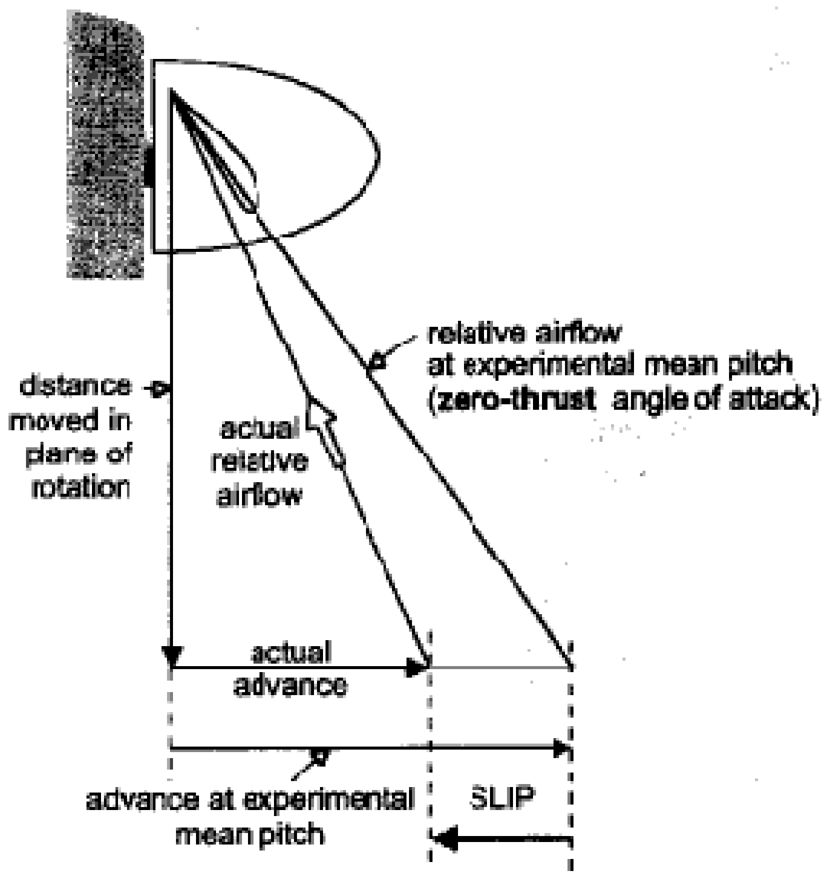
Cap.6 – Caratteristiche propulsive ELICHE



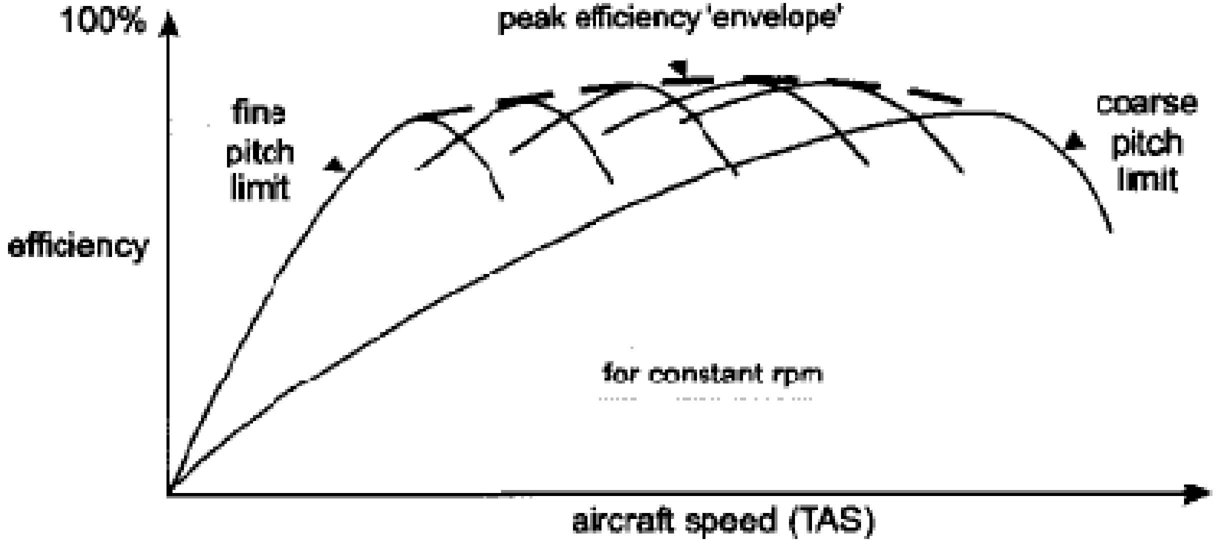


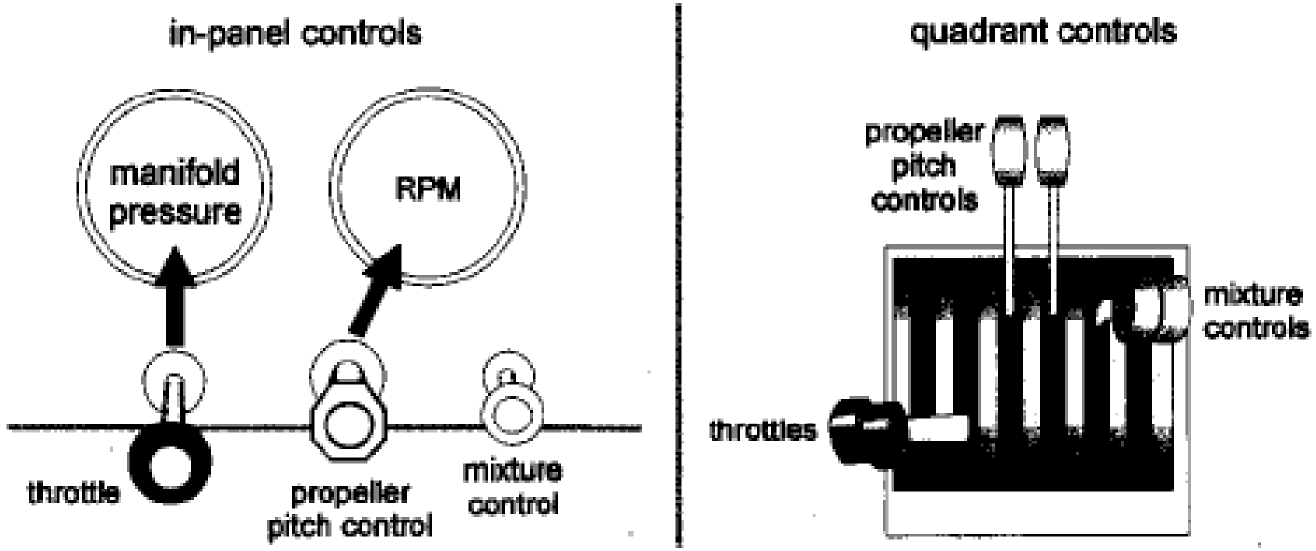
Cap.6 – Caratteristiche propulsive ELICHE



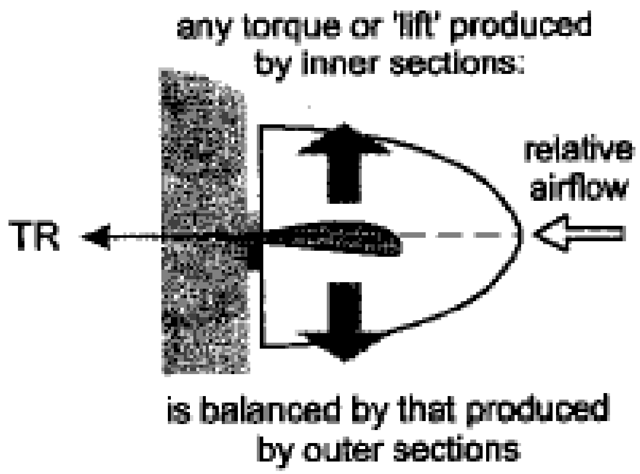


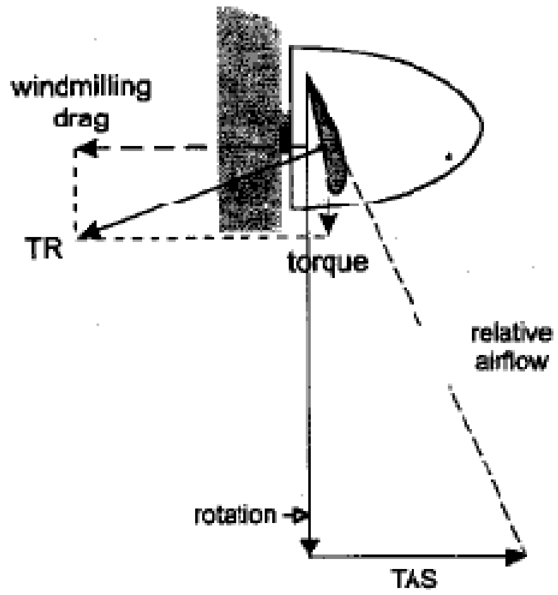
Cap.6 – Caratteristiche propulsive ELICHE

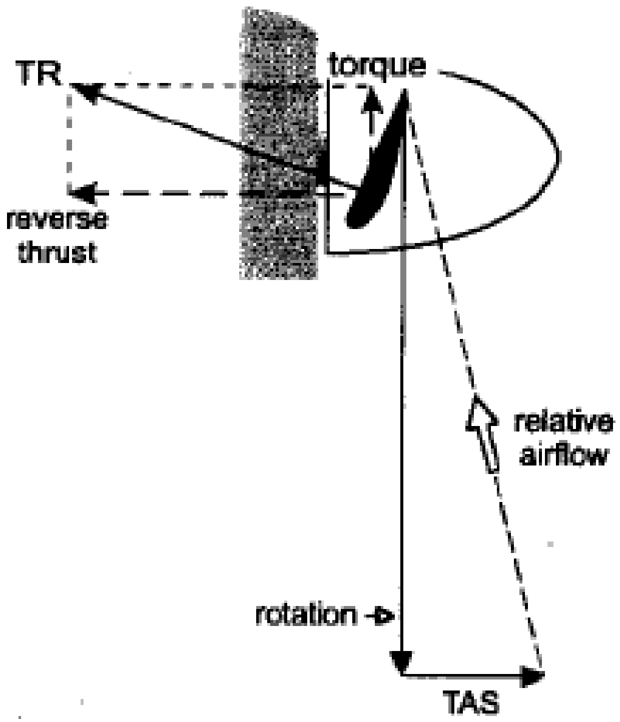




Cap.6 – Caratteristiche propulsive ELICHE



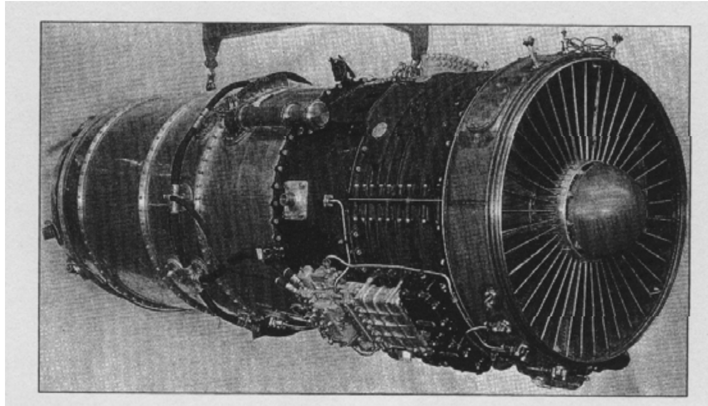


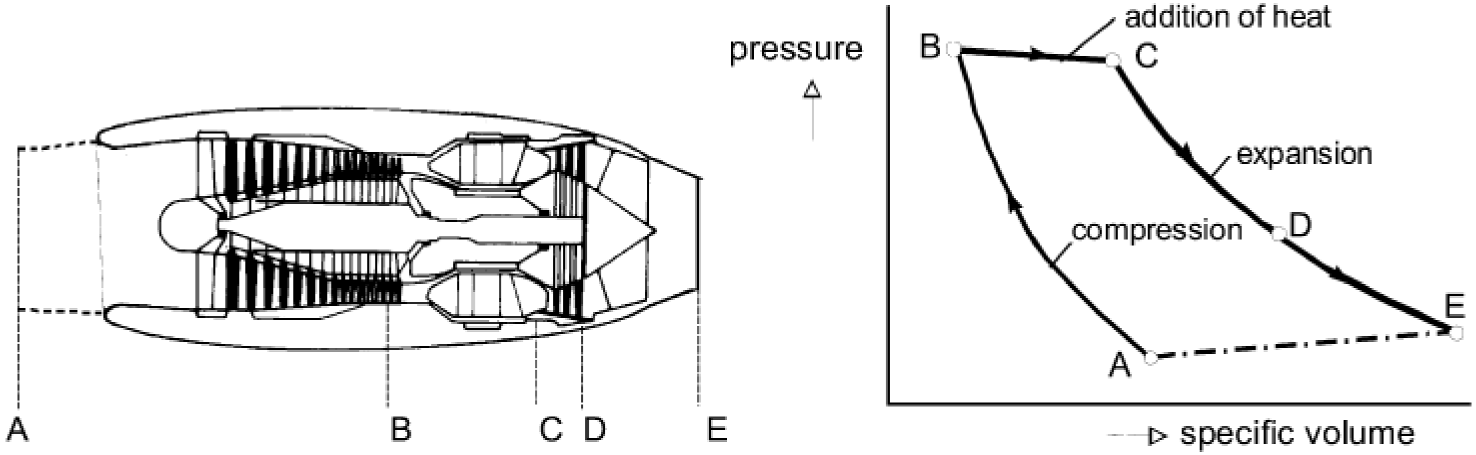


Cap.6 – Caratteristiche propulsive

Turbojet

$$T = \left(\dot{m}_{air} + \dot{m}_{fuel}\right)V_j - \dot{m}_{air}V_\infty + \left(p_e - p_\infty\right)A_e$$





(a) Engine components (b) Brayton cycle

Figure 5.17 Components and cycle of a jet engine.

Cap.6 – Caratteristiche propulsive

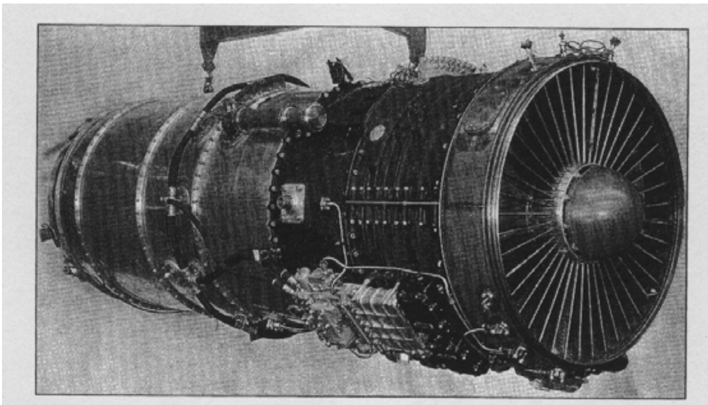
Turbojet

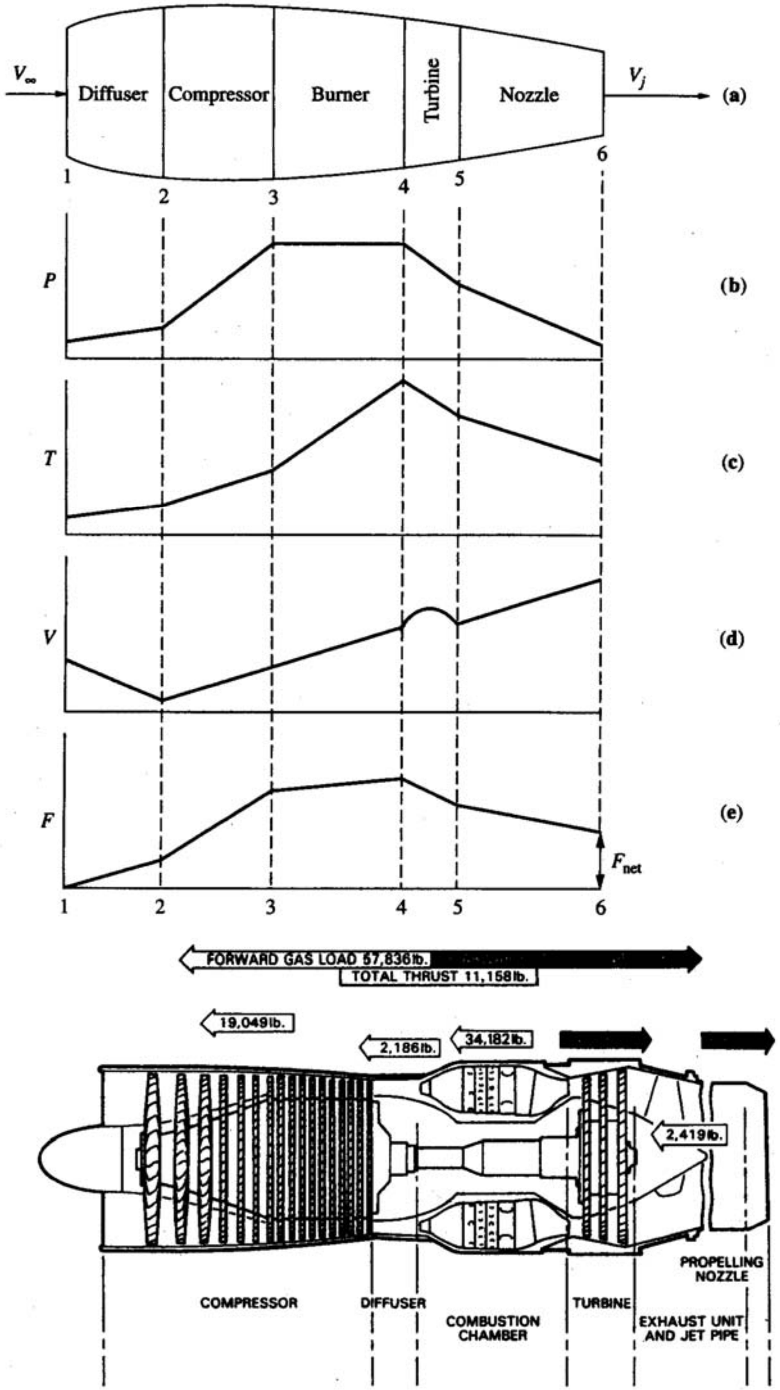
$$T = \left(\dot{m}_{air} + \dot{m}_{fuel}\right)V_j - \dot{m}_{air}V_\infty + \left(p_e - p_\infty\right)A_e$$

$$c_j = \frac{pesodelcarburanteconsumatoperdatoincrementoditempo}{(sp\,\mathrm{int}\,asviluppata)(incrementoditempo)}$$

$$\left[c_j\right] = \frac{N}{N \cdot s} = \frac{1}{s}$$

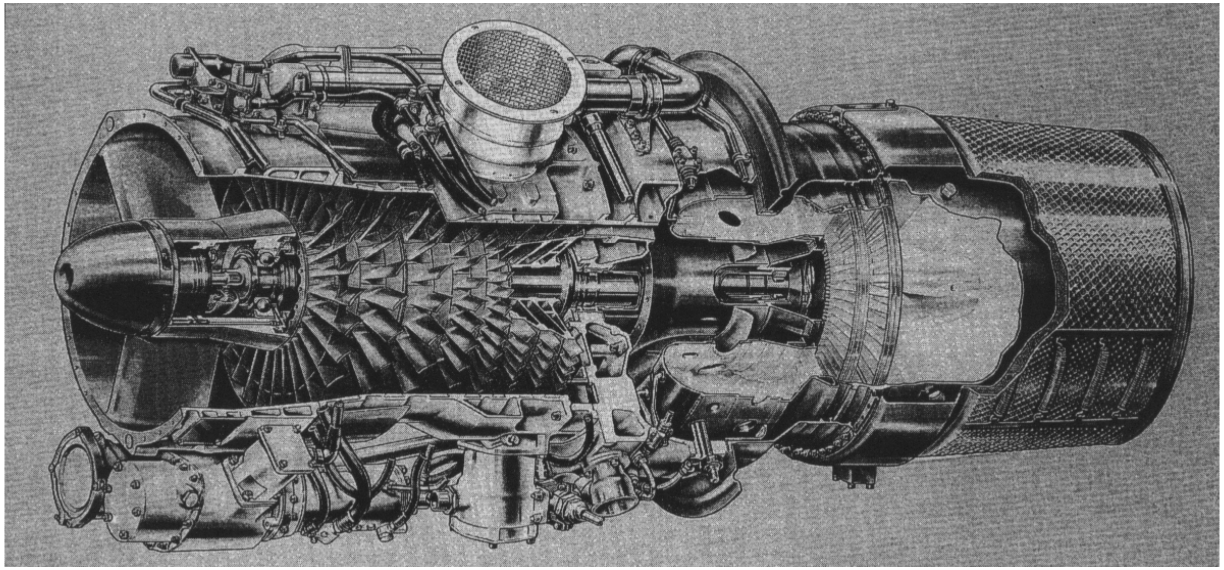
$$\left[SFCJ\right] = \frac{lb}{lb \cdot h} = \frac{1}{h}$$

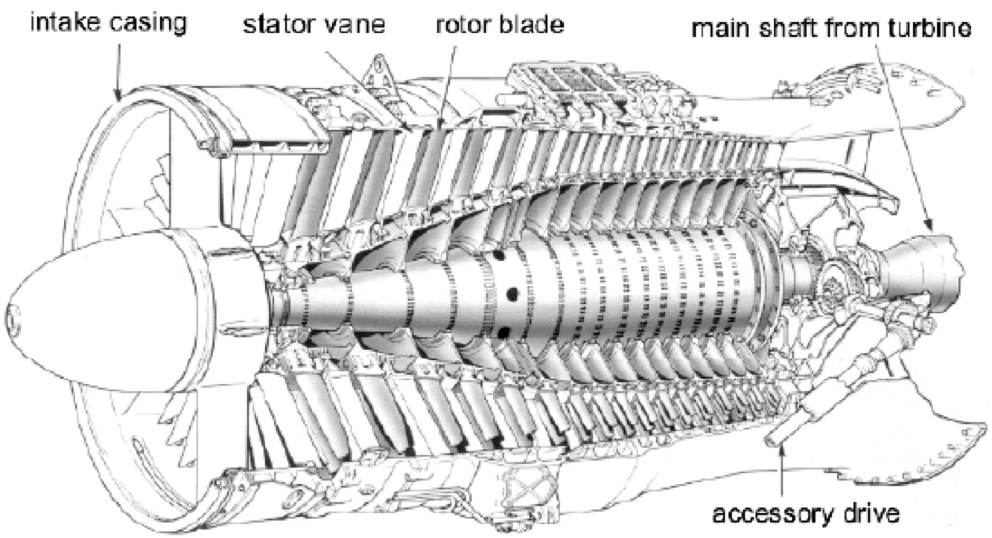


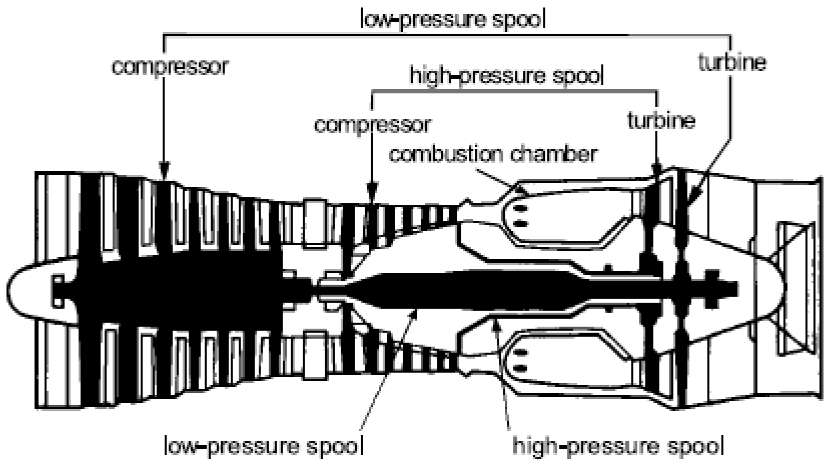


Cap.6 – Caratteristiche propulsive

Turbojet







Cap.6 – Caratteristiche propulsive

Turbojet

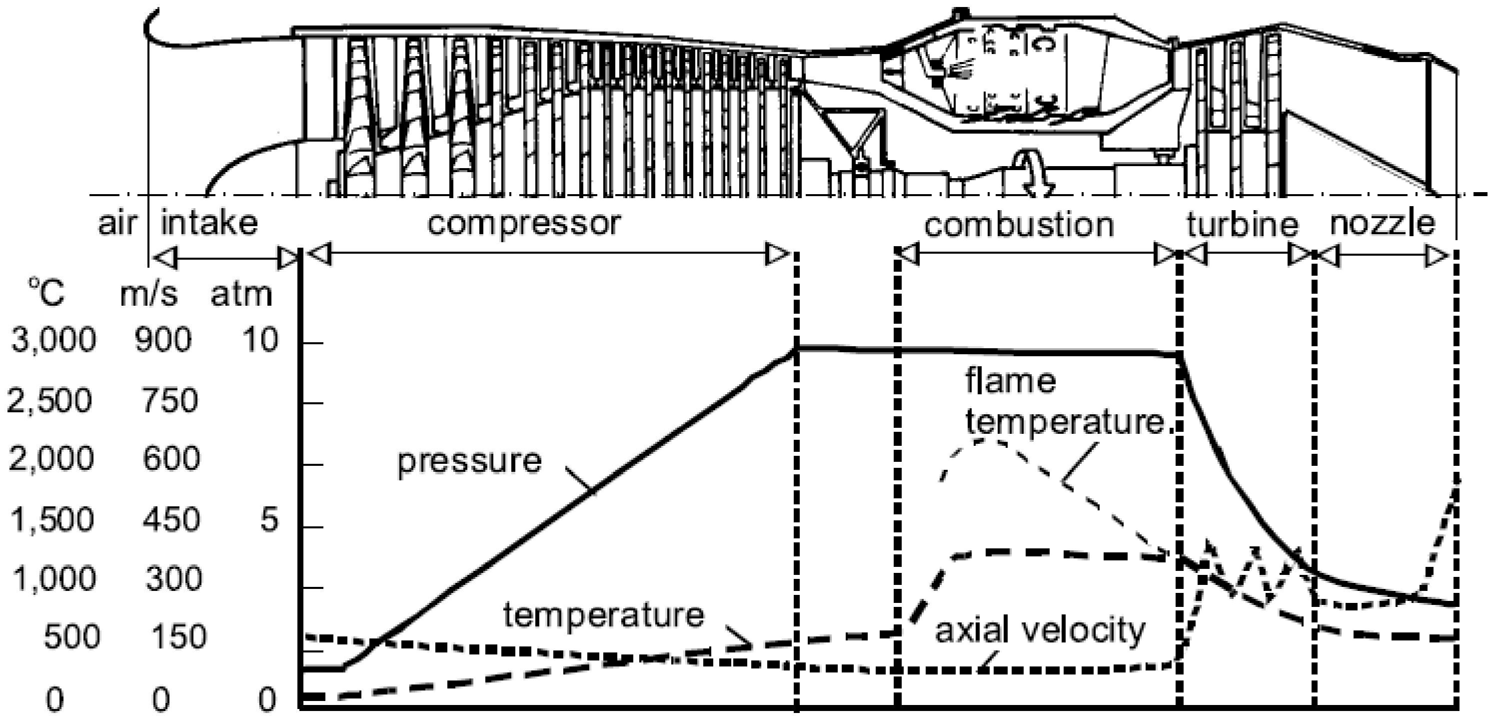


Figure 5.20 Variation of pressure, temperature and flow velocity in a jet engine (courtesy of Rolls-Royce plc).

Cap.6 – Caratteristiche propulsive

Turbojet

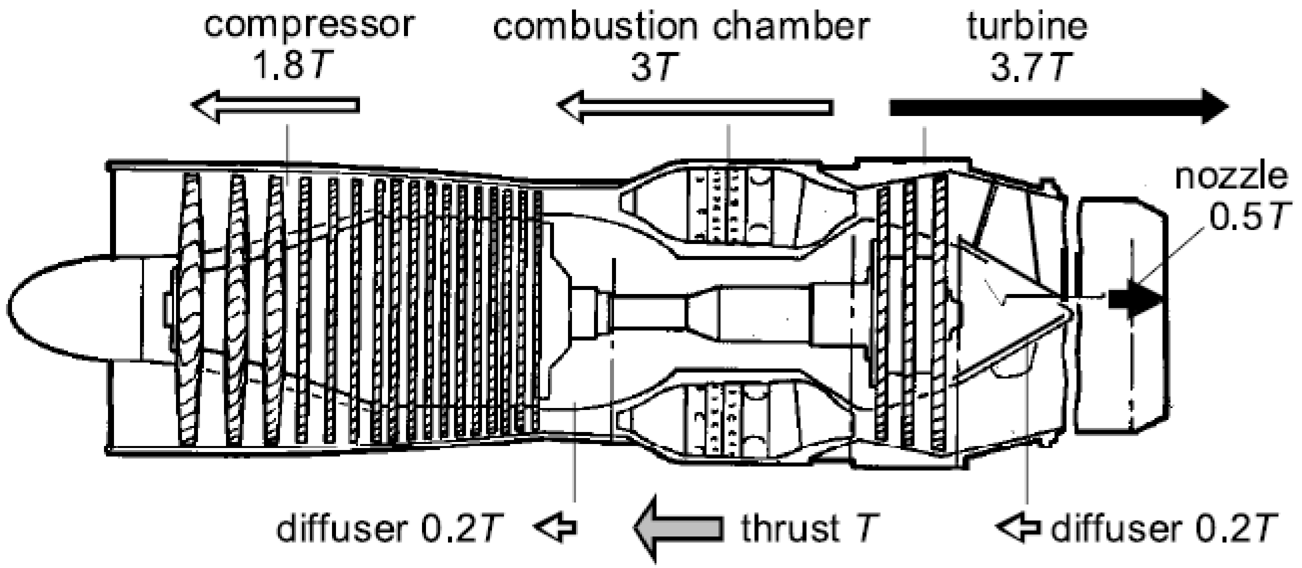
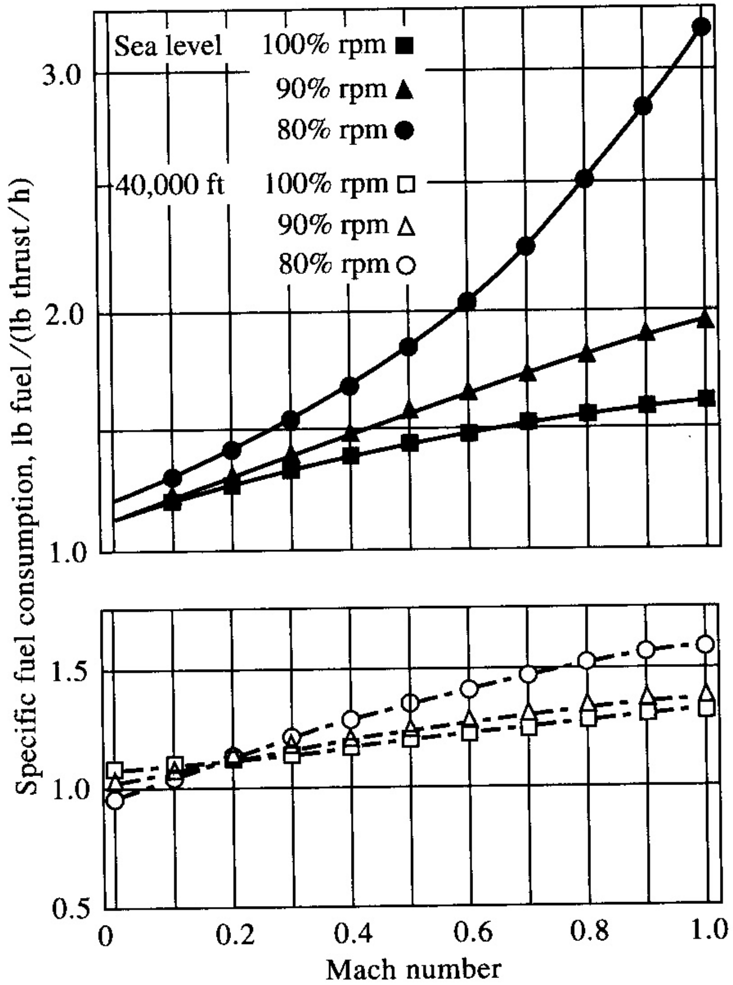


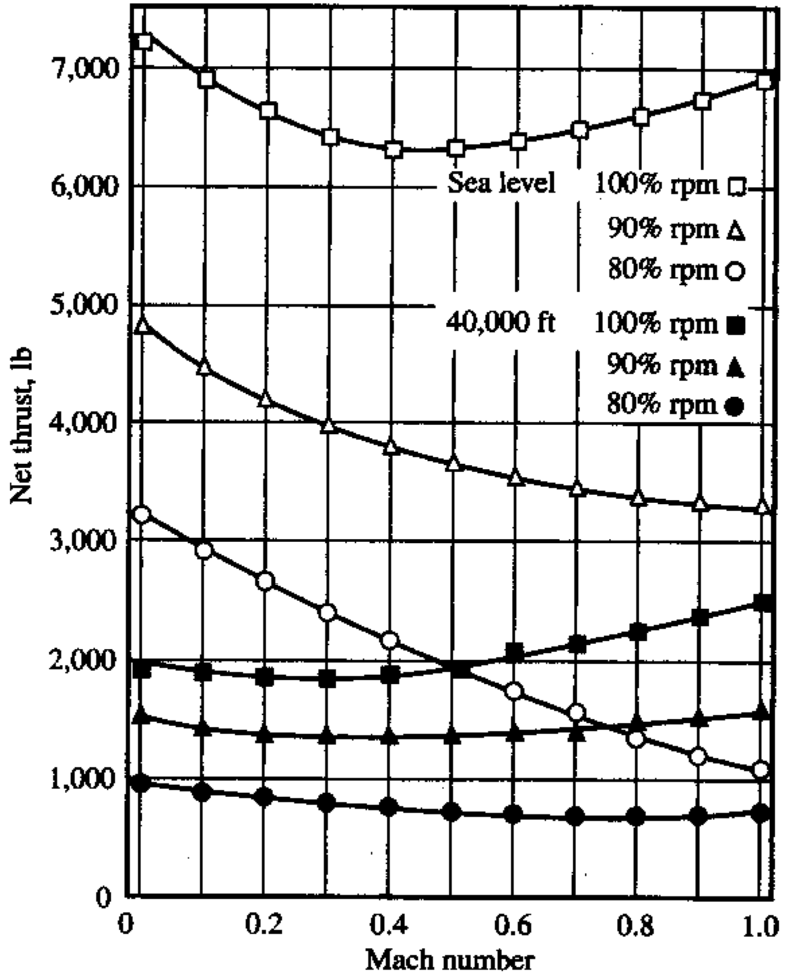
Figure 5.21 Distribution of internal thrust components for a static turbojet.

Cap.6 – Caratteristiche propulsive Turbojet

TSFC = 1.0 + kM_∞

SFCJ è costante con la quota





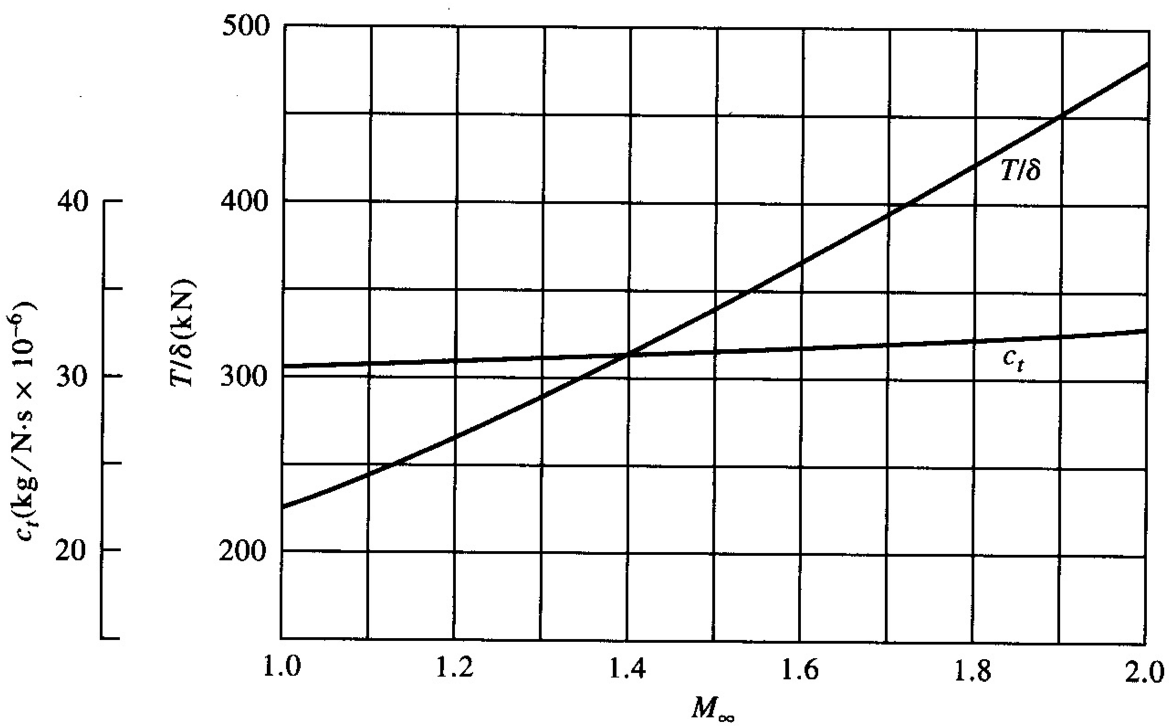
Spinta cost. con V

Effetto quota $\frac{T}{T_0} = \frac{\rho}{\rho_0}$

Cap.6 – Caratteristiche propulsive Turbojet

$$\frac{p_{total}}{p_{static}} = \left(1 + \frac{\gamma - 1}{2} M^2\right)^{\gamma/(\gamma - 1)}$$

Condizioni supersoniche



$$\frac{T}{T_{Mach1}} = 1 + 1.18(M_\infty - 1)$$

Cap.6 – Caratteristiche propulsive

Turbojet

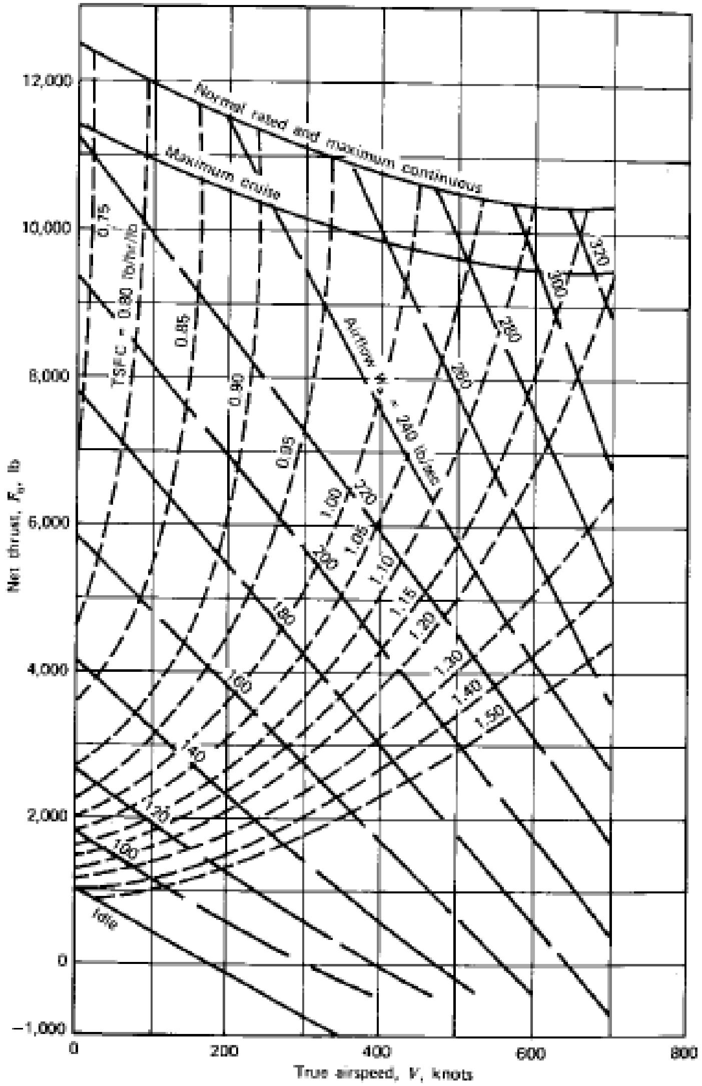


Figure 6.32a Pratt & Whitney Aircraft JT4A-3 turbojet engine. Estimated thrust, TSFC, and airflow at sea level. Standard atmospheric conditions, 100% ram recovery. (Courtesy, Pratt & Whitney.)

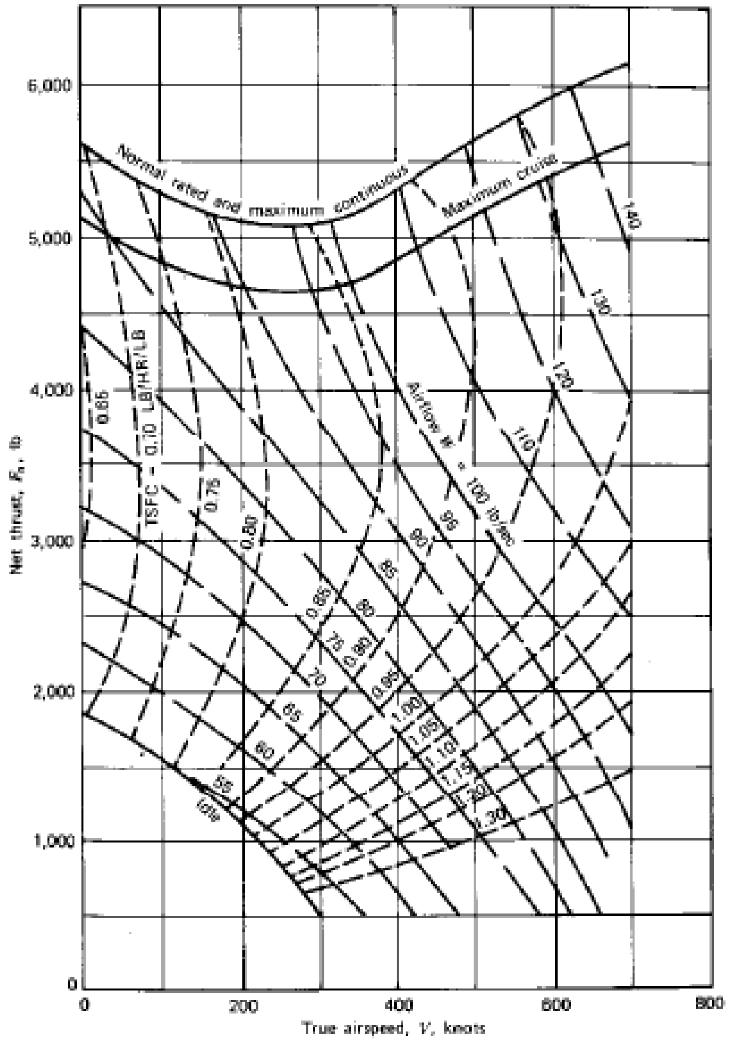


Figure 6.32c Pratt & Whitney Aircraft JT4A-3 turbojet engine. Estimated thrust, TSFC, and airflow at 30,000 ft. Standard atmospheric conditions, 100% ram recovery. (Courtesy, Pratt & Whitney.)

Cap.6 – Caratteristiche propulsive

Turbojet

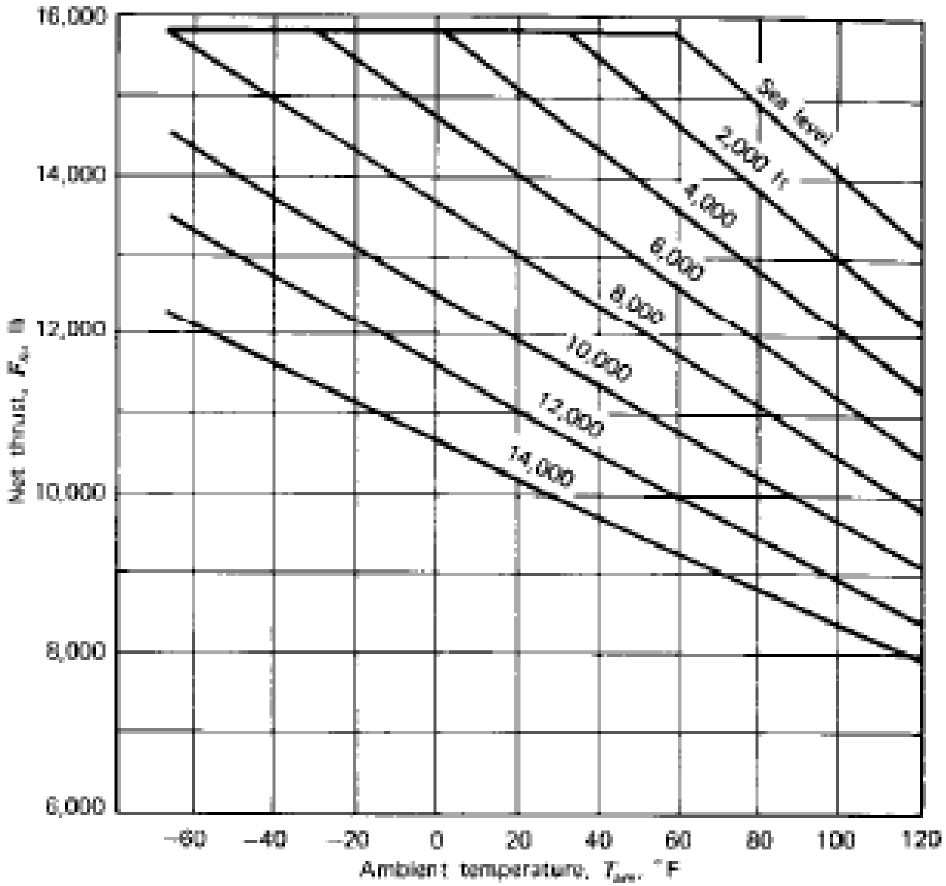
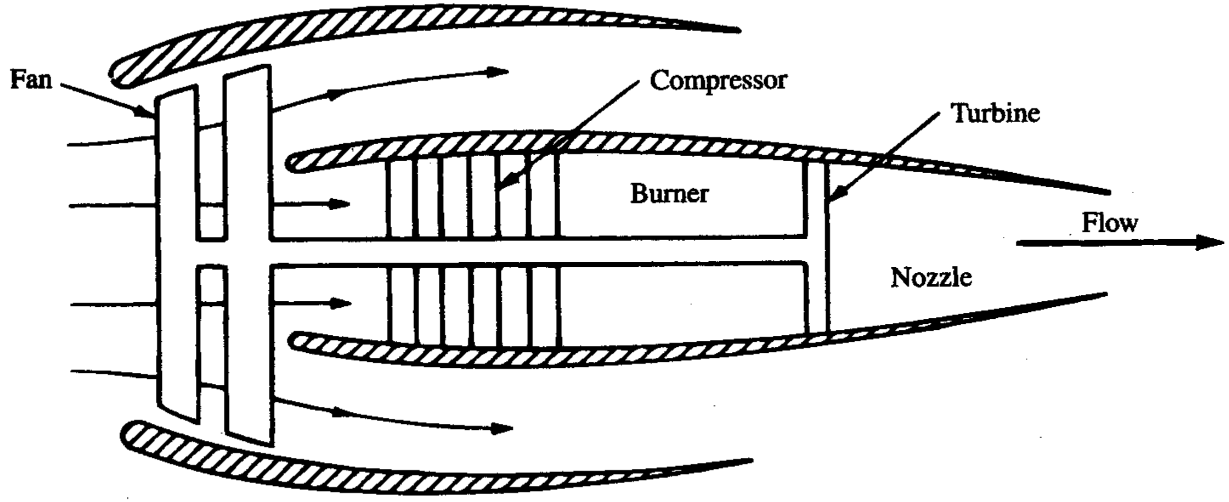


Figure 6.33a Pratt & Whitney Aircraft JY4A-3, -5 turbojet engines. Estimated net thrust on runway during takeoff. Zero knots. (Courtesy, Pratt & Whitney.)

Cap.6 – Caratteristiche propulsive

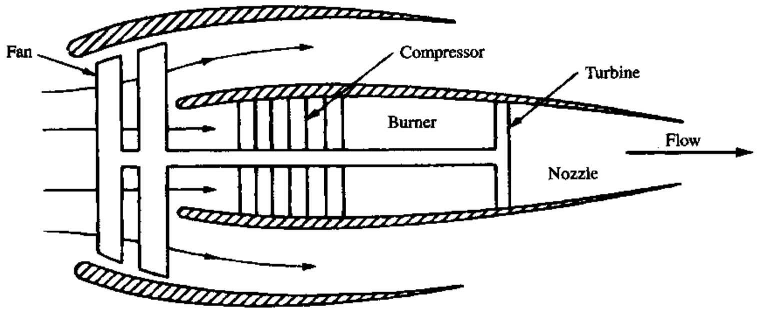
Turbofan

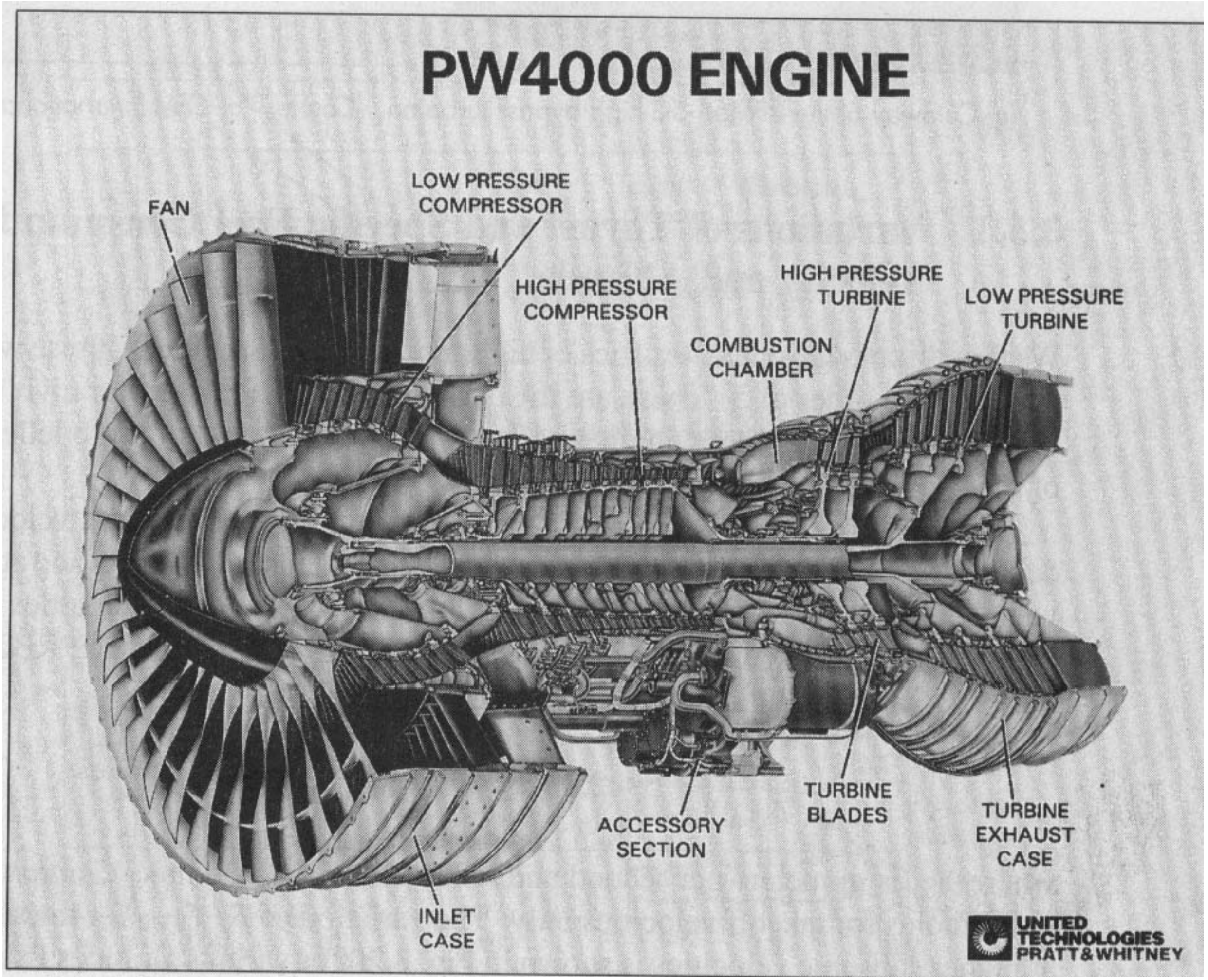


BPR : apporto di By-Pass o anche rapporto di diluizione

Cap.6 – Caratteristiche propulsive

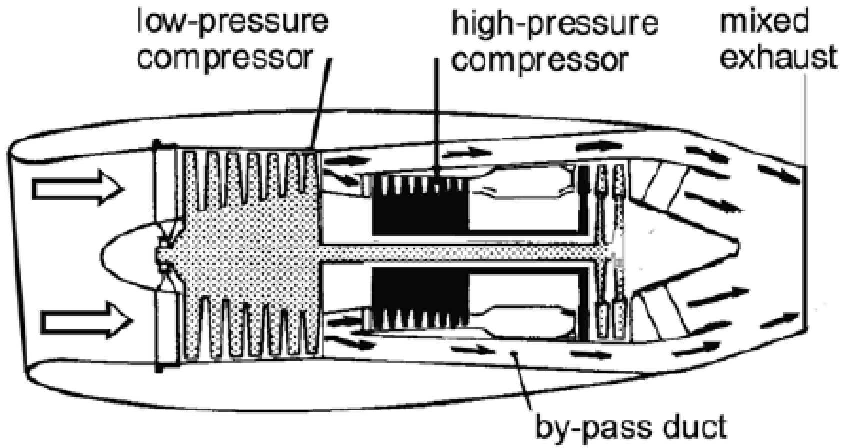
Turbofan



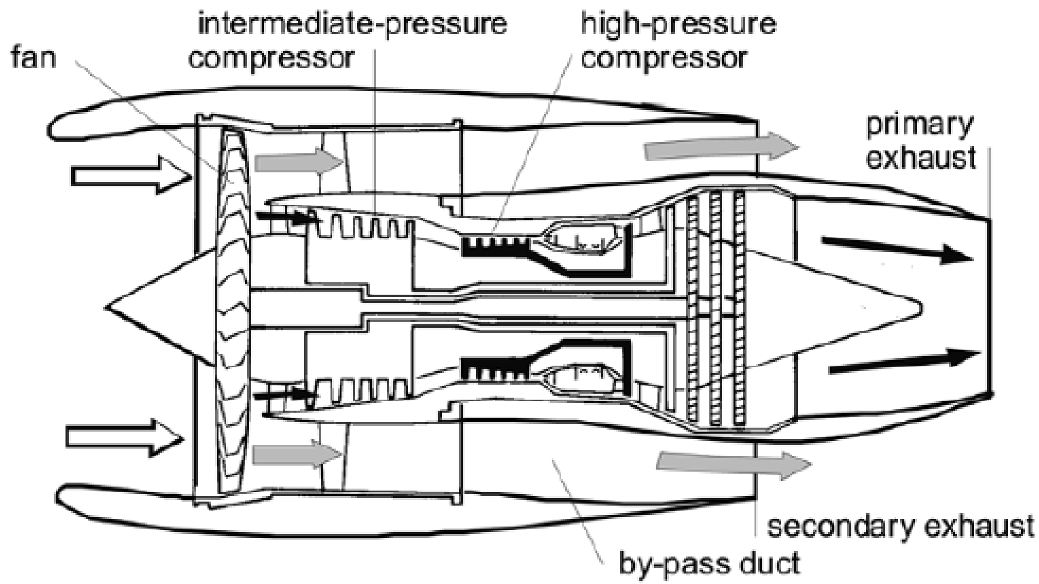


Cap.6 – Caratteristiche propulsive

Turbofan



(a) Low by-pass ratio turbofan



(b) Three-shaft high by-pass ratio turbofan

Cap.6 – Caratteristiche propulsi

Turbofan

- Low BPR

- HIGH BPR

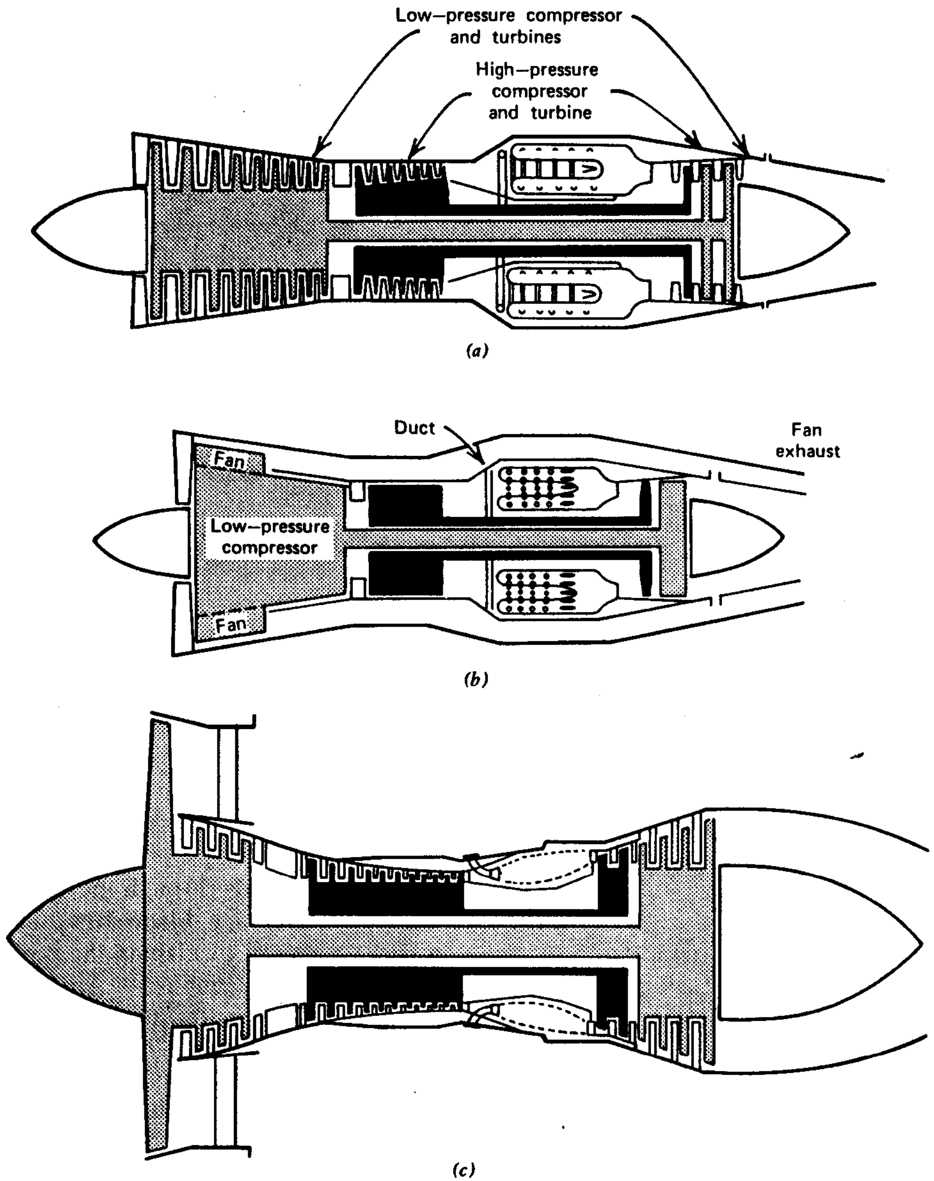


Figure 6.26 Variations on the gas turbine. (*a*) Dual axial-flow compressor turbojet. (*b*) Dual axial-flow compressor, forward fan engine with long ducts. (*c*) High bypass ratio turbofan with short ducts. (*d*) Single axial-flow compressor, direct propeller drive turboprop. (*e*) Single axial-flow compressor, free turbine propeller drive turboprop. (*f*) Dual axial-flow compressor, turbojet with after-burner. (*g*) Dual axial-flow compressor, industrial turboshaft engine.

Cap.6 – Caratteristiche propulsive

The Pratt & Whitney JT9D-7A is representative of a modern high bypass turbofan engine. This engine has a dry weight of 8850 lb (39,365 N) and delivers a maximum continuous static thrust at SSL of 39,650 lb (176,363 N). The static dry takeoff rating of 45,500 lb (202,384 N) is flat rated up to 27 °C (80 °F). The diameter of the engine is 2.43 m (95.6 in.) with a length of 3.92 m (154.2 in.). The compressor incorporates one fan stage, three low-pressure stages, and eleven high-pressure stages. The turbine has two high-pressure stages and four low-pressure stages. The bypass ratio equals 5.1 at the dry takeoff rating, with a total airflow of 1545 lb/sec (6872 N/s). The dash 7A model

<u>Esempio Turbofan HBPR (BPR=5.1)</u>

PW JT9D

To=46000 lb

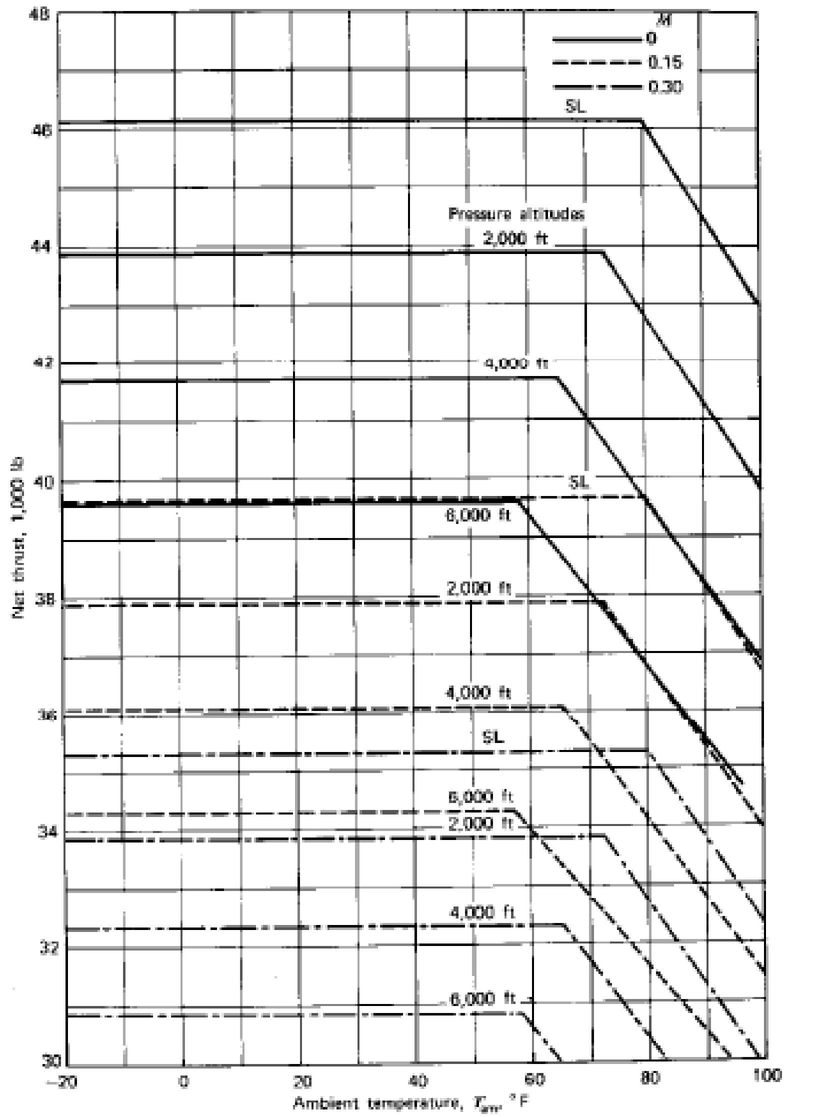


Figure 6.36 JT9D-7A net takeoff thrust. Dry, 100% ram recovery, no airbleed, no power extraction, Pratt & Whitney Aircraft standard exhaust. (Courtesy, Pratt & Whitney.)

Cap.6 – Caratteristiche propulsive

PW JT9D

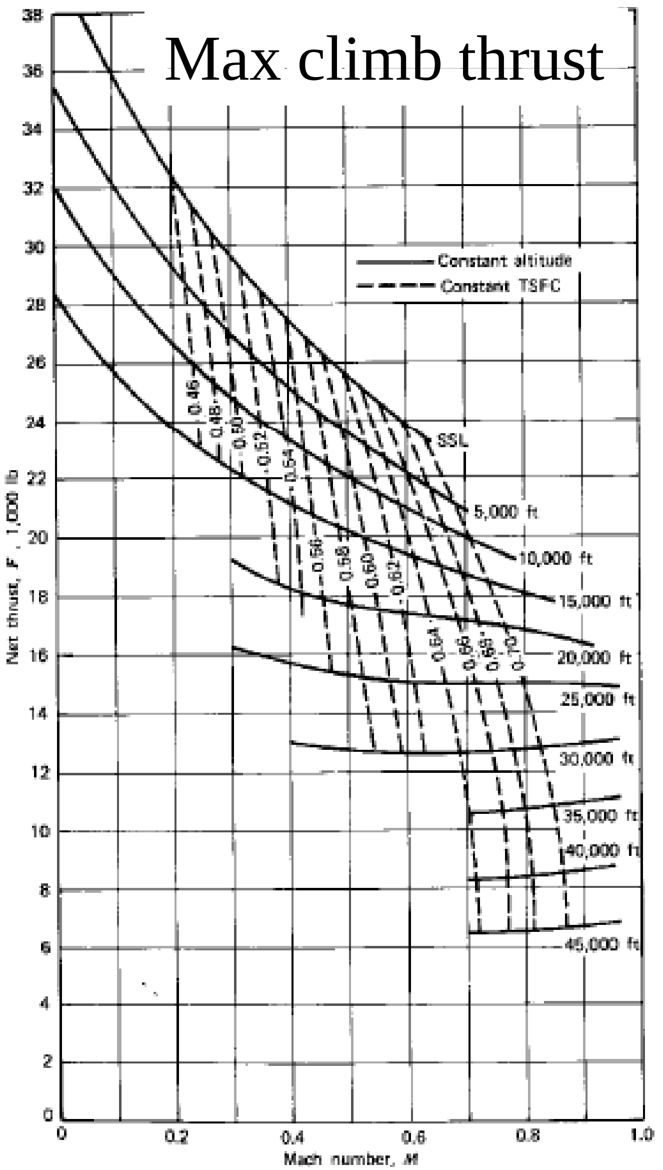


Figure 6.37 JT9D-7A maximum climb thrust. One hundred percent ram recovery, no airbleed, no power extraction, Pratt & Whitney Aircraft reference exhaust system, all curves for ICAO standard day +10°C and below. (Courtesy, Pratt & Whitney.)

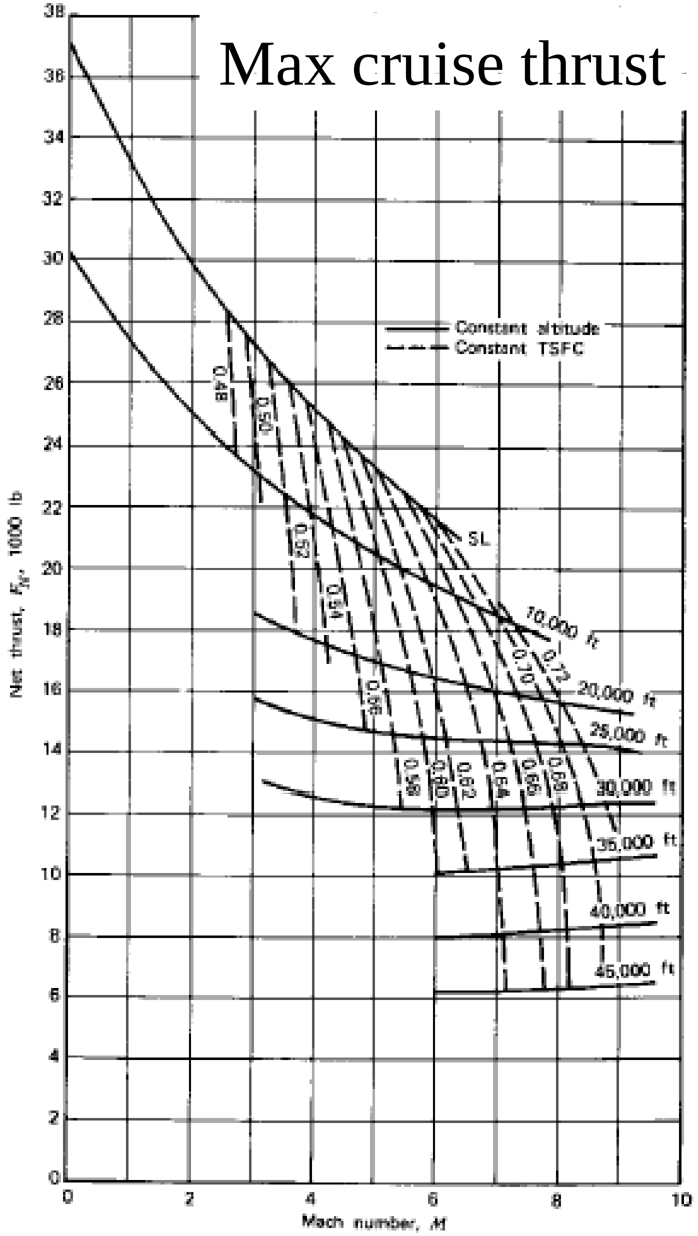
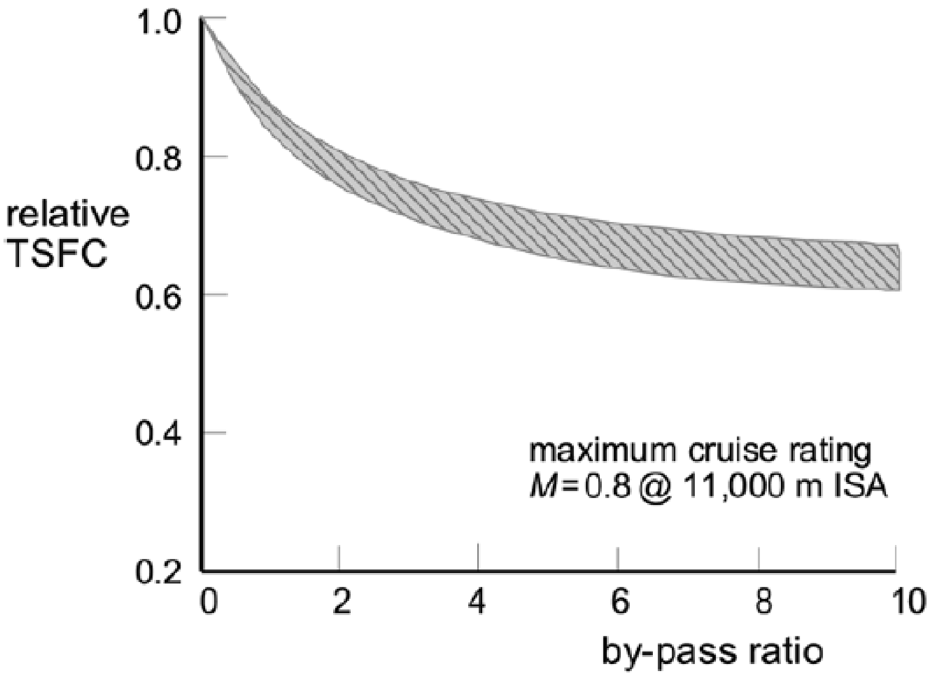
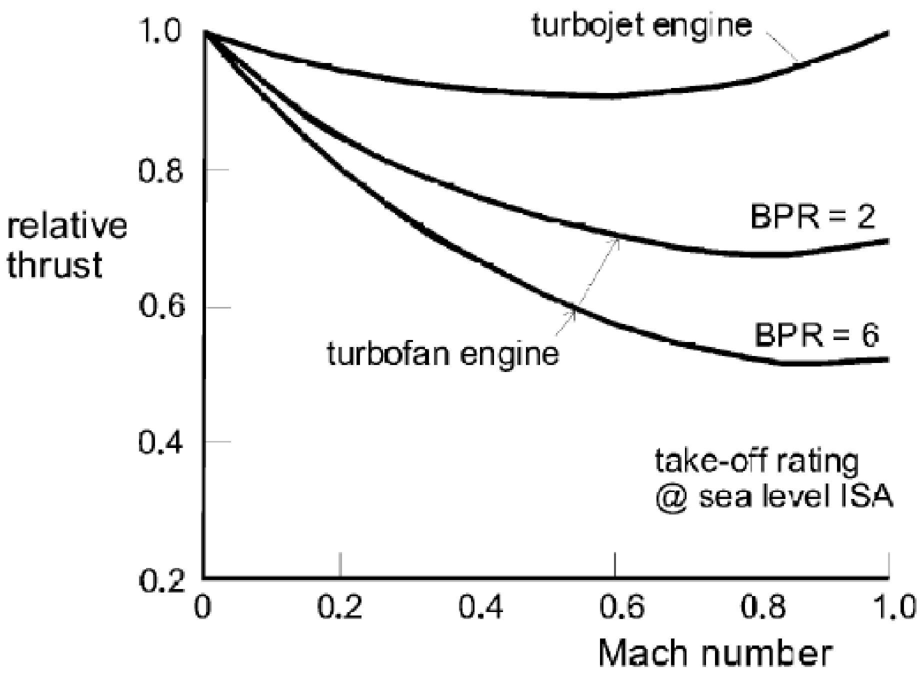


Figure 6.38 JT9D-7A maximum cruise thrust. One hundred percent ram recovery, no airbleed, no power extraction, Pratt & Whitney Aircraft reference exhaust system, all curves for ICAO standard day +10°C and below. (Courtesy, Pratt & Whitney.)

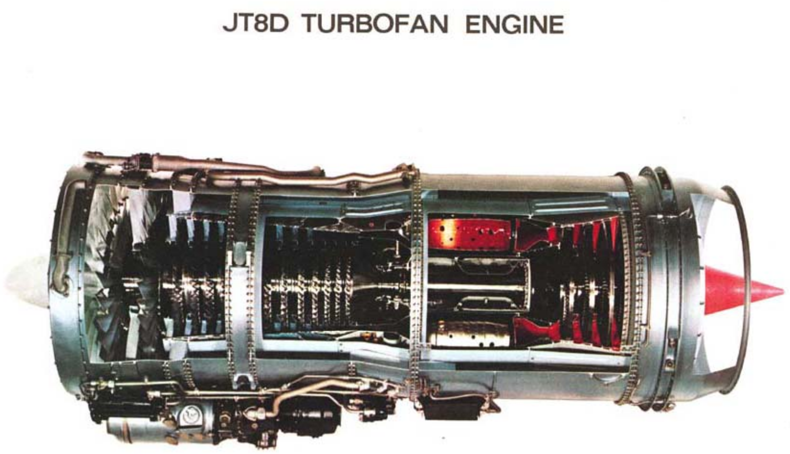
Cap.6 – Caratteristiche propulsive



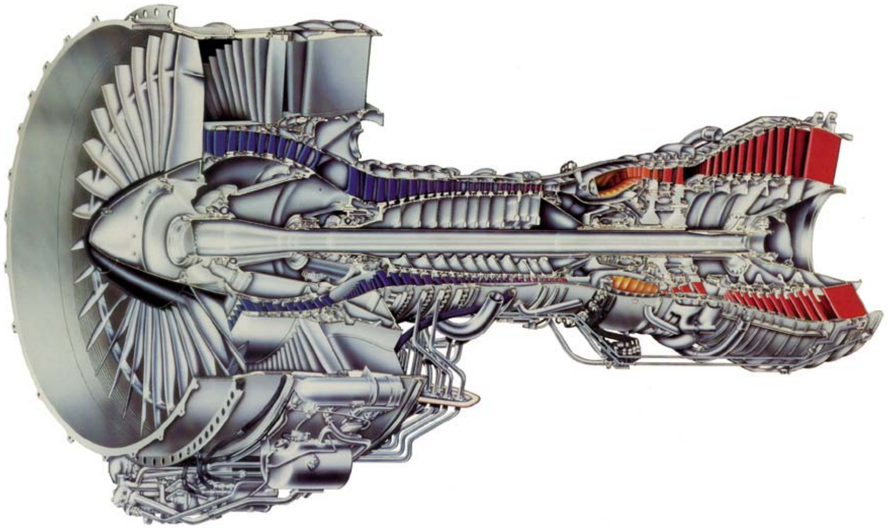
(a) Specific fuel consumption



(b) Thrust lapse with speed



Motore Turbofan basso BPR
Pratt&Whitney JT8-D

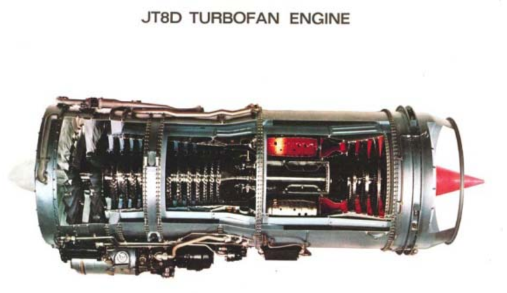


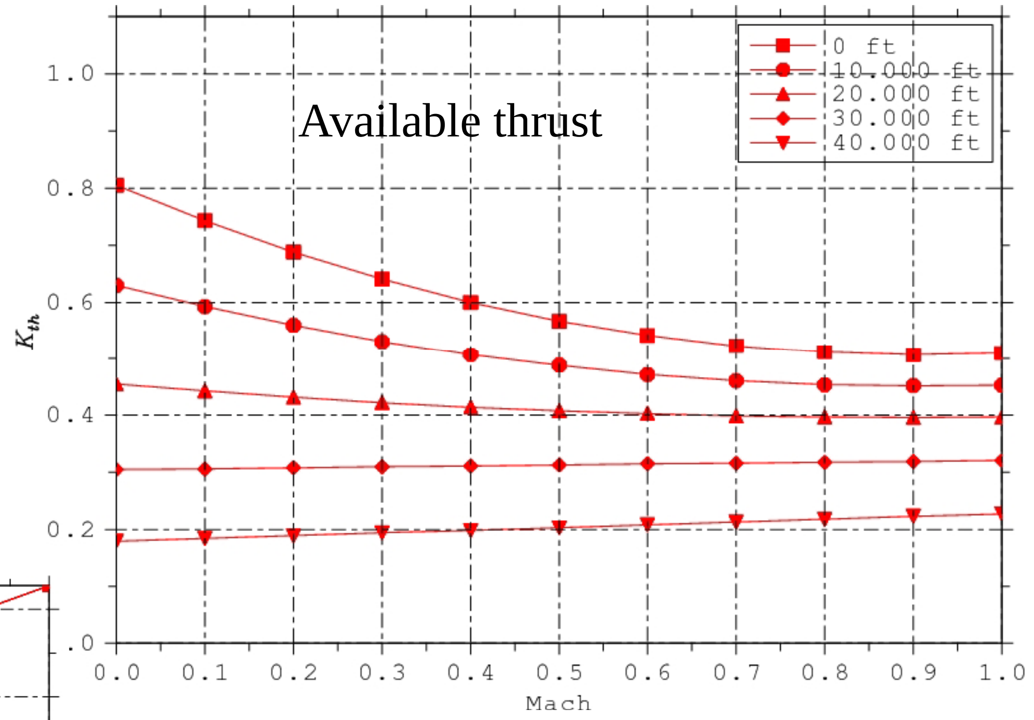
Motore Turbofan alto BPR
Pratt&Whitney PW2037

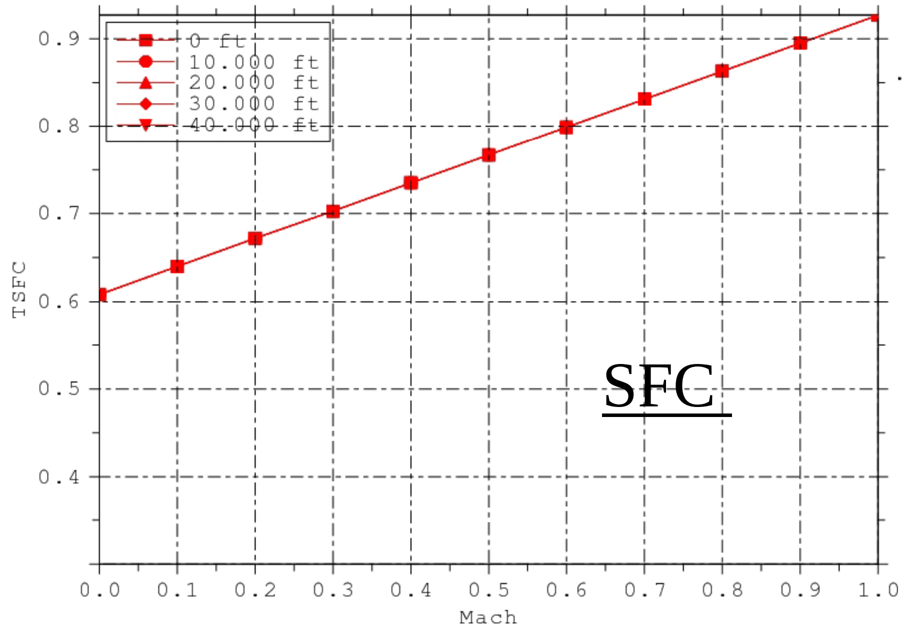
Modello Motore Turbofan basso BPR

Pratt&Whitney JT8-D

$$T = k_{Th}(h, M) \cdot T_o$$







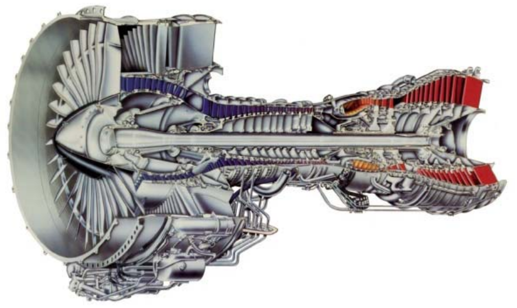
Cruise Setting

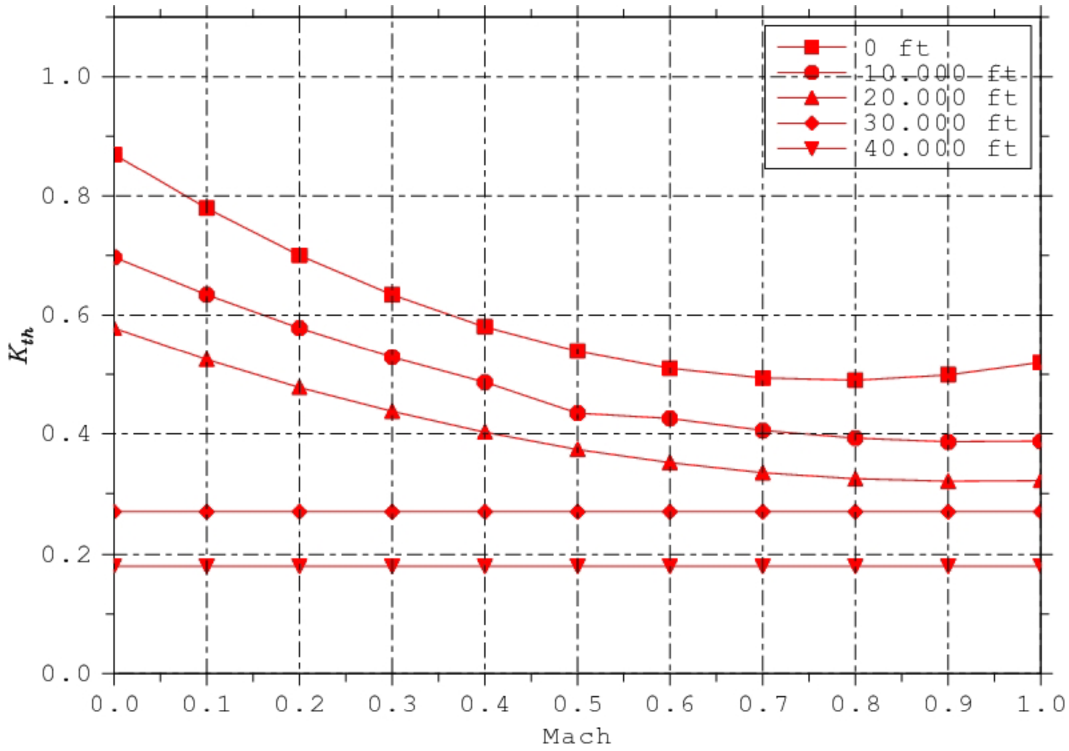
(Per l'assetto di salita moltiplicare per circa 1.10, salita massima continuativa)

Modello Motore Turbofan alto BPR

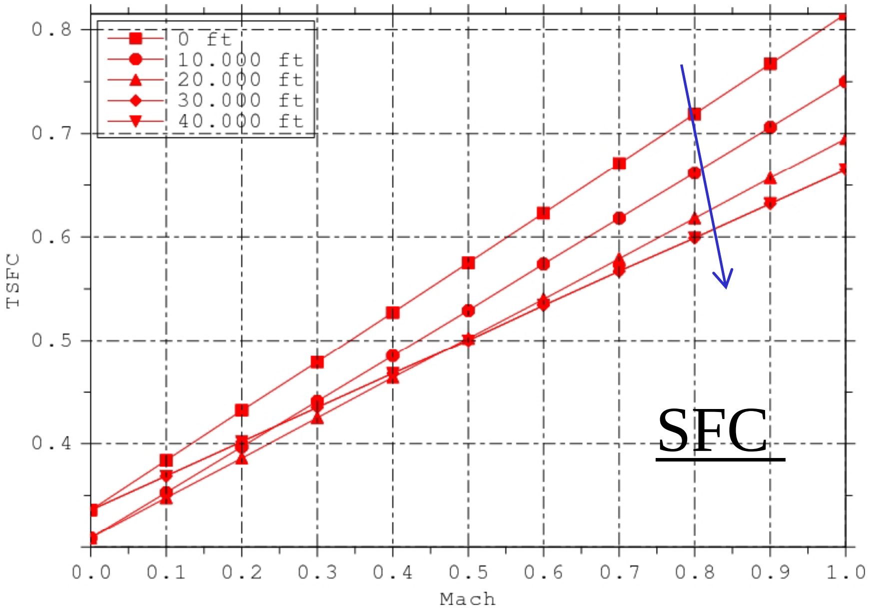
Pratt&Whitney PW2037

$$T = k_{Th}(h, M) \cdot T_o$$





La quota a M=0.80 ha effetto benefico sul SFC
Il motore è ottimizzato a 30000-33000 ft.



Cruise Setting

(Per l'assetto di salita moltiplicare per circa 1.10, salita massima continuativa)

Variazione Spinta con Vel e quota

Condizioni di decollo

$$\frac{T}{T_{V=0}} = 1 - 2.52 \times 10^{-3} V_\infty + 4.34 \times 10^{-6} V_\infty^2$$

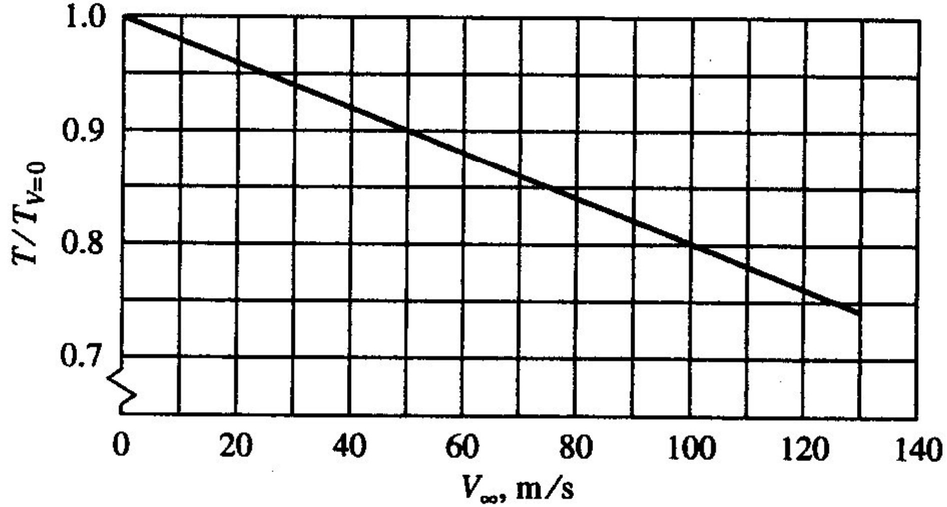


Diagramma tipico per un Tfan alto BPR (es. BPR=5)

Cap.6 – Caratteristiche propulsive Turbofan

Table 6.1 Weight and Performance Data for Turbojet and Turbofan Engines

Manuf./Type/ Config./B.P.R.	Weight (lbs)	Thrust at take–off s.l.s. (lbs)	s.f.c. at take–off s.l.s. (lbs/hr/lbs)	Massflow take–off s.l.s. (lbs/sec)	Alt./ M	Thrust at altitude/M (lbs)	s.f.c. at altitude/M (lbs/hr/lbs)
(1)/CF6–6D/ TBF/5.72	7,896	40,000	0.346	1,303	35K/ 0.8	7,160 (80% max)	0.616
(1)/CF6–32/ TBF/4.90	7,140	36,500	0.357	1,104	35K/ 0.8	6,630 (80% max)	0.609
(1)/CF6–50/ TBF/4.26	8,731	51,000	0.390	1,450	35K/ 0.8	8,720 (80% max)	0.628
(1)/CF6–80/ TBF/4.66	8,435	48,000	0.344	1,433	35K/ 0.8	8,260 (80% max)	0.592
(1)/CF34/ TBF/6.30	1,580	8,650	0.362	332	40K/ 0.8	1,420 (max)	0.728
(1)/CFM56–2/ TBF/6.00	4,610	24,000	???	817	35K/ 0.8	5,188 (max)	0.661
(1)/CJ610–5/ TBJ/1.00	402	2,950	0.980	44	36K/ 0.8	870 (max)	1.150
(1)/CF700/ TBF/1.93	725	4,200	0.660	126	36K/ 0.8	1,060 (max)	0.980
(1)/J79–17/ TBJ/0	3,873	17,820	1.980	170	35K/ 0.9	2,600 (max)	0.980
					35K/ 2.0	18,600 (max)	2.070
(1)/TF34–400/ TBF/6.2	1,478	9,275	0.363	338	36K/ 0.8	1,896 (intermediate)	0.682
(1)/F404–402/ TBF/0.27	2,282	17,700	???	146	???	???	???
(2)/CFE738/ TBF/5.3	1,325	5,725	0.372	210	40K/ 0.8	1,464 (max)	0.640
(3)/535E4/ TBF/4.3	7,264	42,000	???	1,150	35K/ 0.8	8,700 (max)	0.598
(3)/RB211/ TBF/4.3	9,814	60,600	???	1,604	35K/ 0.85	11,813 (max)	0.570
(3)/Trent800/ TBF/???	13,133	90,000	???	???	35K/ 0.83	13,000 (max)	0.557

Type: (1) = G.E.
(2) = G.E./Allied Signal
(3) = Rolls Royce

Manuf./Type/ Config./B.P.R. = Manufacturer/Type/ Configuration/By–pass Ratio

Cap.6 – Caratteristiche propulsive Turbofan

Table 6.2 Weight and Performance Data for Turbojet and Turbofan Engines

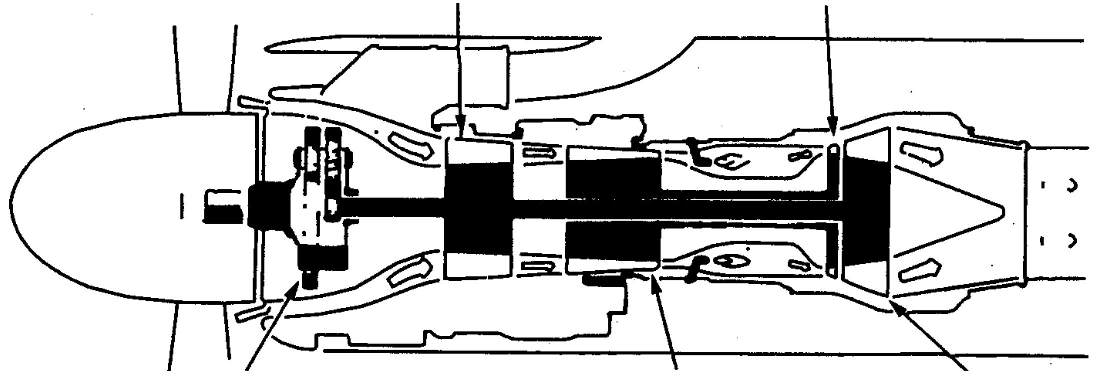
Manuf./Type/ Config./B.P.R.	Weight (lbs)	Thrust at take–off s.l.s. (lbs)	s.f.c. at take–off s.l.s. (lbs/hr/lbs)	Massflow take–off s.l.s. (lbs/sec)	Alt./ M	Thrust at altitude/M (lbs)	s.f.c. at altitude/M (lbs/hr/lbs)
(4)/TFE731–2/ TBF/2.66	743	3,500	???	113	40K/ 0.8	755 (max)	0.815
(4)/TFE731–5/ TBF/3.48	890	4,600	???	143	40K/ 0.8	1,000 (max)	0.760
(4)/ALF502L/ TBF/5.0	1,311	7,500	0.428	???	???	???	???
(5)/JT8D–219/ TBF/1.77	4,612	21,000	???	488	35K/ 0.8	5,250 (max)	0.737
(5)/PW4000/ TBF/4.85	9,400	56,000	???	1,705	35K/ 0.8	???	0.537
(5)/PW2000/ TBF/6.00	7,300	38,250	???	1,340	35K/ 0.8	???	0.563
(5)/PW300/ TBF/4.3	993	4,679	0.388	???	40K/ 0.8	1,155 (max)	0.681
(6)/CFM56–2A2/ TBF/6.0	4,820	24,000	???	817	35K/ 0.8	5,188 (max)	0.661
(7)/IAEV2500/ TBF/4.6	5,224	30,000	???	848	35K/ 0.8	5,752 (max)	0.575
(8)/Larzac 04/ TBF/1.13	639	2,966	0.710	63	35K/ 0.8	772 (max)	???
(9)/FJ44/ TBF/3.28	447	1,900	0.475	???	36K/ 0.7	506 (max. cont.)	0.758
(10)/Adour 871/ TBF/0.80	1,330	5,900	0.740	???	39K/ 0.8	???	0.955

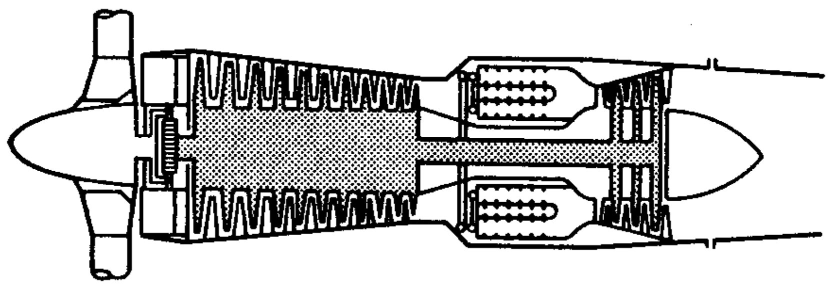
Type: (4) = Allied Signal
(5) = Pratt & Whitney
(6) = CFM International (G.E./SNECMA)
(7) = International Aero Engines
(8) = Turbomeca
(9) = Williams/Rolls Royce
(10) = Rolls Royce/Turbomeca

Manuf./Type/Config./B.P.R. = Manufacturer/Type/Configuration/By–pass Ratio

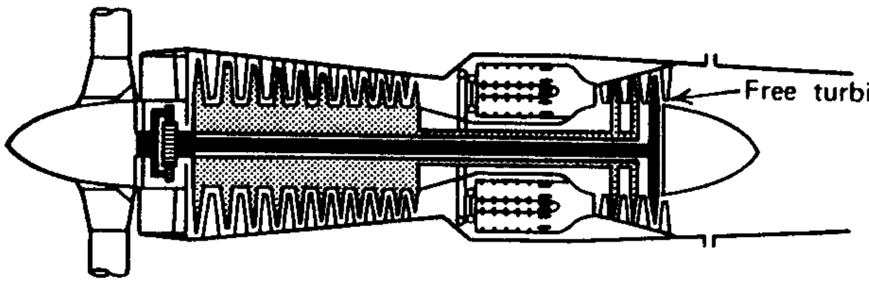
Cap.6 – Caratteristiche propulsive

Turboelica





(d)



(e)

Cap.6 – Caratteristiche propulsive

Turboelica

$$\Pi_d = (T_p + T_j)V_\infty$$

$$\Pi_d = \eta_p \Pi_a + T_j V_\infty$$

Equivalent Shaft Horsepower (Pot all’albero equivalente)

$$\Pi_d = \eta_p \Pi_{ea}$$

$$\eta_p \Pi_{ea} = \eta_p \Pi_a + T_j V_\infty$$

$$\Pi_{ea} = \Pi_a + \frac{T_j V_\infty}{\eta_p}$$

In ultimo forniamo una utile regola basata sull’esperienza pratica: in condizioni statiche (motore che opera con l’aeroplano a velocità nulla al suolo) una turboelica produce circa 2.5 lb di spinta per cavallo vapore all’albero. Questa osservazione va utilizzata se dobbiamo considerare la spinta di un motore turboelica in decollo.

EFFETTO RAM !!

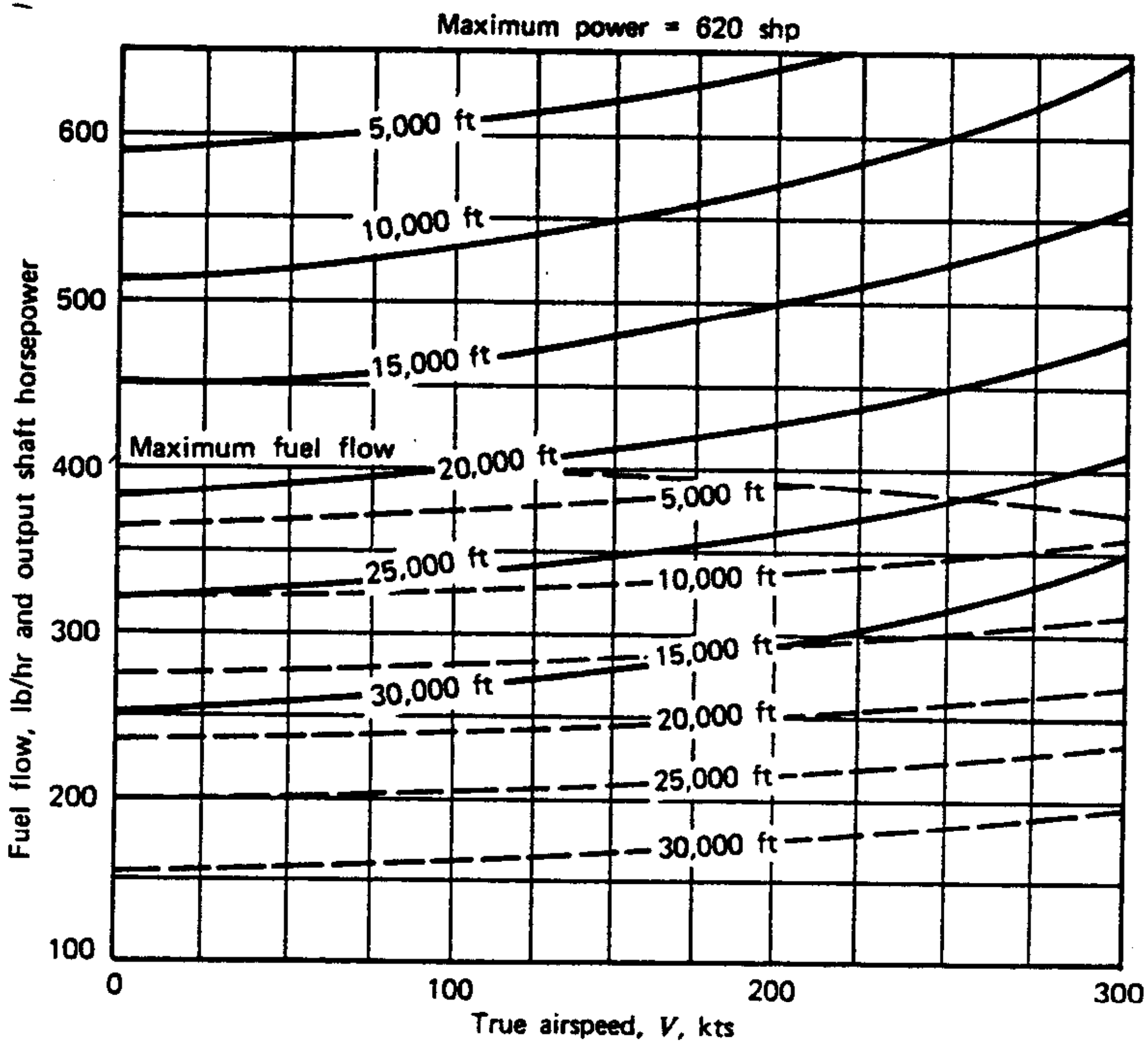
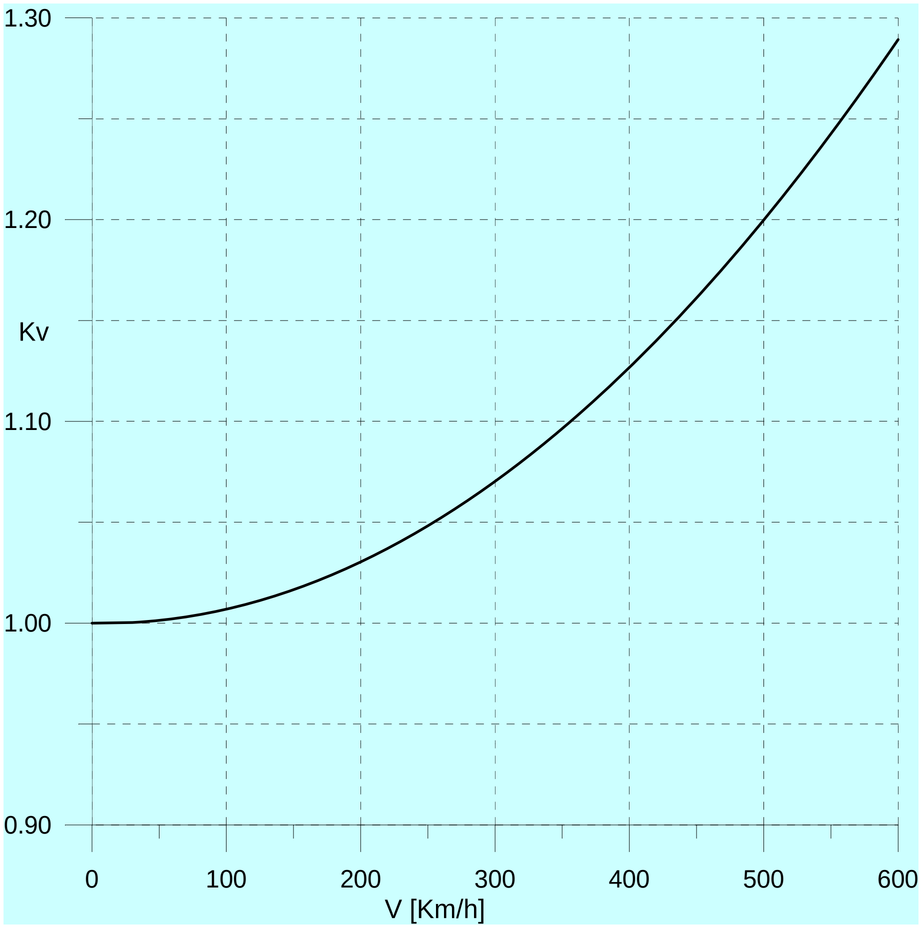


Figure 6.46a PT6A-27 maximum cruise performance. Prop speed—2200 rpm. (Courtesy, Pratt & Whitney of Canada.)

EFFETTO RAM !!

$$\mathbf{Kv = 1.00 - 0.0014 * (V/100) + 0.00827 * (V/100)^2}$$

con V espressa in Km/h



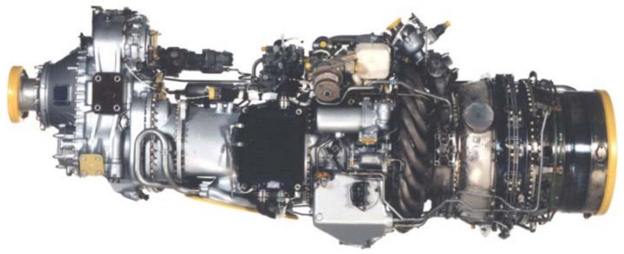
EFFETTO Quota

$$\frac{\Pi_a}{\Pi_{a,0}} = \left(\frac{\rho}{\rho_0}\right)^n \qquad n = 0.7$$

O anche …
$$\frac{\Pi_a}{\Pi_{ao}} = \left(\frac{\rho}{\rho_0}\right) = \sigma$$

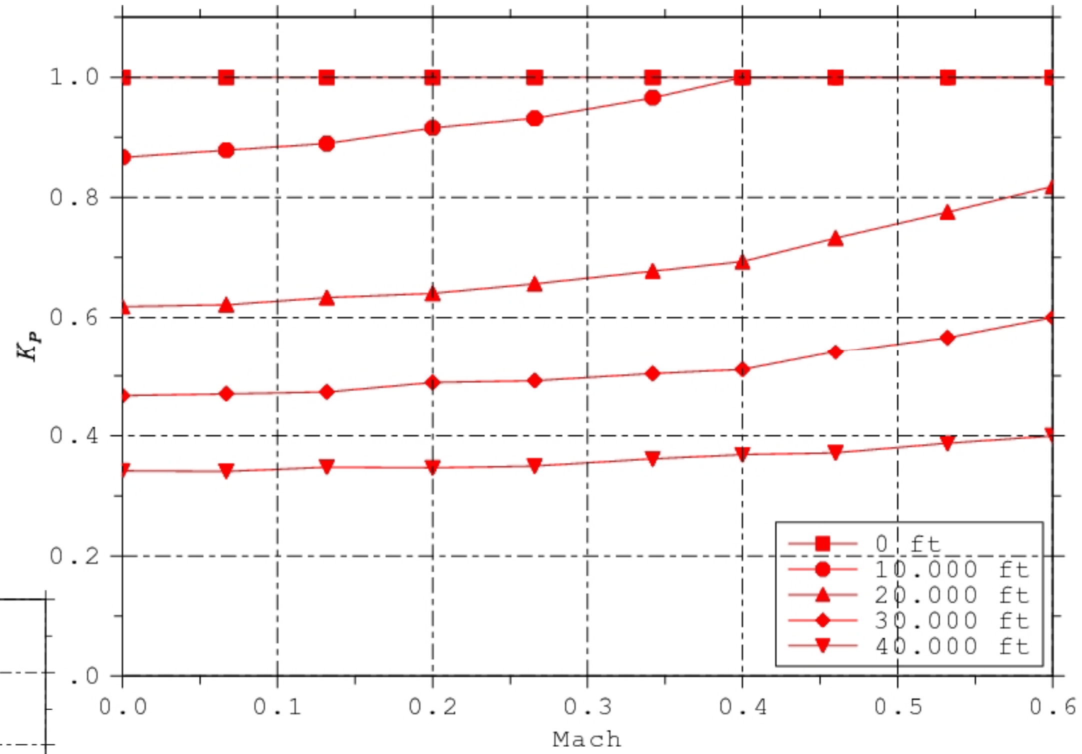
$$\boxed{\Pi_a = \Pi_{ao} \cdot \varphi \cdot \sigma \cdot Kv}$$

MODELLO Turboelica

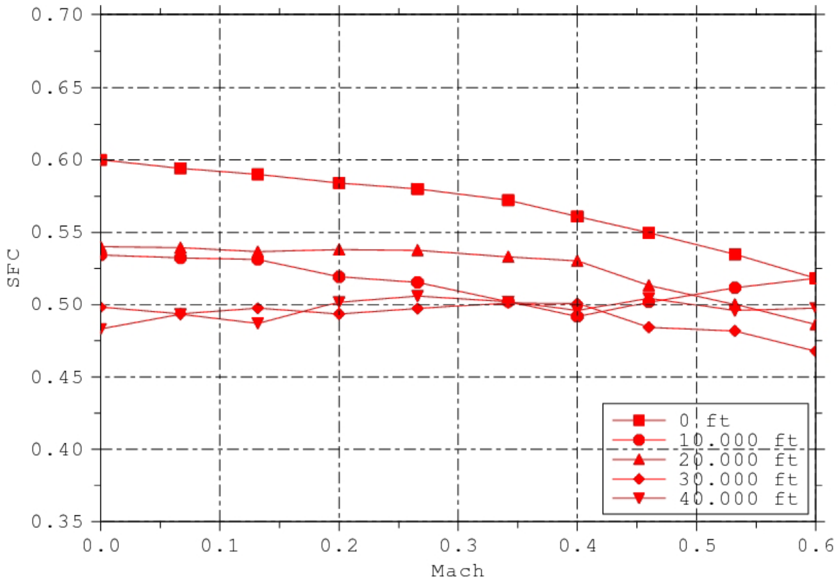


PW 123

$$P = k_P\left(h, M\right)\cdot P_0$$



Si nota l'effetto Mach (effetto RAM)
e l'effetto della quota.



SFCp (lb/(hp h)

SFC poco variabile con Mach

Turboelica

Consumo specifico

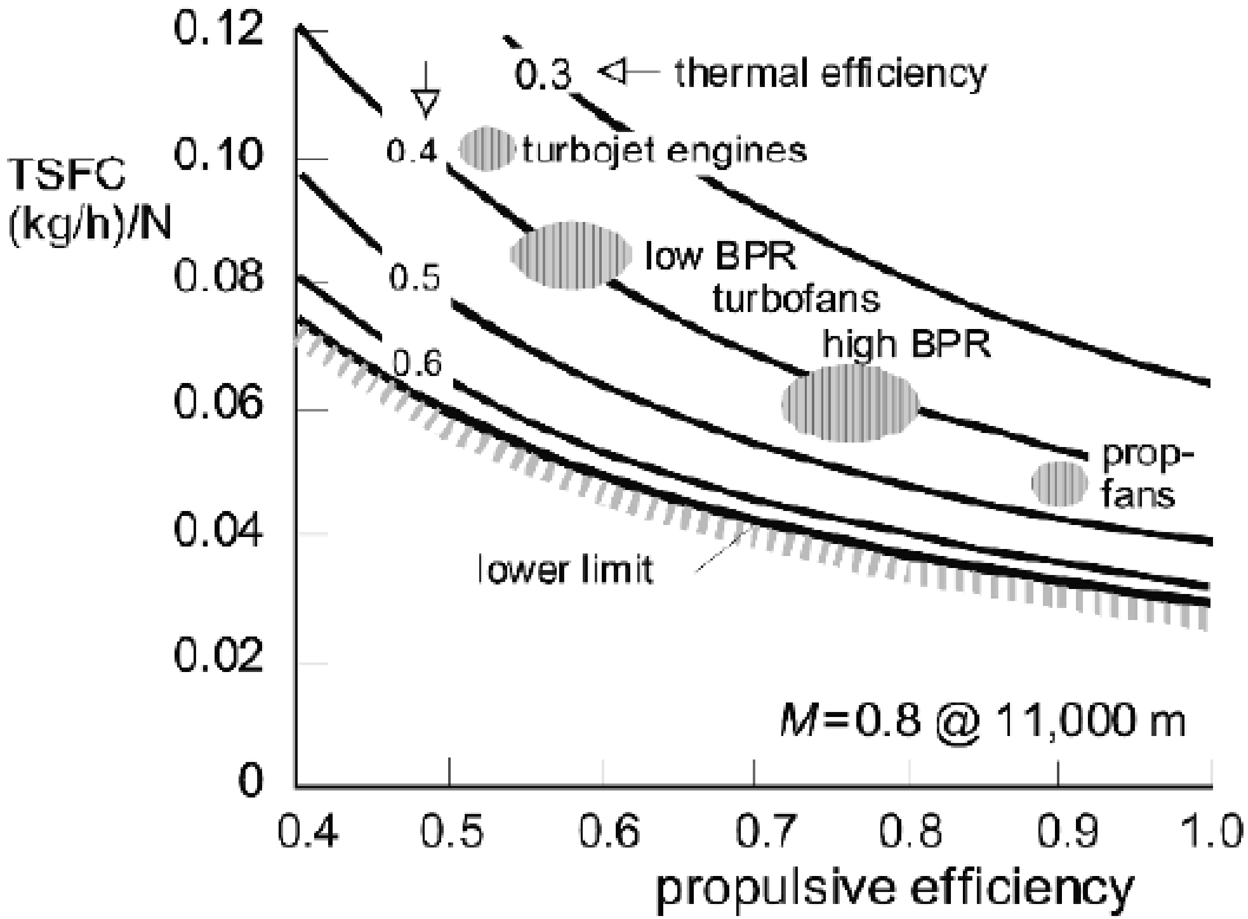
SFC=0.6-0.7 $\frac{\text{lb}}{\text{hp} \cdot \text{h}}$

Table 6.3 Weight and Performance Data for Turboprop Engines

Manufacturer/ Type	Weight (lbs)	ESHP/SHP/Prop RPM at maximum take–off setting, s.l.s.* (hp)	s.f.c. at take–off s.l.s. (lbs/hr/eshp)	ESHP/SHP/Prop RPM at maximum cruise setting, s.l.s.* (hp)	Massflow take–off s.l.s. (lbs/sec)
(1)/PT6A–11	328	528/500/2,200	0.647	528/500/2,200	???
(1)/PT6A–27	328	715/680/2,200	0.602	715/680/2,200	6.8
(1)/PT6A–34	331	783/750/2,200	0.595	783/750/2,200	???
(1)/PT6A–65B	481	1,174/1,100/1,700	0.536	1,174/1,100/1,700	9.5
(1)/PW118	861	1,892/1,800/1,300	0.498	1,593/1,513/1,300	???
(1)/PW123B	992	2,626/2,500/1,200	0.463	2,136/2,030/1,200	???
(1)/PW115	841	1,580/1,500/1,300	0.544	1,580/1,500/1,300	???
(2)/TPE331–1	336	705/665/???	0.605	690/650/???	6.2
(2)/TPE331–10	380	???/1,000/???	0.560	???	???
(3)/CT7–5	676	1,685/1,630/???	0.466	1,465/1,417/???	???
(3)/CT64–820–4	1,145	3,133/3,133/1,160	0.486	2,745/2,745/1,015	???
(4)/Dart RDa7 Mk535–2/TS1637	1,369	????/2,080/????	0.760	????/1,835/????	23.5
(5)/250–B17C	195	420/420/????	0.657	369/369/????	3.45
(5)/250–C30	240	650/650/????	0.592	557/557/????	5.6
(5)/T56–A–15	1,825	4,910/4,591/1,106	0.501	4,365/4,061/1,106	32.4

Type: (1) = Pratt & Whitney, Canada; (2) = Allied Signal; (3) = General Electric; (4) = Rolls Royce; (5) = Allison

* In calculating ESHP from SHP it is usually assumed, that 2.5 lbs of axial jet thrust is equivalent to 1 hp.


0.12
0.10
0.08
0.06
0.04
0.02
0
TSFC
(kg/h)/N
0.3
thermal efficiency
0.4
turbojet engines
low BPR
turbofans
0.5
high BPR
0.6
prop-
fans
lower limit
M=0.8 @ 11,000 m
0.4
0.5
0.6
0.7
0.8
0.9
1.0
propulsive efficiency