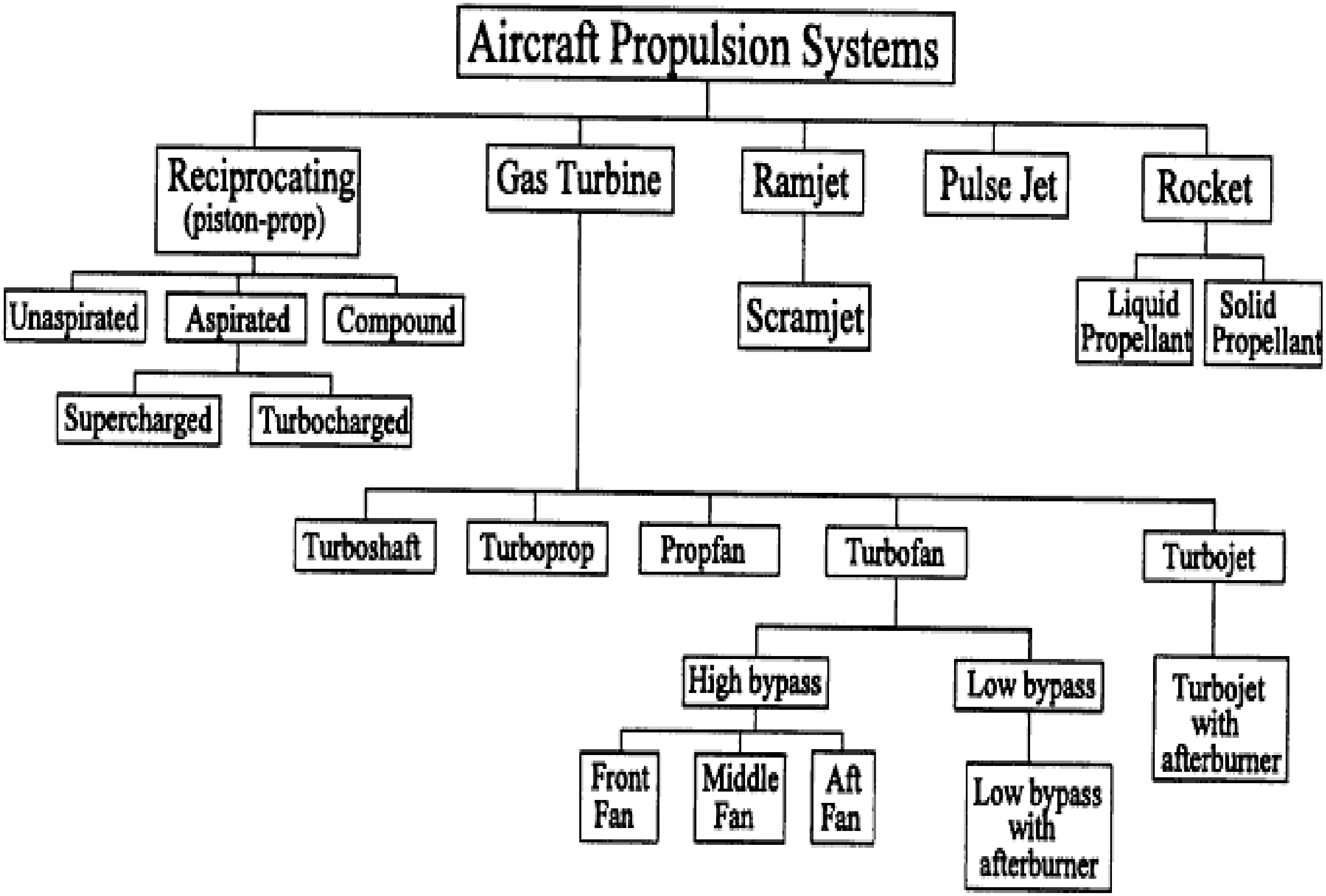
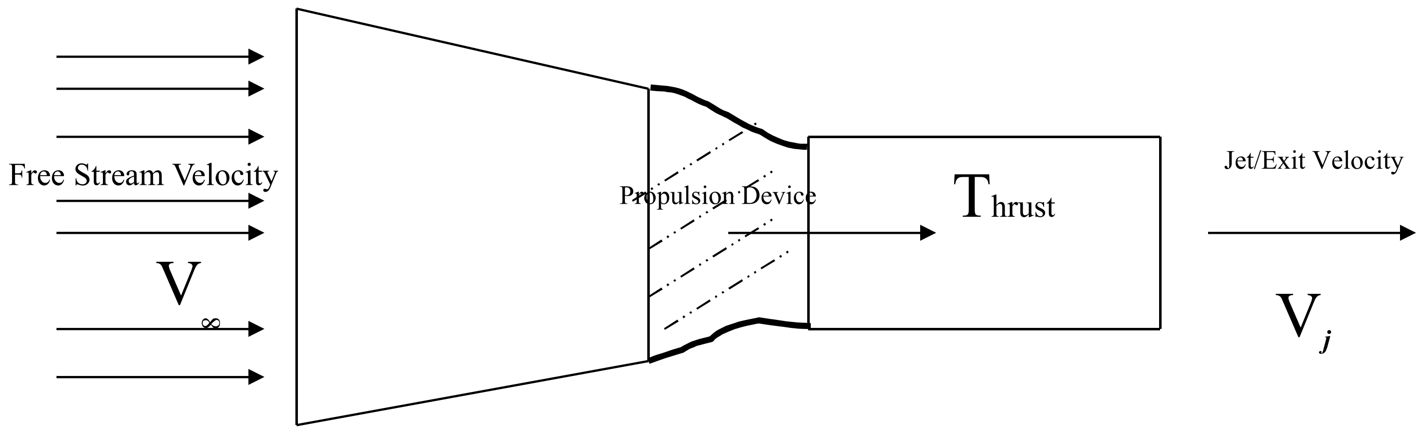


Fig. 2.1 Aircraft engine tree.

Thrust Propulsion

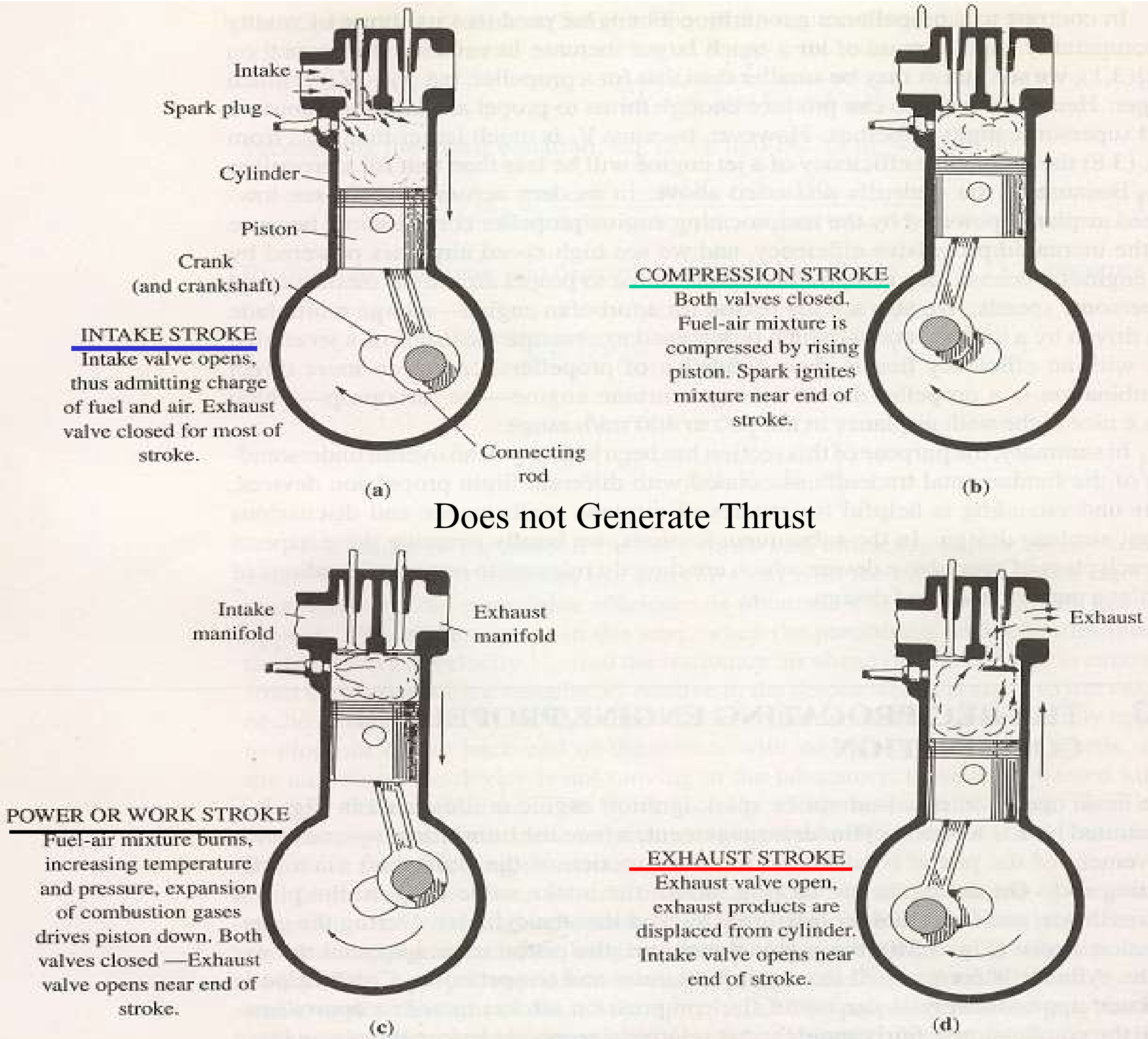


$\dot{m}$= mass flow rate

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

$P_{ower} = T_{hrust} \times V_{elocity}$

Propulsive Efficiency $n_p = \dfrac{2}{1+ V_j/V_\infty}$



Does not Generate Thrust

Figure 3.3 Diagram of the four-stroke Otto cycle for internal combustion spark-ignition engines. (*After Edward F. Obert, Internal Combustion Engines and Air Pollution, Intext, 1973.*)

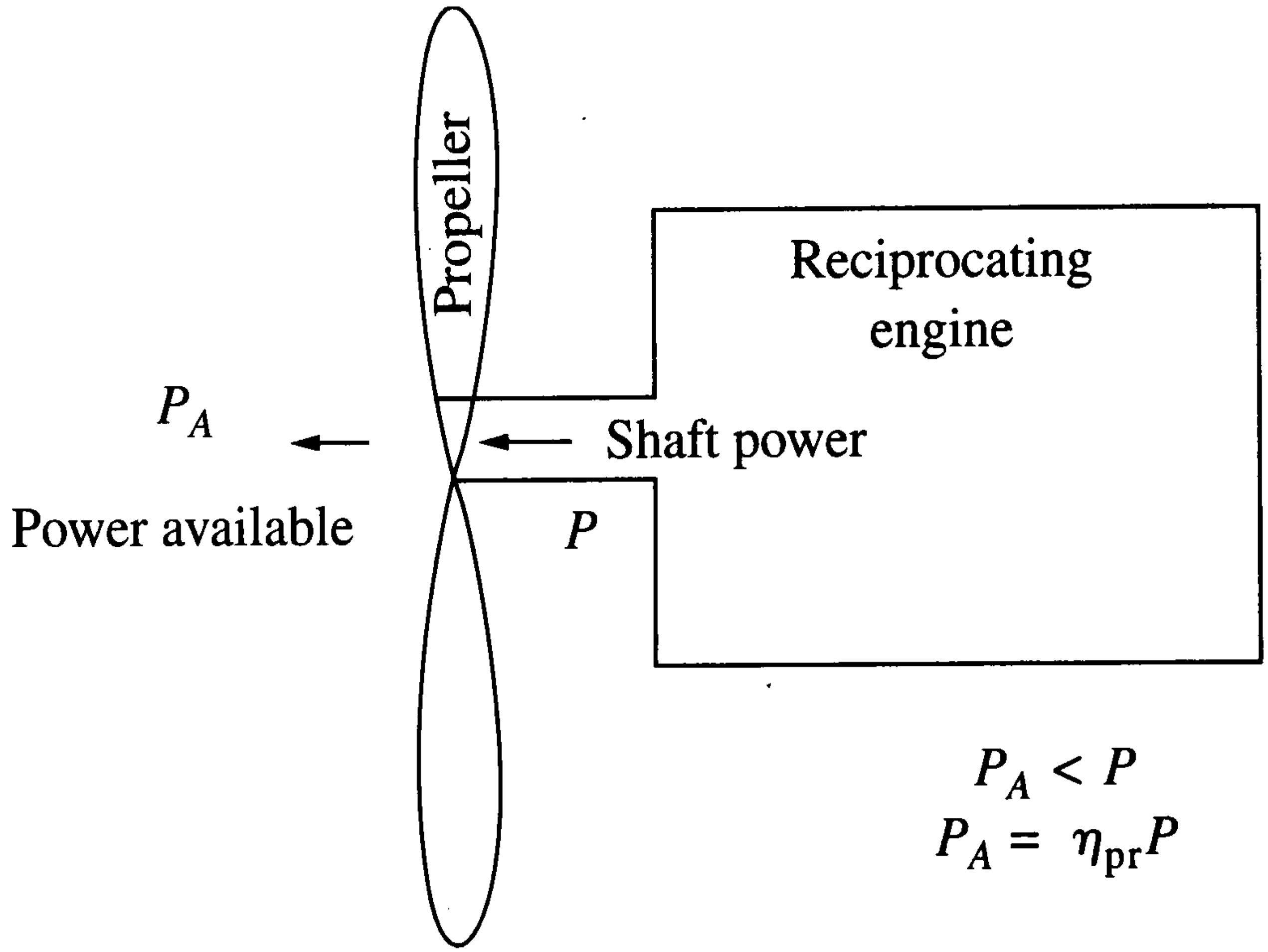


Figure 3.5 Schematic illustrating shaft power P and power available P_A from a propeller/reciprocating engine combustion.

Advance Ratio; $J = \frac{V}{N\,D}$

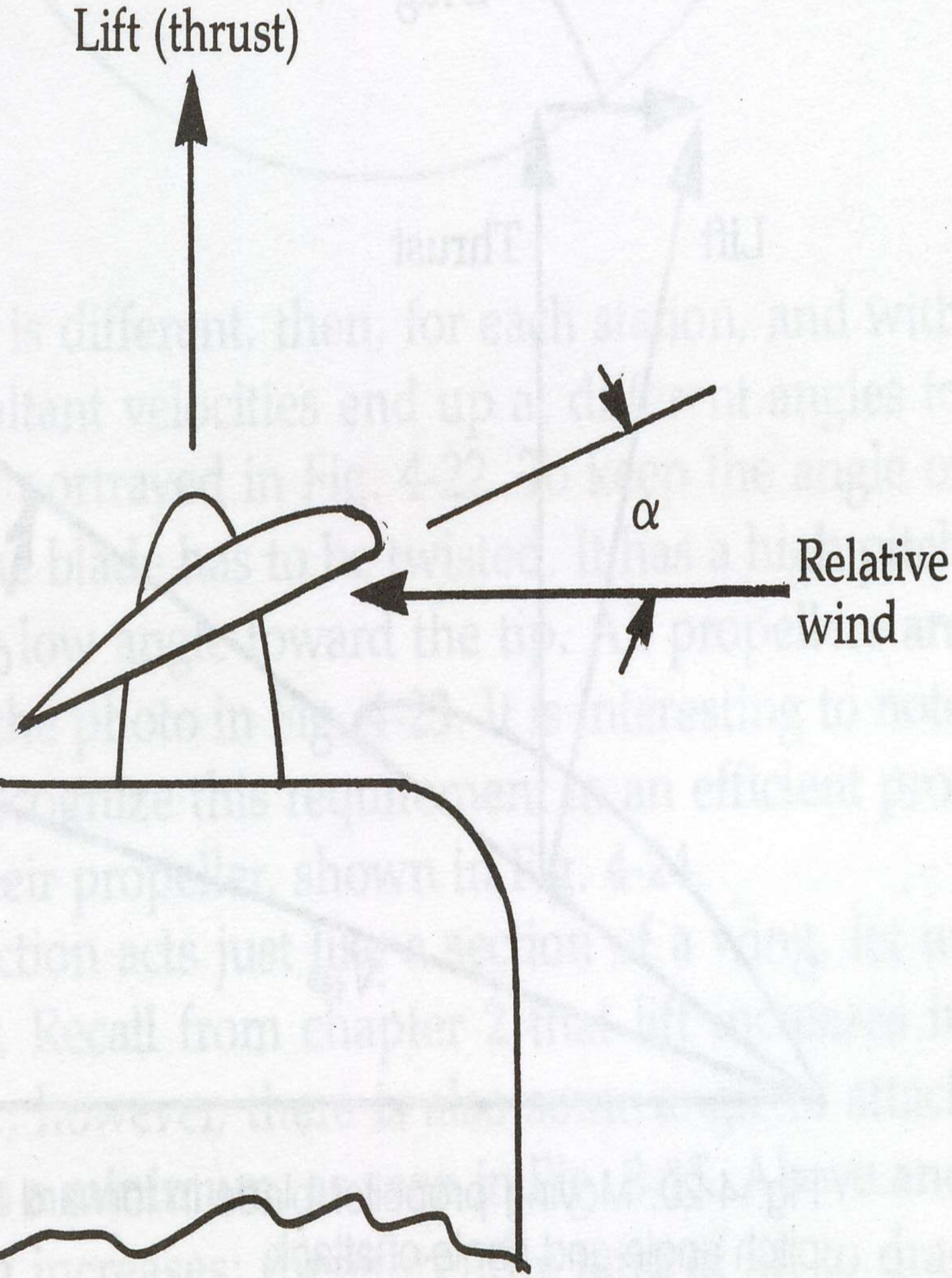


Fig. 4-18. Diagram of a propeller blade creating thrust (similar to lift on a wing) with airplane not moving.

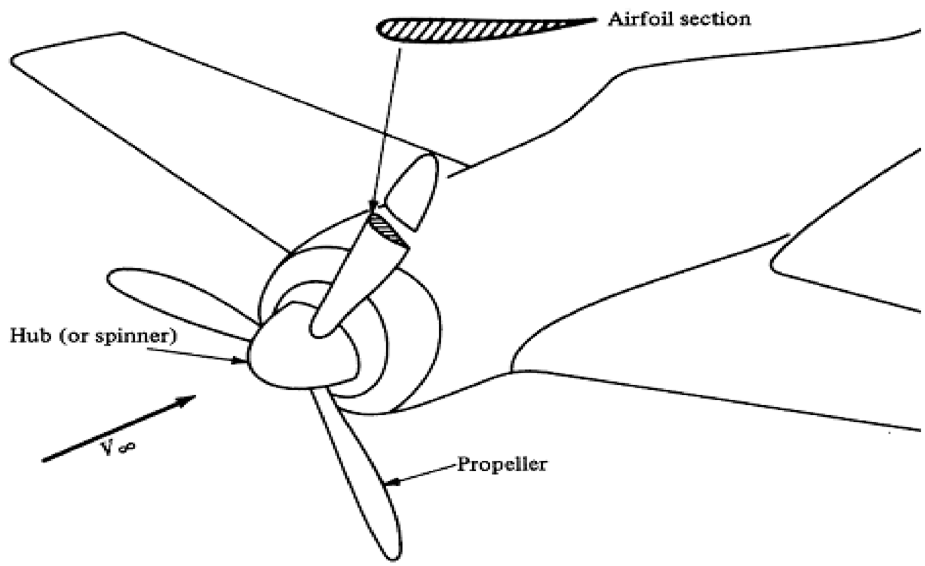


Figure 9.2 The airplane propeller, emphasizing that a propeller cross section is an airfoil shape.

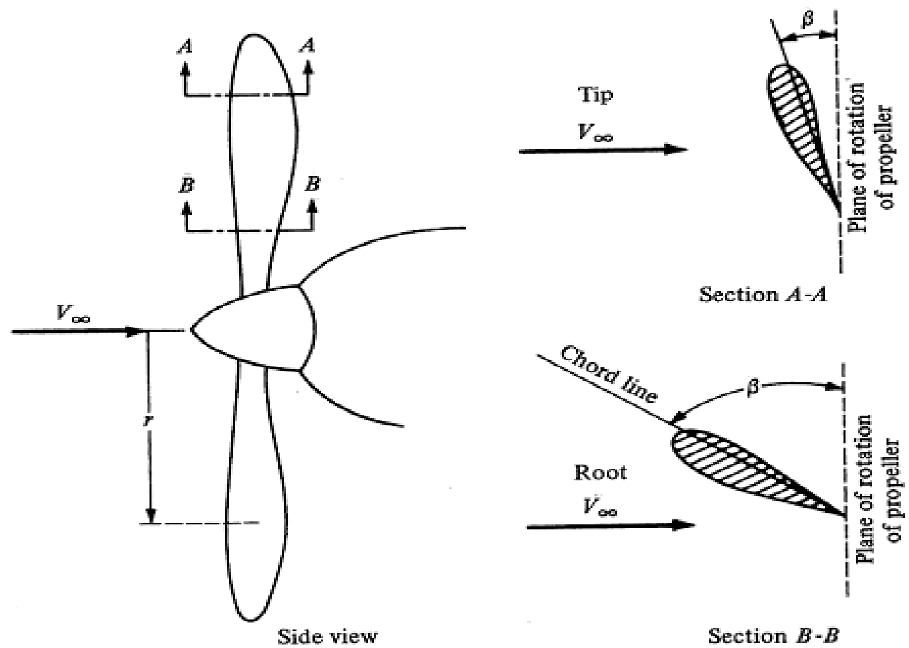


Figure 9.3 Illustration of propeller, showing variation of pitch along the blade.

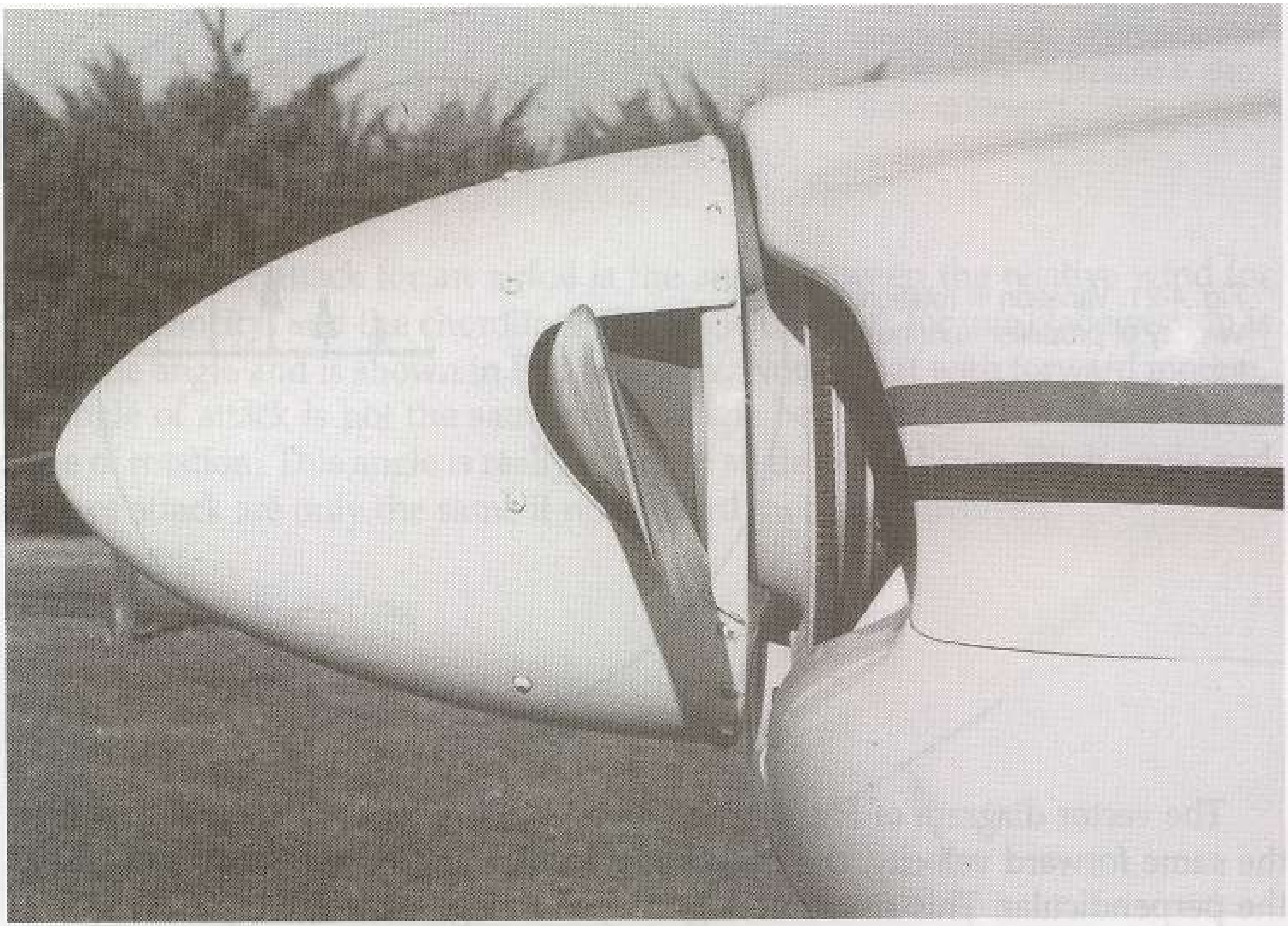


Fig. 4-23. Twist built into propeller blade to maintain the same angle of attack at each radius location.

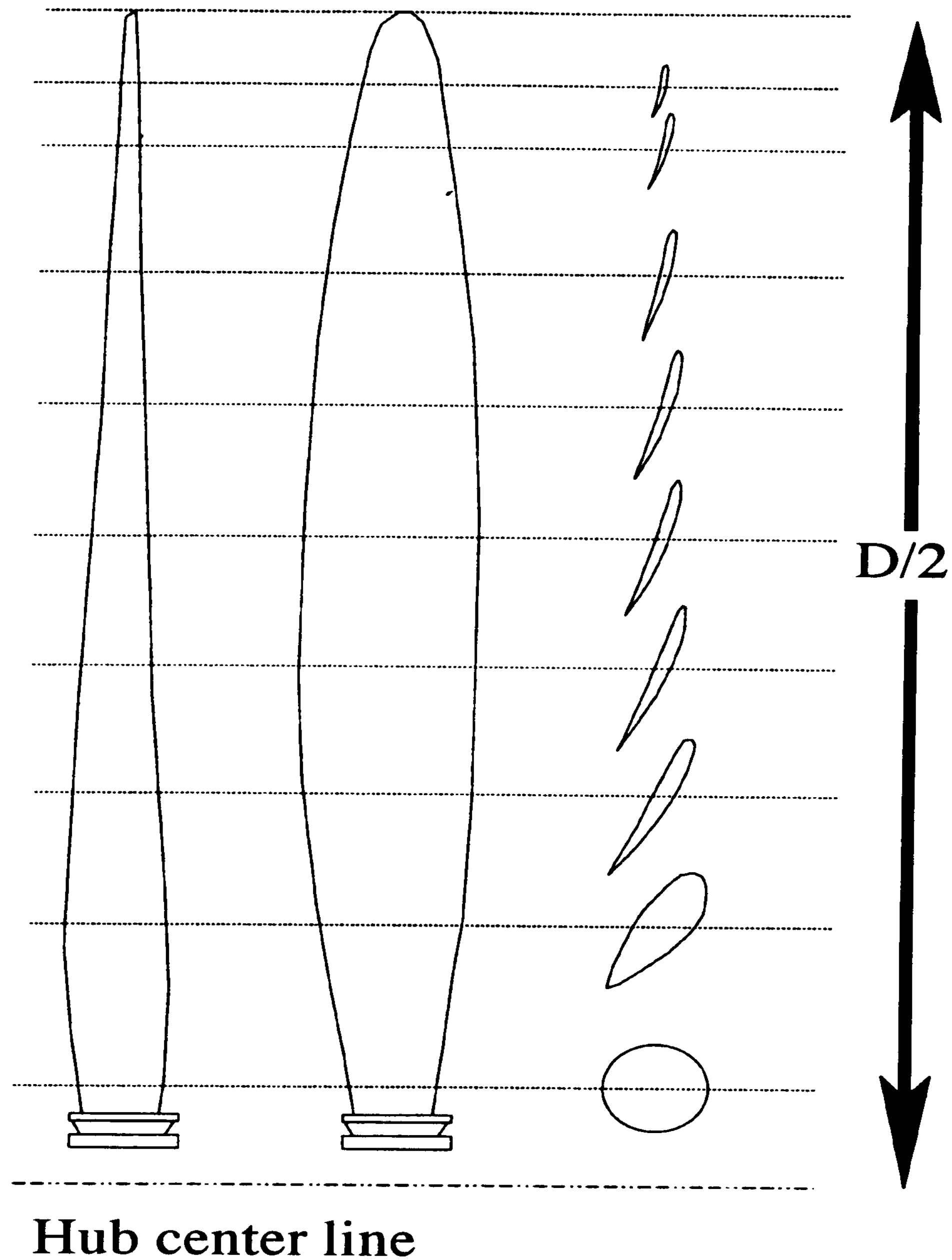


Fig. 2.2 Typical propeller blade.

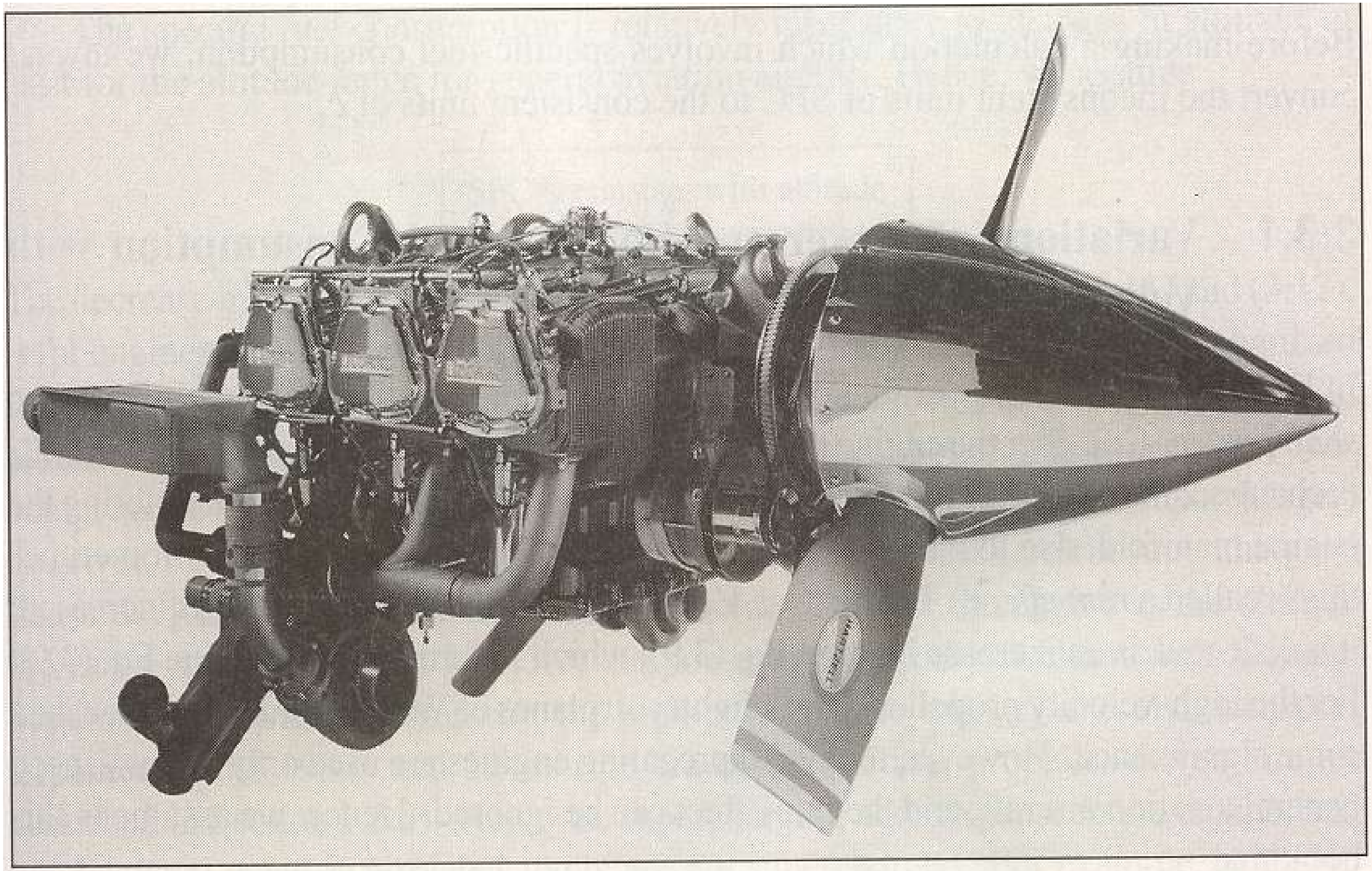


Figure 3.4 Textron Lycoming T10 540-AE2A turbocharged piston engine.

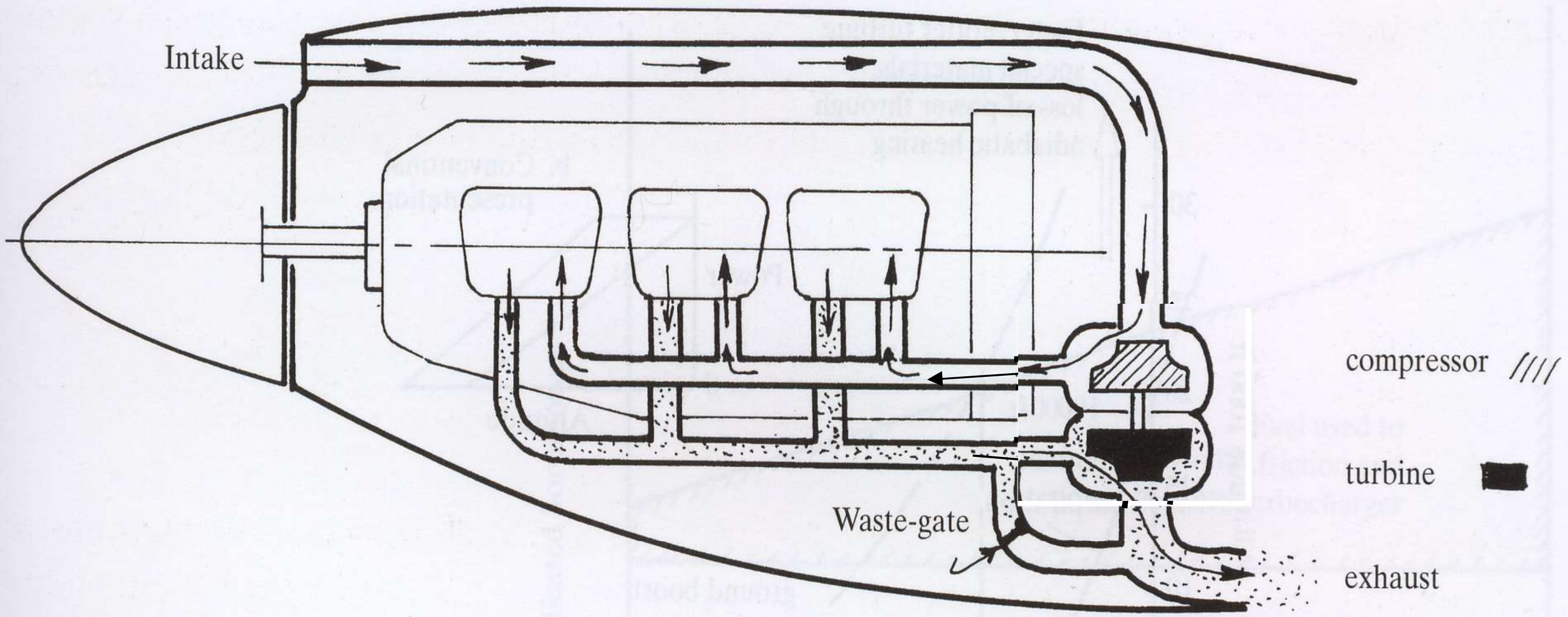


Fig. 7.13 The turbo-supercharger. With the waste-gate closed, exhaust gases drive the turbine and the compressor – which turbocharges air from the intake to the induction system. If the waste-gate is opened, exhaust gases by-pass the turbine and there is no supercharging.

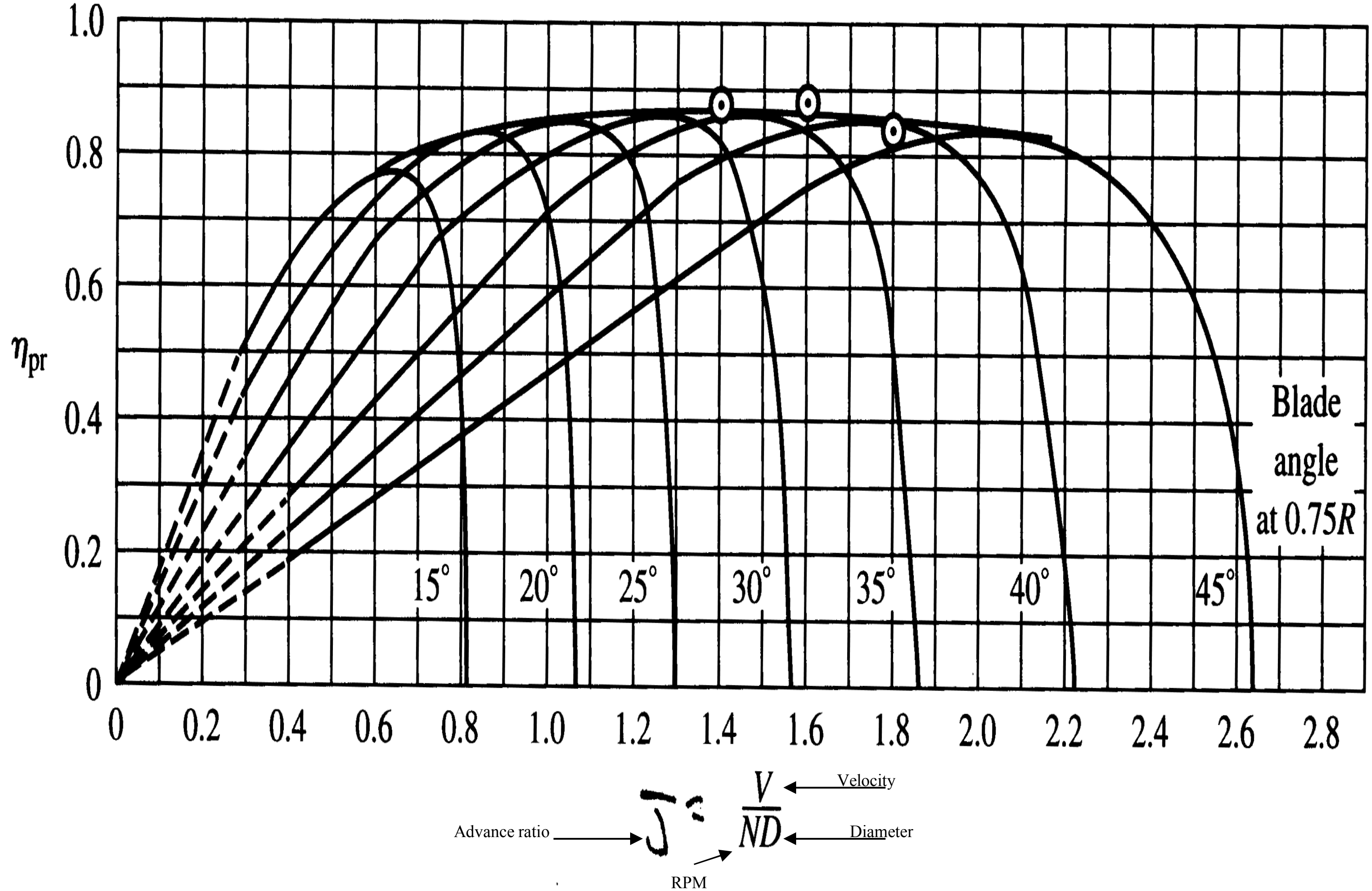


Figure 3.7 Propeller efficiency as a function of advance ratio for various pitch angles. Three-bladed propeller with Clark Y sections. (*After McCormick, Ref. 50.*)

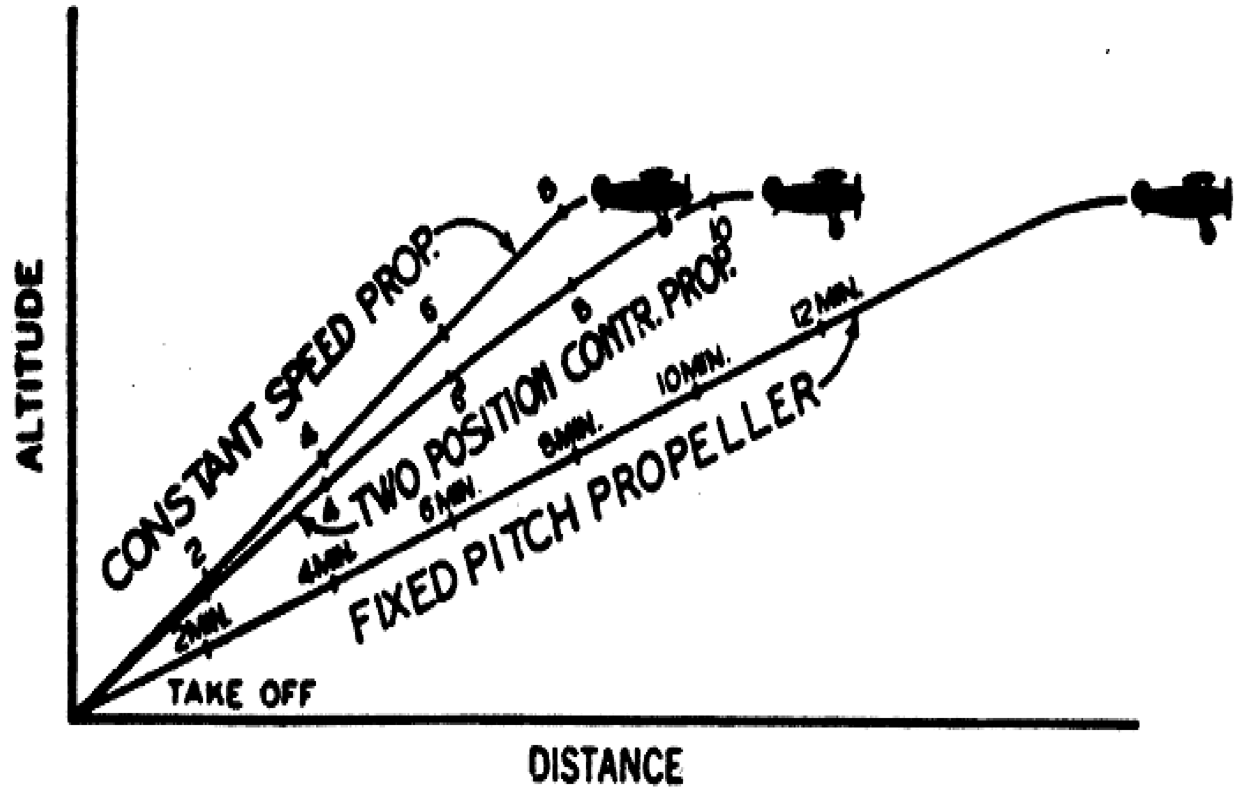


Figure 3.9 Comparison of airplane climb performance for three types of propellers: fixed-pitch, two-position (controllable), and constant-speed. Historic diagram by Carter (Ref. 38).

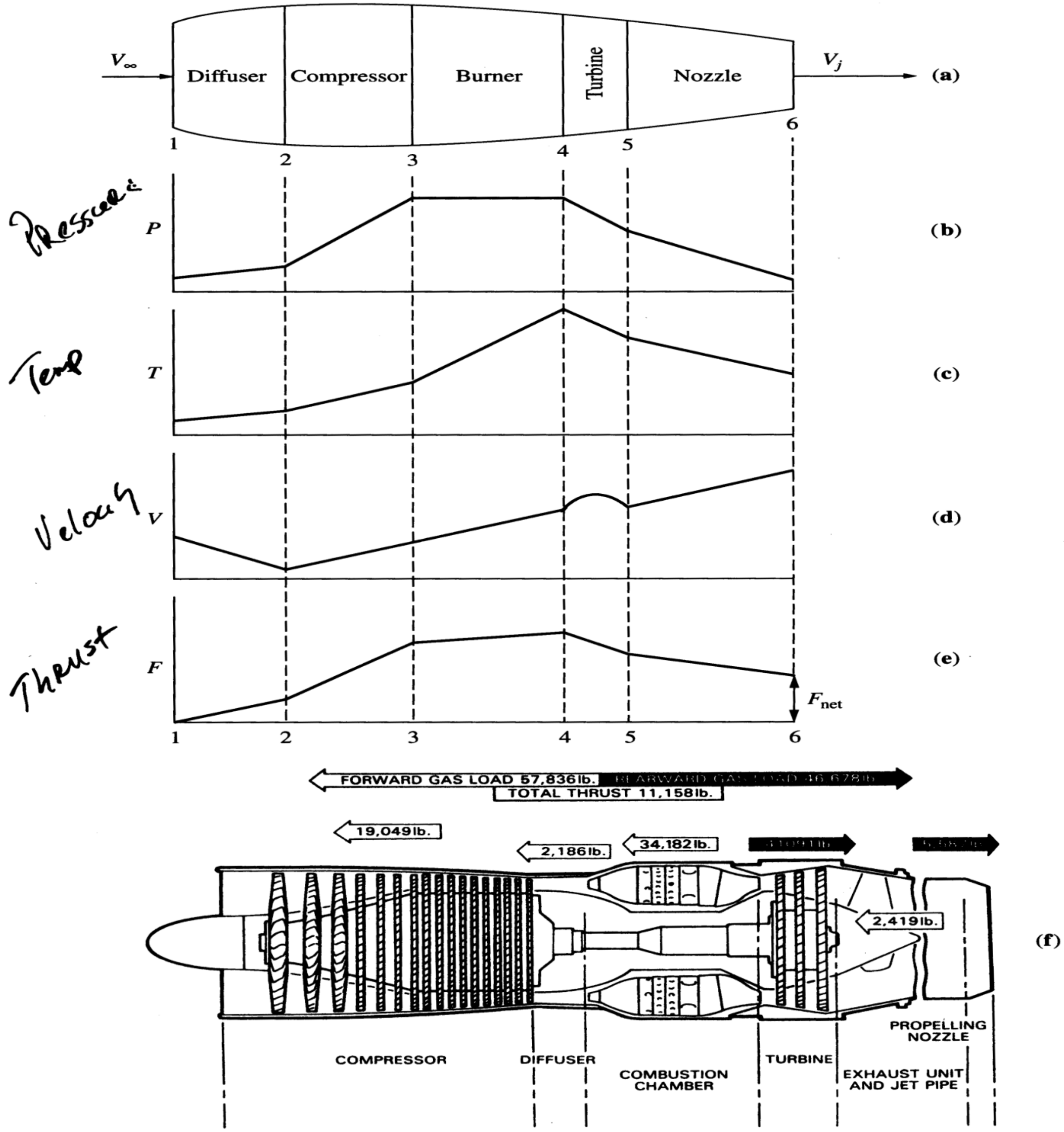
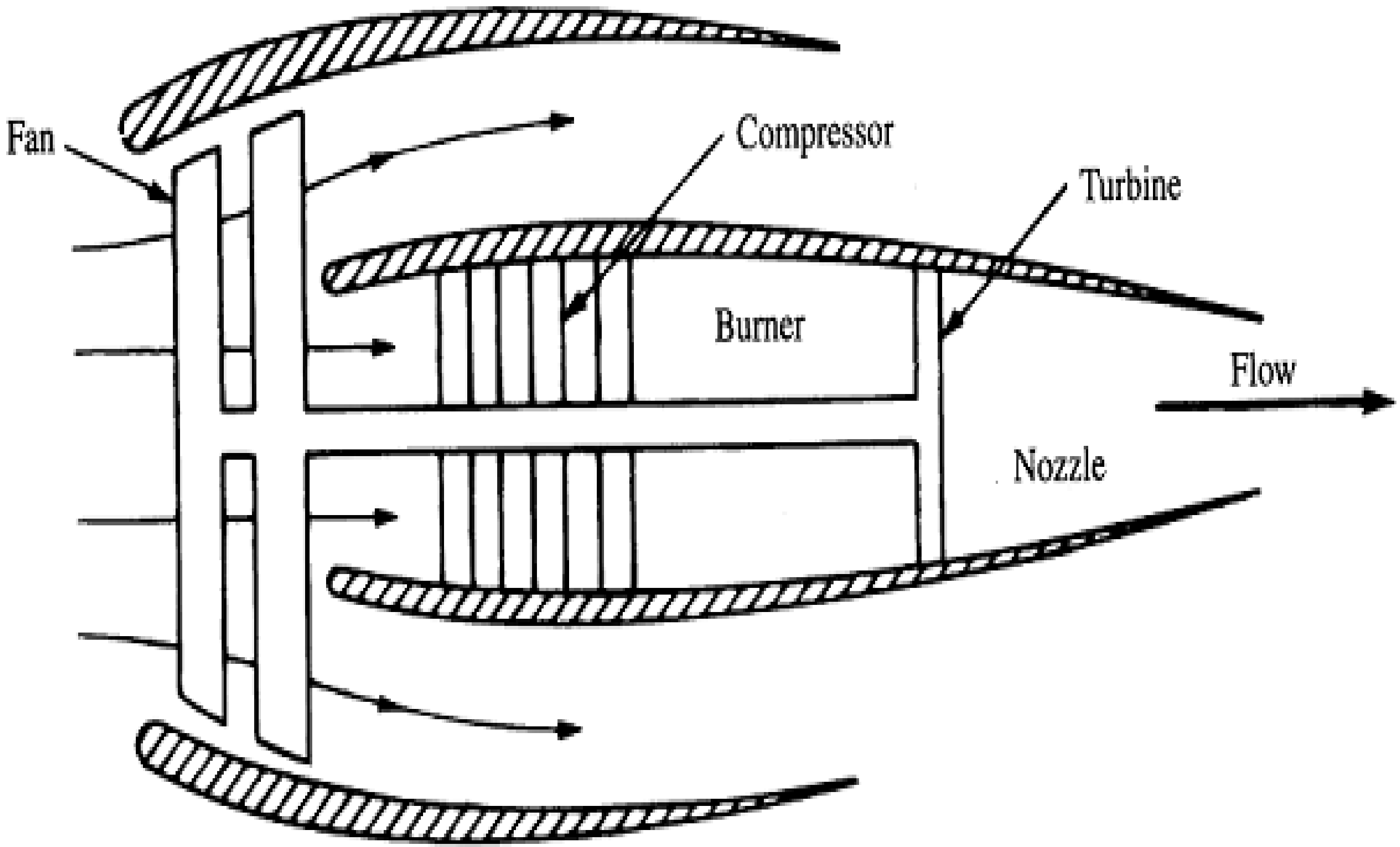


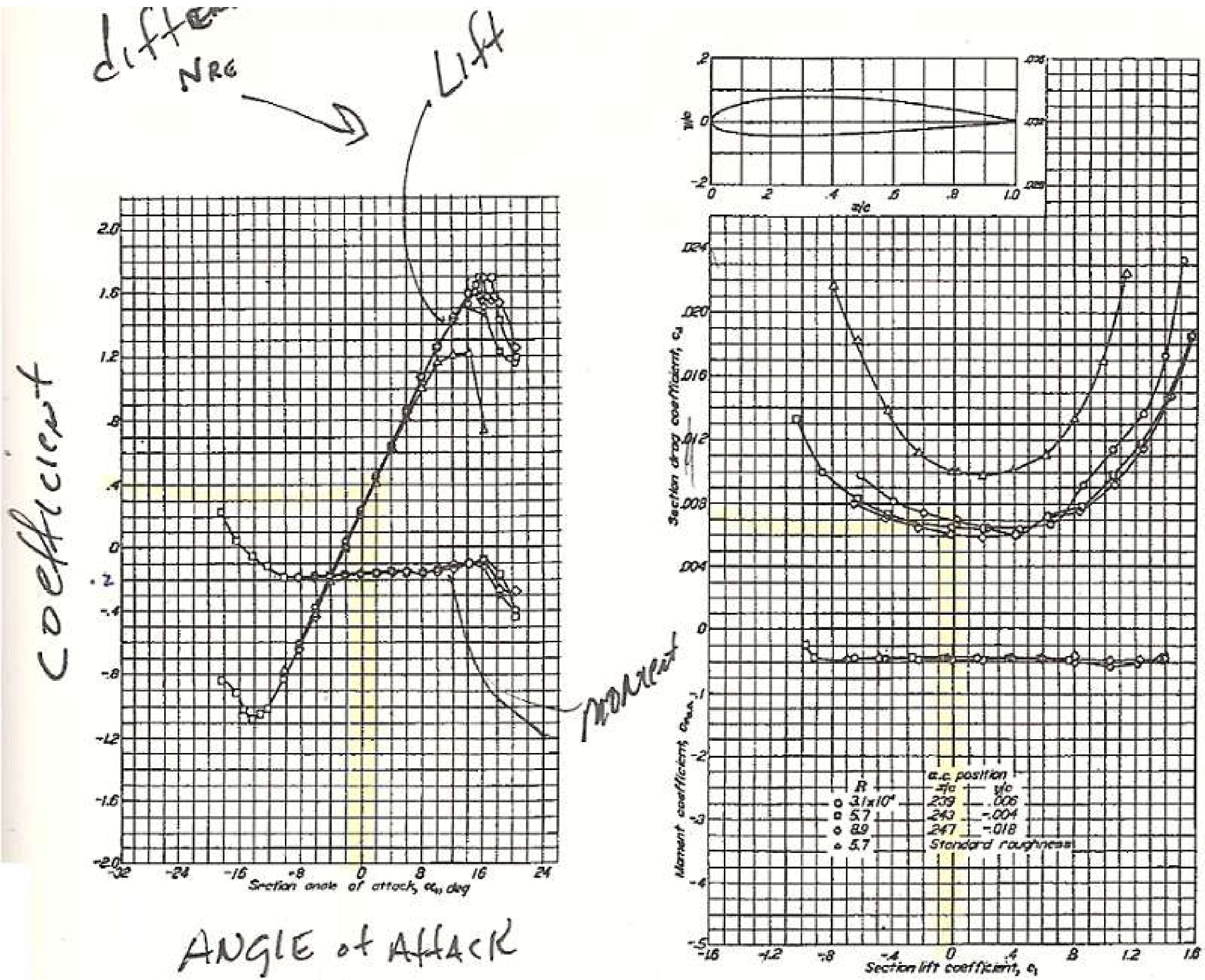
Figure 3.10 Distribution of **(a)** components, **(b)** pressure, **(c)** temperature, **(d)** velocity, and **(e)** local thrust; **(f)** integrated thrust through a generic turbojet engine.


Fan
Compressor
Turbine
Burner
Flow
Nozzle


BOEING
BOEING
707

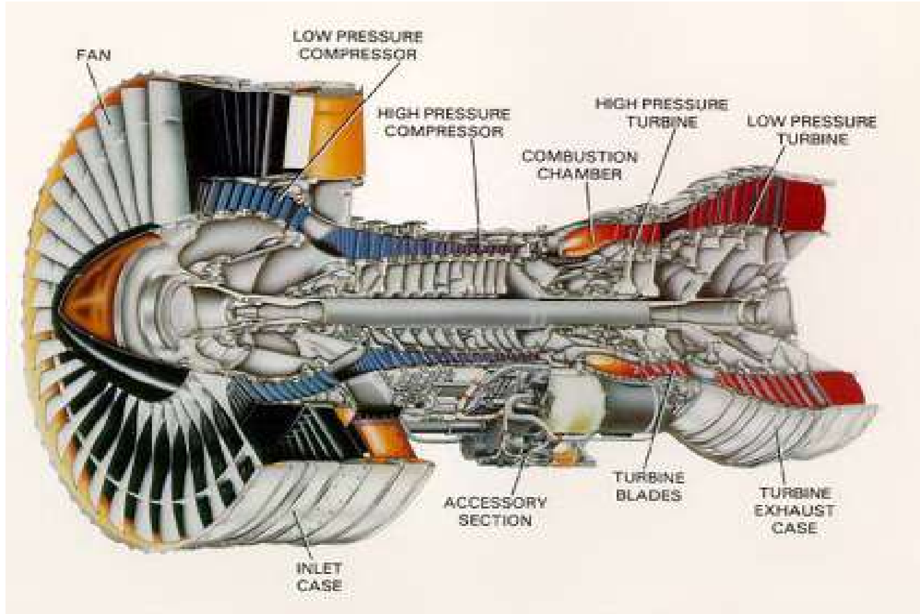
L-1011
TriStar
Lockheed
Lockheed TriStar

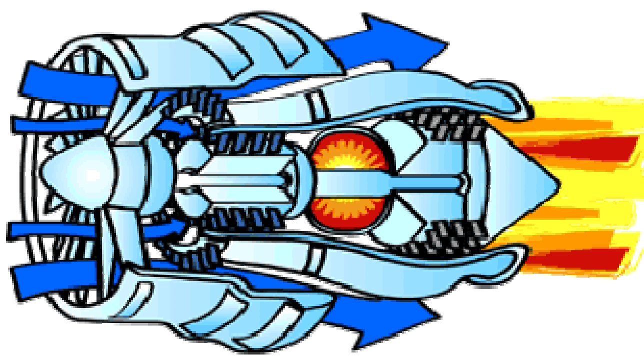

777
BOEING 777



different NRE
Lift
coefficient
moment
ANGLE of Attack
Section angle of attack, α_0, deg
Section lift coefficient, c_l
Section drag coefficient, c_d
Moment coefficient, $c_{m_{a.c.}}$
y/c
x/c
R
a.c. position
x/c y/c
3.1×10⁶ .239 -.006
5.7 .243 -.004
8.9 .247 -.018
5.7 Standard roughness

(a) (b)


FAN
LOW PRESSURE COMPRESSOR
HIGH PRESSURE COMPRESSOR
COMBUSTION CHAMBER
HIGH PRESSURE TURBINE
LOW PRESSURE TURBINE
ACCESSORY SECTION
TURBINE BLADES
TURBINE EXHAUST CASE
INLET CASE



Engine Characteristics

Fan tip diameter:

112 inches

Length,flange to flange:

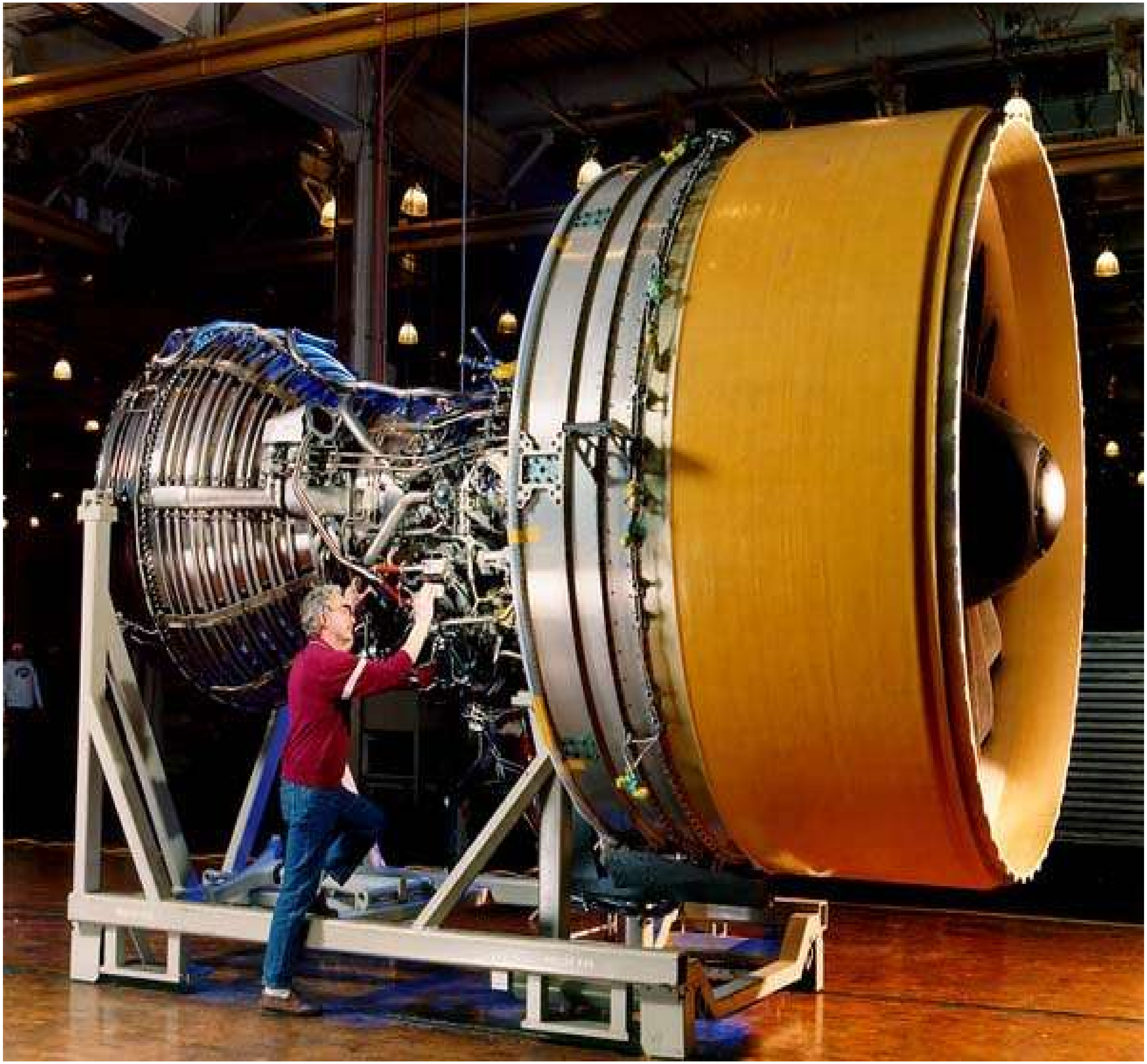
191.7 inches

Takeoff thrust:

4,000 - 98,000 pounds of thrust

Bypass ratio:

5.8-to-1 to 6.4-to-1



The 112-inch-fan PW4000 is an ultra-high-thrust model covering the 74,000 to 98,000-pound-thrust class to meet the current requirements for the Boeing 777 twinjet.

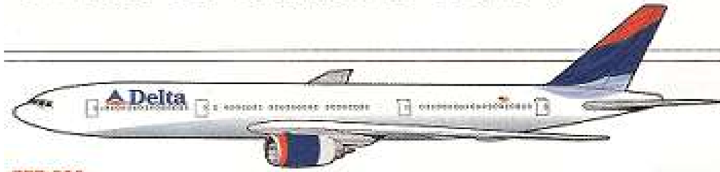
The PW4000 has been selected to power more Boeing 777 aircraft than either of its competitors. It was the launch engine for the 777, entering service in 1995.

The 112-inch PW4000 also is our largest commercial engine, its diameter nearly as wide as the fuselage of a Boeing 737. Using hollow titanium, shroud-less fan blades, the PW4000 provides high efficiency and low noise along with superb resistance to foreign object damage

Delta

Details + Diversions

The Delta Fleet



777-200

WINGSPAN: 199 ft. 11 in. (60.9 m)
LENGTH: 209 ft. 1 in. (63.7 m)
TAIL HEIGHT: 60 ft. 9 in. (18.5 m)
ACCOMMODATION: 268 passengers

CRUISING SPEED: 550 mph (880 km/h)
RANGE: 8,150 miles (13,116 km)
ENGINES: 2 Rolls-Royce Trent 892, which produce 92,000 lb. (41,700 kg) of thrust

757-200

WINGSPAN: 124 ft. 10 in. (38 m)
LENGTH: 155 ft. 3 in. (47.3 m)
TAIL HEIGHT: 44 ft. 6 in. (13.6 m)
ACCOMMODATION: 183 passengers

CRUISING SPEED: 528 mph (850 km/h)
RANGE: 2,620 miles (4,215 km)
ENGINES: 2 jet engines, wing-mounted

737-800

WINGSPAN: 117 ft. 5 in. (35.8 m)
LENGTH: 129 ft. 6 in. (39.5 m)
TAIL HEIGHT: 41 ft. 2 in. (12.5 m)
ACCOMMODATION: 150 passengers

CRUISING SPEED: 531 mph (855 km/h)
RANGE: 2,789 miles (4,488 km)
ENGINES: 2 jet engines, wing-mounted

Additional fleet aircraft:
737-200
737-300

E-170

WINGSPAN: 85 ft. 4 in. (26 m)
LENGTH: 98 ft. 1 in. (29.9 m)
TAIL HEIGHT: 32 ft. 4 in. (9.85 m)
ACCOMMODATION: 70 passengers

CRUISING SPEED: 544 mph (875 km/h)
RANGE: 1,956 miles (3,148 km)
ENGINES: 2 jet engines, wing-mounted

EMB-145

WINGSPAN: 65 ft. 9 in. (20 m)
LENGTH: 86 ft. 5 in. (26.3 m)
TAIL HEIGHT: 22 ft. 2 in. (6.8 m)
ACCOMMODATION: 50 passengers

CRUISING SPEED: 517 mph (833 km/h)
RANGE: 1,956 miles (3,148 km)
ENGINES: 2 jet engines, tail-mounted

767-300ER

WINGSPAN: 156 ft. 1 in. (47.6 m)
LENGTH: 180 ft. 3 in. (54.9 m)
TAIL HEIGHT: 52 ft. (15.8 m)
ACCOMMODATION: 204 passengers

CRUISING SPEED: 537 mph (861 km/h)
RANGE: 6,565 miles (10,563 km)
ENGINES: 2 jet engines, wing-mounted

Additional fleet aircraft:
767-300
767-400ER

MD-88

WINGSPAN: 107 ft. 10 in. (32.9 m)
LENGTH: 147 ft. 11 in. (45.1 m)
TAIL HEIGHT: 29 ft. 7 in. (9 m)
ACCOMMODATION: 142 passengers

CRUISING SPEED: 509 mph (819 km/h)
RANGE: 1,740 miles (2,800 km)
ENGINES: 2 jet engines, tail-mounted

Additional fleet aircraft:
MD-88 Shuttle
MD-90

CRJ-700

WINGSPAN: 76 ft. 3 in. (23.2 m)
LENGTH: 106 ft. 8 in. (32.5 m)
TAIL HEIGHT: 24 ft. 10 in. (7.6 m)
ACCOMMODATION: 70 passengers

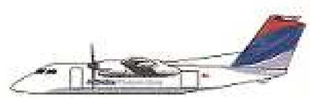
CRUISING SPEED: 544 mph (875 km/h)
RANGE: 1,939 miles (3,120 km)
ENGINES: 2 jet engines, tail-mounted

Additional fleet aircraft:
CRJ-100
CRJ-200

ATR-72

WINGSPAN: 88 ft. 9 in. (27.1 m)
LENGTH: 89 ft. 6 in. (27.3 m)
TAIL HEIGHT: 25 ft. 1 in. (7.6 m)
ACCOMMODATION: 66 passengers

CRUISING SPEED: 322 mph (518 km/h)
RANGE: 1,318 miles (2,121 km)
ENGINES: 2 turboprop engines, wing-mounted



DHC-8-100

WINGSPAN: 73 ft. (22.3 m)
LENGTH: 86.5 ft. (26.3 m)
TAIL HEIGHT: 24 ft. 7 in. (7.49 m)
ACCOMMODATION: 37 passengers

CRUISING SPEED: 308 mph (496 km/h)
RANGE: 1,020 miles (1,889 km)
ENGINES: 2 turboprop engines, wing-mounted

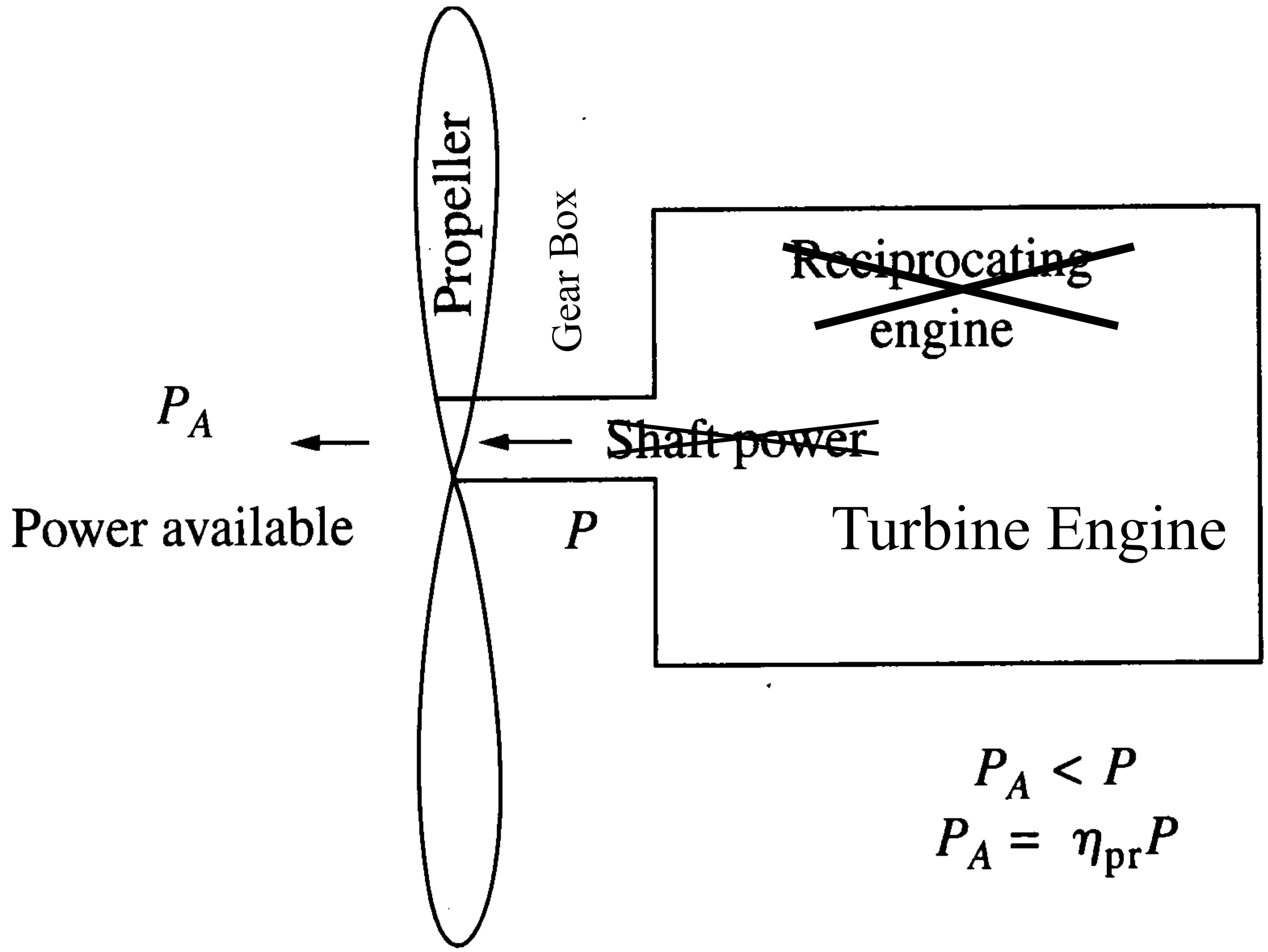
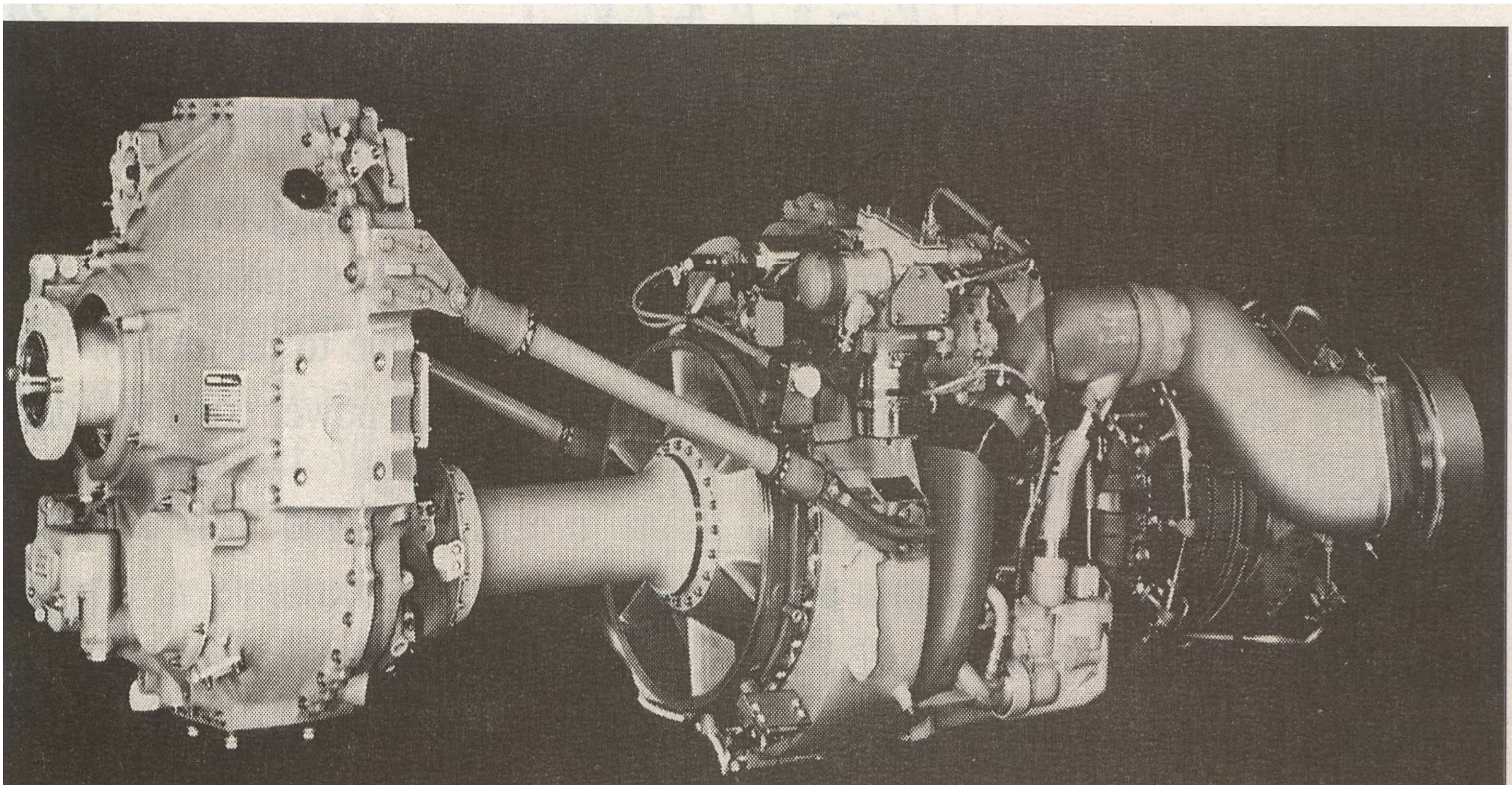
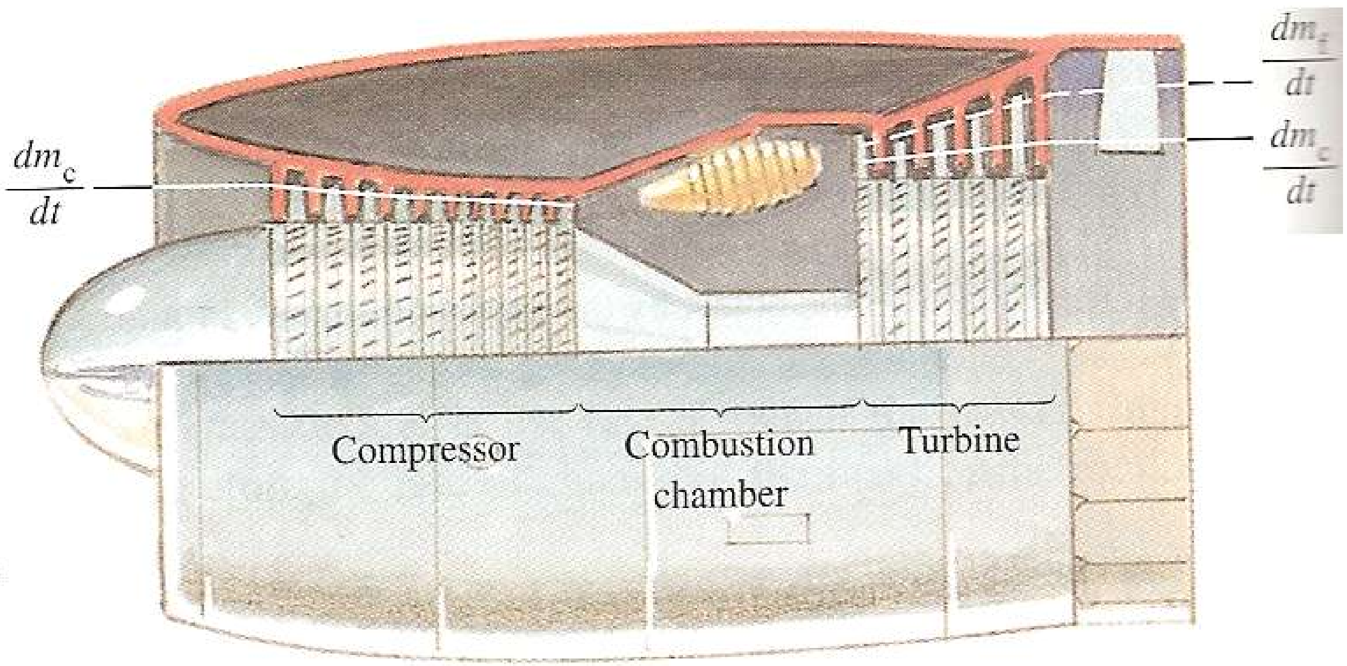


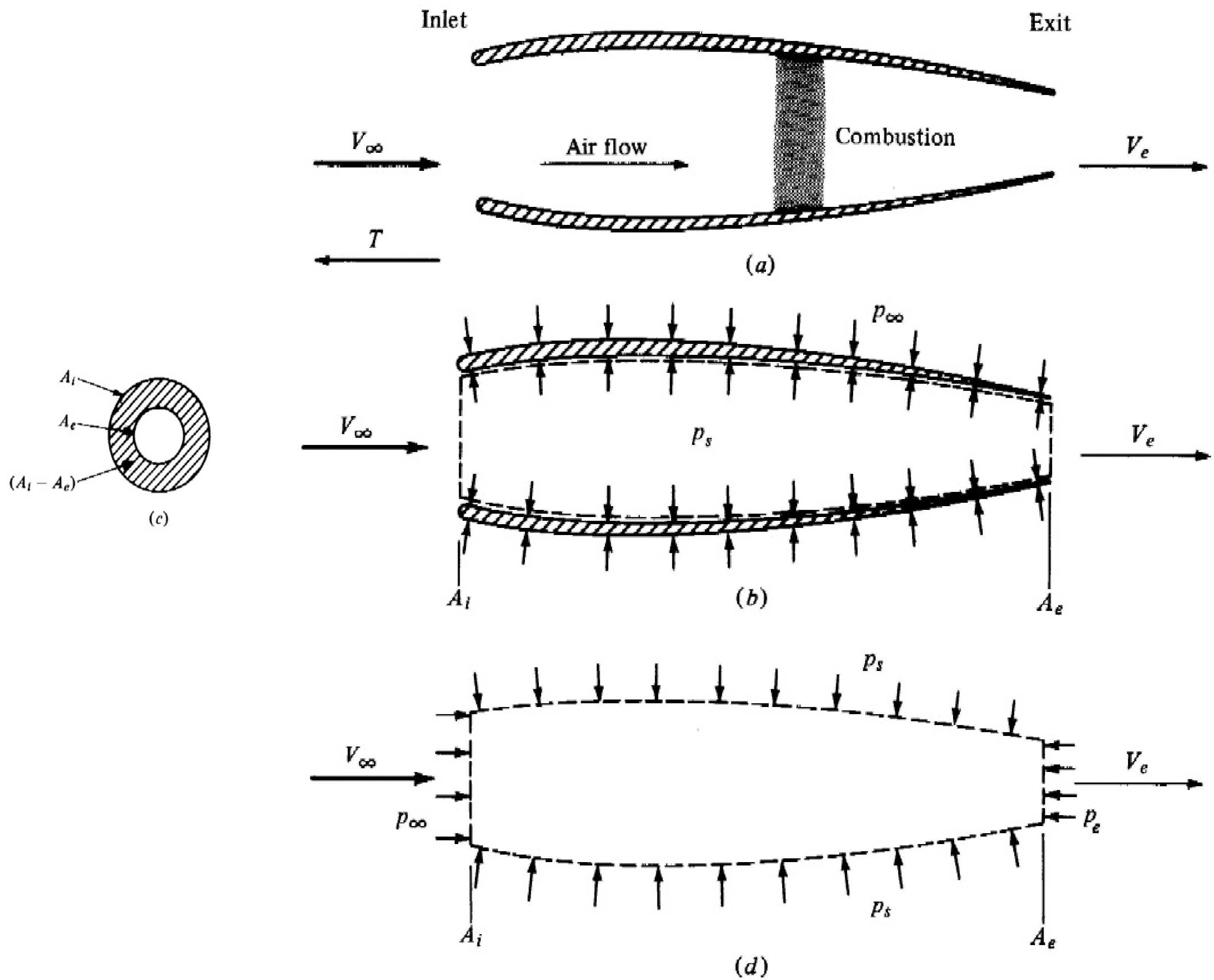
Figure 3.5 Schematic illustrating shaft power P and power available P_A from a propeller/ reciprocating engine combustion.



Shortcut to flowtj.lnk



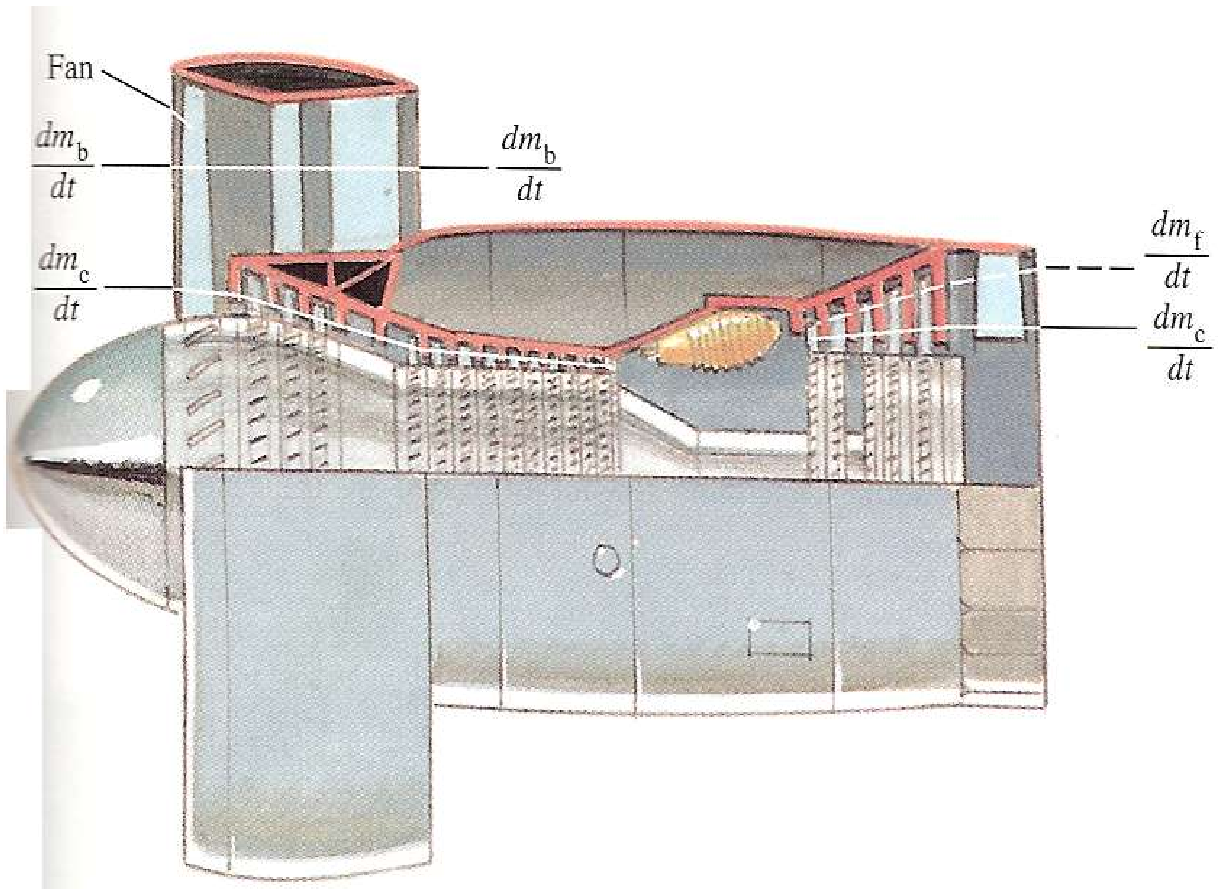
$$\boxed{T = (\dot{m}_{\text{air}} + \dot{m}_{\text{fuel}})V_e - \dot{m}_{\text{air}}V_\infty + (p_e - p_\infty)A_e}$$

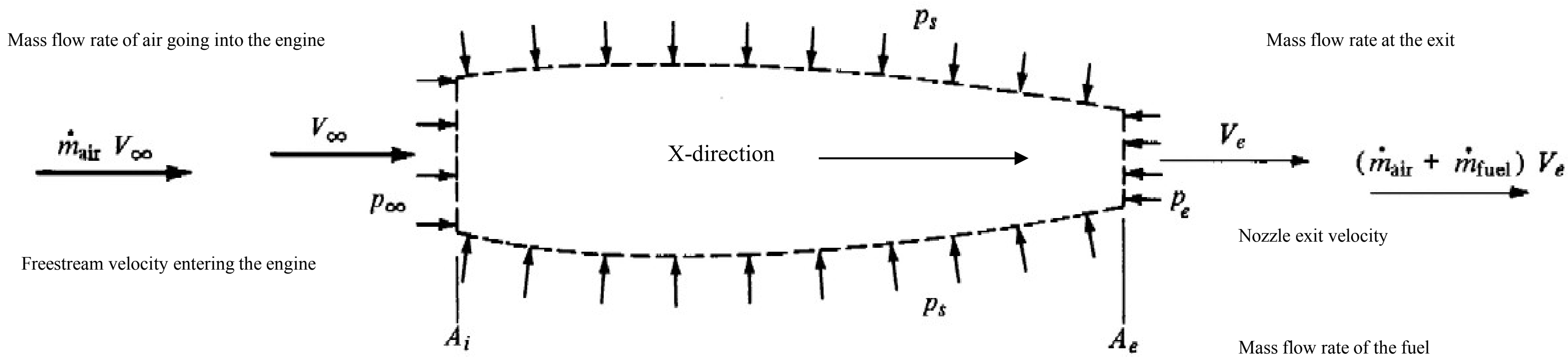


Inlet
Exit
V_∞
Air flow
Combustion
V_e
T
(a)
A_i
A_e
$(A_i - A_e)$
(c)
p_∞
p_s
A_i
(b)
A_e
p_s
p_∞
p_e
A_i
(d)
A_e

By-Pass

$\dot{m}\,(V_{ebp} - V_\infty)$





(d)

$$T = \int (p_s\, dS)_x + \int (p_\infty\, dS)_x$$

In flight this is a constant term

$$\int (p_\infty\, dS)_x = p_\infty \int (dS)_x = p_\infty (A_i - A_e)$$

$$T = \int (p_s\, dS)_x + p_\infty (A_i - A_e)$$

$$F = p_\infty A_i + \int (p_s\, dS)_x - p_e A_e$$

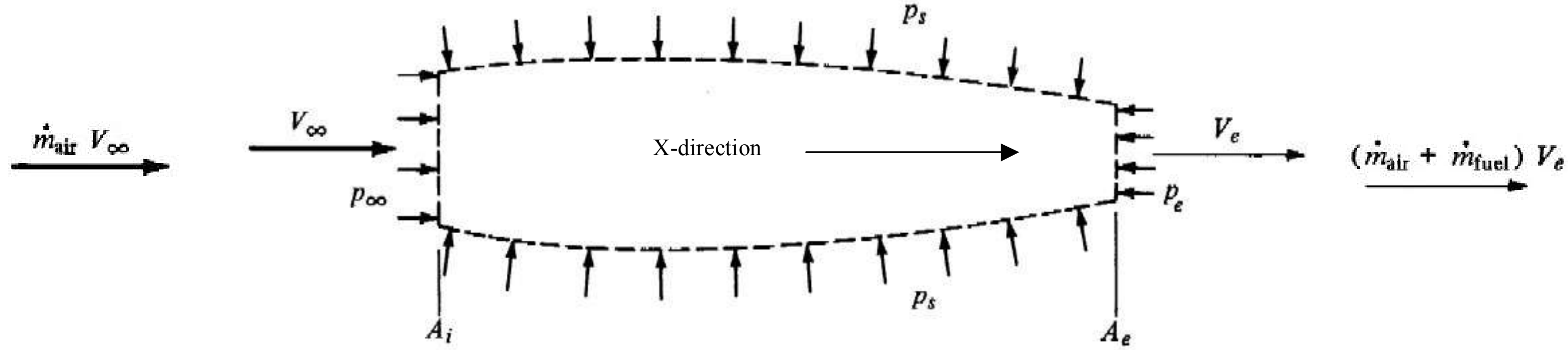
$$F = (\dot{m}_{\text{air}} + \dot{m}_{\text{fuel}}) V_e - \dot{m}_{\text{air}} V_\infty$$

$$(\dot{m}_{\text{air}} + \dot{m}_{\text{fuel}}) V_e - \dot{m}_{\text{air}} V_\infty = p_\infty A_i + \int (p_s\, dS)_x - p_e A_e$$

$$\int (p_s\, dS)_x = (\dot{m}_{\text{air}} + \dot{m}_{\text{fuel}}) V_e - \dot{m}_{\text{air}} V_\infty + p_e A_e - p_\infty A_i$$

$$T = (\dot{m}_{\text{air}} + \dot{m}_{\text{fuel}}) V_e - \dot{m}_{\text{air}} V_\infty + p_e A_e - p_\infty A_i + p_\infty (A_i - A_e)$$

$$\boxed{T = (\dot{m}_{\text{air}} + \dot{m}_{\text{fuel}}) V_e - \dot{m}_{\text{air}} V_\infty + (p_e - p_\infty) A_e}$$



(d)

$$T = \int (p_s\, dS)_x + \int (p_\infty\, dS)_x$$

$$\int (p_\infty\, dS)_x = p_\infty \int (dS)_x = p_\infty (A_i - A_e)$$

$$T = \int (p_s\, dS)_x + p_\infty (A_i - A_e)$$

$$F = p_\infty A_i + \int (p_s\, dS)_x - p_e A_e$$

$$F = (\dot{m}_{air} + \dot{m}_{fuel}) V_e - \dot{m}_{air} V_\infty$$

$$(\dot{m}_{air} + \dot{m}_{fuel}) V_e - \dot{m}_{air} V_\infty = p_\infty A_i + \int (p_s\, dS)_x - p_e A_e$$

$$\int (p_s\, dS)_x = (\dot{m}_{air} + \dot{m}_{fuel}) V_e - \dot{m}_{air} V_\infty + p_e A_e - p_\infty A_i$$

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

$$\boxed{T = (\dot{m}_{air} + \dot{m}_{fuel}) V_e - \dot{m}_{air} V_\infty + (p_e - p_\infty) A_e} \quad + m\,(V \;-\; V_\infty)$$

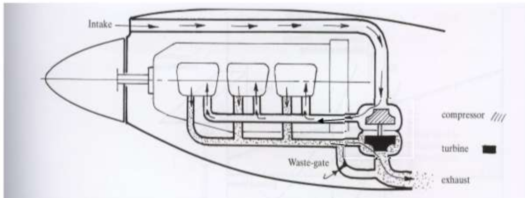


Fig. 7.13 The turbo-supercharger. With the waste-gate closed, exhaust gases drive the turbine and the compressor – which turbocharges air from the intake to the induction system. If the waste-gate is opened, exhaust gases by-pass the turbine and there is no supercharging.

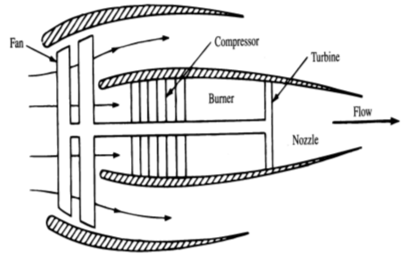


Figure 3.16 Schematic of a turbofan engine.

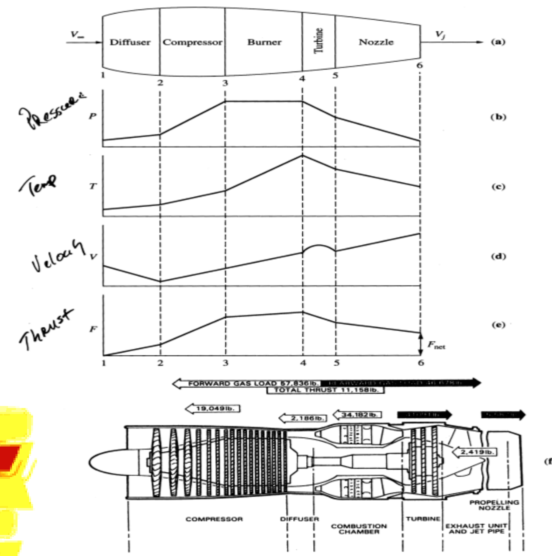
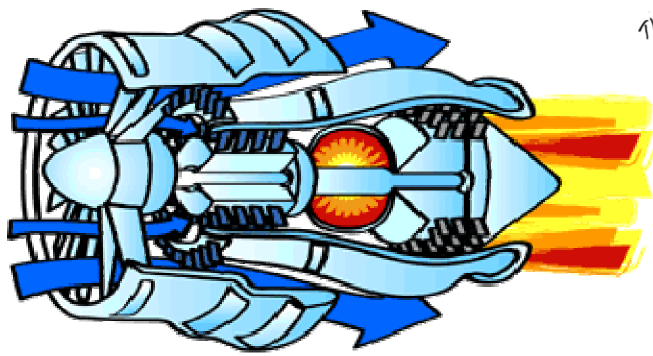


Figure 3.10 Distribution of **(a)** components, **(b)** pressure, **(c)** temperature, **(d)** velocity, and **(e)** local thrust; **(f)** integrated thrust through a generic turbojet engine.



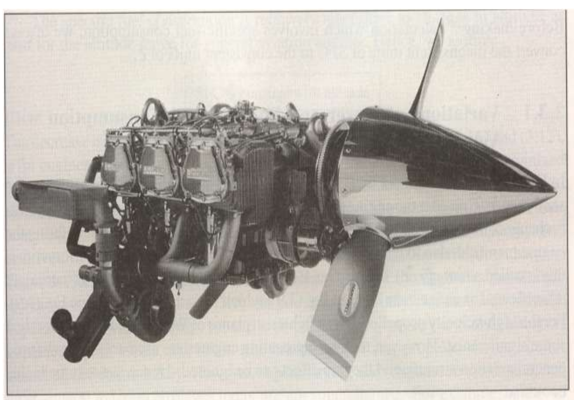
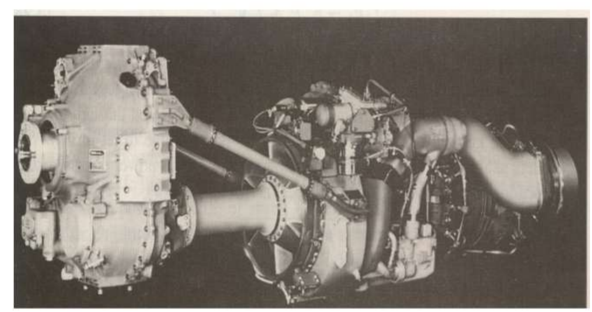


Figure 3.4 Textron Lycoming T10 540-AE2A turbocharged piston engine.



CESSNA 310

Questions

The General Electric J79 turbojet produces a thrust of 10,000 lb at sea level. The inlet diameter is 3.19 ft. If an airplane equipped with the J79 is flying at standard sea level with a velocity of 1,000 ft/s, estimate (*a*) the jet velocity relative to the airplane and (*b*) the propulsive efficiency. **3.1**

The Cessna model 310 twin-engine propeller-driven airplane is powered by two Continental IO-520-M engines rated at 285 hp each at 2,700 rpm at sea level. McCauley three-blade propellers are used, with a diameter of 6.27 ft. The maximum speed of the airplane at sea level is 238 mi/h. Assume the performance of the propeller is given by the propeller efficiency curves in Fig. 3.7, and that the propellers are variable-pitch so as to obtain the maximum efficiency. Calculate the maximum horsepower available from the engine-propeller combination at sea level. **3.2**

Consider the design of turbojet engine intended to produce a thrust of 25,000 lb at a takeoff velocity of 220 ft/s at sea level. At takeoff, the gas velocity at the exit of the engine (relative to the engine) is 1,700 ft/s. The fuel-air ratio by mass is 0.03. The exit pressure is equal to the ambient pressure. Calculate the area of the inlet to the engine necessary to obtain this thrust. **3.3**

3.4 A turbofan engine on a test stand in the laboratory operates continuously at a thrust level of 60,000 lb with a thrust specific fuel consumption of $0.5\ \text{h}^{-1}$. The fuel reservoir feeding the engine holds 1,000 gal of jet fuel. If the reservoir is full at the beginning of the test, how long can the engine run before the fuel reservoir is empty? *Note*: A gallon of fuel weighs 6.7 lb.

3.4 A turbofan engine on a test stand in the laboratory operates continuously at a thrust level of 60,000 lb with a thrust specific fuel consumption of $0.5\ \text{h}^{-1}$. The fuel reservoir feeding the engine holds 1,000 gal of jet fuel. If the reservoir is full at the beginning of the test, how long can the engine run before the fuel reservoir is empty? *Note*: A gallon of fuel weighs 6.7 lb.

3.5 The thrust of a turbofan engine decreases as the flight velocity increases. The maximum thrust of the Rolls-Royce RB211 turbofan at zero velocity at sea level is 50,000 lb. Calculate the thrust at an altitude of 3 km at Mach 0.6.

3.6 The Allison T56 turboprop engine is rated at 4,910 equivalent shaft horsepower at zero velocity at sea level. Consider an airplane with this engine flying at 500 ft/s at sea level. The jet thrust is 250 lb, and the propeller efficiency is 0.9. Calculate the equivalent shaft horsepower at this flight condition.

3.7 The specific fuel consumption for the Teledyne Continental Voyager 200 liquid-cooled reciprocating engine is 0.375 lb/(bhp·h). When installed in an airplane which is flying at 200 mi/h with a propeller efficiency of 0.85, calculate the equivalent thrust specific fuel consumption.

Altitude				
h_G, ft	h, ft	Temperature T, °R	Pressure p, lb/ft^2	Density ρ, slugs/ft^3
−5,000	−5,001	536.52	2.5277	2.7448
−4,500	−4,501	534.74	2.4839	2.7061
−4,000	−4,001	532.96	2.4406	2.6679
−3,500	−3,501	531.17	2.3980	2.6301
−3,000	−3,000	529.39	2.3560	2.5927
−2,500	−2,500	527.60	2.3146	2.5558
−2,000	−2,000	525.82	2.2737	2.5192
−1,500	−1,500	524.04	2.2335 + 3	2.4830 − 3
−1,000	−1,000	522.25	2.1938	2.4473
−500	−500	520.47	2.1547	2.4119
0	0	518.69	2.1162	2.3769
500	500	516.90	2.0783	2.3423
1,000	1,000	515.12	2.0409	2.3081
1,500	1,500	513.34	2.0040	2.2743
2,000	2,000	511.56	1.9677	2.2409
2,500	2,500	509.77	1.9319	2.2079

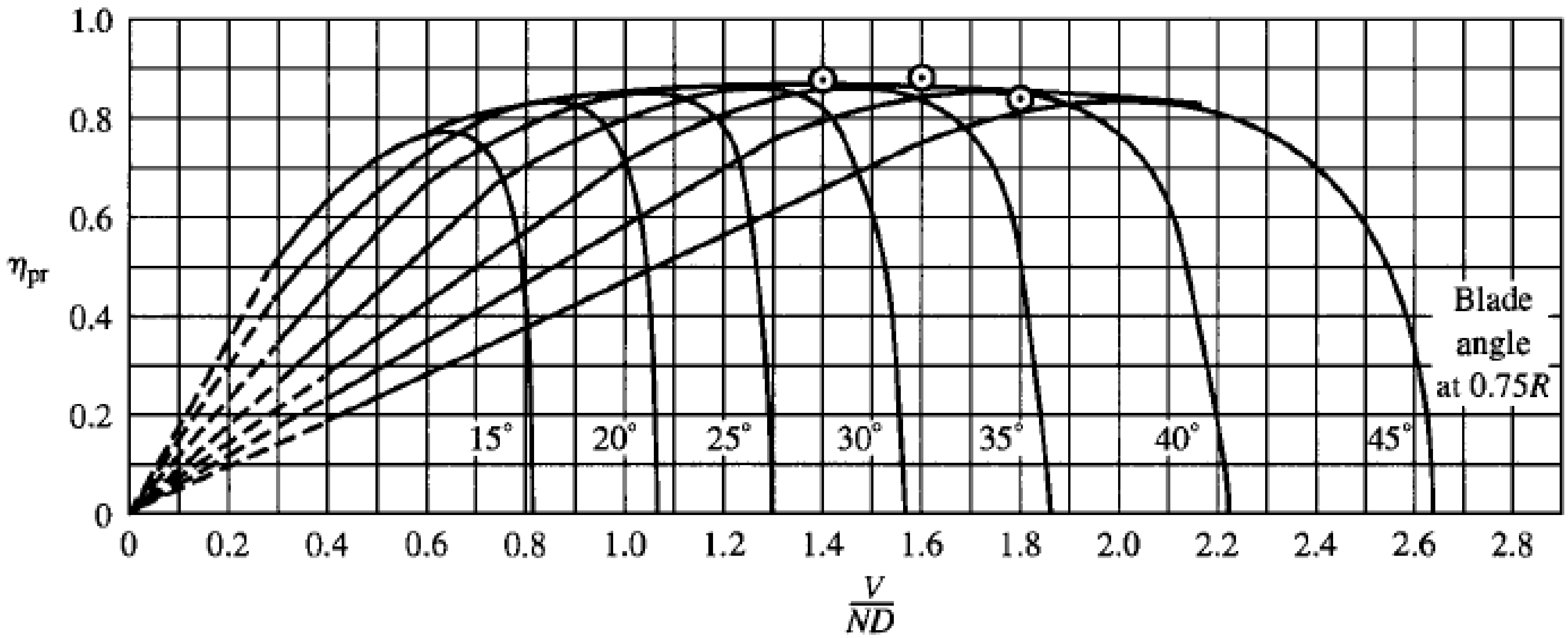
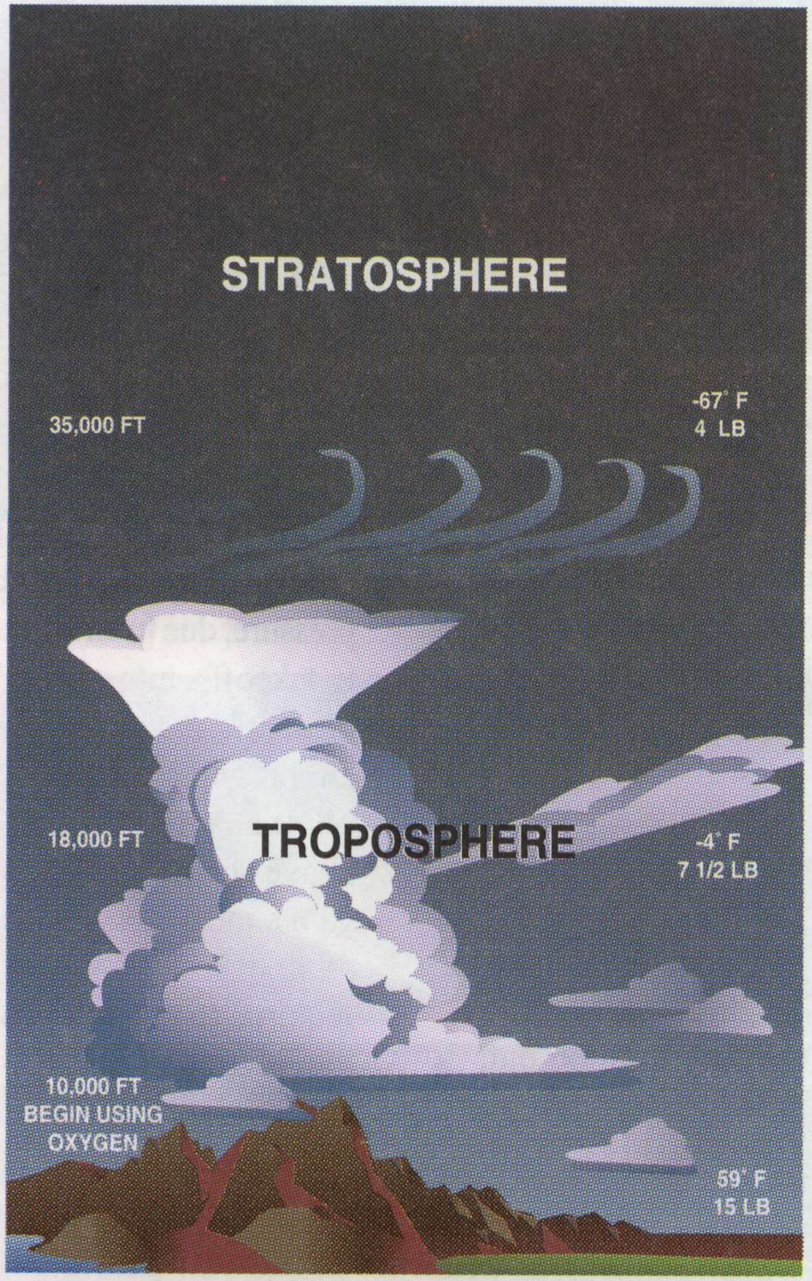


Figure 3.7 Propeller efficiency as a function of advance ratio for various pitch angles. Three-bladed propeller with Clark Y sections. (*After McCormick, Ref. 50.*)



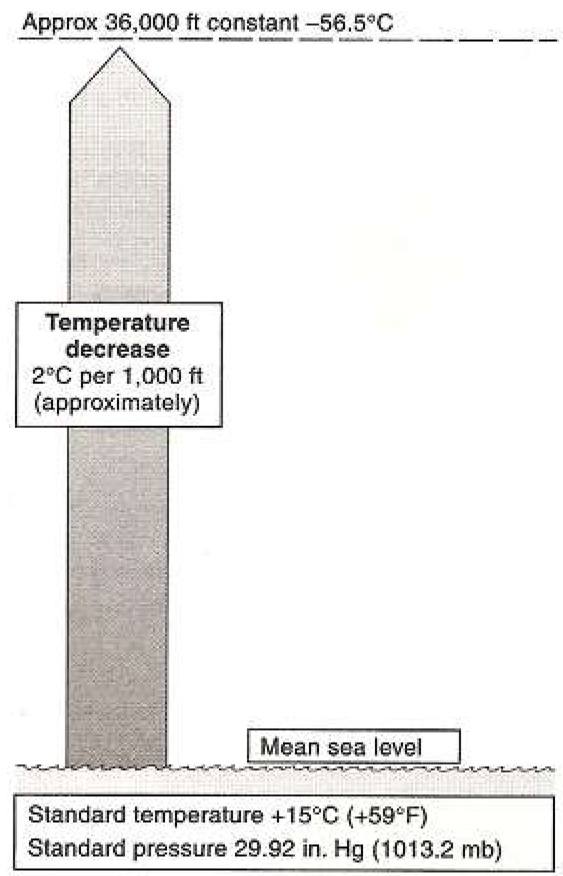
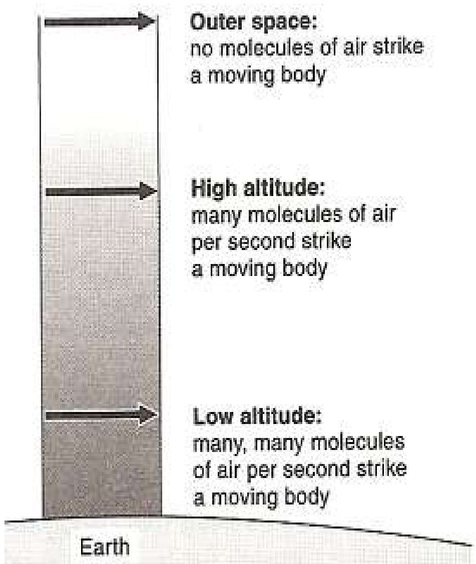


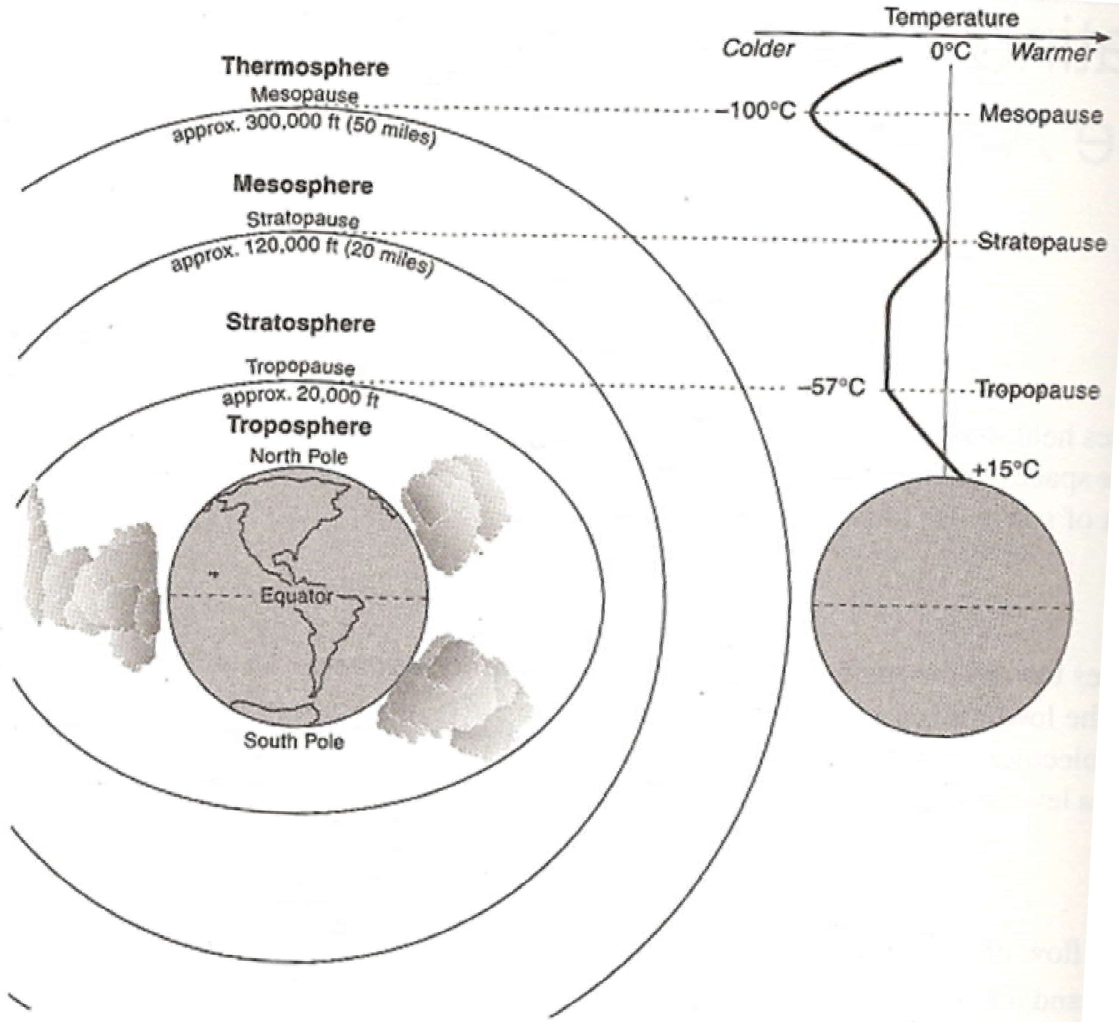
Figure 14-4. The International Standard Atmosphere (ISA)

FIGURE 5-1.—The troposphere and stratosphere are the realm of flight.

Air density decreases with altitude.



The density of air decreases as altitude is gained



The subdivision of the atmosphere is based on temperature

Density altitude is the altitude in the International Standard Atmosphere at which the air density would be equal to the actual air density at the place of observation. "Density Altitude" is the pressure altitude adjusted for non-standard temperature.
Both increase in temperature and increase in humidity cause a reduction in air density. Thus in hot and humid conditions the density altitude at a particular location may be significantly higher than the geometric altitude.
Density altitude can be calculated from atmospheric pressure and temperature (assuming dry air).

$$\mathrm{DA} = 145426 \left[1 - \left(\frac{P_0/P_{SL}}{\mathrm{T}/T_{SL}}\right)^b\right]$$

where
DA = density altitude
P_0 = atmospheric (static) pressure
P_{SL} = standard sea level atmospheric pressure (1013.25 hpa)
T = true (static) air temperature
T_{SL} = standard sea level air temperature(288.15 K)
b = 0.235

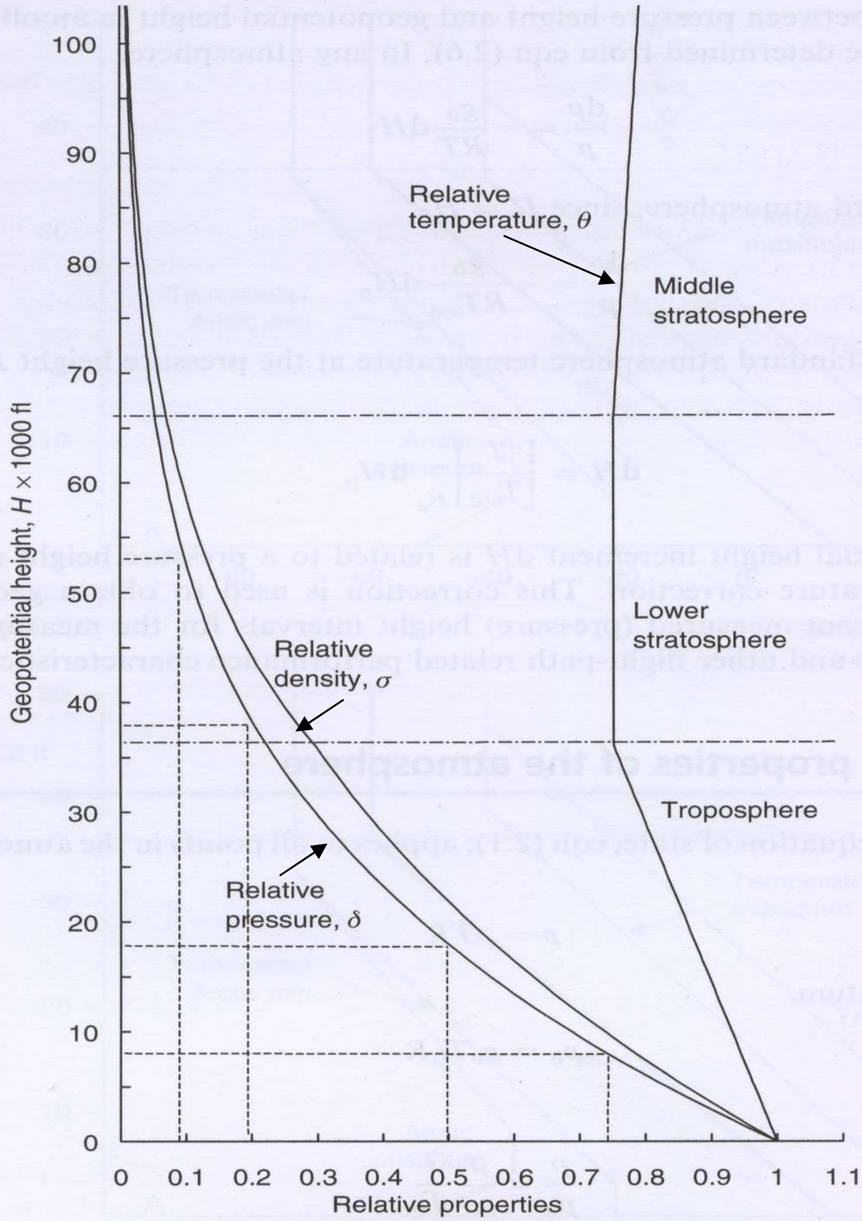


Fig. 2.8 International Standard Atmosphere; relative properties.

Aircraft manufactures and designer design aircraft using standard atmosphere conditions as the reference point.

Pilots need to adjust these theoretical values of lift, power and thrust to take account of differences between the standard atmosphere and the real atmosphere at a particular time and place. They use charts or aviation computers to say that the real atmosphere at a particular time has the density of the standard atmosphere at a certain altitude, which is likely to be different from the true altitude. The aircraft performs as though it were at the density altitude.

HEIGHTS TO STANDARD PRESSURE AND TEMPERATURE

Altitude, feet	Pressure, mb	Pressure, inches	Temperature, °C	Temperature, °F	Altitude, feet	Pressure, mb	Pressure, inches	Temperature, °C	Temperature, °F
0	1013.2	29.92	15.0	59.0	26,000	359.9	10.63	−36.5	−33.7
1,000	977.2	28.86	13.0	55.4	27,000	344.3	10.17	−38.5	−37.3
2,000	942.1	27.82	11.0	51.9	28,000	329.3	9.72	−40.5	−40.9
3,000	908.1	26.82	9.0	48.3	29,000	314.8	9.30	−42.5	−44.4
4,000	875.1	25.84	7.1	44.7	30,000	300.9	8.89	−44.4	−48.0
5,000	843.1	24.90	5.1	41.2	31,000	287.4	8.49	−46.4	−51.6
6,000	812.0	23.98	3.1	37.6	32,000	274.5	8.11	−48.4	−55.1
7,000	781.8	23.09	1.1	34.0	33,000	262.0	7.74	−50.4	−58.7
8,000	752.6	22.22	−0.8	30.5	34,000	250.0	7.38	−52.4	−62.2
9,000	724.3	21.39	−2.8	26.9	35,000	238.4	7.04	−54.3	−65.8
10,000	696.8	20.58	−4.8	23.3	36,000	227.3	6.71	−56.3	−69.4
11,000	670.2	19.79	−6.8	19.8	37,000	216.6	6.40	−56.5	−69.7
12,000	644.4	19.03	−8.8	16.2	38,000	206.5	6.10	Constant to	
13,000	619.4	18.29	−10.8	12.6	39,000	196.8	5.81	65,500 feet	
14,000	595.2	17.58	−12.7	9.1	40,000	187.5	5.54		
15,000	571.8	16.89	−14.7	5.5	41,000	178.7	5.28		
16,000	549.2	16.22	−16.7	1.9	42,000	170.4	5.04		
17,000	427.2	15.57	−18.7	−1.6	43,000	162.4	4.79		
18,000	506.0	14.94	−29.7	−5.2	44,000	154.7	4.57		
19,000	485.5	14.34	−22.6	−8.8	45,000	147.5	4.35		
20,000	465.6	13.75	−24.6	−12.3	46,000	140.6	4.15		
21,000	446.4	13.18	−26.6	−15.9	47,000	134.0	3.96		
22,000	427.9	12.64	−28.6	−19.5	48,000	127.7	3.77		
23,000	410.0	12.11	−30.6	−23.9	49,000	121.7	3.59		
24,000	392.7	11.60	−32.5	−26.6	50,000	116.0	3.42		
25,000	376.0	11.10	−34.5	−30.2					

Most density altitude charts and calculators account for the air pressure and temperature, but not for humidity.
Humid air is less dense than dry air,
which means performance will suffer on a humid day.
But these effects are not as great as temperature and air pressure.

All altitudes are measured above Sea Level (MSL) vs Altitude above ground (AGL)

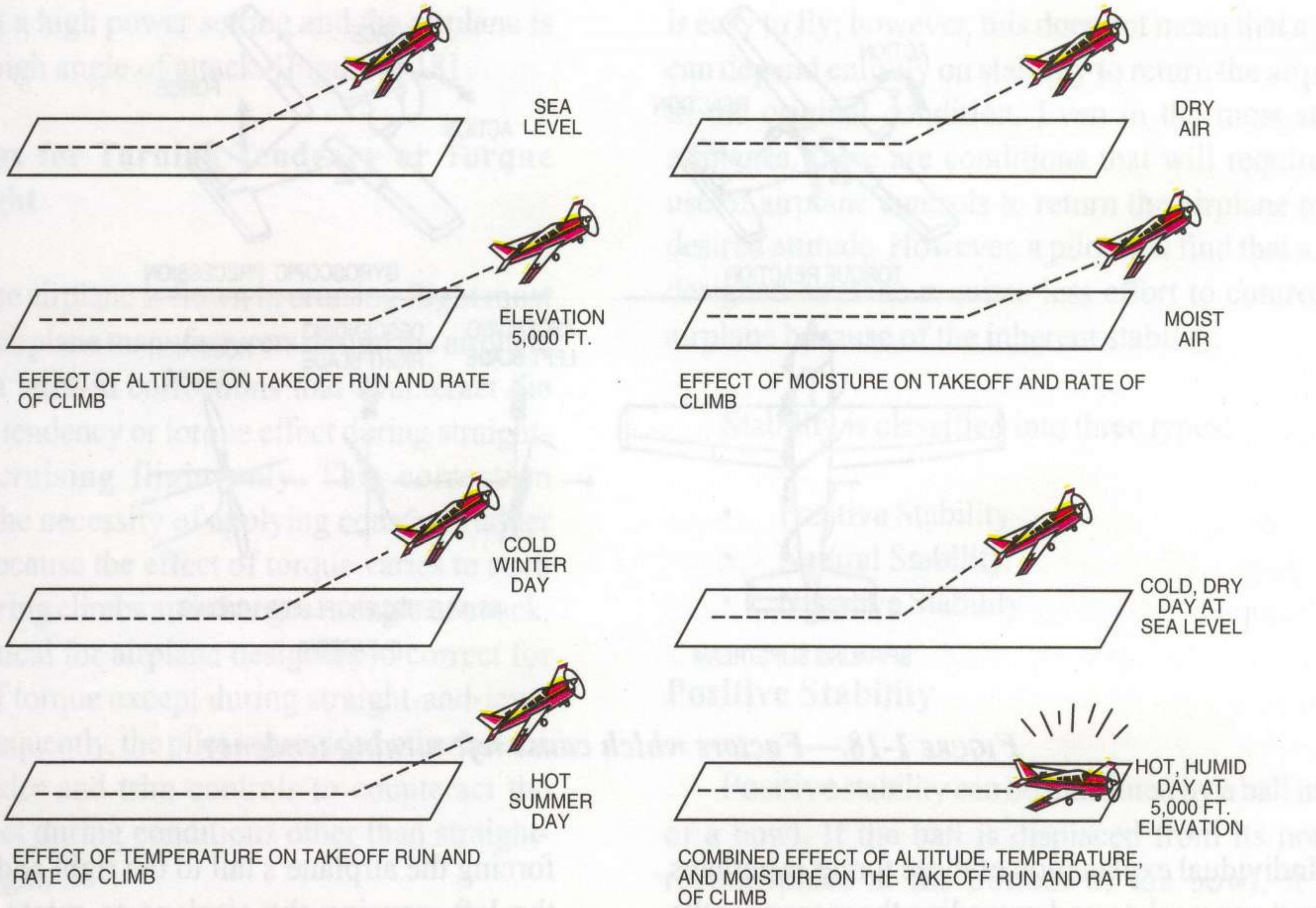


FIGURE 1-17.—Effect of altitude, temperature, and humidity on takeoff run and rate of climb.

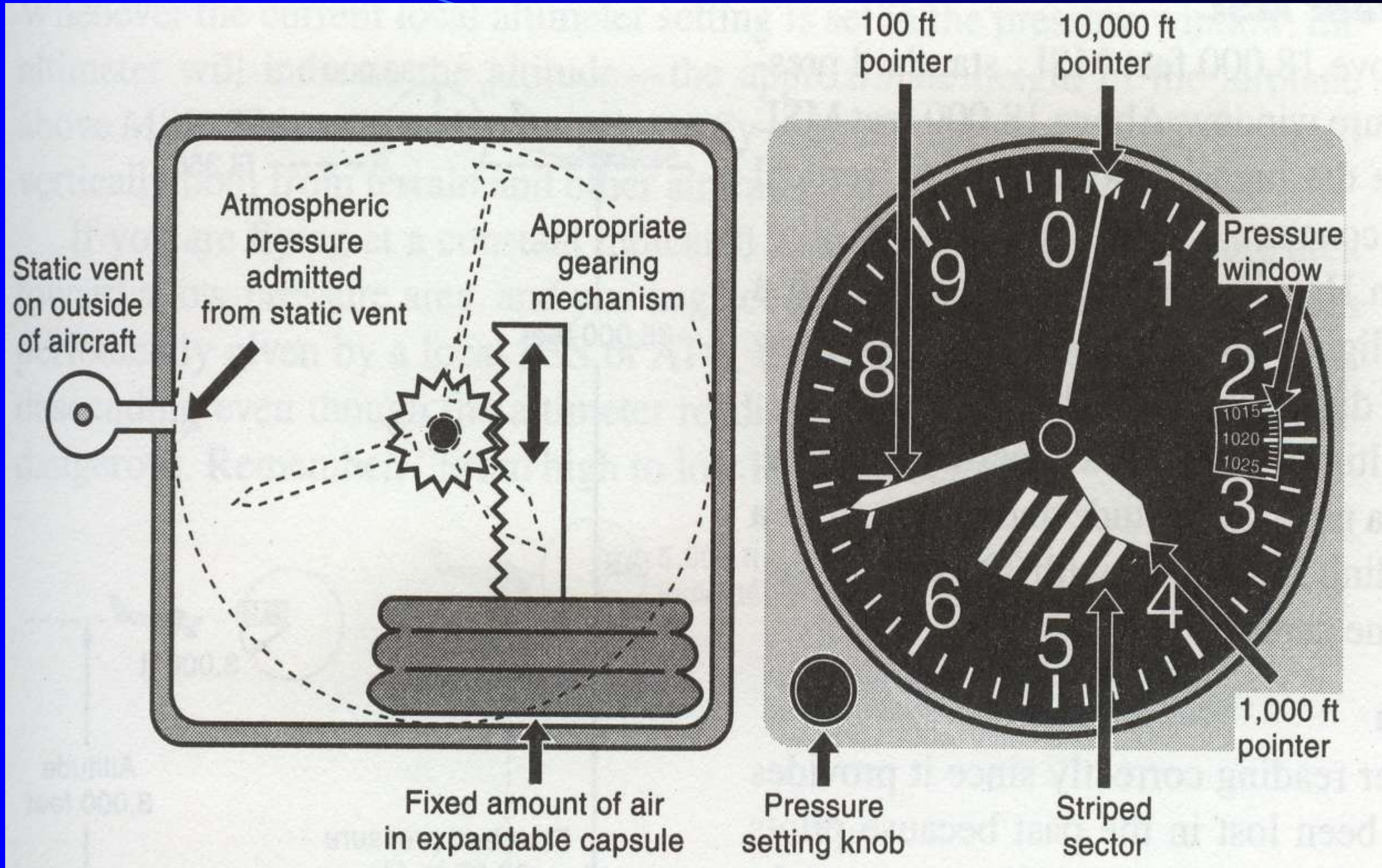


Figure 8-9. The altimeter is a pressure-sensitive instrument

Density Altitude

Interaction between Air pressure, Temperature, Air Moisture and Altitude that impacts all aircraft performance.

Question to ask yourself

At this moment, at this temperature, at this altimeter setting, at this actual altitude and at this relative humidity:

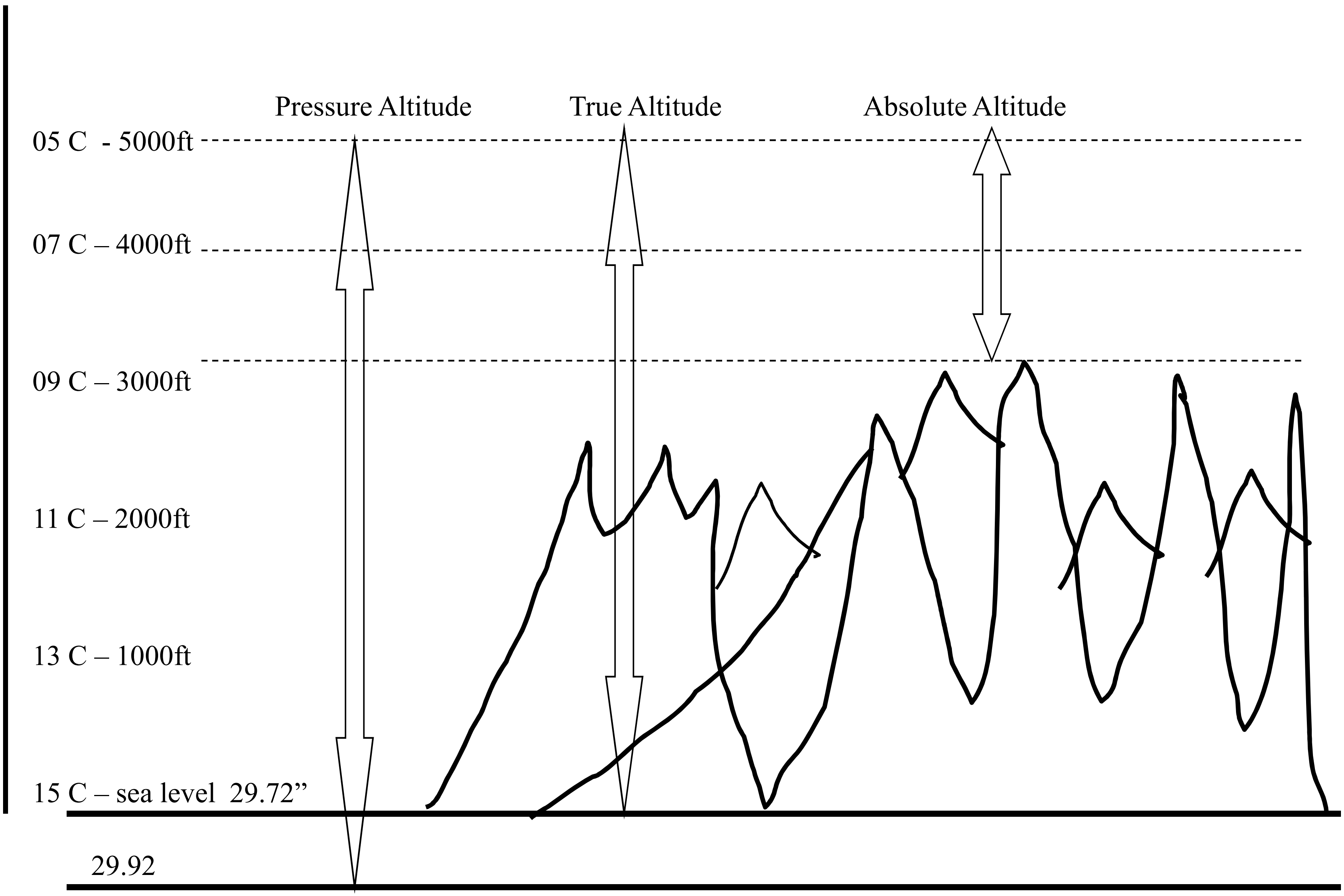
How far from the standard Atmosphere environment will the airplane be operating?

What Altitude does the airplane thinks it is operating at?

The Standard Atmosphere – at Sea level is 59 ºF or 15 ºC and a surface pressure of 29.92

Pressure Altitude – is the altitude deviation from the Standard atmosphere

Density Altitude – Airplane and engine performance depends on air density. It is not practicable for you to have the equipment necessary to measure air density, so we use two pieces of information already available in the cockpit on which air density depends pressure altitude and temperature.


Pressure Altitude
True Altitude
Absolute Altitude
05 C - 5000ft
07 C – 4000ft
09 C – 3000ft
11 C – 2000ft
13 C – 1000ft
15 C – sea level 29.72”
29.92

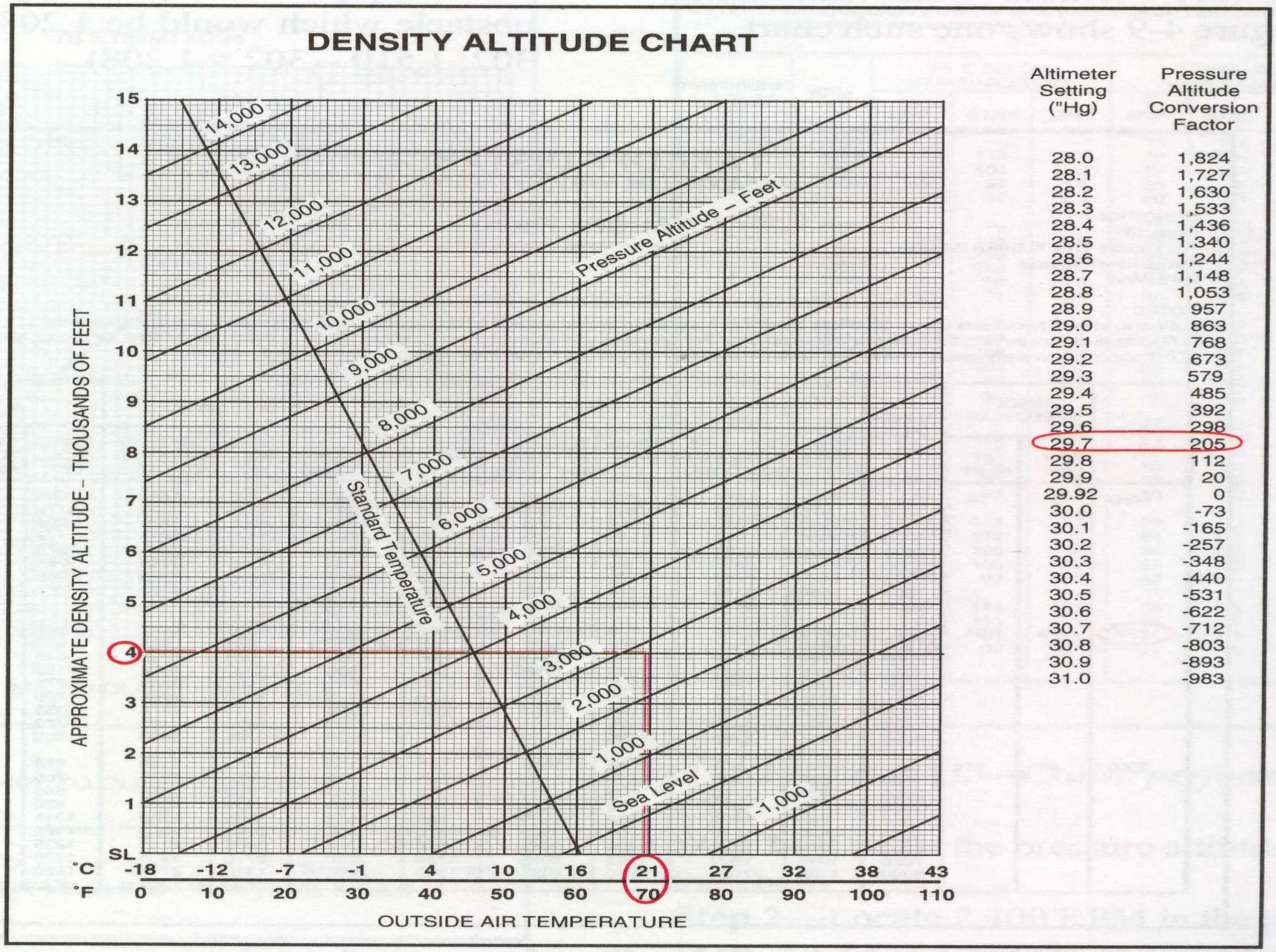


FIGURE 4-8.—Pressure altitude and density altitude chart.

In Class Quiz.

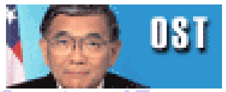
Using the density altitude chart, what is the density altitude if the altimeter reads 5000ft with 28.30 in.Hg in the Pressure window and the true outside air temperature is 90 F?

Dear Fellow Citizens:

I am proud and privileged to lead the U.S. Department of Transportation (DOT). The American people deserve the safest, most secure, and most efficient transportation system possible.

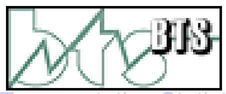
Our top priorities at DOT are to keep the traveling public safe and secure, increase their mobility, and have our transportation system contribute to the nation's economic growth.

DOT employs almost 60,000 people across the country, in the Office of the Secretary of Transportation (OST) and its operating administrations and bureaus: each with its own management and organizational structure:



Office of the Secretary of Transportation (OST)

Maritime Administration (MARAD)



Bureau of Transportation Statistics (BTS)

National Highway Traffic Safety Administration (NHTSA)

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Research and Special Programs Administration (RSPA)

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Saint Lawrence Seaway Development Corporation (SLSDC)

Federal Railroad Administration (FRA)

Surface Transportation Board (STB)

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The Federal Aviation Administration (FAA) is responsible for the safety of civil aviation. The Federal Aviation Act of 1958 created the agency, under the name Federal Aviation Agency. We adopted our present name in 1967 when we became a part of the Department of Transportation. The FAA's major roles include:

- •regulating civil aviation to promote safety;
- •encouraging and developing civil aeronautics, including new aviation technology;
- •developing and operating a system of air traffic control and navigation for both civil and military aircraft;
- •researching and developing the National Airspace System and civil aeronautics;
- •developing and carrying out programs to control aircraft noise and other environmental effects of civil aviation; and
- •regulating U.S. commercial space transportation.

Safety Regulation. The FAA issues and enforces regulations and minimum standards covering manufacturing, operating, and maintaining aircraft. We certify airmen and airports that serve air carriers.

Airspace and Air Traffic Management. The safe and efficient use of the navigable airspace is a primary objective of the FAA. We operate a network of airport towers, air route traffic control centers, and flight service stations. We develop air traffic rules, assign the use of airspace, and control air traffic.

Air Navigation Facilities. The FAA builds or installs visual and electronic aids to air navigation. We maintain, operate, and assure the quality of these facilities. We also maintain other systems to support air navigation and air traffic control, including voice and data communications equipment, radar facilities, computer systems, and visual display equipment at flight service stations.

Civil Aviation Abroad. The FAA promotes aviation safety and encourages civil aviation abroad. We exchange aeronautical information with foreign authorities; certify foreign repair shops, airmen, and mechanics; provide technical aid and training; negotiate bilateral airworthiness agreements with other countries; and take part in international conferences.

Commercial Space Transportation. The FAA regulates and encourages the U.S. commercial space transportation industry. We license commercial space launch facilities and private launches of space payloads on expendable launch vehicles.

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