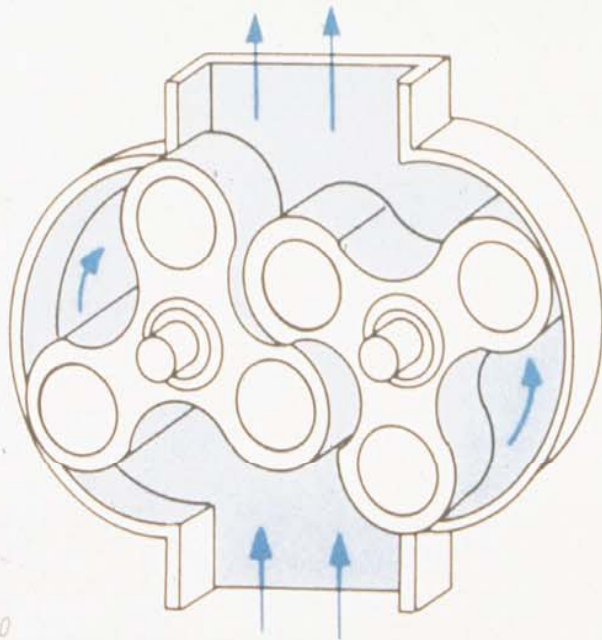


# Superchargers / Turbochargers

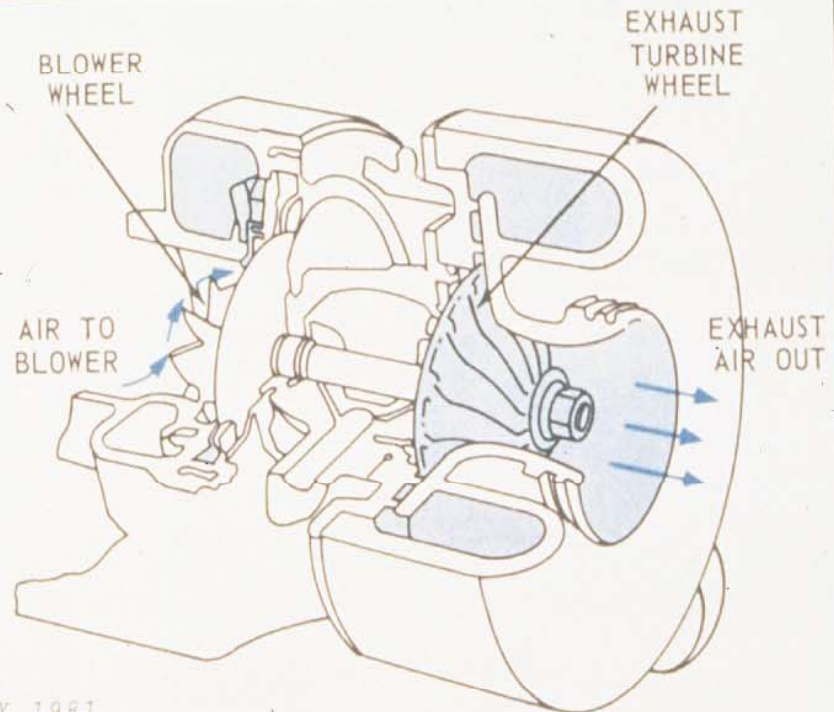
- Boost
  - Boost =  $P_2 - P_1$
- Pressure Ratio
  - Pressure Ratio  $P_r = P_2 / P_1 = (P_1 + \text{Boost}) / P_1$
- Compressor Performance
  - Compressing gas increases Temperature (reduces density)
    - $(T_2 / T_1) = 1 + [P_r^{0.286} - 1] / e_c$ 
      - $e_c$  Compressor efficiency
  - Volumetric Efficiency
    - $e_v = (P_2 / P_1) / (T_1 / T_2)$
- Aftercoolers / Intercoolers
  - Air-to-Air
    - Require at least 25°C (45°F) temperature difference
  - Air-to-Water
    - Specific heat capacity air lower, require much higher volumes air

## SUPERCHARGERS



X 1980

Fig. 24 — Roots-Type Supercharger



X 1981

Fig. 25 — Centrifugal-Type Supercharger  
(Turbocharger Shown)

## Supercharging Engine

- Base Engine, Naturally Aspirated Engine, 100 kW, vol eff. = 0.85
- Turbocharged Engine, Boost 100 kPa, Air Temp 25°C, Compressor eff=0.75
  - $P_r = P_2 / P_1 = \underline{\mathbf{2.2}}$ ,
  - $(T_2 / T_1) = 1 + [P_r^{0.286} - 1] / e_c = 1.337$        $T_2 = \underline{\mathbf{119^\circ C}}$
  - $e_v = (P_2 / P_1) * (T_1 / T_2) = \underline{\mathbf{1.64}}$
  
  - Allow 92 % increase in fuel & Power
  - Actual increase 15% to 115 kW
    - Leaner mixture 10% increase in fuel economy
  
  - Increase fuel to 130 kW
  
  - Intercooler 145 kW

# Turbocharging an Engine

- A turbocharger is fitted to a 5.1L diesel engine, to run at a rated speed of 2200 RPM, and brake power of 86 kW. Ambient air density is 1.16 kg/m<sup>3</sup>, and desired A/F ratio is 27:1. Estimated BSFC is 0.27 kg/kW.h
- Select desired power output
  - $P_b = 86 \text{ kW}$
- Calculate Fuel consumption  $M_f = P_b \cdot \text{BSFC}$ 
  - $M_f = 86 \text{ kW} \cdot 0.27 \text{ kg/kW.h} = 23.2 \text{ kg/h fuel}$
- Calculate air consumption  $M_a = M_f \cdot A/F$ 
  - $M_a = 23.2 \text{ kg/h fuel} \cdot 27 = 627 \text{ kg/h air}$
- Calculate Theoretical air consumption  $M_{at} = D \cdot N / r_c \cdot \text{ambient Density}$ 
  - $M_{at} = 5.1 \cdot 2200 / 2 \cdot 60 \cdot 1.16 / 1000 = 390 \text{ mkg/h air}$
- Calculate volumetric eff.  $e_v = M_a / M_{at}$ 
  - $E_v = 627 / 390 = 1.61$
- Assume Compressor efficiency & Calculate  $e_v = (P_2 / P_1)^* (T_1 / T_2)$
- $T_2 / T_1 = 1 + [P_{rc}^{0.286} - 1] / e_c$        $e_v = (P_{rc}) / (1 + [P_{rc}^{0.286} - 1] / e_c)$ 
  - $1.61 = (P_{rc}) / (1 + [P_{rc}^{0.286} - 1] / 0.7)$
  - $P_{rc} = 2.2$
- From Chart find  $e_c$  given  $M_a = 627 \text{ kg/h}$ ,  $P_{rc} = 2.2$ 
  - $e_c = 0.76$  from chart
- Repeat above with new Compressor efficiency
- $T_2 / T_1 = 1 + [P_{rc}^{0.286} - 1] / e_c$        $e_v = (P_{rc}) / (1 + [P_{rc}^{0.286} - 1] / e_c)$ 
  - $1.61 = (P_{rc}) / (1 + [P_{rc}^{0.286} - 1] / 0.76)$
  - $P_{rc} = 2.1$

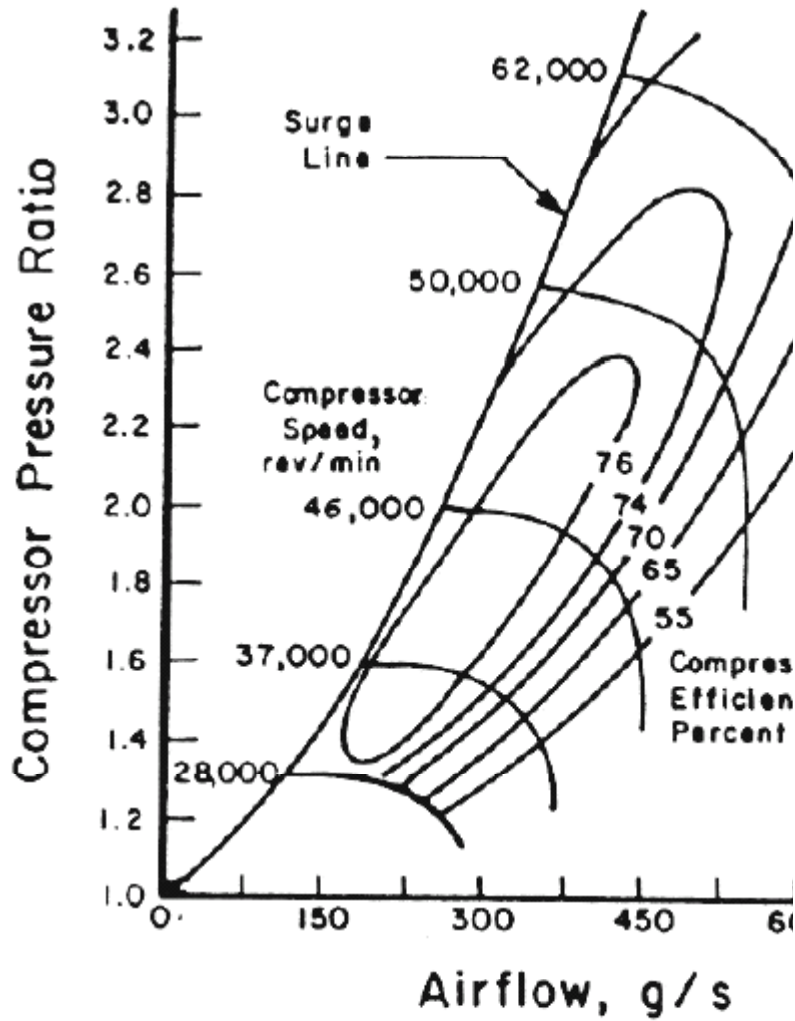


Figure 8.6. A compressor performance map.

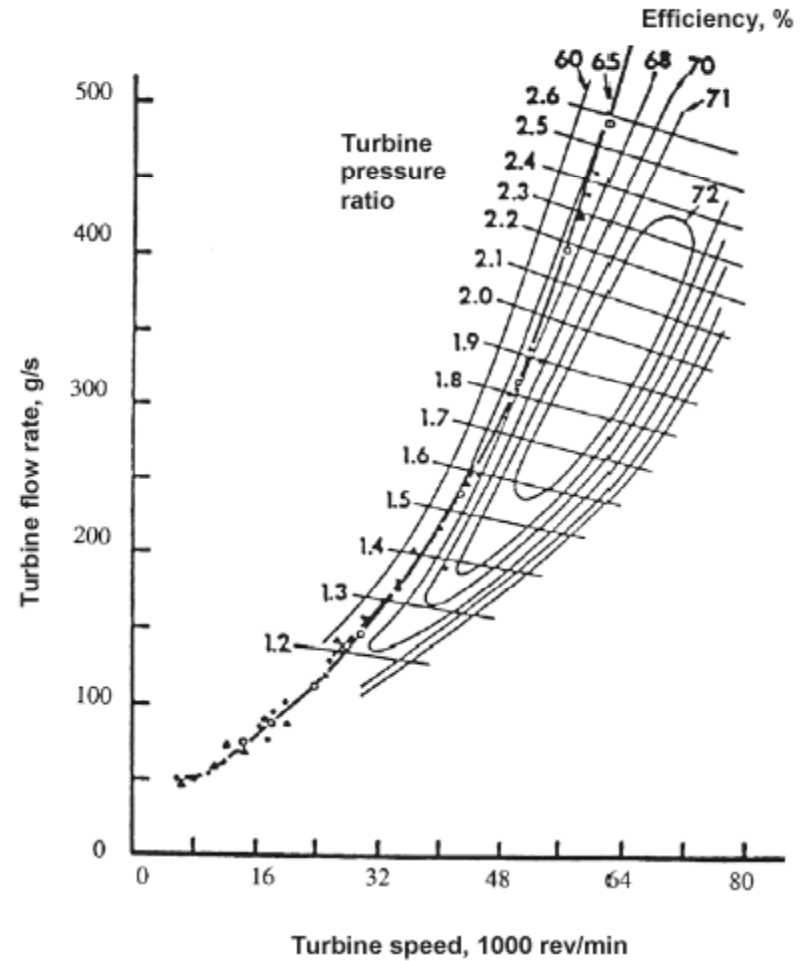
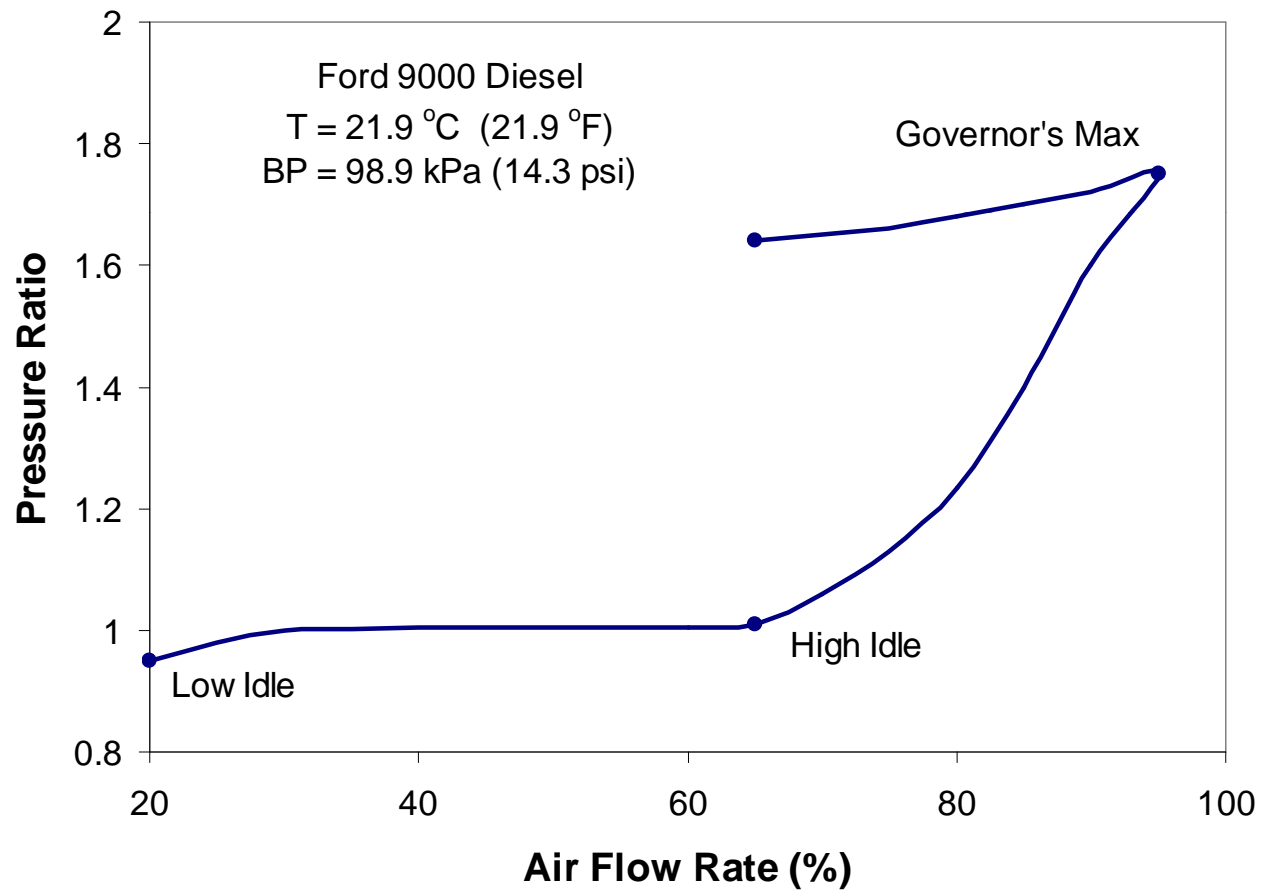
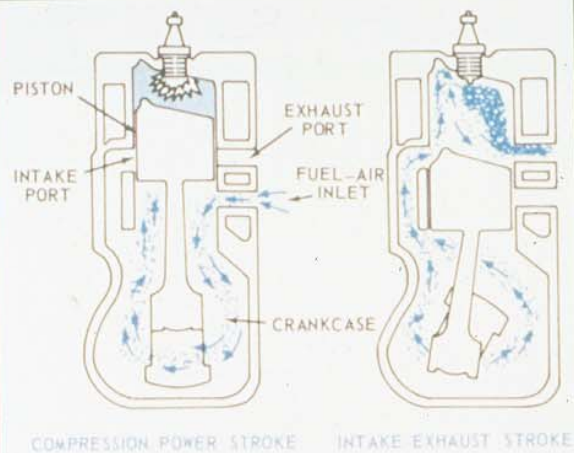


Figure 8.7. A turbine performance map.

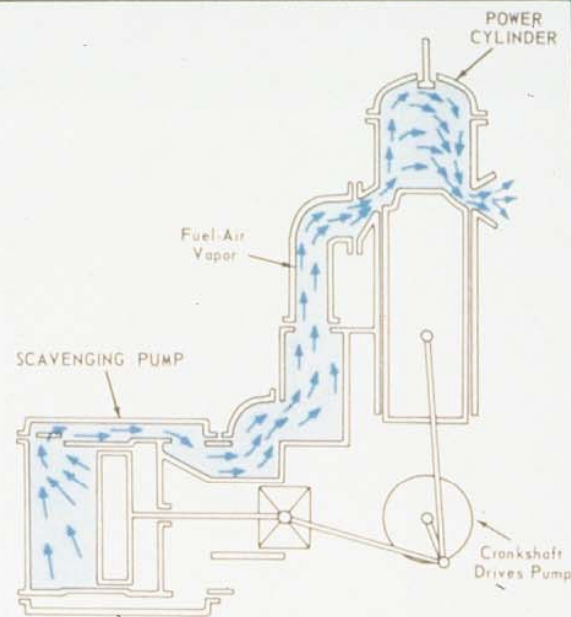
# Intake Manifold Pressure Ratio and AirFlow



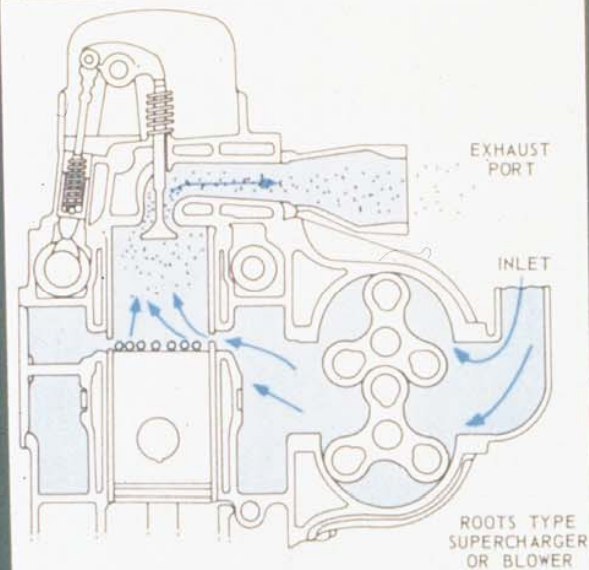
SUPERCHARGERS FOR TWO-CYCLE ENGINES



X 1285  
Fig. 32 — Crankcase Scavenging In Two-Cycle Engine



X 1288  
Fig. 33 — Power-Piston Scavenging



X 1294  
Fig. 34 — Positive-Displacement Blower

## Intercoolers

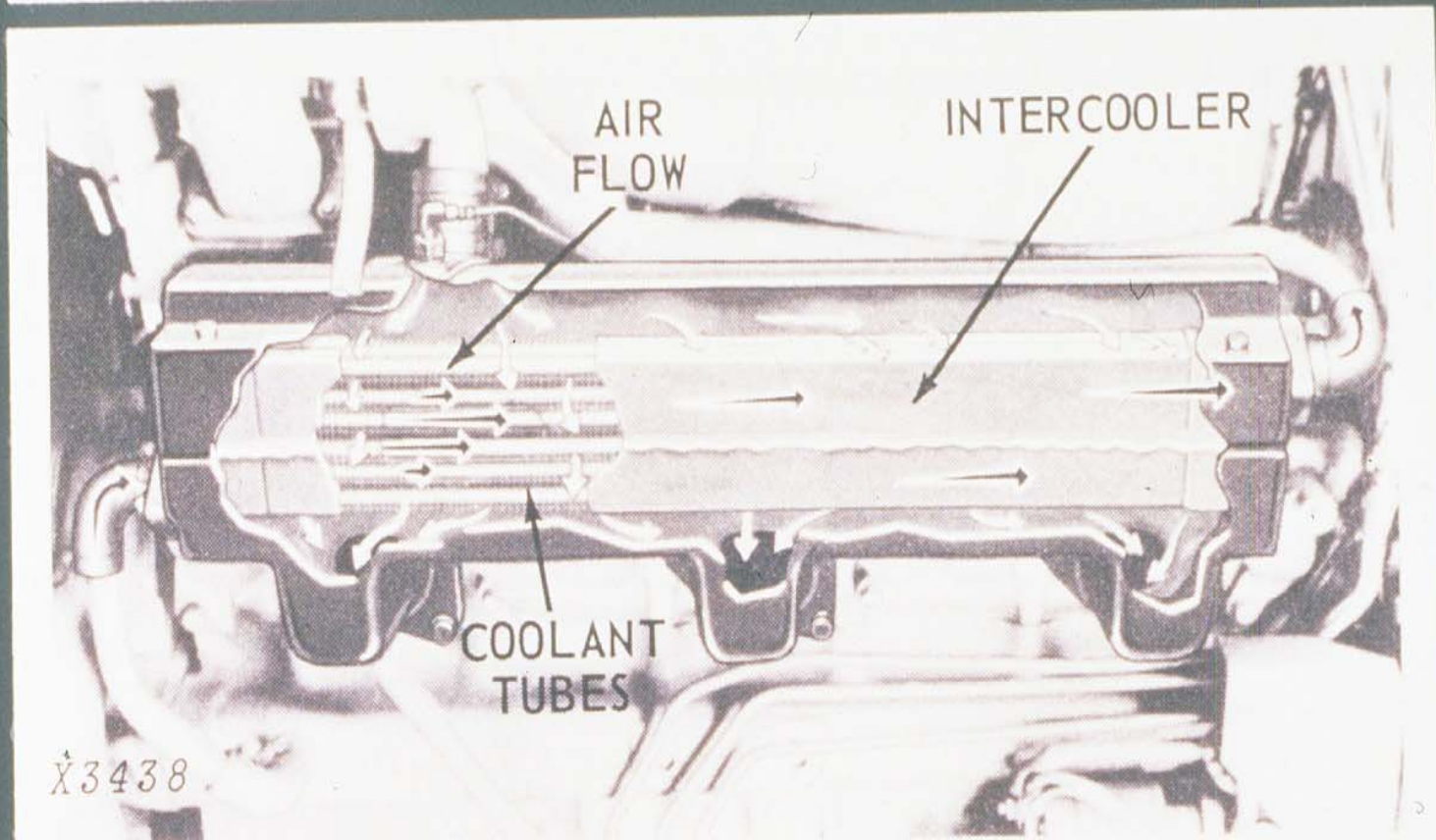


Fig. 37 — Cutaway View of Intercooler