3) **Coefficient of Heat Expansion:** is the tendency of matter to change in volume in response to a change in temperature, or the change amount in density. It depends on API, where decreases with decreasing in API. This property is an important issue in desining of fuel tanks. The following Table is used for this purpose.

API	Coefficient of Expansion
0 – 14.9	0.00035
15 – 34.9	0.00040
35 – 50.9	0.00050
51 – 63.9	0.00060
64 – 78.9	0.00070
79 – 88.9	0.00080
89 – 93.9	0.00085
94 - 100	0.00090

Also Fig. 12. is used to find the change amount via changing in density.

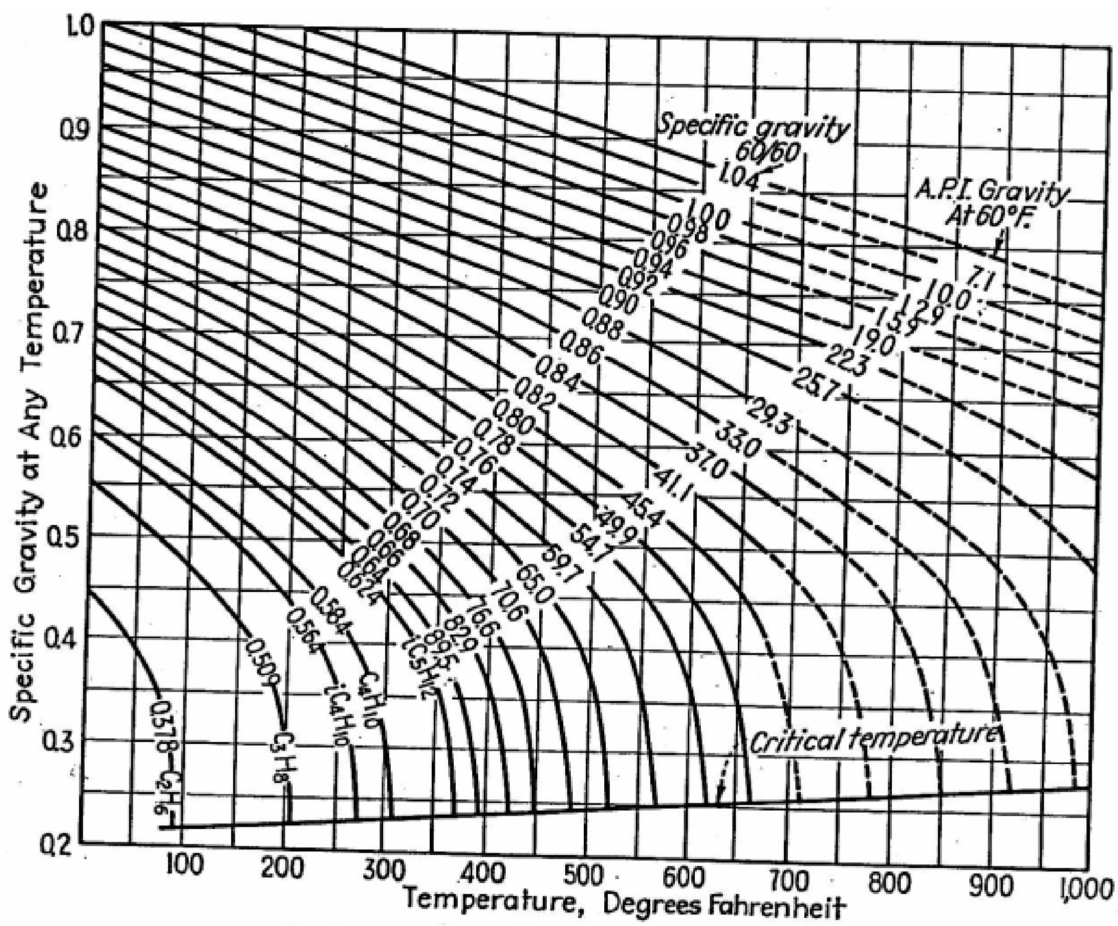

Fig. 16. Approximate change of specific gravity of intermediate- base oils with T.

Ex: One barrel at 19 API oil is to be heated from 60 to 400 F. What volume will it occupy?
Sol: From Table above, Coeff. of Expansion = 0.0004,
Increase in vol. = 1bbl * (400-60) *0.0004 = 0.136bbl
Total vol. = 1+0.136 = 1.136 bbl

Using Fig. 16,
Sp.gr at 60 F (19 API) = 0.942, sp.gr at 400F (19 API)= 0.83
Vol. at 400F = 1bbl *(0.94/0.83) = 1.13

4) **Latent Heat of Vaporization:** is the amount of energy in the form of heat released or absorbed by a substance during a change of phase (i.e. solid, liquid, or gas), or the heat required to complete vaporization under atmospheric pressure.

Fig. 17. is used to find the latent heat of vaporization under atmospheric pressure.

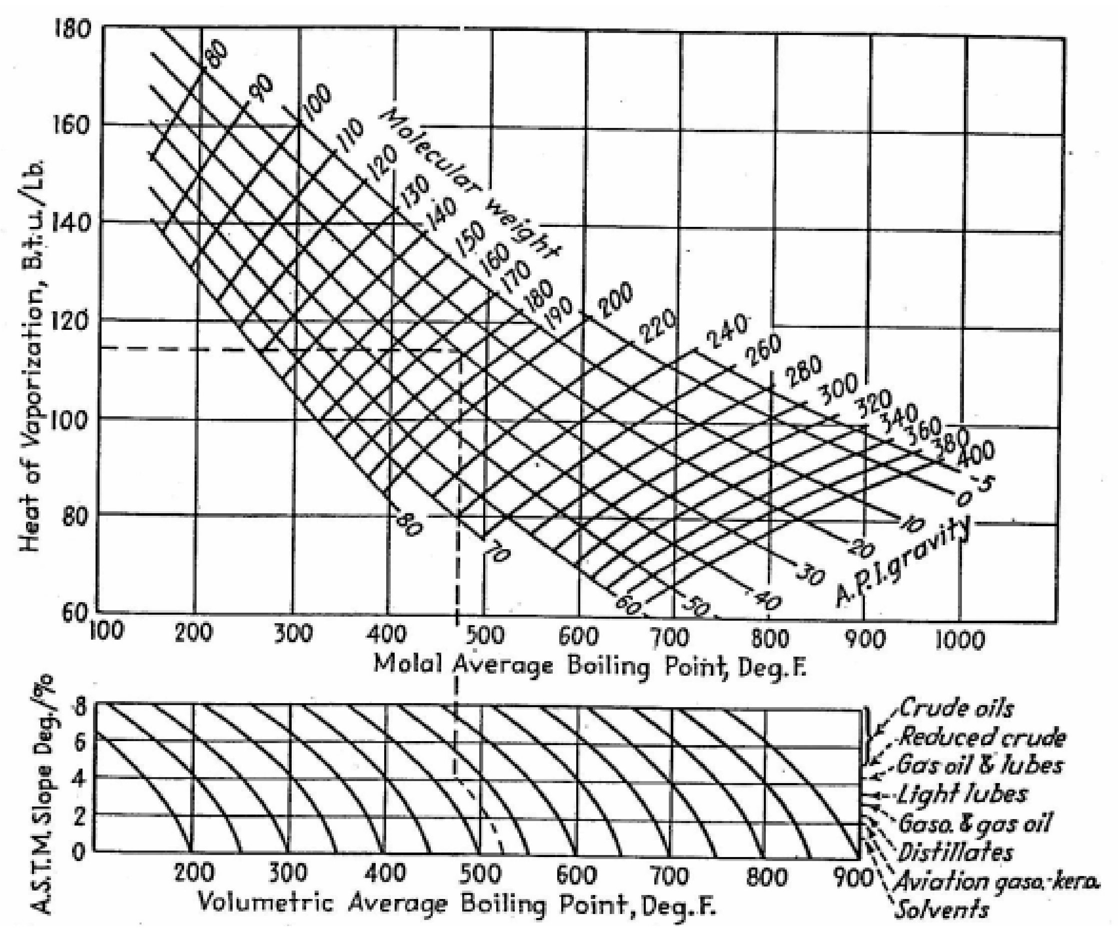

Fig. 17. Atmospheric latent heat of vaporization as a function of molecular weight or API gravity

It can also be calculated at any temp. or press. from the following eq.

$$L = \gamma L_B \frac{T}{T_B}$$

L = is the latent heat of vaporization at any T or P
L_B = is the latent heat of vaporization at normal B.P
γ = correction factor (from Fig. 18)
T = any temp. (R)
TB = normal B.P (R)

Also, Fig. 19 can be used to find MABP (normal B.P)

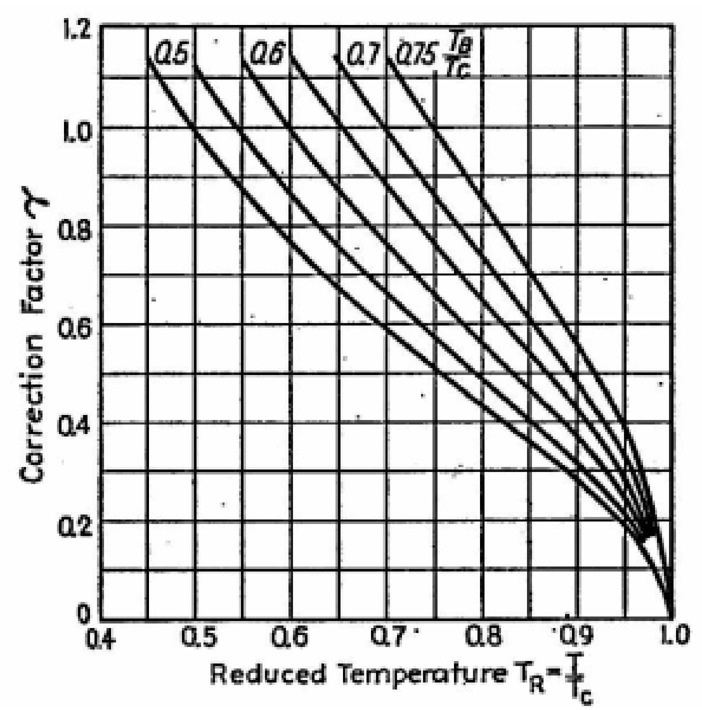

Fig. 18. Temp. correction to heat of vaporization

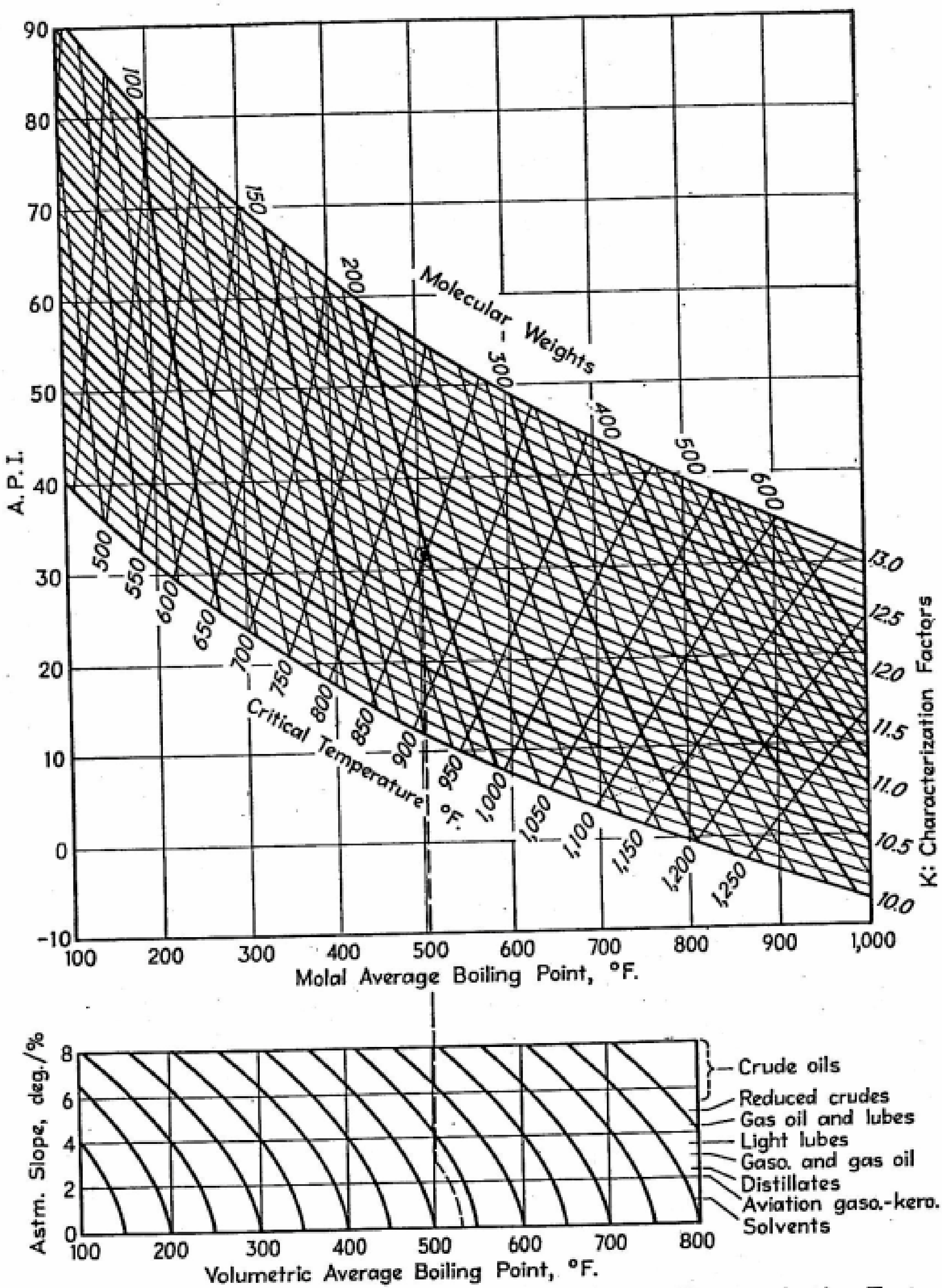

Fig. 19. Molecular weight, pseudo critical temp., charactrization factors and gravities of petroleum fractions

Ex: A mixed base has a gravity of 35 API. The latent heat of this fraction at atmospheric press. and also at 500F is required. Kw =11.9.

Sol.:
From Fig. 15, at API = 35 and Kw=11.9, the MABP = 580F
From Fig. 17 at API = 35 and MABP = 580F, Latent Heat = 92 Btu/lb
In order to estimate La at 500 F, additional factors must be set down

From Fig. 19, Tc = 900F (1360R), $T_R = T/T_C = ((500+460)/1360) = 0.706$, $T_B/T_C = 0.765$
From Figure 18, $\gamma = 1.16$

$$\therefore L = 1.17 \times 92 \times \frac{500+560}{1040} = 98 Btu/lb$$

If T = Tc, γ will be zero and then L = 0

5) **Heat Content (or Enthalpy):** refers to the required heat to rise the substance temperature. Figure 16 is used to find the heat content.

Ex: A sample of gasoline (API = 56) at 60F and Kw=11.4 is to be heated, vaporized and superheated to 500F at 200psia. Calculate the heat required 2) specific heat of vapor.

Sol.: From Fig. 20,
Heat content at 60F = 28 Btu/lb
Heat content at 500F = 397 Btu/lb
Correction of pressure (upper left Fig within Fig.20) = 8 Btu/lb
Correction of Kw (upper center Fig. within Fig. 20) = 0.97 Btu/lb
Heat content at 60F corrected = 0.97 * 28 = 27 Btu/lb
So the heat required (difference between the heat of vapor and the heat of the liquid) =
397 – 27 – 8 = 385 Btu/lb
2) cp for vapor will be between 400 and 500F, So we need the value of T_B (can be calculated from Watson law or from Fig. 19)
T_B = 190F
Then we have to find the temp. under 200psia, which is estimated from Fig. 21
$T_{B.P}$ = 400F
Then from Fig. 14 at $T_{B.P}$ and API
cp = 0.55

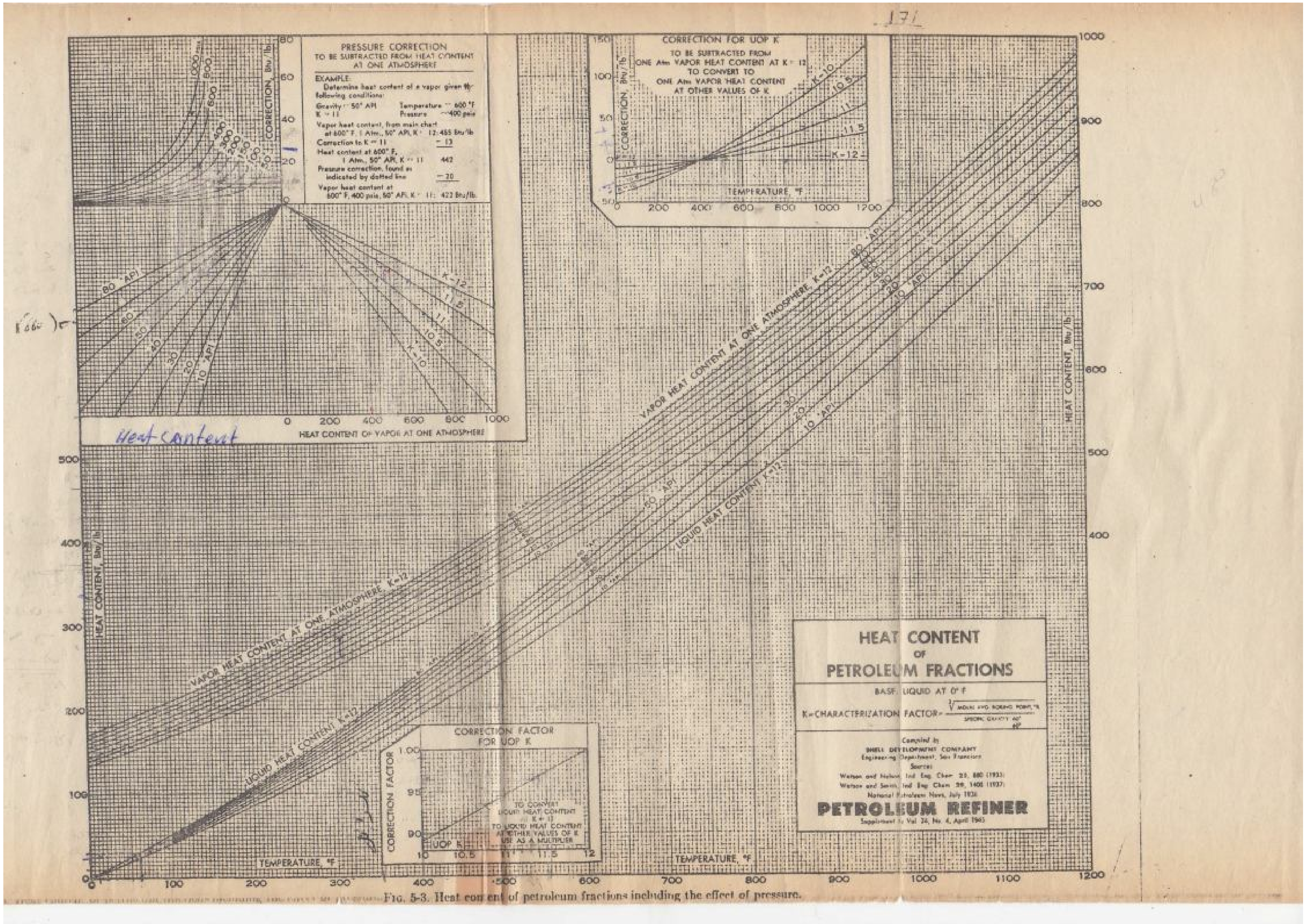

Fig 20: Heat content of petroleum fractions

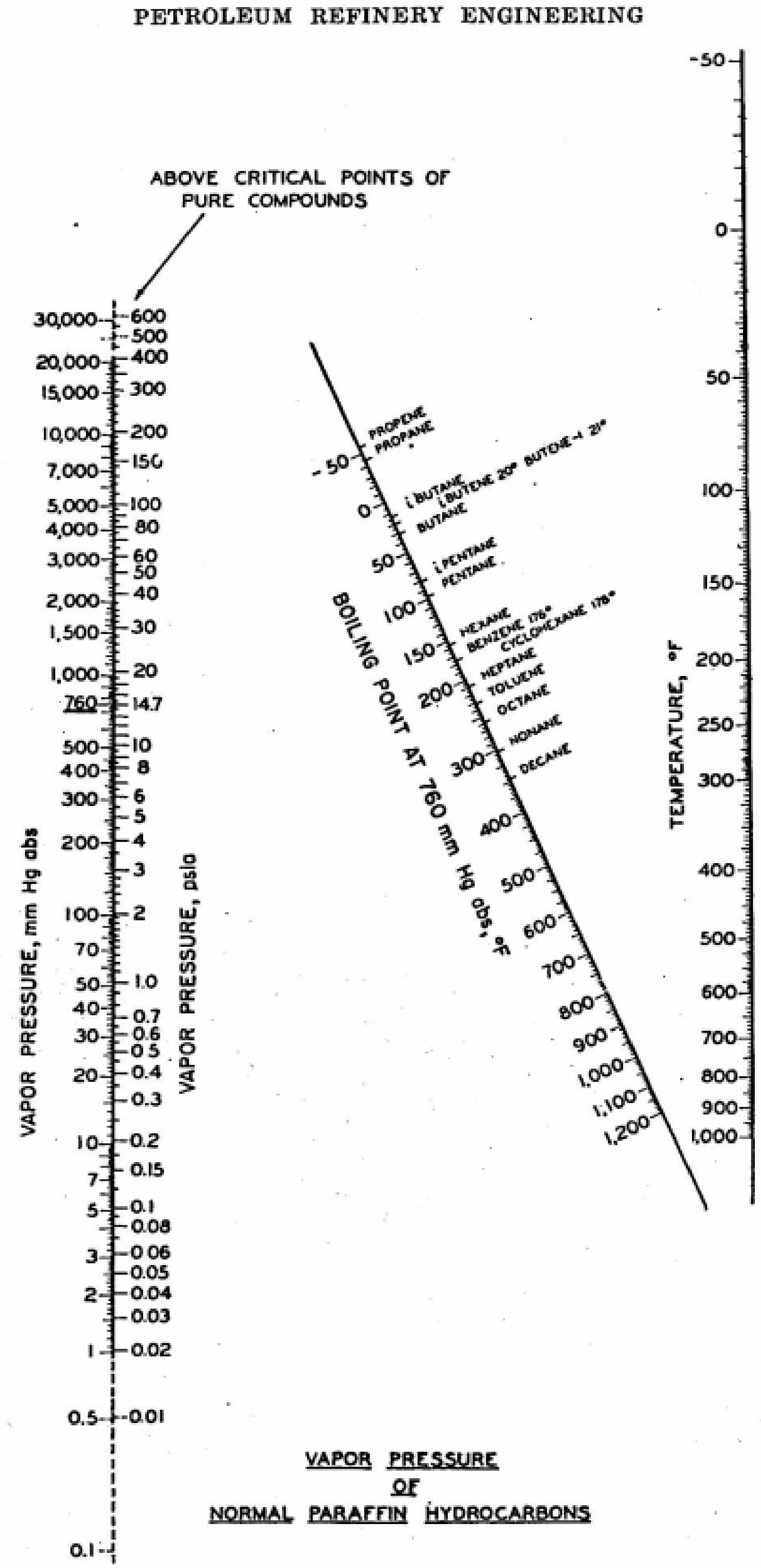

Fig. 21.Vapor Pressure and B.P. corrections for normal paraffins hydrocarbons and petroleum fractions