Physical Properties of Hydrocarbons

Part 41—Cyclic Hydrocarbons

From charts you can get these properties for cyclic hydrocarbons:

- Vapor Pressure
- Heat of Vaporization
- Heat Capacity
- Density
- Viscosity
- Surface Tension
- Thermal Conductivity

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Of the cyclic compounds, cyclohexane is the only major commercial product. The major source of cyclohexane is the hydrogenation of benzene. Most of the two billion pounds a year goes into nylon production. With nylon usage continuing to grow rapidly, cyclohexane can look forward to continued good growth.

Cyclopropane, cyclobutane, and cyclopentane are specialty products. Cyclopropane is widely used as an anesthetic. Cyclopentane became available in commercial quantities for the first time in 1968.

Critical Properties and Vapor Pressure. The critical properties have been measured for cyclopentane[1, 2, 3, 4] and cyclohexane.[1, 5] The critical temperature and pressure are available for cyclopropane.[6] The other critical constants were calculated by the method proposed by Lydersen.[7] When compared with the experimental values for the other compounds, this method gave an average error of 0.5 percent for critical temperature and density, and 1 percent for critical pressure.

The vapor pressures up to the critical point are reported in the literature for cyclopropane[6, 8, 9] and cyclohexane,[8, 10, 11, 12] and to the boiling point for cyclobutane[8, 13] and cyclopentane.[3, 5, 8] The vapor pressures above one atmosphere were estimated by the method used in previous articles,[14] with a probable error of 2-3 percent.

Heat of Vaporization. Various experimenters have measured the heat of vaporization at the boiling point for all four compounds.[3, 5, 9, 10, 13, 15, 16, 17] Kharbanda's nomograph was used to extend the data to other temperatures.[18]

Heat Capacity. The vapor heat capacities have been determined for all but cyclobutane.[16, 19, 20, 21, 22] Cyclobutane was estimated from its molecular structure.[23]

Liquid heat capacity data are available for cyclopropane from −123° C to −30° C;[3, 9] for cyclobutane from −83° C to +7° C;[13] for cyclopentane from −87° C to +27° C;[3] and for cyclohexane from its melting point to 93° C.[3, 24, 25] The data were extended over a wider temperature range by the equation used in previous articles. Nine experimental values showed an average error of 3.2 percent and a maximum of 7.5 percent.

Density. The density of cyclohexane has been measured from its melting point to the critical point.[3, 11, 12, 26, 27, 28] Data on the other three compounds are available up to the boiling point.[4, 26, 27, 28, 29, 30] Lyderson's method[7] was used to calculate the densities up to the critical temperature. Comparison with eight experimental values gave an average error of 0.5 percent.

Viscosity. The vapor viscosities were estimated by the method proposed by Bromley and Wilke.[31] Comparison with the experimental data of McCoubrey and Singh[32] from 24° C to 184° C for cyclopentane showed an average error of 3 percent.

Extensive liquid viscosity data are reported for cyclopentane and cyclohexane from 0° to 80° C.[3, 5, 7, 11, 27] The viscosities of cyclopropane and cyclobutane were estimated by the method developed by Souders.[7] This equation, which relates the viscosity to the density and a structural constant, gave an average error of 6 percent for cyclopentane and cyclohexane.

Surface Tension. Data are available up to the boiling point for cyclopentane[5, 26] and cyclohexane.[11, 26, 33] Sudgen's method was used to calculate the surface tension of cyclopropane and cyclobutane and above the boiling point for cyclopentane and cyclohexane.[34]

Thermal Conductivity. The vapor and liquid thermal conductivities were estimated by the methods used in previous articles.[35, 36]

TABLE 41-1—Physical Properties of Cyclic Hydrocarbons

	Boiling Point, °C	Freezing Point, °C	Molecular Weight	Critical Properties Tc °C	Pc psia	dc g/ml
Cyclopropane	−32.8	−127.4	42.08	124.6	796	.243*
Cyclobutane	12.5	− 90.7	56.10	190*	713*	.258*
Cyclopentane	49.3	− 93.9	70.13	238.6	654	.270
Cyclohexane	80.8	6.5	84.16	281.0	596	.272

* Estimated.

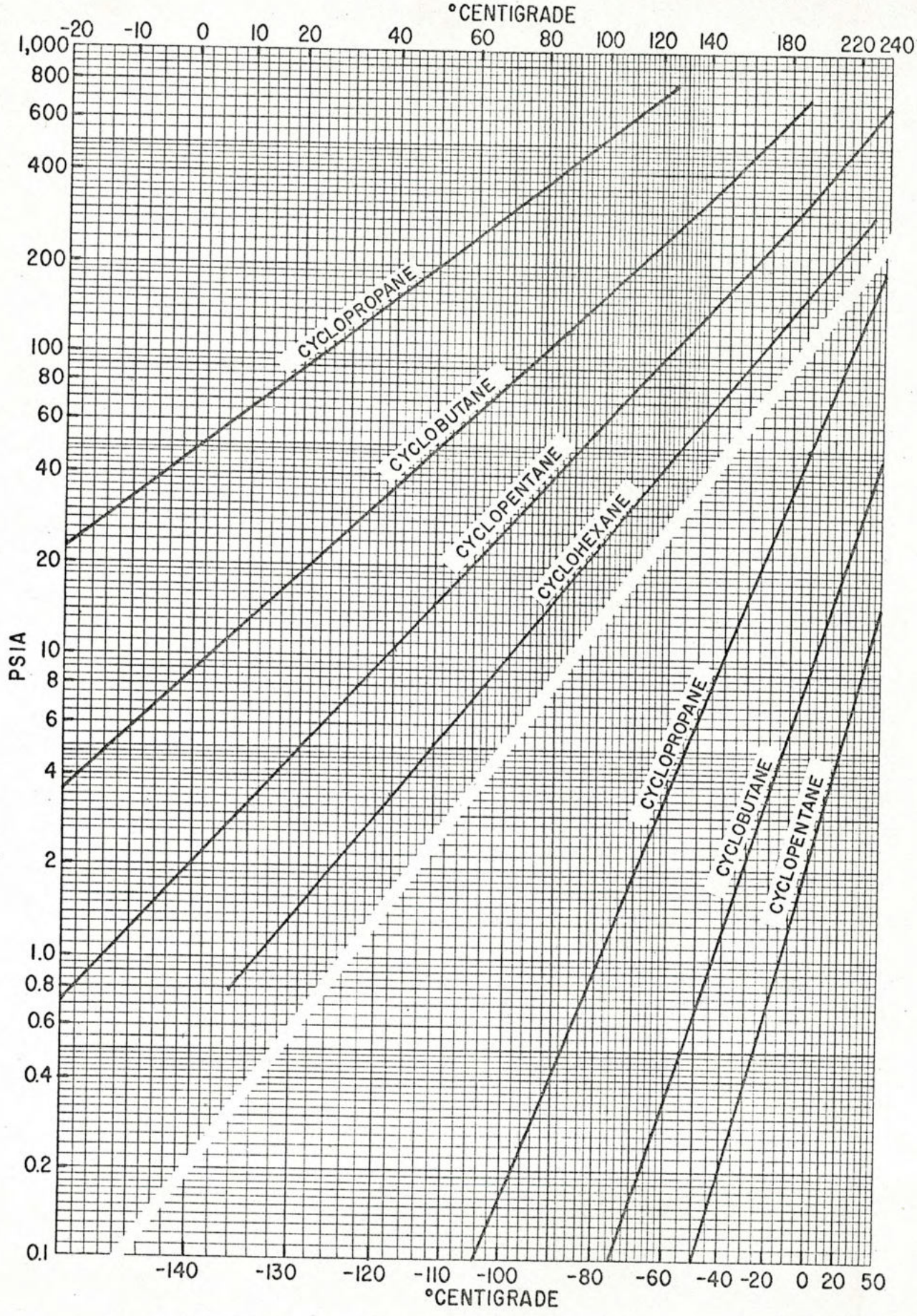

Fig. 41-1—Vapor pressure of cyclic hydrocarbons from —105° C to 240° C.

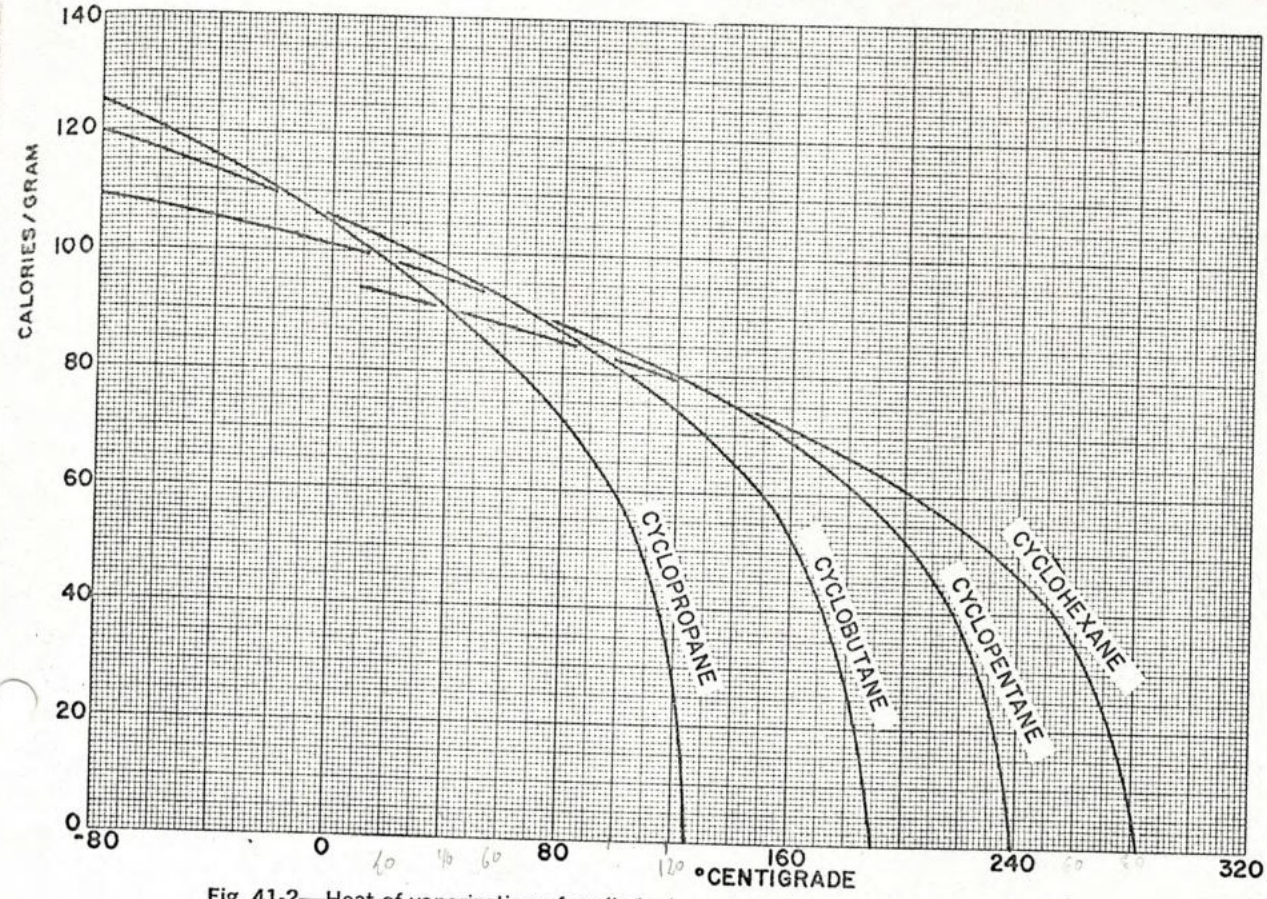

Fig. 41-2—Heat of vaporization of cyclic hydrocarbons from —80° C to +280° C.

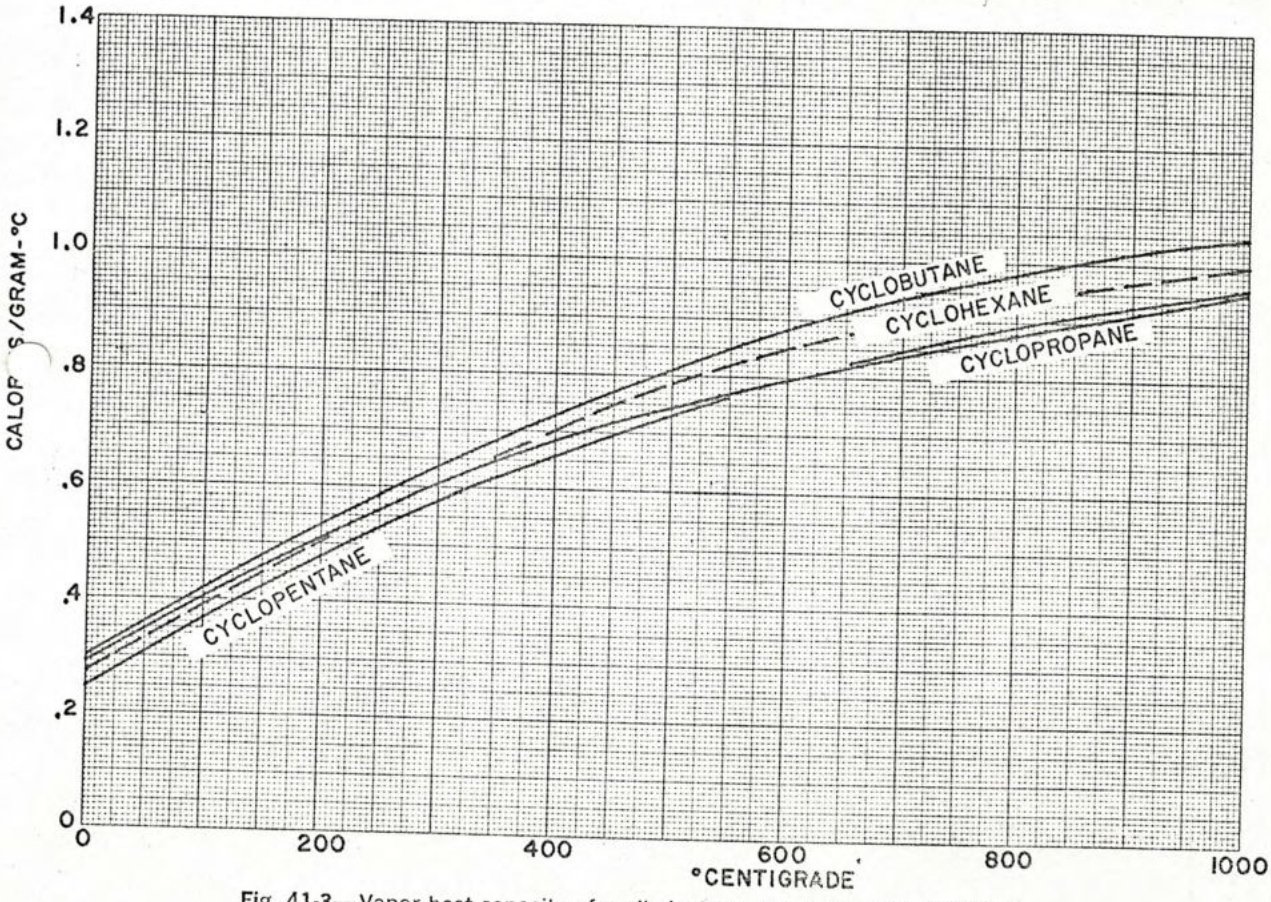

Fig. 41-3—Vapor heat capacity of cyclic hydrocarbons from 0 to 1000° C.

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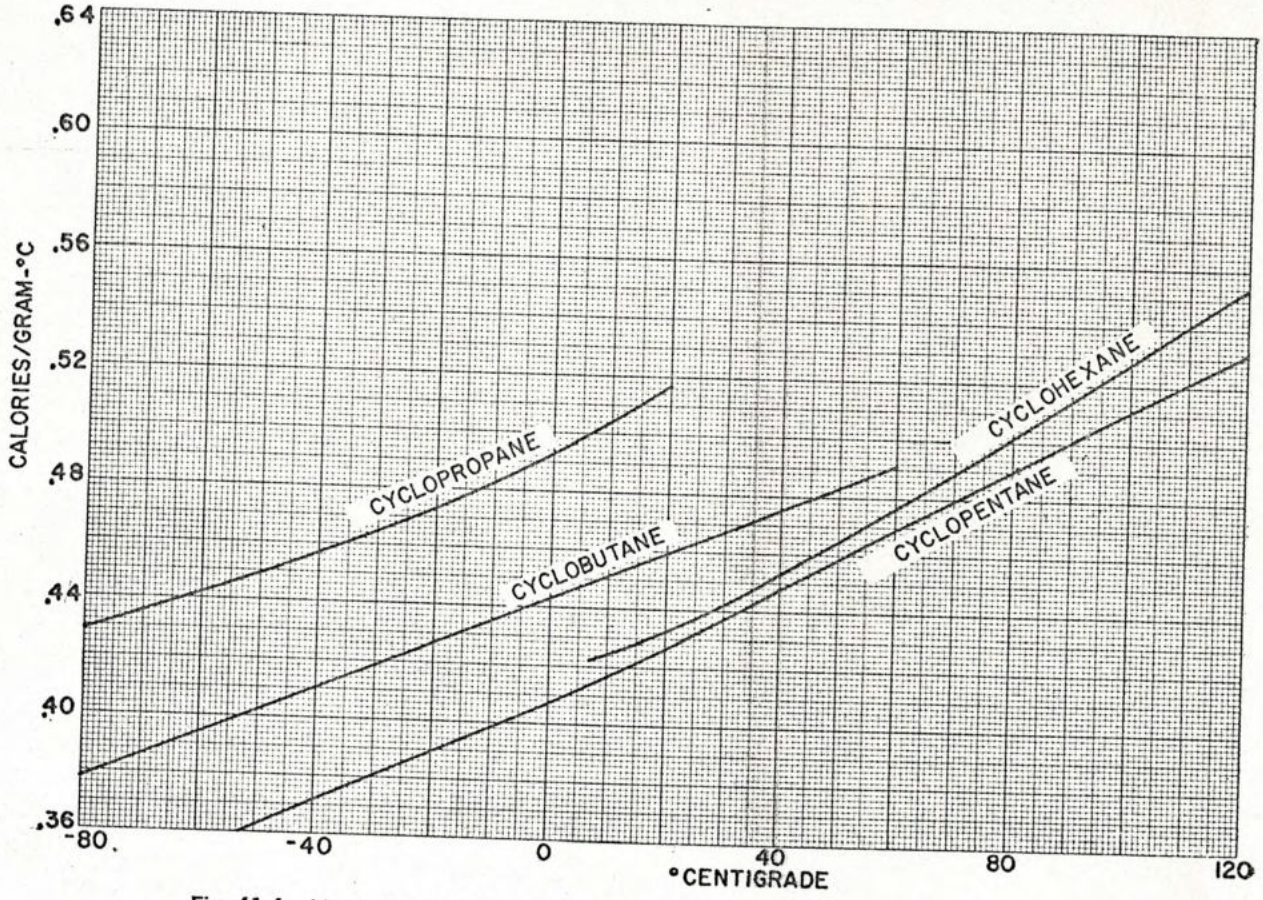

Fig. 41-4—Liquid heat capacity of cyclic hydrocarbons from —80° C to +120° C.

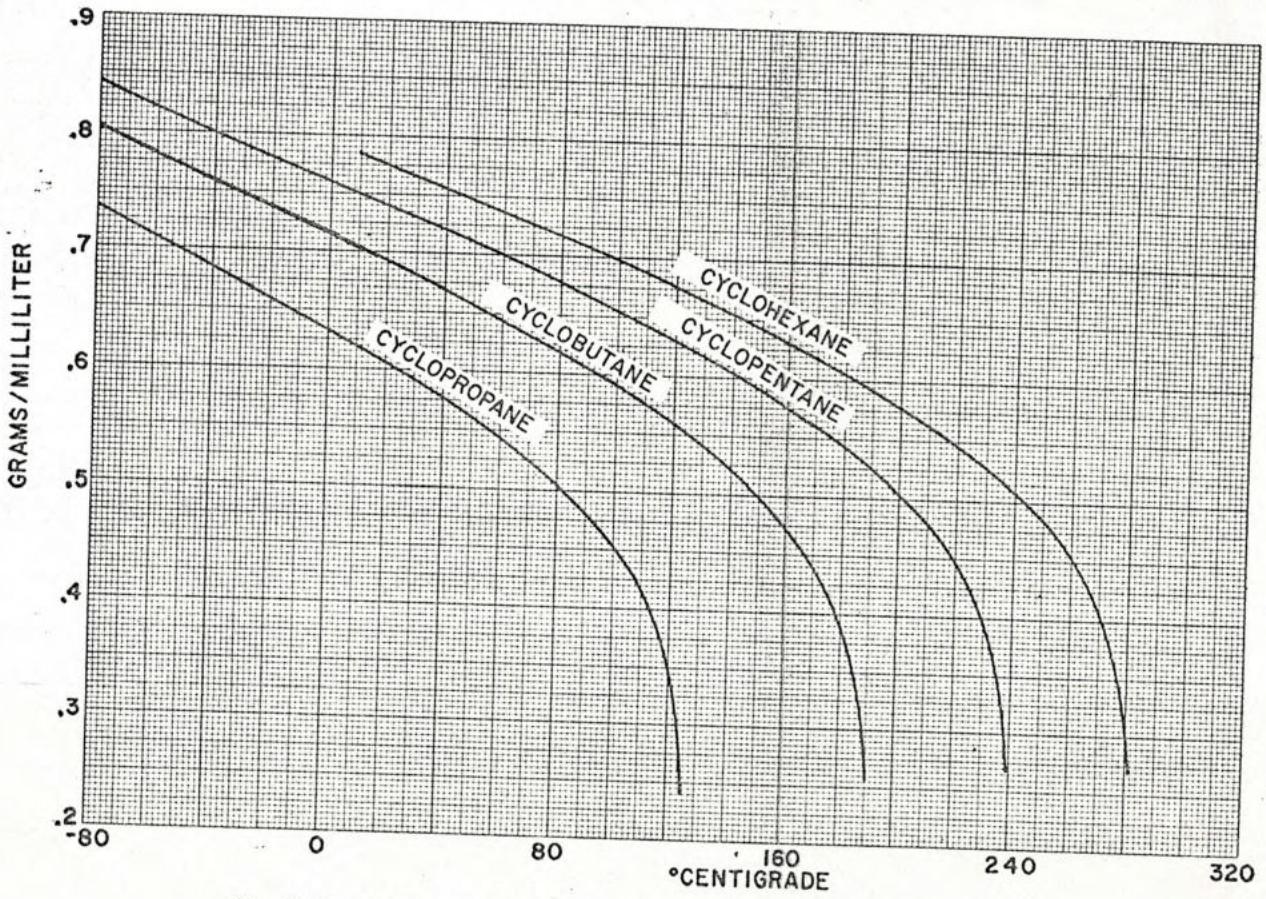

Fig. 41-5—Liquid density of cyclic hydrocarbons from —80° C to +280° C.

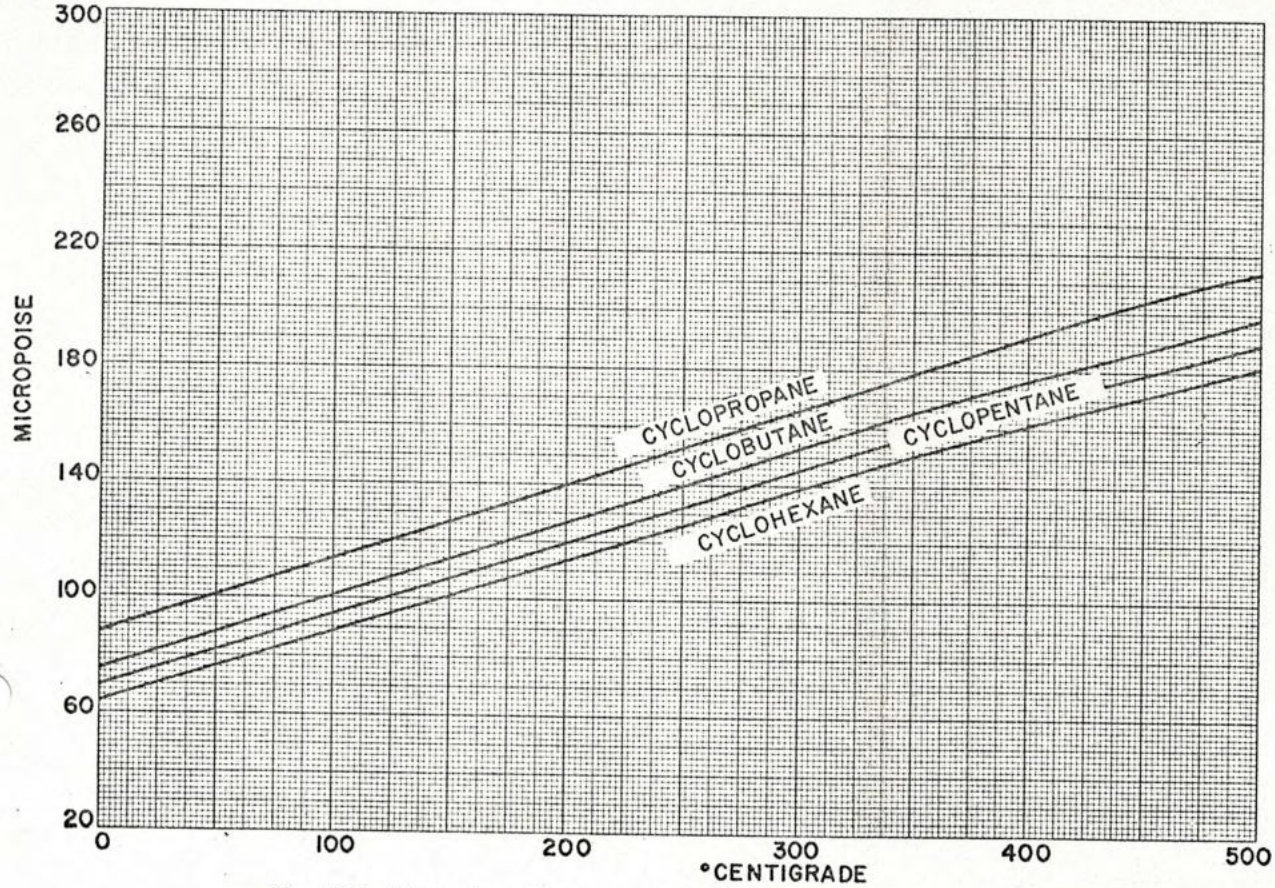

Fig. 41-6—Vapor viscosity of cyclic hydrocarbons from 0 to 500° C.

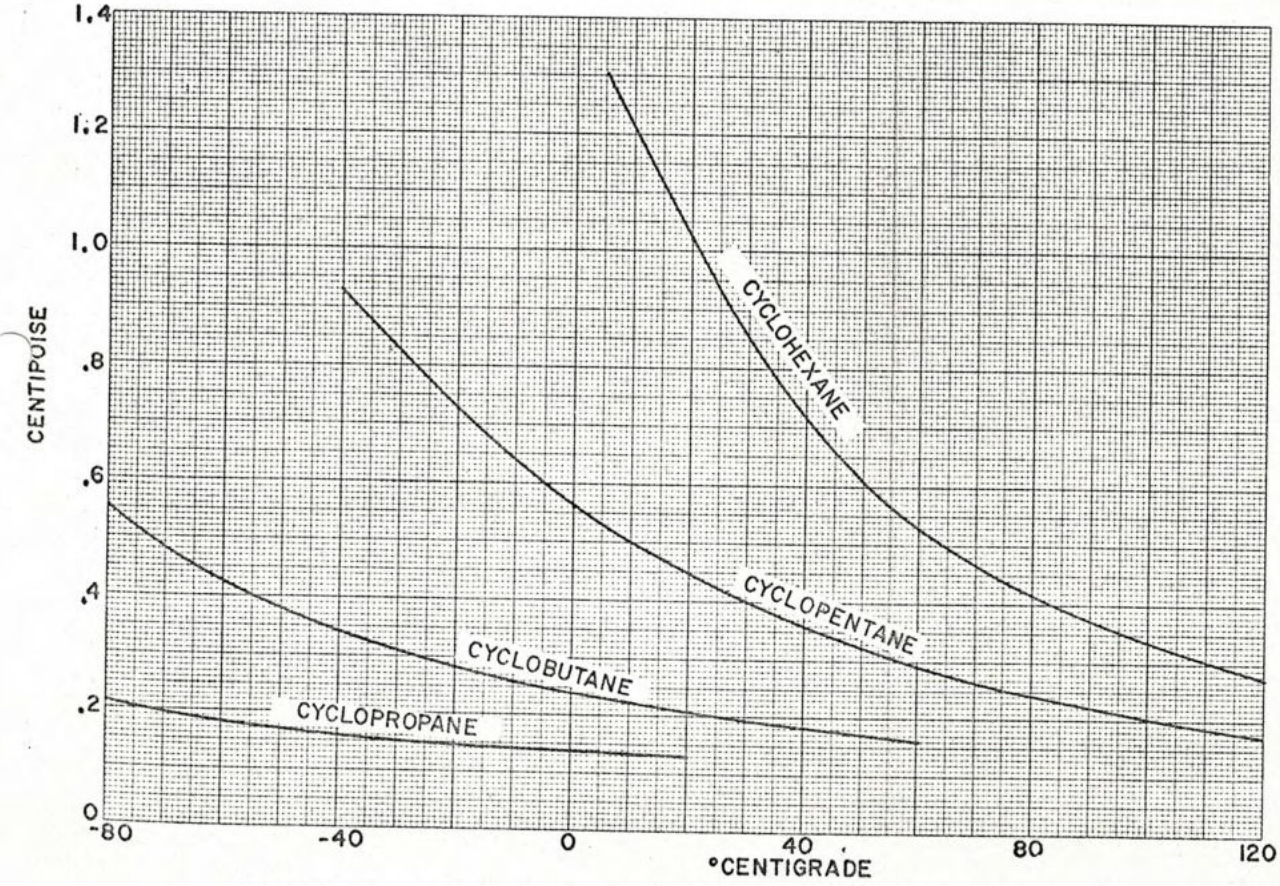

Fig. 41-7—Liquid viscosity of cyclic hydrocarbons from —80° C to +120° C.

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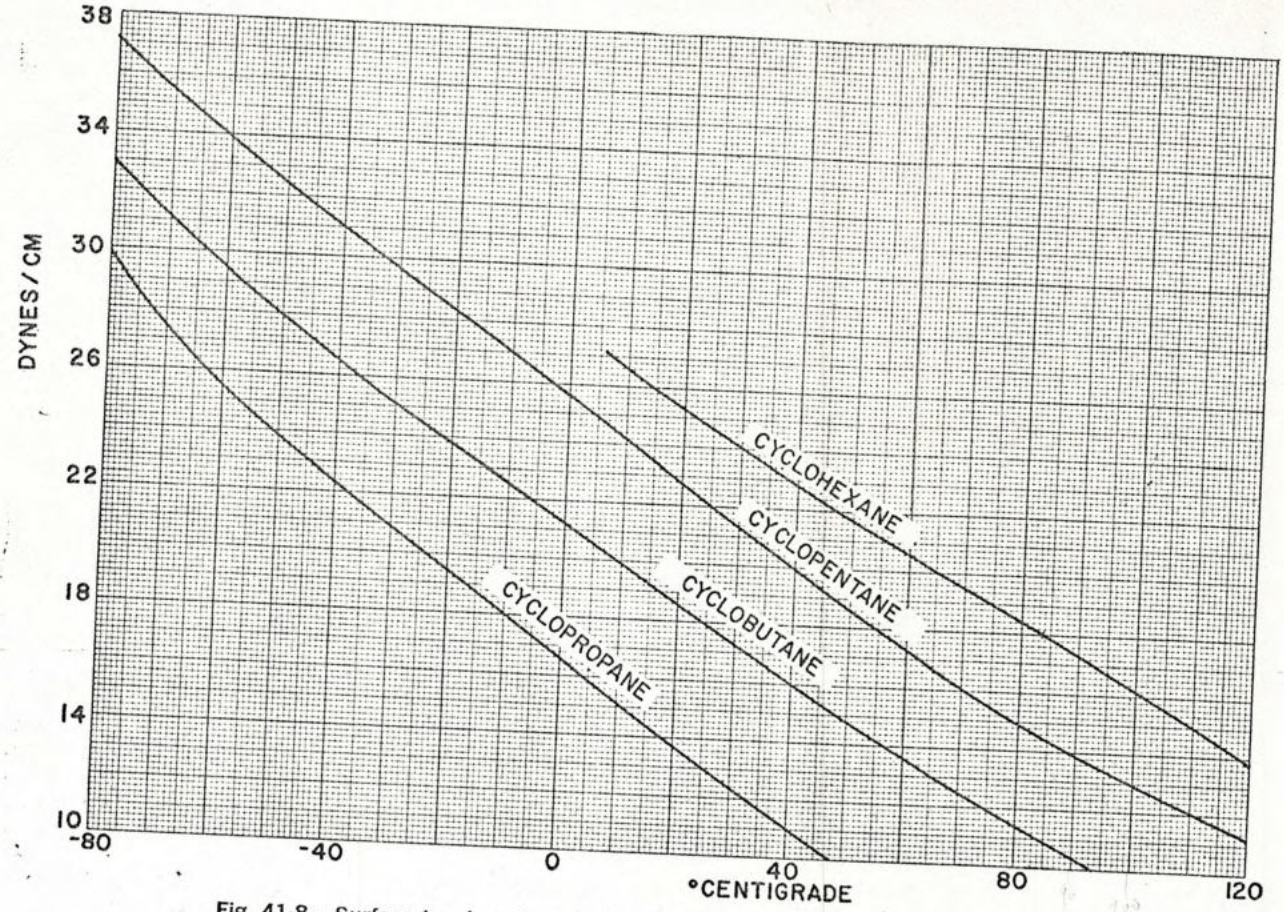

Fig. 41-8—Surface tension of cyclic hydrocarbons from —80° C to + 120° C.

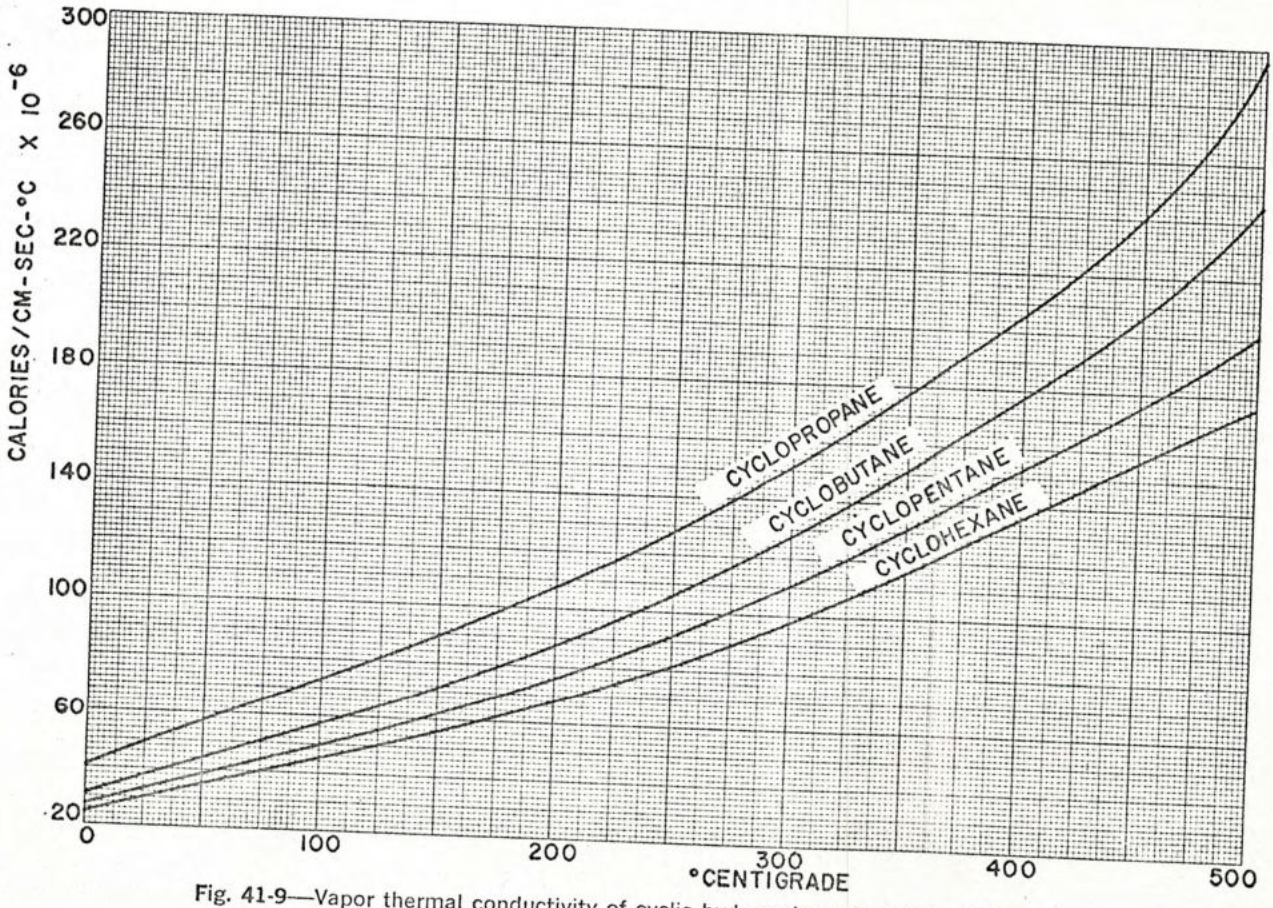

Fig. 41-9—Vapor thermal conductivity of cyclic hydrocarbons from 0 to 500° C.

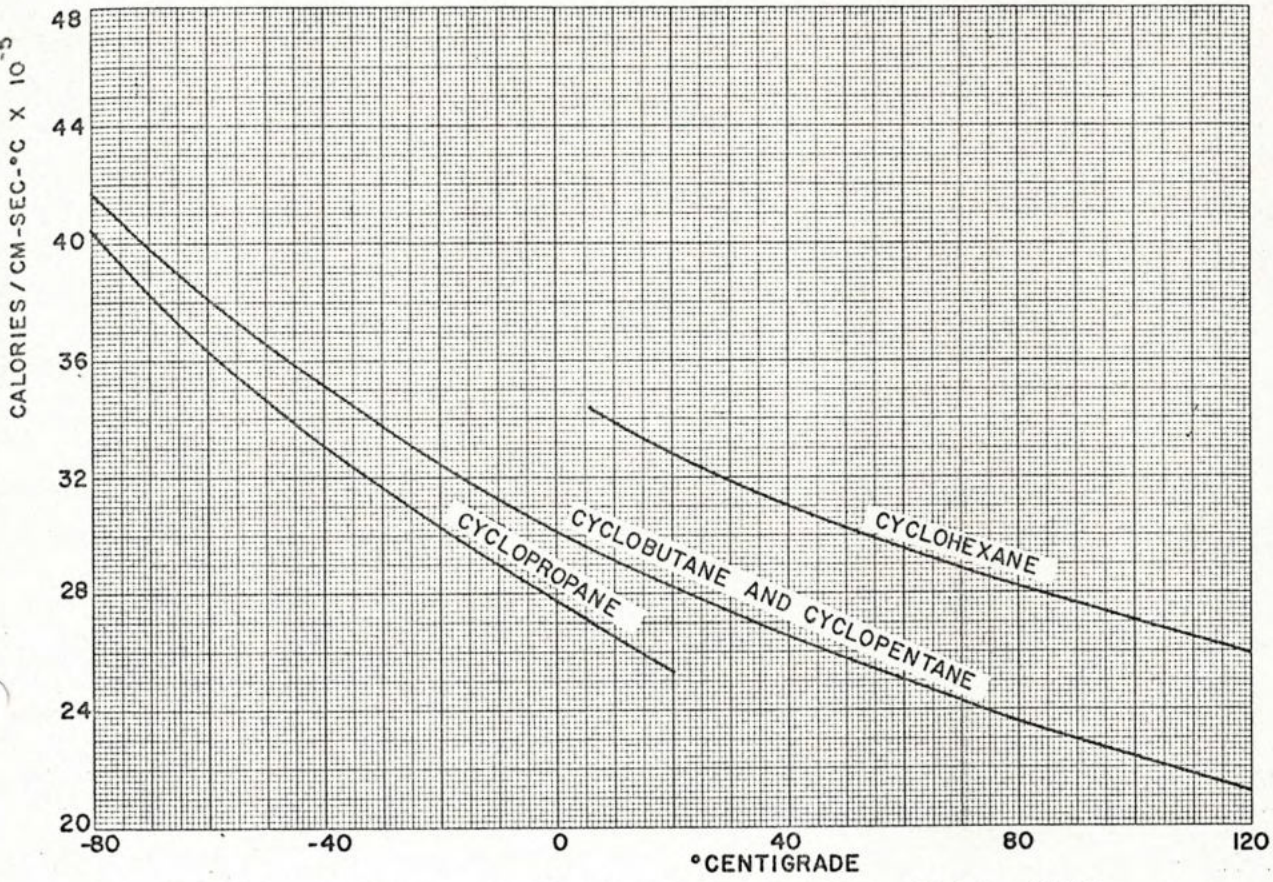

Fig. 41-10—Liquid thermal conductivity of cyclic hydrocarbons from —80° C to +120° C.

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Indexing Terms: Computations-4, Cyclobutane-9, Cyclohexane-9, Cyclopentane-9, Cyclopropane-9, Heat-7, Hydrocarbons-9, Liquid Phase-5, Physical Properties-7, Pressure-6, Properties/characteristics/-7, Temperature-6, Vapor Phase-5.

Part 42—Miscellaneous Cyclic Compounds will appear in an early issue