Physical Properties of Hydrocarbons

PART 37—Nitrogen Containing Compounds

From charts you can get these properties for nitrogen containing compounds:

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

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THE NITROPARAFFINS (nitromethane and nitroethane) became commercially available in the early 1940s. Several million pounds are produced annually by the vapor-phase reaction of propane and nitric acid at elevated temperature and pressure. These compounds and their derivatives find applications as fuels, solvents and explosives.

Ethylenimine is a relative newcomer as a commercial product, topping one million pounds per year for the first time in 1964. Its price has tumbled from $2 a pound to less than 90 cents a pound, because of a new process which produced it from ethylene dichloride and ammonia. With the unique properties imparted by ethylenimine and its derivatives to adhesives, coatings, flocculants and paper, ethylenimine seems destined to become a major industrial chemical.

Hydrazine achieved prominence initially as a rocket fuel, but also finds wide-range use in fuel cells, agricultural chemicals, boiler water treatment and blowing agents. It is produced by the reaction of sodium hypochlorite with either ammonia or urea.

Critical Properties and Vapor Pressure. The critical properties of nitromethane have been reported in the literature.[1] Clark presents the critical temperature and pressure of hydrazine.[2] The other critical properties have been estimated by the methods of Lydersen.[3]

Vapor pressure data are available for nitromethane up to 200° C,[4,5,6] for hydrazine up to the critical point[2,7] and for nitroethane and ethylenimine below the boiling point.[6,8,9] The vapor pressures above the boiling point were estimated by the equation used in previous articles.[10] When compared with experimental data for nitromethane, the average error was 1.5 percent.

Heat of Vaporization. Experimental data are reported for nitromethane from 25 to 100° C,[5,11] for ethylenimine[9] at 20° C and for hydrazine at 25° C and 114° C.[3,12] The method of Giacalone[3] was used to calculate the heat of vaporization of nitroethane at the boiling point, with a probable error of 3 percent. The data were extended over a wide temperature range by the Kharbanda nomograph.[13]

Heat Capacity. The vapor heat capacities of nitromethane,[5,14] ethylenimine[9] and hydrazine[12,15] have been

TABLE 37-1—Physical Properties of Nitrogen-Containing Compounds

	Boiling Point, °C	Freezing Point, °C	Molecular Weight	Critical Properties		
				T_c °C	P_c psia	d_c g/ml
Nitromethane	101.2	−28.6	61.06	315	915	0.352
Nitroethane	114.1	−89.5	75.07	303*	749*	0.329*
Ethylenimine	57.0	−74.1	43.07	260*	993*	0.276*
Hydrazine	113.5	2.0	32.05	380	2126	0.333*

* Estimated.

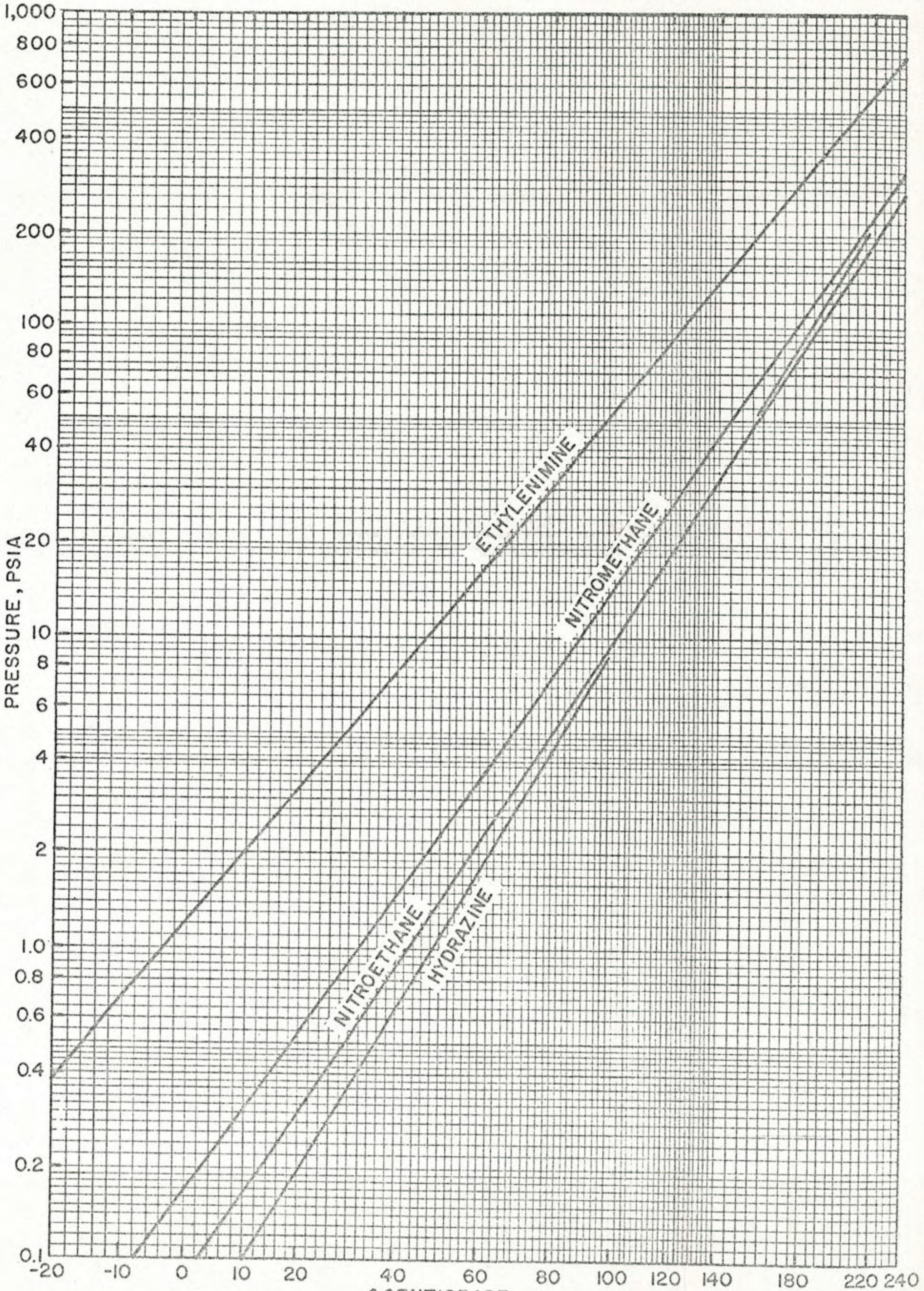

Fig. 37-1—Vapor pressure of nitrogen containing compounds from −20°C to + 240°C.

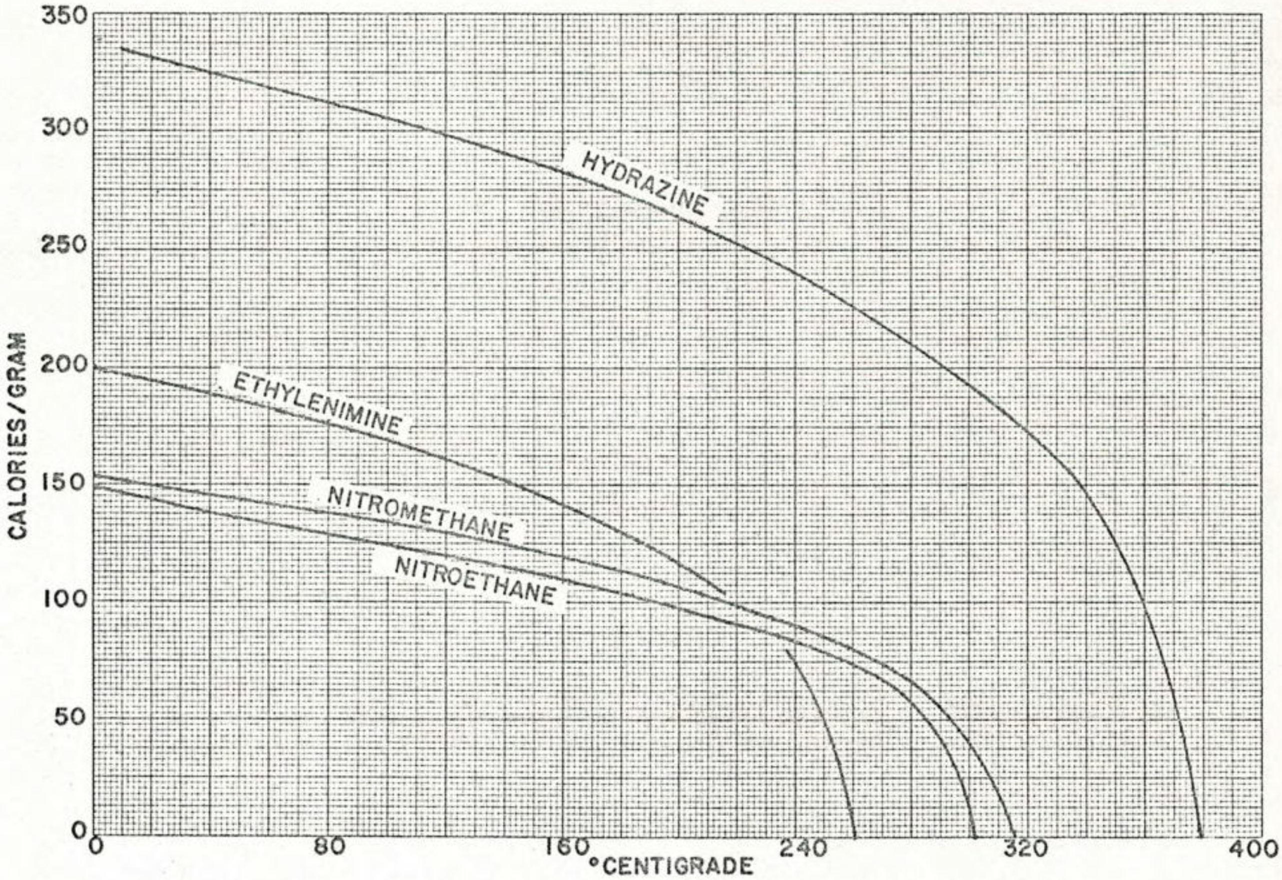

Fig. 37-2—Heat of vaporization of nitrogen containing compounds from 0° C to 380° C.

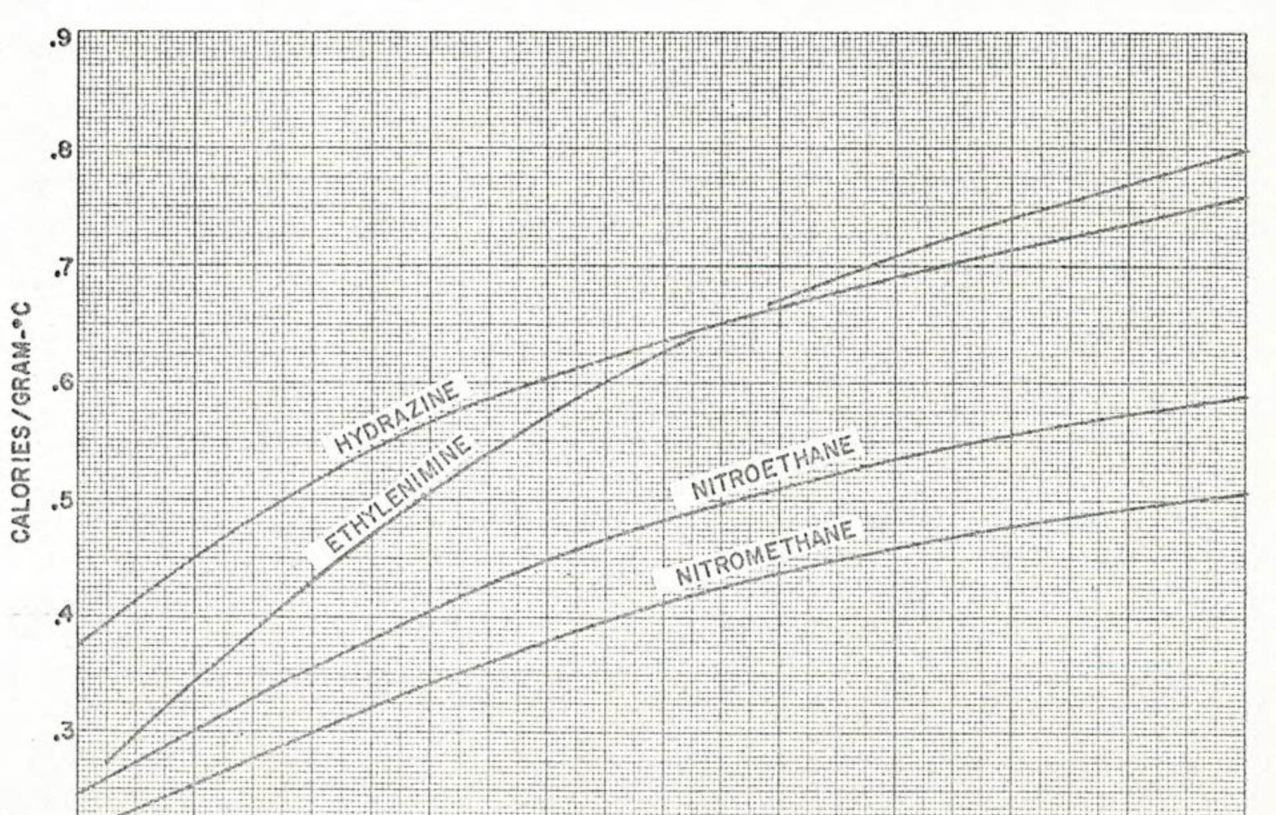

Fig. 37-3—Vapor heat capacity of nitrogen containing compounds from 0°C to 1,000°C.

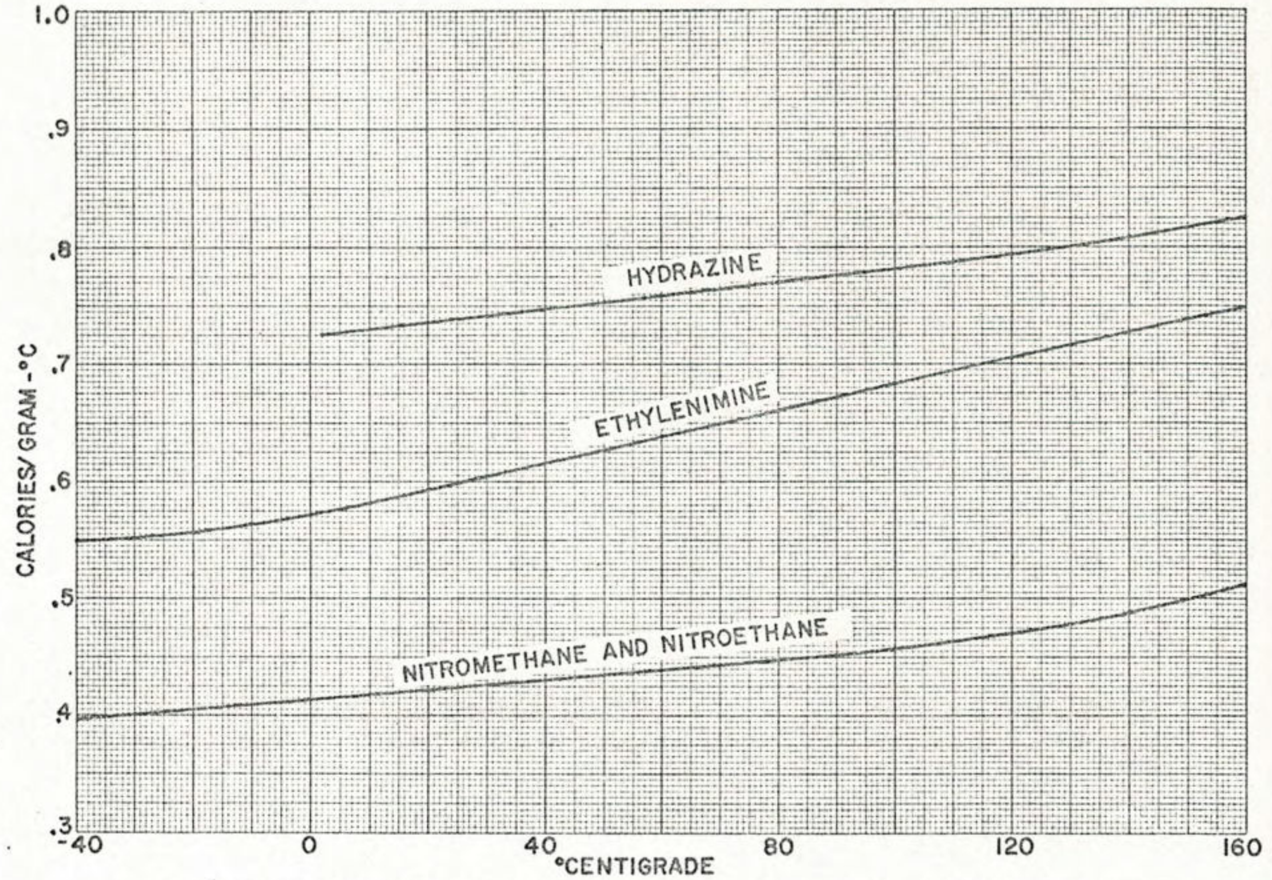

Fig. 37-4—Liquid heat capacity of nitrogen containing compounds from −40°C to +160°C.

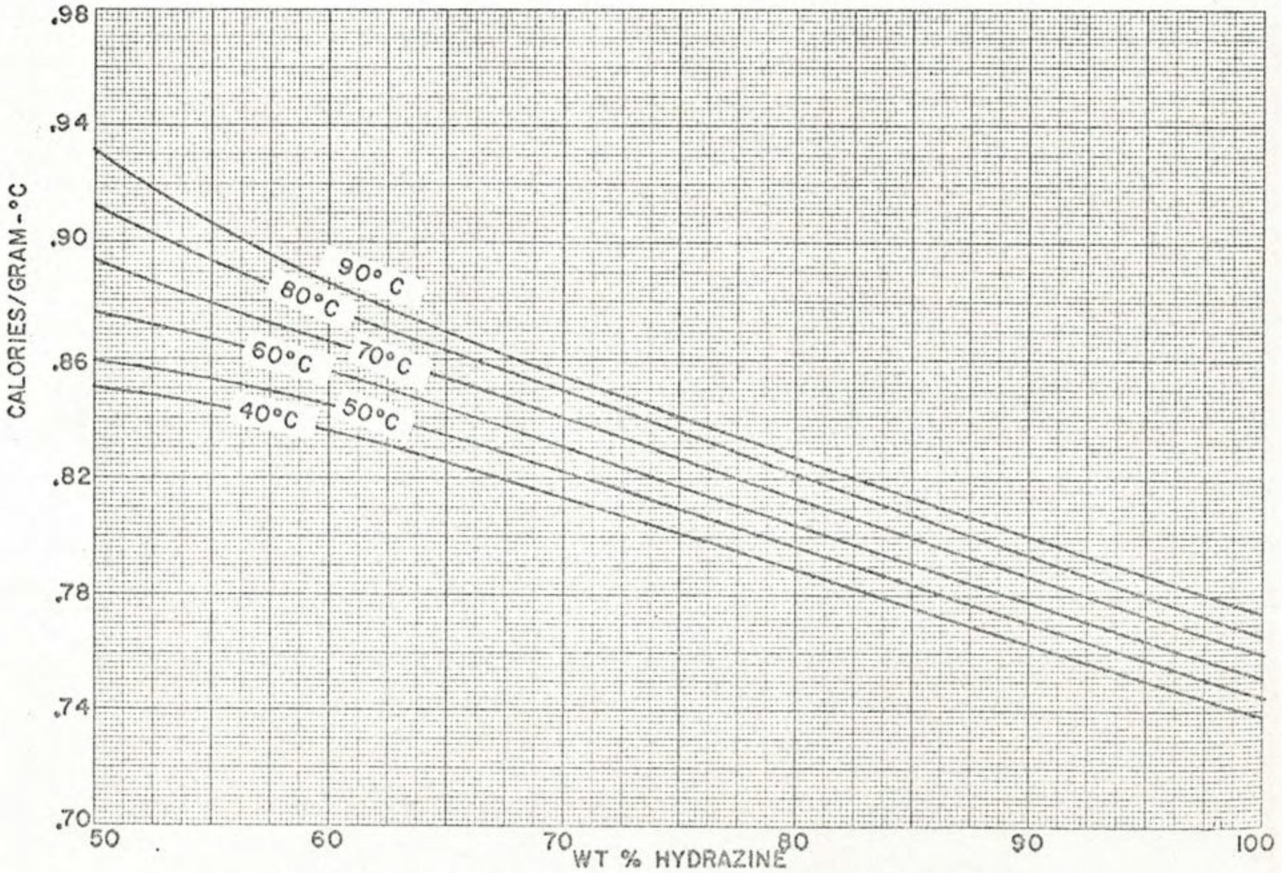

Fig. 37-5—Heat capacity of aqueous hydrazine from 40°C to 90°C.

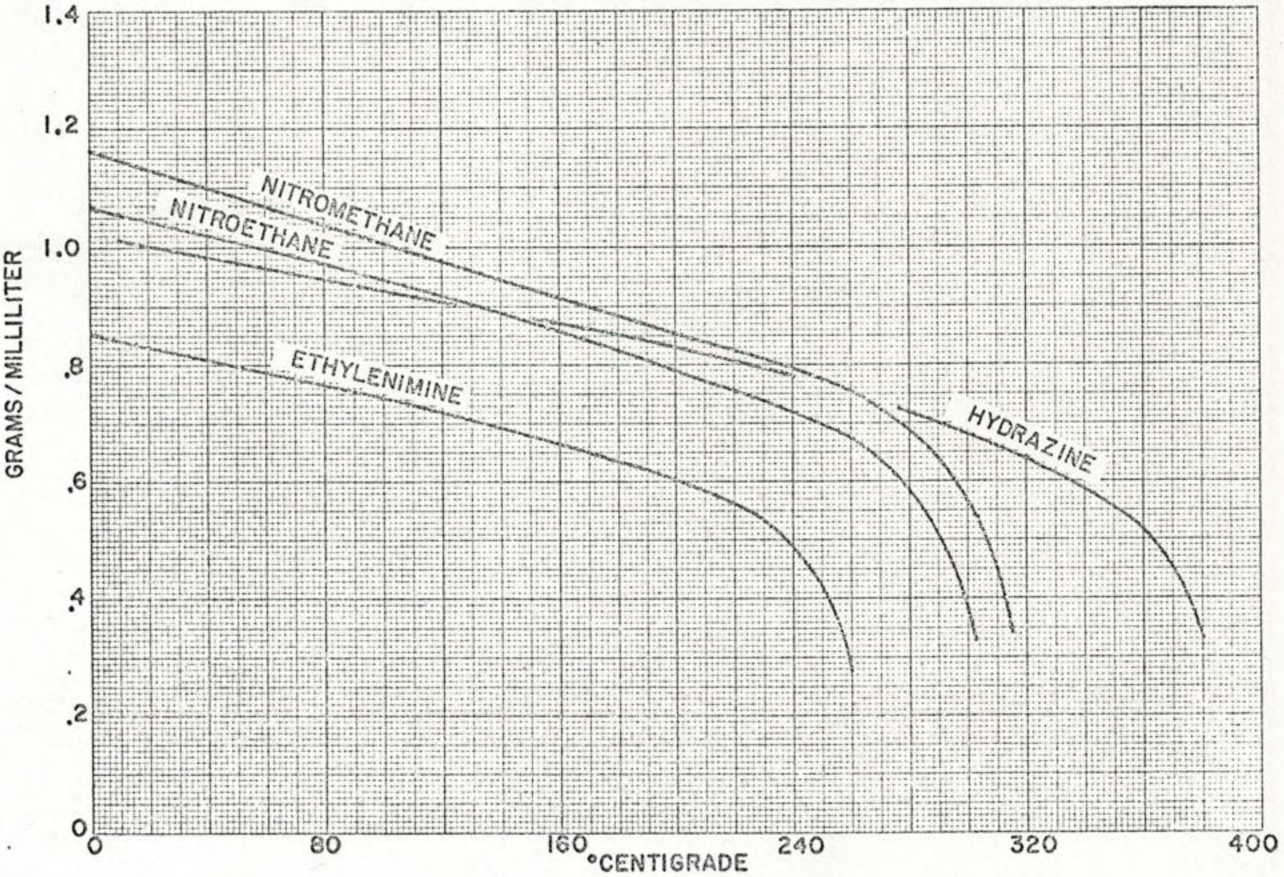

Fig. 37-6—Liquid density of nitrogen containing compounds from 0° C to 380° C.

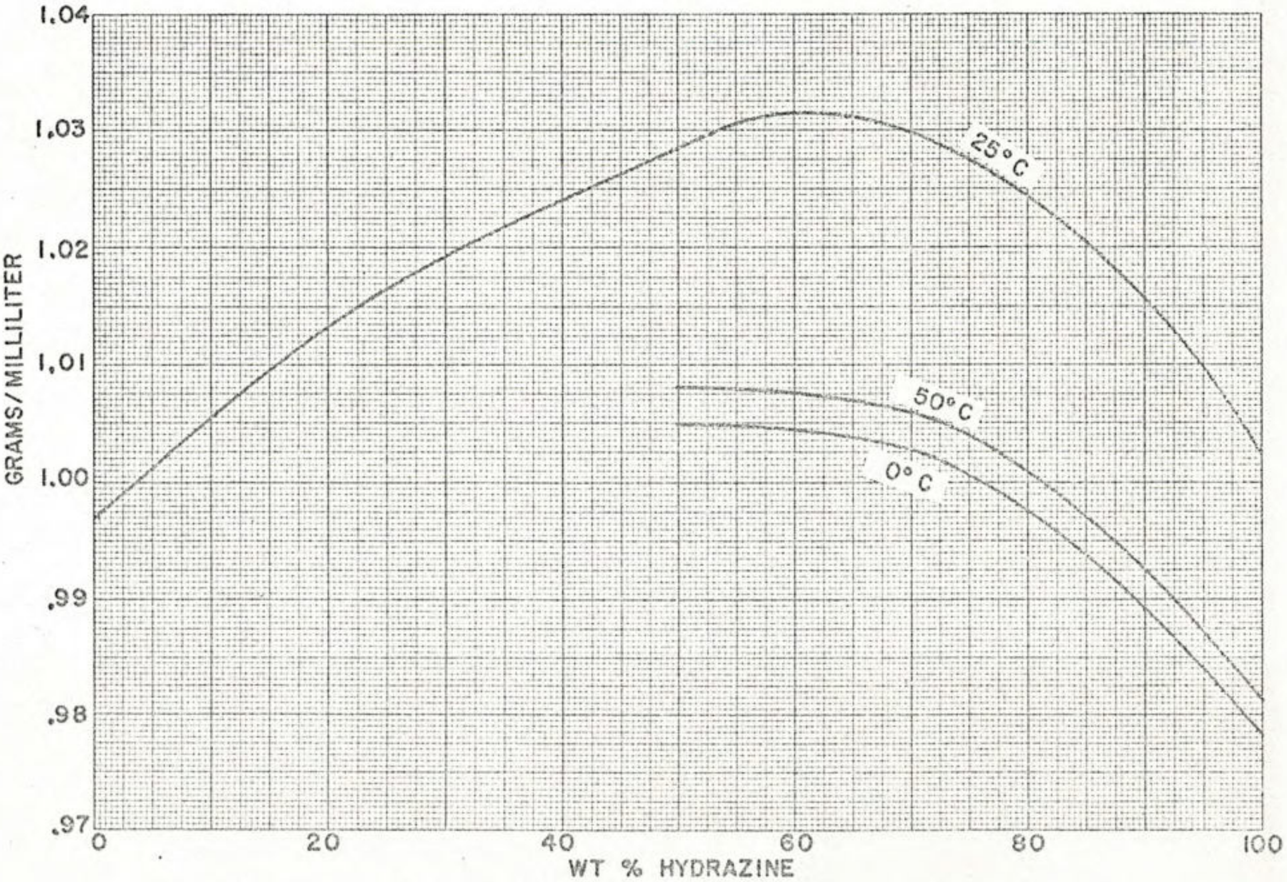

Fig. 37-7—Effect of temperature on the densities of aqueous hydrazine solutions.

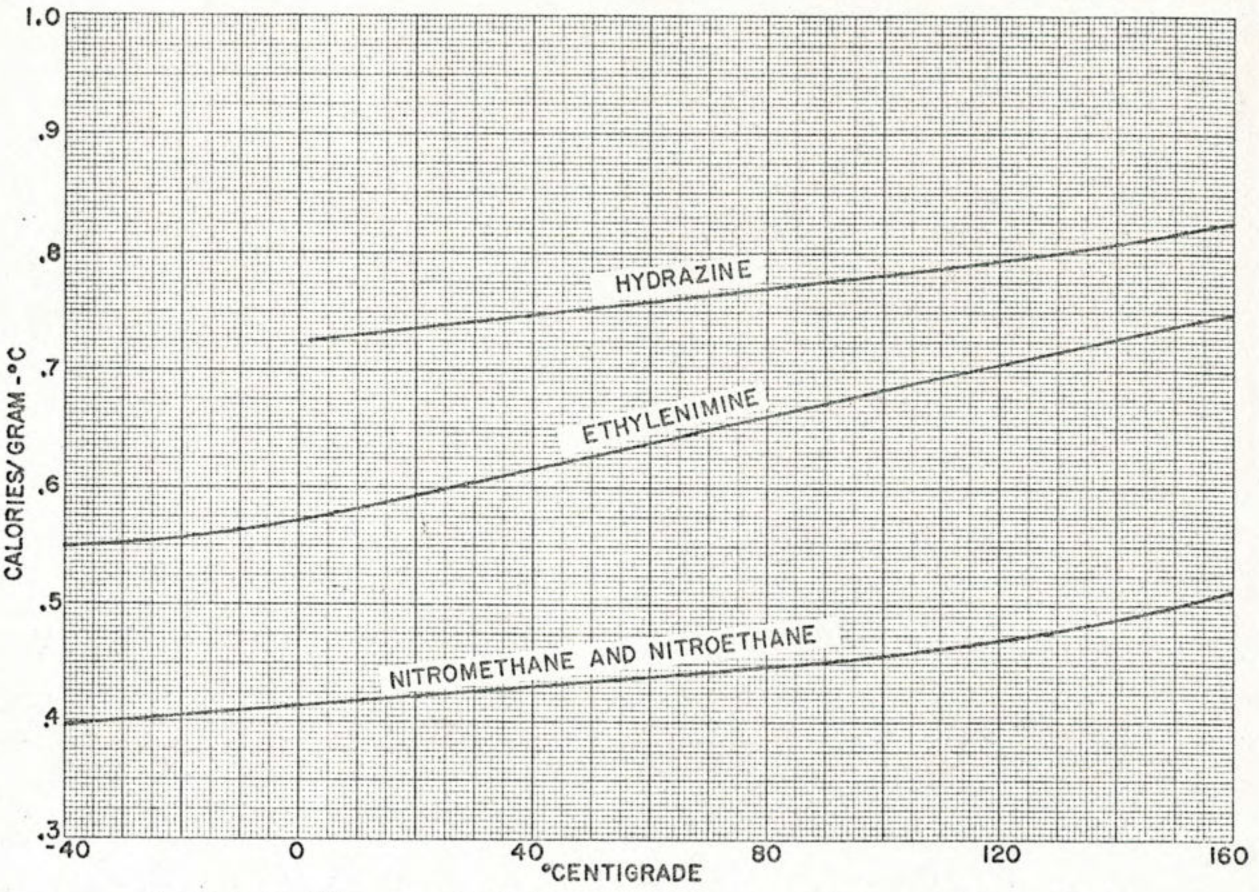

Fig. 37-4—Liquid heat capacity of nitrogen containing compounds from −40°C to +160°C.

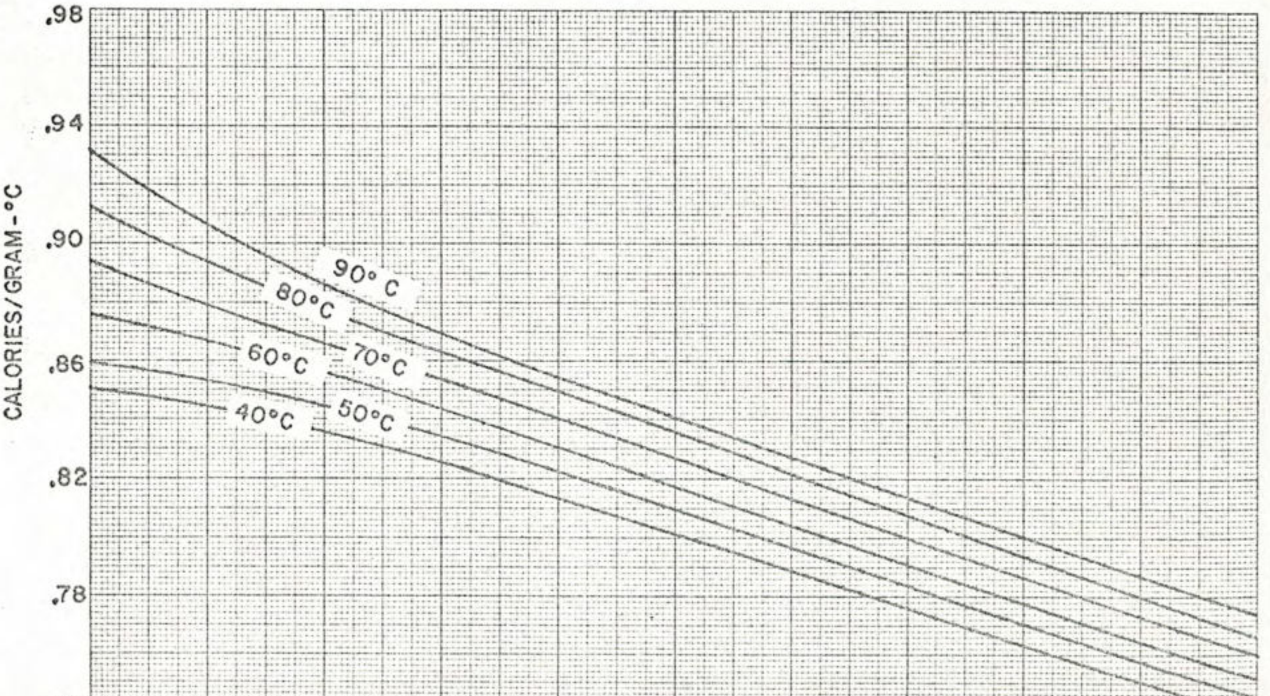

Fig. 37-5—Heat capacity of aqueous hydrazine from 40°C to 90°C.

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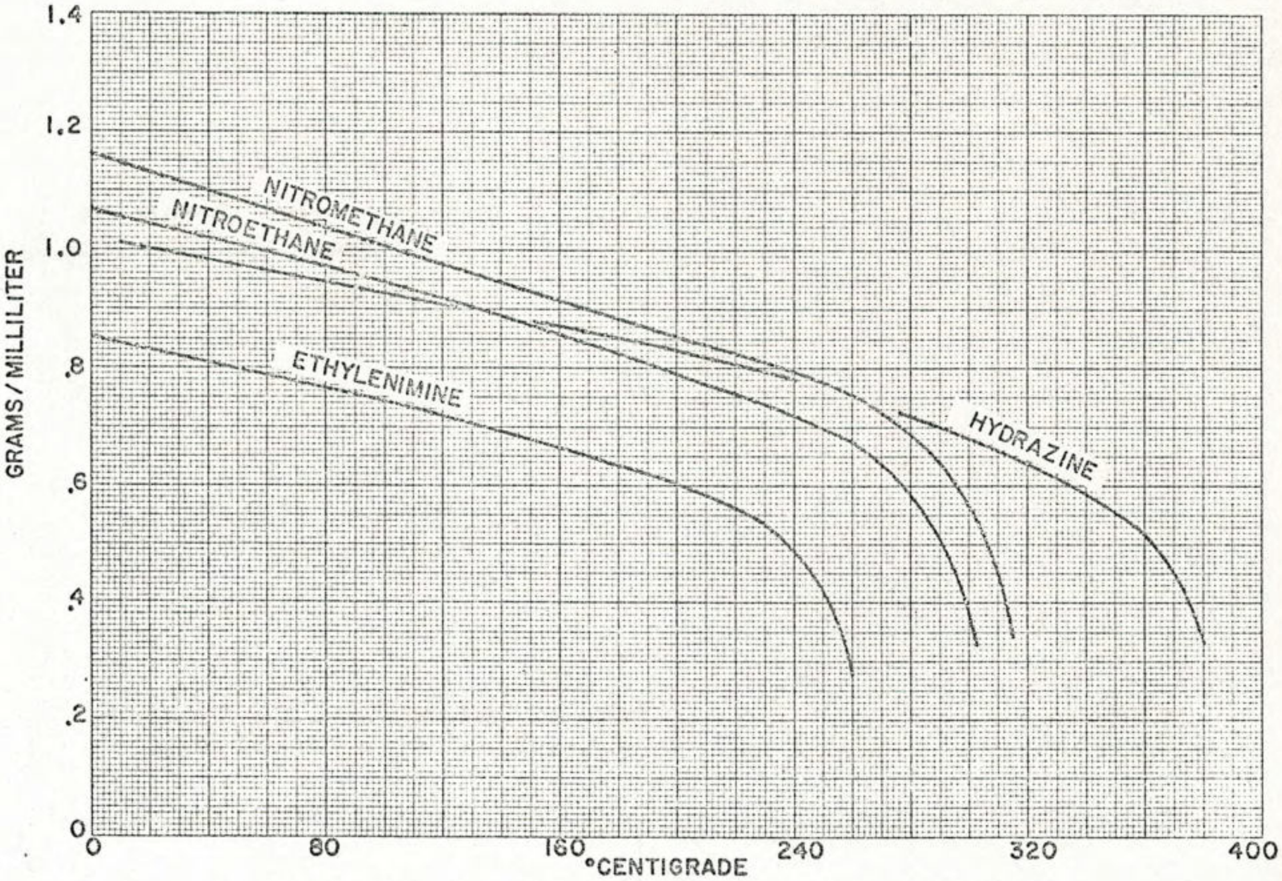


Fig. 37-6—Liquid density of nitrogen containing compounds from 0° C to 380° C.

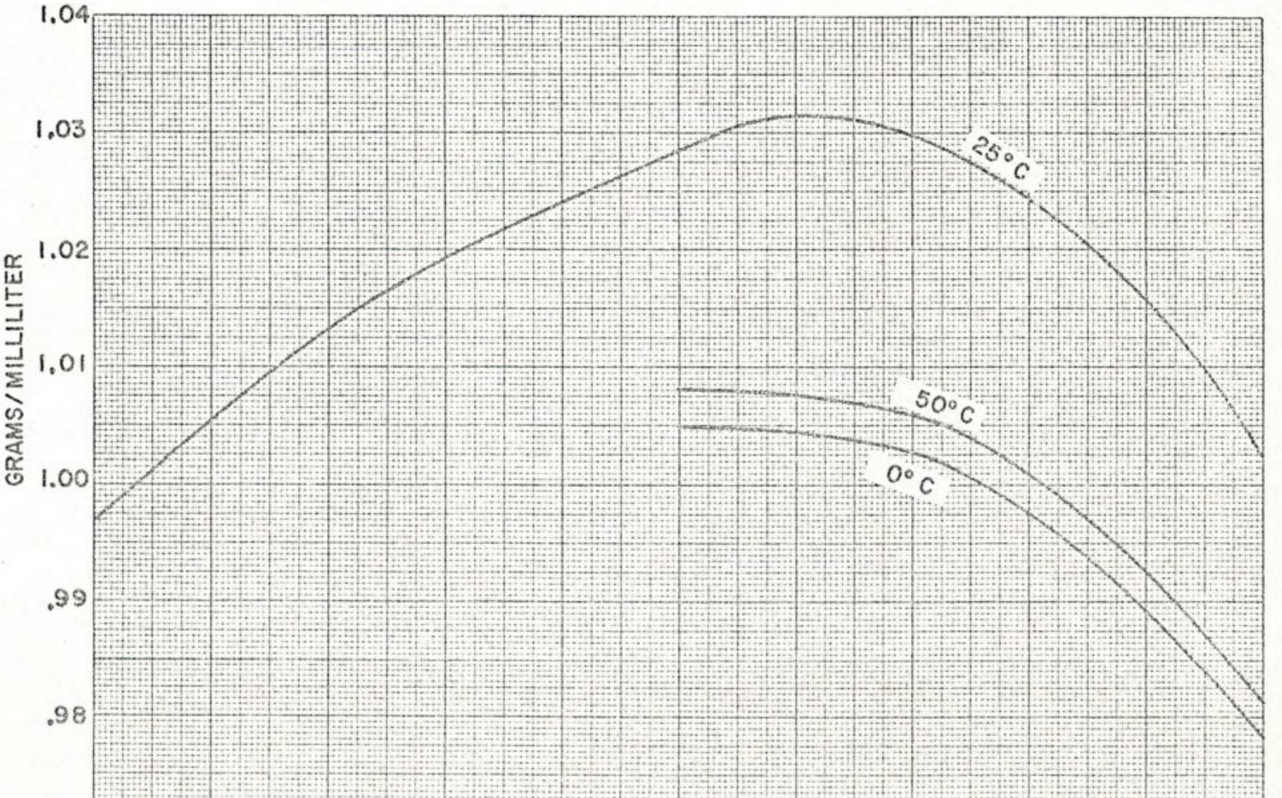


Fig. 37-7—Effect of temperature on the densities of aqueous hydrazine solutions.

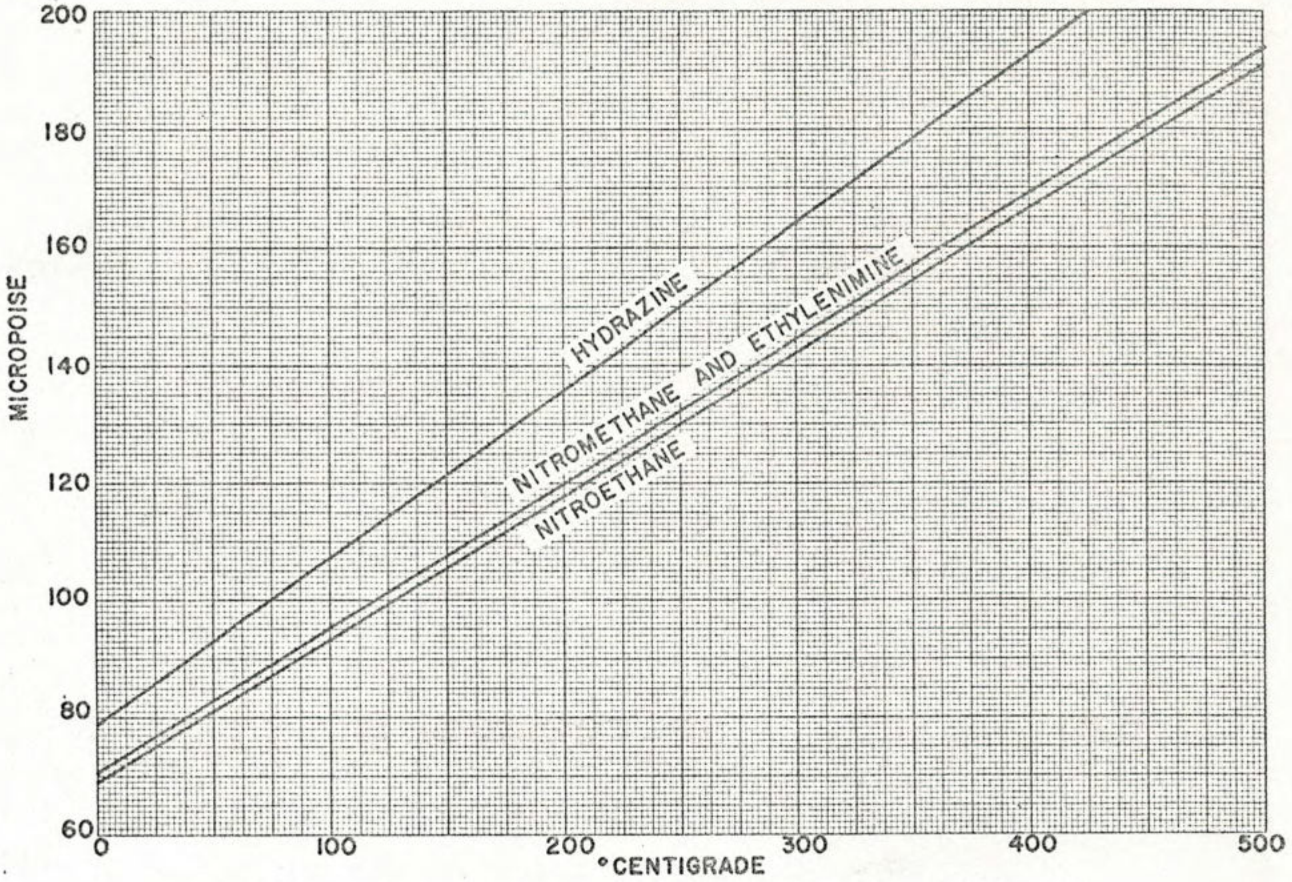


Fig. 37-8—Vapor viscosity of nitrogen containing compounds from 0°C to 500°C.

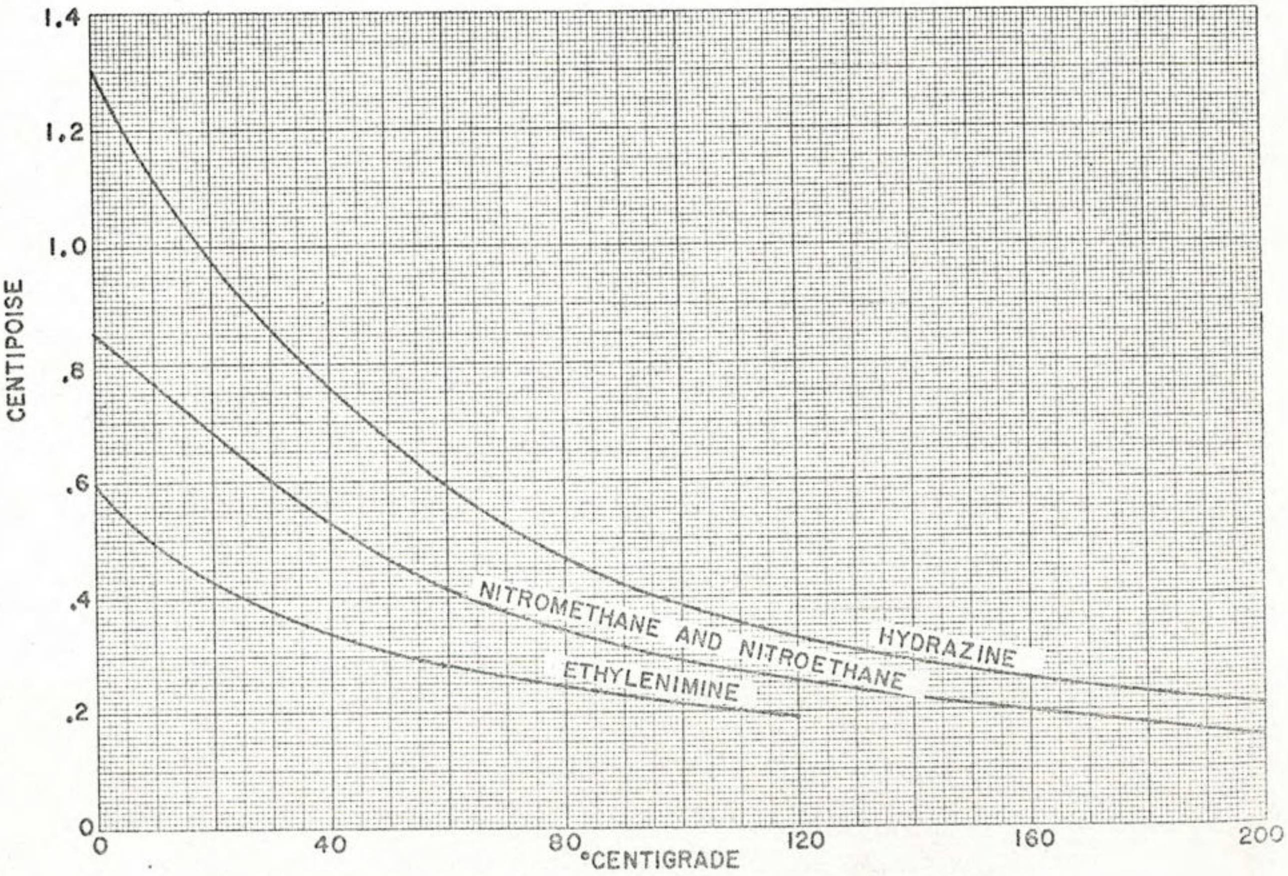


Fig. 37-9—Liquid viscosity of nitrogen containing compounds from 0°C to 200°C.

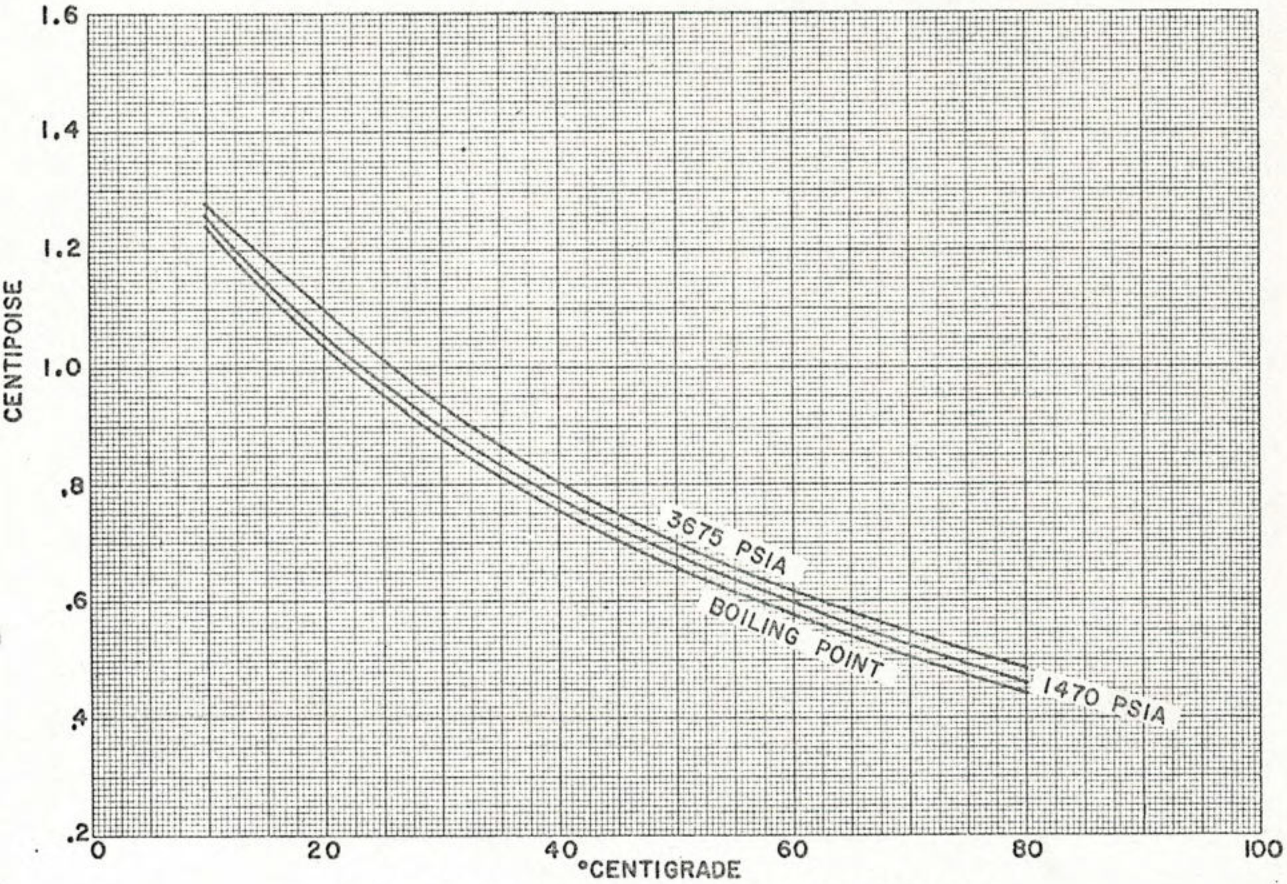


Fig. 37-10—Effect of pressure on the liquid viscosity of hydrazine.

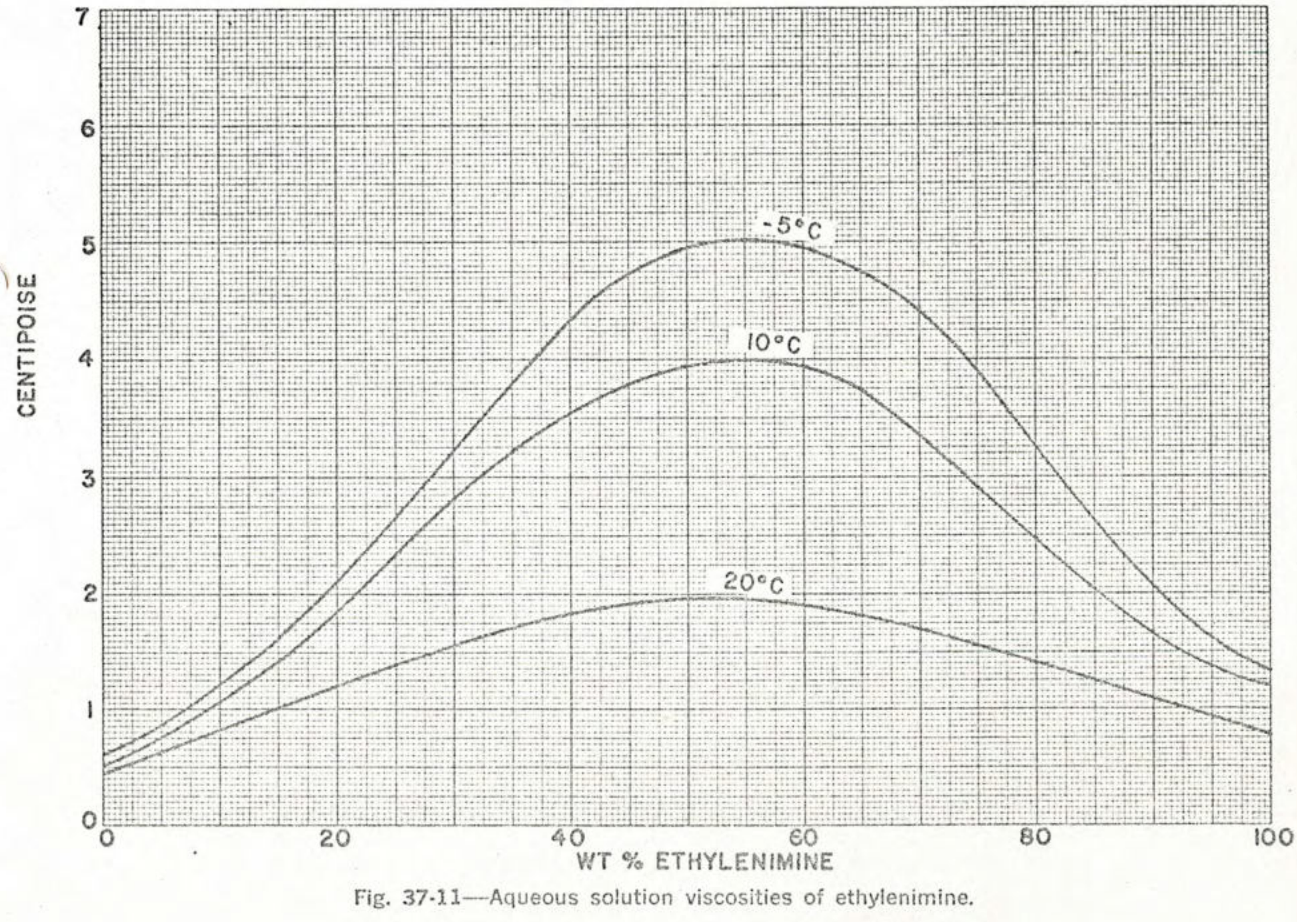


Fig. 37-11—Aqueous solution viscosities of ethylenimine.

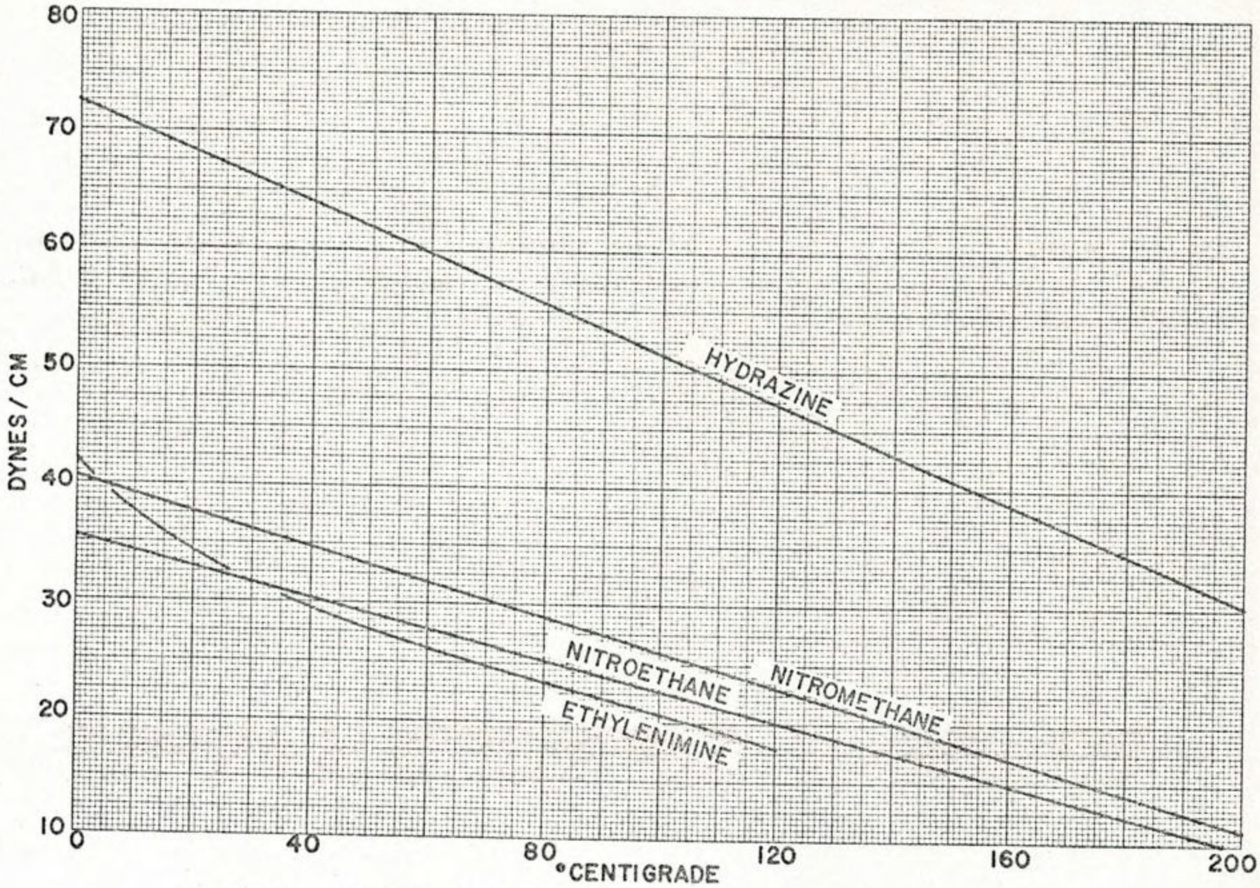


Fig. 37-12—Surface tension of nitrogen containing compounds from 0°C to 200°C.

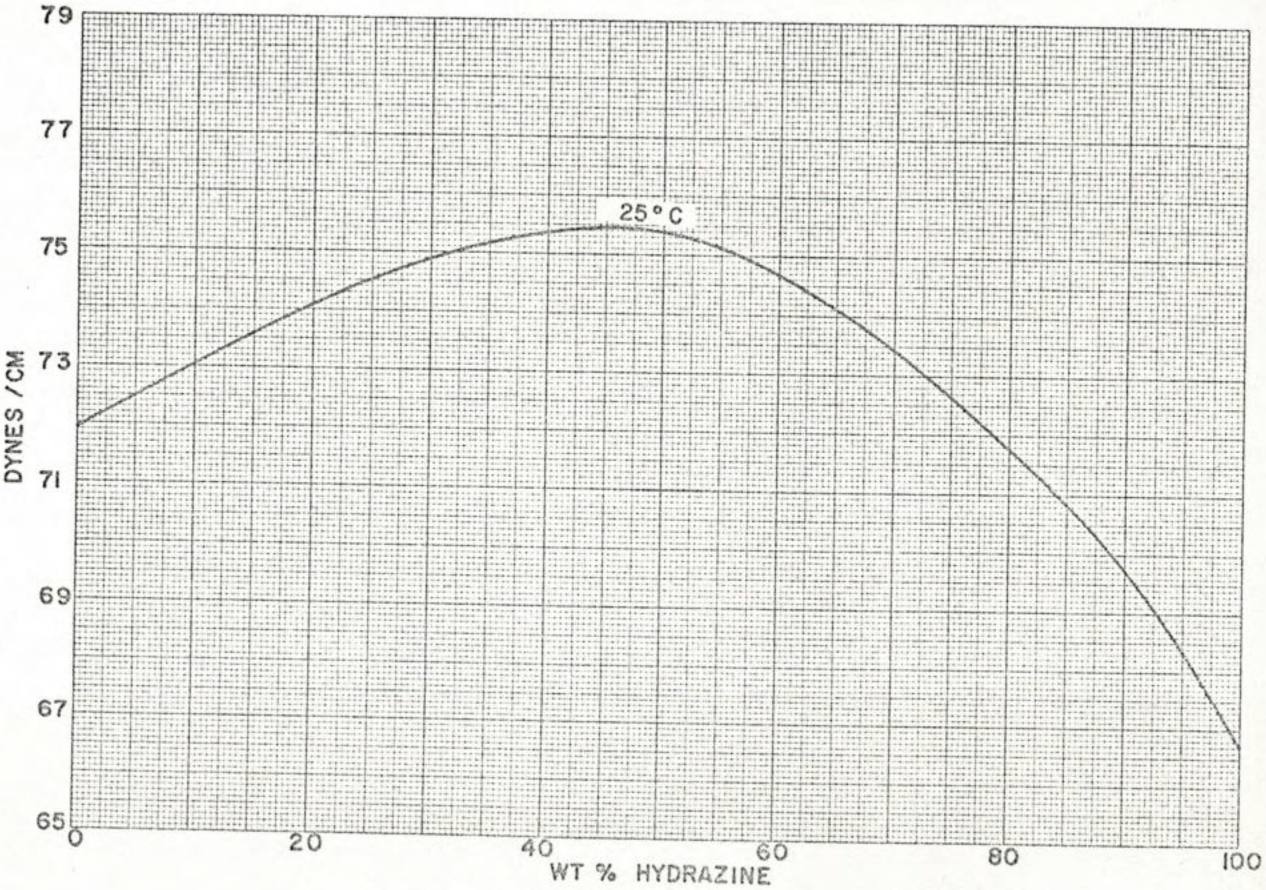


Fig. 37-13—Surface tension of aqueous hydrazine at 25°C.

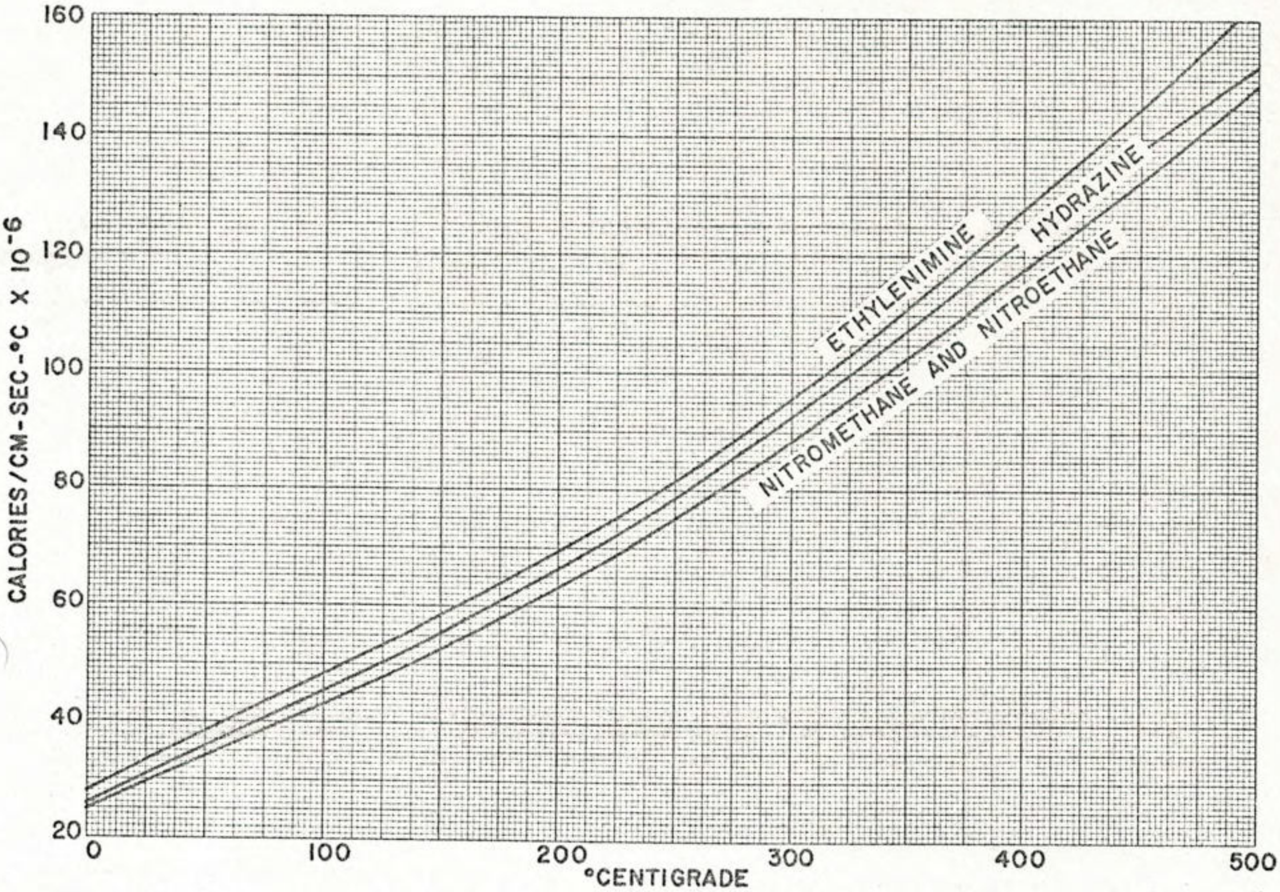


Fig. 37-14—Vapor thermal conductivity of nitrogen containing compounds from 0°C to 500°C.

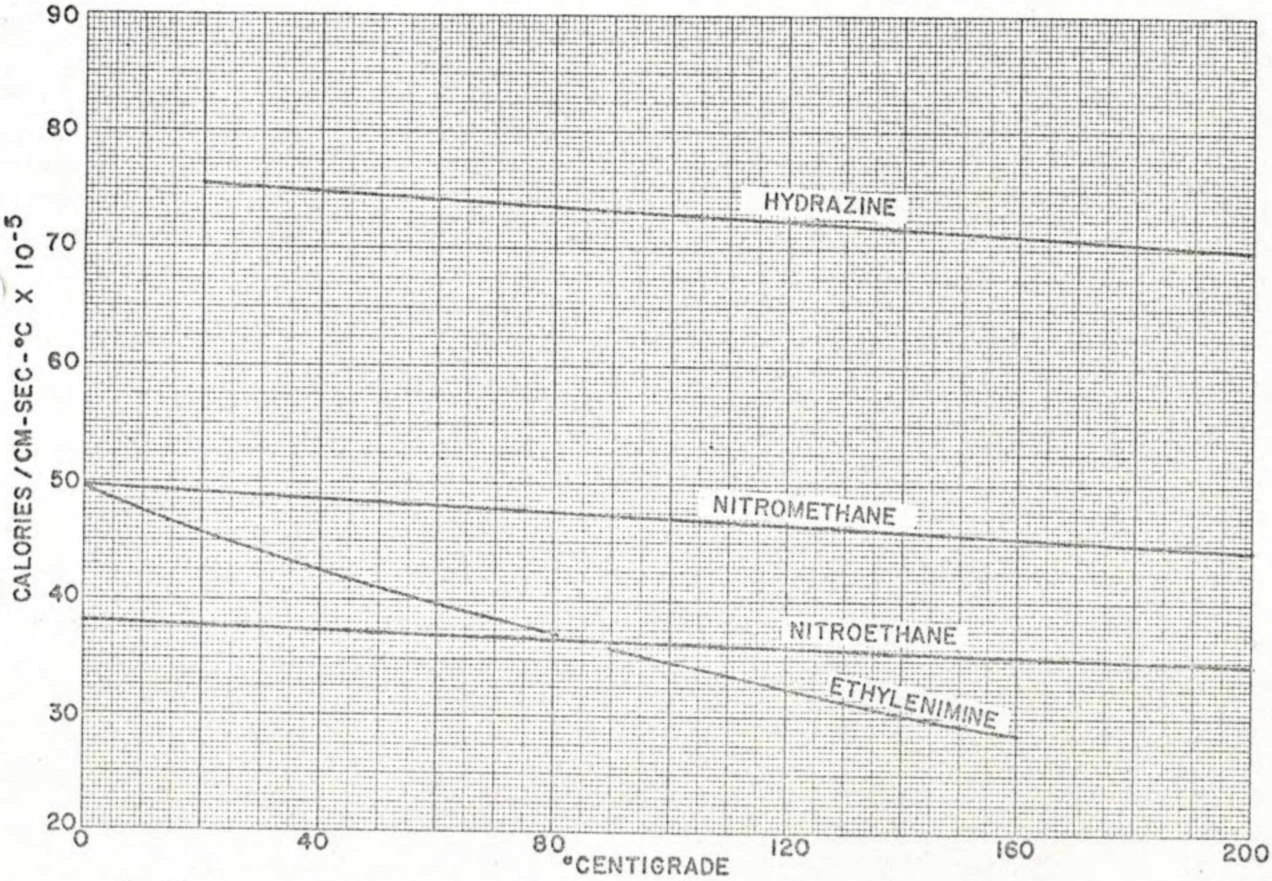


Fig. 37-15—Liquid thermal conductivity of nitrogen containing compounds from 0°C to 200°C.

measured. The procedure of Rihani and Doraiswamy[16] was used to calculate the vapor heat capacity of nitroethane, with a probable error of 1 percent.

Liquid heat capacities have been measured from −25 to 100° C for nitromethane,[5,11,17] from 0-40° C for ethylenimine,[9] and from the freezing point to 90° C for hydrazine.[12,17] The heat capacity of nitroethane at 20° C was calculated from its molecular structure. This method yielded an error of less than 1 percent for nitromethane. The data were extended to 160° C by the equation used in previous articles. The average error for seven experimental points was 1.9 percent.

Fig. 37-5 presents the heat capacity of aqueous hydrazine from 40-90° C.

Density. The liquid densities from 0 to 200° C are reported for nitromethane[4,8] and hydrazine.[2,17,18] Room temperature measurements have been made on nitroethane[8,19] and ethylenimine.[9] Lydersen's technique has been used to calculate the densities up to the critical point, with an average error of 1.1 percent for seven experimental values.

Fig. 37-7 shows the effect of temperature on the densities of aqueous hydrazine solutions.[17,20]

Viscosity. The vapor viscosities have been calculated by the equation proposed by Bromley and Wilke.[21]

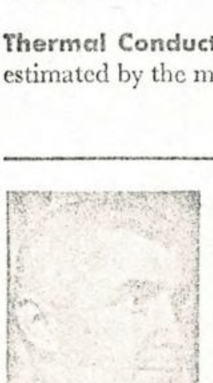
Liquid viscosities have been measured from 0-80° C for nitromethane,[7] from −10 to 25° C for ethylenimine[9] and from 0 to 180° C for hydrazine.[18] The method of Thomas[3] has been used to calculate the liquid viscosities of nitroethane and to extend the data on nitromethane and ethylenimine.

Fig. 37-10 presents the data of Mason on the effect of pressure on the liquid viscosity of hydrazine.[22] Fig. 37-11 shows the aqueous solution viscosities of ethylenimine.[9]

Surface Tension. Experimental data are reported from 0-100° C for nitromethane and nitroethane,[7,23] and at 25° C for ethylenimine[9] and hydrazine.[20] The data were extended to 200° C by the equation relating surface tension to liquid density and a constant calculated from the molecular structure.

Fig. 37-13 shows the surface tension of aqueous hydrazine at 25° C.[20]

Thermal Conductivity. The thermal conductivities were estimated by the methods described in previous articles.[24,25]



About the author

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