Results and discussion
The variation with carrier concentration of the resistivity at 10 kbar, normalised to zero pressure, is presented in Figure 1. For comparison, the data of Sagar (1958), Hutson et al. (1967), and Pitt and Lees (to be published) have also been included.

Ehrenreich (1960) has shown that the resistivity normalised to zero pressure is

$$\frac{\rho(10)}{\rho(0)} = \frac{\mu(0)}{\mu(10)}\left[1+\left(\frac{m^*(0)}{m^*(10)}\right)^{3/2}\frac{N_2}{N}\exp\left(-\frac{\Delta E(10)}{kT}\right)\right], \tag{1}$$

where $m^*(p)$ and $\mu(p)$ are respectively the effective mass and mobility in the Γ_{1c} conduction band, N_2/N is the pressure-independent ratio of the densities of states in the X_{1c} and Γ_{1c} conduction bands and, for non-degenerate material, $\Delta E(p)$ is the energy separation between the X_{1c} conduction band minima and the Γ_{1c} minimum, while in degenerate material, it is the separation of the X_{1c} minima from the Fermi energy in the Γ_{1c} band. The band structure (Pollak et al., 1966), with single-group labels for band edges, is shown in an inset to Figure 1. The results may now be divided into two regions.

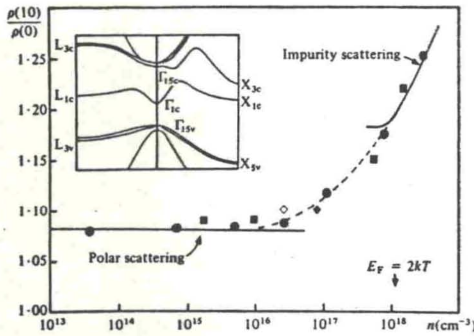

Figure 1. The resistivity of n-type GaAs at 10 kbar, normalised to zero pressure, as a function of carrier concentration.

● This work; ■ Pitt and Lees (to be published); ♦ Sagar (1958); ◇ Hutson et al. (1967).

Low carrier concentration (polar scattering)
When polar scattering is the dominant scattering process, Equation (1) becomes

$$\frac{\rho(10)}{\rho(0)} = \left(\frac{m^*(10)}{m^*(0)}\right)^{1/2} + \frac{N_2}{N}\exp\left(-\frac{\Delta E(10)}{kT}\right).$$

Moreover, the effective mass of the electrons in the Γ_{1c} band of GaAs may be calculated from $\mathbf{k}\cdot\mathbf{p}$ theory, in the manner described by Kane (1957) for InSb. Since the spin-orbit splitting Δ of the valence band is small compared to the direct forbidden gap E_g, the effective mass is adequately described by

$$\frac{1}{m^*} = \frac{1}{m_0^*}\left[1-\frac{5kT}{E_g}\left(\frac{F_{3/2}}{F_{1/2}}\right)\right], \tag{2}$$

where $F_{3/2}$ and $F_{1/2}$ are the Fermi integrals (Madelung, 1957) and m_0^* is the effective

mass at the bottom of the Γ_{1c} conduction band; this may be written as

$$\frac{1}{m_0^*} = \frac{1}{m}\left[1+\frac{2m\mathcal{M}}{3\hbar^2}\left(\frac{2}{E_g}+\frac{1}{E_g+\Delta}\right)\right], \tag{3}$$

where $\mathcal{M}$ is the momentum matrix element between Γ_{1c} and Γ_{15v} states. Since lattice vibrations are ignored in the derivation of Equations (2) and (3), only the dilational change in the energy gap E_g should be introduced in calculating the temperature dependence of m^*/m_0^* (DeMeis and Paul, 1965). Finally, the Fermi energy E_F, as determined by the doping level, is found from the expression

$$n = \frac{\sqrt{2}(kT)^{3/2}m_0^{*3/2}}{\pi^2\hbar^3}\left(F_{1/2}+\frac{5kT}{2E_g}F_{3/2}\right).$$

The change in effective mass with pressure may therefore be found, assuming that $\mathcal{M}$ and Δ are essentially constant.

The calculation of $\rho(10)/\rho(0)$ in the polar scattering region, namely $n \leqslant 10^{16}$ cm^{-3}, is included in Figure 1. The following values, for the parameters used in the calculation, were taken from the literature:

$T =$ 296°K
$m_0^*(0) =$ 0·065 m (DeMeis and Paul, 1965)
$\Delta =$ 0·35 eV
$E_g(0) =$ 1·52 eV
$\Delta E(0) =$ 0·38 eV (Ehrenreich, 1960)
$\partial E_g/\partial p =$ $10{\cdot}7 \times 10^{-6}$ eV bar^{-1} (Feinleib et al., 1963)
$\partial \Delta E/\partial p =$ $-11{\cdot}0 \times 10^{-6}$ eV bar^{-1} (Pitt and Lees, to be published)
$N_2/N =$ 45 (Pitt and Lees, to be published)

The agreement with experiment is very good. A larger value of $\partial E_g/\partial p$ (DeMeis, 1965), however, produces a much less satisfactory fit, but the calculation is rather insensitive to changes in the other parameters.

High carrier concentration (impurity scattering)
Figure 1 shows that the experimental values of $\rho(10)/\rho(0)$ deviate from the polar scattering curve at a carrier concentration of about 10^{16} cm^{-3} and thereafter are increasingly affected by scattering from screened impurity ions. Owing to the small effective mass in the Γ_{1c} conduction band, the carriers become degenerate at relatively low concentrations (4×10^{17} cm^{-3}). The consequences have been discussed in great detail by Moore (1967), but when polar scattering is negligible, the mobility (Mansfield, 1956) is approximately

$$\mu = \frac{3h^3\epsilon^2}{16\pi^2e^3m^{*2}f(x)} \qquad \text{for } E_F \gg kT,$$

where

$$f(x) = \ln(1+x) - \frac{x}{1+x},$$

$$x = \left(\frac{h}{e}\right)^3\frac{\epsilon}{m^*}\left(\frac{3n}{8\pi}\right)^{1/3},$$

and ϵ is the dielectric constant at the impurity energy.

The resistivity, normalised to zero pressure, now becomes

$$\frac{\rho(10)}{\rho(0)} = \left(\frac{m^*(10)\epsilon(0)}{m^*(0)\epsilon(10)}\right)^2\left[1+\left(\frac{m^*(0)}{m^*(10)}\right)^{3/2}\frac{N_2}{N}\exp\left(-\frac{\Delta E(10)}{kT}\right)\right].$$