numerous colleagues, particularly Messrs. R. G. Hambling, A. Knight and R. Willows of this Establishment. My thanks are due to Sir William Penney, director of this Establishment, for permission to publish this communication, and to Sir John Cockcroft, director of the Atomic Energy Research Establishment, for facilities.

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Concurrently with the above work, a more extensive programme of research was carried out at the Atomic Energy Research Establishment, Harwell. The transition temperatures between the five allotropic modifications of plutonium have been determined by several methods, the results being summarized in Table 4. The temperatures quoted are approximate typical values, given to the nearest multiple of five degrees: extensive experiments show considerable variations from specimen to specimen. In most cases actual experimental values are within a range of ± 5° C.; but isolated results have been obtained well outside this range.

The electrical resistance and the coefficients of electrical resistance and thermal expansion on heating are given in Table 5. Behaviour on cooling is complicated by severe hysteresis effects and sluggish transformations, so that to quote simple values without extensive qualification would be misleading. Values for cooling are therefore omitted.

The density of α-plutonium has been determined by the displacement method, and values for the other phases have been calculated from the dilatation curves on heating. Variations in the density have been observed from specimen to specimen. The value quoted is for a specimen after standing for several months at room temperature. A typical value for specimens immediately after dilatation runs is about 18·7 gm./c.c., the low figure being presumably due to the retention of other phases. The values given for the β- γ-, δ-, ε-phases are typical for these phases at the lower end of their stable range (Table 6).

Table 6

Phase	Density (gm./c.c.)
α	19·25
β	17·3
γ	16·7
δ	15·7
ε	16·3

Full discussion of the theoretical implications will become possible only when security limitations permit the disclosure of some other properties of plutonium; but in addition to the negative coefficient of thermal expansion of the δ-phase, and the large density difference between the latter and the α-phase, the following points may be noted:

(*a*) The relatively high values of electrical resistivity and the negative and extremely low temperature coefficients of resistance of some of the phases.

(*b*) The large hysteresis associated with the δ → γ, γ → β and β → α phase-changes, and the complete absence of hysteresis in the onset of the δ-phase change which, however, proceeds only partly to completion, even with long soaking periods.

(*c*) The large variations in properties between one specimen and another, which it is difficult to account for by the presence of impurities if normal experience is taken as a basis for comparison.

Table 4

Phase	Transition temperatures (°C.)					
	Thermal analysis*		Dilatometry†		Electrical resistance*	
	Heating	Cooling	Heating	Cooling	Heating	Cooling
$\alpha \rightleftharpoons \beta$	140	80	135	80§	135	90§
$\beta \rightleftharpoons \gamma$	235	145‡	225	Transformation obscured on all specimens due to sluggishness	220	160‡
$\gamma \rightleftharpoons \delta$	325	245‡	315		325	225‡
$\delta \rightleftharpoons \varepsilon$	475	475	480	480‖	480	480‖
Melting and freezing points	640	640				

* Rates of heating and cooling, approximately 2 deg. C. per min.
† Rates of heating and cooling, approximately 1 deg. C. per min.
‡ Ill-defined transitions on some specimens; arrests obscured on others.
§ Start of transition: transformation occurs progressively to room temperatures, and sometimes continues isothermally.
‖ On cooling, the change does not appear to go to completion: the density decreases only from 16·3 to about 16·1.

Table 5

Phase	Resistivity* (micro ohm cm.)	Coefficient of electrical resistance on heating per deg. C. (× 10^{-5})	Linear coefficient of thermal expansion on heating per deg. C. (× 10^{-6})
α	150	− 20 to − 40†	+ 50 to 65†
β	116	− 10	+ 43
γ	115	− 4 to − 20‡	+ 39
δ	111	+ 7	− 27§
ε	123	—	+ 20‖

* Mean figures for several specimens; they refer to the low-temperature end of each range. The variation from specimen to specimen is about ± 3 micro ohm cm. The values for β-, γ-, δ- and ε- have been corrected for volume changes on the basis of isotropic expansions from the α-phase.
† The curve is not linear; these are limiting values for several specimens.
‡ These are limits for several specimens; one specimen gave a value of + 20 × 10^{-5}.
§ The curve is not linear over the whole range; this is a typical value for the linear portion of the curve.
‖ Typical value for several specimens; variations from approximately 5 to 30 × 10^{-6} have been observed on some specimens.

Many features of the behaviour of plutonium have been necessarily omitted from this short summary; but it is hoped to publish a more detailed account of the experimental results elsewhere.

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