"Gold-Aluminium Alloys." By C. T. Heycock, F.R.S., and F. H. Neville, F.R.S. Received October 31,—Read December 7, 1899.

(Abstract.)

The first part of this paper gives the equilibrium curve for the liquid alloys and the various solid bodies that can form in them. The curve is based on the determination of the freezing points of mixtures varying in composition from pure gold to pure aluminium.

The freezing points were determined by means of platinum resistance pyrometers of the Callendar-Griffiths type, and the composition of each alloy was found by extracting a sample from the crucible and analysing it.

The ordinate in the curve is the freezing point on the air-centigrade scale, and the abscissa is the composition of the alloy expressed in atomic percentages of aluminium.

The curve was found to consist of seven branches, each branch corresponding to a state in which a particular solid crystallises first. In harmony with this, seven substances can be detected in the solid alloys. The bodies are :—

Gold; Au_4Al; Au_5Al_2 or perhaps Au_8Al_3; Au_2Al; a body which is probably AuAl; $AuAl_2$, Roberts-Austen's purple alloy; aluminium.

The bodies Au_2Al and $AuAl_2$* are indicated by well-marked summits in the curve, at 33·4 and at 66·6 atomic per cents. of aluminium respectively.

The melting or freezing point of Au_2Al is at 625° C., that of $AuAl_2$ is at 1062° C., apparently identical with the melting point of gold itself. The body whose formula we give as either Au_5Al_2 or Au_8Al_3 has its melting point at 575° C. The body Au_4Al has its melting point near 550° C. That of the hypothetical AuAl is not given by the curve.

The curve has three well-marked eutectic angles. One of these is at 527° C. and 3·6 per cent. by weight of aluminium, the alloy here being a mixture of Au_4Al and Au_5Al_2. The next is at 569° C. and 8·36 per cent. by weight of aluminium; this alloy has a composition corresponding to the formula Au_3Al_2, but it is a mixture of Au_2Al and AuAl. The third eutectic is at 648° C., and the alloy contains 1·87 per cent. by weight of gold; it is a mixture of $AuAl_2$ and aluminium. We see from the above that the mixture with the lowest melting point of all is that containing 3·6 per cent. by weight of aluminium, this small percentage depressing the melting point of gold from 1062° C. to 527°, that is more than 500°. A liquid of this composition, though

* See footnote, p. 21.

almost wholly composed of gold, will not begin to solidify until this comparatively low temperature of 527° C. is reached.*

Each of these eutectic points gives rise to a horizontal row of second freezing points in the curve, and the alloys containing more than 44 and less than 60 atomic per cents. of aluminium have three distinct freezing points corresponding to the successive formation of three solid bodies.

The four compounds, Au_4Al, Au_5Al_2, Au_2Al, and the hypothetical AuAl, are pure white substances. $AuAl_2$, as is well known from the work of Sir W. Roberts-Austen, is a magnificent purple body.

The latter part of the paper gives the result of a microscopic examination of polished and etched sections of alloys taken from various parts of the curve. All the bodies referred to above could be distinguished under the microscope. The photomicrographs accompanying the paper show that the structure of the solid alloy is everywhere in strict harmony with the indications of the freezing point curve. Speaking generally, we may say that the patterns observed in the photographs repeat themselves at corresponding points of each branch of the curve. For example, near the summit of the branch corresponding to the pure alloy, Au_2Al, the photograph shows us more or less hexagonal polygons of this substance almost entirely filling the field, and only separated from each other by very fine lines of impurity. If we take a section of an alloy a little way below the summit, we see the polygons of Au_2Al surrounded by a ribbon-like network of mother substance. Still further down, the crystals of Au_2Al are scanty, and arranged in such regular patterns, generally in lines at right angles to each other, as to render it certain that they crystallised freely while surrounded by liquid. Finally, at the bottom of the branch, that is at the eutectic point, the large crystals of Au_2Al are absent, and the whole field is full of the mother substance, which is sometimes but, as we explain in the paper, not always a eutectic mixture.

If, leaving the eutectic point, we ascend the next branch, these phenomena repeat themselves, but the primary crystallisation (that is the matter which solidified first) is now of a different substance.

Some of the photographs of alloys very rich in aluminium were taken by the Röntgen rays, and an enlargement made from the negative. The contrast between the Röntgen ray photograph and the surface photograph of the same alloy shows what a much better picture of the structure of the alloy is given by the Röntgen rays.

* The rapid depression in the freezing point of gold, due to the presence of small quantities of aluminium, and the great rise in the freezing point as the composition corresponding to the compound $AuAl_2$ is approached, have been already discovered by Sir William Roberts-Austen.