The work described above has been carried out as part of the research programme of the National Physical Laboratory, and this communication is published by permission of the Director of the Laboratory.

J. W. Gates

National Physical Laboratory,
Teddington, Middlesex.
March 24.

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Embrittlement of Tungsten Wire

The embrittlement of tungsten wire heaters for oxide cathodes has been a frequent source of trouble to the vacuum-tube engineer. The trouble has persisted despite the many technological advances made in the manufacture of the wire and in its subsequent handling.

In the processing of a heater the wire is coated with a refractory oxide (normally alumina) and the coating fired to hardness in an atmosphere of wet hydrogen at a temperature usually above 1,500° C. It is customary to test the quality of a batch of wire by submitting it to firing tests under somewhat more exacting conditions (of temperature and time) than would be met in normal processing: the singular feature of the type of embrittlement to which we refer is that it frequently occurs in heaters made from wire which on such firing tests has appeared to be of excellent quality.

The purpose of this communication is to direct attention to what is, we believe, one of the major causes of such embrittlement, namely, surface contamination of the tungsten by nickel. We have found that very slight traces of nickel on the tungsten surface can cause embrittlement. The amount of nickel which is significant is extremely small: a film of the order of 10 A. thick on the surface of otherwise good-quality wire can make that wire so brittle that it cannot be handled, and even smaller amounts can materially impair ductility.

Such traces of nickel are readily picked up on the surface of a heater during the normal processes of manufacture. Making use of electrographic techniques, we have found nickel contamination in damaging quantities to arise from such practices as bending the wire around a nickel former, or winding it over nickel rollers or on to nickel-alloy spools. Spot welding of an uncoated heater to nickel wire can splash embrittling quantities of nickel on to the tungsten in patches as far as two inches from the weld.

On heating contaminated wire there is rapid diffusion of the nickel into the tungsten; when this diffusion occurs the wire is embrittled (brittleness is not apparent at temperatures below about 1,200° C.); but if the contaminated surface of the tungsten can be removed before being heat treated, so that no diffusion of nickel takes place, the wire is undamaged.

Work is proceeding to ascertain whether or not the related elements, iron and cobalt, exhibit similar embrittling properties. Preliminary indications are that both metals do so—iron only slightly, and cobalt to a lesser extent than nickel.

We cannot yet offer a theoretical explanation of these phenomena.

B. Thomson

Materials Laboratory,
Valve and Transistor Division,
Standard Telephones and Cables, Ltd.,
Dowlish Ford Mills,
Ilminster, Somerset. April 5.

Large Type II Diamonds

In an article on "The Problem of the Two Types of Diamond" by Prof. G. B. B. M. Sutherland, D. E. Blackwell and W. G. Simeral[1], it is remarked that "in our experience all large diamonds of gem-stone quality are always type I diamonds". Actually, the four largest and finest diamonds we have come across at the Diamond Research Laboratory since 1951 were all of type II. Some details are given in Table 1.

Table 1

Type	Weight in carats	Colour	Origin	Transmittance in ultra-violet	Laminations	Lit. reference
II	34½	Pure white	Premier Mine	Down to 2250 A.	Present	*Research*, **4**, 131 (1951)
II*b*	66	Pure white	Premier Mine	Down to 2750 A., and probably shorter	Present	*Physica*, **18**, 489 (1952)
II*a*	160	Pure white	S.W. Africa	Down to 2375 A.	Present	Laboratory Report No. 94, May 1, 1951. *Gems and Gemmology*, **7**, 275 and 287 (1953)
II*b*	426½	Pure white	Premier Mine	Down to 2375 A.	Present	*J. Gemmology*, **4**, 300 (1954)

The difference between types II*a* and II*b* is that II*a* is an excellent insulator for electricity whereas II*b* is a temperature-sensitive semiconductor. Type II*b* shows, moreover, a green-blue phosphorescence after having been irradiated with short-wave ultra-violet (resonance line of mercury, about 2536 A.) whereas type II*a* does not. None of the diamonds of Table 1 fluoresces in the near ultra-violet, that is, about 3650 A. At the time when the 34½ carat diamond was examined, the existence of type II*b* diamonds was still unknown.

The diamonds of Table 1 are all of the finest gem quality, and it is my firm opinion that nearly all the larger gem stones belong to this category. However, it is true that not one of the larger gem diamonds shows a regular crystal form. Quite a few of them show not only growth triangles but also growth figures of a hexagonal shape.

Finally, it is worth while mentioning that the Premier Mine produces a very much higher percentage of type II diamonds than any other mine.

J. F. H. Custers

Diamond Research Laboratory,
P.O. Box 916,
Johannesburg. March 21.

[1] *Nature*, **174**, 901 (1954).