a crack inside the joint. The crack was propagated in the steel itself along a plane parallel to, and at a distance of several microns from, the joint interface; it was often associated with the presence of a partially oxidised steel layer. The crack plane approximately marked the boundary of the zone into which palladium and copper had diffused into the steel during brazing. The only external evidence of the development of this failure was the formation of blisters in regions where the brazing alloy coating was sufficiently thin. Photomicrographs of a specimen that had failed in this way are reproduced in Figs. 2 and 3.

It should be added in conclusion that metallographic examination of specimens in the as-brazed condition revealed no differences between joints made with the same alloy under a flux cover, in a reducing atmosphere, and in the presence of both these fluxing media (Fig. 4).

Further studies will be necessary to establish the precise conditions leading to joint failure of the kind described above and to ascertain that the effects observed were not due to some extraneous, as yet unidentified factors. Nevertheless, the evidence available so far is sufficient to advise against using a brazing flux in combination with a reducing atmosphere in the joining of stainless steel parts that may be exposed to the influence of water or humid atmosphere in service.

Thermocouples Under Neutron Bombardment

CHANGES IN VOLUME AND COMPOSITION

Under severe neutron radiation thermocouples are known to be unstable although little data on the changes in composition which occur has hitherto been published. A recent report by C. B. T. Braunton, D. N. Hall and C. M. Ryall, of the Atomic Energy Research Establishment, Harwell, (U.K.A.E.A., A.E.R.E. – R5837, 1968), now provides information which will greatly simplify the selection of thermocouple materials for experiments carried out under radiation at high temperatures. Under such conditions lattice damage anneals out and changes of thermoelectric behaviour can be predicted from the compositional changes. These have been computed from differential equations which were developed to describe the exponential transmutation of isotopes, and curves defining the composition of the various alloys at successive stages of time and radiation are provided in this report.

Pure platinum when irradiated produces only gold and mercury, each reaching a maximum concentration of rather less than 1 per cent after a year's exposure to a flux of 10^{15}n/cm^2/sec. Under similar conditions, however, the rhodium content of rhodium-platinum alloys is almost completely consumed, to form palladium, mercury, gold and iridium.

Ruthenium alloys are far more stable. The ruthenium remains unchanged, all transmutation effects being confined to the platinum. The palladium content of palladium-platinum alloys is not greatly affected although small quantities of mercury, gold, cadmium, silver, iridium and rhodium are formed by transmutation. Molybdenum-platinum alloys are considerably more stable than rhodium-platinum alloys when irradiated being comparable to ruthenium-platinum alloys in this respect.

Tungsten, rhenium and tantalum all suffer severely in a neutron flux. Some 40 per cent of the rhenium is lost after one year at a flux of 2×10^{14}n/cm^2/sec; tungsten is rapidly replaced by rhenium, rhenium by osmium, and tantalum by tungsten. The compositional changes in molybdenum are small.

Platinum alloys increase in volume under neutron irradiation by amounts ranging up to 2 per cent after one year at 10^{15}n/cm^2/sec. Tungsten, tantalum and rhenium decrease in volume to a considerably greater extent.

A significant conclusion of this report is that tungsten-rhenium thermocouples will suffer more damage, and are likely to be less stable than platinum-based thermocouples under similar conditions of neutron bombardment. It will be interesting to see whether the results of the experimental programme now being carried out in mixed thermal and fast neutron fluxes, referred to in this report, confirm this prediction.

A. S. D.