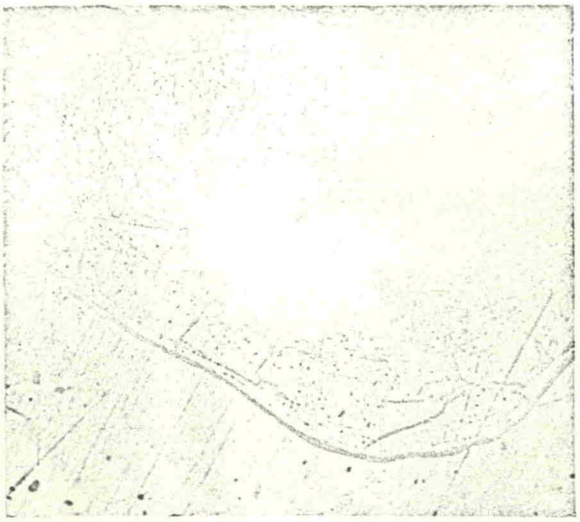


[*Courtesy Weld. Research Council.*
53 Solidification cavity in copper-to-nickel bond. × 280. (*Holtzman and Cowan.*[21])

55 Explosive weld in titanium. × 170.

in nature (Fig. 54). Philipchuk[7] has also reported the presence of hard, white layers in welds in a low-alloy steel and in titanium. Lucas and Williams[37] noted two distinctly different types of resolidification structure in a titanium/titanium weld. As shown in Fig. 55, one appears to be martensitic with a hardness of ~ 550 Hm, while the dark-etching region has a hardness of 850 Hm. These authors suggested that these pockets might have resulted from the entrainment of air or surface oxides in the molten vortices, as indicated in Fig. 17, followed by rapid cooling. Clear evidence of surface-oxide entrainment in aluminium/aluminium welds has been reported by Davenport[11] and by Murdie and Blankenburgs.[67] Zones of high hardness in welds between tantalum plates have been observed by Addison.[60]

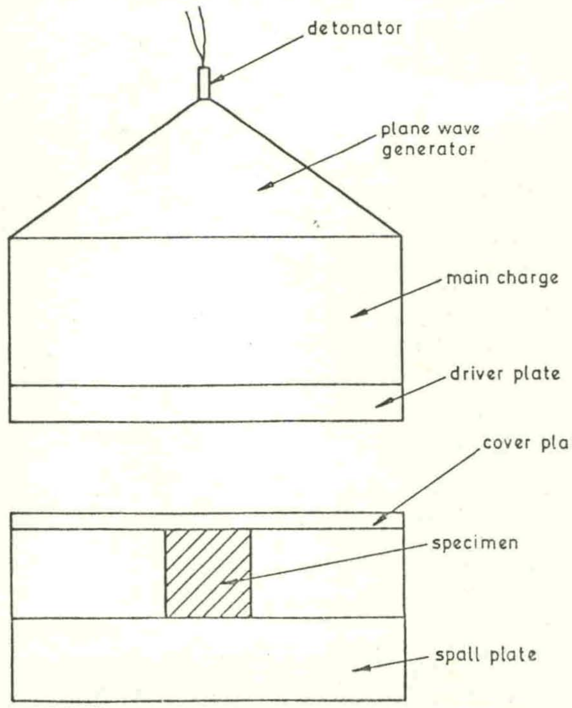
4. Effects of shock waves in welding

On detonating the explosive charge, the flyer plate experiences progressively along its length an oblique stress wave which reverberates within the plate. The compressive component of stress normal to the plate surface is reflected as a tension wave from the lower surface. Consequently, the plate is accelerated downwards in a series of steps. Duvall and Erkman[78] have shown that 90% of the terminal velocity is reached after three compressive waves have passed through the plate. When the flyer plate impacts the parent plate, further stress waves are generated in both plates.

Much work has been reported on the effects of shock waves [e.g. 79-92]. Experimental arrangements used in shock-wave studies are shown in Fig. 56; they are designed to impart a plane shock wave with a peak pressure of 15–9000 kbar[93] to the specimen, depending on the explosive charge. However, in explosive welding the peak pressure in the oblique shock wave rarely exceeds 200 kbar.[28] Consequently, it might be expected that structural changes in explosively welded components would be similar to, but less severe than, those observed in shock experiments; reports of their presence have not appeared extensively in the literature. The heat generated at the interface may further modify the structure after the shock waves have decayed.

Mechanical twinning is frequently observed in explosive welds, not only in b.c.c

54 Carbon replica of vortex of a weld in low-carbon steel. × 850.



56 Arrangement for plane-shock-wave experiments. ▷