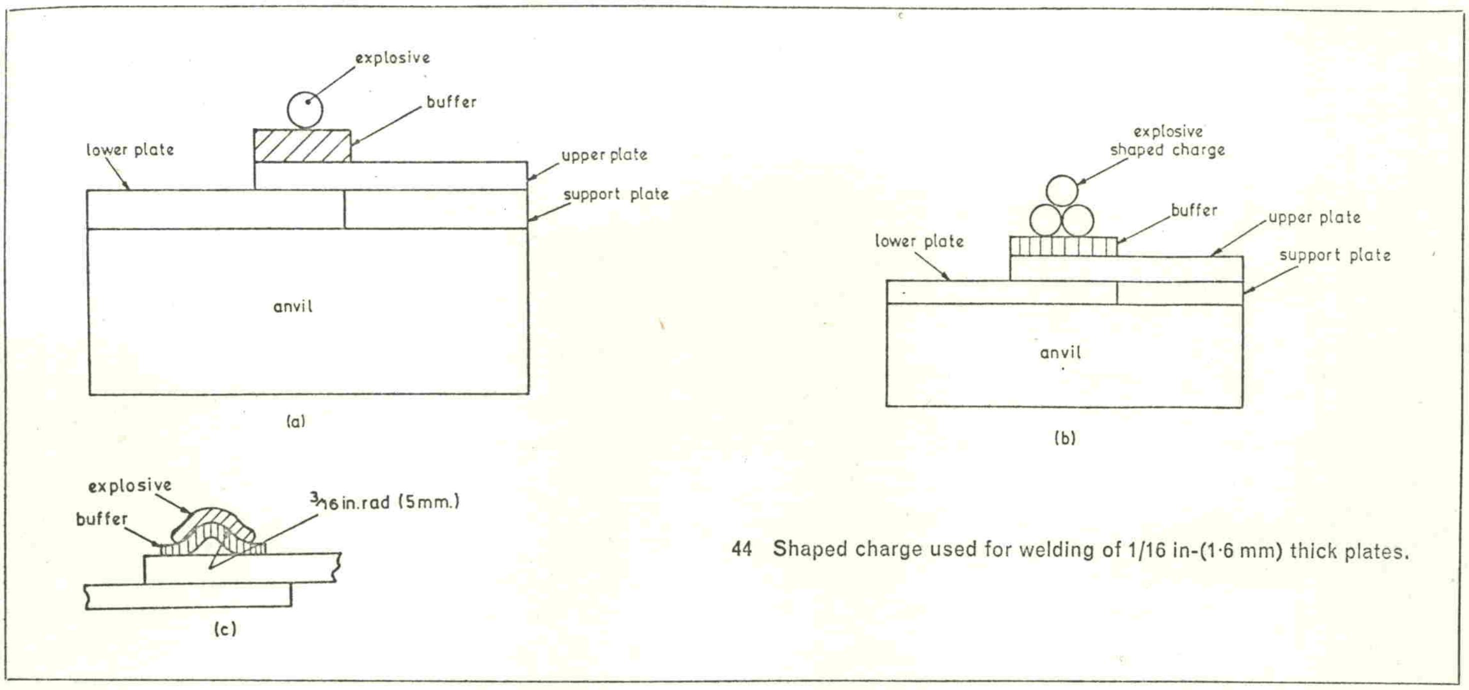


44 Shaped charge used for welding of 1/16 in-(1·6 mm) thick plates.

lisation across the weld zone and the presence of a weld can be detected only by the different residual grain size.[37,67,68]

The extent to which localised heating during welding affects the nature of the interface in the very short time for which it exists is not well established. Holtzman and Cowan[21] and Trueb[66] have found no evidence of solid-state diffusion zones in explosive welds, although the latter author has reported that clear evidence of recrystallisation exists, particularly in small isolated hot spots along the bond zone. Buck and Hornbogen[64] observed recrystallisation and evidence of melting in a zone of $<10^{-4}$ cm thickness.

Differential polishing and etching of bimetallic welds present difficulties in metallographic examination. Trueb[66] found that the resulting step in the replica completely prevented observation of any diffusion zone that may have been present. Buck and Hornbogen[64] overcame this difficulty by careful vibration-polishing and polish-etching techniques. Also, by careful vibration polishing and shadowing of the replicas in a direction parallel to the interface, Lucas *et al.*[28] have obtained definite evidence of diffusion layers $< 10^{-4}$ cm thick in weld couples whose alloy systems normally contain intermetallic compounds. These authors also reported clear evidence of recovery and recrystallisation, revealed by transmission microscopy of thin foils taken from the interface regions of welds in aluminium, copper, and stainless steel.

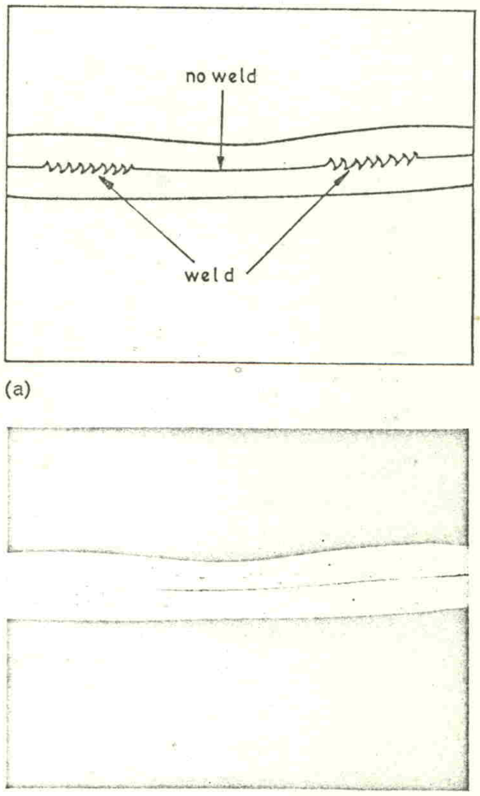
Thin foils taken from positions adjacent to the interface in copper/copper welds have shown high dislocation densities of the order of 10^{11} cm^{-2} and intense microtwinning.[28,37,65,66] Trueb[66] succeeded in producing thin foils from sections normal to the interface between brass/copper and 1070/1008 steels. No evidence of interfacial diffusion was found, although his transmission microscopy of copper/copper welds showed that the structure could vary between heavily deformed, recrystallised, and melted, from place to place along the interface.

Microhardness traverses across sections normal to explosive welds have been reported by several authors. The results of such tests vary considerably. Without exception, the general hardness of the flyer and parent plates is found to have been increased by the passage of shock waves through them. In many cases extremely high hardnesses have been reported in phases formed at the interface as a result of melting and rapid quenching. Both these features will be discussed in later sub-sections.

Referring to microhardness values across solid-phase bond interfaces, three basic types of behaviour have been noted; these are shown in Fig. 52. It is clear from Fig. 52(a) that, in addition to shock-hardening, there is localised interfacial work-hardening due to severe plastic flow in the weld zone.[60,65,69–72] Hardness profiles, as shown in Fig. 52(b), have also been reported[17,71] and it would appear in such cases that sufficient heat has been generated at the interface to cause total recrystallisation during and subsequent to the welding process. Figure 52(*c*)[17,24] represents the intermediate case where a smaller quantity of heat has been generated, thus allowing only partial recrystallisation.

Electron-microprobe and X-ray diffraction techniques have been employed to examine the nature of the explosive-bond interface. It is doubtful whether either technique can reveal the presence of diffusion at the interface unless this has occurred in layers several microns thick. Such layers would be expected only as a result of melting and they will be discussed in the next section. Holtzman[72] and Buck and Hornbogen[65] have reported abrupt transitions of the type 100% A → 0% A in dissimilar metal welds over distances smaller than the resolution of the electron-probe microanalyser.

According to Wright and Bayce,[20] their electron-probe analysis results afford a clear indication of solid-phase diffusion in a copper/gold weld. In support of this



45 Seam weld in brass sheet made with *Cordtex*. (a) Form of interface under the line charge; (b) micrograph of interface in the region of the line charge. × 1¼.