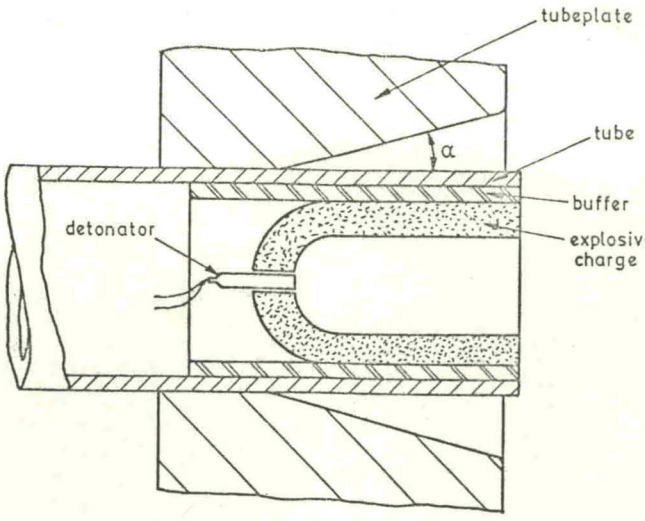
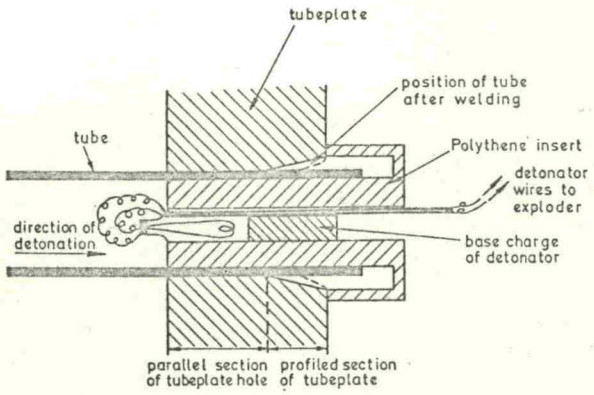


34 Tapered-hole technique. (Before detonating the explosive charge).

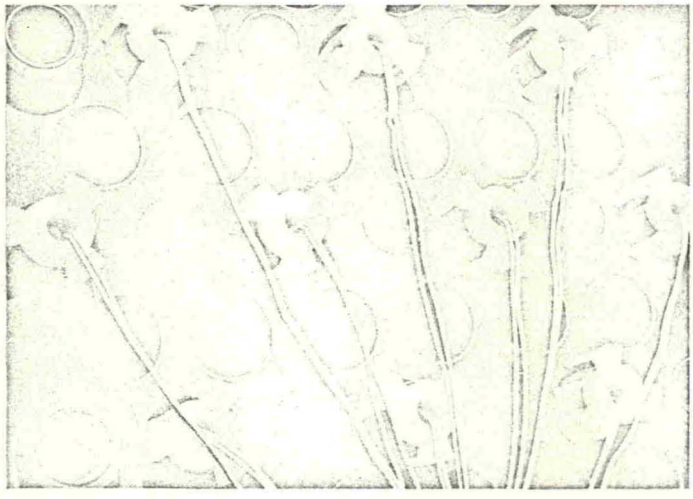


[*Courtesy Welding Inst.*

35 Schematic diagram of assembly for explosive welding (*YIMpact* system). (*Cairns and Hardwick.*[54])

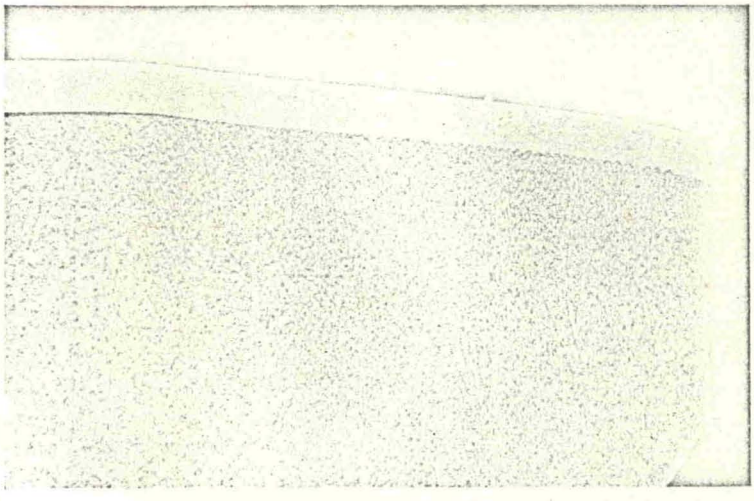
So far, data are not available for the radial velocity imparted to the tube wall immediately before impact. Chadwick[36] considers that the equations for estimating the velocity of the flyer plate in cladding are equally applicable to tube welding, though as in that case the charge is more confined this may not be true. If the minimum charge weight for a reliable weld is determined, then the minimum ligament thickness can be established for which the distortion in adjacent unwelded tube holes is acceptable.

Chadwick *et al.*,[53] Cairns and Hardwick,[54] and Robinson *et al.*[59] have discussed methods of testing the integrity of the welds between tube and tube plates obtained by the angular-geometry method. Chadwick *et al.* reported on push-out or pull-out tests on tubes in which a plug was used to try to push out a length of $1\frac{1}{4}$ in (31·8 mm) of $\frac{3}{4}$ in (19·1 mm) O.D. × 0·040 in (1 mm) wall thickness stainless-steel tube from a mild-steel tube plate. A load of 18 tonf (180 kN) was applied without failure of the bond at 20° and 600° C (295 and 875 K), and after quenching 200 times from 600° C into hot water. Peel tests have also been conducted but peeling stops abruptly in the weld zone and ultimately the strip breaks without failure of the bond. In shear tests failure occurs away from the weld interface. Chadwick *et al.* also mention fatigue tests in which the tube/tube-plate joint was subjected to repeated bending and satisfactory results were achieved. Cairns and Hardwick also carried out thermal-cycling tests in which three aluminium-brass tubes were welded into small tube plates at each end. The tube plates were connected by steel tie-bars and the whole assembly was then subjected to 10 cycles at a given temperature, followed by a hydraulic-pressure test applied to the outside of the tubes. The explosively welded tubes showed no signs of leakage even up to a cycling temperature of 450° C (725 K), whereas roller-expanded joints showed a significant decrease in the leakage pressure above 200° C (475 K) and they were completely ineffectual above 250° C (525 K). Robinson *et al.* describe manual and automatic ultrasonic tests of tube-to-tube plate welds that give results which are confirmed by metallography, peel, and leak tests. However, the method cannot detect unfavourable metallurgical conditions at the interface, such as a cast interlayer or brittle intermetallic phases.



[*Courtesy Welding Inst.*

36 Arrangement of charges and hard-steel rings in the *YIMpact* system. (*Cairns and Hardwick.*[54])



[*Courtesy Welding Inst.*

37 Aluminium brass tube *YIMpact* welded to Naval brass tube plate. × $6\frac{1}{2}$. (*Cairns and Hardwick.*[54])