REPAIR OF AN ALLOY STEEL CRANKSHAFT BY FLASH-BUTT WELDING.

Flash-butt welding is an electrical welding method in which the two parts to be joined are held firmly in clamps attached to the secondary of a transformer. By bringing the faces close together an arc is struck and is maintained for a sufficient time to render an adequate amount of the metal plastic. At this stage the two pieces are pressed together and the current is cut off. At the time when the surfaces are pressed together all molten metal, oxide, etc., is forced out and a clean metal to metal junction is obtained. From the manner in which the welding heat is generated it will be evident that the only limitation to size which can be welded by this method is the amount of electrical energy available and the power available for pressing the pieces together.

Until a few years ago the use of this process was confined almost entirely to mild and medium carbon steel. It has recently been applied extensively to the welding of chromium molybdenum steel tubing for aircraft construction, but this is the only type of alloy steel which has been joined by flash-butt welding on a large scale.

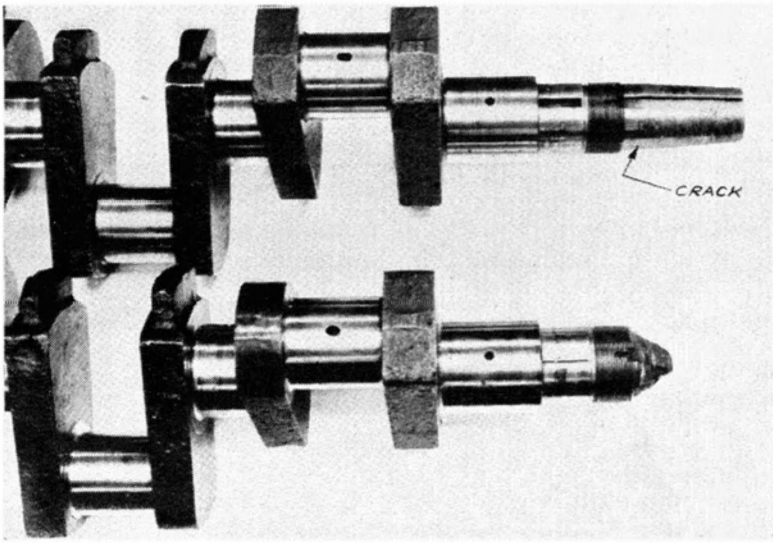

FIG. 1.—TWO DEFECTIVE CRANKSHAFTS OF KERMATH ENGINES

Early in 1942 a problem arose of attempting to salvage a number of crankshafts from Kermath engines, all of which were cracked or fractured in the extension of the end journal as shown in Fig. 1. The crankshafts were made from a nickel-chromium-molybdenum steel heat-treated to a tensile strength of about 65/70 tons/sq. in. and the diameter at the position of failure was about 2½ inches. It was thought at the Admiralty Engineering Laboratory, West Drayton, that flash-butt welding might be a suitable method of attaching new extension pieces to the end journals of the failed shafts and some experiments were undertaken to examine the practicability of this method.

Lengths of steel similar in composition, tensile strength and cross-sectional area to the crankshaft were obtained and, by the co-operation of the welding

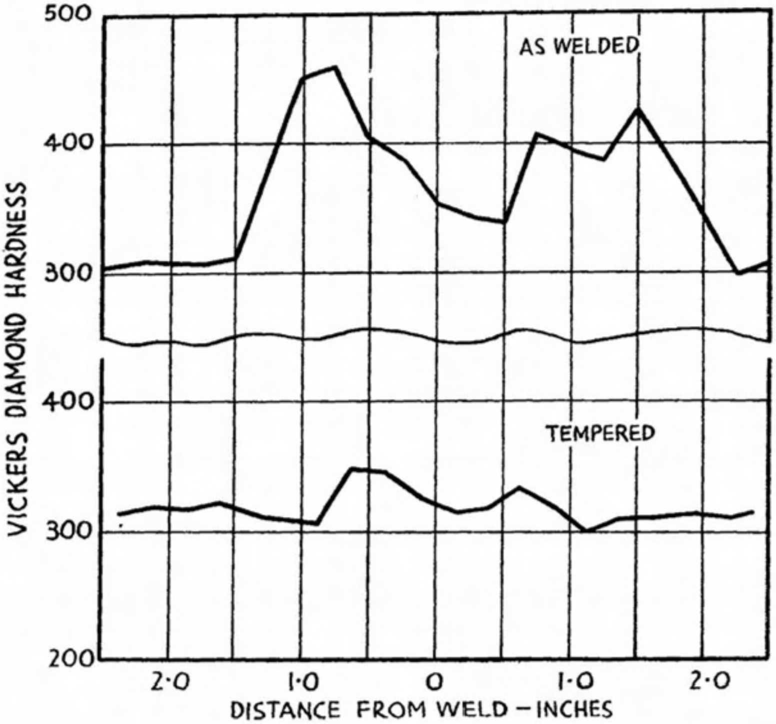

FIG. 2.—HARDNESS SURVEY BEFORE AND AFTER TEMPERING

machine manufacturers and the owners of a machine of suitable capacity, were welded together. A hardness survey along the length of the welded bar showed, as might be expected, that on either side of the junction there was a region of high hardness as indicated in Fig. 2 due to rapid conduction of heat from the high temperature region to the water-cooled clamps. Tests made across the weld after tempering the weld region back to about the original hardness of the steel showed that the tensile strength was practically equal to that of the unwelded material and the ductility was reasonably good.

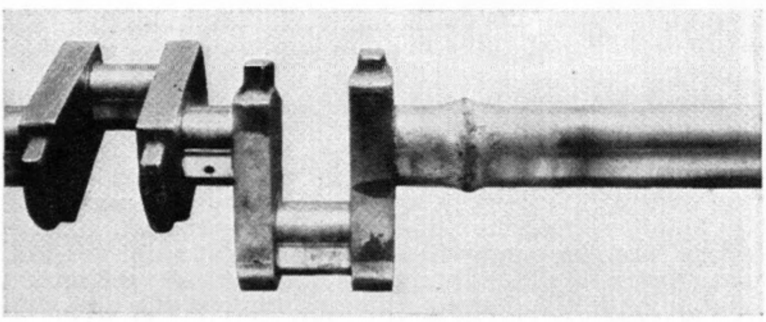

FIG. 3.—REPAIRED SHAFT BEFORE MACHINING

The weld region of the trial bar had been tempered in a furnace, but this method could not be used on a fully machined crankshaft because of difficulties with scaling of the steel. A further trial was therefore made of the possibility of tempering the weld region by passing sufficient current through the bar while still in the welding machine to raise the weld region to about 600° C. A hardness survey of a bar tempered in this manner is shown in Fig. 2, and it will be seen that a very satisfactory levelling off of the hardness was achieved.

A suitable clamp for the welding machine to hold one end of the crankshaft was made and some fifteen shafts had new ends welded on to them by the flash-butt welding process, one of the repaired shafts before machining being shown in Fig. 3. It is of interest that one such shaft when cut up for test purposes showed a tensile strength in the weld region of about 84% that of the original crankshaft material and a fatigue strength in the Haigh test about 78% that of the original material. Later tests on other materials have indicated that the fatigue strength under bending stresses may not be so good as under tension-compression stresses, but this point remains to be explored further.

Another application of the process which has been attempted was the fabrication of a nickel steel crankshaft having $2\frac{3}{8}$ in. diameter journals. Owing to its design it was difficult to manufacture the crankshaft as a single drop stamping but it could be readily made in the form of two drop stampings if some means of joining the two parts was available. One shaft has been made up from two halves flash-butt welded together at the centre journal but no opportunity has arisen as yet of testing the behaviour of this shaft in an engine.