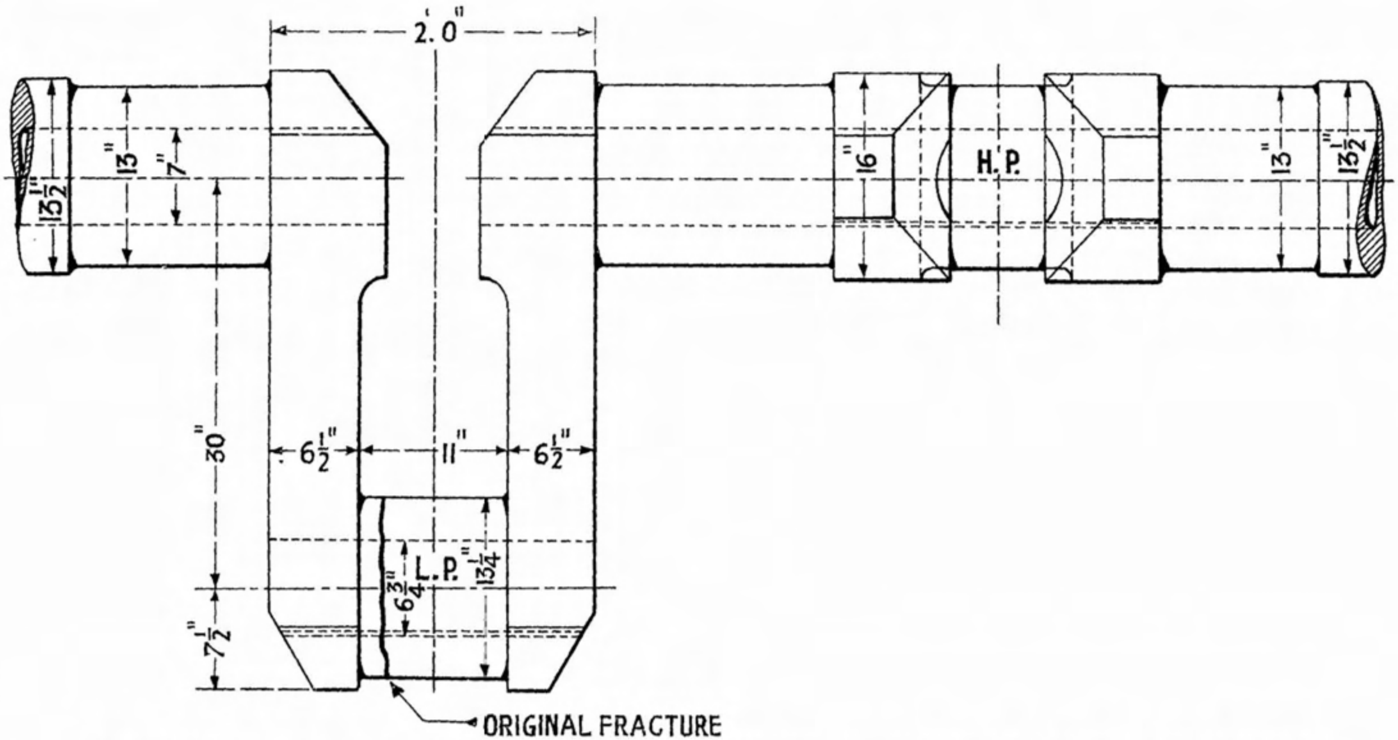


FIG. 1.—PART OF STARBOARD CRANKSHAFT OF H.M. PADDLE TUG "FIRM" SHOWING POSITION OF FRACTURE IN L.P. CRANK PIN

AN INTERESTING CRANKSHAFT REPAIR

Although paddle machinery for seagoing vessels disappeared from the Navy many years ago and the inclusion of an article dealing with such a subject may seem out of date, the following description of an emergency repair to a fractured crankshaft has been included as it shows what can be achieved using modern methods. The work was only undertaken under the stress of war by Chatham Dockyard for the reason that no firm in the country could supply a replace shaft within the time limit imposed.

The starboard crankshaft of H.M. tug *Firm* was found to be fractured at the junction of the L.P. crank pin and L.P. web (Fig. 1) and was removed from the vessel by H.M. Dockyard, Sheerness. The shaft was sent to Chatham where the fractured crank pin was burnt through close to the webs and machined flush. This revealed hitherto unsuspected cracks in the outboard web (Fig. 2). The web was therefore cut back about 18 in. and prepared for welding. A forging was prepared from which a new portion of the web could

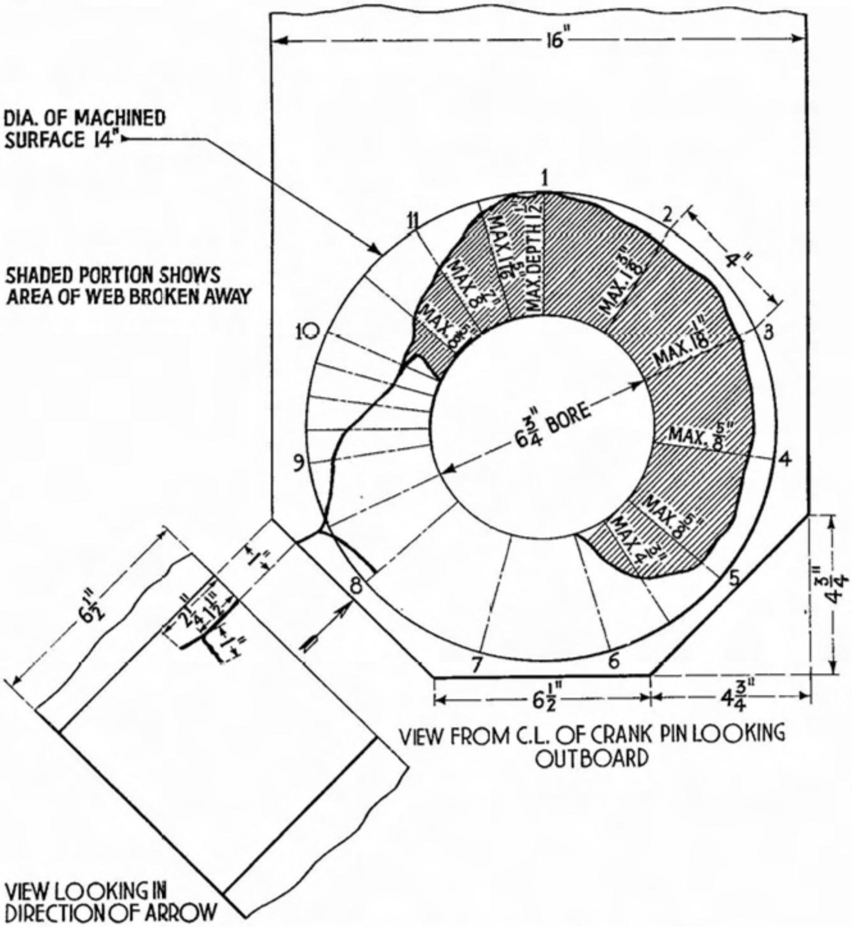


FIG. 2.—CRACKING DISCOVERED IN OUTBOARD WEB

be made. This was rough machined and bored and prepared for welding with a similar profile to the original portion of the web.

The new portion of the web was rough machined $\frac{3}{8}$ in. larger on all dimensions to form a finishing face and $\frac{3}{8}$ in. plates were tacked on the face of the old web to conform to the section of the welding groove as shown in Fig. 3. The webs were then aligned to allow a 1/16 in. gap between the throat faces (Fig. 4) and angle iron stiffeners were tacked in position. The joint was then tack welded, the gap being maintained by fox wedges and four stay bars of $1\frac{1}{2}$ in. square section were tack welded in position as shown in Fig. 3. These operations were carried out while the two components were fixed to the aligning slab, the whole unit was then lifted so that the shaft was in the vertical position to enable gravity welding to be carried out. This is shown in the upper illustration on page 76.

The actual welding sequence with Ironex No. 1 electrodes is shown diagrammatically in Fig. 5 and was as follows :—

(a) Two runs of 8 gauge were deposited on one side and the two stay bars were then temporarily removed.

(b) Two runs of 5/16 in. gauge were deposited at an amperage of 410 on the same side.

(c) As a result of (a) and (b), the new portion of the web had lifted 3/16 in, relative to the old portion. The two stay bars were replaced and the whole shaft turned upside down, thus placing the opposite welding groove in position for gravity welding. The other two stay bars were then removed and although good penetration was observed at the gap in the throat the joint was thoroughly chipped out to ensure that a good groove was obtained. The web was preheated to a low temperature to remove the chill and was allowed to warm through for approximately $1\frac{1}{2}$ hours.

(d) Two runs of 8 gauge and two runs of 5/16 in. gauge were then deposited on this side.

(e) the angle support at the side was cut to facilitate movement and two more runs of 5/16 in. gauge were deposited. This resulted in the new portion of the web distorting 5/16 in. in the opposite direction.

(f) The stays were replaced and the whole shaft reversed again.

(g) Three runs of 5/16 in. gauge at 410 amps were deposited after the stays on the upper face had been removed. This caused the web to lift 3/16 in.

(h) The shaft was again reversed and one run of 5/16 in. gauge at 410 amps. and five runs of 5/16 in. gauge at 460 amps. were deposited. This caused the web to lift 7/16 in.

(i) The shaft was reversed and nineteen runs of 5/16 in. gauge at 460 amps. were deposited. This brought the new portion of the web level with the old.

(j) The shaft was reversed and five runs of 5/16 in. gauge at 460 amps. were deposited. Slight distortion occurred.

(k) The web was then placed in a furnace at approximately 150° C. the shaft, being accommodated outside. The furnace temperature was gradually increased to 650° C. over approximately $6\frac{1}{2}$ hours and then allowed to cool for approximately $4\frac{1}{2}$ hours, after which the furnace was opened and allowed to cool for a further three hours. The shaft was then removed and allowed to cool until capable of being handled and transported to the welding site.

(l) Seven runs of 5/16 in. gauge at 460 amps. were deposited and the web lifted 1/8 in.

(m) Shaft was reversed and twenty runs of 5/16 in. gauge at 460 amps. were deposited which brought the web level.

(n) Shaft was reversed and twenty runs of 5/16 in. gauge at 460 amps. were deposited. The web remained level. The welding grooves were then completely filled with weld metal which involved a further deposition of approximately 83 runs of 5/16 in. gauge at 460 amps. No further distortion of the web was noted.

(*o*) The welds were then trimmed and the shaft transported to the furnace for further heat treatment. The web was charged into the furnace at approximately 150° C. and the temperature raised slowly to 880° C. over approximately $6\frac{1}{2}$ hours. The temperature was maintained at 880° C. for a further $6\frac{1}{2}$ hours when the furnace was shut down. After about half an hour the shaft was removed and covered with asbestos sheets and allowed to cool in still air to shop temperature.

Machining of the welded webs

The sides and inner face of the web were machined and a pilot hole drilled to mandrel size. The inboard web was bored out to finished size and a new crank pin made with particulars shown in Fig. 6. Two cast iron bushes to fit the finished bore of the holes in the webs and a mandrel were made to assist

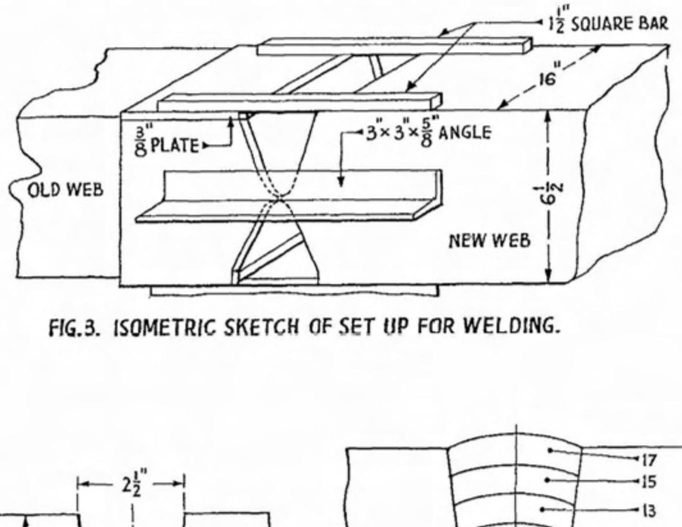


FIG. 3. ISOMETRIC SKETCH OF SET UP FOR WELDING.

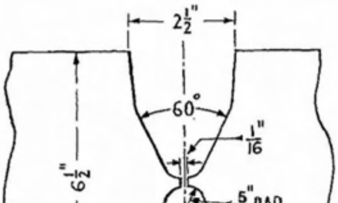


FIG. 4. DETAILS OF PREPARATION.

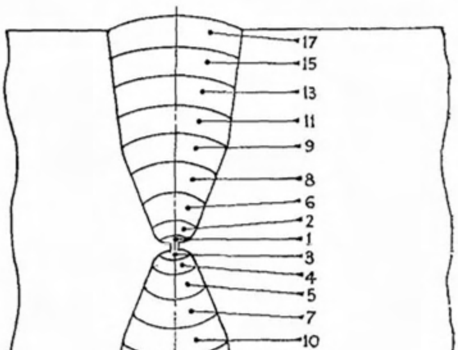


FIG. 5. ORDER OF WELDING STAGES.

FIGS. 3, 4 AND 5.—PREPARATION FOR WELDING OPERATIONS AND SEQUENCE OF RUNS

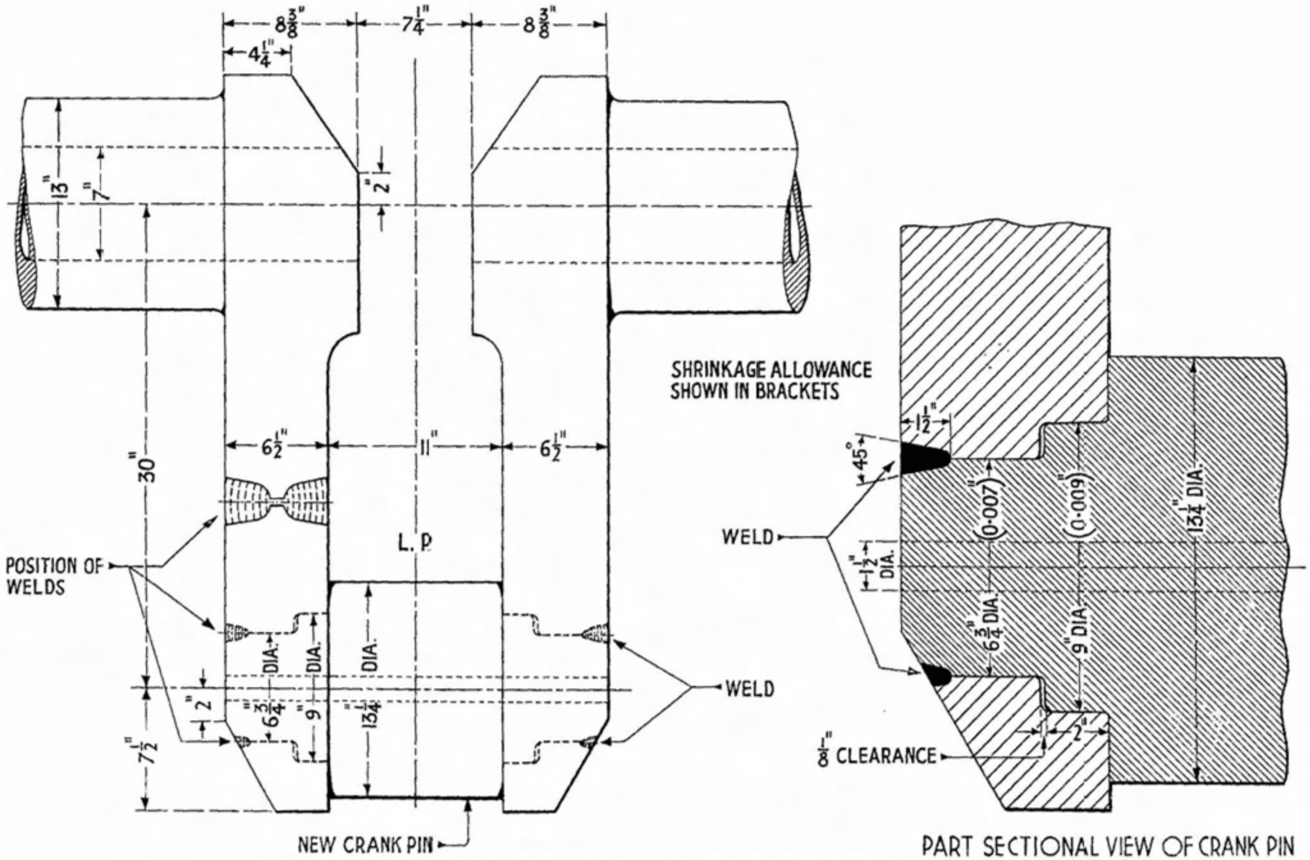


FIG. 6.—DETAILS OF NEW CRANK PIN FOR SHAFT OF "FIRM"

in lining up the webs for assembly. The two webs were then set up face to face with the mandrel inserted through the pilot hole and the cast iron bush in the other web. An error of .003 in. was found in the centre distances of the crank shaft journal and pin centre line. This error was corrected and the holes in the webs for the new crank pin were bored and counter-bored to finished size.

Setting up and assembly (First attempt)

The inboard part of the shaft was set up and secured to a carriage which was either free to move or could be locked to the bed of the large propeller shafting lathe, the outboard part being mounted on a similar carriage secured to the lathe saddle. Main bearing journals were checked for parallelism vertically and horizontally and the webs were aligned so that the mandrel was a push fit in the bushes in the two webs simultaneously.

The new crank pin was soaked for three hours in 2 cwts. of dry ice and the two crank webs were heated for approximately $\frac{3}{4}$ hour by gas torches to a black heat. The pin was then removed from the dry ice and placed on a " V " block between the two webs which had been adjusted so that the pin would be exactly in line with the holes in the crank webs. The lathe saddle was then moved so that the outboard web slid over the pin and pushed it into the corresponding hole in the inboard web. A strongback was applied across the two webs to keep them close up to the shoulders of the pin but in spite of this a gap of approximately .015 in. was found between the inboard face of one crank web and the cheek of the pin which it was not possible to close. The assembly was allowed to reach shop temperature and was then placed in the large lathe and checked for truth. This check revealed that the outboard journal was $\frac{1}{4}$ in. out of truth. It is considered that the .015 in. gap was due to the web and pin making contact first on the smaller diameter ($6\frac{3}{4}$ in.) at a point remote from the inner face of the web, the relative expansion of the pin and contraction of the web resulting in the appearance of the .015 in. gap at the $13\frac{1}{4}$ in. diam. shoulder.

Setting up and assembly (Second attempt)

The pin was burnt through and bored out and a new pin made. A $1\frac{1}{2}$ in. diam. hole was drilled through the pin so that a strongback could be applied axially. Similar methods of shrinking the pin and heating the webs were adopted, but as soon as the pin was in place and the lathe saddle was moved up so that the shoulders of the pin were in contact with the cheeks of the webs the strongback was applied by means of a $1\frac{1}{4}$ in. bolt through the centre of the crank pin. At the same time the carriage to which the inboard portion of the shaft was attached was freed from the lathe bed so that relative movement between the two portions of the shaft, due to the expansion of the pin on warming to shop temperature, would not be restricted. In spite of these precautions, a maximum gap of .004 in. appeared at the $13\frac{1}{4}$ in. diam. shoulder. On checking for truth the sponson bearing was found to be 1/16 in. out of truth due to the slight opening of the web faces.

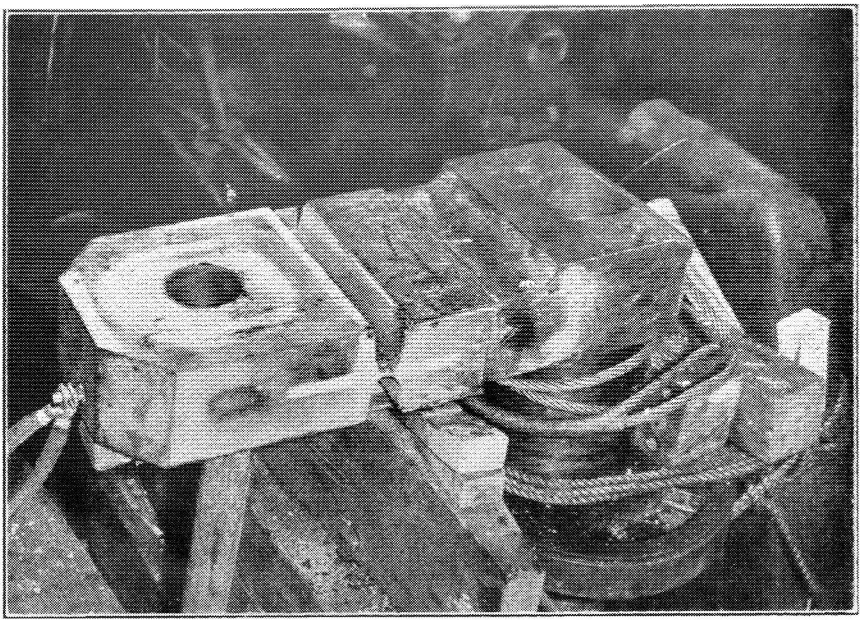
In order to weld the crank pin to the webs the shaft was slung vertically from an overhead traveller to enable gravity welding to be carried out.

(a) Six runs of 8 gauge, Ironex No. 1 electrode, were deposited in web 'A.'

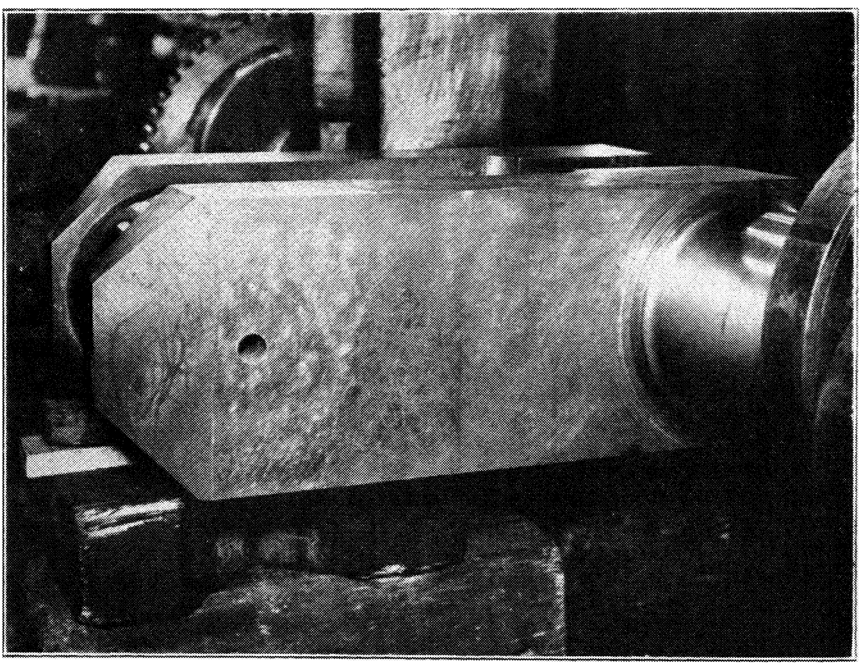
(b) The shaft was reversed and six runs 8 gauge were deposited in web 'B,' followed by seven runs of 6 gauge to complete the weld.

(c) Shaft was reversed and fifteen runs of 6 gauge were deposited in web 'A' to complete the weld.

Weld surfaces between pin and web were machined off flush and the chamfer on the new web was machined. The shaft was then set up in the lathe



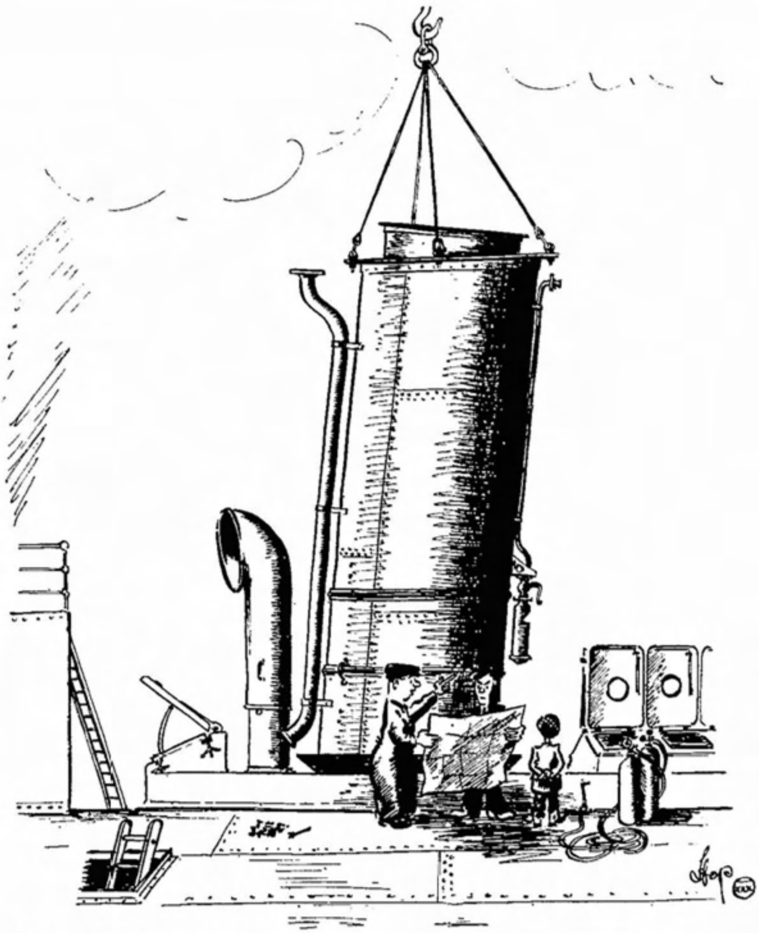
SHAFT IN POSITION FOR WELDING



THE COMPLETED JOB, READY FOR DESPATCH

with the inboard end in the chuck and steady bearings placed under each main bearing and the journal in turn. The shaft was finally set up so that the sponson bearing and the journals between the H.P. and L.P. crank and inboard of the H.P. crank were running true. This resulted in the journal outboard of the L.P. crank running .025 in. out of truth. This journal was then machined true, approximately .050 in. on diameter being removed. (See lower illustration on page 76.) The paddle hub and keys were then fitted and the shaft was despatched for installation.

The work of repair was taken in hand during the second week of February, 1944, and completed during the third week in April. Satisfactory sea trials were carried out on May 26th, 1944.



"That's the boiler shop again! The whistle should be higher up on the other side."

By courtesy of "Shipbuilding and Shipping Record"