NOTES FROM SEA

RUDDER REPLACEMENT AFLOAT

The following account of the replacement afloat of the starboard rudder of a BIRD *Class patrol vessel is supplied by Lieutenant P. J. Horsted, R.N., Base Engineer Officer on the staff of Senior Naval Officer Northern Ireland.*

Introduction

Recently a BIRD Class patrol vessel lost her starboard rudder whilst on Grenada patrol. She arrived alongside in Belfast (with about four feet of water in her tiller flat) to be met by the Base Engineer Officer and a diving team provided by the Royal Engineers.

It was quickly established that her starboard rudder had sheared inboard and dropped out, leaving a 6-inch hole that was causing the flood. The lower bearing housing was plugged by the divers and the tiller flat was pumped out.

Decision

The following options were now considered:

(a) The rudder gland could be made watertight and the ship could return to Rosyth to await refit six weeks hence.

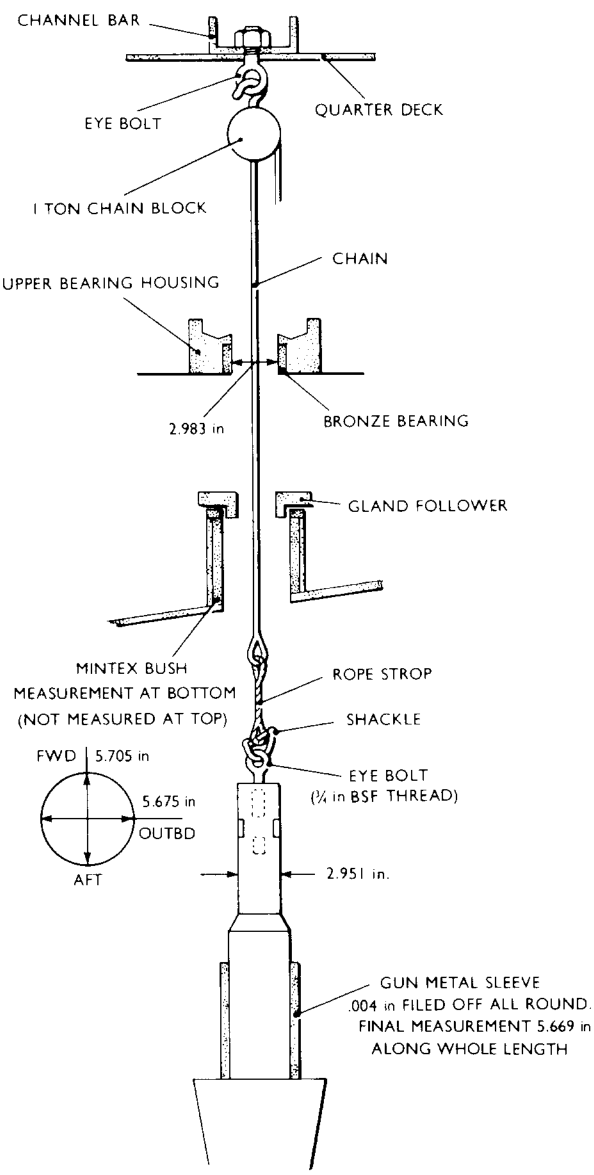
(b) The ship could be given an emergency docking in Belfast and have the rudder replaced commercially.

(c) The new rudder could be put in with the ship alongside the Naval Jetty.

It was decided to attempt option *(c)* and the appropriate storedem was raised.

Rectification

The new rudder was conveyed from Wales by a Type 42 destroyer and finally arrived underslung from a Lynx helicopter. After unpacking and measuring the new rudder, a hole was drilled in the top of the stock (using an industrial heavy-duty electric drill) and tapped to take a ¾-inch BSW eye-bolt.



The upper keyway in the new rudder was found to be only roughly machined. This was faired with a hammer and chisel and finish with a scraper and fine file. Also two new keyways were manufactured using the base's lathe.

Meanwhile in the tiller flat, a 1-ton chain block was slung from the deckhead, an eye-bolt being fitted through the deckhead with a section of channel bar to spread the load. The hook was removed from the chain hoist and a rope strop substituted.

The tiller flat was then allowed to flood up and the bung removed. At this point the rudder bearing was measured using an internal micrometer. The chain was then lowered through the hole until the rope strop was some six feet below the ship. Meanwhile the rudder was lowered by mobile crane vertically into the water at the stern. The end of the strop on the chain hoist was then shackled to the eye-bolt in the top of the rudder stock and the crane strop cut, leaving the rudder suspended from the chain hoist.

The rudder stock was then pulled into position. It did, in fact, take three attempts to get the rudder fully home since 0·004 inches had to filed from the gunmetal sleeve before it would fit. When the rudder was fully home, the steering gear was reassembled and a successful steering-gear trial carried out.

The total time taken to remedy the defect from receipt of the new rudder was twenty-five hours.

Conclusion

Replacing the rudder whilst the ship was alongside at a tidal berth saved considerable time and expense, and required little in the way of specialist equipment. It was also an excellent example of inter-Service co-operation, with the Royal Engineers' diving team doing an excellent job in unfamiliar circumstances.

IRON-IN-STEAM FIRE

Narrative of Events before the Outbreak of Fire

In a recent incident, a ship's main boiler was completely destroyed by an iron-in-steam fire of the type that is described in *BR 3000,* art, 1238, *BR 3001,* art. 1216, and in the June 1980 issue of the *Journal of Naval Engineering.*

The ship was in harbour with steam raised for auxiliary purposes. The middle watch had experienced difficulties with an unsteady boiler-water level. However, the difficulties were controllable and not thought to be unusual. Both gauge glasses were in use and showing similar levels, but the Igema water-level indicator was out of action. On taking over the watch, morning watchkeepers were informed that hand control of the Robot feed regulator was necessary and that the emergency bypass (shut-off) control was in the 'slightly cracked-open position'. At approximately 0415 when the LMEM water tender reported that he was unable to control the rising water level, the POMEM of the watch shut down the boiler to prevent priming.

Having supervised the restoration of auxiliary power using oil-driven generators, the Engineer Officer of the Day joined the watch below to assist with re-lighting the boiler. He personally carried out gauge-glass drill, using the longer of the two gauge classes, and perceived that the water level was over the top of the gauge glass. It had previously been confirmed, by use of the superheater header drains, that the water level had not flooded over from the steam drum. With the boiler pressure at 310 psi, an attempt was made to restore the water level by blowing down. Seven blows, each of one minute's duration, were applied to each leg—a total of fourteen minutes blowing down. During this sequence, the water tender almost continuously conducted gauge-glass drills 'to establish the water level'. With the boiler pressure at 250 psi, the EOOD decided to re-flash the boiler to regain boiler pressure for a further blow down. Before doing so, he conducted a shortened version of gauge-glass drill (close water/open drain only) and concluded that the water level was still too high. The foreshortened drill was done to confirm the checks carried out by the water tender. By the time the steam range had been opened out and a flame established using the dieso lighting-up pump, the boiler drum pressure had dropped to zero psi.

Ten minutes after lighting up, the steam pressure had risen to 7 psi. Some ten to fifteen minutes later, with drum pressure no more than 10 psi, muffled bangs/pops were heard. Throughout the flashing-up period, the water tender was checking and reporting that the water level in the steam drum was still over the top of the gauge glass. After a further series of pops and bangs, followed by a flame issuing from the boiler front, the water tender again tested the gauge glass and reported that he could not find the water level. This

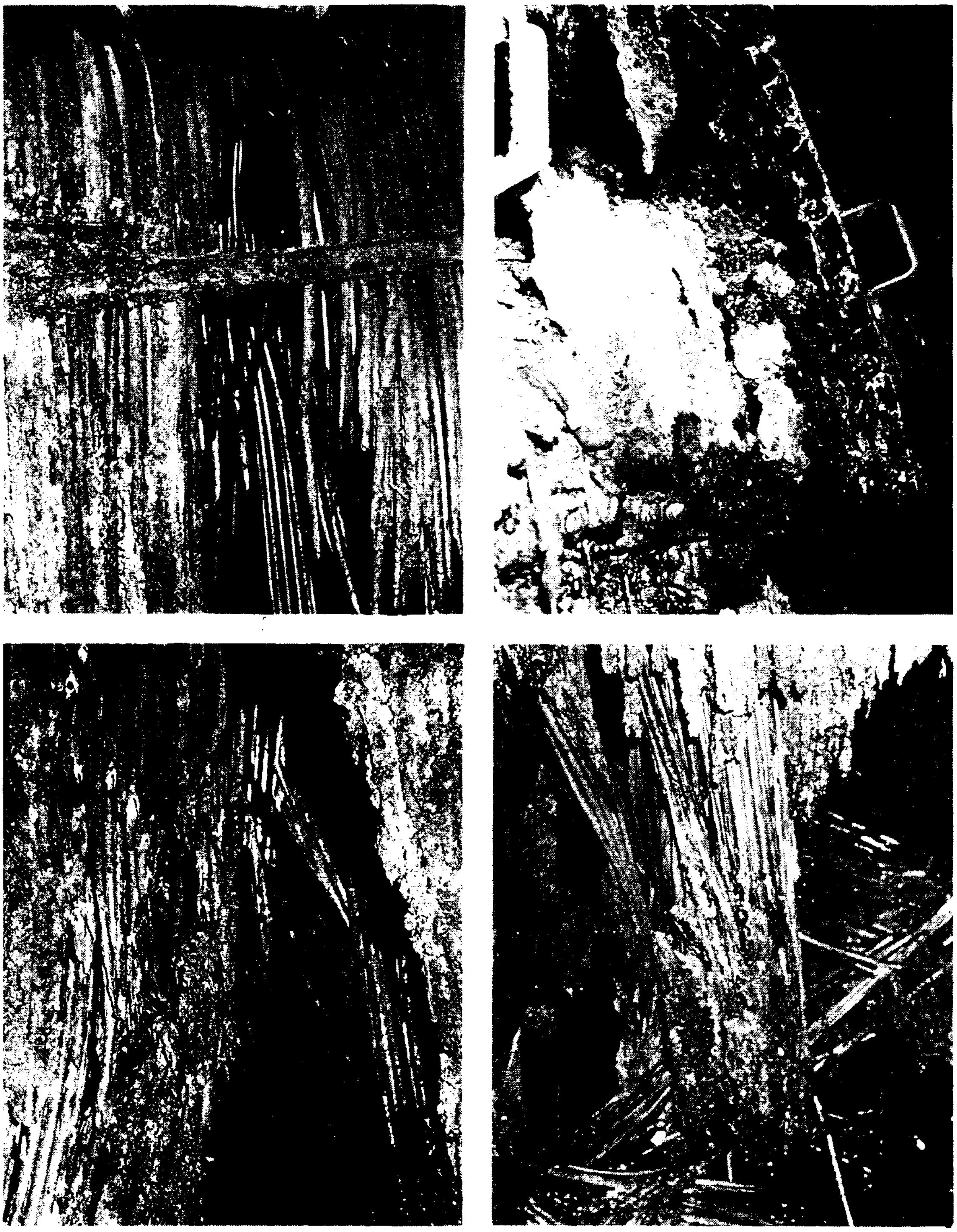


FIG. 1—PHOTOGRAPHS OF THE BOILER AFTER THE FIRE

fact was immediately confirmed by the Auxiliary POMEM of the Watch, and the POMEM of the Watch shut down the boiler. The burner fuel cocks were shut off and the boiler was fed using the motor-driven extraction pump. This was stopped very shortly afterwards as the boiler room became enveloped in steam and smoke. Action was then taken to report the fire to HQ1.

Narrative of Events during the Fire-fighting Episode

While retracting the burners after shutting down the boiler, the POMEM of the Watch noted smoke in the uptake mirrors and a fire between the water drum and casing on the starboard side. This was tackled with an extinguisher. Molten metal was seen to be dropping into the bilge creating smoke as it came into contact with the oily surface of the bilge water. The watch below began rigging fire hoses, but before these could be brought into use dense smoke made it necessary to evacuate the boiler room.

As steam drenching was not available, foam was injected down the standpipes. A total of twenty-four drums of AFFF was used. After a brief discussion, the MEO realized that the incident was possibly an iron-in-steam fire. He therefore decided to make an early re-entry into the boiler room to attack the seat of the fire. By this time the local fire brigade had arrived to assist. The re-entry was achieved with their help (using No. 1 hoses and foam) through the normal air lock. Local secondary fires were pushed back and the team reached the top plates. At this level, the intense heat prevented further progress for several minutes, but the natural updraught through the boiler greatly assisted the firefighters by carrying away heat, smoke, and steam.

The foam level was waist high on the bottom plates. It soon became apparent that the seat of the fire was in the starboard after corner of the boiler itself. All effort was therefore concentrated on cooling the boiler through every access that could be made available. A hose was inserted into the furnace sighting tube and another through a register after the burners had been removed. At this stage, the steam drum was seen to be glowing white hot and molten boiler tubes were seen to be dropping into the furnace. Boiler casing doors and uptake accesses were removed at considerable risk to personnel to gain access to the fire as cooling down continued.

The effects of the heat generated by the fire were felt on its boundary, particularly the uptake area on 5 deck and up to the funnel. On 5J fan-flat boundary, cooling water was reported to be boiling off. The cofferdam forward of the boiler and the reserve feed tanks were filled with water and boundary cooling was applied in the engine room, as the paint began to blister. Hoses were rigged to boundary cool the ship's side and to pour water down the forward section of the funnel. Boundary cooling was applied for some three and a half hours and, in all, it took five hours to extinguish the fire.

Lessons to be Learned for the Operation of Main Boilers

Onset of an Exothermic Reaction

As a result of the investigation, there can be no doubt that conditions existed to create an iron-in-steam fire. Such conditions result when steel is heated above 700°C in the presence of steam and, in this instance, occurred because of the loss of water level in the boiler. Other reasons for poor heat transfer, and hence overheating, were considered but discounted.

In highly-forced naval boilers, the critical temperature can be reached very quickly if the heat generated is not dissipated by the water circulation through the tubes. Had all or even some of the points outlined below been acted upon, then the incident might never have occurred or, at least, the resultant damage and consequences might have been less severe.

Controlling Boiler Water Level

Throughout this incident, the boiler water level could only be properly observed by the water tender on the upper plates because the Igema was out of action. Controlling that level by means of emergency valves on the feed regulator directly contravenes the instruction given in *BR 3000,* art. 1232, para. 4. Where a feed regulator's performance is degraded, the secondary method of feeding is by manual control of the main feed check, the feed regulator being held open by means of the emergency bypass (rapid-opening) valve *(BR 3000,* art. 1232(3)). The tertiary method of feed, made necessary when the feed regulator is totally out of action, is by manual control of the auxiliary feed check. The rapid-opening and the rapid-shut-off valves are provided for emergency use only and should never be used as the means of regulating the water level in a steaming boiler.

Water-level Indicators

The Igema had been put out of action because the procedure for opening it up to the boiler, on flashing up, had been carried out incorrectly and, consequently, the fluid had been lost. Details of the procedure for bringing Igemas into use are given in *BR 3104* and should be known and understood by all boiler operators.

Examination of the gauge-glass mountings showed the orifices to have been clear, but some of the stops that limit the rotary travel of the cocks were missing allowing the possibility of cock bores becoming misaligned with their orifices. Information on water-level indicators is given in *BR 3000,* art. 1232 and *BR 3001,* art. 1203.

Blowing through Water-level Indicators

Having proved the orifices clear and checked the resetting of the cocks, it is thereafter only necessary to note and observe any change in the level. Water level is liable to be inaccurate when blowing down; the boiler level should have been given a chance to settle between individual blows to establish an accurate reading in the gauge glass.

Blowing down the Boiler

Detailed instructions for this operation are given in *BR 3001,* art. 1212, and in particular in art. 1212(5) concerning the quantity of water removed from the boiler on each 'blow'.

Lessons to be Learned from the Fire

Steam Drenching

The correct diagnosis of an iron-in-steam fire and the decision to make the earliest possible re-entry into the boiler room were decisive factors in the successful containment and ultimate extinction of the fire. If steam drenching had been used, it would have prevented the early re-entry and so the fighting of the fire by the only effective means—that of cooling by the application of large quantities of water (see *BR 3001,* art. 1216, para. 7).

Containment of the Fire

The speed with which the ship's containment group was able to locate the hot boundaries and gain access to apply boundary cooling was significant in containing the fire and no secondary fires occurred.

Y.100 MAIN TURBINE ROTOR JOURNAL DAMAGE

Over the past ten years, there has been a high usage rate of Y.100 turbine bearings. This fact was not fully appreciated until the latter half of 1980 when H.M. ships *Argonaut, Danae, Dido,* and *Sirius* suffered serious turbine journal damage. The damaged journals were all found to have been reclaimed by electroplating with nickel. The recent change of lubricating oil from OEP 69 to OM 100 was first thought to have been a significant factor, but reversion to OEP 69 in *Argonaut* and *Sirius,* following journal damage and repolishing, proved only to be a temporary expedient.

Journal damage is believed to occur predominantly to nickel and sometimes to steel journals under the following conditions:

(*a*) During manoeuvring and, in particular, prolonged astern running, when casing hogging causes journal/bearing misalignment and excessive bearing loading.

(*b*) During turning with turning gear when the hydrodynamic oil film is absent.

Damage has been mutually destructive to journal and bearing in the case of nickel-plated journals because of the inherent properties of nickel. Not infrequently in the case of steel journals, circumferential scoring leads to corresponding markings in the whitemetal, the latter taking on a polished appearance. Often the weardown in these conditions is imperceptible; a stable situation occurs and satisfactory service is obtained. This is in sharp contrast to the mutually destructive nature of nickel/whitemetal combinations.

Nickel has now been withdrawn as a reclamation material for main turbines. Excepting *Sirius* whose port turbine is out of action, the only fescolized rotor in service is in *Yarmouth*.

Investigations are proceeding in two areas. Firstly, an alternative reclamation material is being sought, thus avoidng the requirement for undersize bearings. A tungsten carbide coating, developed by Union Carbide, looks promising. It is extremely hard, and thus virtually incapable of being scored. Tests are required to ensure its compatibility with whitemetal under all operating conditions including misalignment.

Secondly, turning must be minimized. Some measures have already been taken, but it is still possible that turbines are turned too frequently. Trials will shortly be conducted to assess rotor deflections during warming through and cooling down. It should then be possible to define the barring requirement at a minimum satisfactory level. Subsequently, it may be possible to develop a relative rotor deflection meter that would indicate when a single turn through 180° becomes necessary, thus reducng the barring to the absolute minimum.