AN AFLOAT REPAIR OF BOW THRUST DOOR LIFTING GEAR

BY

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ABSTRACT

The port bow thrust door of H.M.S. *Herald* jammed and was moved by hand to the open position. After trimming by the stern, divers shored the door open so that the stripped lifting nut and screw could be renewed through a hole cut in the deck above.

Introduction

HECLA Class Ocean Survey Ships (OSS) are fitted with a 270 kW transverse bow thrust unit. The openings of the transverse tunnel are fitted with sliding doors to eliminate turbulence caused by the action of the sea on the tunnel mouths, and during normal operation of the bow thrust unit these doors are retracted upwards into recesses.

The doors are raised and lowered by screw shafts and lifting rods which are connected to the bow doors by lifting crossheads and links (FIGS 1 and 2). The screw shafts are driven by 7·5 kW electric motors through a hydraulic slipping clutch unit and right angle bevel reduction gearboxes. The lifting rods, while retracting or lowering the doors, pass through sea glands fitted at the top of the door recesses. The doors run in guides and to ensure the doors are flush with the hull when fully closed a lost motion linkage is fitted to the upper crosshead which forces the door outwards when it has reached the limit of its downward travel.

Ship operating instructions state that when raising or lowering the doors speed must be below 4 knots and that when the doors are fully open speed must not exceed 10 knots.

Background

All OSS have experienced problems with bow doors which previously have led invariably to a docking. Whilst the exact nature of the failures in other ships is unknown, in the case of H.M.S. *Herald* there are two recorded failures of the starboard lifting screw and nut, occurring in 1977 and 1979. On both occasions the ship was docked for repairs to be carried out, but it is understood that the design of H.M.S. *Herald*'s bow doors is slightly different from that in the other three ships of her class. In event of the lifting screws detaching from the lifting rods there is no danger of the doors falling off, as has happened in the other vessels.

The cause of the failures in 1977 and 1979 was stripping of the nut threads and stretching of the lifting screw threads. The term 'stretching of the lifting screw' is used to indicate that the thread form was tending to change from acme to buttress. The shaft length remained unchanged.

Following the 1979 failure it was discovered that the alignment of the thrust bearings fitted to the top of the starboard lifting screws was not within specification. Realignment was carried out at the following refit and no further problems have been experienced with the starboard door. It was also suspected that the grade of steel used in the manufacture of the lifting rods was inadequate and recommendations were made for a better grade of steel to be used.

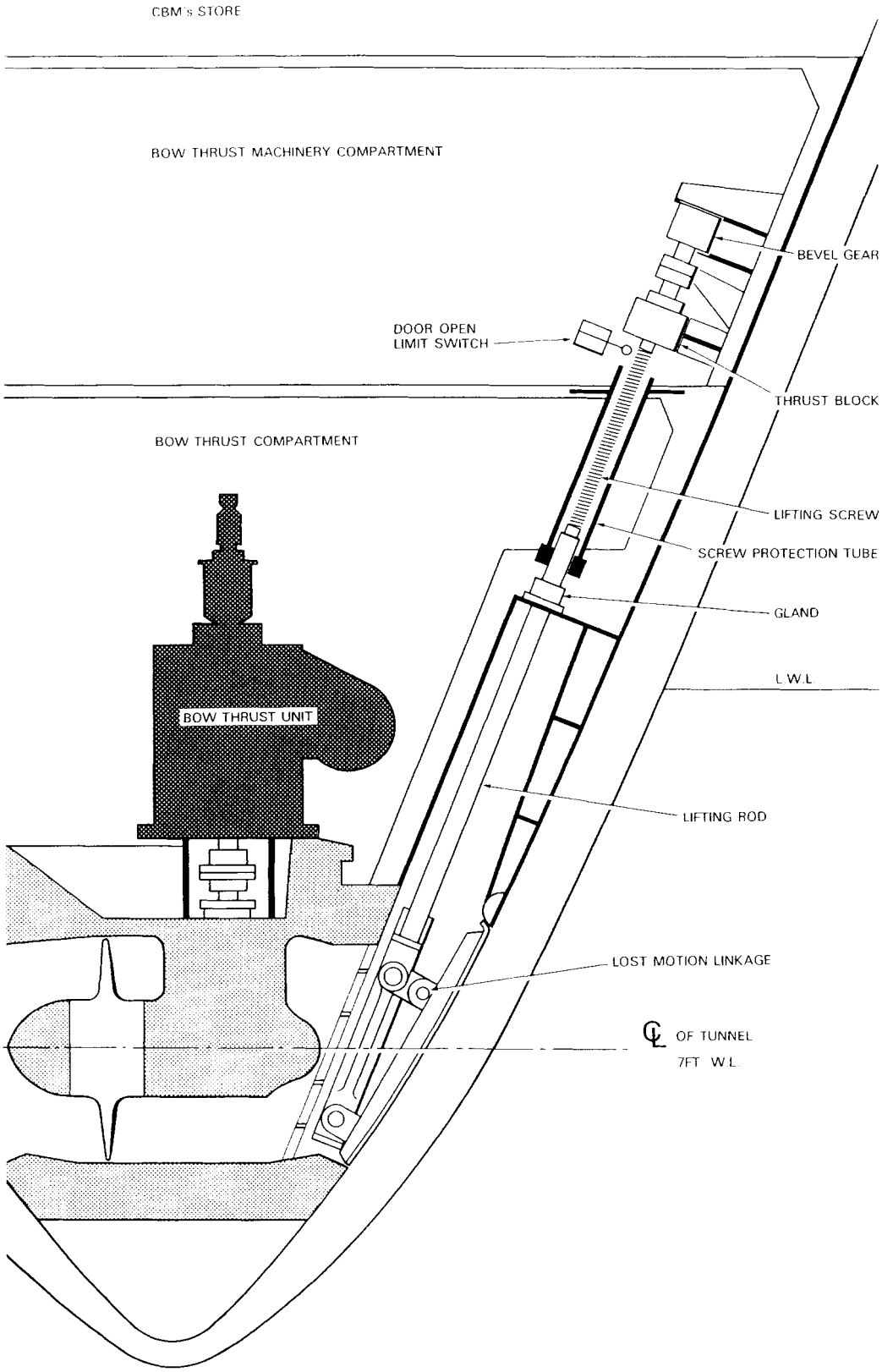

FIG. 1—BOW THRUST DOOR, CLOSED

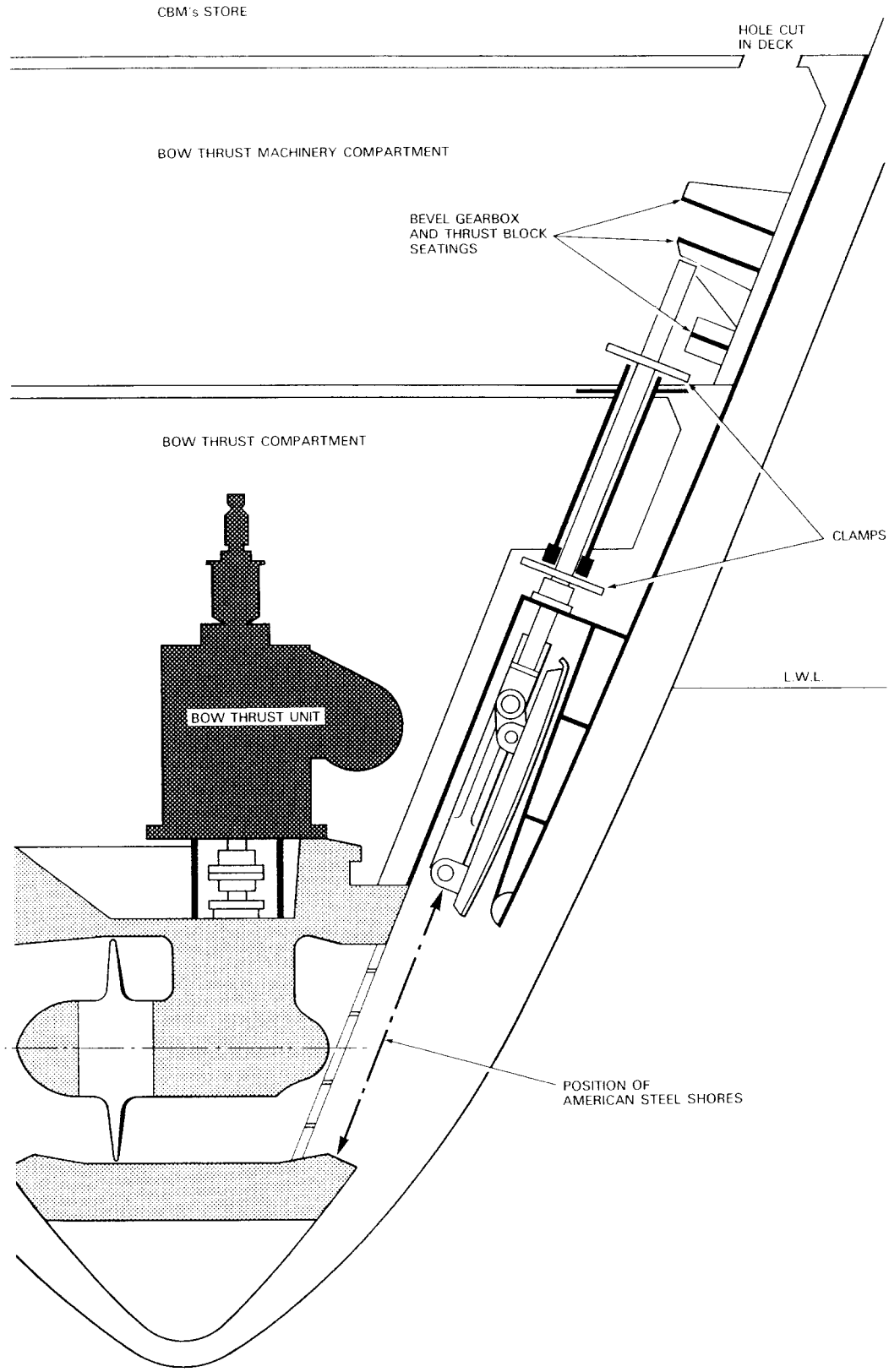

FIG. 2—BOW THRUST DOOR RAISED, SHOWING POSITIONS OF CLAMPS AND SHORES

Since that refit in 1980–1981 both doors have worked perfectly well. Inspections of the door lifting mechanisms by ship's staff and dockyards at subsequent refits and DED periods has revealed no defects, although it is not known if the dockyard maintenance schedule requires the lifting nuts to be turned out of the tops of the lifting rods and to be examined for signs of wear. Door opening times and currents drawn by the lifting motors have remained almost identical to those obtained following post-repair trials in 1979.

The Incident

Whilst surveying in the Falkland Islands with the nearest dry dock some 8000 miles away the bow thrust unit was required for use. During opening of the bow doors in preparation for bringing the thrust unit into operation the port door open lamp in the machinery room failed to operate after the normal 2 mins 10 seconds. Indication that the starboard door had opened was obtained. Investigation revealed that the port door opening motor fuse had blown indicating an overload and that the door had stopped in mid travel. Normal methods to raise the door by hand failed and, because all inboard equipment appeared to be in order, it was thought the cause of the jamming was most likely to be fouling of the door or door guides by a foreign object.

Whilst at anchor in Swan Passage, Falklands Sound, divers were sent down to investigate and a thorough inspection was carried out by viewing the port door through the transverse tunnel and by inspecting the guides that were visible below the partly raised door. No foreign objects or obvious defects were discovered.

A further attempt was then made to raise the door by hand using the hand turning gear and additional leverage on the drive shaft between the lifting motor and bevel reduction gearbox. This proved successful and the door was raised to the fully open position. In this position the tops of the

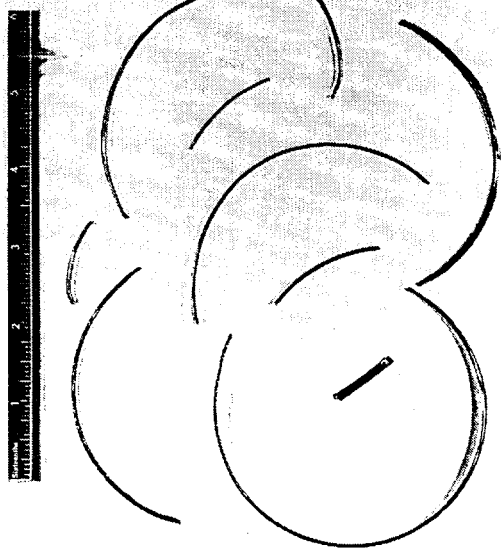

FIG. 3—STRIPPED THREADS REMOVED FROM LIFTING NUT

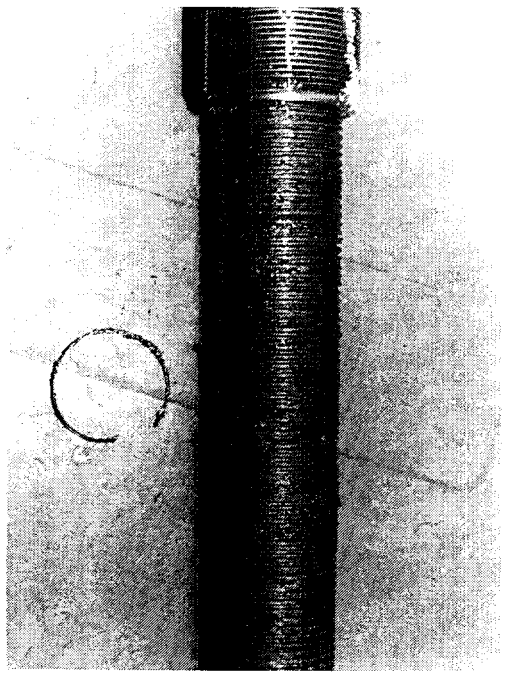

FIG. 4—FAILED LIFTING SCREW SHOWING STRETCHING OF THREAD FORM AND MORE STRIPPED THREADS FROM LIFTING NUT

lifting rods were visible where they emerge into the bow thrust machinery compartment from the tops of their protective tubes and it was obvious that the cause of the failure was stripping of the threads of the lifting nut (FIGS. 3 and 4). Portions of the failed thread were protruding from the nut and several sections of stripped thread were resting on the top of the nut and lifting rod.

At this stage, with the doors fully raised, the ship was able to proceed at speeds up to 10 knots and the bow thrust unit was available. To remove this speed restriction it first appeared that a docking would be necessary so that the lifting nut and screw could be changed. After consulting drawings, however, an afloat repair plan was established.

The Repair

The repair was planned to be conducted alongside R.F.A. *Diligence* in San Carlos Water using personnel from NP 2010 in support of ship's staff. The intention was to support the door, cut a shipping route above the failed screw and lift the screw inboard. Following replacement of the lifting nut a new screw shaft could be fitted, trials conducted and the shipping route closed.

Safety Precautions

To maintain watertight integrity it was planned that the glands at the top of the door recess (FIG. 1) would not be disturbed and that the ship would be trimmed by the stern to ensure the glands were above the water line. A draught of only 3·8 metres at the bow was achieved by pumping out the forepeak, emptying the stabilizer tank and pumping all remaining fuel (70%) into the after tanks. Main line suction to the bow thrust compartment was proved, a portable pump rigged and damage control equipment provided. Power supplies to the bow door lifting motors were disconnected and 'tagged out'.

Supporting the Door

Each door weighs 1·75 tonnes and, as this weight is taken totally on the two lifting screws, it was of vital importance that the door was fully supported when the failed screw shaft and lifting nut were removed. It was also important to ensure that the door did not drop at one edge, become canted and therefore jam in its guides. The following methods of support were adopted:

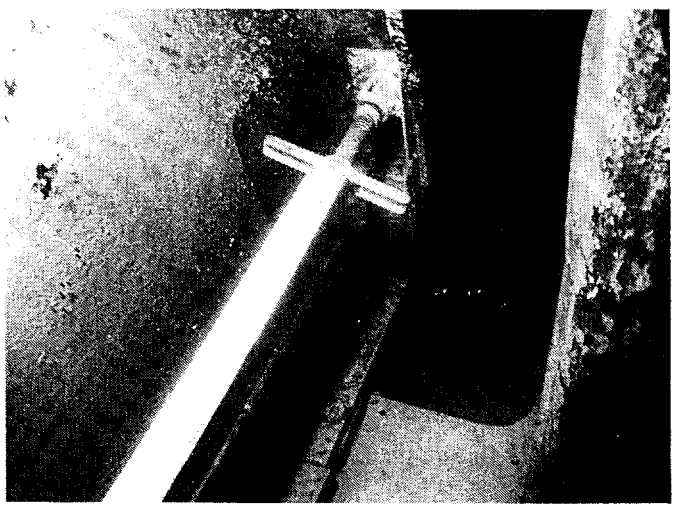

FIG. 5—TOP OF AFTER SHORE BEARING ON LOWER CROSSHEAD

FIG. 6—LOWER END OF AFTER SHORE. THE SHORE WAS PREVENTED FROM MOVING OUT BY THE LIP OF THE BOW DOOR OPENING

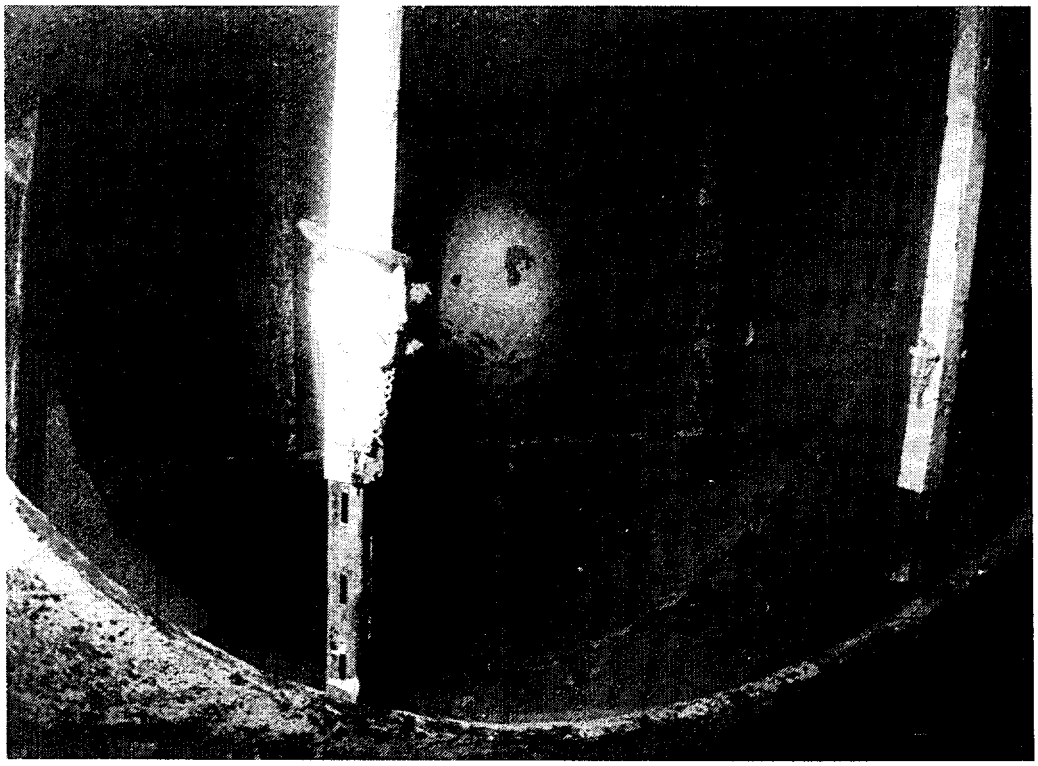

FIG. 7—THE LOWER ENDS OF BOTH SHORES

(*a*) Two American steel shores were placed by divers under the lower crossheads of the door (FIGS. 5, 6 and 7). The screw adjusters of these shores were tightened until a slight upward deflection was detected by a Dial Test Indicator (DTI) fitted at the top of the lifting rod. By using a DTI, positive support of the door was ensured; also it ensured the door remained square within its guides. (Before any attempt was made to support the door divers had already checked it was square in its guides by using feeler gauges).

(*b*) Two locally produced high density cork-lined clamps were fitted round the lifting rod, one just above the gland where the rod passes out of the ship into the door recess (FIGS. 8 and 12), the other just above the screw protection tube in the bow thrust machinery compartment. These clamps were supported by wooden blocks and wedges and again the DTI was used to check that no movement occurred which might have caused the door to cant.

To ensure the door was fully supported, the DTI was left in position whilst the thrust block and bevel gearbox (FIG. 9) at the top of the screw shaft was loosened. No downward movement was detected, proving that the clamps and shores had taken the weight of the door.

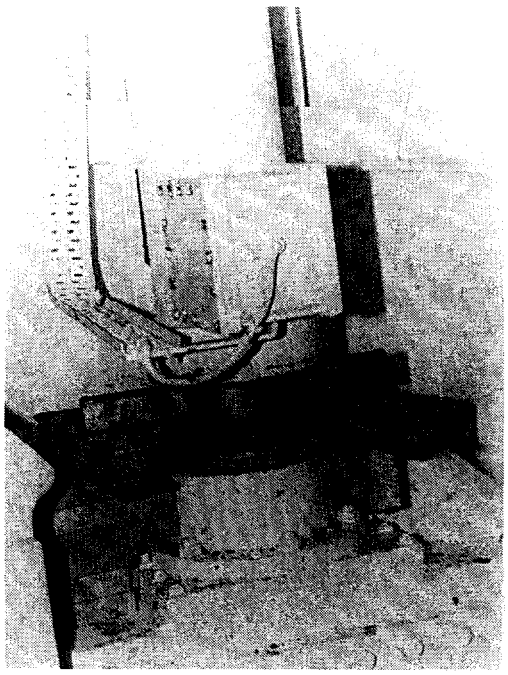

FIG. 8—LOWER CLAMP, FITTED TO LIFTING ROD ABOVE GLAND

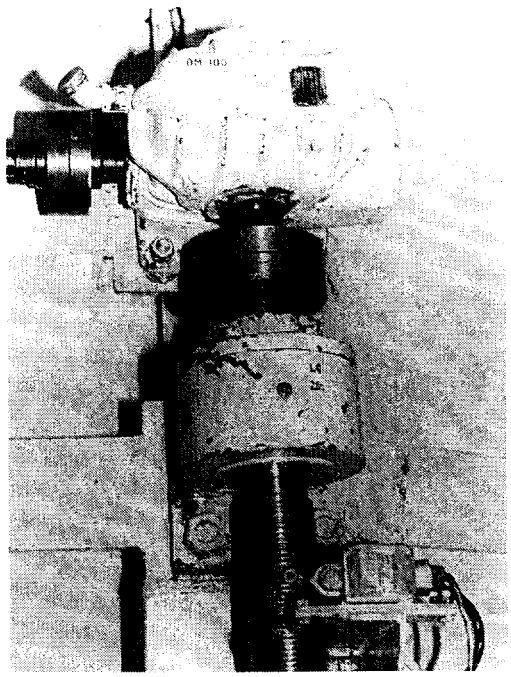

FIG. 9—BEVEL GEARBOX, THRUST BLOCK AND TOP LIMIT SWITCH

Cutting the Shipping Route

The compartment above the port forward lifting screw is the Chief Bosun's Mate's Store (CBM's Store). The deck is non-watertight and it was fortunate that no ventilation trunking or cable runs fouled the proposed route. A 350mm by 450mm hole was burnt in the deck above the failed screw (FIG. 10) in line with the direction in which the screw would be withdrawn. A section of workbench and shelving in the CBM's store was also removed to ensure adequate clearance when the screw shaft was raised. Usual safety precautions were observed during the burning operations.

Had the failure been any other than of the port forward lifting screw then the opening of the shipping route would have involved the removal of ventilation trunking, messdeck furniture, windlass ballast resistors or laundry machinery.

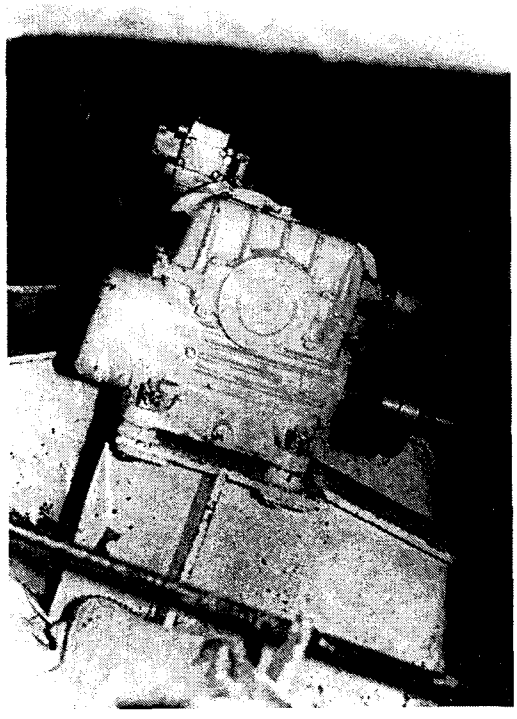

FIG. 10—VIEW THROUGH HOLE IN DECK OF CBM'S STORE, SHOWING BEVEL GEARBOX BEFORE REMOVAL

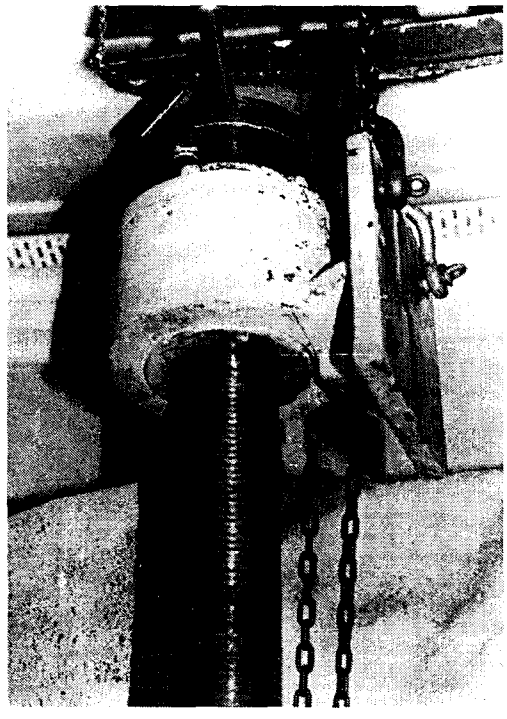

FIG. 11—FAILED SHAFT SUSPENDED BY CHAIN BLOCK

Removal of Failed Shaft and Nut

The upper limit switch, lifting nut locking plate and bevel gearbox were removed. To ensure that the new screw was fitted back into the same position, the distance between the top of the lifting rod and the thrust block was measured and the number of threads showing was counted before the thrust block was fully unbolted. A plate with a square drive lug was fitted to the coupling above the thrust block; this was to accept a ratchet handle which could be used to turn the lifting screw out of the nut.

The thrust block mounting bolts were removed and, by using the ratchet handle, the screw shaft and thrust block were raised sufficiently for a chain block to be shackled to the thrust block mounting bolt holes. The chain block was suspended from an eyebolt in the deckhead of the CBM's Store. By using the ratchet handle together with the chain block the shaft was screwed completely out of the lifting nut and pulled clear (FIG.11).

Using a locally manufactured lugged 'C' spanner, the failed lifting nut was screwed out of the top of the lifting rod. It was clearly evident that the internal 4 (t.p.i. acme) thread had failed as, not only was there very little of the thread remaining, but up to 0·25 inch lateral movement was possible when the nut was replaced on the failed shaft. Also several more sections of failed thread were recovered.

The thrust bearing housing was opened, the nut locking split pin was withdrawn and the nut removed (FIG. 12). The failed lifting screw was removed and both thrust roller bearings were then driven out of the housing. Although there were no signs of excessive wear in the bearings they were renewed.

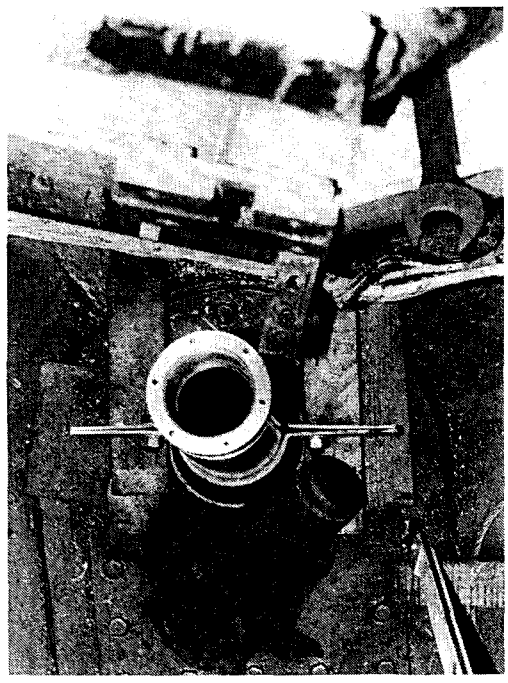

FIG. 12—VIEW THROUGH HOLE IN DECK OF CBM'S STORE WITH FAILED LIFTING SCREW REMOVED

Reassembly

Before any reassembly took place all new components were checked against the old to ensure compatibility. All new components were well lubricated and the new lifting nut was checked to ensure it fitted the screw throughout the full length and also that its external thread (6 t.p.i. Whitworth) matched that in the top of the lifting rod.

The new bearings were fitted into the thrust housing and the new shaft inserted. Some difficulty was experienced in tightening the thrust bearing securing nut as there are no flats on which to fit a spanner nor are there any figures stated in the handbook for the torque loading on the nut. Eventually the nut was driven home using a drift until sound engineering judgement indicated that it was tight enough. The shaft was then drilled in line with slots on top of the nut and a new locking split pin inserted. The thrust bearing top housing was then replaced using the same shims as had been removed on strip down.

Having ensured the top of the lifting rod was clean, the new lifting nut was screwed in until it bottomed; it was then tightened using the lugged 'C' spanner. The new lifting screw together with the refitted thrust block were then suspended by the chain block and, to ensure no damage was caused to the threads during lowering, the edges of the hole in the deck of the CBM's Store were well padded.

The screw was lowered until it entered the lifting nut and then turned by the ratchet handle until the clearance between the top of the lifting rod and the thrust block were the same as before removing the thrust block securing nuts. When this clearance had been obtained the same number of threads were showing above the lifting nut and the bolt holes on the thrust block accurately lined up with the holes on the seating, indicating that there had been no movement of the door or lifting rod.

The thrust block was secured to its seating, the plate with the square drive lug removed, and the bevel gearbox replaced. Full alignment checks of all couplings were carried out, allowed tolerances obtained, and couplings connected. The lifting screw locking plate and top limit switches were replaced and a final check on all work carried out before removal of the clamps and shores.

Once the clamps and shores had been removed the door guide clearances were again checked by divers to ensure that there had been no movement or canting of the door during replacement of the screw shaft. No change in the clearances was discovered.

Testing

Having ensured all parts were well lubricated, the hand turning and hydraulic slipping clutch locking gear was fitted. It was intended to lower and raise the door by hand but as this would have taken several hours it was decided to lower the door from its upper stop by hand, move the door down approximately 300 mm and then use the motor to drive the door down to within 300 mm of its lower stop. The hand turning gear would then be used to fully close the door. This procedure was used and no binding or tight spots were detected. The reverse procedure was used to raise the door and once again it moved smoothly throughout its full travel. During this initial lowering and raising the power to the motor was controlled locally from the bow thrust machinery compartment.

Having ensured freedom through the full travel, the door was tested under power and times taken for opening and closing were recorded. Figures obtained were identical to those before the defect occurred. As a final check, the complete system was restored and operated from the Machinery Control Room in the normal manner and on completion the doors were left in the lowered position so that divers could make a final check that the door was fully closed.

Closing the Shipping Route

The hole cut in the deck of the CBM's Store was closed by welding a plate back into position and the workbench and shelving were replaced. Some thought had been given to bolting a cover plate over the hole but, as the functional test had proved successful and A and A action would have been necessary for a bolted plate, a weld repair was decided upon.

Later Events

Following the trials the bow doors were lifted successfully on three further occasions then once again the port door jammed. The jam occurred after less than 20 mm movement of the lifting rod and despite extra leverage being applied to the drive shafts no further upward movement could be obtained.

Investigation by divers revealed that the door was moving upwards, fouling the top edge of the aperture in the ship's hull and not inwards as it is designed to do, indicating a possibility that the lost motion linkage pivot pins had seized. Because the door was down it was not possible for the divers to examine the linkage other than by a general view through the transverse tunnel from starboard. No obvious defects could be seen.

All attempts to move the door inwards failed; these included levering with crowbars, hammering with sledge hammers and rigging a heavy battering ram from the ship's fo'c's'le crane. The door remained stuck and a docking was necessary so that access plates fitted in the door recess could be removed and the linkage pivots examined from inboard. The ship remained with very limited manoeuvrability at low speed but without any restriction on higher speeds.

On return from the South Atlantic the ship entered Devonport for a routine DED period. The repair of the port bow door was obviously of prime importance and no time was lost in starting the job once the ship was docked down.

Despite ship's staff's previous experience of changing lift screws and nuts and their diagnosis that the door crossheads or lost motion linkage had seized, the repair authority took a fresh look at the job. They concluded that backlash on the port aft lifting screw (which had not been changed)

was causing the door to cant and thus become jammed, and that by simply changing the lifting screw and the nut the door would rise squarely in its guides.

The port aft lifting screw was changed but still the door would not move. It was finally accepted that the fault was seizure of the crossheads or the lost motion linkage. The lost motion links were cut through by burning and the door allowed to pivot outwards on the lower crosshead; examination revealed that the pins of the linkage had seized and therefore, instead of the door was being allowed to move inwards, it moved only upwards and jammed.

With the pins dressed, and new thrust washers and new links fitted, the door reconnected to the lifting rods and successful trials carried out.

Acknowledgements

NP2010 and R.F.A.*Diligence* manufactured the lifting rod clamps and drive plate, and provided able support in all aspects of a satisfactory repair.