# CPP BLADE CHANGE USING AN INFLATABLE HABITAT

## HMS 'BIRMINGHAM' MARCH 1998

BY

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ABSTRACT

The concept of changing CPP blades whilst afloat was developed in the early 1980's and was first used during the Falklands campaign during 1982. There have been improvements in the technique used over the years; the introduction of Hedley Purvis hydraulic bolt removal and torque setting tool to replace the large spanners and chain hoists originally used and the introduction of nylon blade bolt covers to facilitate underwater blade change.

The latest development is the introduction of an inflatable Habitat, giving a safer working environment for divers and the ability to carry out NDE on the crankring whilst afloat.

In September 1997 members of the Southern and Fleet Diving Groups undertook an aquaint course in the use of the Habitat at F.J. Marine Services (Norwest Divers). This course was arranged by ME 212 as part of a plan to improve the procedures for CPP blade change afloat.

This article details the use of the Habitat during a CPP Blade change and repair to HMS *Birmingham's* Starboard shaft in March 1998 at Portsmouth, by members of the Fleet Diving Squadron.

## HMS 'Birmingham' repair

HMS *Birmingham* sustained damage to her Starboard propeller and hub when the ship picked up a berthing hawser whilst transiting a lock during a routine visit to Amsterdam. *Birmingham*'s Ships Divers worked to clear bights of steel wire rope and berthing hawser from the propeller for approximately 3 hours and were then assisted by a salvage company to cut off remaining bights, to allow full ahead pitch to be applied prior to the transit back to Portsmouth with a locked shaft. Unfortunately the visit to Amsterdam was cancelled.

Southern Diving Unit 2 (SDU 2) were tasked by Captain Fleet Maintenance (CFM) Portsmouth to clear the remainder of the foul screw and carry out a shaft survey. 6 turns of 50cm berthing hawser, the remains of the steel wire rope and the rope guard were subsequently removed at Fountain Lake jetty in very poor visibility.

A video survey was carried out of the blades and hub, witnessed by the ship's MEO and ME 212 (Ship Support Agency (SSA)). Due to the extremely poor visibility, with the video camera only able to obtain a picture at a maximum of 2" from the blade, the resulting video was not of a good quality and did

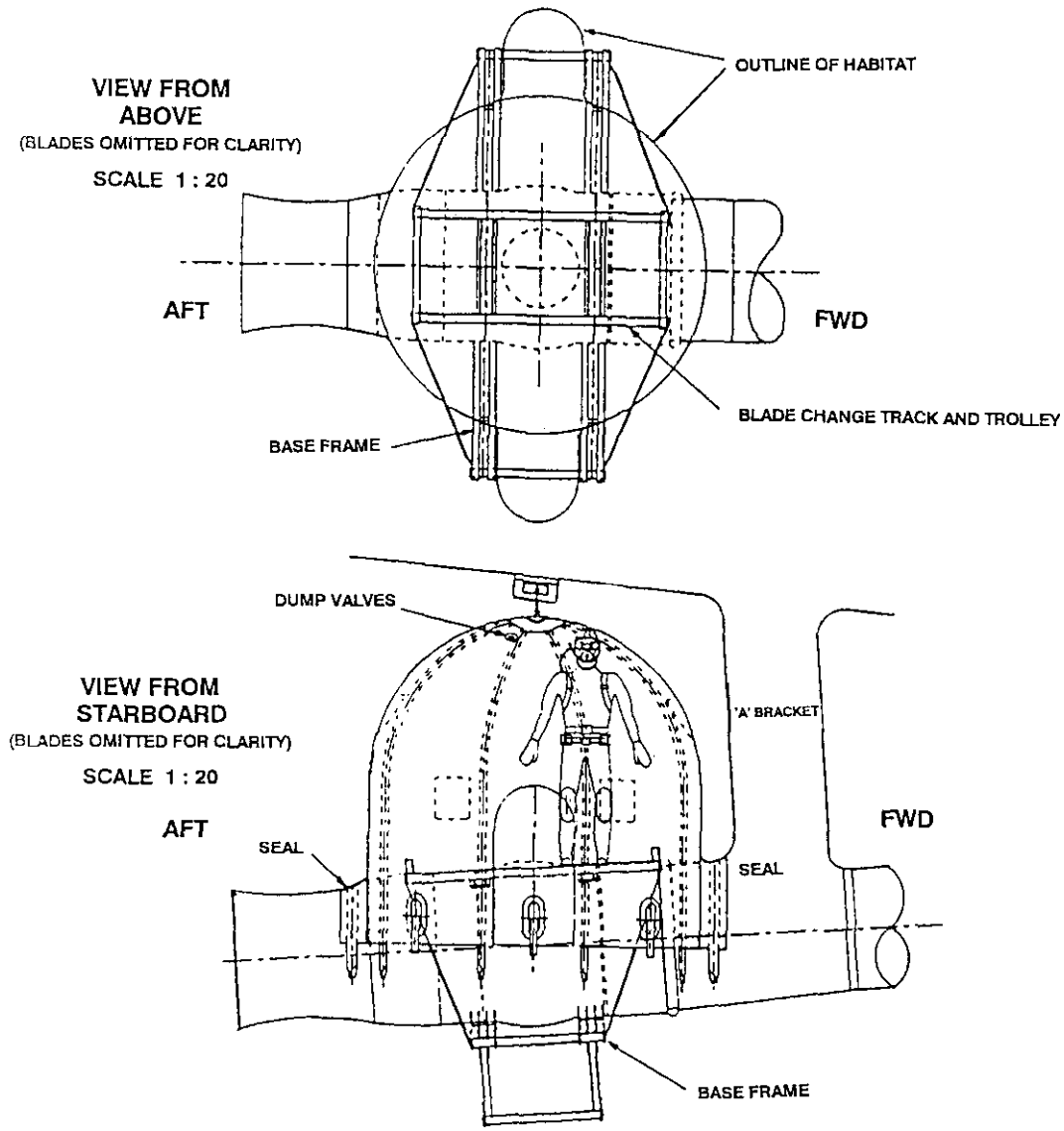


FIG. 1—GENERAL ARRANGEMENT OF INFLATABLE CPP HABITAT

not give a true indication of the damage (similar to misleading, magnified, results that can be obtained with an endoscope)

After discussions between the ship, ME 212 and MSM/W1 (SSA), SDU 2 were tasked to replace one damaged blade and dress the damaged areas of the other blades in the Habitat. Other work included replacing wire locking on the hub protection plate bolts, replacing the damaged after rope guard and measuring A bracket bearing clearances with feeler gauges.

To assist the underwater repair the ship was moved to a non-tidal berth in 3 basin, which gave far better visibility. SDU 2 had severe manpower restrictions and to enable the repair to be carried out, assistance was therefore requested from the Southern Diving Unit 1 and the Northern Diving Group. The Warrent Officer Fleet Diving Group and the Support Engineer Officer (Diving) (SEO(D)) from the Fleet Diving Headquarters were also on site to ensure that there were a sufficient number of Habitat trained personnel. CPO(D) GALE of SDU 2 supervised the diving operation as SDU 2 were the lead team for the evolution.

## General description of Habitat

The inflatable Habitat was designed and built by Fred MCNALLY and Dave TAYLOR at F.J. Marine Services (Norwest Divers) and first used in 1995.

The Habitat is a reinforced coated nylon 'bag' (similar to a parachute style flotation bag) which is inflated over the hub, enclosing the blade at Top Dead Centre (TDC) and the upper portion of the blades each side (FIG. 1). The bag is connected to, and supported by, an inverted A frame slung underneath the hub. A top frame, with rails, is positioned over the hub to carry a wheeled trolley to assist in the blade change operation.

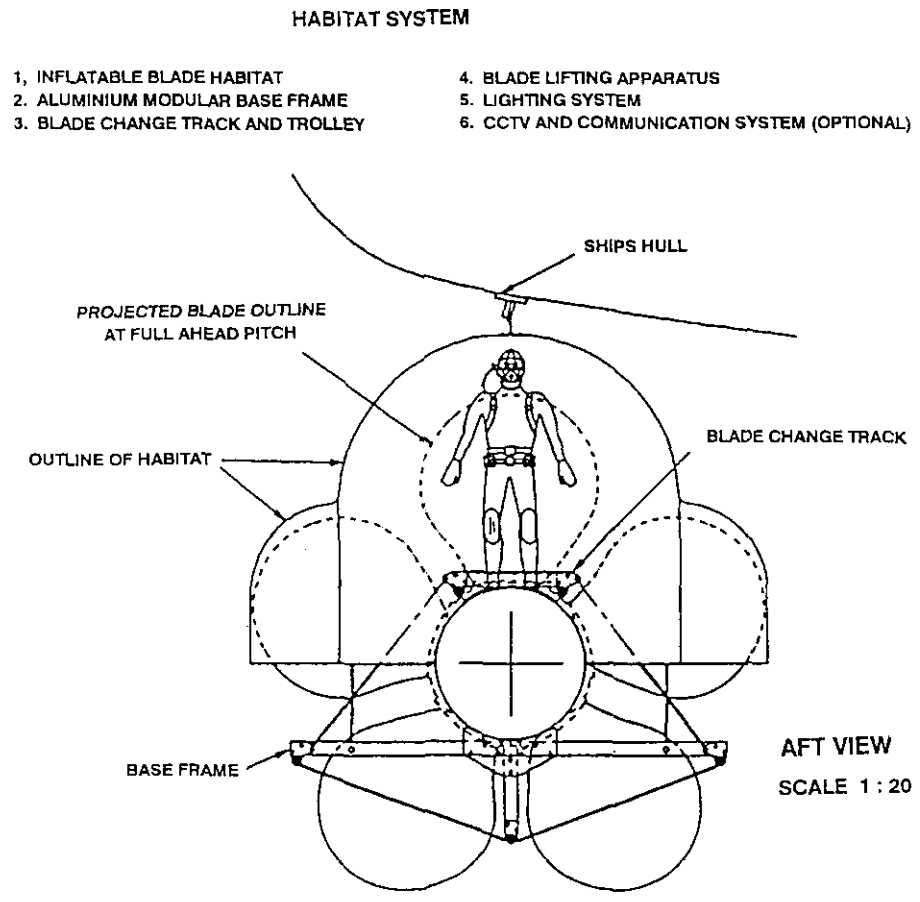


FIG. 1—GENERAL ARRANGEMENT OF INFLATABLE CPP HABITAT

## Diving Equipment

Rigging of the Habitat is conducted with the diver wearing in-service surface supplied diving equipment (KMB 17 or 18) but using a small bale out cylinder and a 40M umbilical.

To work inside the Habitat safely it is essential that the divers come off gas, unclip their umbilical and remove weights and fins. The edges of the blades are sharp and an umbilical continuously chafing against the blade edges would be liable to fail. Additionally there is only limited space inside the Habitat and the ability to erect and operate lifting gear and Hedley Purvis bolt removal equipment would be seriously hindered if trailing an umbilical.

To enable the diver to easily remove and replace his facemask, a hybrid surface supplied diving equipment has been designed, with consultation with Inspector of Diving. This equipment consists of a surface supplied, positive pressure AGA mask, worn with a simple harness. This equipment is solely for transit between surface and the Habitat. Once inside the Habitat the mask and umbilical are removed from the diver and stowed in purpose made pockets adjacent to the point of entry. A secondary air supply for the divers is supplied by connecting a first stage reducer with hose, second stage demand valve and mouthpiece to the small baleout cylinder. This can be worn by the diver, strapped to his leg, for ease of use in an emergency.

This hybrid diving equipment was unfortunately not available at this time so dispensation was given by Superintendent of Diving to use KMB, without a baleout cylinder, for transit between surface and the Habitat. The disadvantage of using this rig was difficulty donning the mask prior to exiting the Habitat.

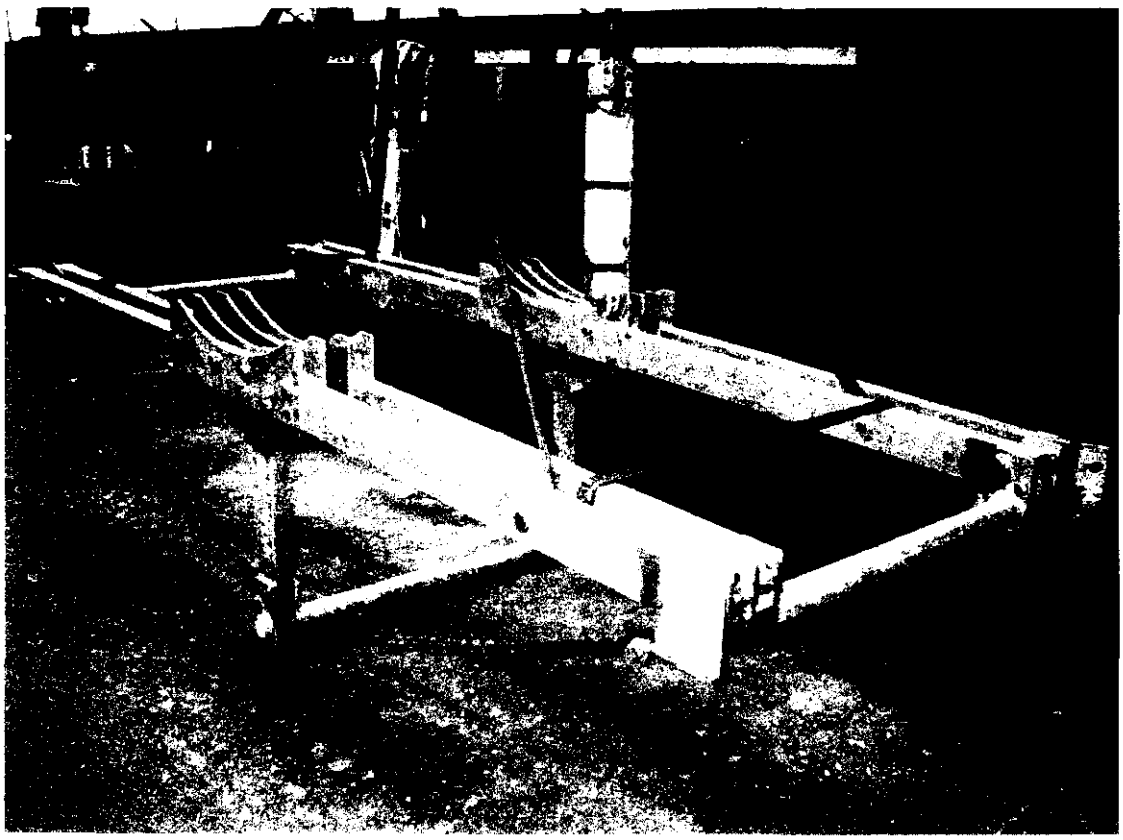

FIG. 2—LOWER FRAME PREPARED FOR SLINGING

## Rigging the Habitat

Prior to rigging the Habitat the damaged blade was positioned at TDC, with 19 deg AH pitch applied, the CPP system was isolated at the Oil Transfer (OT) Box, and the ship 'tagged out' for diving.

The first diving task was to remove blanks and bolt a pad eye to the hull above the blade at TDC. Experience has shown that the pad eye positions differ from ship to ship; a Type 42 rarely has a pad eye position directly over the blade. *Birmingham*'s were displaced about 1m aft and 0.75m fwd of the blade.

The upper frame was then assembled on the hub over the blade at TDC. The frame is of a 2-piece construction with saddles that position over the hub and support rails which run along the length of the hub, protruding forward and aft of the blade. The frame is secured with spansets around the hub.

The lower frame was assembled ashore and made ready to be slung vertically into a position outboard of the lower 2 blades (FIG. 2). The dockyard crane

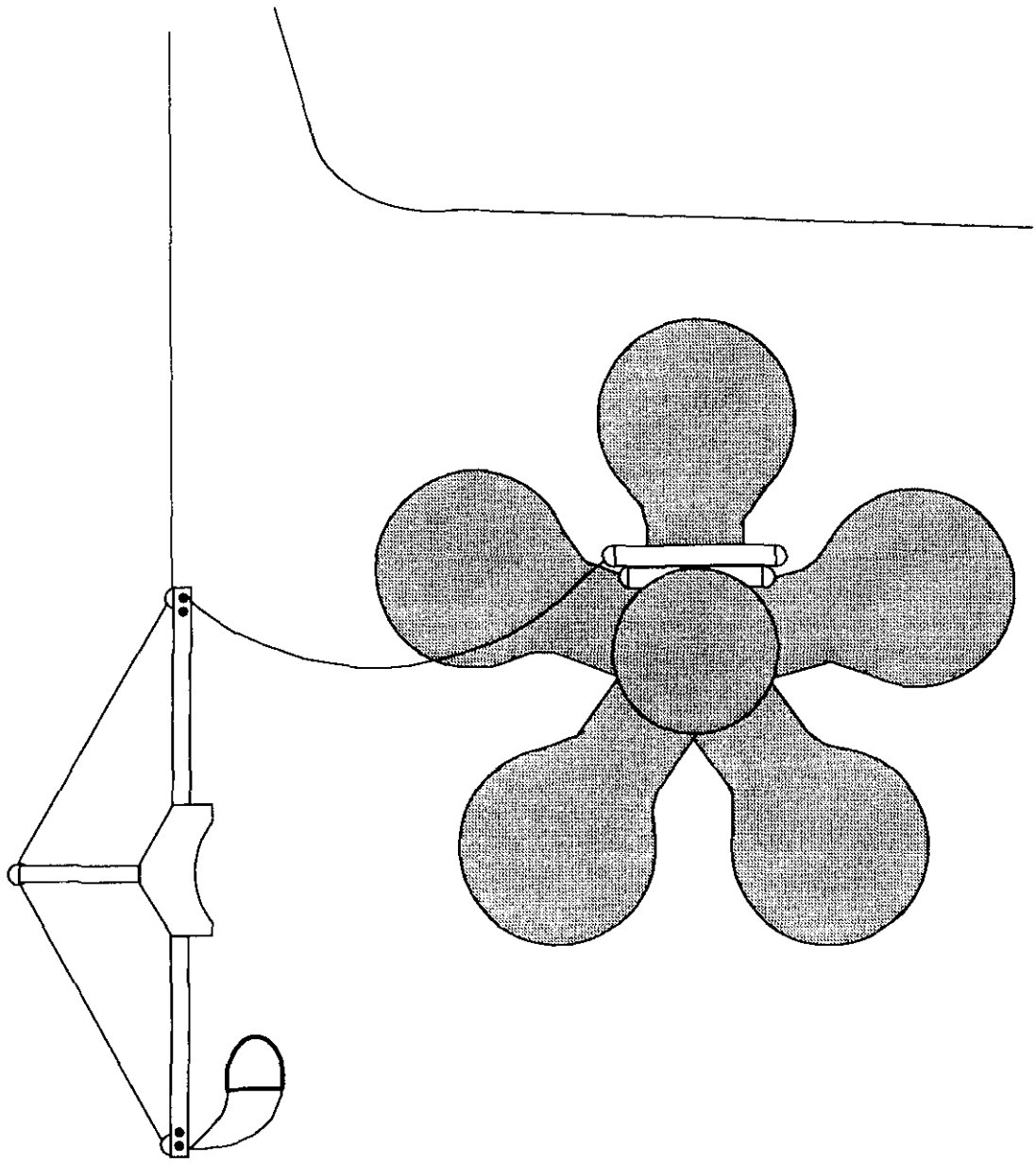

FIG. 3—LOWER FRAME POSITIONED OUTBOARD OF PROPELLER

driver failed to turn up, reporting that no cranes could operate in the dockyard due to high winds. A bottom line was rigged and the lower frame was then manhandled into the water. Once in a vertical position outboard of the blades the securing chains were connected to the top 2 legs of the frame and the outboard side of the top rail (FIG. 3). Flotation devices (air bags) were inflated on the lower legs of the lower frame to allow the frame to be floated into position against the underside of the hub, with the lower blades protruding through (FIG. 4). The inboard chains were then connected between the upper and lower frame and bottle screws tightened to secure the 2 frames to the hub (FIG. 5).

During this time the ship was hastening the replacement blade, which duly arrived, along with a mobile crane from CFM. The blade was positioned and secured on a trolley and slung into place on the rails at the fwd end of the hub, then secured with 2 spansets. This evolution did not go as planned; There are inherent problems with the sling design, which hindered slinging the blade and trolley into the confined space between the hull and the top of the rails. The slinging plan was flawed as there should have been a chain

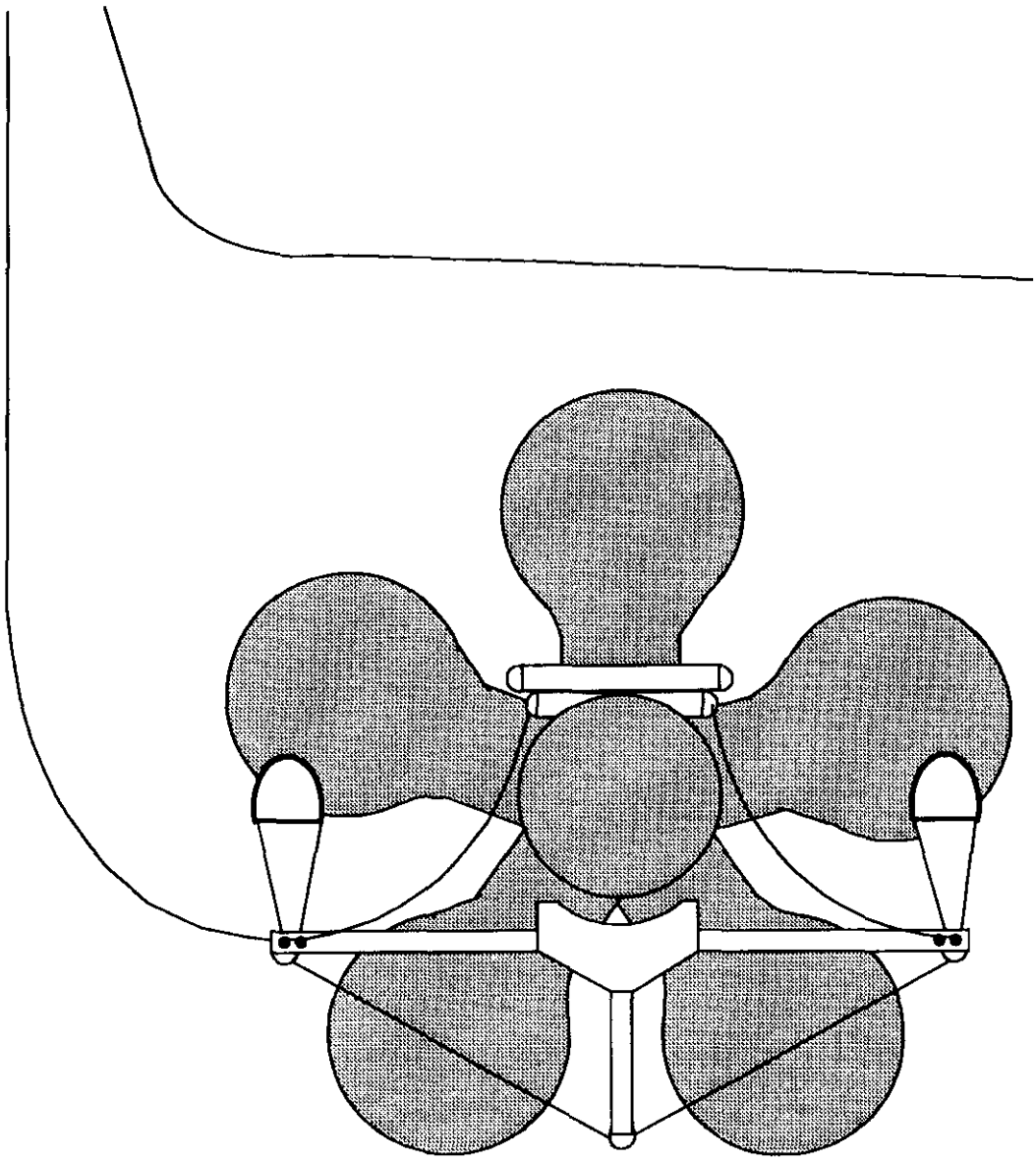

FIG. 4—LOWER FRAME BEING FLOATED INTO POSITION

hoist on the end of the crane strop to facilitate lateral movement onto the hub and the blade was not correctly aligned on the trolley to allow the wheels to locate on the track due to the limited clearance between propeller and A bracket.

The other trolley was then located on the rails aft of the damaged blade.

The Habitat bag was then prepared for deployment by binding with rope along its length to minimize the amount of trapped air and then lowered upside down into the water. It was still a struggle to get the bag to leave the surface; a down line connected to the top of the bag would have aided this process. Once the bag was under water it was opened out and lowered over the hub and blades, with the seals positioned fwd and aft as marked, and the rest of the material positioned to line up the ends of the restraining strops over the bottom frame.

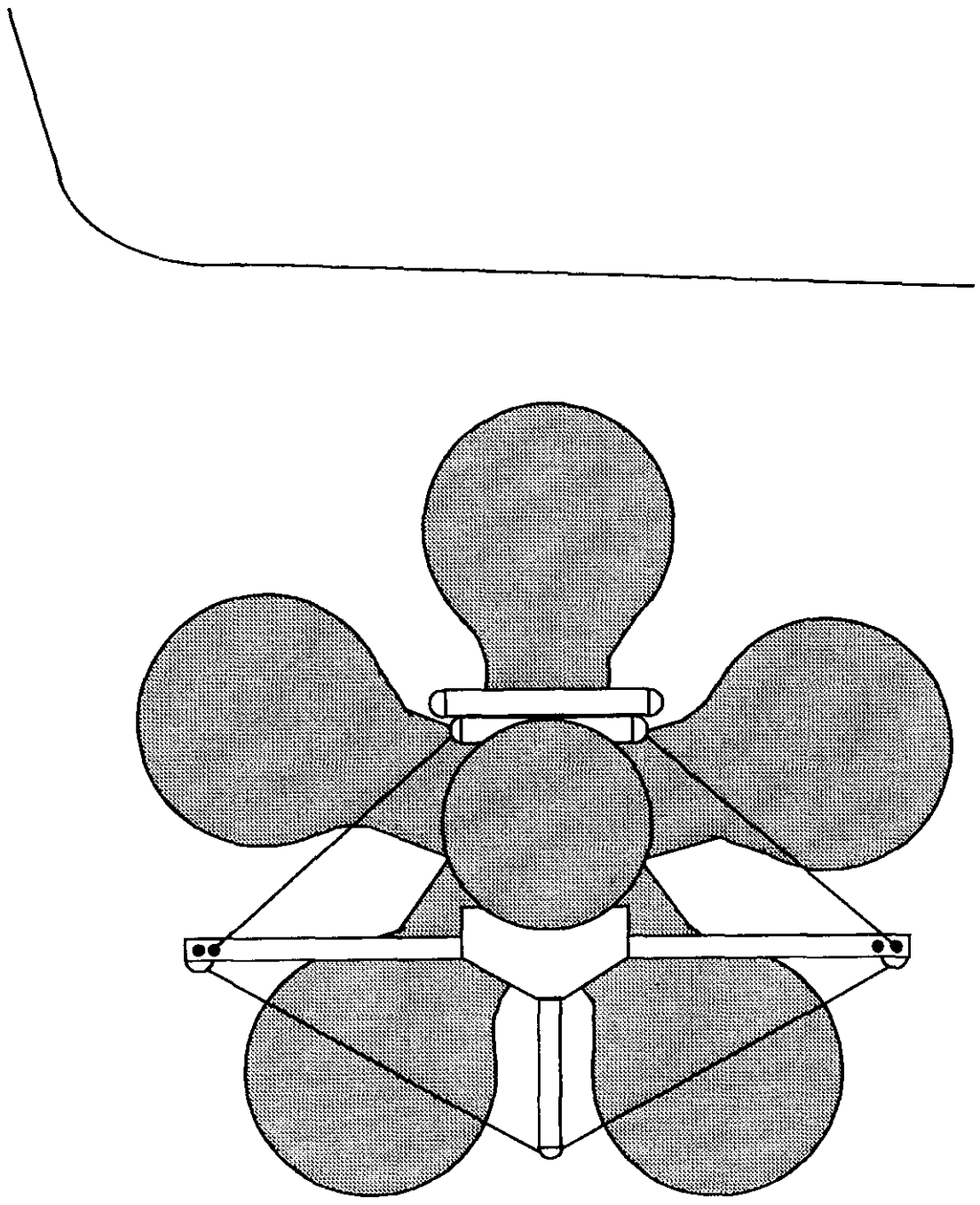

FIG. 5—LOWER FRAME CONNECTED TO TOP FRAME AND HUB

FIG. 6—UPPER FRAME RAILS AND A FRAME

The seals are made with 1" neoprene strips between the Habitat material and the hub, which is then tensioned with a spanset. An additional spanset is placed over the seal, close to the Habitat body. The Habitat was designed for a Type 22 hub, which makes it difficult to obtain a seal at the A bracket on a Type 42 due to the small dimension of the flat area between rope guard and A bracket legs (approx 70mm). The after seal is also troublesome; it is necessary to rig retaining strops on to the spansets to prevent the seal sliding off the cone on the hub. (Type 22 has a divergent nozzle)

The 8 Habitat securing strops were then shackled to the bottom frame, with a further 2 strops secured by a metal bellyband beneath the hub. The 2 'ears' were then secured to the lower frame and reduced HP air applied to inflate the Habitat. During inflation problems arose due to the 'ears' being secured

too close to the frame. The retaining ropes were slackened off and inflation continued. A good seal was obtained but the strops around the fwd seal took up no tension. Initially the problem was thought to be due to incorrect rigging of the strops and bellybands, but further investigation found the obstacle was due to the connection at the top of the bag to the pad eye. The pad eye was not directly over the blade and was causing the bag to tilt forward, preventing the strops taking any strain. The bag was again deflated and the decision made to remove the connection to the pad eye. A good seal was then obtained.

The divers then had a good check round prior to entering the Habitat. Once inside the diver removes his weights and fins and then comes off gas. The next task is to rig secondary air supplies, lights, communications and a video camera. The Habitat is supplied with a continuos supply of reduced HP air (4 bar) from the charging panel in the dive store, to ensure a safe, breathable atmosphere at all times. To prevent the reducer lifting the pressure relief valves on the charging panel it is necessary to isolate the charging panel and HP air reservoir on the quarterdeck from the HP air ringmain and reduce the pressure to below 207 bar. In the event of a ship emergency this section can easily be reinstated and diving halted.

## Blade change

An 'A' frame is erected inside the Habitat to act as a strongback for slinging the blades. The frame is located on the ends of the upper frame and secured to the top of the Habitat to prevent movement whilst slinging (FIG. 6). Once the frame was rigged the blade bolt covers were drilled, tapped and pulled out then the blade was unbolted using Hedley Purvis gear. The blade was then lifted using 2 lever pulls slung from the lifting frame (FIG. 7). The trolley aft is slid into position under the lifted blade and the blade then lowered. The trolley was then pushed back to its original position. There was some concern prior to this stage with regards to oil spillage from the hub, even with the CPP system isolated at the OT box. Dryzit bags were positioned between the blade root and the rails to soak up any spillage, should it occur. In practice it was found that the pressure in the Habitat is greater than the head of oil in the hub and there was no spillage. Once the blade was removed the exposed crank ring was evacuated of surface oil using a hose connected to a container at the surface (Habitat pressure forces oil to the surface) and prepared for dye penetrant testing.

The MEO witnessed the dye penetrant procedure on the video monitor on the surface and was then able to debrief the diver (SEO(D) with the aid of the video and talk through any minor concerns. The clarity of the video was excellent as a high-resolution digital camera was used, which possibly gave a better indication than the naked eye. Due to the highly toxic nature of the substances used to carry out this procedure it was necessary for the divers to wear breathing apparatus with positive pressure facemasks (AGA)

The crank ring was then cleaned, seals were renewed and the new blade slid into position, lifted clear of the trolley, trolley removed and the blade lowered into position. Hedley Purvis gear was then used to tighten and torque the blade bolts in the laid down sequence. Plastic blade bolt covers were then cut and faired off after insertion.

## Additional repairs

The fwd trolley was then removed and the area between the A bracket and hub inspected for further damage. The A bracket bearing retaining ring was seen to be damaged, with 2 studs sheared off. The remaining studs and the retaining ring were removed. The Habitat was then de rigged to give better

FIG. 7—CPP BLADE ON TROLLEY RIGGED FOR LIFTING

access and after drilling and eazi-out the damaged studs were removed. New retaining ring, studs, nuts and split pins were then fitted.

The fwd rope guard was unbolted from the A bracket (without separating the 2 halves) and slid up the shaft to gain access for taking bearing clearance readings.

Whilst this work was progressing a video was taken of the remaining blades. The damage discovered, in improved visibility, was found to be only minor. After consultation with the MEO and MSM/W1, and endorsement by ME 212 it was clear that the damaged areas could be dressed with a smooth file and wet stone without the use of the Habitat. To rig the Habitat on each blade would involve turning the shaft to put the blade at TDC and re-rigging the frames and the Habitat bag.

The fwd A bracket rope guard was replaced. The hub protection plate bolts were then proved tight and wire locked. The final task was to clean the aft rope guard bolthole threads and fit the new rope guard.

## Time scale of repair

The original estimate of time to repair was 12 working days. The actual time taken for the underwater repair was 10 working days, as follows:

| Operation | Time (day) |
|---|---|
| Initial inspection, foul screw clearance and rope guard removal | 1 |
| Rigging top and bottom frame | ½ |
| Slinging blade into position | 1 |
| Rigging Habitat bag | ½ |
| Rigging inside Habitat | ½ |
| Changing CPP blade | 1 |
| Dye Penetrant | ¼ |
| De-rigging Habitat | ½ |
| Removing and replacing A bracket bearing retaining ring | 1 |
| A bracket clearances | 1 |
| Dressing blades | ¾ |
| Replacing wire locking | ½ |
| Replacing rope guard | 1 |
| Waiting time | ½ |

The repair was completed within the estimated timescale, although had the Habitat been used to dress all the remaining blades the task would have over run by an estimated 2 days.

## Future developments

The Habitat used is a prototype. ME 212 are procuring two further CPP Habitats, designed to accommodate the Skew blades being fitted to Type 22 FF. The new Habitats will be stored and maintained by the Portable Specialized Support Equipment Store at Devonport and Portsmouth and will be an integral part of the 2 CPP Blade change outfits being developed to allow water borne exchange of CPP blades anywhere in the world, by suitably trained military or commercial divers. The CPP blade change outfits have been cleared by JATE to ensure air transportability in a C130 and have been given clearance for commercial and military flights.

The new Habitats will have improvements incorporated to alleviate the shortcomings highlighted during use. The redesign will include:

- An improved sealing arrangement
- Measured strops for the 'ears'
- Additional internal pockets
- A lighter A frame for lifting.

The procedure for using the Habitat will be re-written by ME 212 and SEO(D), which will include a revised slinging plan. The blade sling is in the process of being re-designed, with the intention of having a generic sling to fit all types of CPP blade.

**Conclusion**

Use of the Habitat has clearly shown that Non Destructive Examination of the crank rig can be successfully carried out in dry conditions, without the need to dock the ship, and ship's staff can witness all operations from the surface on the video monitor.

Lifting and slinging of blades is safer, with the problems associated with poor visibility and communications overcome. The lifting is carried out in a controlled manner and handling of blades is easier due to the trolleys. Additionally good visual and audio communications with the surface provide a safer working environment for the divers.

The air pressure in the Habitat is greater than the head of oil in the hub and the CPP system, giving environmental benefits as there is minimal oil contamination of the water. Any oil that does leak can be contained with Dryzit bags or, should any enter the water it would be contained by the lower edges of the Habitat and could be easily reclaimed.

This was the first occasion that military divers have had to rig the Habitat on a live ship. The aquaint, at F.J. Marine premises in a test tank, did not involve rigging the frames or slinging the replacement blade into position. The repair to HMS *Birmingham* proved to be excellent continuation training. Lessons were learnt and the deficiencies highlighted will be rectified in the 2 new Habitats for the CPP Blade Change Outfits.