# NEEDLE(S) IN A HAYSTACK

## DISTRIBUTION OF FEED PUMP TURBINE BLADES IN AN EXHAUST STEAM RANGE

BY

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During trials of her GWS 25 equipment, H.M.S. *Penelope* at anchor off Mevagissey was preparing for sea and another day of trials which included steaming up and down a range at 20 shaft r.p.m. The TMFP 35 feed pump was out of action because of an unusual distortion of its turbine casing attributed to an originally faulty casting. The TWL 35 feed pump, which was in use and had been running satisfactorily for the preceding 55 hours, tripped on overspeed and, as was subsequently discovered, shed eight turbine blades and a 5·2-inch length of shrouding.

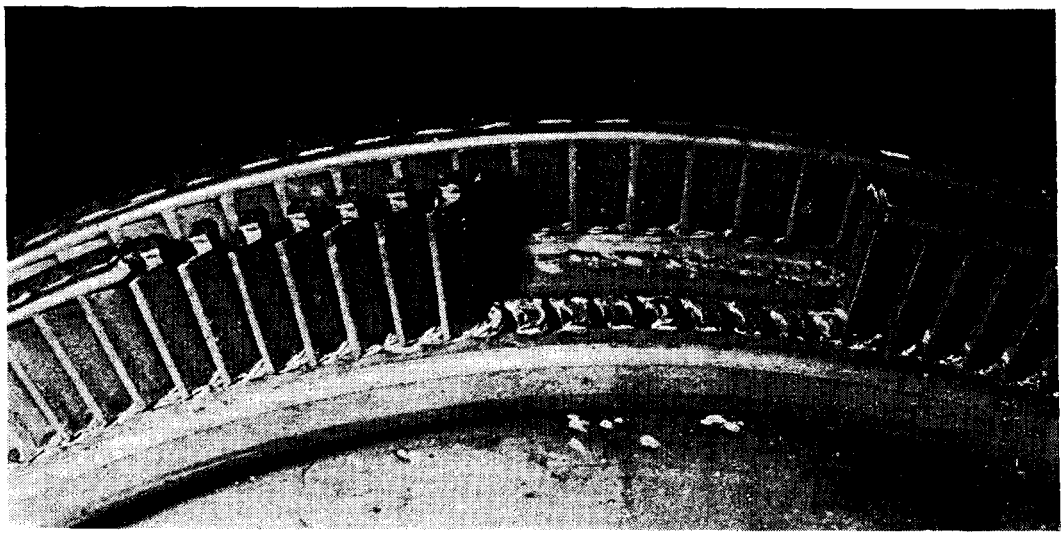


FIG. 1—TWL 35 FEED PUMP TURBINE ROTOR SHOWING MISSING BLADES

On return to Devonport, the dockyard was tasked with the replacement of both feed pumps while the ship's staff and the Devonport FMG were faced with the problem of retrieving the missing blades and shrouding. FIG. 1 shows what was being sought (the needle(s)) somewhere in the complete exhaust range (the haystack). An initial search of the TWL turbine casing and the adjacent exhaust pipe and valve revealed only two tiny mangled fragments of shrouding. It soon became obvious that a much wider search would be required. What had to be found was known; the big question was where to find it. Where do turbine blades go, once free, within an exhaust system?

A plan of attack was drawn up, the results of which are shown in the TABLE. The total weight of the missing metal was calculated to be approximately 105 grammes of potentially trouble-making fragments, any of which could become wedged in any valve, controller, etc., at any inopportune and embarrassing moment with obvious results.

Some 75 parts constituting the whole of the exhaust system and its associated tentacles were examined. The date of removal and of replacement of each part together with the weight (measured on the sick-bay scales) of any

TABLE—*Part of chart of examinations*

| *Item examined* | *Date removed* | *Date replaced* | *Result* | *Piece No.* |
|---|---|---|---|---|
| Pipe from star'd blower to exhaust valve | 18.12.73 | 7.1.74 | Pieces of blade and shrouding in pipe 1 ft. from blower (11·6 g) | (4) |
| Star'd blower exhaust valve | 18.12.73 | 20.12.73 | Pieces of blade and shrouding (27·4 g) | (5) |
| Pipe from outb'd fuel pump to exhaust valve | 18.12.73 | 20.12.73 | Clear | — |
| Inb'd fuel pump Glissard valve | 3.1.74 | 3.1.74 | Clear | — |
| Exhaust to atmosphere valve | 18.12.73 | 20.12.73 | Small piece of blading or shrouding | (2) |
| Pipe to port main engine Arca valve | 9.1.74 | 11.1.74 | Clear | — |
| Exhaust valve in E.R. to evaporators | 20.12.73 | 10.1.74 | Piece of blading (2·1 g) | (8) |
| TWL feed pump exhaust valve | 12.12.73 | 20.12.73 | Small pieces of shrouding (2·6 g) | (1) |
| B.R. T/G extraction pp suction pipe and condenser sump | 7.1.74 | 11.1.74 | Small piece of metal (0·55 g) | (3) |
| E.R./B.R. exhaust isolating valve in E.R. | 19.12.73 | 10.1.74 | 1½ blades including roots. Shrouding from 4 blades complete (24·7 g) | (7) |
| Inside D.A. on trays | 20.12.73 | 21.12.73 | 1 blade and part blade (12·3 g) | (9) |
| For'd evap. element | 27.12.73 | 3.1.74 | Part of blade (5·25 g) | (6) |

piece found was recorded on a tabular chart. The TABLE (which includes all the pieces found) shows about 15 per cent. of this chart. The numbers in brackets in column 5 of the TABLE refer to FIGS. 2 and 3.

In the de-lagging operation which preceded the search of the exhaust system, flanges only were denuded except where brackets, etc. rendered de-lagging of complete pipes and valve-boxes necessary. This and the subsequent re-lagging was done by the dockyard.

The search of the exhaust system together with the main and turbo-generator condensers and extraction pump suction pipes was begun on 18th December 1973. FMG staff under the control of the ship's staff worked in watches round the clock. Additional labour was provided by the ship's staff when other essential maintenance permitted. FIGS. 2 and 3 show the pieces that were found; each find has been given a station number which is marked on the isometric view of the exhaust system (FIG. 4). In all approximately 83 per cent. (including unrecognizable fragments) of the calculated total weight of missing material was retrieved. The remainder is assumed either to have been ground to minute particles or to be still concealed in some corner of the system. A precautionary measure of fitting 'top hat' gauze strainers in the extraction pump suction pipes was taken in order to catch any pieces which may have lodged temporarily between condenser tubes.

An air pressure test (about 10 p.s.i.) of the system before re-lagging proved worthwhile for it revealed several leaking joints. A total of more than 2000

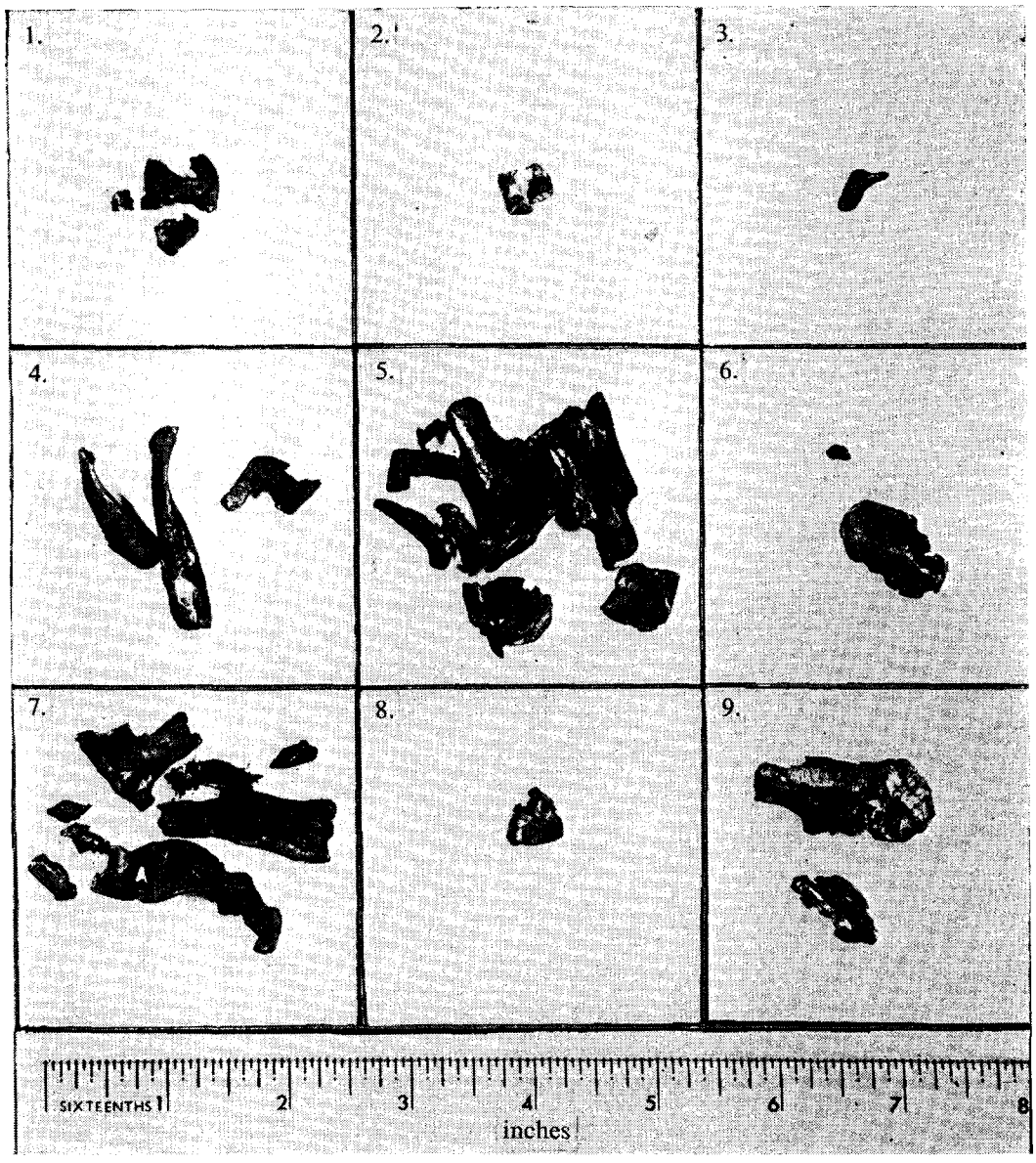



FIG. 2—RETRIEVED MATERIAL (NUMBERS REFER TO THE TABLE)

man-hours was expended on the search. The job was completed on 13th January, the FMG and ship's staffs having worked continuously except for a three-day break at Christmas.

After completion of the installation of the two feed pumps by the dockyard, a successful basin trial was carried out on 21st January. The ship then sailed for feed pump SATs and resumed the GWS 25 trials programme on 22nd January.

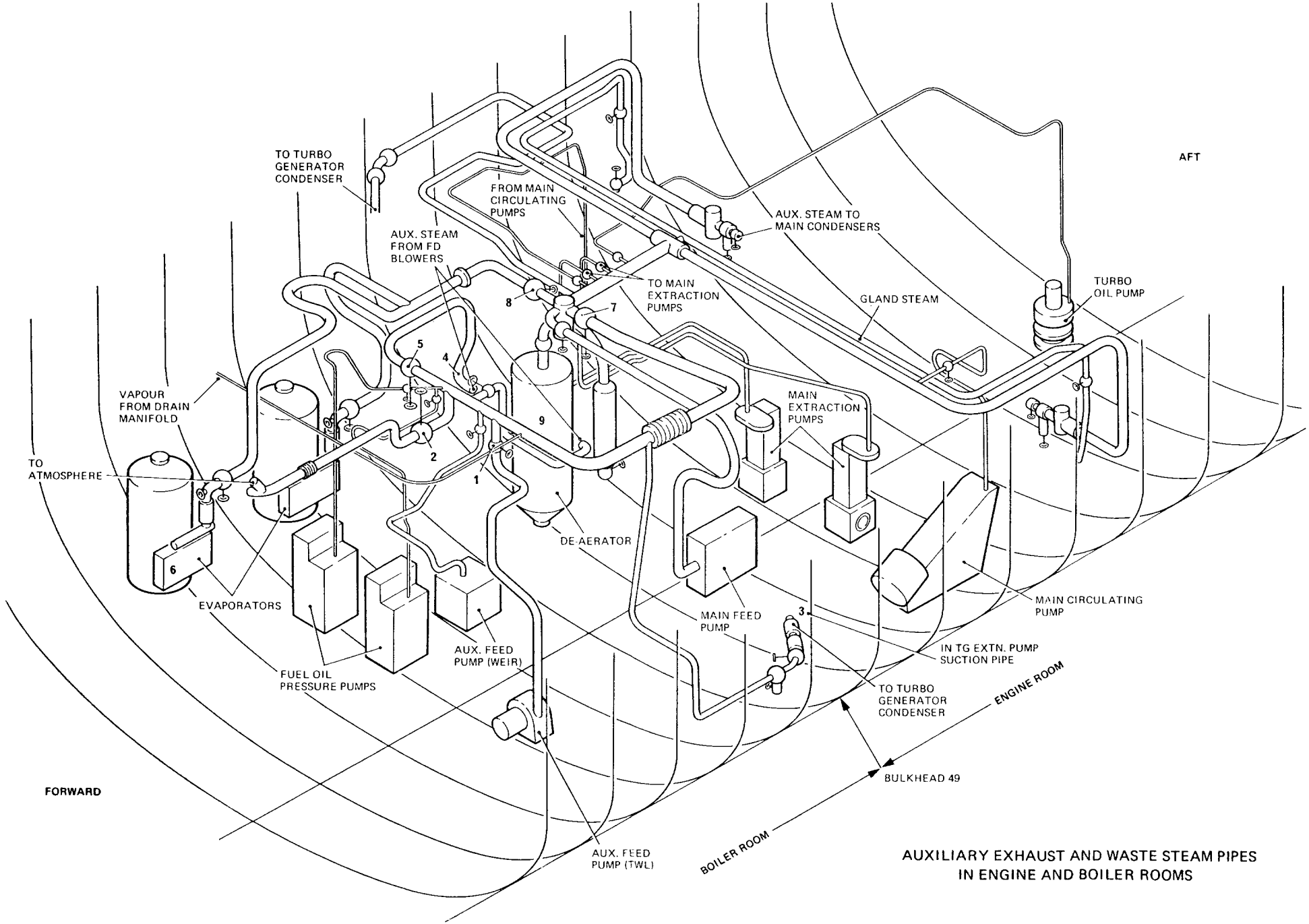
## Conclusions

The answer to the initial questions 'Where does one begin to look?' and 'Where can one expect to find?' appears to be 'anywhere and everywhere'. Valve boxes and any nooks and crannies out of the main exhaust steam flow were, of course, prime targets. The surprising fact was that the missing pieces had travelled so far from the TWL feed pump, e.g. to the evaporator element and to the turbo-generator extraction pump suction. Some pieces


FIG. A—THREE OF THE PIECES SHOWING LOCATION AND WEIGHT

had been blown upwards through long vertical lengths of pipe and, even more surprisingly, had even travelled against the exhaust flow, e.g. into the exhaust from the starboard forced-draught blower (The blower had been running until arrival alongside when all machinery was shut down).

A real touch of irony was added when, having searched for 105 grammes of potential trouble, at least 2 lb. of 'ironmongery' in the form of what is presumed to be half a dozen de-aerator-baffle spacers were found lodged inside the exhaust pipe adjacent to the exhaust steam inlet valve to the de-aerator. The latter may well have been resting 'safely' there since the ship was built.




AUXILIARY EXHAUST AND WASTE STEAM PIPES IN ENGINE AND BOILER ROOMS

FIG. 4—EXHAUST STEAM SYSTEM SHOWING LOCATIONS OF MATERIALS RETRIEVED