MAIN ENGINE FAILURE H.M.S. NAIAD

BY

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During the last refit, in the spring of 1970, a Metastream coupling was fitted between the starboard main turbine and its associated gearing for trial in H.M.S. *Naiad*. At 0530 on Sunday, 23rd January 1972, some 59 783 miles later, the trial came to a sudden and decisive conclusion.

Setting: Her Majesty's ships *London*, *Dido* and *Naiad* proceeding across the Atlantic to take part in Exercise Caribtrain and approaching the Azores.

Time: The morning watch on Sunday, 23rd January 1972.

Dramatis Personae:

MEO	—in bed, the wardroom having honoured 'Saturday Night at Sea' in the traditional manner the previous evening.
DMEO	—in a remarkably similar position.
FCMEA(P)	—in Portsmouth on compassionate leave.
EOOW	—in the engine room, having only joined the ship eight days before.
A POMEM	—in Portsmouth on compassionate draft to H.M.S. *Sultan*.
Boiler room POMEM	—a local acting Petty Officer of three day's standing who had been awarded his boiler room watch-keeping certificate the previous day.
Water tender	—the local acting leading hand who had been rated up to fill the petty officer's original billet.

The stage is set, the cast assembled; only described in detail to illustrate that this is another example of that well-known law and to emphasize that it is very much to the ratings' credit that they coped so well with the forthcoming

FIG. 1—FORWARD END OF THE COUPLING SHOWING THE FAILED SAFETY TEETH

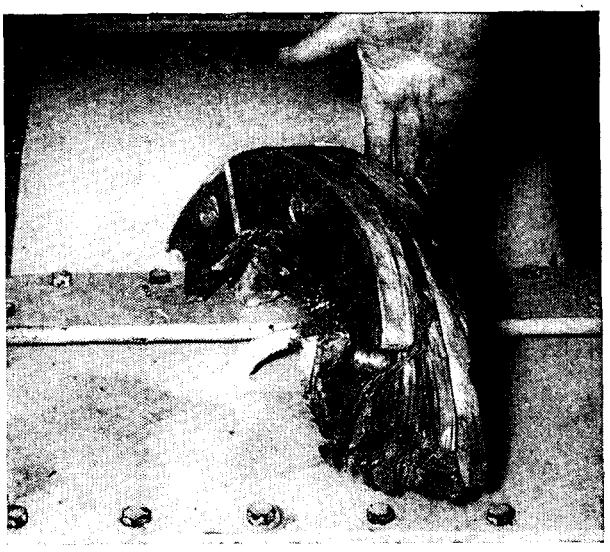

FIG. 2—SECTION OF THE METASTREAM COUPLING SHOWING THE SHEARED BOLTS

events. It may serve to explain some mistakes made in the heat of the moment, which in the cold light of day could have been avoided.

The first indication that something was wrong was a heavy vibration on the starboard side of the engine room. Initially the EOOW thought that it was being caused by a failure of the controls of the starboard stabilizer and therefore centralized the fins and sent the MEM to stop the motors. The MEM noticed that it was the starboard turbine casing which was vibrating and straightway returned to the control platform and closed the manoeuvring valve. As steam came off the engine the coupling cover exploded, scattering bits of the coupling and its housing across the after end of the engine room. In this manner both the membranes of the metastream and the safety teeth of the coupling failed and left a free running turbine.

Despite the fact that steam was already being removed from the turbine at the moment of failure, acceleration was immediate and catastrophic. The last two rows of blades stripped from the rotor and flying metal chewed up the condenser tube nest in a spectacular manner.

The effect of the damage was threefold. Firstly, the disintegrating coupling had exposed the gearing and damaged the pipework in such a way that lubricating oil was being pumped to bilge. In a *Leander*, with a common lubricating system, oil lost in this fashion endangers both main engines. One MEM played 'Little Dutch Boy' with the hot oil until the valves were unlocked and the oil supply was isolated from the starboard turbine. As may well be expected, the hot oil ignited once it came in contact with the steam pipes, although it was only after the event that it was appreciated that the flames had been found and extinguished without comment as a matter of course.

FIG. 3—AHEAD TURBINE SHOWING THE 7TH AND 8TH STAGES AND THE INTERVENING DIAPHRAGM

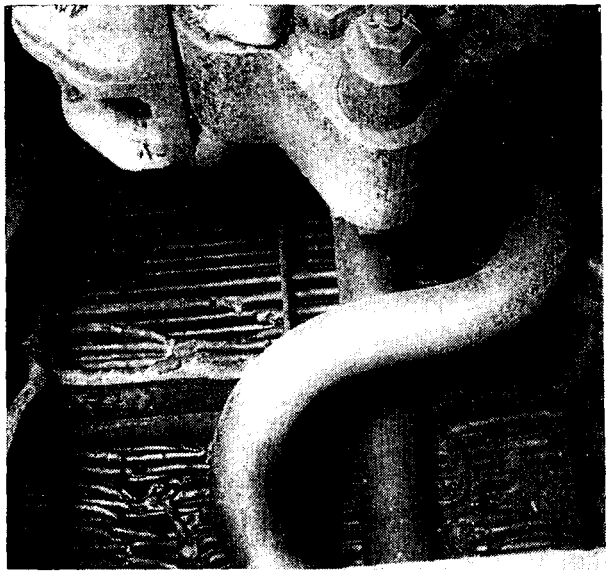

FIG. 4—CONDENSER SHOWING SOME OF THE DAMAGED TUBES

The second effect was that the damaged tubes in the condenser under full vacuum caused rapid flooding up of both turbine and condenser. Possibly this was a blessing in disguise because while the oil was being pumped to bilge from one side of the gearing a roughly compensating quantity of salt water was pouring from the turbine glands into the open gear box. Even salt water was better than nothing! The situation was brought under control by isolating the main condenser and its associated inlets and discharges and draining the condenser to bilge.

By this time, with the decision taken to shut down, a Diesel generator was running but not on load, and one boiler was already dead; both main stop valves were shut and the engines were isolated with turning gear being engaged. It was only afterwards, when cleaning the starboard lubricating oil drain tank, that it was appreciated how much of the metastream had been thrown into the gearbox and had found its way right through to the drain tank. The starboard turning gear was run before the implications of the damage had been fully appreciated: if, however, solid material was going to interfere with the mesh of the teeth, damage would have occurred at the moment of the explosion while the gearing was still rotating at speed.

The third effect of the damage was the obvious contamination of the feed system. It will be appreciated from the example shown in FIG. 4 that, from the instant of the explosion and the resultant overspeed, the starboard extraction pump would have been pumping neat salt water through the boilers where the forcing rate was cut right back when the steam was taken off the main engines. Even the first test of the shut down boiler showed it to be well over the limit for a mandatory internal clean.

With the port engine safeguarded and the second Diesel generator ready for

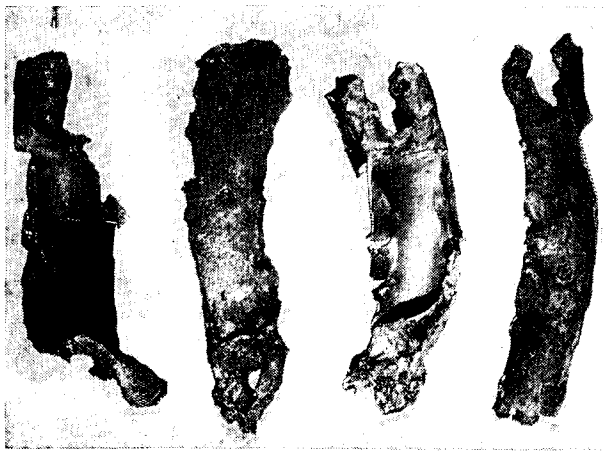

FIG. 5—SELECTION OF TURBINE BLADES REMOVED FROM THE STARBOARD CONDENSER

load, fate took another cruel turn. The rapid influx of cold sea-water and other fluctuating conditions had caused the main feed pump to trip. Initially the reciprocating feed pump was started and then the TWL pump was brought into use. As extraction pump discharge pressure was apparently available, the pump was changed to 'hot suction'. It is appreciated now that this would have been pure sea-water, but the degree of contamination of the feed system was not known by the boiler room at that time. Although the power supplies were being interrupted and the feed pumps proving unreliable, the petty officer did all that was necessary to maintain the water level in the steaming boiler within the glass at all times. What was not understood until later was the degree of priming which would be caused by contamination despite keeping the levels correct. As forseen in all laid-down machinery breakdown exercises, the boiler-room generator proved most vulnerable to the priming and, before the electricians were ready to take it off load, the emergency and control valves had been so liberally coated with salt that they were seized. Removal of load from the generator produced the obvious result, an immediate overspeed to destruction. It was only the water tender's instinctive reaction on hearing the turbine accelerate to rush over and close it down by hand that saved a further catastrophe. However, despite damage to the turbo alternator, both Diesel generators were now on load and the starboard boiler could be shut down.

After a few minutes breathing space, it was realized that little could be gained by remaining shut down. Steam was needed for the turbo pumps and an essential requirement was to get the evaporators back into use. The port boiler was known to be the better of the two and, with partial dilution using reserve feed water and the furnace purged using the residual steam from the starboard boiler, it was reflashed on its turbo blower and fuel service pump. The exhaust was taken by the evaporators which were soon distilling usable, if not strictly clear, water.

With 'H' turbo alternator out of action it was not feasible to contain activity within the boiler room, and soon 'J' turbo alternator followed by the port main circulator were run up to meet the need for boiler load. Feed water consumption at that time was discouraging as both the evaporator element drains and the turbo-alternator condensate were showing heavy clouds. The boiler-room crew successively played every tune in the book to satisfy the boiler feed requirements and slowly there was light at the end of our darkness.

Attention could now be turned to the main engines. From the sight glasses it was known that a dirty black liquid had been circulated in lieu of lubricating oil for the past three hours. However, the four-hour cooling down period was shortly achieved and it was now considered safe to proceed with the oil change. The specified method using the separators was far too slow, so the oil was discharged by the expedient of opening the drain tank manholes and using a portable submersible pump. The accessible areas of the tanks were wiped out and a fresh charge run down. After the initial flush, the appearance of the oil was much improved. Momentary heart failure did occur before the port shaft revolved as the turning motor overloads chose that most embarrassing moment

to play up. However, it was only a contact failure and nothing to do with the turning current which was found to be normal.

During the forenoon *London* had stayed in close proximity and the MEO came across to advise and give mutual support. It was appreciated that *Naiad's* greatest need was feed water and by midday the ships were connected by an umbilical cord through which passed 40 tons of cool, clear water. The fact that feed transfer pumps have an output of only five to ten tons per hour was of little significance as the time involved allowed full use to be made of every drop. By 1600, all the tanks and the feed system had been washed through and replenished and the salinity at these points was under control though not yet reduced to the specified limits.

London also transferred 250 gallons of OEP 69 by vertrep in order to provide a reserve for any unforeseen happening on the homeward run. As this additional task in itself was a lengthy procedure due to the shortage of suitable receptables, time was available to make a further demand on *London's* apparently inexhaustible supply of feed water. The starboard boiler was drained, washed through, replenished and reflashed. Once connected, it was possible to shut down the port boiler which had been bearing the load all day and was known to be even more heavily contaminated than before.

At 1800, a little more than twelve hours after the initial incident, *Naiad* got under way on one shaft, slowly building up speed to approximately 12 knots. With *London's* good wishes for our safe return and our gratitude for her help all that day, *Naiad* commenced the four-day passage to Portsmouth. Although inclement weather conditions made impressive reading in the Report of Proceedings, the trip was busy but uneventful below. The port boiler was drained, opened, and hosed through with fresh water using the other portable submersible pump in the port reserve feed tank. After washing, the boiler was boxed up, filled to capacity, and allowed to soak. With this charge run to bilge, the boiler was compounded, topped up with feed water, and flashed. So successful had the washing routine been that the initial tests gave a salinity reading of 60 ppm and an alkalinity of 0·48 per cent. In Portsmouth after a standard boil out and a mechanical clean using Lagonda gear, a CBIU examination revealed little adverse effect.

The other major activity while homeward bound was the full sodium nitrite treatment of the main lubricating oil system, a lengthy procedure which was barely completed by the time of arrival in Portsmouth. The subsequent 48-hour circulation of an entirely fresh charge of oil appears to have removed all traces of water from the gearboxes and the system, and the initial examination of the teeth has revealed nothing to cause concern.

Unfortunately the saga has a sad ending. The estimated repair time for the damage was not acceptable operationally and *Naiad* has now jumped the queue for her Ikara special refit, where the renewal of a main engine and a generator can be absorbed within the overall planned time.

One error has been made since *Naiad's* return to harbour. As the silver nitrate tests of all drains and condensates were clear on shutting down, the steam systems and turbines were thought to be clean. However, the progressively deteriorating state of the steam and exhaust valves, removed by the ship's staff, showed that active chlorides were still present. In practice, a fortnight's delay was permitted to elapse before the steam systems and turbines were washed through with hot distilled water. The effect of this dilatory action can only be assessed when all the equipments and systems are fully surveyed over the next two years. It is now clear that, under the high temperature conditions of superheated steam, the salt carry-over was lying dormant in the pipes and turbines awaiting the onset of condensation after shutting down.