FAILURE OF A BELLOWS EXPANSION PIECE

—H.M.S. ASHANTI

BY

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On 4th June, 1962, H.M.S. *Ashanti* was on passage from Plymouth to London when a major steam leak developed in the boiler room which necessitated the shutting down of the steam plant. Passage up the Thames was completed on the gas turbine. Investigation revealed that a five-inch diameter flexible bellows piece in the exhaust range had split after only seven months in service. This was considered to be an isolated occurrence. A spare was obtained and fitted and nothing further was thought of it.

On 9th September, 1962, the ship was on passage from the United Kingdom to the Azores, en route to the West Indies, when the same bellows piece failed again. It was decided to continue the programme on the gas turbine (not for the first time—more like the thirteenth) but it was also considered desirable

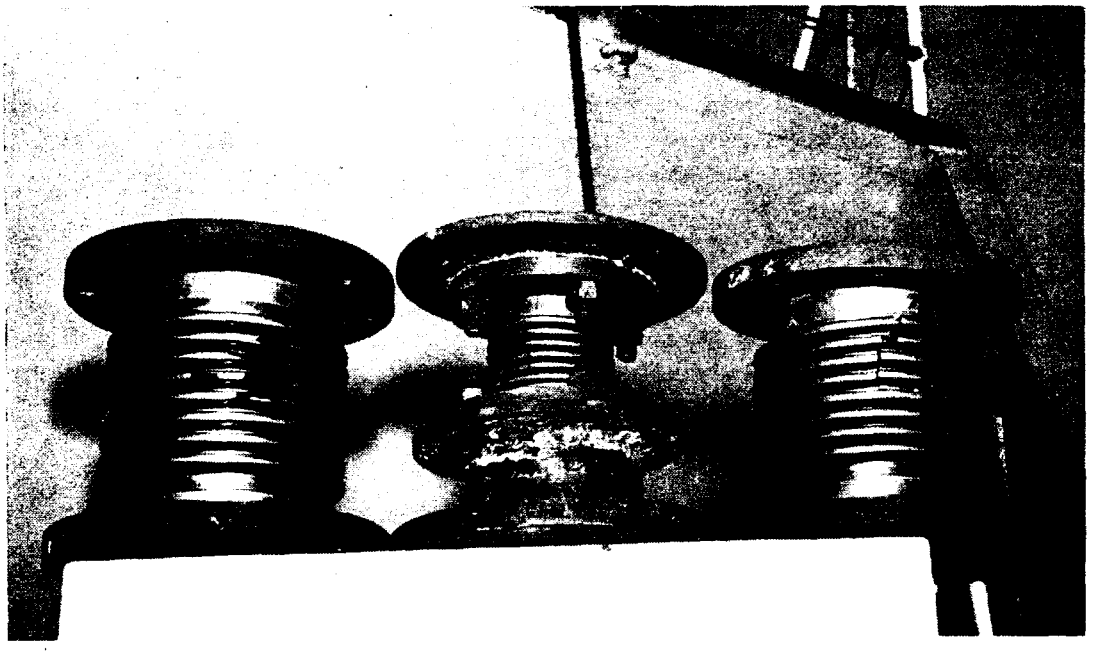

FIG. 1—THE DEFECTIVE BELLOWS PIECES AND THE JURY RIG

to attempt a temporary repair. The flexible piece was $8\frac{1}{2}$ inches long and 5 inches in diameter, and the only item of spare gear remotely similar was a cooling-air bellows piece for the gas turbine, $4\frac{1}{2}$ inches long and 3 inches in diameter. The latter was designed for air conditions of 90 lb/sq in. and 500 degrees F, which compared well with the exhaust steam conditions of 10 lb/sq in. and 400 degrees F although the length available for expansion was much reduced.

Careful measurement showed that the hot length must be $8\frac{1}{2}$ inches but the cold length $8\frac{7}{8}$ inches. To give minimum tensile stress on the installation and compressive stress in operation, it was decided to make adaptors to give an overall free length of $8\frac{11}{16}$ inches. A copper-nickel-iron erosion piece having the correct diameter was used to provide the flanges as it was not wished to destroy the original bellows piece before it had been metallurgically examined. Mild steel blank flanges were sif-bronzed to the erosion piece with 3-inch holes burned out of the centres and four studs welded on to suit the new expansion piece. One flange was offset $\frac{1}{4}$-inch to allow for a measured misalignment of the pipes. The final result, ungainly but serviceable, can be seen in FIG. 1.

The replacement was fitted and steam raised, steam propulsion being achieved eighteen hours after the initial failure. The design heat balance figures were available on board and it was calculated that the maximum power on cruising auxiliaries could be obtained with approximately 20 per cent full power flow through the line. The same ship's speed on main auxiliaries would require nearly 50 per cent full power flow, the large difference being largely accounted for by the supply to the steam/air heater which is only used with the cruising blower. Since the available area for flow was 36 per cent, it was decided to use cruising auxiliaries only, using gas turbine boost when higher speeds were required.

The ship reached the Azores on 11th September and took on fuel. A spare bellows piece was collected which had been flown out from the U.K., obviously from its condition having been removed from a sister ship still under construction. This was received less than 48 hours after the failure—a most commendable effort on the part of the authorities at home. The instant the spare was received on board, the ship got under way on the gas turbine while it was fitted. Steam propulsion was achieved once more about eight hours after

sailing. Thirty-six hours later the replacement bellows piece failed in a more or less identical manner and was again replaced by the ships staff jury rig. This enabled the passage to San Juan, Puerto Rico, to be completed. Yet another bellows piece was flown out from home and very careful measurements were taken of the pipes. The apparent misalignment turned out to be that the flanges were not parallel and a tapered shim to correct this was manufactured by the Industrial Manager of the United States Tenth Naval District, who is based at San Juan.

The new bellows piece was fitted with the shim and survived only nine hours' steaming before failing in the same manner. The jury rig was again fitted and the ship returned to San Juan. The ships staff had by now completely lost faith in bellows pieces and considerable ingenuity was exercised in trying to explain the increasingly rapid incidence of failure. A sketch design was therefore produced for a sliding gland. On arrival in San Juan, a representative of the Industrial Manager arrived on board with a design virtually identical to that produced by the ship and, displaying remarkable initiative, had already started to manufacture it. This was subsequently completed and fitted, together with the shim, and enabled the trials to continue with steam up to full power.

Ship's opinion inclines to the view that failure was due to high frequency vibrations of the convolutions set up by the steam flow, and the rapid failure of the final two due to the fact that the lagging blanket was not fitted. In the earlier cases lagging would have provided appreciable damping. This view is supported by the fact that the bellows piece whistles when in use but the ships staff jury rig and the expansion gland do not. A design has therefore been proposed with an internal shield to prevent the setting up of eddies in the steam flow.

It is of interest that the jury rig steamed for 81 hours with no apparent deterioration.

Comment by D.M.E.

The ships staff are to be congratulated on their initiative in producing both the jury rig and the design for the expansion gland.

The most likely cause of the failures would appear to have been a combination of the misalignment of the pipe flanges and the high frequency vibrations mentioned in the article. It is of interest that there are five other similar bellows pieces in a G.P. frigate installation none of which have failed in *Ashanti* so far, nor have any failures occurred in other ships of the Class.

The attention of all shipbuilders has been drawn to the importance of proper alignment of pipe flanges and, as stated, sleeved bellows will be provided in future for similar expansion arrangements.