DESIGN FAULT 2

Construction of the non-return flap valves

The construction drawings of the duff and offal chutes indicate that the counterbalanced non-return flap, within each chute, was assembled from parts, which were bolted together. The strength and rigidity of each flap assembly was therefore dependent, to some extent, on nut and bolt clamping forces and the corresponding **friction** forces that were developed on the surfaces of the joined parts.

It is a known fact that bolted joints may be liable to slip when subjected to the type of loading that promotes the rotation of one part relative to another (bending moments or torque). This form of construction was therefore not wholly appropriate for these fittings and the service that was envisaged on the Gaul.

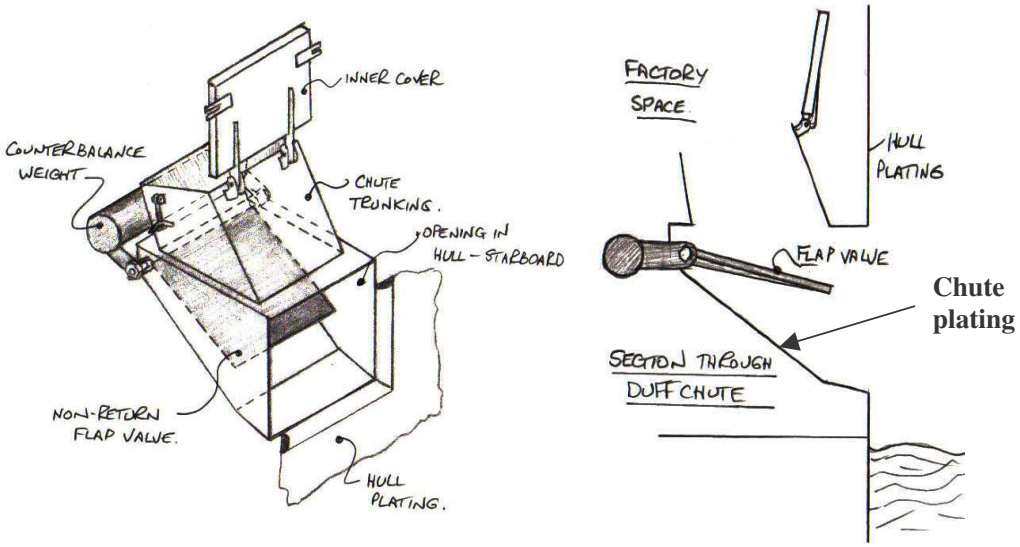

Fig 1. Arrangement of the Duff chute

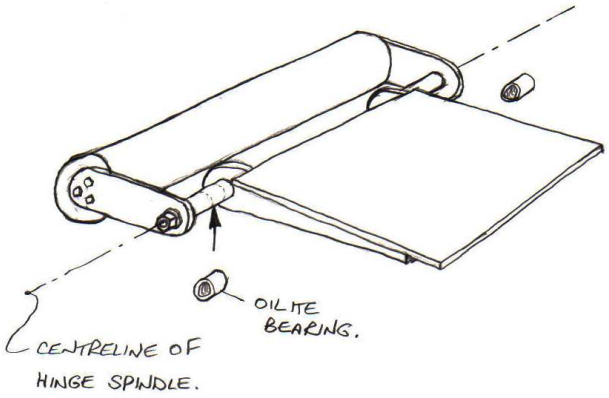

Fig 2. If we take out the non-return flap valve assembly from the duff chute

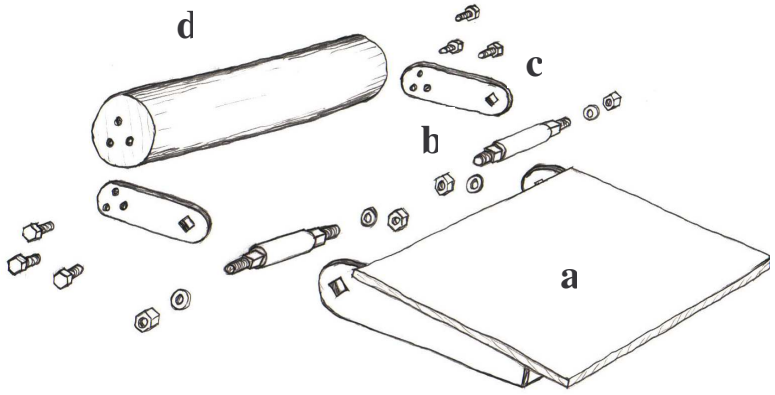

Fig 3. If we then dismantle this flap valve assembly:

a *the steel valve plate*

b *the steel spindle*

c *the steel counterbalance arm*

d *the steel counterbalance weight*

Each of the holes in the above sketch (including those for the spindle square drive) would have been dimensioned to provide tolerances and clearances to their mating parts. The role of these clearances is to enable the flaps to be assembled and the spindles to be aligned within their Oilite bearings.

Comment: If the flaps are loosely assembled (i.e. the nuts and bolts are not tightened), it is apparent that the flap assemblies are ***not inherently rigid*** *and that a certain amount of flexibility or twisting is possible until the clearances and tolerances in the boltholes are taken up.*

During the initial assembly at the shipyard, this flexibility would be utilised so as to allow the correct alignment of the spindles within their bearings. After alignment, the nuts and bolts would be tightened up and the flap would become rigid; however, this rigidity would only be assured by the nut and bolt clamping forces and the surface friction forces that developed on the surfaces of the parts joined together.

Non-return flap valves - Loads whilst in service

In normal everyday usage, the non-return flaps would be subjected to the purely nominal loads associated with the discharge of duff and offal waste - certainly nothing that would give cause for concern.
However, when the flaps were performing their principal function (i.e. providing a strength barrier against the ingress of seawater in rough weather), they would be subjected to significant forces from ocean waves.
Notwithstanding this point, the flaps are of substantial construction and, when fully closed, would be more than adequate to withstand the forces of the sea.

However, if, for any reason, the flaps were not fully closed, the force of the sea could act on the exposed edge of the flap and push it open.

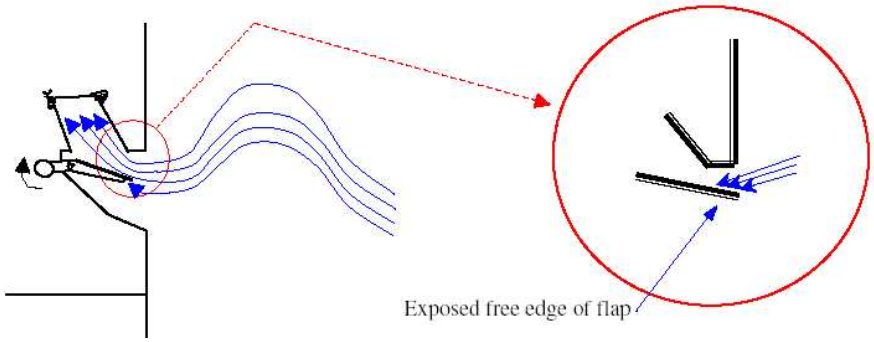

Fig. 4 section through chute

Additionally, in heavy weather, wave loading on the flap valve plate could cause the flap plate to rotate and slam against the chute plating.
It has been calculated that the dynamic loads arising from relatively modest waves (say 5m) acting in this way on the flap plate, would be sufficient to cause slippage at one of the flap's bolted (friction) connections.

The results of slippage at a bolted connection

Minor slippage at one of the assembly's connections (*say between parts **b** and **c** in the sketch on the previous page*) would result in twisting or distortion of the flap assembly and subsequent misalignment of the steel spindles within their bearings.

Misalignment of these spindles within their bearings would then be sufficient to cause the flap to become stiff, to stick or to seize.

After seizure, the flap would be in the fully open position.

Note

This design fault would have not been present if, instead of a nut and square drive connection, the spindles and the counterbalance arms (parts **b** and **c**) had been joined together by means of welding:

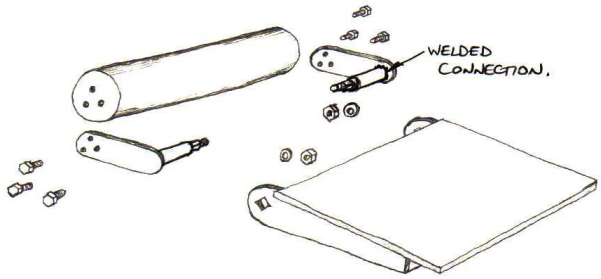

Fig 5. Flap assembly with alternative welded connection

Dismantling, repairs and maintenance would still have been possible with such an arrangement.