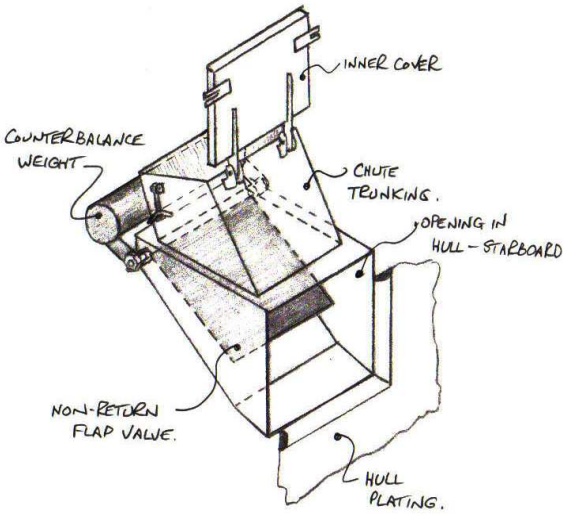
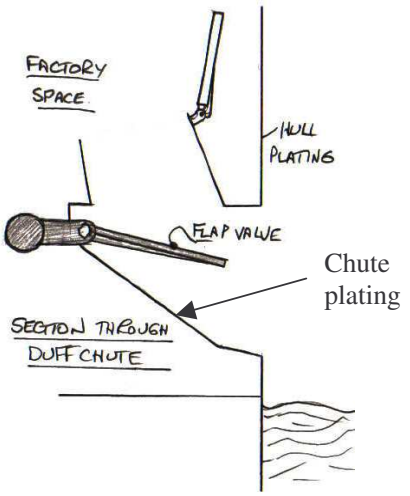
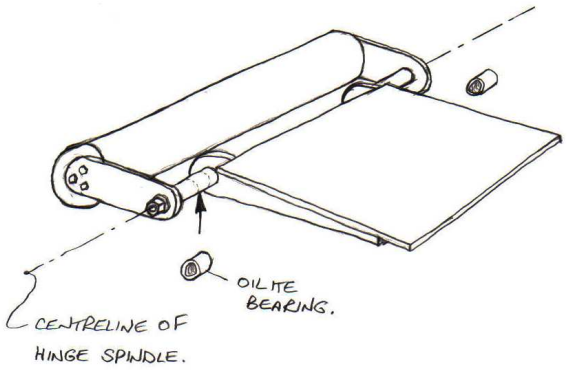
DESIGN ERROR 1

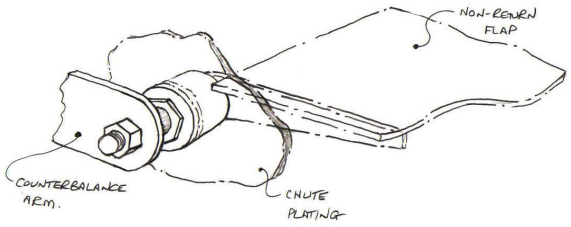
The construction and arrangement of the duff chute:





Sketches showing the internal moving parts in the duff chute: the flap valve, the spindles, the counterbalance weight and arms:





A false premise

One of the facts revealed by the 2002 underwater survey of the wreck of the Gaul was that the non-return flaps, in both the duff and offal chutes, were in the fully open position. Hence, the final Report of the 2004 Re-opened Formal Investigation (RFI) made the following statement, which, as we are now trying to show, was not wholly correct:

> *Paragraph 18.17 "…although both chutes were found on the wreck to be open both in way of the non-return flap and the internal top cover,* ***there is no known mechanical reason why this was so****."*

The information on the following pages shows only one of a number of possible failure mechanisms that could have led to the valve flaps being open at the time of the vessel's loss. This failure results from a simple **design error** on the shipyard drawing.

The design error

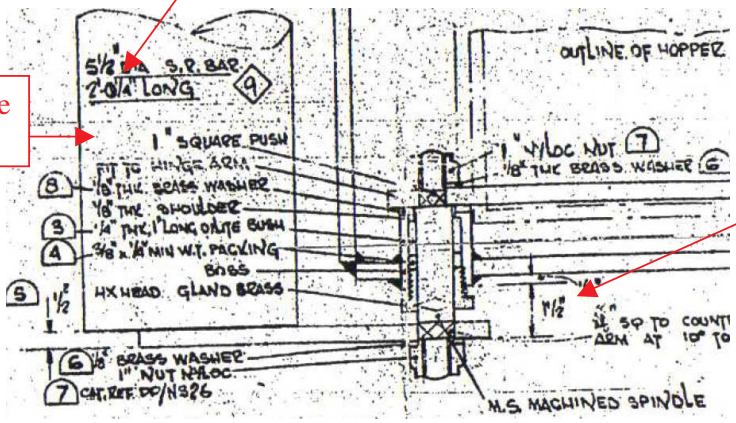
There was a dimensional error on the shipyard's construction drawing for the duff and offal chute valve flap hinge assembly in that the length of the median portion of the spindle should have been 3¼" instead of only 3", as the design prescribed. (for further information on this point see the part prints below and Annex 1) this dimensional error only becomes apparent when the distance between the two counterbalance arms (indicated to be 2'-0¼" on the drawing) is matched against the sum of the dimensions of the parts between the counterbalance arms and the position of the hinge spindles, which was fixed. Although the effect of this error would not have appeared as significant at the time of assembly, it would have reduced the clearance between the end of the brass glands and the steel counterbalance arms, making it insufficient.

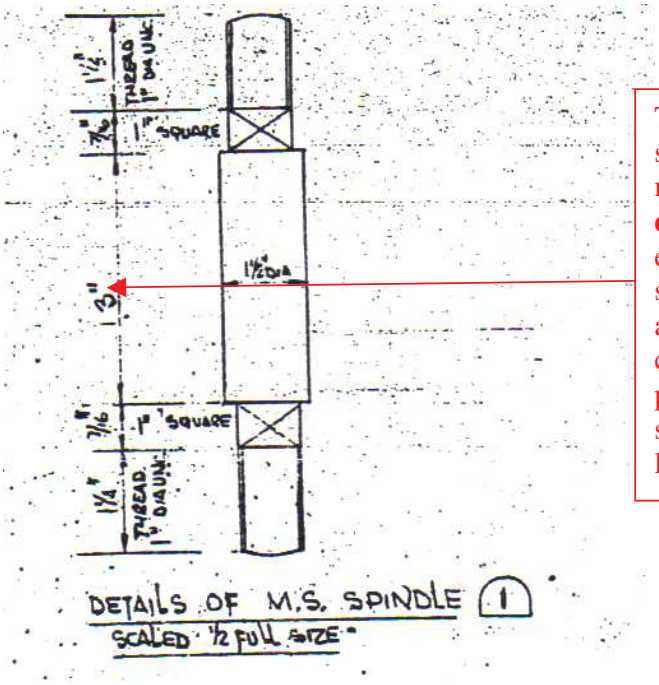
The hinge assembly

2'-0¼" = Distance between counterbalance arms

Counterbalance weight

Designed Dimension = 1½"





The fact that this portion of the spindle was indicated as 3" long meant that the **designed dimension** of 1½" between the end of the boss and the outer surface of the counterbalance arm (that is indicated above) could not be achieved in practice. This part of the spindle should, in fact, have been 3¼" long.

The consequences of the dimensioning error

For those of us familiar with bicycle mechanics, the reasons for left and right-hand screw threaded connections are well known.

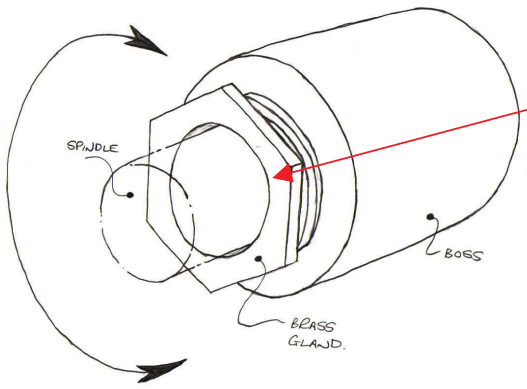
Wikipedia has an entry on this topic:

- *Nearly all threads are oriented so that when a bolt or nut, seen from above, is tightened in a clockwise direction, the item turned moves away from the viewer. If the item is loosened by turning anticlockwise, the item moves towards the viewer. This is known as a* ***right-handed*** *thread.*

Where the rotation of a shaft would cause a conventional right-handed nut to loosen rather than to tighten a left handed thread is normally used.

The brass glands within the hinges of the duff and offal chutes were each provided with a right-handed screw thread (which was normal) and this would mean that when the steel spindle was rotated, one gland would have a tendency to screw into the steel boss (to tighten) and the other gland would have a tendency to screw out from the steel boss (to loosen). It can be shown that in some circumstances the threaded brass glands on the Gaul would unscrew and, as a result of the drawing error that has been detailed previously, come up tight against the steel counterbalance weight support arms.

Sketch of steel boss, brass gland and steel spindle:



Various factors, such as oxide and dirt build-up or misalignment could cause the spindle and gland to bind together intermittently and, in time, cause the brass gland to unscrew (loosen).

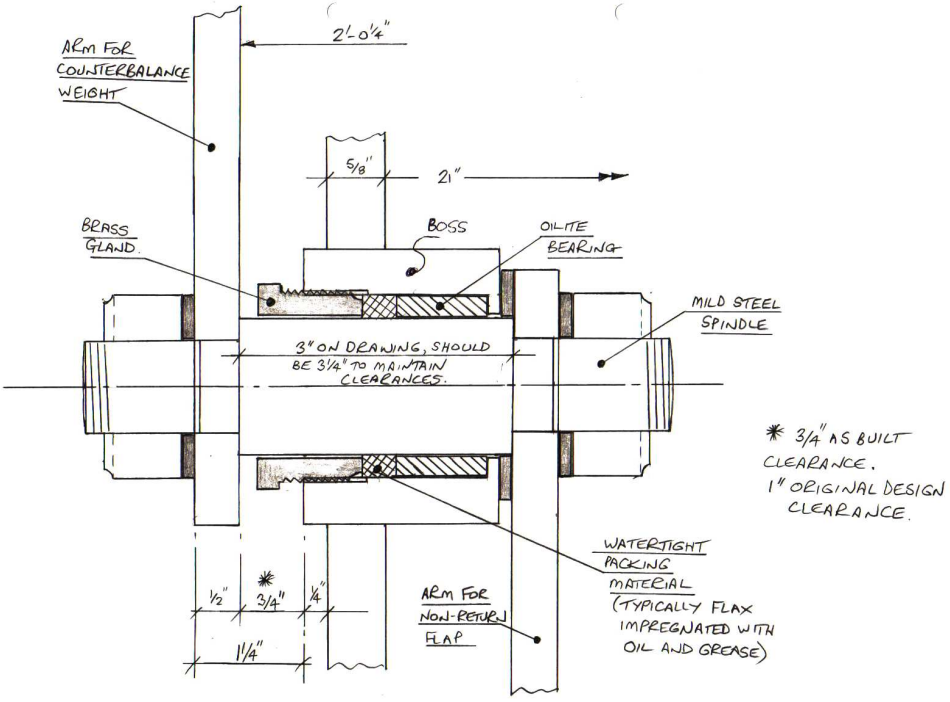
The significance of the drawing error is that, if the brass gland were unscrewed, it would make contact with the steel counterbalance arm while still engaged in the threads of the steel boss. Further rotation would cause the gland to unscrew further and this would induce significant axial loads into the spindle, thus causing the hinge to bind and the non-return flap to stick in an open position.

Annex 1

Sketch of the hinge assembly in the duff and offal chute flap valve:

On page 2, partial copies of the flap valve hinge drawing are shown, on those copies three dimensions are indicated which are incompatible (the 3" dimension indicated on the M.S. spindle is obviously an error). The hinge has been redrawn below and it may be seen that the clearance between the end of the boss (and brass gland) and the counterbalance arm has been reduced by **¼"**.

With the clearance as originally designed, the brass gland would be capable of being fully unscrewed without contacting the counterbalance arm. However, the error in the spindle dimension has meant that the clearance has been reduced such that if the brass gland were unscrewed it would come into contact with the arm while the threaded portion of the gland remained in the thread of the boss.



*The dimension marked with an asterisk in this drawing (**¾"**) is fixed by the dimensions of the steel spindle. This dimension should have been 1".

Supplementary information:

The functions of each part of the hinge are detailed below:

- **Spindle** - connects the steel counterbalance arm to the non-return flap, both of which are secured by means of locknuts. The spindle may rotate through an arc of 50º within the oilite bearing thus allowing the non-return flap to open and close as duff and offal waste is discharged.
- **Oilite bearing** - two bearings are provided in each of the duff and offal chutes. These bearings provide the means of support for the mild steel spindle, the non-

return flap and the counterbalance weights. The bearings are self-lubricating and allow the spindles to rotate.

- **Watertight packing** - this is compressed onto the spindle by the brass gland. This seals the spindle and prevents the entry of water (this arrangement is similar to the gland on the top of a garden tap)
- **Brass gland** - when the gland is screwed in, the flax packing is compressed against the spindle, thus providing a watertight seal for the hinge assembly. Unlike a nut or bolt, the threaded brass gland should remain loose and not be tightened.
- **Boss** - this provides the structural support for the bearing, the watertight flax packing and the brass gland.