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David Taylor's Marine Test Tank

Between September 1979 and June 1980, David Taylor, a pupil at Swaffham Hamond's High School designed and built a test tank for model boats as his major project for 'O' level Technology (Cambridge Board). The project was also entered for the Schools Design Prize (Design Council) and won a prize. The tank is now the property of the school and is in constant use. This is an account of the project.

David wanted to build an airship. It would have to be a model, he realized, but he wanted to test the feasibility of larger designs capable of carrying enormous loads. The whole ship, he felt, could be a huge aerofoil section which would supply dynamic lift. I pointed out that Barnes Wallis had said that airships should never be flown with dynamic lift as it made them susceptible to catastrophic stalling and that it was suspected by many, Wallis and Nevil Shute included, that this may have been a contributory factor to the R101 disaster. David quietly pointed out that what was true in the 1920s and 30s was not necessarily true today: advances had been made in material science and aero-engines. But I began to feel we were getting lost in detail. What gas could we use? I wouldn't counenance Hydrogen. And where would we get a supply of expensive Helium? Firmly, and with great regret, I ruled out the project.

Guiding pupils towards a suitable 5th year project is always a problem, but I could see that in this case it was going to be particularly acute. David is a boy with large ideas and the ability to carry them out, but had we the resources to meet his demands, particularly financially? His project would, we decided, have to be something for the school so that we could share the cost, but also it would have to be something he was interested in. A consideration of David's interest didn't narrow the field much; he is interested in most things technical, but I knew what I wanted – a test tank for model boats. And that fitted in nicely with one of David's many hobbies.

It was here that a doubt that was to haunt us throughout the project loomed up, particularly once we had decided to enter for the School Design Prize. Marine test tanks are scarcely new. Was this a legitimate design project? Should it be more original? In the end we resolved the matter something like this: I as the client was approaching David as the designer with a particular problem to be solved within a set of very strict limitations. This, we felt, must be more typical of a professional designer's position than one in which the designer of his own volition chooses his own project and can work without restrictions.

David noted in his folder, 'At first I was not at all keen on the idea, but over a relatively short period of time this project's appeal grew on me as I thought about what it might involve. It was a challenge, and I met with many unexpected snags'.

From then on my role became easy. I looked after the rest of my group and David looked after his project, occasionally discussing a problem or asking advice or chatting about requirements. I was a store-keeper, a financial backer, an information resource, critic, and I hope, a friend.

David's analysis of the problem pinpointed seven basic problems to be solved,

1. basic tank design
2. wave and turbulence absorption
3. boat towing systems
4. towing tracks and rails
5a. motor mounting and power transmission
5b. the final belt and pulley systems
6. strain gauge electronics
7. motor control electronics.

To each of these, David applied the design approach: analysing the situation, determining its specification, investigating it, posing possible solutions, selecting the most appropriate, building and testing and evaluating it on its own and in relationship to the other problems.

The critical area, David felt, would be the towing system. This area in particular would distinguish an effective test tank from an elaborate puddle, and the following section of this folder is a good example of his approach. *(See pages 92-95).*

To this David added his working drawings, sheet after sheet of superbly executed ink drawings on tracing paper. So well done were they that many who looked at them could only be convinced that they were the work of a 5th year pupil by pointing out spelling mistakes! Only this and the stencilled lettering distinguished them from the work of a professional draughtsman.

About halfway through the project we finally decided to enter it for the Design Council Schools Design Prize. We went through weeks of doubt about its suitability for entry, but in the end felt it could do no harm and Rolls Royce, who sponsored the competition, said that they would send an engineer round to talk to entrants.

Mr. Scarfe, a design development engineer who works on helicopter engines came on 12 May and spent the whole afternoon looking at the project and discussing it with David. It was a particularly good time for this visit. The tank was constructed, filled with water, working and yet not working.

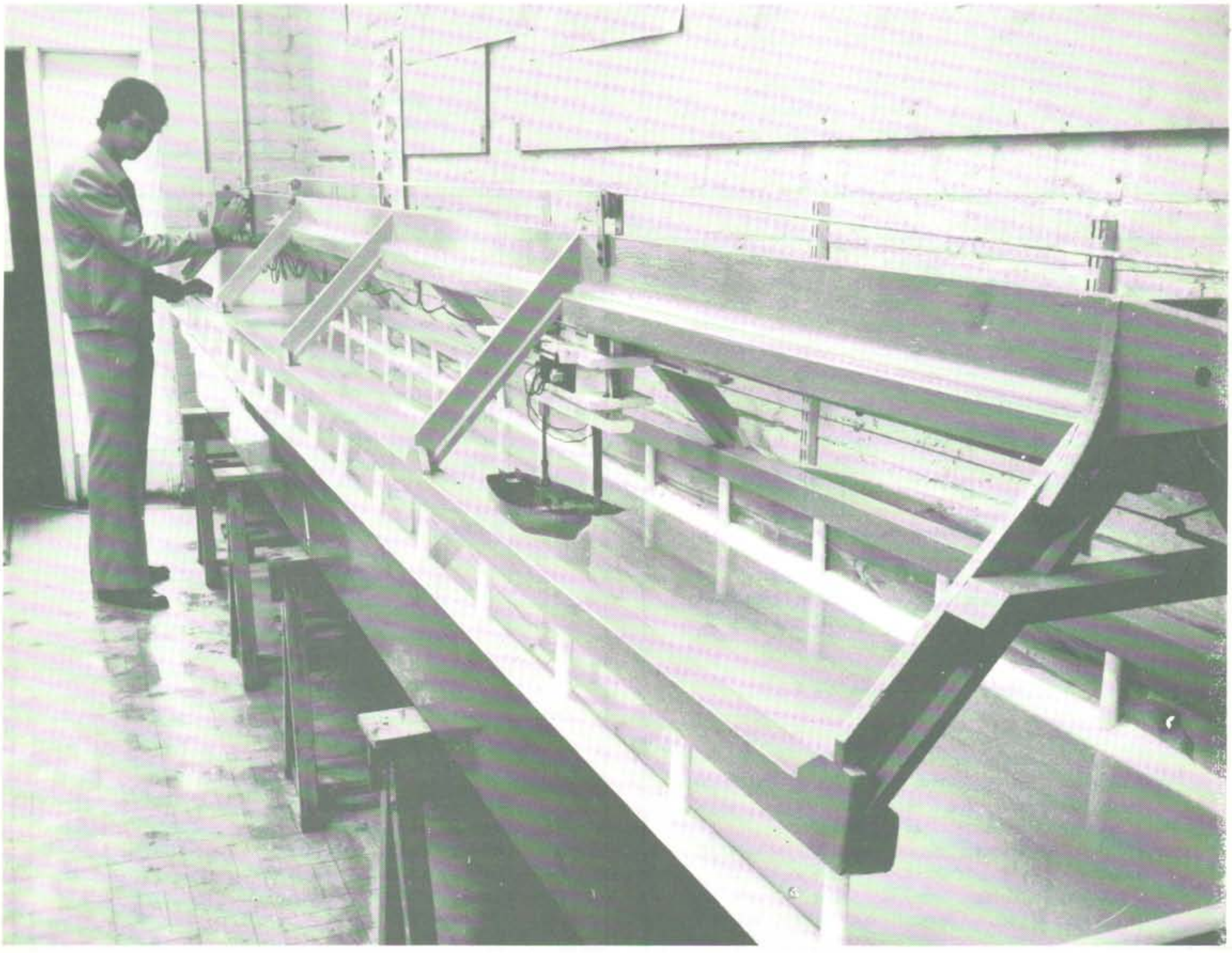
The meter from the strain gauge which should register the drag was not giving stable readings. The cause had to be identified, if possible, before the 'O' level project moderation (the 'O' level folder had already gone off to the moderator) and certainly in time for the competition.
The difficulty, we all agreed, was to isolate the one effect we wished to measure from all the other variables. The problem was how it should be done. David had built a completely floating towhead which should, he felt, by rising and falling with the boat, eliminate all the forces but drag. Mr. Scarfe said it wasn't exactly his field, but perhaps by locking the towhead and towing with strıng . . .? That shocked David. How could this professional

engineer from Rolls Royce possibly resort to something as crude as string? In the event, both were right. The towhead did need to be locked but the string didn't work because it allowed the boat to yaw.

Mr. Scarfe left us, promising to talk the problem over with his colleagues and write to us, but before his letter arrived David had followed up on his suggestions and a solution had been found.

Soon after, David left school, coming back occasionally to make a modification and when the judges' representative called to look at the hardware. The presentation of his prize has come and gone. The school bought mechanisms kits with its prize money. David, I think, bought drawing equipment, for he is now training as a technical illustrator. I will be seeing him again soon as we will be visiting Rolls Royce in Derby together along with all the other Schools Design Prize winners. In wonder if Mr. Scarfe will be there . . . I've got these boys working on energy from waves using the test tank and I've got a little problem I'd like to talk over!

David Taylor of Swaffham Hamonds High School, designed this test tank so that he could test the design of the model boats he makes.



Boat Towing Systems

Specification - Brief

In order to use the tank, an automatic boat towing system of some sort must be built.

It must be powered by a motor of some sort.

It must give readings that lend themselves to calculations.

It must allow the boat to ride on deliberate waves without distorting any readings.

It must be able to keep the hull perfectly straight at all times.

The towing equipment must not touch the water.

It must not interfere with the beach or increase the over all width of the tank.

It must be detachable for storage.

The system must employ a strain gauge, to measure the degree of drag on a hull moving through the water.

Investigation

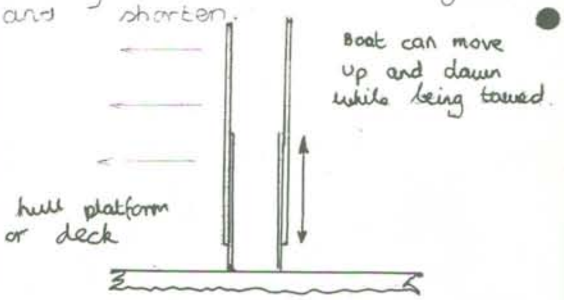
Because of the specification-Brief, the only form of motor really suitable is an electric motor.

It can be easily controlled.

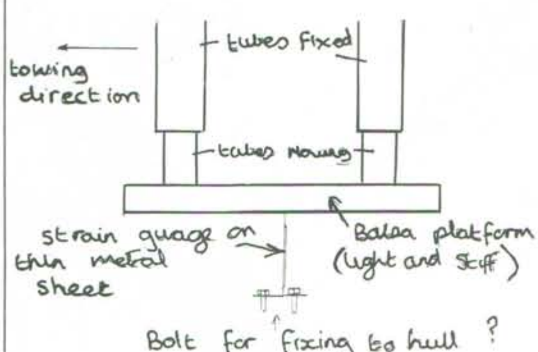
It is easy to start.

And its power requirements can be easily found with meters, For calculations.

For the boat to ride on the waves without affecting readings, the actual part of the system fixed to the boat must incorporate a towing arm that can lengthen and shorten.



As the system for wave riding as shown, is two tubes, moving one inside the other, a strain gauge cannot be very easily used.



If the fixed tubes were fixed to a trolley on skids of some sort, the above assembly could then be towed by the motor along a track.

Although this system would work, I really thought I ought to have the moving parts as free as possible

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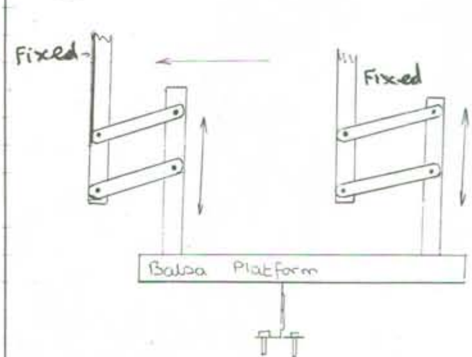
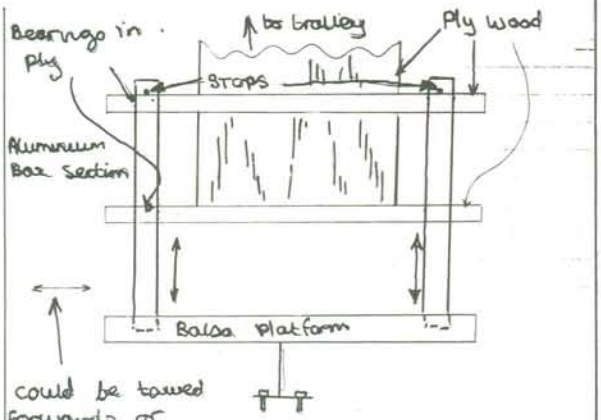
and stay that way even under tremendous acceleration, and high speeds. The tubes might bend and sieze up, or the top rim of the moving one might catch on the inside wall of the fixed one, if they were a loose fit.

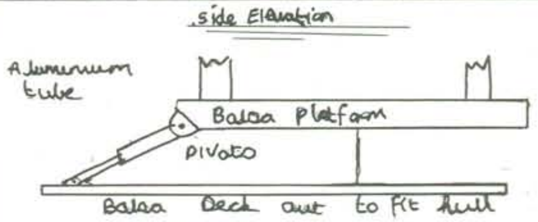


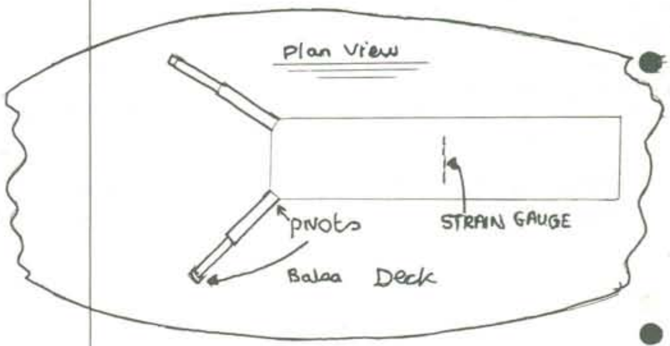
This system using parallel motion could be much looser than the tubes, but might be rather heavy and would not work very well in reverse.



This system would be light for the hull to support, work in foward and reverse, and withstand high acceleration.

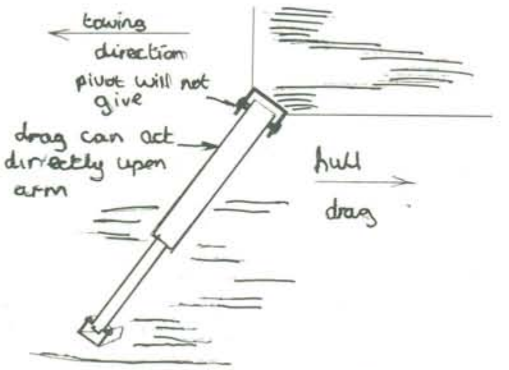
Although the two rods hold the balsa platform straight when in operation, the strain gauge cannot hold the boat straight so it needs something to help it doso.





The pivots and telescoping effect of the Aluminium tube allow the bows of the boat to rise slightly taking on their natural angle as they hit the on coming wave. Because the pivots only allow movement up and down, the bows of the boat cannot swing from side to side. The metal strip on which the strain gauge is mounted, should be sufficient to hold the stern in place.

Unfortunately the two angled tubes will tend to help with the towing, because of the manner inwhich they are pivoted.



This means that the strain gauge isnt doing all the towing. ∴ inaccurate readings of drag are given.

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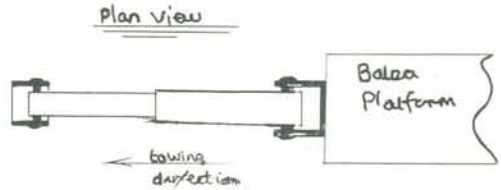
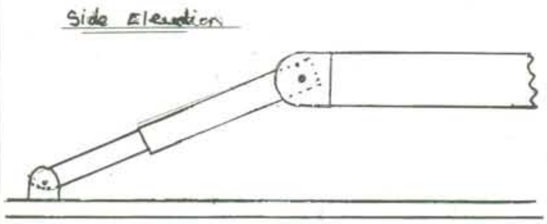
The effect can be put to good use with just one telescopic arm.

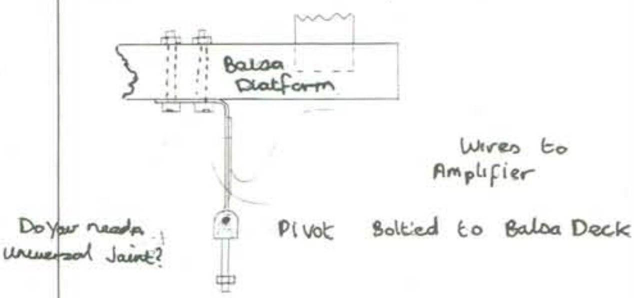


Balsa deck as before



This system will allow the bows of the boat to move up and down, but not left and right, because of the pivots.

But however, when the bows of the boat move up and down, the strain gauge will be affected by this motion, so the base of the strain gauge must also be pivoted



Side Elevation

Having designed a system (tow head) which will allow the boat to ride deliberate waves, while keeping perfectly straight and distorting no reading from the strain gauge, a system for testing the stability of a hull is required.

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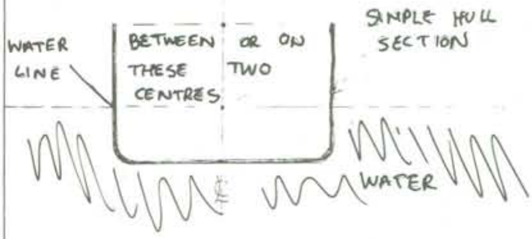
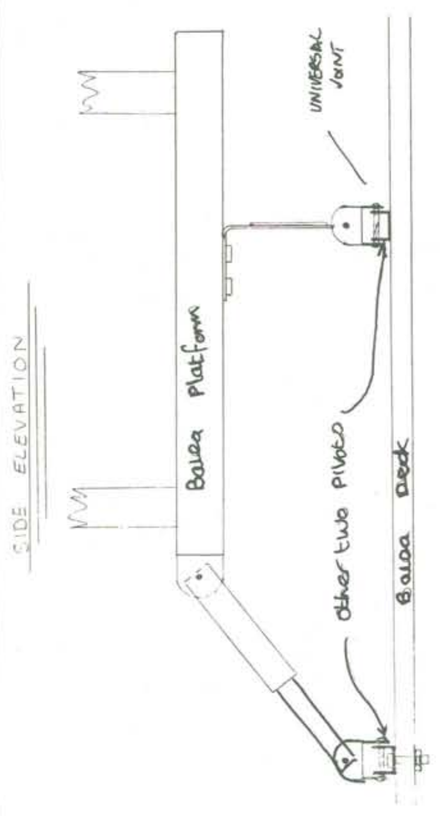
This system has to be part of the tow head and allow the hull to rock from a centre below or on the same level as the top rim of the hull, and above or on the water line of the hull.



This means that two extra pivots have to be introduced into the tow head system. One at the base of the first strain gauge pivot, and one at the base of the arm that keeps the bows in a straight line.

CLAMPS?



I'M NOT KEEN ON YOUR SYSTEM OF ATTACHMENT. SOME PEOPLE WILL NOT BE PREPARED TO DRILL HOLES IN THEIR NICE NEW BOATS!

I felt that it would also be a good idea to incorporate an auto stop system for the towhead and motor when they reach the end of travel.

This system would involve roller switches mounted on the rail, but triggered by the towhead as it passed them at each end of the tank.

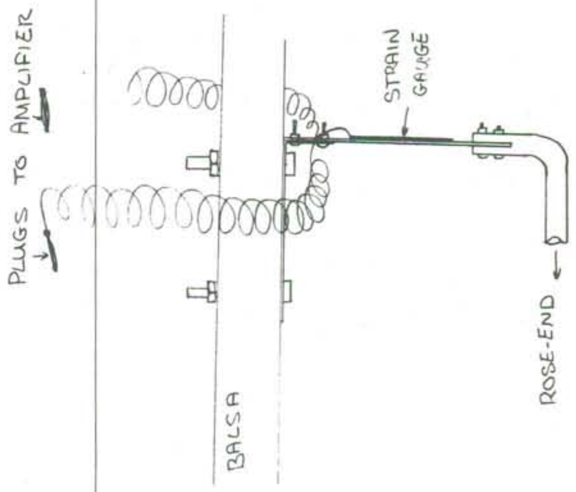
observations and updates

On the floating part of the towhead, I decided to use rose-ends as shown on the large towhead plan sheet instead of the self made pivots, this simplifies construction, and increases durability.

I also improved the teleoscopic stabalizing arm, by making it far stronger and allowing it more movement.

The actual strain gauge mount is a piece of hacksaw blade bolted to a bracket, at one end, and the rose-end mount at the other.

The wires from the strain gauge are wound in a spring fashion to allow for the up and down movement of this part of the towhead.



In testing however the strain gauge mount failed in two major ways.

① The effect of the castor angle given to the rose end for directional stability was that of a lever on the actual strain gauge as the boat moved up and down in the water while stationary. This produce a reading on the meter sometimes greater than towing strain.

② The mounting bracket and strain gauge backing plate were not of a tough enough spring steel. They bent and cracked.

I have now mounted the rose-end directly under the now stronger strain gauge backing plate, which is inturn bolted to a far stronger bracket.

The floating deck should now be of greater effect.