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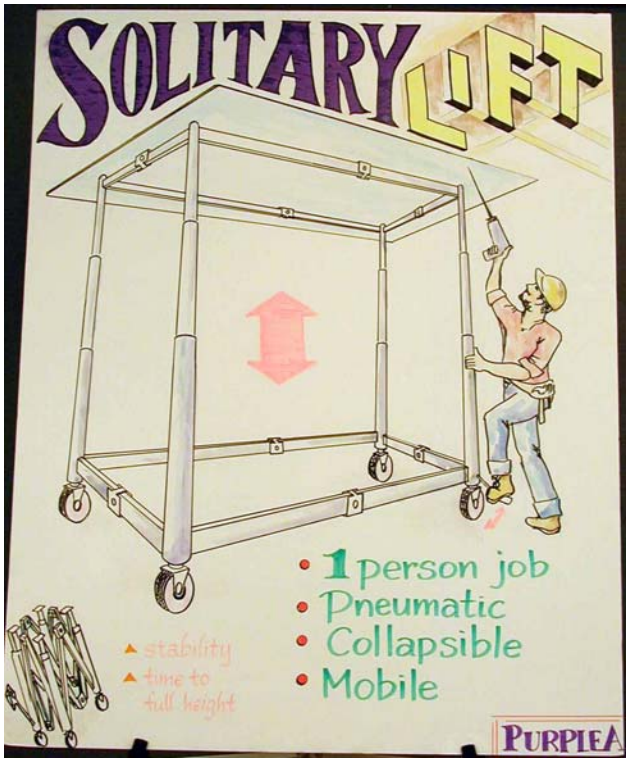
21M.735 Tech Note 7: Fluidics

Case Study of Using Hydraulics/Pneumatics to Lift Drywall

Pneumatics and hydraulics, methods of actuation based on fluid motion, are two great ways to move stuff, particularly heavy stuff, around in theater. Up and down, left and right; these methods can do it all. In this tech note, I will talk about a design experience I went through where we seriously considered the merits and drawbacks of these two systems, among others, in an application outside of the theater. Then, I will relate the learning from that experience back to the theater.

For last fall's session of 2.009, the Product Engineering Process, I was on a team of 19 engineers. We were charged with the task of creating something that would assist volunteers at Habitat for Humanity, and given a $6000 budget to create a working prototype. After spending some time on a site and talking to Habitat for Humanity representatives, we decided to focus on the problem of drywall. Drywall is heavy, and to affix it to a ceiling or wall, it must be held in place before all the screws or nails are in. The most common way to do this is to get two or three other people to assist the person installing the drywall. However, in a volunteer situation, this isn't as applicable.

We decided to create a machine to lift sheets of drywall into place either against walls or ceilings. The preliminary design drawing appears below:



As can be seen, at the time, we were planning on making it pneumatically driven at each of the four pistons in the drawing. However, we quickly realized that this would nearly impossible to actuate and keep perfectly aligned, so we decided to go with a single-piston design:

In this rudimentary mock-up, the sheet of “drywall” can be seen resting atop the central pillar, which is supported by legs down at the bottom. We blew this model up into a much larger mockup:

The question was: what should we use to actually do that lifting? Should it be pneumatic, hydraulic, or something else?

The pneumatic cylinder, filled with air, would likely bounce around because of the compressibility of air, which might affect consumer confidence in the product. A hydraulic cylinder would require an oil reservoir, and both would require external hardware, in the form of a pump or compressor.

Also, it was unlikely that given our fabrication abilities, we would be able to create either one of these devices, with the precision tolerances necessary to prevent leakage. We looked into existing cylinders that we could buy. We were interested in a highly variable length (initially 3ft, extending to 12 ft), which meant we would need

telescoping sections and lots of them. We were unable to find anything out on the market to fill these requirements and also fit into our budget.

Because of these drawbacks, we ended up going with a cable-driven set of nested segments, as shown below:

The drive mechanism is the small black motor seen attached to the base. The extensible lift was tilted slightly backward, so that as the drywall was lifted, it brought

the center of gravity further back toward the center of the base. This was light-weight, and it met our lifting needs both in terms of load and displacement.

The lessons learned from this encounter that can be applied to theater for me were that fluidic pistons are good at what they do: transmit a lot of force over limited ranges. If this is what the theatrical design calls for, be it a very heavy wagon or elevator loading, and the budget is there to make it happen, then fluidics is the right choice.

P.S. Here's a picture of me kissing the complete machine: