Pneumatic Actuators

Brief Overview

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Pneumatic Actuators

- Use Pressurized Air to achieve motion
- Add great deal of power and speed to any actuation system.
- Variety of Actuation mechanisms available
  - Cylinders
  - Grippers
  - Motors

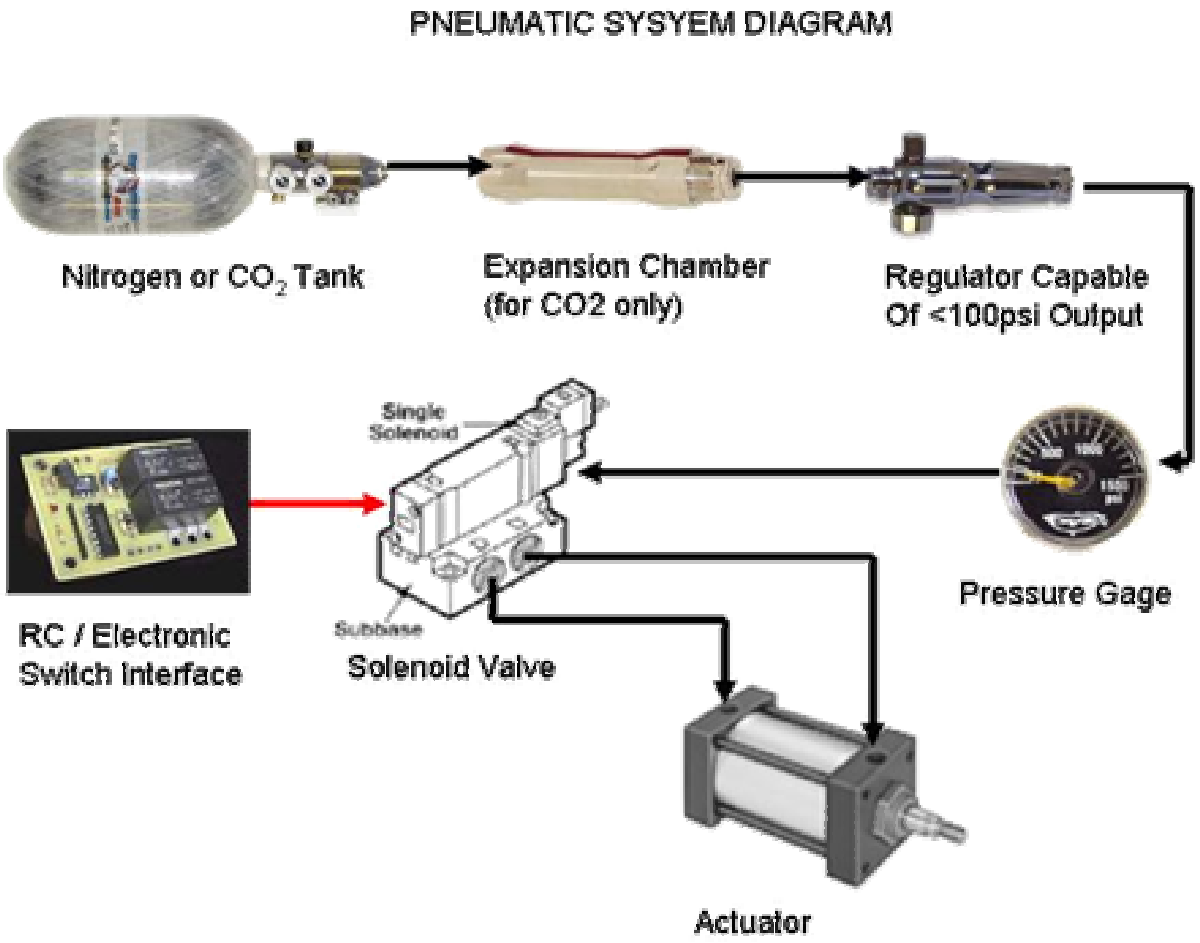
Why go the Pneumatics' Way?

- Weight
  - Cylinders much lighter than motors
- Simple
  - Much easier to mount than motors
  - Much simpler and more durable than rack and pinion for linear motion
- Fast on/off type tasks
- Big forces with elasticity
- No leak problems
- No burnout
  - Cylinders can be stalled indefinitely without damage

What can deter you on your way?

- All the components are quite expensive
- A properly designed system is more complex than an equivalent electromechanical system (electric motors, power screws, linear actuators, etc.).
- All these components take up quite a bit of valuable space within a robot.
- All the way in or all the way out
- No weight advantage if only one cylinder used (still need compressor, reservoir, pressure sensors, regulator)

A Typical Pneumatic System



The Air Muscle

an extraordinary actuator

Introduction

- **The Air Muscle is an extraordinary actuator that is small, light, simple and 'friendly'. It is soft, has no stiction, is easily controllable and exceptionally powerful.**
- The Air Muscle consists of a rubber tube covered in tough plastic netting which shortens in length like a human muscle when inflated with compressed air at low pressure.
- An Air Muscle has a power-to-weight ratio as high as 400:1, vastly outperforming both pneumatic cylinders and DC motors that can attain a ratio of only about 16:1. It has been in continuous development for advanced robotics work by Shadow since 1982, and is now available for use in a variety of applications as a powerful, lightweight actuator. Air Muscles are normally operated using compressed air in the 0-70psi (0-5 bar) range.

General Overview

- The Shadow Air Muscle is a simple yet powerful device for providing a pulling force. It behaves in a very similar way to a biological muscle. When actuated with a supply of compressed air, they contract by up to 40% of its original length. The force it provides decreases as it contracts, and the first few percent of the contraction is very powerful indeed.

- The simplest use of a muscle is to move a lever. One muscle will pull the lever in one direction, and a spring can return it. Two muscles will allow the lever to be pulled in either direction, with considerable force. Because the muscle contracts over a known distance, it can be used to provide a safe movement: there is no need to ensure that the lever is not going to be rotated beyond its end-stop, because the muscle will only move the lever to its set up angle.

Advantages

- **Lightweight** - Air Muscles weigh as little as 10 grammes - particularly useful for weight-critical applications.
- **Lower Cost** - Air Muscles are cheaper to buy and install than other actuators and pneumatic cylinders.
- **Smooth -** Air Muscles have no 'stiction' and have an immediate response. This results in smooth and natural movement.
- **Flexible** - Air Muscles can be operated when twisted axially, bent round a corner, and need no precise aligning.
- **Powerful** - Air Muscles produce an incredible force especially when fully stretched.
- **Damped** - Air Muscles are self-dampening when contracting (speed of motion tends to zero), and their flexible material makes them inherently cushioned when extending.
- **Compliant** - Being a soft actuator, Air Muscles systems are inherently compliant.

Range of Air Muscles Available

Thumbnails	Diameter	Length (Fully Stretched)	Weight (approx.)	Pull (3.5 bar)	Maximum Pull
	6 mm	150 mm (Stretched)	10 g	3 Kg	7 Kg
	20 mm	210 mm (Stretched)	40 g	12 Kg	20 Kg
	30 mm	290 mm (Stretched)	80 g	35 Kg	70 kg

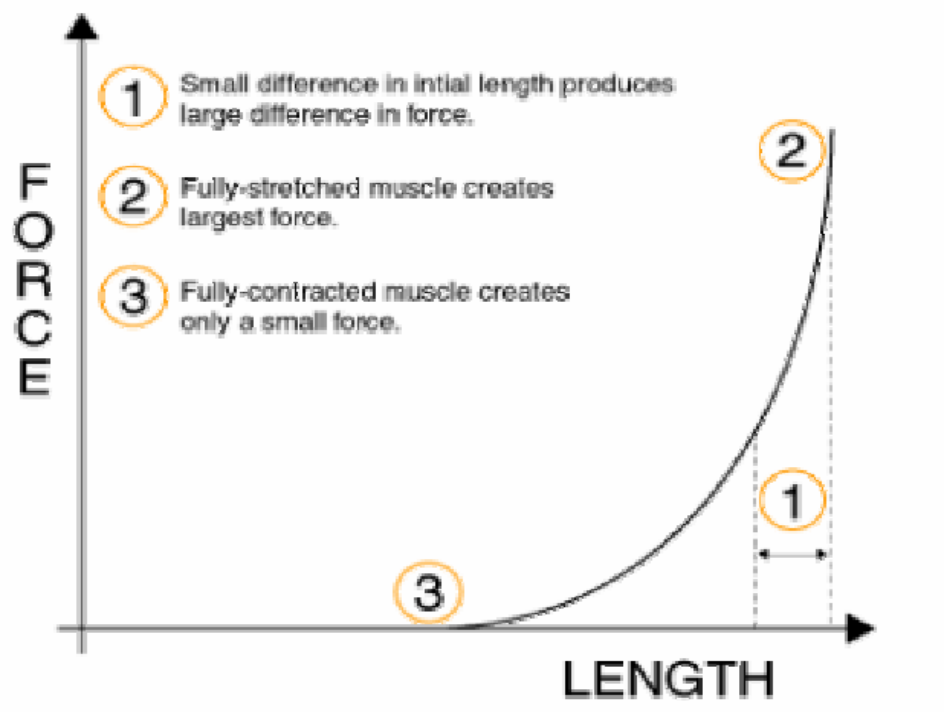
Construction

The Core of an Air Muscle is a rubber tube....

....wrapped in a tough plastic weave....

....which shortens in a scissor action when pulled out, just like a Chinese finger puzzle. As the rubber tube fills with air it is forced to expand.

Properties


1 Small difference in intial length produces large difference in force.
2 Fully-stretched muscle creates largest force.
3 Fully-contracted muscle creates only a small force.
FORCE
LENGTH
1
2
3

Operational Requirements

- The Air Muscle is a pneumatic actuator and so the following guidelines must be adhered to:
  - ***Shadow Air Muscles should never be operated above 90 psi (6 Bar).***
  - ***When the Air Muscle is not loaded, it must not be inflated above 45 psi (3 Bar***)
- Over-inflation will cause the life of the Air Muscle to be significantly reduced, and may cause the assembly to burst. The Air Muscle is not rated for use outside the 0-50 Celsius temperature range. Air supplied to the Air Muscle should be clean and oil-free. It is not possible to make a general prediction about the life of the Air Muscle in use; lifespan is dependent on operating conditions and ambient conditions.

Fixtures and Fittings

- The 6 and 20mm Air Muscles are supplied with an attached air line of 4mm diameter (Outside) and have looped ends, for easy attachment to hooks or pegs.
- The 30 mm Air Muscle has an attached air line of 6mm diameter (Outside). The 30mm muscle are supplied as standard with M6 studding. It is possible to supply them with eyebolts if required, or other fittings according to customer's requirements.

Ordering Info

THE SHADOW STARTER KIT	Price @
1. One standard 15cm air muscle. 2. Three-way-valve for controlling the air flow. 3. Bottle cap adapter for attaching an air reservoir. 4. Fizzy drinks bottle to be used as the air reservoir. 5. Footpump adapter for connecting a car footpump to the 3mm air line. 6. Tee piece, in case you want to connect one footpump to more than one system. 7. Two releaseable nylon cable ties, to attach the muscle to your device. 8. Plus a length of 3mm air line which can be cut and push-fitted into the other components. • NB You will need to supply a foot pump for charging the reservoir.	£18.70
The Shadow Starter Kit is exempt from the Air muscle minimum order restriction.	

Ordering Info

THE SHADOW AIR MUSCLE RANGE

Please note: Muscle lengths differing from the list below can also be supplied.

Thumbnails / Products	Braid Diameter	Length (See Notes)	Air fitting size	Pull at 3.5bar	Price @
	6mm	150mm (Stretched)	4mm	3 kg	**£6.38**
	20mm	210mm (Stretched)	4mm	20 kg	**£24.75**
	30mm	290mm (Stretched)	6mm	70 kg	**£61.95**

Total minimum order value of £40.00 must be placed UNLESS you are purchasing a Shadow Starter Kit.

Future Trends

- Incorporation of Thermal Damping in Hydro Pneumatic suspension system

References

- http://www.shadow.org.uk/products/airmuscles.shtml#Anchor-Sources
- http://dc.cen.uiuc.edu/
- http://www.industrialtechnology.co.uk/2000/apr/west.html