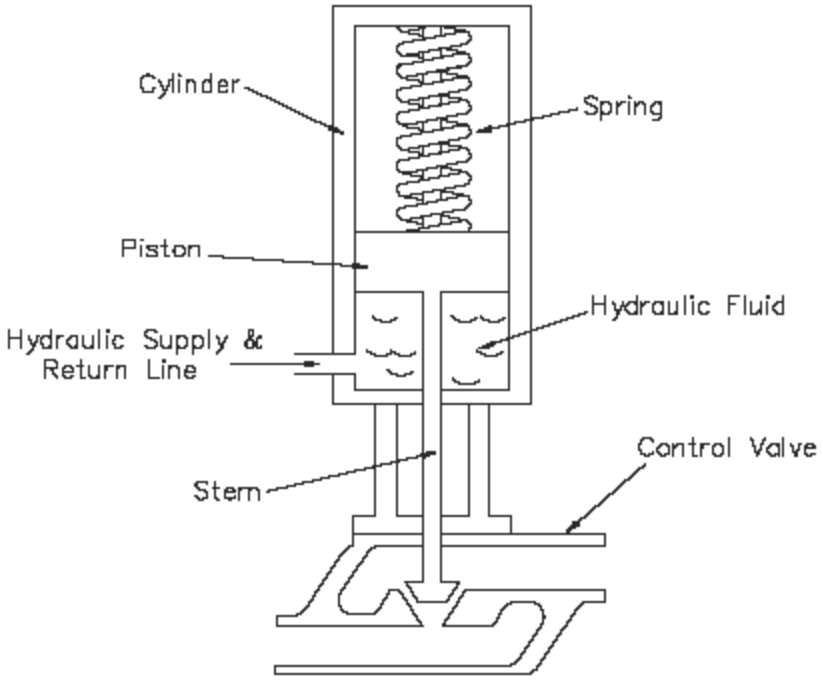
Break Findings

Piston Cylinder Actuators



- Creates 1-directional motion, returning force is generated with a spring.
- To meet both resolution and max travel a large range is needed for pumping mechanism.

Pro's and Con's

Pro's

- Easy to manufacture
- Small footprint
- Can multiply forces or distances easily

Con's

- Tight tolerances required to make a seal

Syringe Pumps

- Uses some type of controlled actuator to precisely move the plunger of a syringe
- Also may be possible to make a Syringe Pump with micrometer screws and servomotor or stepper motor

Syringe Pumps

Pro's

- Easily configured to run with a computer
- Easily meets low flow requirements for high resolution

Con's

- Expensive
- Need one for each axis of motion
- Large footprint

Possible Syringe Pumps

- KD Scientific KDS100Y
- Linear force: 20 lb
- Min step size **0.529 microns**
- http://www.kdscientific.com/products/pumps/kds100Y.asp

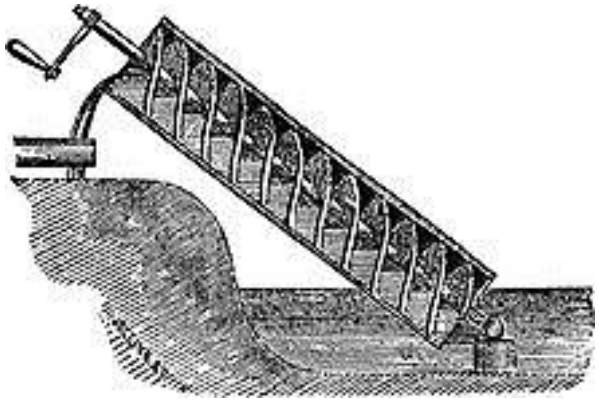
- Chemyx OEM Module
- Linear Force: 30 lb
- Min Step Size: **0.098 microns**
- Fully programmable-USB
- ~$950
- http://www.chemyx.com/products/module_syringe_pump_specs.html

Micrometers

- Using Precisely calibrated screws, a certain amount of rotation corresponds to a certain axial displacement
- Accuracy depends on the preciseness of the screw pitch (machining Tolerances)
- Would need a very precise screw for our minimum resolution or some way to “step down” the displacements (like gears or other forms of mechanical advantage)

Screw Pumps

- Single Screw – Archimedes Screw.



- Multiple Screws

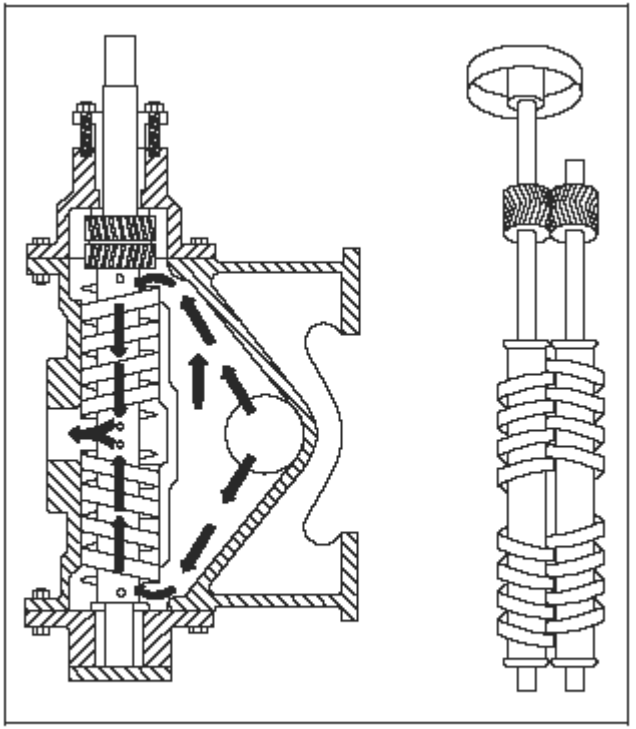


Figure 17 Two-Screw, Low-Pitch, Screw Pump

Pros and Cons

- Usually used for dirty fluids on large scales (sewage)
- One way pumping

- Difficult to Manufacture
- Difficult to achieve precision at very low flow rates
- Lots of parts

LabView Control

Pro's

- Easy Programming

Con's

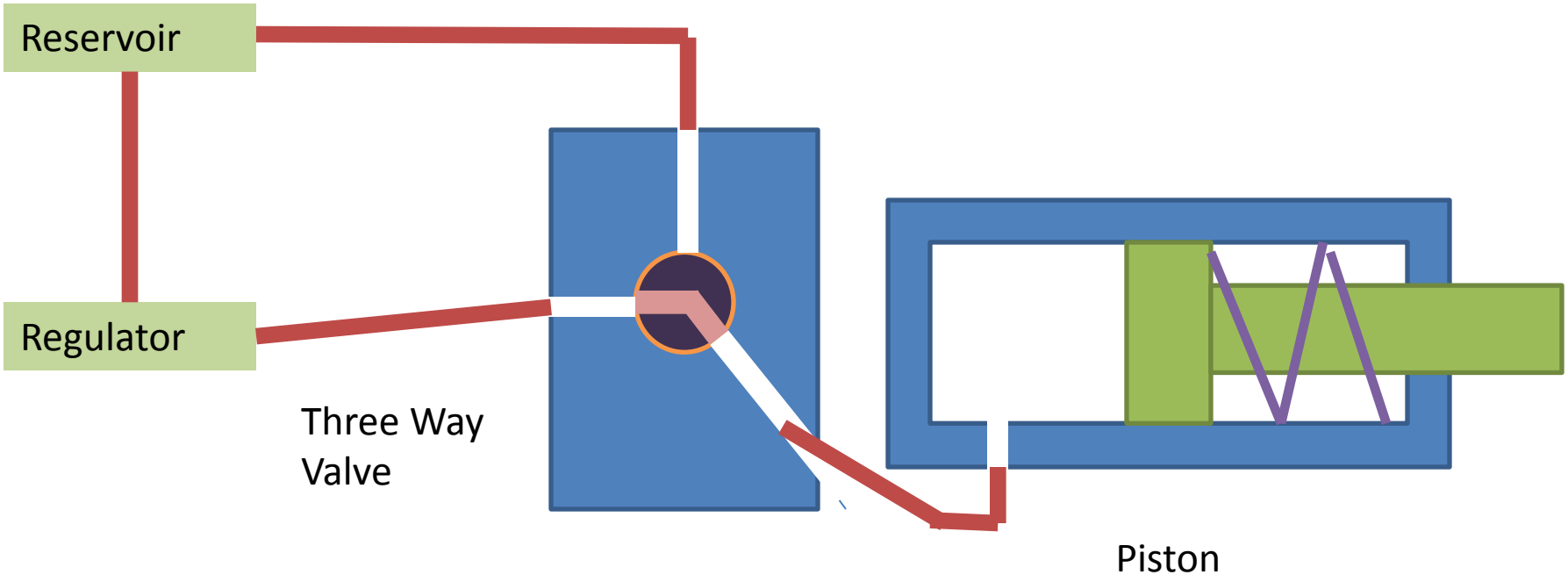
- Expensive software
- Need to use NI instruments
- Non-transferrable software

Pneumatic solutions

Pneumatic System Constituents

- Three main components of pneumatic system
- General safe operating range of 0-150 PSI
  - Regulator
  - Valves
  - Ram/piston
    - Single and double acting ram/pistion

Average Pneumatic Schematic



Key Component is Regulator

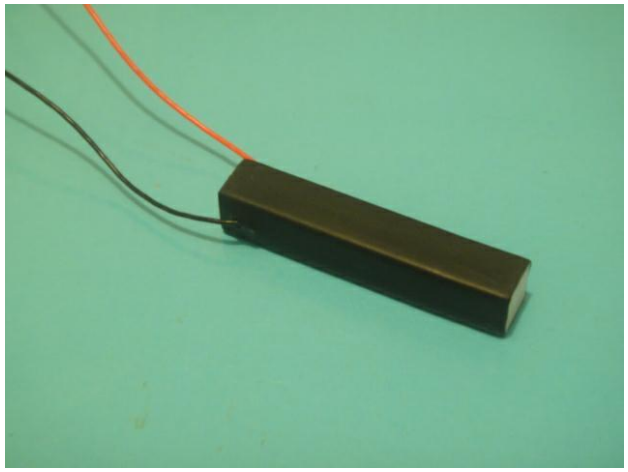
- Different piston positions based off of what pressure is being applied to ram
- How many different pressures can you apply?
  - Fairchild T7800 regulator or similar (700$+) has a accuracy of 0.15% of pressure range or (100/.15) 666 possible steps
    - Regulator controllable by signal of 0-10 V d
  - To achieve 100nm resolution on 1 cm of travel you need (1cm/100nm) 100,000 possible steps

Three Way Valve/Piston

- Three way valve
  - Park U331 or similar (70$)
    - Response time of ~100 milliseconds
    - In order to maintain resolution need control law with position feed back
    - Part only good for air, similar hydraulic part is same price with a 15 ms response time
- Piston
  - Prebuilt ones for less then 100 dollars
  - Would need to respiring to calibration
  - Dual acting piston would be more flexible but schematic would require more parts.

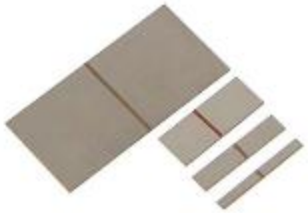
Peizo-Electric Linear Acutuators

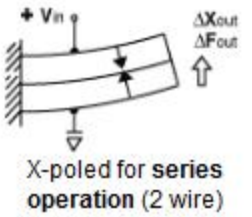
- Commercial available (Steminc SMPAK157742D50 or similar) and reasonably priced devices have a travel of 10-50 um with an accuracy of 1 um
  - Will hear back on the possibility of .1 um devices
  - Require complicated calibration with a device that can calibrate to 100 nm
  - 0-150 volt input



Peizo-Electric Bending Actuators

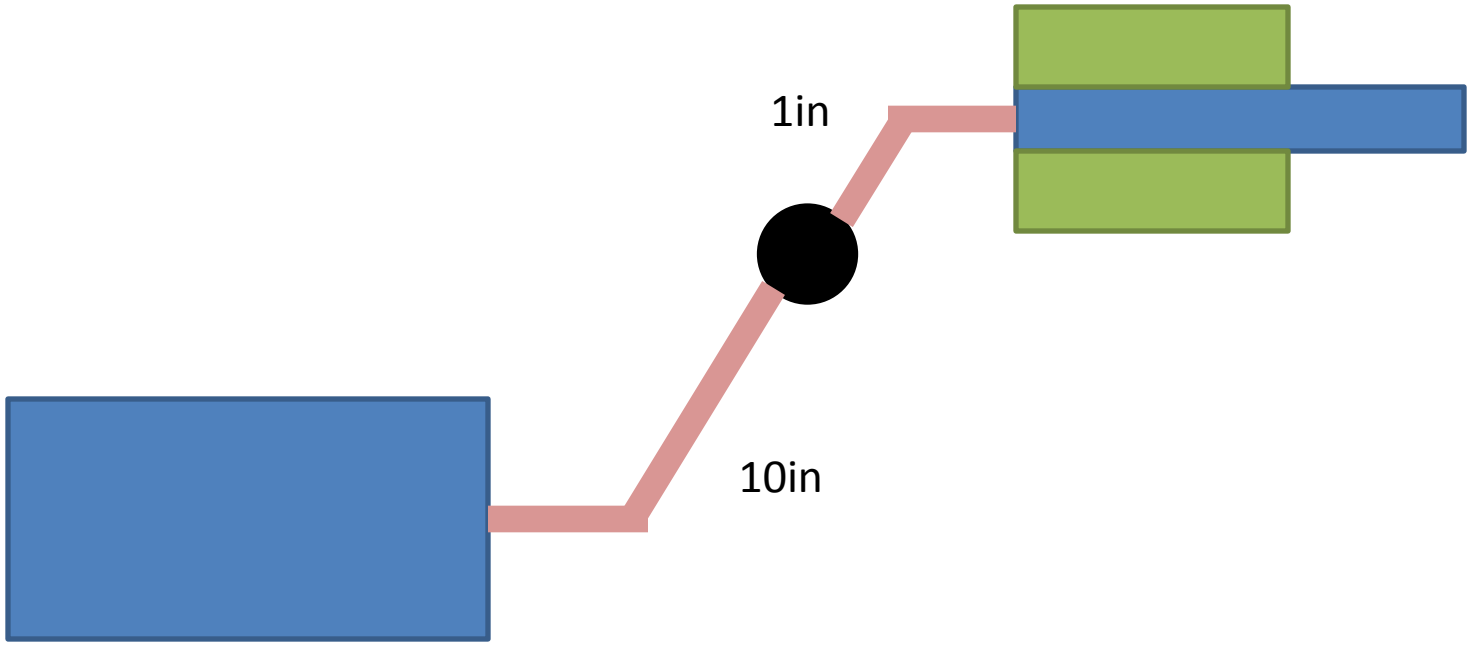
- Fairly cheap (100$ + mounting system for PIEZO SYSTEMS, INC – 330 or similar)
- Can achieve 100 nm resolution when operate in the elastic region (low voltage less then 2 um travel)
- Highly nonlinear (hysteresis and plastic creep)
  - Requires closed loop position control





Levers

- Can give continuous mechanical advantage or disadvantage between driver and actuator
  - Allows a low resolution actuator to achieve higher resolution at piston

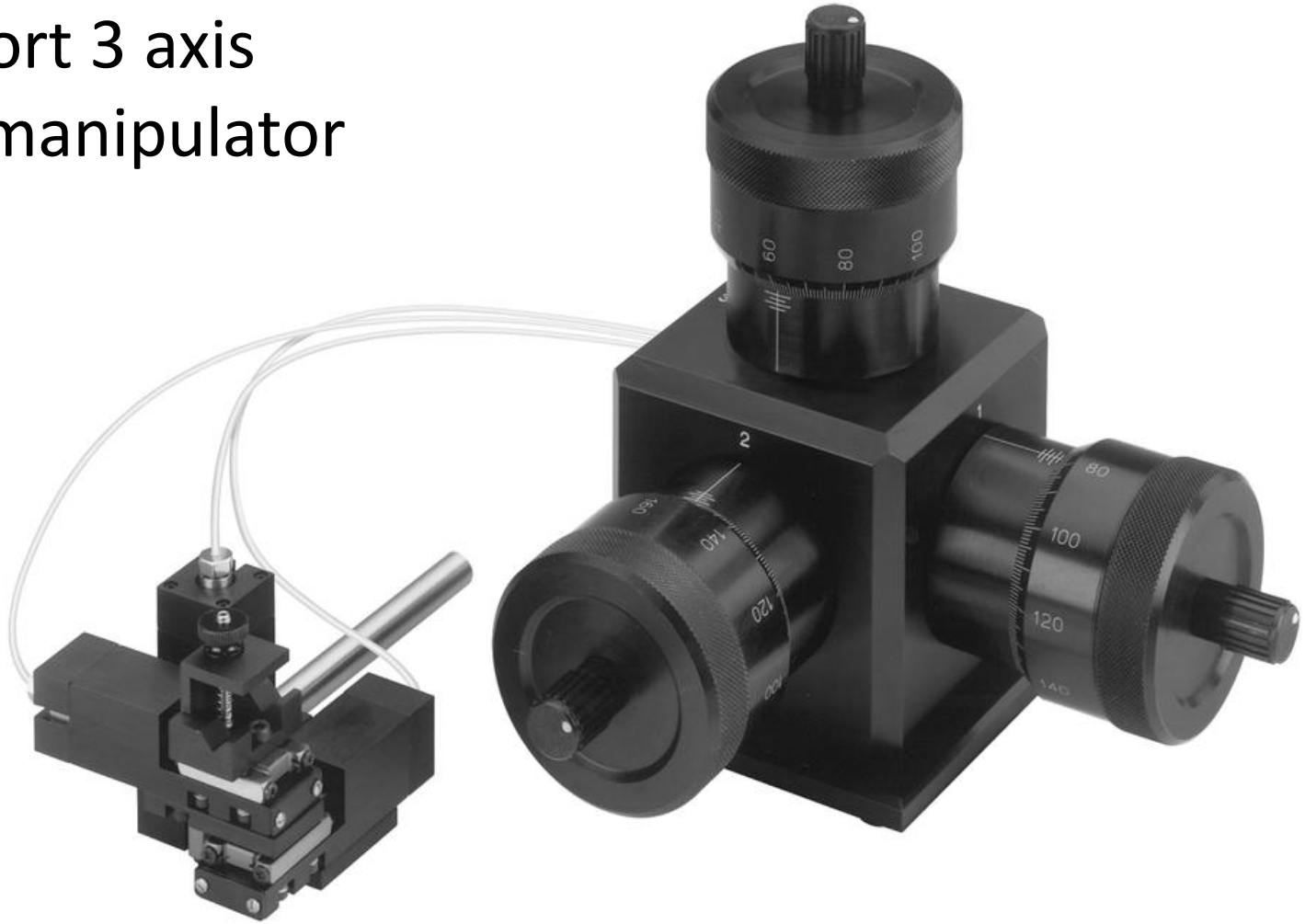


Levers cont.

- Resolution advantage directly proportional to the relative arm lengths
  - Limits the design to about a ~10x increase in resolution (10in to 1 inch arm)
- Big advantage in the fact that it is a direct mechanical linkage
- Biggest concern is the slop in the bearings/connection (much greater then 100nm) must be overcome before movements

Purchasable Maniuplators

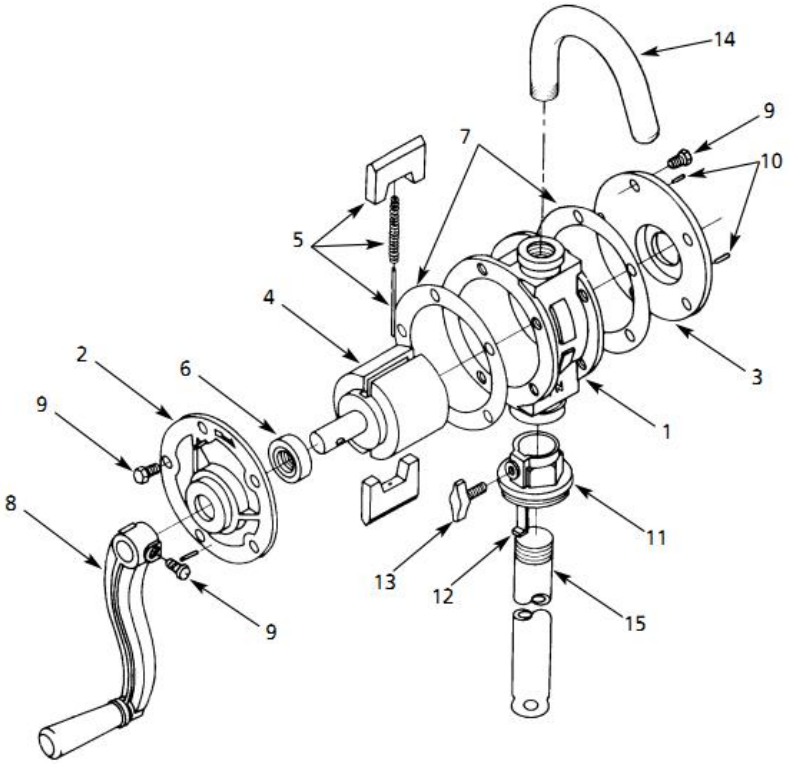
- Newport 3 axis micromanipulator



Newport products

- A proprietary hydraulic mechanism reduces drift to less than 1 micron per hour at constant temperature, while providing enough travel for fine positioning.
- Water, the hydraulic medium, has a thermal expansion 2 to 3 times less than that of an oil-based fluid. The hydraulic mechanism is designed for field-refill if needed.
- Each manipulator axis is guided by crossed roller bearings, ensuring smooth and straight motion.
- The axis is actuated by hydraulic pressure via a low-friction hose connected to a **rotary drum**.

Rotary Drum Pump



- Bi-Directional pump
- Pulls from reservoir on either direction

Control Related Research

Sabine Loebner

Website

PROS

- Provides easy user access
- UI itself is easy to program since javascript, HTML design provides many features for that

CONS

- Cost to host the website ?
- May be difficult to have the web interface and remote joystick input interact with the control of the local workstation

SSH client/server setup

PROS

- Easy to set up
- The user interface input and remote joystick input interacts with the local station directly which is easier to handle

CONS

- Can the local workstation recognize the remote joystick input?

Microcontrollers

- Can use range of voltage to control connected pumps
- selection of controller depends on pump technology used
- cost highly depends on capability required (port connection, wireless capability, CPU, etc)
- Pro:
  - interaction with connected motors (e.g servo) may be easier due to the sending voltage capability
- Cons:
  - remote access options require PC interaction and therefore having an additional microcontroller is redundant computation power
  - once programmed microcontroller works independent from PC

use PC to control

- computation can be done right on the PC's CPU
- may be more simple interaction between UI and device
- issue: how to make PC and device talk to each other?
- possible solutions:
  - open source alternatives with Labview or Matlab capabilities:
    - Octave - Matlab alternative
    - Scilab - capable of system modeling similar to Labview, computational functionality of Matlab
    - QT - UI development tool
  - USB control boards
    - connects to USB and controls motors through voltage
    - MotorBee: controls 2 DC motors bidirectional, price: $50
    - USB-GPIO Interface Adapter, PWM control, $80