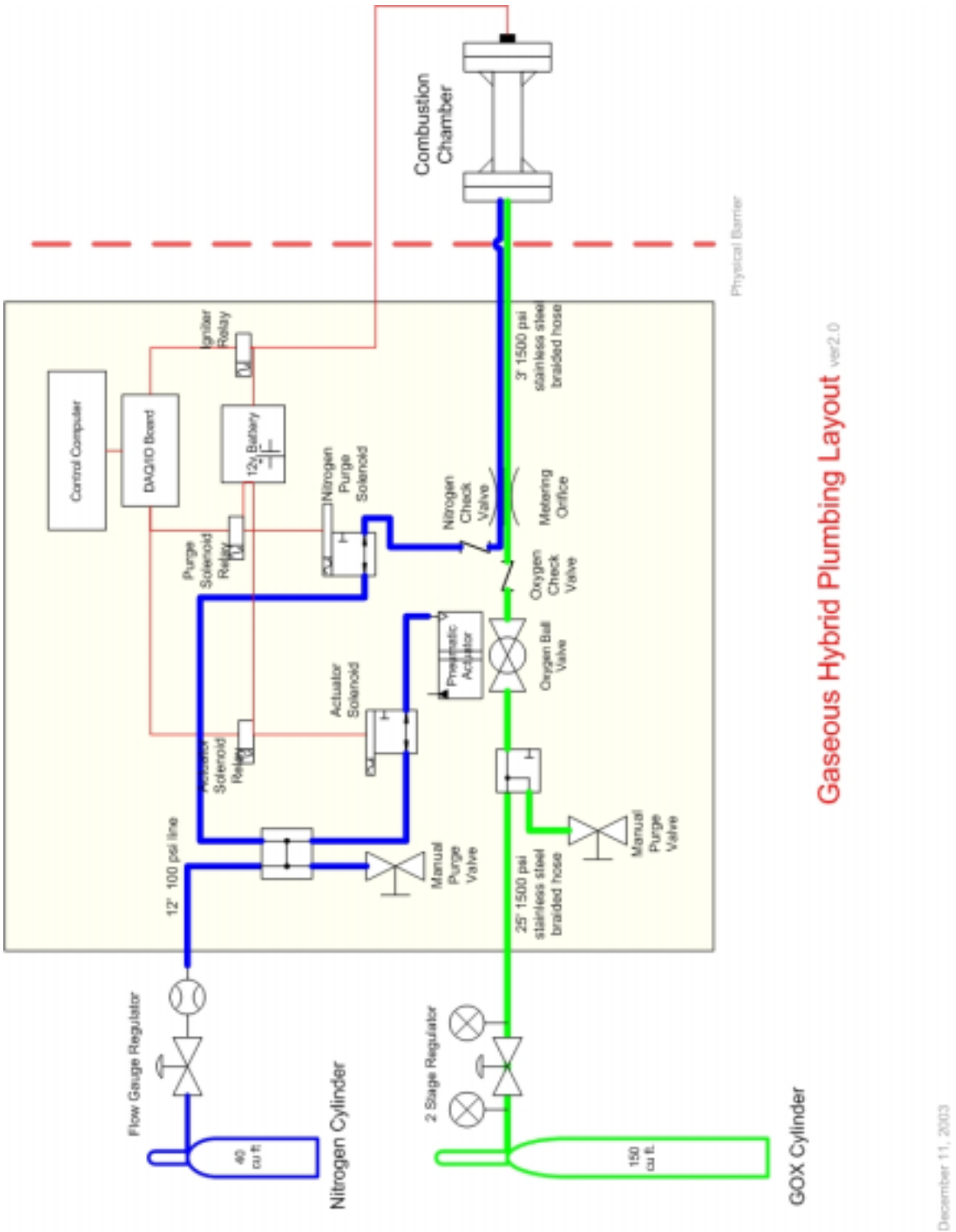
Hybrid Update Dec. 12th, 2003



Theory of Operation:

The gaseous oxygen/paraffin hybrid is fairly simple. The control of the static firing sequence will be done with a laptop computer running a small script that will communicate out a serial port to a 'Flextek' I/O board. This board is capable of data collection through several 10-bit A/D channels and the board is also capable of triggering single events through several TTL level output channels.

At T-1second the control board will signal the igniter to start. This signal will trip a small igniter relay, which will dump a larger voltage and current to the igniter from a 12v battery.

Immediately after igniter start the control board will signal the actuator solenoid relay. The relay will channel power from the 12v battery to the actuator solenoid, the actuator solenoid will in turn switch on the 80psi gaseous nitrogen source to the pneumatic actuator. The pneumatic actuator turns a stainless steel ball valve, which will turn on the gaseous oxygen source to the motor.

The gaseous oxygen flow, once started, will travel from the ball valve through an oxygen check valve that will protect the oxygen plumbing system in the event of an over-pressurization situation in the combustion chamber. Once the oxygen flows through the oxygen check valve it will go through the metering orifice. This is a small flat plate style orifice that will regulate the flow through it to the exact volume needed to react with the paraffin for optimal combustion.

The gaseous oxygen will then be injected into the combustion chamber through a brass injector/diffuser that insures the oxygen will be turbulent and not have a large velocity down the central port of the paraffin fuel grain.

The motor should burn for approximately 10 seconds at 50 lbf of thrust.

The controller will handle burn termination by de-energizing the actuator solenoid. This will cause the pneumatic actuator to lose pressure and therefore close the ball valve.

Once oxygen flow has been halted the controller will signal the purge solenoid relay. The purge solenoid relay will provide power from the 12v battery to the nitrogen purge solenoid, which will open the flow of nitrogen from the source. The nitrogen will then flow through a nitrogen check valve and then into the combustion chamber.

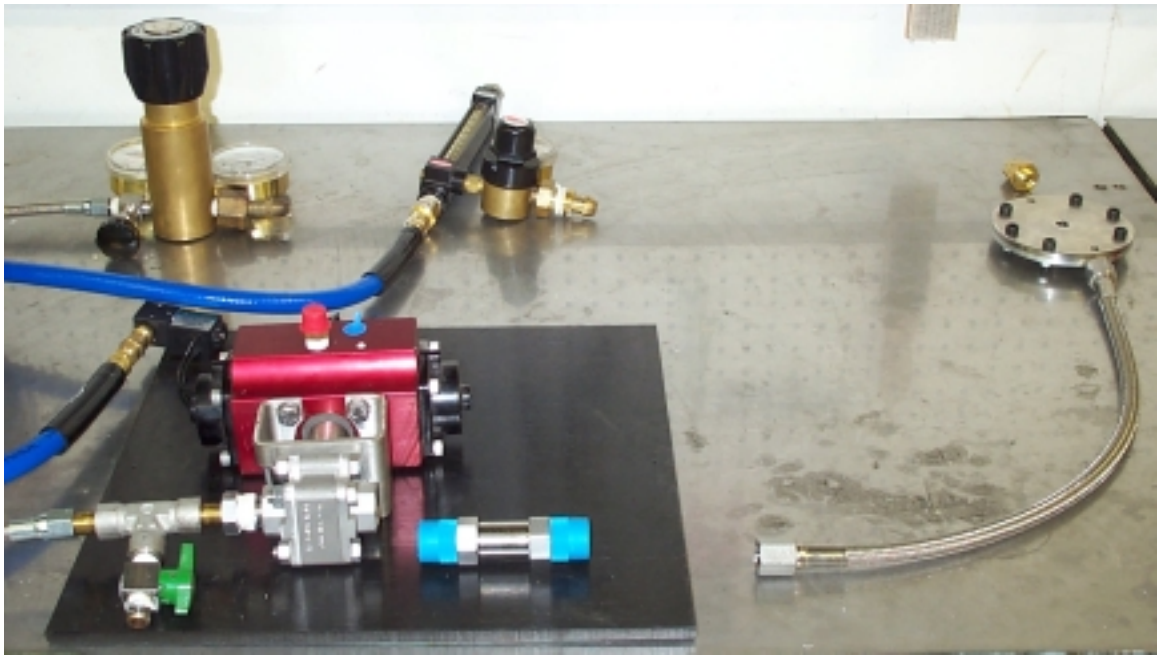
The nitrogen will serve two functions. The first is to extinguish the motor from any residual burning from oxygen still in the system or air coming back into the combustion chamber through the nozzle. Second is to cool the graphite nozzle after firing to hopefully reduce the possible effects of stored heat in the graphite further melting the

remaining paraffin in the combustion chamber. We would like to keep the paraffin undamaged after firing so we can do a post-mortem analysis to look at the regression. Once the system has finished firing and purging and is deemed safe the excess pressurized oxygen and nitrogen stored in the 12' and 25' feed lines can be discharged thorough the manual purge valves.

Once the system has cooled. We can remove the forward nozzle-retaining flange and remove the spent fuel and nozzle and replace it with a new nozzle and fuel grain and refire.

Component Details:

Name	Description	Data
Laptop computer	Toshiba Portege 660CDT (P166Mhz)	
I/O board	FC1F010 FlexController	http://www.flex-tek.com/FTman10.pdf
Igniter relay	? still looking	
12v battery	Elk sealed lead-acid 12v 8.0Ah	
Actuator solenoid relay	? still looking	
Actuator solenoid	Spartan Scientific 12vdc 3823 series	http://www.spartanscientific.com/file_management/3800.pdf
Nitrogen source	40 cu.ft. nitrogen tank	
Pneumatic actuator	PAS-180	http://www.contromatics.com/ACTUATOR/F-PA/FPA.HTM
Oxygen source	150 cu.ft. Oxygen tank	
Oxygen check valve	Swagelok SS-8C-VCR-1	http://www.swagelok.com/downloads/webcatalogs/MS-01-176.PDF
Metering orifice	?Evan has details	
Injector/Diffuser	Brass fitting with diffuser holes drilled @45 deg.	
Purge solenoid relay	? still looking	
Nitrogen purge solenoid	Predyne 12vdc solenoid with ¼" NPT fittings	http://www.predyne.com/series/d.asp
Nitrogen check valve	Swagelok SS-8C-VCR-1	http://www.swagelok.com/downloads/webcatalogs/MS-01-176.PDF
Manual purge valves	Nupro SS-4P4T2	http://www.swagelok.com/downloads/webcatalogs/MS-01-59.pdf
Oxygen Regulator	Tescom Model #44-1116-24	http://www.tescom.com/images/pdf/catalog/icd/44-1100s.pdf
Nitrogen Regulator	Smith H1103B Flowmeter	



Assembled plumbing as of Dec.12th, 2003

Still several things that need to be done before Dec. 31st target test fire date.

1. Awaiting arrival of Nitrogen purge solenoid.
2. Awaiting Arrival o Nitrogen check valve.
3. Need another Nupro SS-4P4T2 valve and stainless T-junction (Tim??? You got the last one, can you get another?)
4. Figure out leak situation in Tescom regulator
5. Integrate metering orifice in with the rest of plumbing. (Evan?)
6. Attach oxygen braided feed hose to injector/diffuser
7. Bolt and Weld analysis (Peter)
8. Machine 3 nozzles of different sizes
9. Pour at least 3 paraffin grains
10. Cut and install pre-ignition solid propellant boosters. (I have the solid propellant stock in my possession)
11. Spec. out and acquire low-voltage relays.
12. Hook together all this damn plumbing.
13. Build a test stand.
14. Integrate all the electronics and hardware.
15. Find a test fire location