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Characterization and Failure Analysis of Ceramic Filters Utilized for Emission Control During Coal Gasification

Quarterly Report
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The research activities performed at PV A&M University in the third quarter of 1997 are summarized below.

- PV A&MU had performed mechanical and back pulse testing to characterize the performance of the filter and is using the process of elimination to perform the failure analysis for filters.

- The mechanical testing performed on the filters are categoried as follows:
  1) The acceleration testing
  2) The vibration testing
  3) The air jet impulse testing
  4) The impact testing

One piece of 1.0 meter long, IF&P filter was installed within a filter test chamber with the neck clamped on a metallic fixture bolted onto filter test chamber. The filter passed all of the 4 types of mechanical testing without cracking. Details of the test environments and test results are under calculation. It appears that the filter is characterized with appropriate mechanical strength and toughness to survive the mechanical and flow induced forces during the filtration processes.

- A layer of particulate was noticed depositing onto the top sealing area of the filter test chamber throughout the back pulse cleaning test cycles. There appears to be a dead area that the particulate can hardly be removed once it had been trapped in the stgnant spots. This phenomena will be further studied to gain more insights into the dust deposition aspect in the field testing filter chambers.

- PV A&MU researchers started to perform back pulse cleaning test to clean particulates accumulated on IF&P filters to gain insight into the pulse cleaning mechanism. Based on the prelimunary back pulse test data, it indicates that a parametric study on back pulse cleaning testing is indispensable to understand the issues regarding filter permeability variations, ash bridging and micro-thermal cracks induced during cold back pulse cleaning. The test data of the parametric study will help large scale filter system plenum configuration design, the gas flow pressure field control within the filter chamber, and the optimization for filter cluster design.

- The parametric study on particulate removal mechanism to be continued at PV A&MU will be concentrated on the following parameters: 1) the size distribution of particulate vs the ease of its removal, 2) the threshhold strength of the back pulse for effective cleaning, 3) pulse duration effect on dust cleaning, 4) the frequency of pulse cleaning needed vs the pressure differential between the inside and outside of the filter, 5) the size and the geometric configuration of the back pulse injection lance and 6) the position of the back pulse lance relative to the entrance of the filter.

- To optimize particulate removal filter system, PV A&MU had prepared devices and facility including the following items: (a) an innovative test setup design, (b) a dust loading device, (c) particulate size screening, (d) a back pulse cleaning system, (e) an automatic data acquisition system, (f) fast response, micro-machined pressure sensor cells, and (h) theoretical CFD analysis.

- The control of particulate size distribution will help identify the desirable particulate size to be favorablely removed. The optimized particle size distribution could be used to control that of the disposable sorbent samples to enhance particulate agglomerate into size to be favorably removed during back pulse cleaning cycle. PV A&MU has ordered metallic oxides from IF&P company. The oxides size ranges between 40 to 120 micron. This size effect test during filtration test will help future commercial disposable metallic oxides size control.

- The back pulse cleaning system had been built to provide controllable pulse strength with to indentify the threshhold pulse strength required for particulate removal for the corresponding back pulse system design. The test data will support CFD calculations to provide an adequate correlation between gas flow field and gas plenum designs.

- The major work completed in Q3, 1997 for filter back pulse cleaning testing included the following items:

1) the completion of the test system
2) the procurement of particulate sample
3) the development of a data acquisition system
4) the filtration pressure field monitoring with the use of micro-fast pressure sensor assembly
5) the design of a back pulse system
6) completed a back pulse cleaning test plan
7) started performing parametric testing on particulate removal

USER'S MANUAL

FOR

AUTOMATIC TESTING

ON INSTRUMENTATION INTERFACING

PREPARED

BY

MECHANICAL ENGINEERING

PV A&M UNIVERSITY

Table of Contents

Section 1 - General Information

The automatic testing requires the integration of high quality instrumentations, meters, a microprocessor controlled pressure controller and temperature chamber, a set of sophisticated data acquisition system, advanced software package and well experienced testing technology.

The key element of this automatic testing system is the interfacing of one personal computer with a variety of testing equipment to calibrate, test sensors installed on the system and perform automatic testing as planned.

The testing system can be expanded with minimum cost by pre-selected communication arrangement, GPIB-488 and RS-485, to integrate the current setup to a more versatile system. RS-485, instead of RS-232, is utilized to make multi-instrument control easier in the future.

Section 2 - Installation

The automatic test system had been completely installed at mechanical engineering at PV A&M University. Maintenance on the equipment and parts shall conform to the manuals of each equipment and parts utilized.

Section 3 - Programming

3.1 General description of instrumentation interfacing and test programming

The programming of the testing system is built on LabVIEW software structure, procured from National Instruments. LabVIEW programs are called virtual instruments (VIs). VIs have three main parts: the front panel, the block diagram, and the icon/connector. LabVIEW programming can be developed with the use of the graphical programming language G. The block diagram is the source code of the programming. The hierarchical nature of LabVIEW VI makes application programming easy to control and flexible for future modification.

The main test program is developed with the aid of using subvis programmed with lower layers of subvis. All of the vis had been installed in the PC (personal computers).

3.2 Detail description of the testing programming

The first sample test program is a vi named as "CALBTEST" for pressure sensor calibration prior to installation on the testing system. CALBTEST is a five point pressure testing program performed at 25.0, 0.0, 70.0, 0.0 and 25 degree C. There are four groups of "five point pressure testing and data acquisition" performed for each individual temperature level. Each temperature is first preset at the beginning of each test subgroup. The procedures of the adjustment required for each temperature profile and its duration for parts soaking in the temperature chamber are well defined in each temperature vis. The procedures for pressure level adjustment are also described on different pressure vis. Parameters and procedures for the data acquisition vis are also well defined in its corresponding vis.

The most difficult part of work for the integration of the system is the design layout and the communication interface between LabVIEW and each equipment. The temperature chamber interfacing with LabVIEW is via RS-485 control, this programming can provide multi-chamber connection under the control of a single PC in the future. All the other equipment is interfaced with LabVIEW via GPIB 488 to maximize the flexibility and enhance the communication speed. Based on PV A&MU trouble shooting experience on instrumentation interfacing, the speed matching on commands communication between PC and equipment needs to be adjusted by providing proper waiting time during the command sending cycles to let each instrument to respond; otherwise error messages could be developed even with proper programming.

The supporting vis for CALBTEST include temperature, datascan, DAQ basic, and pressure controller vis. All the subvis and the vis and LabVIEW functions related to the programming are attached in the Appendix for reference.

Section 4 - Operation of sample program testing

The hardware interfacing testing was successful and complete. National Instruments SCXI assembly and its DAQ system is capable to acquire and output the test data to EXCEL spread sheet to make data analysis easy to perform.

Automatic testing programming can be implemented based on the sample examples cited above. The data acquisition of pressure sensors outputs will help visualize the pressure field and flow profile of the flow under testing. Automatic testing for different systems will be developed at PV A&MU in the near future.

APPENDIX

Documentation of Sample Test Program

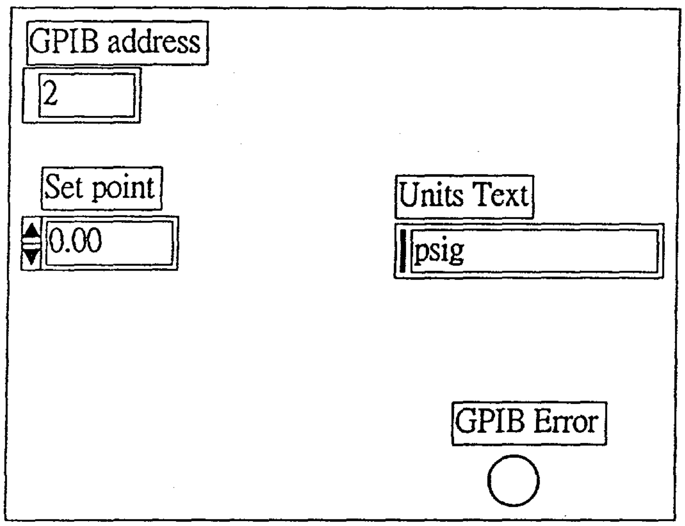
Connector Pane

C:\LABVIEW40\GPIBlopress.vi

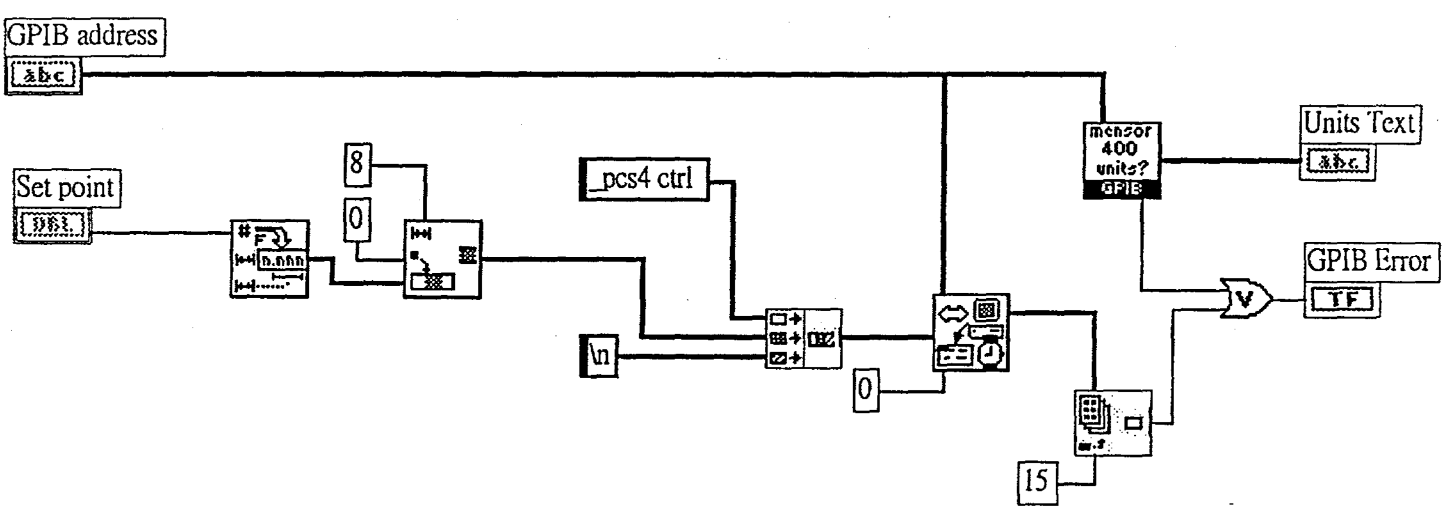
Use this VI to change the control setpoint of the PCS 400

MENSOR CORPORATION
PCS 400
Version 1.00
12/09/94

Front Panel



Block Diagram

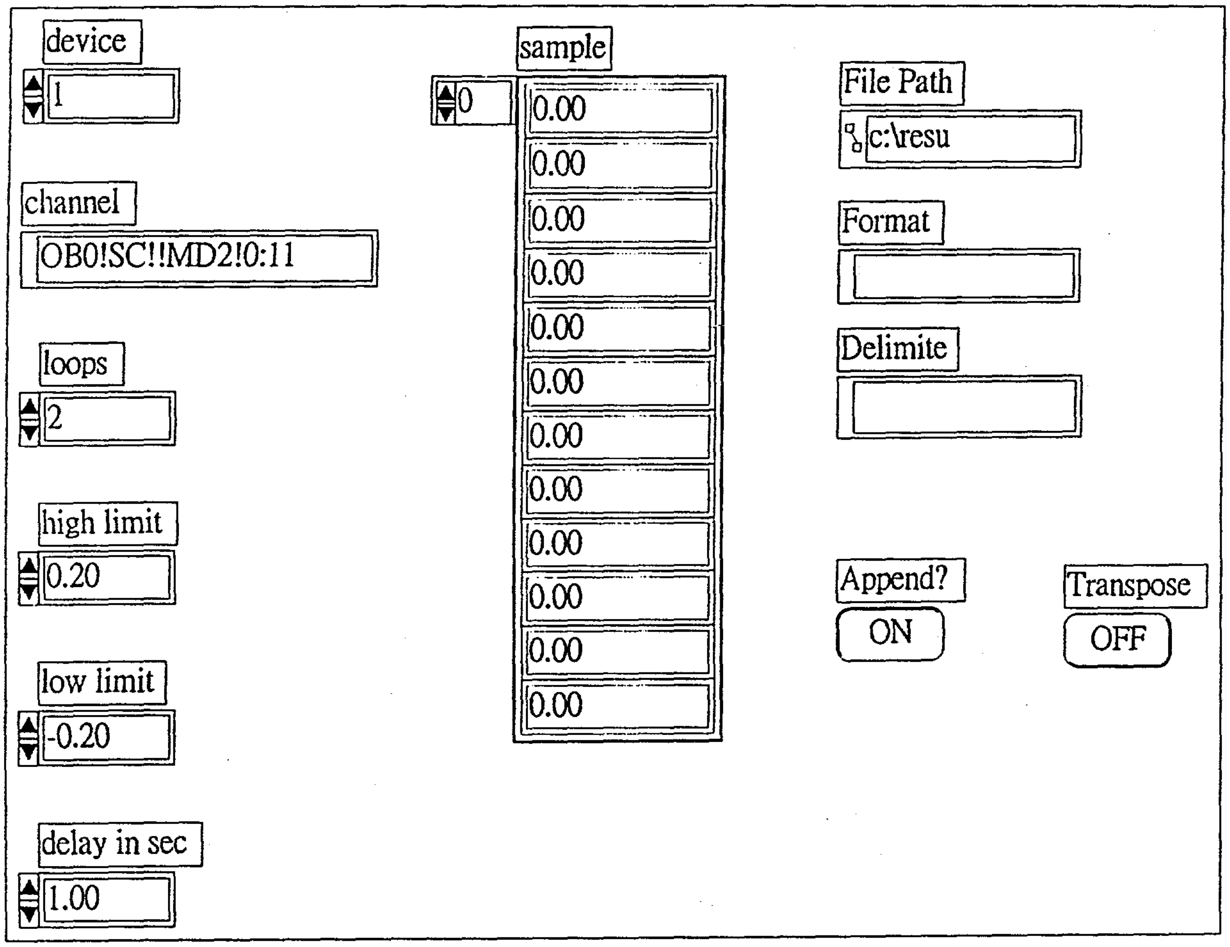


Connector Pane

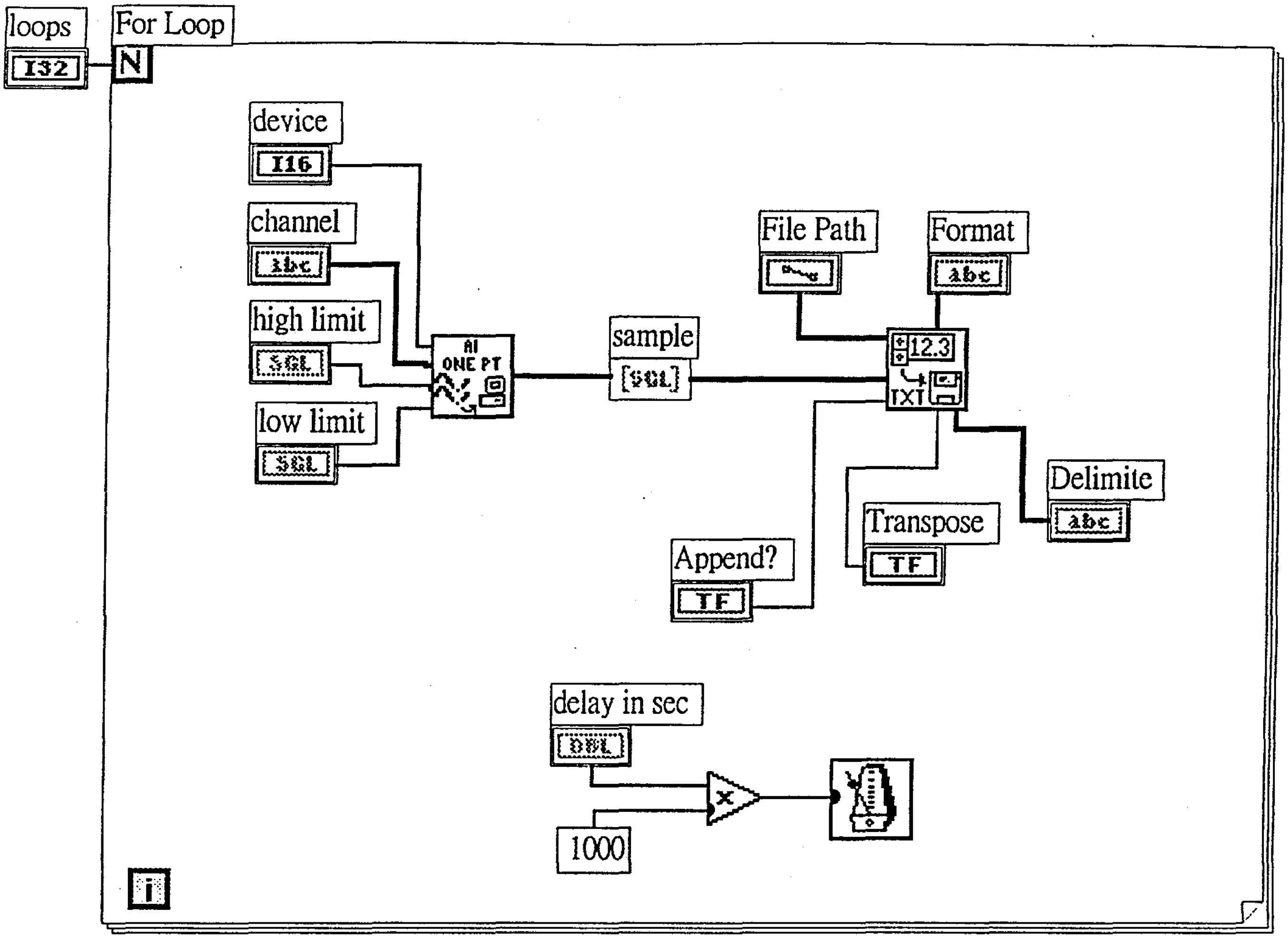
DAQ basic

C:\LABVIEW40\DAQbasic1.vi

Front Panel



Block Diagram



Connector Pane

TEMP
room

C:\LABVIEW40\temproom1.vi

Front Panel

No of total commands

6

NOTE: The number of total commands must be equal to the number of the command strings you programmed. The command string is fed into temp chamber control in series, one string each loop.

Delay time sec

1.00

NOTE: You have to slow down the input speed of each command string, otherwise the controller is not fast enough to accept your instructions; and error message will display.

Command string list

0

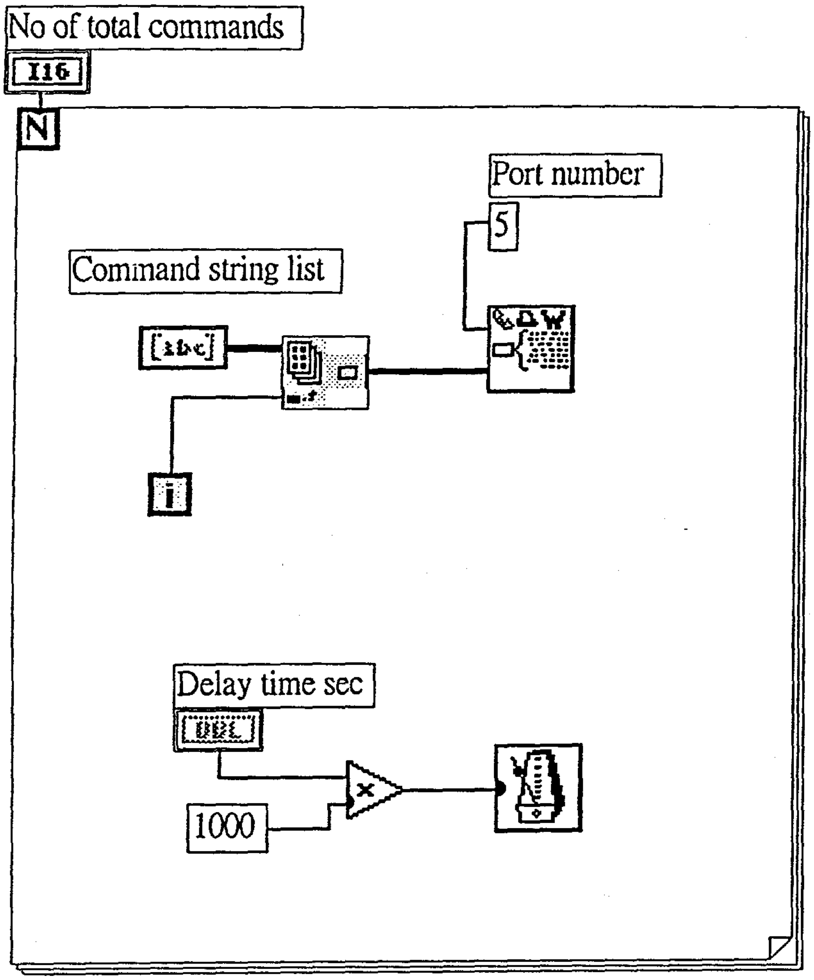
- #\01S\r\n
- #\01LPM1,3,V\r\n
- #\01LPI0,25\r\n
- #\01LPI1,25,,,0,5\r\n
- #\01LPI2,25,,,0,20\r\n
- #\01LPI\01\n

NOTE: The communication between LabVIEW vi to The temperature controller is via RS-485 serial port. The port number assigned for this system is port number 5.

- Programming Instructions -

#\01 is the prefix of each command string. 01 is the channel number one, which is for the chamber temperature control; 02 is for humidity control which is not available in this chamber design. At the end of each command string, use \r\n to terminate the command string. At the end of the last command string, use \n to terminate the string. To ensure adequate temperature profile control, the first command instruction string "S" (upper case) is served to terminate previous temperature profile to allow a new temperature profile input according to the command strings followed. The last string is to instruct the controller to "RUN" the above command instruction strings. LPI is the programming instruction, and the sequence of each string is numbered from 0,1,2,3, etc as required. LPM1,3,V instructs the controller that there are up to 3 command strings, with value instructions. LPI0,25 set the initial temperature to 25 degree. LPI2,25,,,0,20 sets the holding time period of 25 degree C to 0 hour 20 minutes. If you need 1 hr and 30 minutes holding time, change instruction to LPI2,,,1,30. Adjust each temperature holding time as required to saturate parts in the temperature chamber. Please check the programming manual for details, this is a programming demo.

Block Diagram



Connector Pane

CALB TEST

C:\LABVIEW40\CALBTEST.vi

Front Panel

Time waited prior to room temp testing.

0

Time waited prior to cold temp testing.

0

Time waited prior to hot temp testing.

0

Time waited prior to room temp testing.

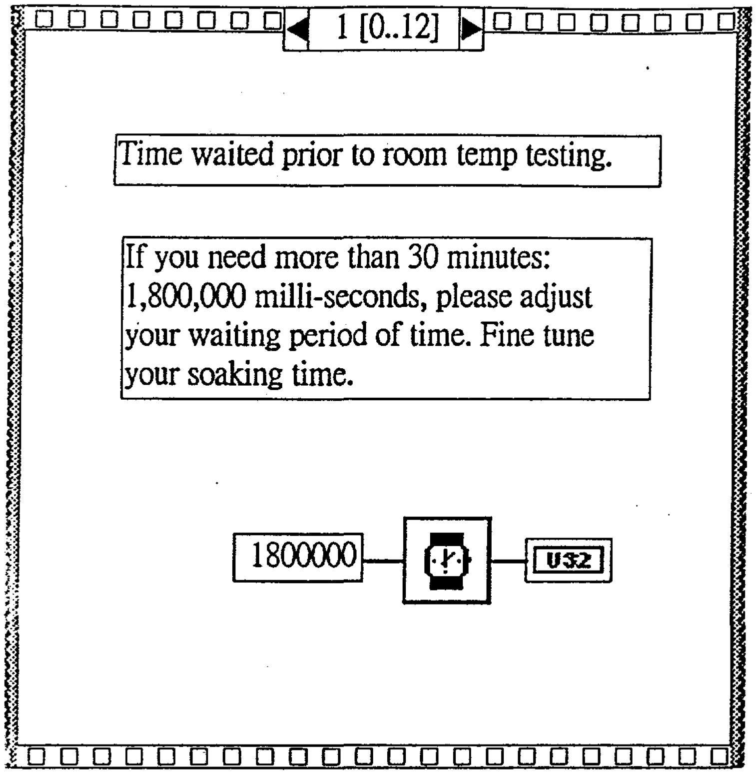
0

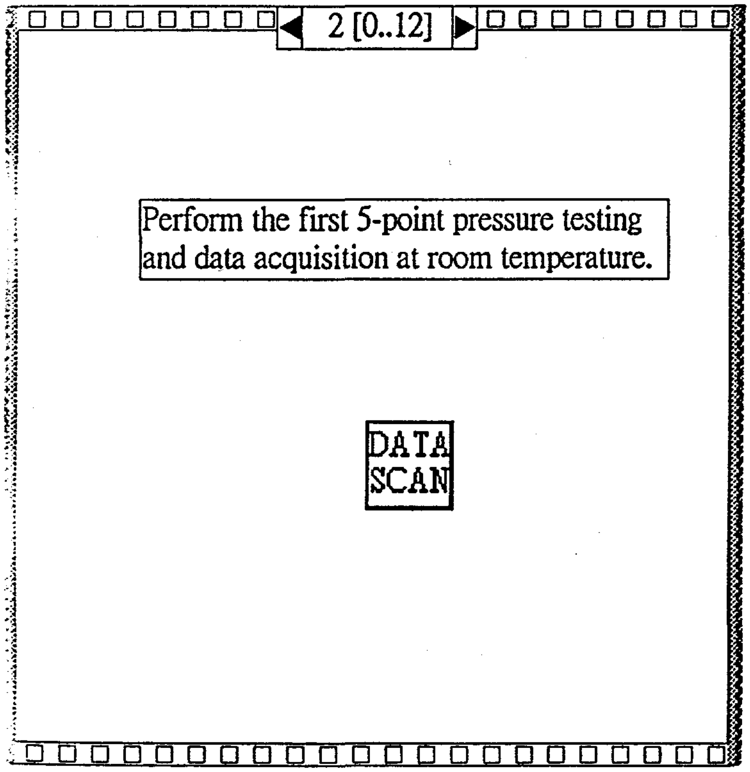
Block Diagram

0 [0..12]

Setup the temperature profile at room temperature first, if room temperature is different from 25 degree C. Change the command strings in your "Temproom.vi" to proper temperature. Adjust the holding period of time for the room temperature to stabilize all the parts in temperature chamber before performing data acquisition with the use of datascan.vi. Roughly 30 minutes soaking time is good enough for room ambient temperature test starting at room ambient environment. You will need about 60-90 minutes to stabilize the temperature other than room ambient temperature.

TEMP room


1 [0..12]
Time waited prior to room temp testing.
If you need more than 30 minutes: 1,800,000 milli-seconds, please adjust your waiting period of time. Fine tune your soaking time.
1800000
U32


2 [0..12]
Perform the first 5-point pressure testing and data acquisition at room temperature.
DATA SCAN

3 [0..12]

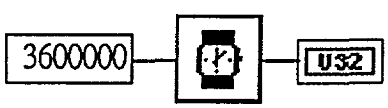
Set the cold temperature at 0 degree C. Please adjust the command strings accordingly if your cold temperature is different than 0 degree C and/or the holding time period is less than 75 minutes. Fine tune the soaking time you need.

TEMP COLD

4 [0..12]

Time waited prior to cold temp testing.

The soaking period of time for cold temperature at 0 degree C is 60 minutes. If you need more soaking time, please adjust accordingly.



5 [0..12]

Perform the second 5-point pressure testing and data acquisition at cold temperature.

DATA SCAN

6 [0..12]

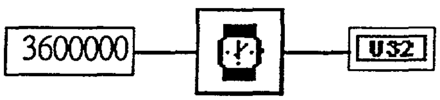
Set the hot temperature at 70 degree C. If your hot temperature is different and/or your temperature holding period time is less than 75 minutes, please adjust your command strings in Temphot.vi accordingly. Fine tune your soaking time.

TEMP HOT

7 [0..12]

Time waited prior to hot temp testing.

The soaking time is 60 minutes, if you need more soaking time and/or your hot temperature is different than 70 degree C, please adjust the Temphot.vi accordingly. Fine tune your soaking time.



8 [0..12]

Peform the 3rd 5-point pressure testing and data acquisition at hot temperature.

9 [0..12]

Set the temperature back to room temperature, 25 degree C. If your room temperature is different than 25 degree C and/or the holding time is less than 75 minutes, please adjust the Temproom.vi accordingly.

TEMP room

10 [0..12]

Time waited prior to room temp testing.

The soaking time from hot temperature back to room temperature is 60 minutes. If you need more soaking time, please adjust accordingly. Fine tune your soaking time.

3600000 — U32

11 [0..12]

Perform the last 5-point pressure testing and data acquisition at room temperature.

DATA SCAN

12 [0..12]

To ensure safety, the pressure controller is set at "VENT" mode to release pressure after the 5-point testing is complete.

MODE setup GPIB

Connector Pane

DATA SCAN

C:\LABVIEW40\Datascan.vi

Front Panel

Time req'd to stabilize lopress (2sec) upward

0.00

Time req'd to stabilize middle pressure (2 sec) upward

0.00

Time req'd to stabilize high pressure (2 sec) peak point

0.00

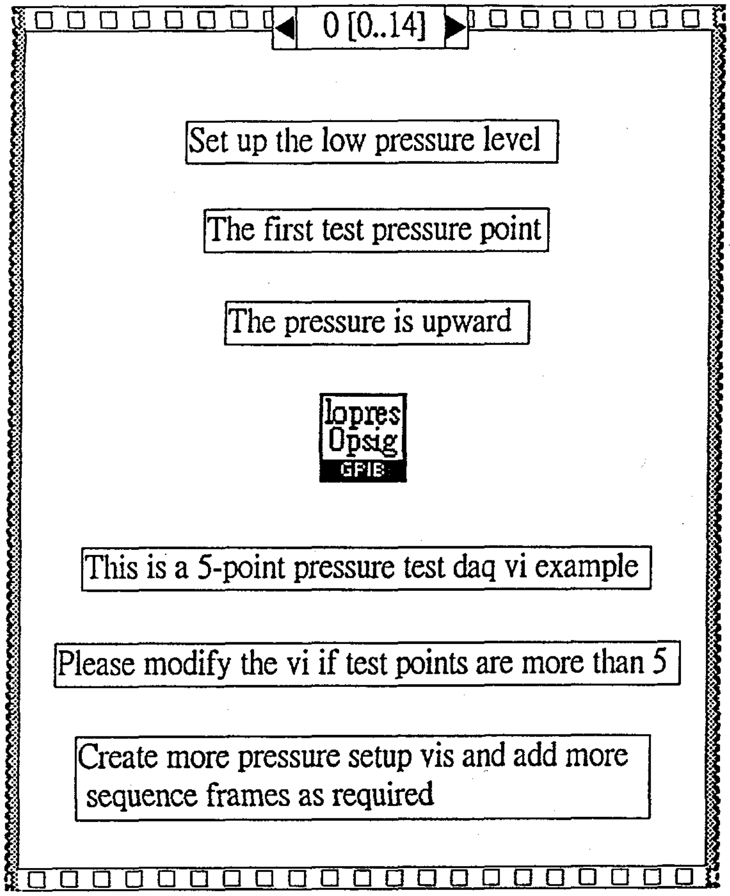
Time req'd to stabilize middle press (2 sec) downward

0.00

Time req'd to stabilize lopress (2sec) downward

0.00

Block Diagram

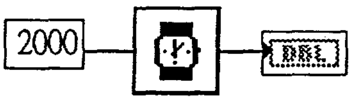


1 [0..14]

Time needed shall be adjusted as required

Time req'd to stabilize lopress (2sec) upward

This is an example to set waiting time = 2 sec



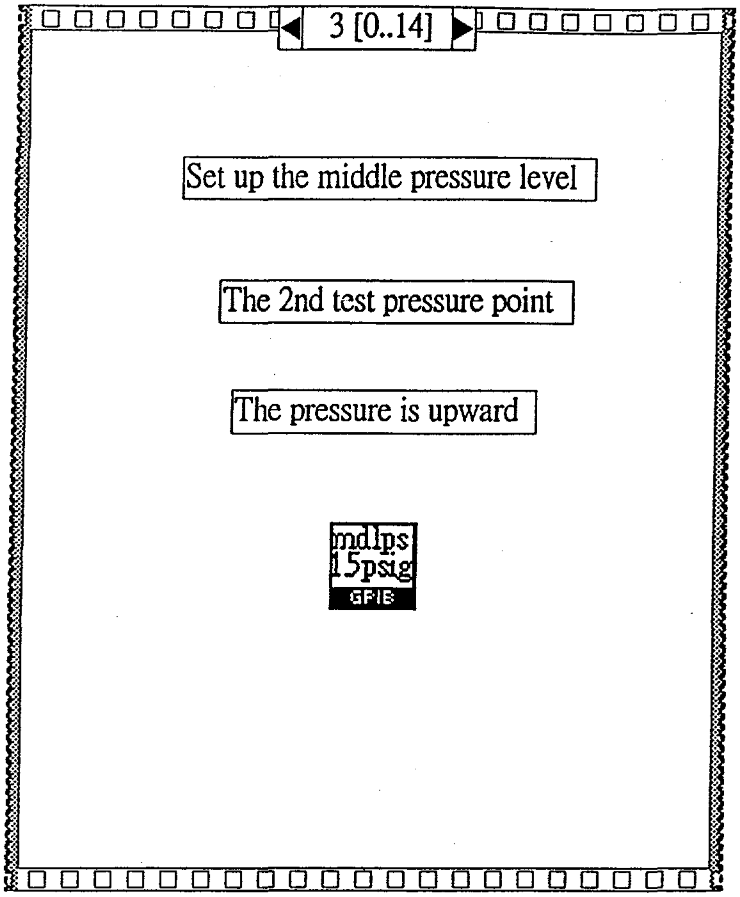
All setup time req'd in this vi is 2 sec for demo only

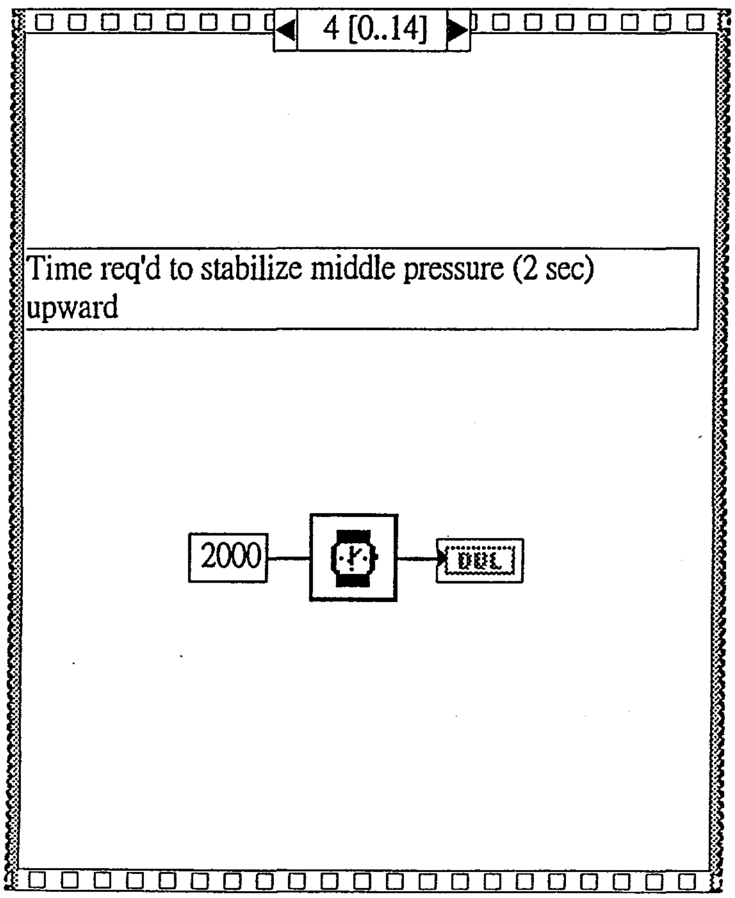
2 [0..14]

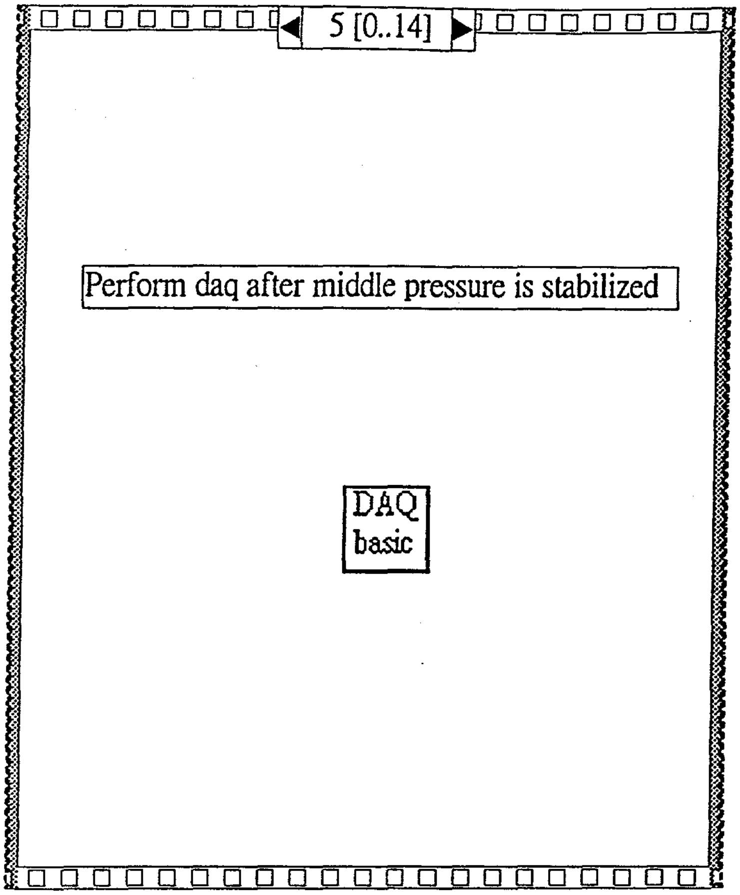
Perform daq after low pressure is stabilized

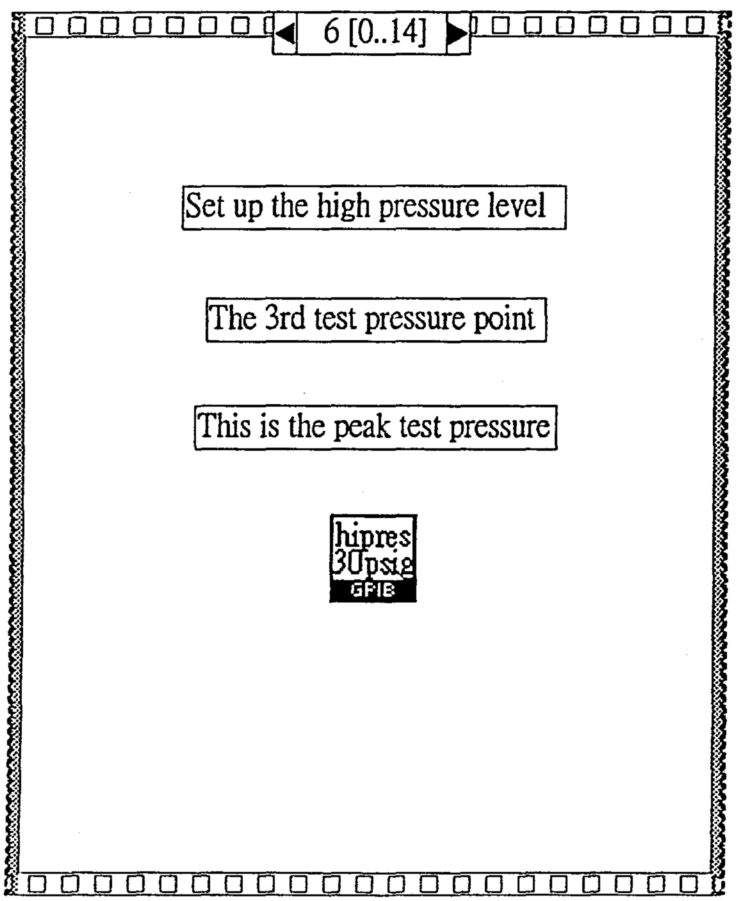
DAQ basic

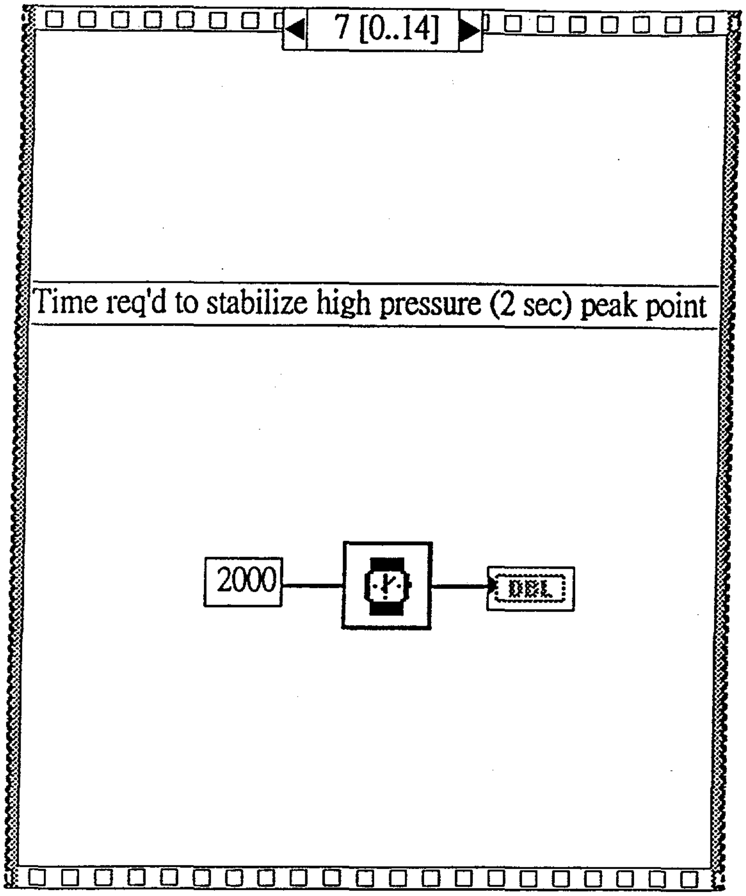
Make sure the channel no. matches the setup no.

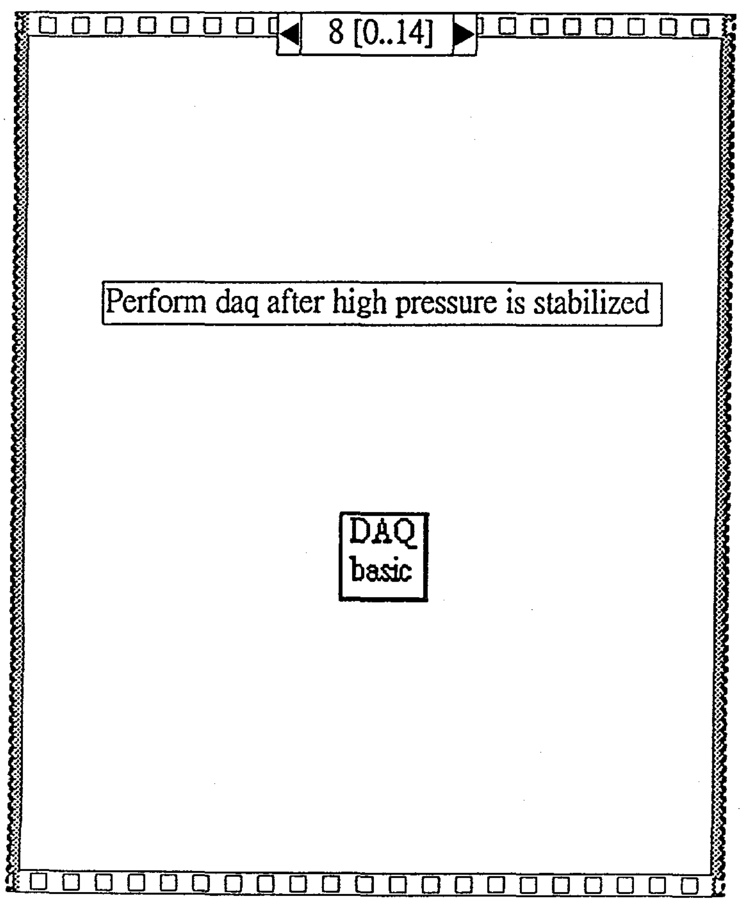

3 [0..14]
Set up the middle pressure level
The 2nd test pressure point
The pressure is upward
mdlps
15psig
GPIB

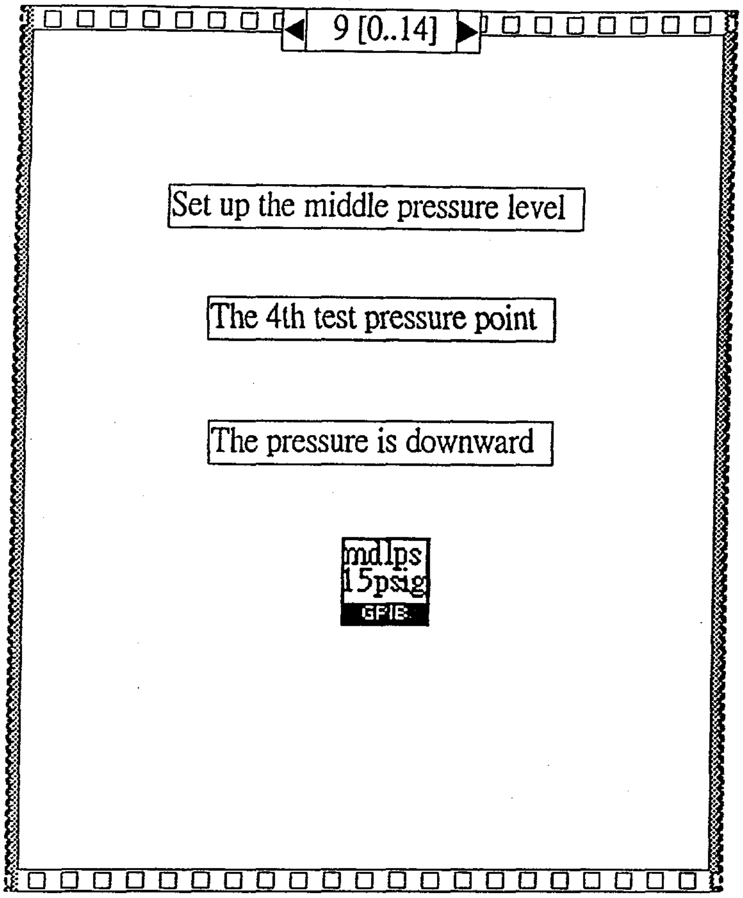

4 [0..14]
Time req'd to stabilize middle pressure (2 sec) upward
2000
DBL

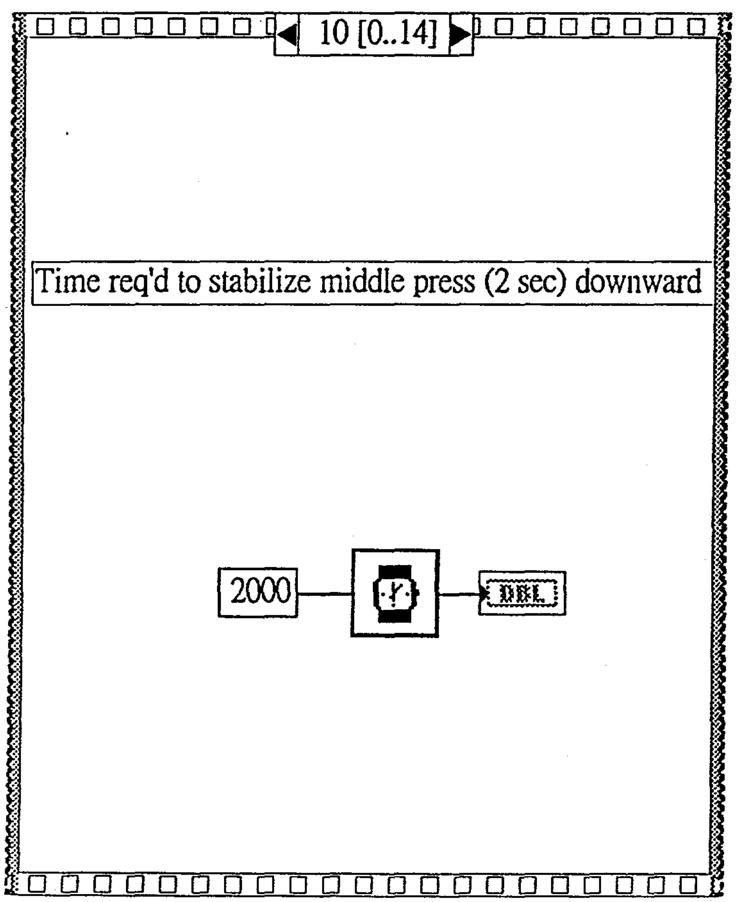

5 [0..14]
Perform daq after middle pressure is stabilized
DAQ
basic

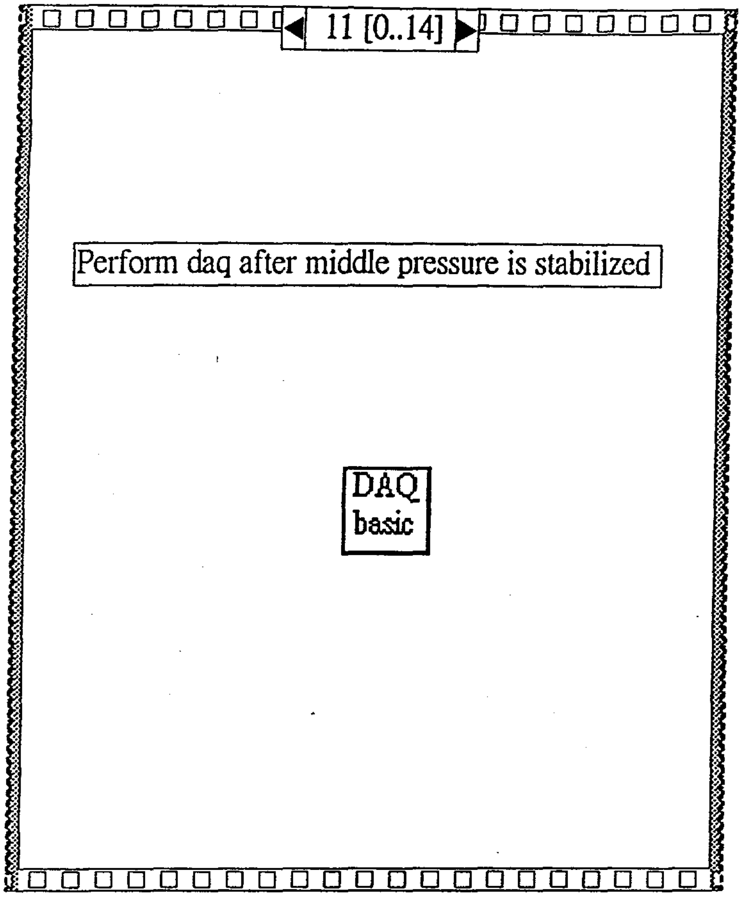

6 [0..14]
Set up the high pressure level
The 3rd test pressure point
This is the peak test pressure
hipres
30psig
GPIB

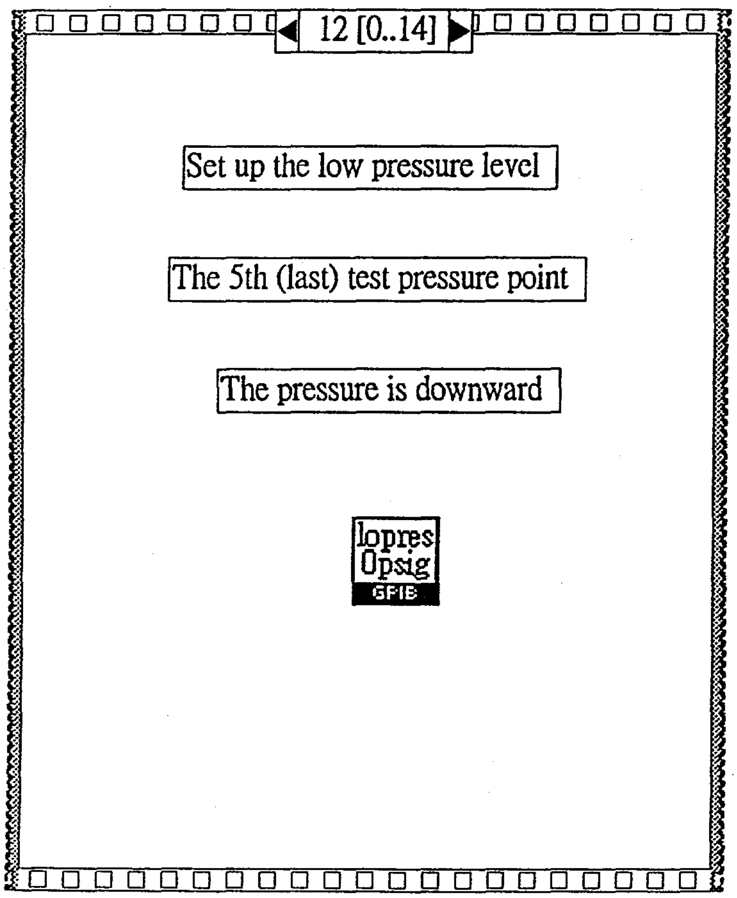

7 [0..14]
Time req'd to stabilize high pressure (2 sec) peak point
2000
DBL

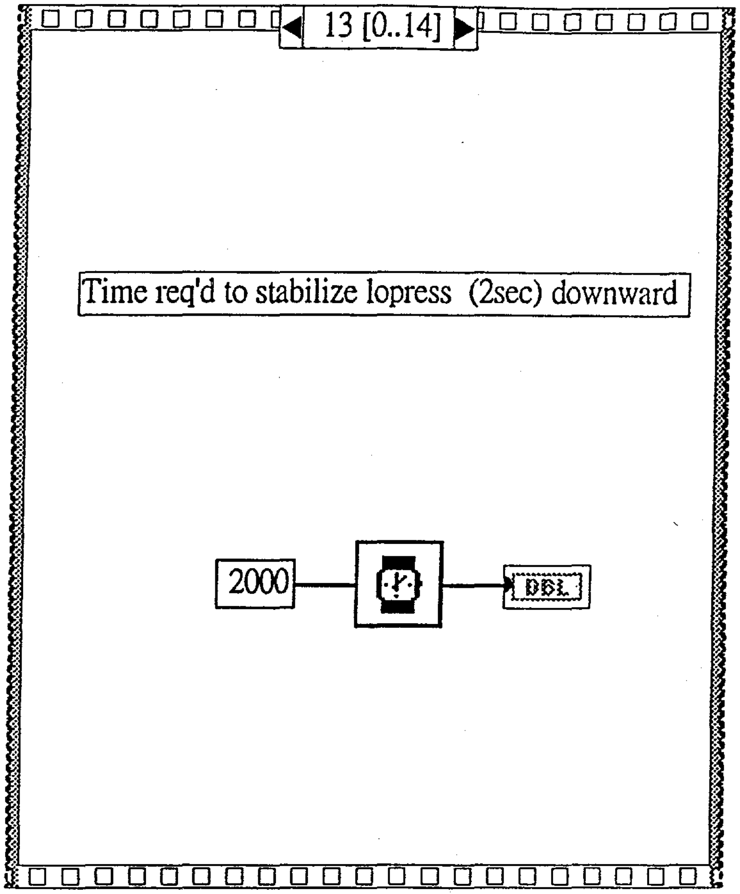

8 [0..14]
Perform daq after high pressure is stabilized
DAQ
basic

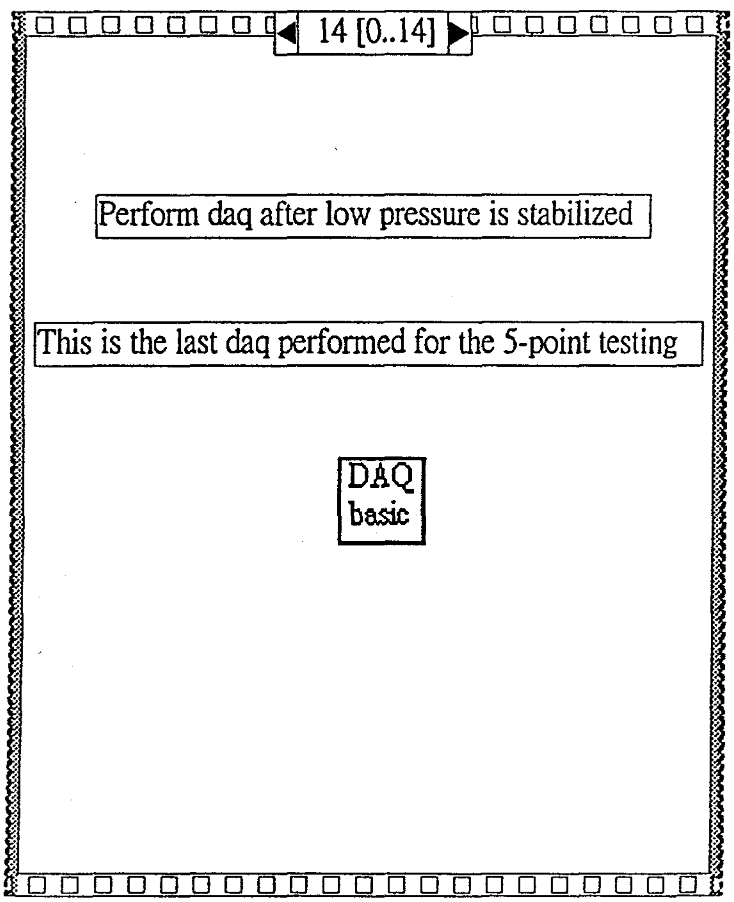

9 [0..14]
Set up the middle pressure level
The 4th test pressure point
The pressure is downward
mdlps
15psig
GPIB


10 [0..14]
Time req'd to stabilize middle press (2 sec) downward
2000
DBL


11 [0..14]
Perform daq after middle pressure is stabilized
DAQ
basic


12 [0..14]
Set up the low pressure level
The 5th (last) test pressure point
The pressure is downward
lopres
Opsig
GPIB


13 [0..14]
Time req'd to stabilize lopress (2sec) downward
2000
DBL


14 [0..14]
Perform daq after low pressure is stabilized
This is the last daq performed for the 5-point testing
DAQ
basic