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VACUUM AND GAS FLOW CONTROL SYSTEM FOR A MWPC AND AN AXIAL CHAMBER

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ABSTRACT

An automatic system that controls the vacuum, gas flow and pressure regulation operations has been constructed for two gas-filled detectors operating in series. To keep constant the amount of the gas in the detectors the pressure values are adjusted as a function of the temperature.

The system is based on a CPU (Motorola 68000) in a VME bus.

The performances of this system have been tested with satisfactory results.

1. - INTRODUCTION

In Nuclear Physics experiments, it is often necessary to use two or more gas detectors, in series or in parallel, operating with different gases and at different pressures. In such cases it is convenient an automatic system to perform a sequence of operations and controls, that is:

a) detectors pumping down;

b) gas flow and stabilization of gas pressure in the detectors;

c) automatic adjustment of the pressure according to temperature variations;

d) filling of the detector volumes at atmospheric pressure with an inert gas as N_2.

A system able to perform these operations has been developed and applied to an apparatus with a MWPC and an Ionization Chamber in series, used for the measurement of nuclear reaction life time with the Blocking technique. The experiment has been performed at the 16 MV XTU Tandem of the L.N.L.

Operations a) and d) are very critical; they must be done slowly and simultaneously in the detectors so that the thin windows of the detectors (about 1.5 μm mylar or 0.5 μm stretched polypropylen foils) do not be damaged.

The rate of pressure increase or pressure decrease, can be selected via a VT100 terminal within the interval 0.1 - 9.99 mbar/s.

The cost of the system is considerably lower than that of a commercial one (1,2), moreover, it permits the preliminary and final operations such as a) and d).

The performance of the apparatus during a long period, is quite satisfactory.

2. - VACUUM AND GAS FLOW CONTROL SYSTEM

The gas detectors to which this system has been applied(3) consist of:

- a MWPC to determining the X and Y positions of the emitted fragments;
- a Bragg ionization chamber for energy and Z identification of the fragments.

They are operated with two different gases: C_4H_{10} for the MWPC and CF_4 for the IC and at different pressures of 10-20 mbar and 100-200 mbar respectively.

These detectors are mounted on a sliding-seal scattering chamber, the IC following the MWPC.

The volumes that have to be controlled as far as vacuum and gas flow operations, are (see Fig.1):

1) the volume connecting the Scattering Chamber to the MWPC (BC);
2) the MWPC;
3) the ionization chamber (IC).

The MWPC is separated from the high-vacuum Scattering Chamber by a thin polypropylene foil (0.5 μm) and connected to the IC through a thin mylar foil (1.5 μm) also used as its cathode.

When not in operation, the scattering chamber volume is isolated from the MWPC with a manual valve DN 100CF, so that it can be pumped indipendently from the detectors.

The system uses commercial valves and sensors.

The valves 1-10 are ON/OFF SIRAI electromagnetic valves (operating voltage 24 V).

F1-F3 are 248 A MKS solenoid valves.

M1 is an ON/OFF Leybold manual valve.

S1-S4 are Leybold manual variable leak valves that allow gas flow rates from 1000 to 1×10^{-5} cm^3/s.

P1-P3 are BHL 3040 Transamerica pressure transducers (typical accuracy ± 0.25 %).

V1-V2 are Leybold vacuum gauge (from 10^{-2} to 10 mbar and from 10^{-3} to 10^{-6} mbar respectively).

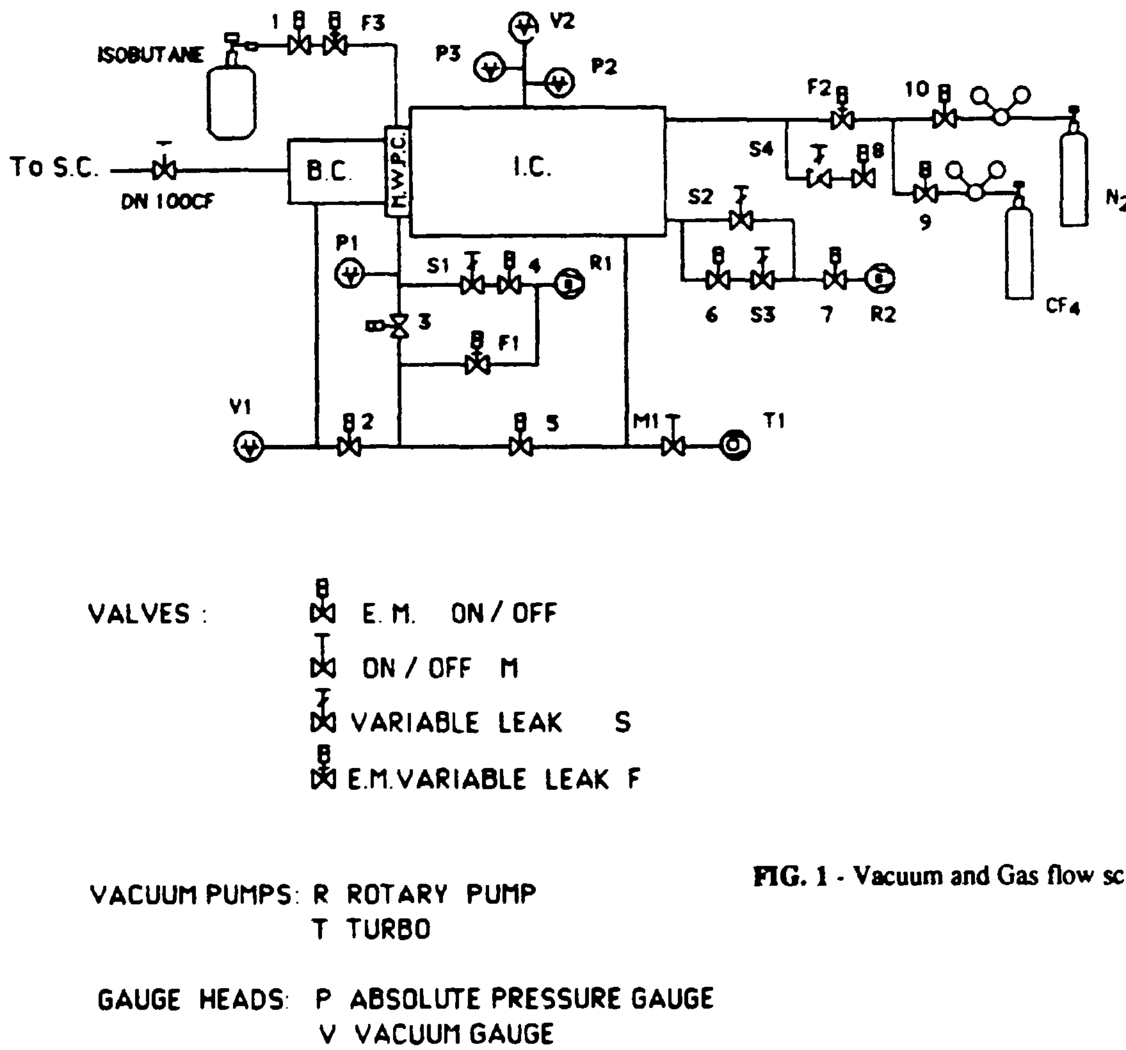

FIG. 1 - Vacuum and Gas flow scheme.

The control system is based on a 16 bit microprocessor (Motorola 68000) mounted on a card MVME110-1 card (Fig. 2). The I/O channel, is an interfacing system that provides fast transfer of the data from the I/O slave devices and the core system.

The I/O channel allows the connection of the microprocessor to two conversion cards:

- MVME 600: an analog data acquisition device, capable of sampling a voltage signal and converting the sample into a 12-bit offset binary value;
- MVME 605: a four channel analog output; it can accept 12-bit offset binary data from the host, convert the data into a voltage signal and send the equivalent analog values to the analog output channel.

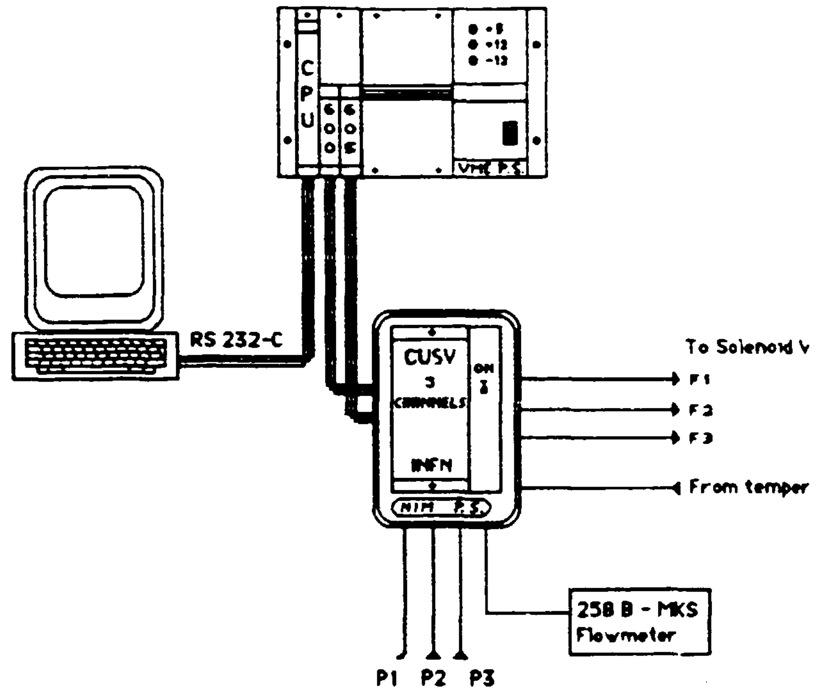

FIG. 2 - Vacuum and Gas flow control system for MWPC and Axial Chamber.

The pressure value, set by the user via the console and here quoted as reference value, is converted into a proportional voltage signal by the DACs. This signal passes to the Control Unit of the Solenoid Valves (CUSV)(4), a two slots Nim-bin module that can supply current intensities adequate to operate most of the commercial electromagnetic valves.

The existing pressure values in the detectors are measured with the transducers P1, P2, P3 and sent to the CPU via the ADCs, as voltage signals. The same pressure values are also sent, as voltage values, to the CUSV. The CUSV compares these values with the reference ones and gives an output current signal proportional to their differences. This current opens or closes the gas flow control valves F1, F2, F3. Typical current values necessary for the controlled solenoid valves are of the order of 65-85 mA.

The response time of MKS 248A valves is of about 15 ms that is sufficient to control pressure variations in the detectors.

2.1. - Detectors pumping down

The three volumes (BC-MWPC-IC) are connected opening the electromagnetic valves 2-3-5, while the manual valve M1 is closed.

The pumping down is done very slowly by the rotary pump R1, through the controlled solenoid valve F1. The user can set the rate of pressure decrease in mbar/s (generally 0.5-1 mbar/s) and, via console, can stop the operation at any time. The pressure value to the CUSV is given by the transducer P3 (range 0-1bar).

When the pressure reaches a value of about 10^{-1}- 10^{-2} mbar, F1 is closed from the console, so that R1 is excluded. Through the manual valve M1, the turbomolecular pump T1 is inserted untill a pressure of about 10^{-5}-10^{-6} mbar is reached.

2.2. - Gas flow and pressure regulation

Once M1 is closed, and the three volumes (BC-MWPC-IC) are isolated closing the electromagnetic valves 2-3-5, the manual valve DN100CF is opened and the filling of the detectors can start through the electromagnetic valves 1 and 9.

The operating pressures are reached controlling the solenoid valves F3 and F2 via software. The user can choose :

- the operating pressures in the MWPC and the IC;
- the rate of pressure increase, in mbar/s (generally 0.5-1 mbar/s) ;
- the maximum admitted difference between the theoretical and the operating pressure.

During the experiment, it is possible:

- to have, at any time, the status of the pressure values in the detectors, on the video terminal;
- to change the pressure of a single detector in a few minutes;
- to generate alarm signals in case of pressure variations outside the selected range and identify the instable detector.

The pressure values to CUSV are given by the transducers P1 (range 0-1 bar) and P2 (range 0-500 mbar).

The control of the gas pressure due to changement of the local temperature, is assured; in fact a sensor National LM35 measures the temperature in the range of interest (0°, 50°C).

The CPU compares this value with the reference one of 20°C and changes automatically the pressure inside the detectors.

The results have shown that the adjustement is as expected.

The gas flow, necessary to assure a good purity of the gas, is (once opened the electromagnetic valves 4, 6, and 7) realized through the manual variable leak valves S1, S2 (opportunely calibrated to obtain a definite flux) and the rotary vane pumps R1 and R2.

The two solenoid valves F3 and F2 stabilize the pressures in the detectors at the values fixed by the user.

In the case of window break the gas inputs (valves F2 - F3) are stopped automatically.

It is possible to connect 258 B- MKS Flowmeter to the C.U.S.V. to read the gas flow.

The gas flow is choosen as to change the full gas volume of the detectors (15-30 l/h) in 1-2 h.

The stability of the system has been verified during an experiment (Fig. 3). Its performance is quite satisfactory: the variation of the pressure with respect to the reference value is ± 0.2 mbar in one day operation.

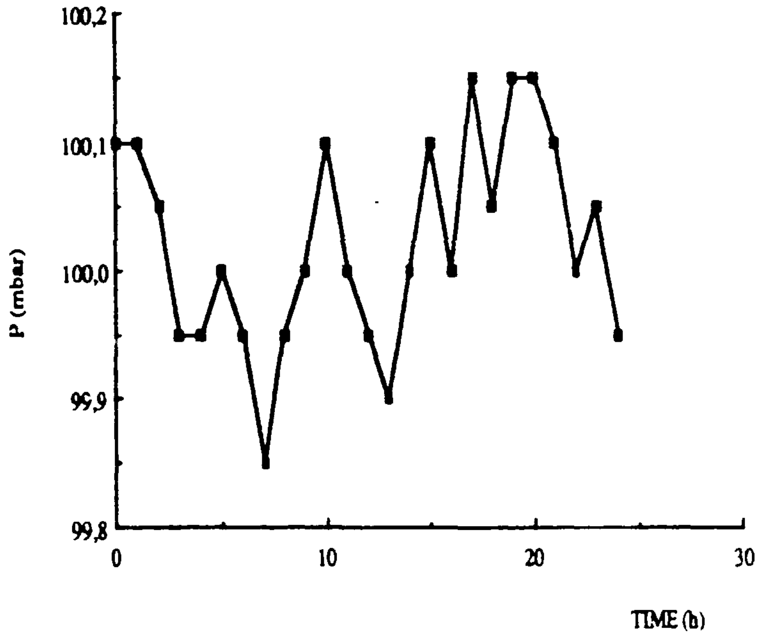

FIG. 3 - Pressure variations around the references value during 24 h.

2.3. - Filling of the detectors

When the detectors have to be brought to atmospheric pressure, to reduce pollution and humidity, they are filled with N_2.

In this case the gas inputs are stopped closing F2 and F3, the detectors are pumped down through the manual variable leak valves S1, S3 and the pumps R1 and R2, (the manual valve DN 100CF is closed) and after the three volumes (BC-MWPC-IC) are connected by the electromagnetic valves 2-3-5. The filling with N_2 starts opening the electromagnetic valve 10 and controlling via software the solenoid valve F2.

Also in this case the user can set the rate of pressure increase in mbar/s. When the pressure in the three volumes is about 990 mbar, F2 is automatically closed and the valve 8 to is opened to complete the filling by the S4 manual variable leak.

By the same way it is possible to make a purge of detector volumes with their partial filling with N_2 and subsequent pumping down before the filling with the proper gases.

3. - CONCLUSIONS

The control system that we have built is able to handle detectors systems based on a large number of elements.

In fact, it will be extended to handle 48 gas systems operating in parallel used in an experiment at intermediate energies.

The cost of the CUSV module (built in our laboratory) amounts to ~ 400 $.

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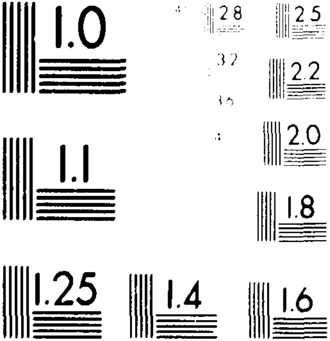

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