MICROPROCESSOR-CONTROLLED GAS ANALYSER SYSTEM FOR MULTI-CHANNEL MASS SPECTROMETRIC MEASUREMENT OF PLANT GASES**

G. LANGER, S. FEKETE, I. GÁL, J. GÁL, K. SEPSY, J. SZÁDAI
L. MÓZSIK* and F. SÁGI*

Hung. Acad. of Sci. (ATOMKI), H-4001 Debrecen

Institute of Nuclear Research

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Quadrupole mass spectrometer system with multi-probe sampling unit has been developed for analysing gases involved in the gas metabolism of plants. The gas components were measured continuously during many week-long programs. To ensure automatic day-and-night operation, a microprocessor control unit was used for guarding the apparatus.

The determination of gas exchange of plants is carried out under artificial conditions or discontinuously, and includes only a very limited number of components in most cases. Thus, some kinds of experiments cannot be carried with the conventional techniques, or the obtained results cannot be interpreted easily at the in vivo level. In order to overcome these difficulties an analyser system was constructed consisting of quadrupole mass spectrometer, microprocessor controlled vacuum system equipped with ten membrane probes and growth chamber (Fig. 1). The membrane probe is a tiny, perforated stainless stell capillary (diameter: 1 mm) covered with a silicone membrane. This probe is introduced in the stem of the plant hermetically.

The gases in tissues, liquids and hollows of the plant diffuse across the membrane of the capillary at the rate of 10^{-6} cm^3/sec and get directly into the quadrupole mass spectrometer with response time of 50 seconds. To the quadrupole mass spectrometer ten sampling probes can be attached with the help of electropneumatic valves (Fig. 2). At a given time only one probe is connected to the mass spectrometer while the others are pumped by separate high vacuum system. This is the way of preventing gas accumulation in the idle probes. The vacuum for the quadrupole mass spectrometer and the sampling probes is produced by 300 1/sec oil diffusion pumps. The ultimate pressure is 5×10^{-8} mbar.

Microprocessor control unit guards the vacuum systems. The instrument houses two ionization and three Pirani vacuum gauge control circuits. The measuring ranges are 1×10^{-3}—1×10^{-9} mbar and 1×10^{3}—1×10^{-3} mbar respectively. Independent switching levels can be set for each of the gauges

* Cereal Research Inst., H-6701 Szeged, Hungary.

** Dedicated to Prof. J. Giber on the occasion of his 60th birthday.

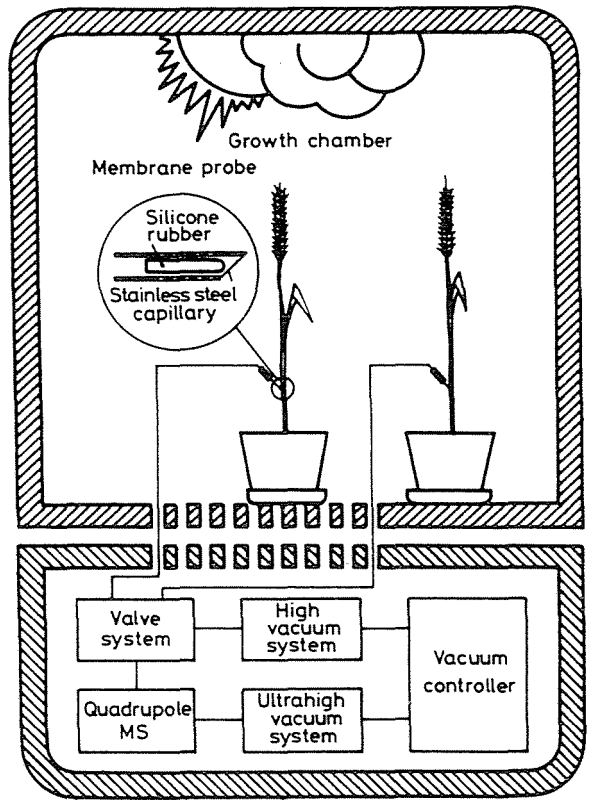

Fig. 1. Schematic diagram of the analyser system

for control purposes. The measured values and the preset switching levels can be read on a digital display.

When the vacuum systems are switched on, the controller checks the presence of the necessary conditions i.e. cooling water, compressed air to operate valves. If every condition is met, an automatic pumping down process begins and when the preset high vacuum level is reached a ready signal is given. The actual state of the vacuum systems can be followed on the schematic diagram of the front panel. In case of any malfunction — interruption in water or compressed air supply — appropriate safety operations are done automatically. After the failure has ceased the microprocessor control unit is able to restart the vacuum systems. The pumping process will be continued according to the actual state of the vacuum system. This is highly important in the measurement of gas exchange of plants where prolonged processes are monitored.

The daily changes of some gaseous components in the wheat stalk were investigated to demonstrate the capabilities of the measuring system (Fig. 3).

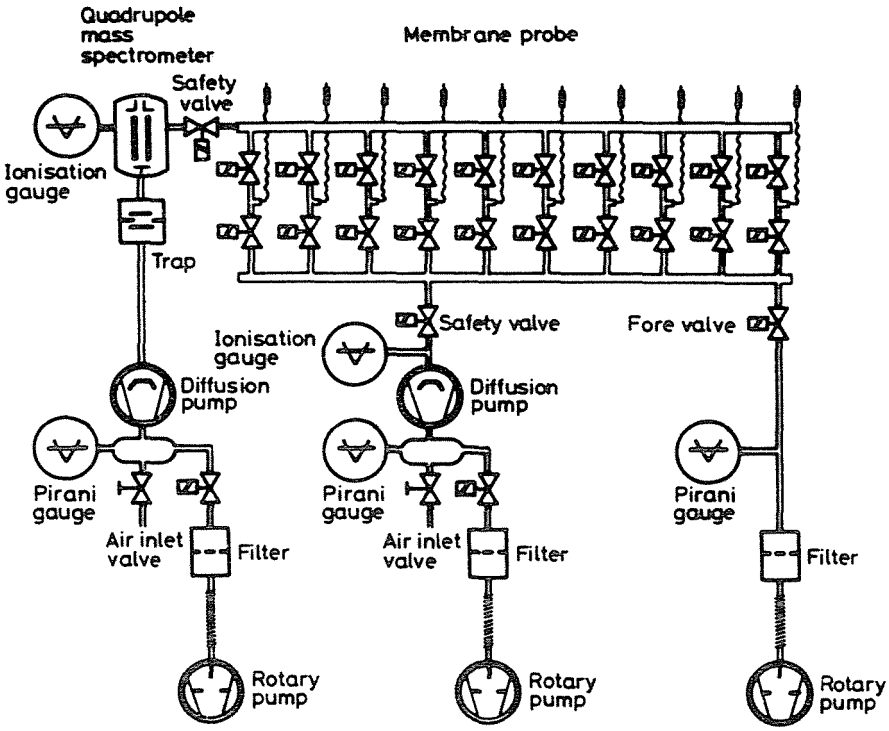

Fig. 2. Set-up of the multi-probe sampling system

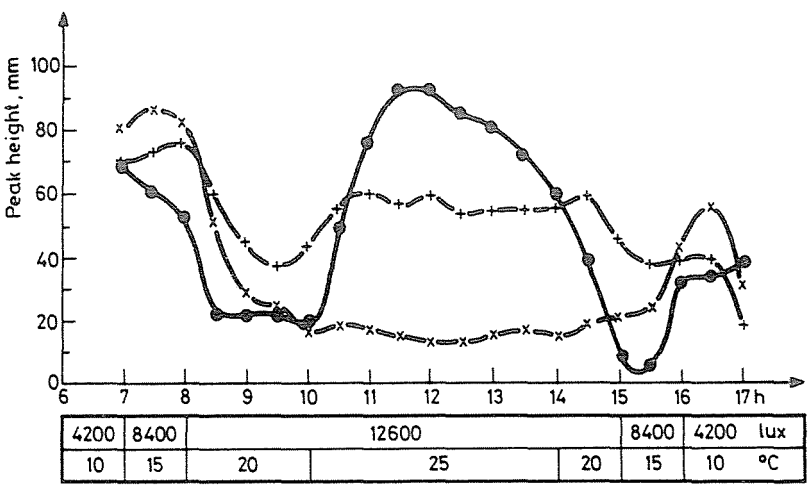

Fig. 3. Daily changes of some gaseous components in the wheat stalk (compensated for temperature sensitivity of the sampling probe)

The plants are placed in a growth chamber to control the illumination and temperature.

The example only illustrates the applicability of the analyser system, the biological aspect of the problem will not be examined.

Quadrupole mass spectrometer has unique features: multi-component analysis, high sensitivity and fast detection. These capabilities, combined membrane inlets and multi-probe sampling made it possible to measure the in vivo continuous, endogenous gas metabolism of plants.

References

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G. LANGER
S. FEKETE
I. GÁL
J. GÁL
K. SEPSY
J. SZÁDAI
Inst. ATOMKI H-4001, Debrecen

L. MÓZSIK
F. SÁGI
Cereal Research Inst. H-6701, Szeged