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MICROCOMPUTER INTERFACING TO MASS FLOW TYPE GAS CONTROLLERS FOR BIOTECHNOLOGY APPLICATIONS

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SUMMARY

An Apple IIe microcomputer with an Isaac analog-digital package has been interfaced to Tylan proportionating mass flow gas controllers to regulate three substrate gases which are introduced into an anaerobic bioreactor. Advantages of the system include: straightforward interfacing and programming, accurate monitoring and controlling, and advanced real time control capabilities.

INTRODUCTION

The use of microcomputers in biotechnology is increasing due to their usefulness as tools for real time monitoring and controlling as well as data storage and handling. The microcomputer is relatively inexpensive and therefore practical for small scale laboratory bioreactors. Presented here is an application which allows highly accurate control of gases which are introduced into an anaerobic bioreactor. The oxidation of hydrogen sulfide gas by the bacterium Chlorobium thiosulfatophilum is currently being investigated (Cork et.al. 1983). The microorganism is capable of photosynthetically utilizing H_2S, CO_2, and N_2 gases as sole sources of electrons, cellular carbon and nitrogen, respectively, in defined medium in an illuminated bioreactor (Cork and Ma, 1982).

Flow controllers. Tylan mass flow controllers are proportionating type valves. Each controller has a 0 to 5 VDC controlling and a 0 to 5 VDC metering circuit (mass flow meters have only the metering circuit). The controllers are accurate to 1% full scale, and response to applied voltage is linear. Several flow ranges are available, and are factory pre-set, so that extensive calibration in the laboratory is not required. The 0 to 5 VDC controlling and metering circuits make these controllers ideal for computer interfacing.

Microcomputer system. Fig. 1 is a schematic layout of the microcomputer system in use. The Apple IIe (Apple Co. Cupertino, CA) is connected to an Isaac 41A, a commercially availible data aquisition and control hardware/software package (Cyborg Co. Newton, MA). Remote housings contain the analog-digital and digital-analog modules, where the metering and controlling circuits (respectively) of each Tylan mass flow unit are connected. All Isaac hardware is configured for 0 to 5 VDC operation. An infrared CO_2 analyzer (Horiba Co. Irvine, CA) is also interfaced to the computer for off-gas monitoring. Programming is in Apple BASIC and LABSOFT, supplied with the Isaac package. The disk drive and printer are used for program storage and data logging.

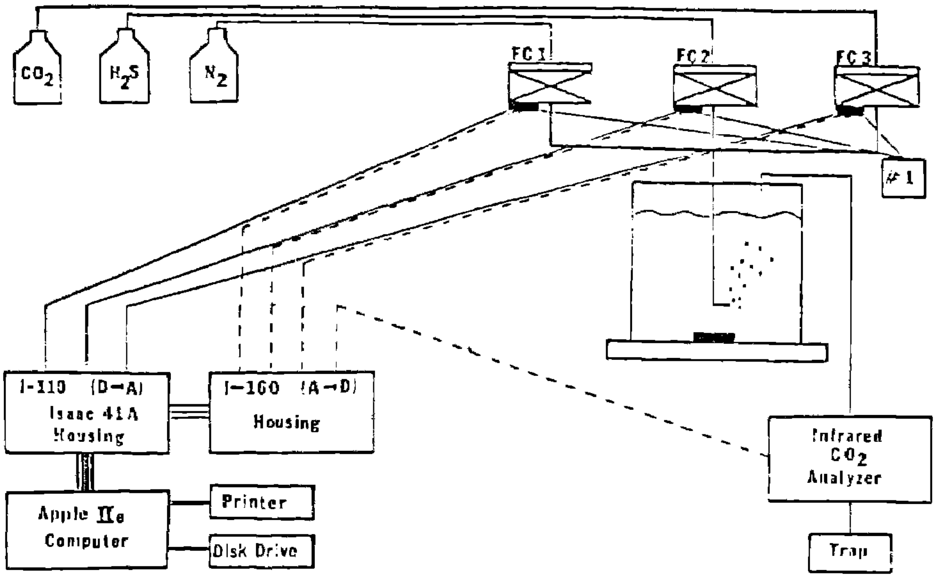

Fig. 1. Hardware for gas monitoring and control. FC1, FC2, FC3: Tylan controllers
#1: 15 vdc power supply.

MATERIALS AND METHODS

Photosynthetic oxidation of sulfide to elemental sulfur and sulfate in a fed batch reactor has been described previously (Cork et.al. 1982-3). A feedback program was set up where CO_2 and H_2S gases were initially set at low, growth limiting flow rates (0.18 and 0.26 ml/min respectively). N_2 served as a carrier gas to minimize gas throughput time(5.67 ml/min). Under these conditions, there is little photosynthetic CO_2 fixation and CO_2 consequently passes through the reactor and is detected on the effluent side by the infrared analyzer. Increasing the flow of H_2S gas under these conditions results in increased metabolism as the microorganisms are supplied with an electron source. The increased availability of reducing power results in increased metabolism and growth, therefore CO_2 is fixed and the detected concentration of effluent CO_2 decreases. Fig. 2 shows the logic employed for increasing and setting the H_2S flow rate for optimum fixation of CO_2.

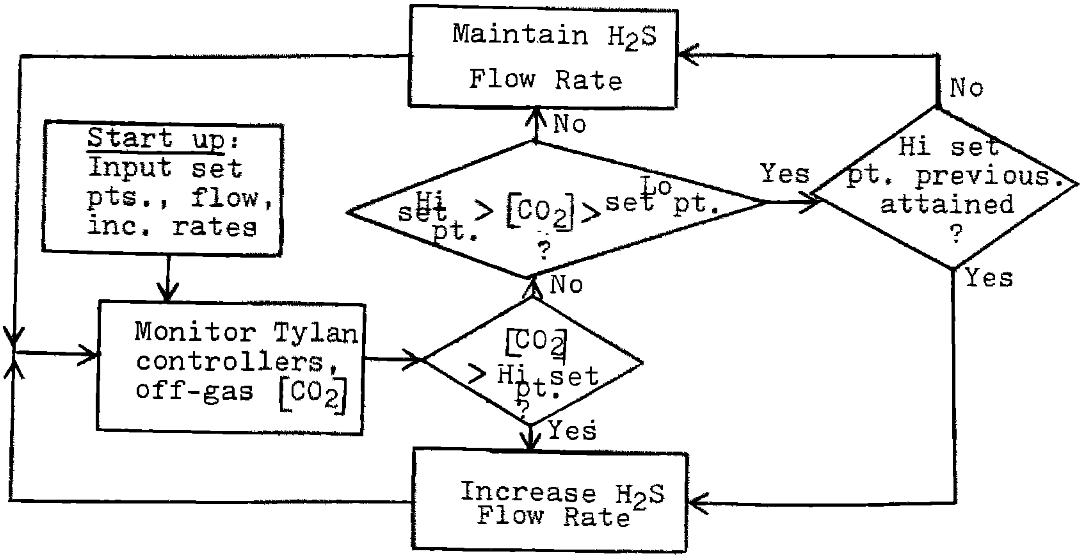

Fig. 2. Logic for $[CO_2]$-dependent feedback control of H_2S flow rate.

RESULTS AND DISCUSSION

Fig. 3 shows the CO_2 concentration and the H_2S flow rate during execution of the feedback control program. The net effect of the program execution was that of a self-correcting system where the biocatalyst is supplied with a concentration of soluble sulfide necessary for optimal CO_2 fixation and growth. Supraoptimal H_2S flow rates cause poisoning of the biocatalyst due to critically high soluble sulfide concentrations.

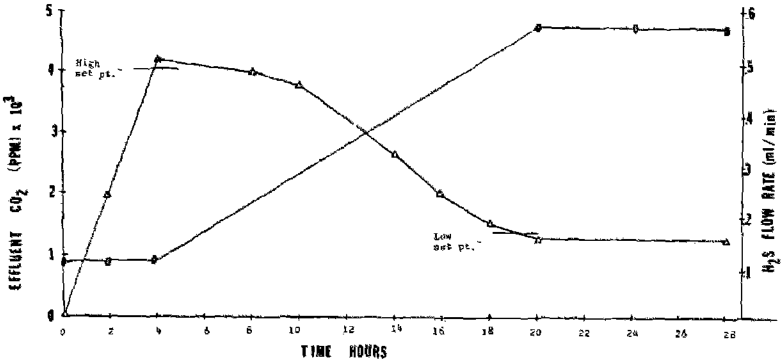

Fig. 3. Effluent CO_2 concentration and H_2S flow during program execution. (Δ), CO_2 (0), H_2S

The advantages of this system are apparent considering that the software may be specifically designed for any bioreactor requiring accurate molar flow of gases, as well as changes in flow during an experiment. Programming is in enhanced BASIC, so a program could be designed by a person with intermediate computer skills. Additionally, other experimental variables may be interfaced, such as temperature, pH, Eh, light, agitation, etc. Current research is being directed at optimizing the microbiological oxidation of H_2S to elemental sulfur using the computer to control these and other variables.

REFERENCES

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