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COMMISSION OF THE EUROPEAN COMMUNITIES

POLYP: AN AUTOMATIC DEVICE FOR DRAWING SEQUENTIAL SAMPLES OF GAS

by

P. GAGLIONE, C. KOECHLER and L. STANCHI

1974

Joint Nuclear Research Centre
Ispra Establishment - Italy

Chemistry Division
Electronics Division

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ABSTRACT

POLYP is an automatic device consisting of an electronic equipment which drives sequentially 8 small pumps for drawing samples of gas. The electronic circuit is driven by a quartz oscillator and allows for the preselection of a waiting time in such a manner that a set of similar instruments placed in suitable position in the open country will start simultaneously. At the same time the first pump of each instrument will inflate a plastic bag for a preset time. Thereafter the other seven pumps will inflate sequentially the other bags. The instrument is powered by rechargeable batteries and realized with C-MOS integrated circuits for a nearly negligible consumption. As it is foreseen for field operation it is waterproof.

1. GENERALITIES

In the study of the complex problem which is atmospheric pollution, of utmost importance is the knowledge of the dynamical behaviour of pollutants. Mathematical models enable to forecast to an acceptable degree of approximation the pollutant diffusion in the atmosphere, depending on the local micrometeorology conditions. In most cases, however, because of the particular nature of the emission sources (single, multiple or extended) as well as of the soil profile and nature (vegetation, cover, water bodies, buildings , hills) in the studied area, the development and testing of a mathematical model needs some sort of experiments.

At the state of the art, the most suitable experimental technique appears that of making use of tracers, i. e. of substances in the aerosol or gaseous state which, if injected in the atmosphere, can simulate the dynamical behaviour of pollutants.

An atmospheric tracer must have several requirements and therefore only a limited number of substances is actually considered suitable for air pollution tracing experiments.

Among these, Sulfur Exafluoride (SF_6) is one of the most interesting and widely used for its following main characteristics:

- no toxicity, lack of odour, colour and taste, no fire hazard;
- high thermal stability (up to 600 °C) and therefore possibility of release from industrial stacks;
- chemical stability towards hydrolysis, oxidation and photolysis;
- chemical inertness to some of the most reactive atmospheric

pollutants;

- resistance to solar radiation and to removal by washout and rain-out.

An atmospheric diffusion or transport experiment, using SF_6 like a tracer, usually needs an air sampling network properly distributed downwind the release point and along the atmospheric path of the tracer. Frequently, in each sampling point, there is also the necessity of sampling air at different times during the transit of the tracer plume.

Sampling of SF_6 is normally done by pumping air with a small battery operated pump into a plastic (Saran) bag and this operation is done by a man. As a consequence, since a few score of sampling points are required for each experiment, finding manpower is one of the biggest difficulties which conditions the execution of the experiments.

To overcome this problem an automatic battery operated device has been realized, which is able to collect up to eight air samples into plastic bags for SF_6 analysis, starting from a prefixed time and running in sequential progression for fixed preselectable time intervals. This instrument can be used in field (waterproof), adapted easily to many different experimental conditions and its cost is relatively low when compared with other commercial instruments suitable for the same purpose.

2. DESCRIPTION OF THE EQUIPMENT

POLYP is essentially composed of:

a) a set of eight membrane pumps

b) an electronic circuit.

Both parts a) and b) , powered by recheargeable batteries, are enclosed in a waterproof box, which is easily installed before its operation, on the top of an overturned metal basket which holds the sampling bags also. An inlet tube allows the immission of the air into the box for sampling.

Fig. 1 shows the general layout of the whole apparatus. A small membrane pump (commercial type for aquarium) has been used to collect air samples into the Saran bags which will be partially filled, to prevent leaks due to overpressure and to mantain a constant pump flow-rate.

In Fig. 2 the flow-rate of three of such pumps is plotted versus the applied D.C. voltage. From the graphs one can see that around the operation point (1,3 V), the flow-rate is fairly constant and its value is about 1,4 l/min. This flow-rate can be reduced, if necessary, by placing an appropriate orifice at the outlet tube of the pump.

The outlets of the eight pumps are connected by plastic tubes to the inlets of the sample collection bags which are inside the metal basket. A diaphragm between the pumps'membrane and its outlet assures no leakage of the sampled air back through the pump.

3. PRINCIPLE OF OPERATION

POLYP is conceived to operate simultaneously with many others similar instruments. In order to reduce manpower the instrument is able to be preselected in such a manner that it will start at a defined time. A single operator can as a consequence go around the country and place in suitable positions some tens of instruments. Any successive instrument is put into place and set to a decreasing time. The time which is selected , named WAITING TIME, is the number of minutes before the start of operation. This time is fixed by the operator (or by the operators) simply by calculating the number of minutes needed to go to the effective start of the experiment. To be concrete: let's consider the start of the experiment at 12. 00 A. M. The operator sets in the correct position an instrument at 10. 39 A. M. He presumes that the waiting time will start in the next minute. He will therefore preselect the waiting time as 80 minutes and he will switch on the instrument at exactly 10.40 A. M. The same some minutes later for another instrument. He will preselect 75 minutes to start at 10.45 A. M. As a consequence of this all the instruments suitably placed in a limited region will start exactly at 12.00 A.M.

At this time each POLYP will inflate its 8 tentacles (Saran bags) sequentially each one begins when the preceding ends. As a matter of fact the state of the atmosphere during 8 successive intervals of time is kept and will be analyzed in the lab.

Two variables of time are allowed to the operator: a) the Waiting Time which can be selected by a two decades thumbwheel switch and a "x 2" multiplier, b) the Operation Time which can be selected by a rotating switch in binary progression. The time in unit of minutes can be directly read on the front panel. Times from O to 99 minutes (with the x 2 multiplier if the case) are preselectable for waiting time. These times will be set by the field operator. Times from 2 up to 64 minutes (in binary steps) are allowed for the operation time and are settled in the lab before the experiment. Obviously each one of the 8 pumps will inflate its "tentacle" for the same time as the others.

4. DESCRIPTION OF THE CIRCUITS

The instrument is designed to work in the country so that particular care has been taken in order to have a self contained equipment working with a unique independent power supply. Four rechargeable batteries are connected in series. The nominal voltage of 1.3 V is used for the pumps while the series of the batteries allows for a 5.2 V that is sufficient for driving C-MOS integrated circuits.

The very low power requirements of C-MOS circuits are well known. In effect they have a nearly negligible sink of current when they are not operated or switched at moderate frequency. In this instrument (see Fig. 3) there is a quartz oscillator at the frequency of

279620 Hz which drives by a suitable divider the whole operation. Two C-MOS I. C.'s type 4020 A are used for obtaining the frequency of 1/60 Hz, say a period of one minute. This clock (or the clock divided by a factor of two) drives a two decades synchronous counter (Waiting Time realized with two I. C.'s type 4029 A) which will operate a diode AND when the preselected number is reached. At that time the Waiting Time is stopped and the operation time is started. A. Johnson type scale of 8 (C-MOS I. C. type 4022A) will drive in succession the eight pumps via a divider obtained by six D-type flip-flops. A suitable four input gate will prevent the operation of the first pump during lazy times. The power circuit is obtained by two cascaded transistors which drive the pump with a small saturation voltage.

The power consumption is of the order of 200 mA from the 1.3 V battery and 5 mA (or something more depending on the h_{fe} of transistors BFY56A) on the 5.2 V battery during the operation time. This time can be set up to a maximum of 64 x 8 minutes giving a total consumption of approximately 1.7 Ah. In order to have the pumps with a sufficiently constant flux the 1.3 V battery is chosen of 6 Ah. The other three batteries for obtaining the 5.2 V voltage for the integrated circuits are chosen with another concept. In effect during the operation their consumption is negligible. On the other hand a certain leakage of current is found even with C-MOS and this is of the order of 300-350 uA at 25 °C for the complete instrument working at 5.2 V. This leakage of current increases strongly with supply voltage so that we have 600 uA at 6 V. For the measured current we have a consumption of 1 Ah for 3000 h of storage i. e. more than 4 months. So suitable batteries of 1.6 Ah have been chosen. By that no switches on the batteries are used.

A specially designed battery charger is being developed and it will be used after the experiment if the case.

CONCLUSION

Only preliminary tests have been performed with the prototype instrument shown in Fig. 4. As the obtained results are satisfactory a series of 50 instruments will be realized by an external industry.

ACKNOWLEDGMENT

The authors are grateful to Mrs. L. Tortora for the determination of the pump characteristics and to Messrs. M. Bernede and N. Coppo for technical assistance in the development of the circuit.

FIGURE CAPTIONS

Figure 1.	General layout of the equipment
Figure 2.	Flow-rate vs. supply voltage
Figure 3.	Schematic of the electronic circuit
Figure 4.	View of the prototype.

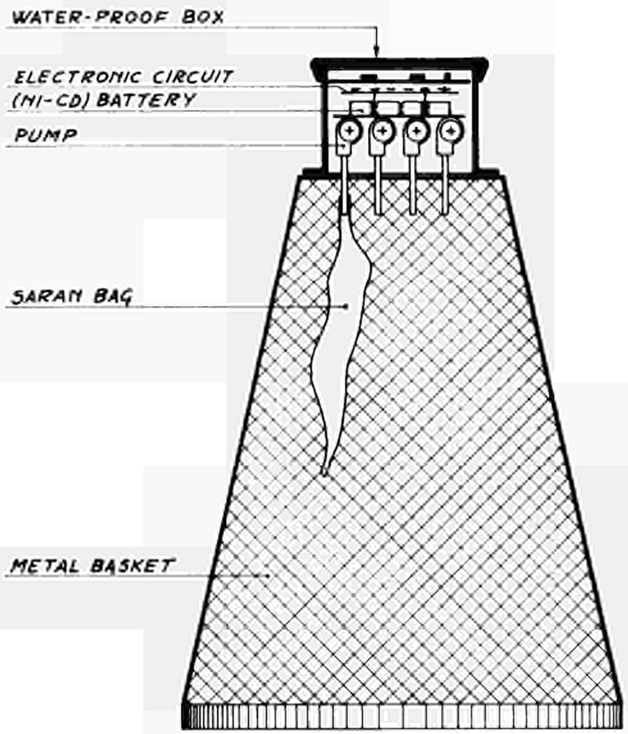

Fig. 1 GENERAL LAYOUT OF THE EQUIPMENT

ME 055-00-003

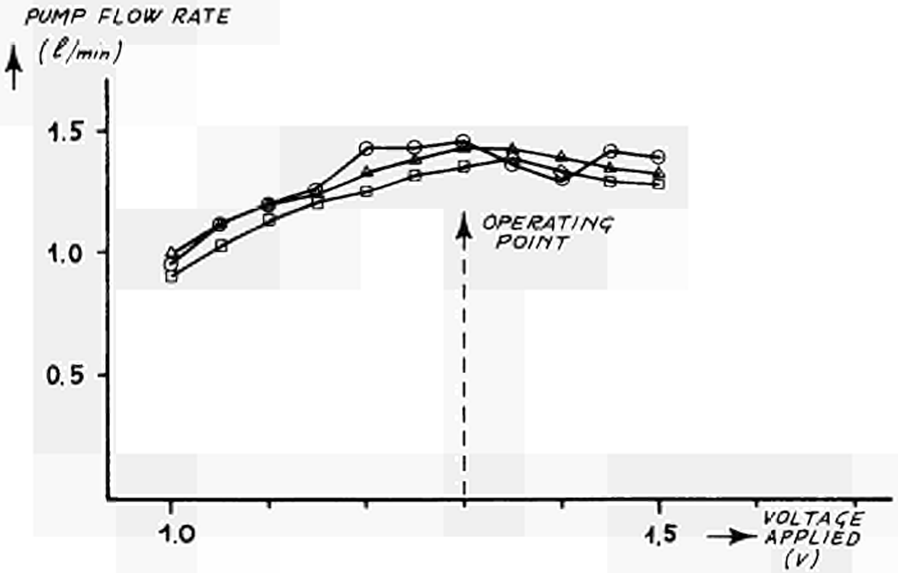

Fig. 2 PUMPS FLOW RATE Vs. SUPPLY VOLTAGE

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GATES A2, A4 : 4011 A

GATE A3 : 4012 A

+V = 5,2 v

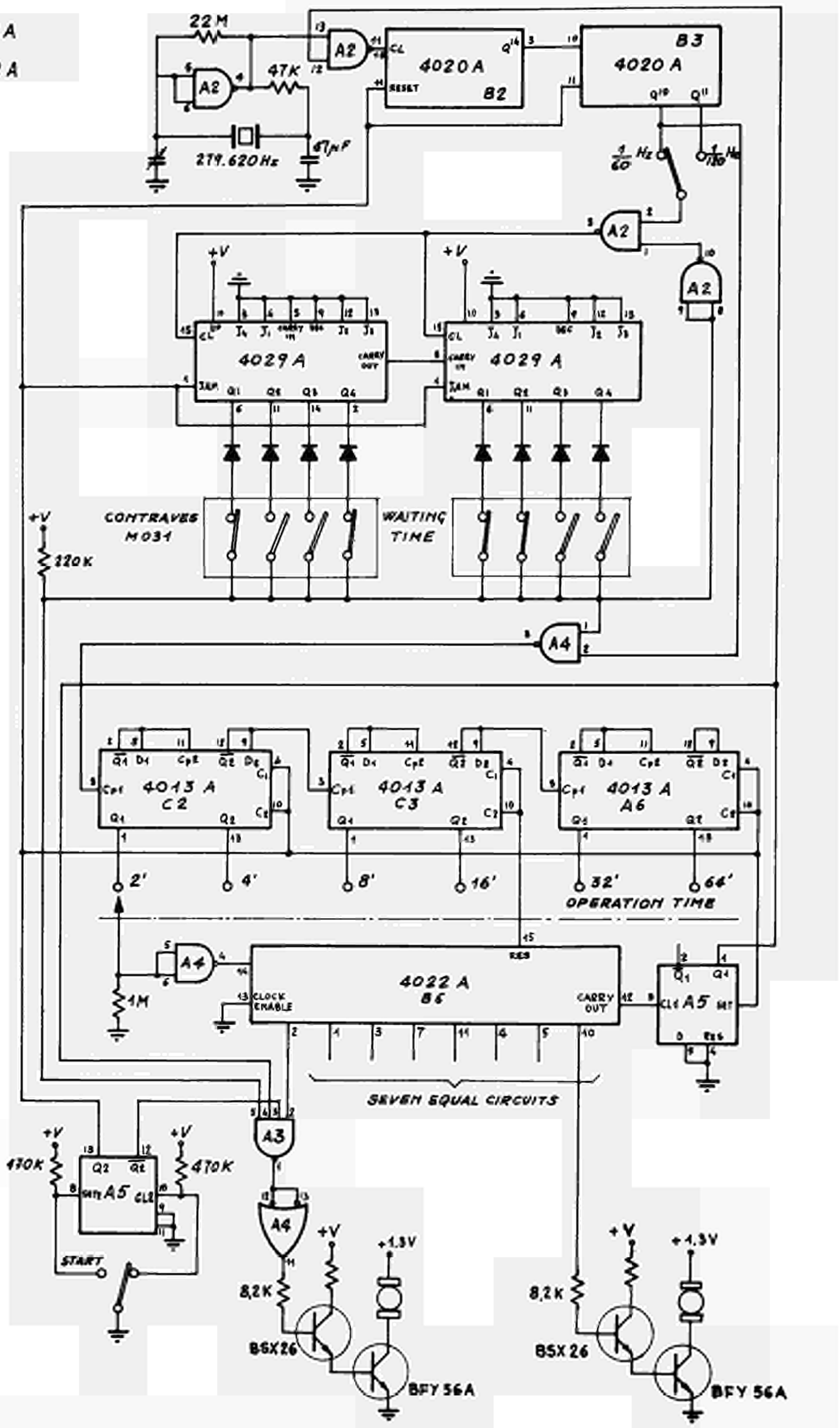

FIG. 3 SCHEMATIC OF THE CIRCUIT

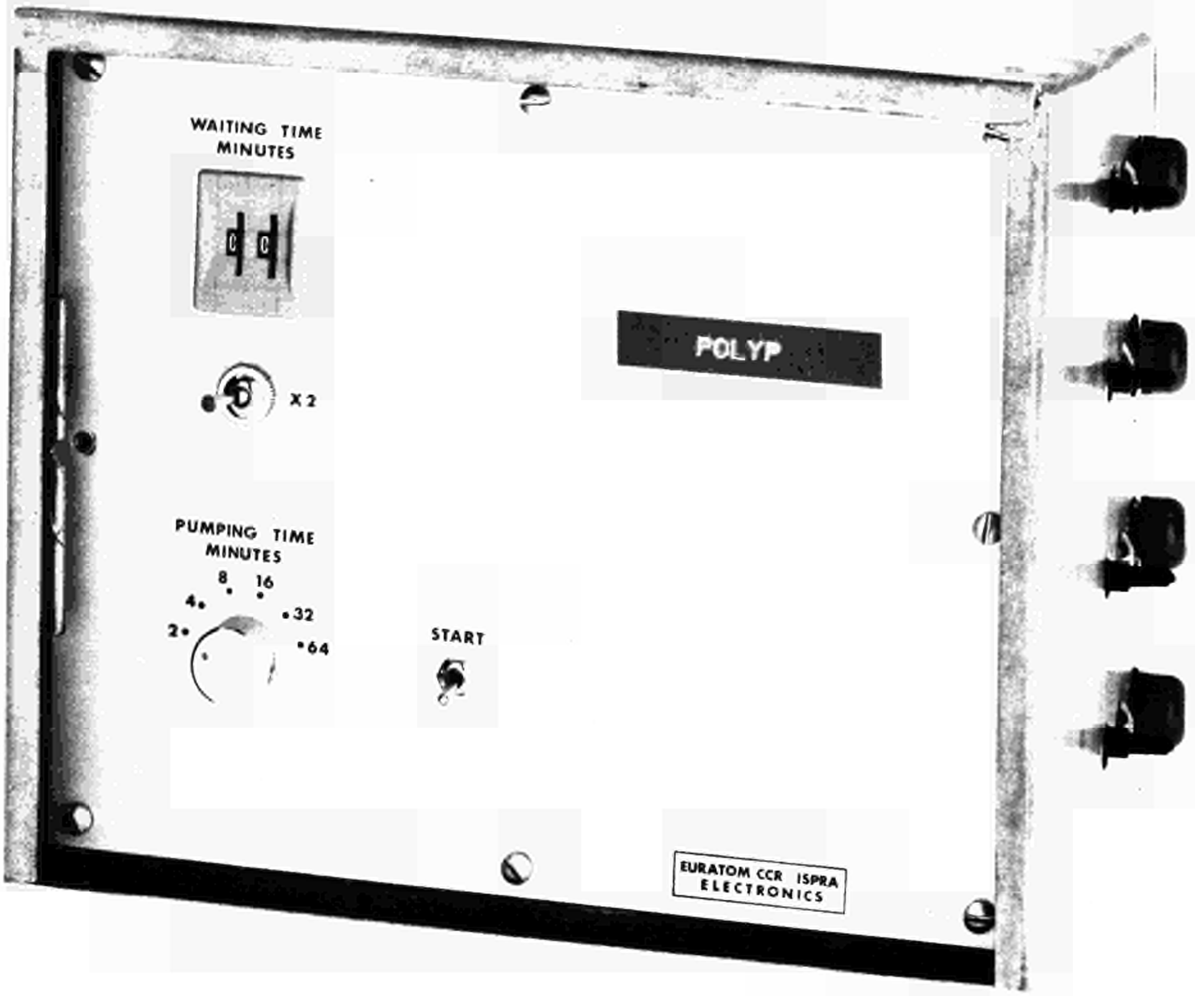

FIG. 4 VIEW OF THE PROTOTYPE

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Alfred Nobel

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