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AN OPERATIONAL AMPLIFIER-BASED LOW-COST CONDUCTOMETER

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Fabrication details are described for a low-cost conductometer of general utility. The circuit of the unit is based on IC operational amplifier (opamp) 741 in conjunction with a push-pull transistor couple operated in common base mode. A stable, ripple-free DC supply energises the circuit at ± 12 V and ± 15 V, 500-600 mA. Zero-cost carbon electrodes comprise the cell. Conductance measurements within the range 10^{-2}-10^{-6} mho can be made with an overall accuracy of ± 1 %.

Key words: Low-cost electroanalytical equipment; Opamp application; Conductometry.

INTRODUCTION

Low-cost chemical instruments intended for the teaching of chemistry at college and university levels have become increasingly popular during the recent years. This is specifically true of pH meters, colorimeters, spectrophotometers, polarographs, autotitrators and conductometers, the low-cost fabrication being based on the use of modern active and passive components of high precision and tolerance. The use of integrated circuits and operational amplifiers (opamps) in this application have become well known during the last two decades [1]. With the advent of high-gain opamps it has now become possible to design and fabricate low-cost equipment comparable in performance with any counterpart imported from advanced countries.

In 1979, the Division of Scientific Research and Higher Education, UNESCO, in collaboration with IUPAC, started a programme on promoting laboratory teaching in colleges and universities through the fabrication of chemical equipment using low-cost, locally available components. A project in this area was initiated and sponsored by UNESCO to be carried out at the university of Delhi, India [2]. Under the scheme worked out, the EDUTRONICS group of the university developed some basic equipment including pH meter, colorimeter and conductometer. A follow-up of the programme was then extended to other countries in the region, including Pakistan. University Grants Commission in Pakistan funded the ever first project on low-cost equipment in 1984. Since then a colorimeter, a pH/mV meter, a conductometer, a digital pH meter and a polarimeter have been designed and fabricated from components that are either locally produced or available.

The present work stems from this background. The fabrication aspects of a general purpose conductometer based on CA 741 opamp are described in relation to the electric characteristics of the circuit involved. A completed unit was presented at the National Conference on Low-Cost Equipment held in December 1986 at Islamabad under the sponsorship of UNESCO.

Circuit details. The circuit diagram of the conductometer is given in Fig. 1. Details of the basic principles of opamp circuits are described in literature [3,4]. The opamp in the current application acts as a multivibrator with the provision of negative and positive feedback, the former being derived from the RC circuit and the latter from the variable resistor arm of the cell. The opamp saturation is achieved at ± 12 V supply voltage capable of delivering 500-600 mA current through the common-based transistors, AC 187 and AC 188. The transistors are energised with ± 15 V DC supply obtained through rectification, and subsequent filtration of AC output from the step-down transformer. The 22 k variable resistor at IC pins 1 and 5 is the voltage offset adjuster, while the 100 k variable resistor in series with 10 k connected to pin 2 of opamp is used for matching a given cell with the amplified signal to be recorded within full-scale range of the meter. Various ranges are available to cover conductance measurements between 10^{-2}-10^{6} mho. The overall accuracy is better than ± 1 %.

Measurement of conductance. Zero-cost carbon electrodes, made from carbon rods taken out from 'dry cells' no longer in use, constitute the conductance cell (Fig. 2). The conductance, y, of a given solution is related to the meter reading, R, at a given range through the relation: y=k (mR+c), where k is a constant characteristic of the circuitry and m and c are respectively the slope and the intercept of the line obtained by plotting y vs. R. Linearity is observed for values of R close to the maximum of meter

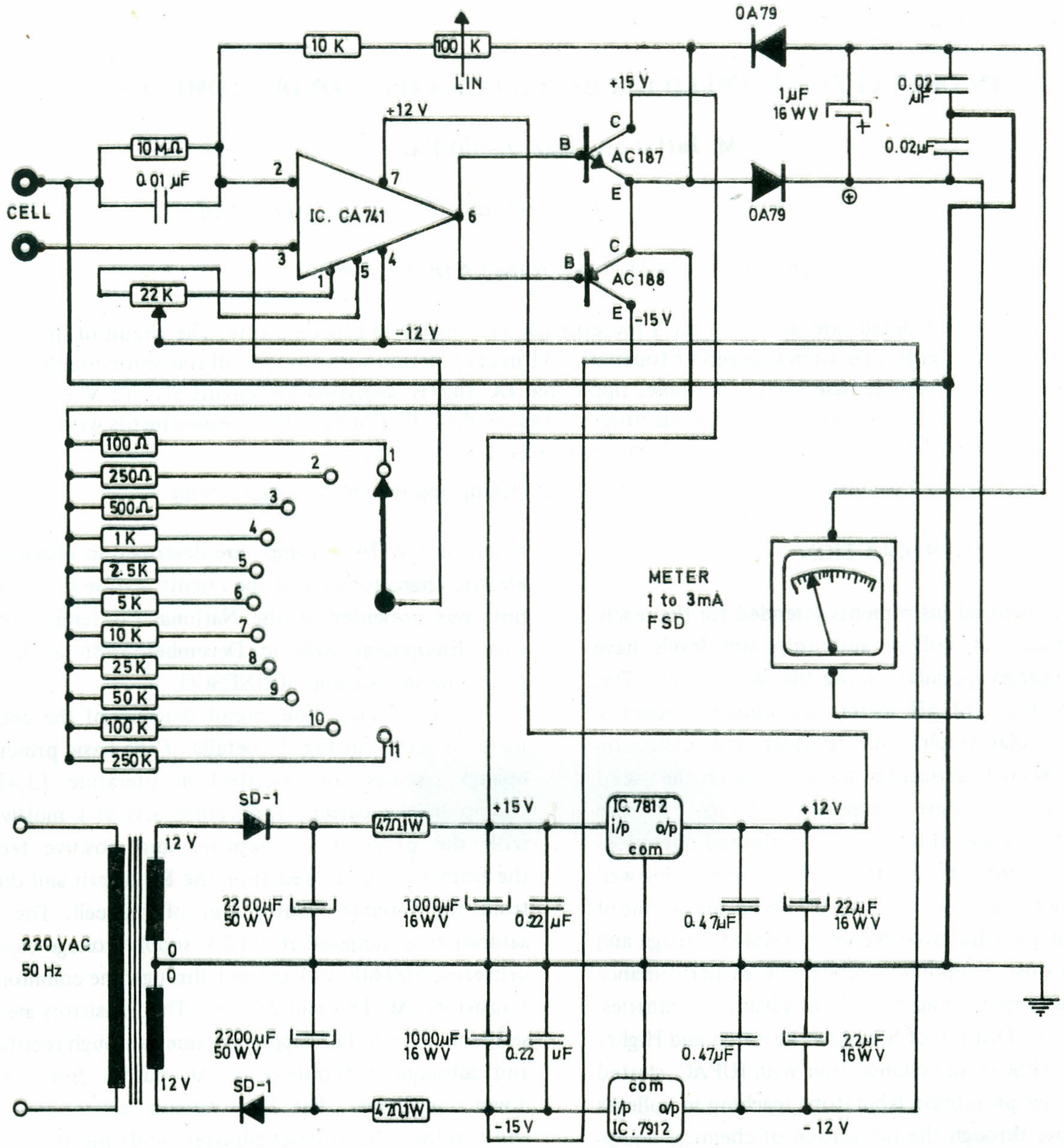

Fig. 1. Circuit details of the conductometer.

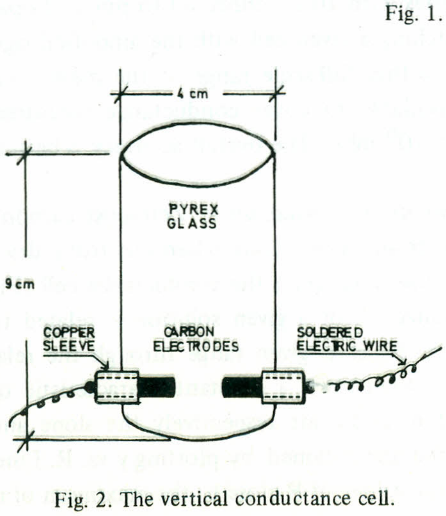

Fig. 2. The vertical conductance cell.

reading. Thus, by connecting a decade resistance box as a substitute of resistance of any unknown solution the constants in the above equation can be determined at a given range. This then allows for the computation of the conductance of solutions at any desired range at which readings on meter scale can be obtained within scale. The cost of the finished product is Rs. 450.

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