ENVIRONMENTAL CORROSIVITY MONITOR

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Due to rapid industrialisation the atmosphere is polluted by acidic gases like SO_2, H_2S, NO_2 etc, which increase the corrosivity of atmosphere. For continuous monitoring of the atmospheric corrosivity a probe and coulometer have been designed. From the measured coulombs the corrosivity of atmosphere can be monitored. This paper presents the results of the performance of the monitor.

Keywords: Atmospheric corrosivity, probe, coulometer.

INTRODUCTION

Material degradation due to corrosion is a severe problem. The economics of this problem forces one to look for a better monitoring and good remedial measure. The atmospheric corrosion is an electrochemical phenomenon with an electrochemical reaction which is highly complicated [1-3]. Unlike the general corrosion which occurs in an aqueous phase, the atmospheric corrosion takes place when there exists an electrolyte layer over the surface exposed to the atmosphere. This electrolyte layer normally originates from the condensed phase of moisture which is extremely thin (approximately 1 μm). Factors like temperature, humidity, and the other pollutants present in the air contribute significantly to the corrosion due to this thin electrolyte layer. Due to rapid industrialisation, the atmosphere gets polluted by the flue gases containing acidic and toxic gases like SO_2, H_2S, NO_2 etc. These pollutants which are soluble in the moisture of the atmosphere enhances the rate of corrosion.

The loss of metal through the atmospheric corrosion is a direct function of time (t_f) during which the thin aqueous film persists over the surface as given by

$$W = r \times t_f$$

where 'r' is the average corrosion rate.

Since the conventional means of monitoring corrosion requires the electrodes to be immersed in electrolyte which do not mimic the situation of atmospheric corrosion, extensive attempts [4-8] have been reported in designing newer experimental setups to assess the atmospheric corrosion and to forecast its corrosion rate. Among all the new experiments developed, the most popular one is the use of monitoring the galvanic current flowing through a galvanic couple.

In this paper a new electrode arrangement and a five digit digital coulometer have been reported. The use of this setup for the atmospheric corrosion has been tested with the acidic vapour condensation setup.

Circuit description

The principle of working of the environmental corrosivity monitor can be explained with the help of a schematic block diagram shown in Fig. 1. The block diagram consists of a
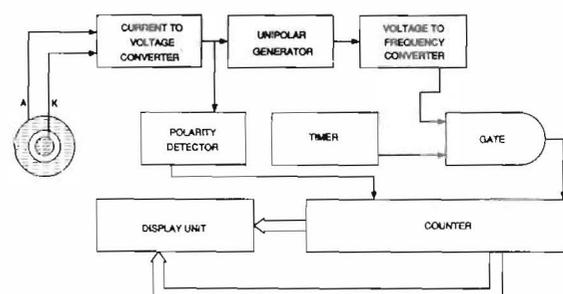

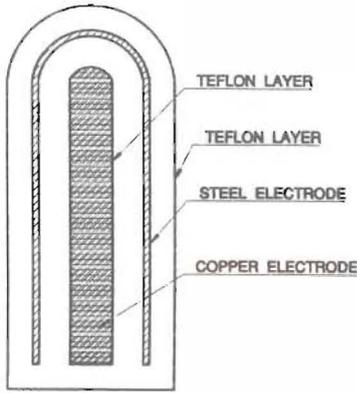*Fig. 1: Block diagram of environmental corrosivity monitor*

Fig. 2: The arrangement of the electrochemical probe

current-to-voltage converter, an unipolar generator, a voltage-to-frequency converter, an AND gate, a timer, a polarity detector, a counter and the display unit. The schematic circuit diagram is shown in Fig. 5.

Current-to-voltage converter (CVC)

The schematic circuit diagram of CVC is shown in Fig. 3. The output voltage V_o is proportional to the input current I_{in} and is given by

$$V_o = R_f \times I_{in}$$

This circuit is used for input current ranges upto 1 A, and the output is fed to the input of the unipolar generator.

Unipolar generator (UPG)

IC 2 and IC 3 constitutes the unipolar generator. When input is positive, it results a negative output at IC 2 due to rectification. This negative signal is inverted by IC 3 and a positive signal is obtained at the output. When the input is negative, it is directly inverted by IC 3. Thus the output of UPG is always positive. The voltage to frequency converter responds only for positive input voltages and therefore this stage is needed.

Voltage-to-frequency converter (VFC)

In this application, the XR-4151 (IC 4) functions as a stand alone VFC operating on a single positive power supply [9]. The functional block diagram of XR-4151 is shown in Fig. 4. It consists of a voltage comparator, a one shot, and a precision switched current source. The output of the UPG is applied at pin 7 of the VFC and the VFC gives a periodic square wave. The voltage comparator compares the input voltage to the voltage at pin 6. If the input voltage is higher, the comparator will fire the one-shot monostable

multivibrater. The output of the one-shot is connected to both the logic output and the precision switched current source. During the one-shot period T, the logic output will go low and the current source will turn on with current I. At the end of the one-shot period the logic output will go high and the current source has injected an amount of charge $Q = I_o T$ into the network $R_Q - C_B$. If this injecting charge does not increase the voltage V_B such that $V_B > V_I$, the comparator again fires the one-shot and the current source injects another lump of charge Q, into the $R_B - C_B$ network. This process continues until V_B is again equal to V_I. This completes one cycle. The VFC will now run in a steady state mode. The current source dumps lumps of charge into the capacitor C_B at the rate fast enough to keep $V_B > V_I$. Since the discharge rate of capacitor C_B is proportional to V_B/R_B, the frequency at which the system runs will be proportional to the input voltage on pin 7 and is given by

$$F_o \propto V_I$$

$$F_o = KV_I$$

where $K = 0.486 \, R_s/(R_B \, R_o \, C_o)$

The input voltage range is from 0 to +10 V, and the output frequency is from 0 to 10 kHz.

Counter

The frequency output from VFC is fed to the count input of the counter ICM 7217M (IC 7) through an AND gate, and a clock signal from the timer NE 555 (IC 5) is also applied to the gate that desires the counting time. The counter 7217A is a four digit LED display programmable up/down counter
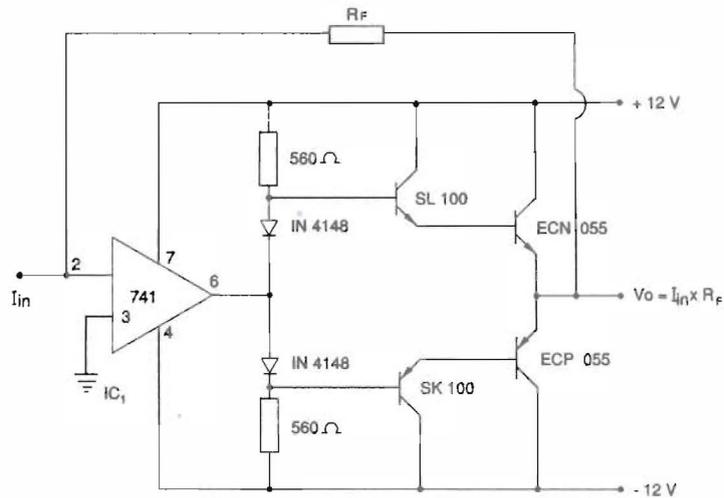

Fig. 3: Circuit diagram of current to voltage converter (CVC)