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A combined sonde for the measurement of electrical conductivity and potential gradient in the atmosphere

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ABSTRACT. The paper describes a combined sonde for the simultaneous measurement of the vertical distribution of electrical conductivity and potential gradient in the upper atmosphere during a balloon flight. The data obtained helps in evaluating the third parameter, *i.e.*, air earth conduction current at all levels. Thus all the three main parameters of the atmospheric electricity can be measured with a single sonde. A typical sounding taken with the above instrument is also presented.

1. Introduction

The three main parameters of importance in atmospheric electricity measurements are the electric field F, the specific conductivity λ and the conduction current density i given by $i=V/R$ where , R is the columnar resistance and V the potential of the atmospheric layer. The relationship between the three parameters is expressed by the fundamental formula—

$$F = i\lambda$$

Variations in F in fine weather are mainly caused by variations in λ, since the conduction current i is generally constant. Simultaneous measurements of F and λ would therefore give a complete picture of the electrical etate of the atmosphere and of great value on any programme of atmospheric electricity observations.

Balloon borne sondes to measure independently the electrical field and electrical conductivity in the free atmosphere have been developed in many countries. A sonde which could measure both these parameters simultaneously would be of great value in all atmospheric electricity studies. Hatakeyama *et al.* (1958) describes such a sonde used during the IGY in Japan. The present note describes such a combined sonde and summarizes the results of soundings made at Poona, during 1971.

2. Description

Since the first balloon borne sondes for the measurement of the electrical and conductivity of air in the free atmosphere were developed in India (Venkiteshwaran *et al.* 1952, 1953), fairly regular soundings for the measurement of the electrical potential gradient and positive electrical conductivity of the upper atmosphere, have been made at Poona during the last two decades. Simultaneous soundings using both types of sondes suspended from the same balloon were made on a few cccasions (Mani and Huddar 1965) and measurements of the conduction current made up to heights of 16 km. The individual sondes required separate ground equipment once they were released and one could not be sure that the two sondes were measuring values in the same parcel of air. With heavy pay loads the balloon could not reach great heights, and the data obtained were limited to about 18 km. Other technical difficulties arose from the reception of two close frequencies resulting in loss of useful data from either one or both the sondes. An integrated sonde to measure both the potential gradient and conductivity simultaneously and telemeter these to the ground station using a single telemetering system had obvious advantages.

The integrated sonde (Fig. 1) consists of two valve electrometers (inverted triode), one for potential gradient measurement and the other for conductivity, the two electrometers being switched in alternatively by a sequencing switch, in the input of the modulator of the telemetering system (Fig. 2).

The sequencing switch consists of a miniature motor which gears down two commutators on a printed board. One of the commutators makes one revolution in 60 seconds. The eight contacts of the commutators are alternately connected to the output of the potential gradient and conductivity electrometer valves. The moving contact on the commutator connects these to the modulator. Thus in 30 seconds four signals each of potential gradient and conductivity are switched

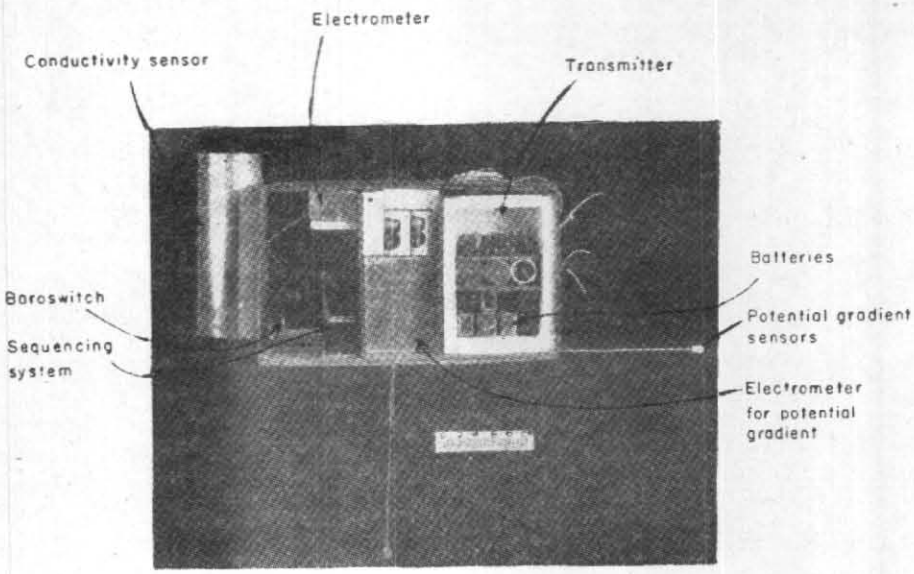

Fig. 1

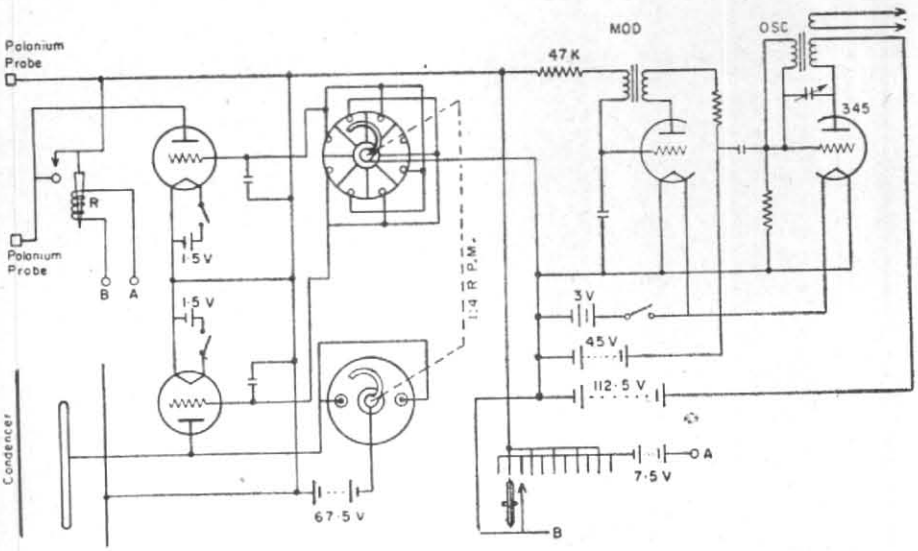

Fig. 2

Circuit diagram of integrated sonde for measurement of electrical potential gradient and conductivity

on one after the other. The second commutator makes one revolution in two minutes. The moving contact of this commutator makes a contact with two teflon insulated terminals to give a charge of —67·5 volts to the inner rod of a Gerdien condenser which measures positive conductivity. The condenser is charged once every two minutes. Since two independent electrometers are connected alternatively to the input of the modulator, more or less continuous records of both potential gradient and conductivity are obtained without loss of any significant data of either parameters.

A baroswitch is incorporated in the input of the modulator to measure the height reached by the balloon and to monitor the zero of the two systems. The baroswitch shorts the input of the modulator, through one set of contacts which are calibrated

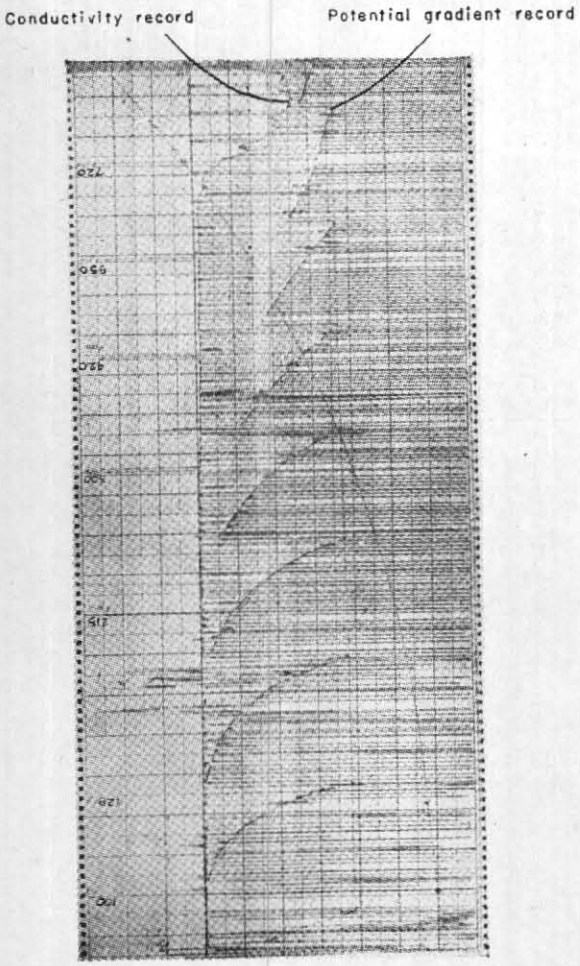

Fig. 3

Sounding made at Poona on 12 March 1971

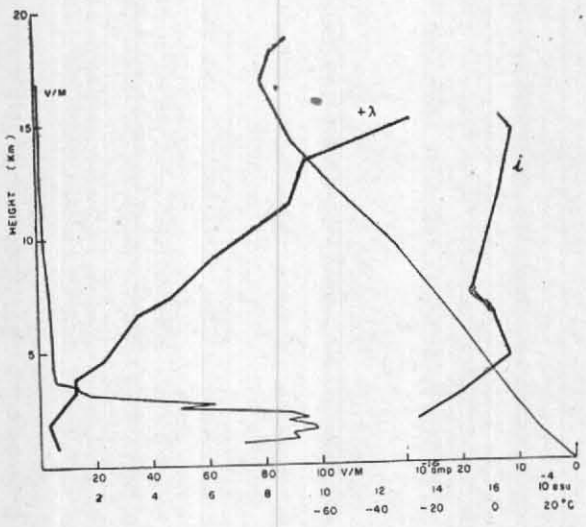

Fig. 4

Poona, 25 February 1971 at 1630 IST
clear skies, slight haze

for pressure levels to give a reference frequency. Another set of contacts operates a miniature relay in the potential gradient electrometer circuit. The relay momentarily shorts the input of the potential gradient electrometer (anode and filament) to monitor the 'zero' of the electrometer.

The important features of the combined sonde are —

(1) the sonde transmits potential gradient for a duration of 7 seconds every 15 seconds,

(2) the zero of the potential gradient electrometer is monitored at suitable intervals upto the balloon bursting point,

(3) the sonde transmits conductivity signal every 15 seconds for a duration of 7 seconds,

(4) the Gerdien condenser is charged with —67.5 volts every 2 minutes, giving a decay of the condenser for 2 minutes and

(5) pressure contacts in the form of reference frequency are given till the balloon bursting point.

Since both potential gradient and conductivity parameters are measured simultaneously, it is possible to calculate the conduction current upto the maximum height reached by the balloon. As the pay load thus has been reduced to about 2700 gm it is possible to make soundings upto heights of 30 km.

3. Results of measurements

The record of the sounding made at Poona on 12 March 1971 is shown in Fig. 3. Fig. 4 shows measured values of the vertical profiles of potential gradient and conductivity against height and the computed values of the conduction current upto a height of 27 km. The ionospheric potential for the day computed from the data was 351 KV.

4. Conclusion

The paper describes a technique using an integrated sonde for the simultaneous measurement of the electric field and conductivity of air in the atmosphere upto heights of 30 km. The measurements also give directly the vertical profile of the conduction current in the atmosphere, while the value of the ionospheric potential can be inferred from the field measurements.

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