Sensor and Simulation Notes V

Underground Testing of Close-In EM Sensors

I. Introduction

As is well known the most difficult problems in the design of close-in EM sensors are their sensitivities to the Compton current and the conducting environment. Both of these problems are closely connected with the EM pulse which is desired to be measured. Therefore it is desirable to measure the performance of such sensors in a controlled environment which is similar to the actual environment present during a surface test.

II. Electric and Magnetic Field Production

Figure 1 shows the general geometry to be used for this purpose. A beam of γ-rays from the device is collimated and passed through a sealed conducting box containing air and a lead γ-ray attenuator to collect most of the Compton electrons. This configuration can be used to produce strong electric fields by making R very large or it can be used to produce magnetic fields by making R small and allowing currents to flow.

The electric field attainable by this technique approximates the "saturation" electric field in the near field region, providing R is larger than $\frac{l}{\pi r^2 \sigma}$ where σ is the conductivity of the air.

The magnetic field attainable by this technique can be approximately calculated from

$$J_c = e n_e = e n_\gamma r_e / r_\gamma$$

where J_c is the Compton current density, n_e is the electron flux, n_γ is the gamma flux, r_e is the electron range and r_γ is the gamma mean free path. This gives a current approximatley as

$$J_c \simeq 2.62\times10^{-8}\,\dot{\gamma} \qquad \text{amps/meter}^2$$

where $\dot{\gamma}$ is in roentgens/sec. From this the maximum magnetic field (near the boundary of the irradiated region) is given by

$$H_{max} = \frac{r}{2} J_c$$

or

$$H_{max} \simeq 1.31\times10^{-8}\,\dot{\gamma}\, r \quad \text{amps/meter}$$

where r is in meters or

$$B_{max} = \mu_0 H_{max} \simeq 1.65\times10^{-14}\,\dot{\gamma}\, r \quad \text{weber/meter}^2$$

III. Experimental Technique

By proper variation of parameters E and H field sensors can be subjected to various environments to test their sensitivities to other parameters such as the radiation intensity and other field components. The fields themselves are measured by the output voltages and currents from the γ-ray attenuator. The radiation intensity is measured by standard techniques.

IV. Examples

Figure 2 shows a configuration which might be used to test a sensor designed to measure the radial E field. Note that a "window" for the γ-rays is provided through the lead attenuator. This is so that two such sensors have everything alike except that the electric field is in opposite directions and therefore the outputs should be identical except for sign reversal. A third sensor is shielded such that its output should be zero.

Figure 3 shows a configuration for testing the response of a sensor designed to measure the vertical E field. By geometric means a radial E field is changed to a vertical E field. Again a second sensor can be shielded to give (hopefully) no output.

In Figure 4 is shown a configuration for testing H field sensors. The one in the center of the cavity should give no output. Figure 5 shows a method for checking the response of H field sensors to electric fields, i.e., shield one of the sensors against the E field.

These examples are not meant to exhaust all the variations on this technique, but to illustrate what can be done. For any real test the various problems will have to be looked at very closely to determine the optimum and most efficient configurations.

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Fig. 1 SENSOR TESTING GEOMETRY

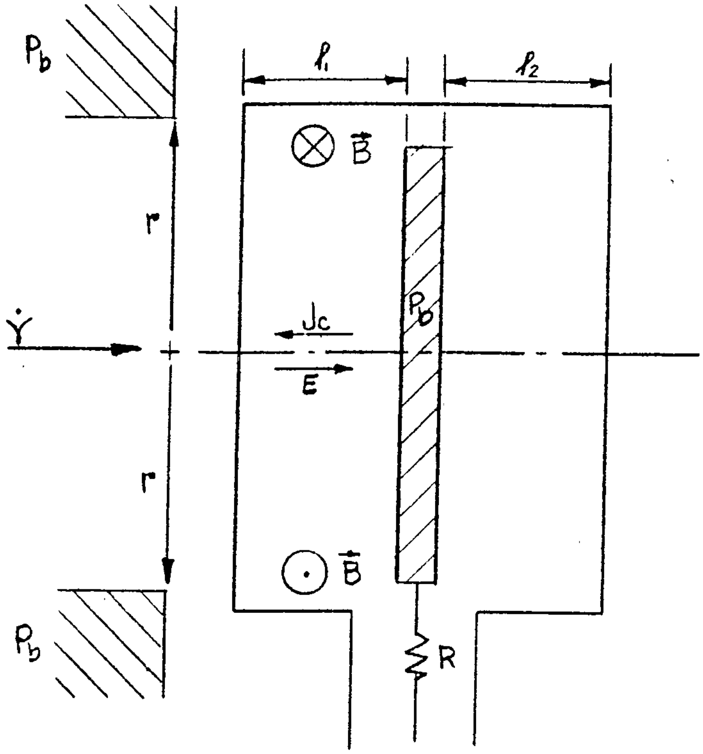


Fig. 2 RADIAL E FIELD

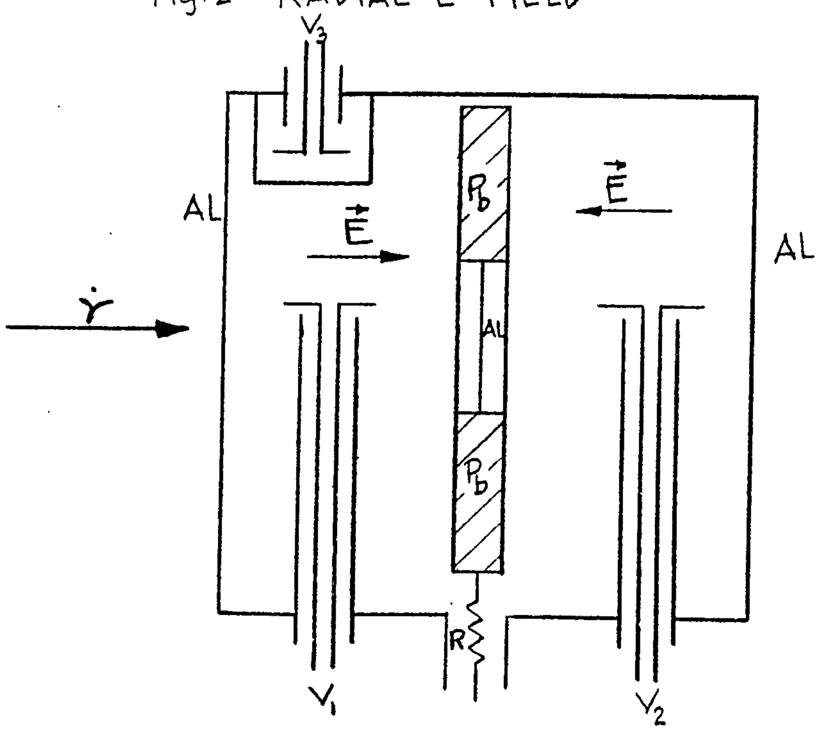


Fig.3 VERTICAL E FIELD

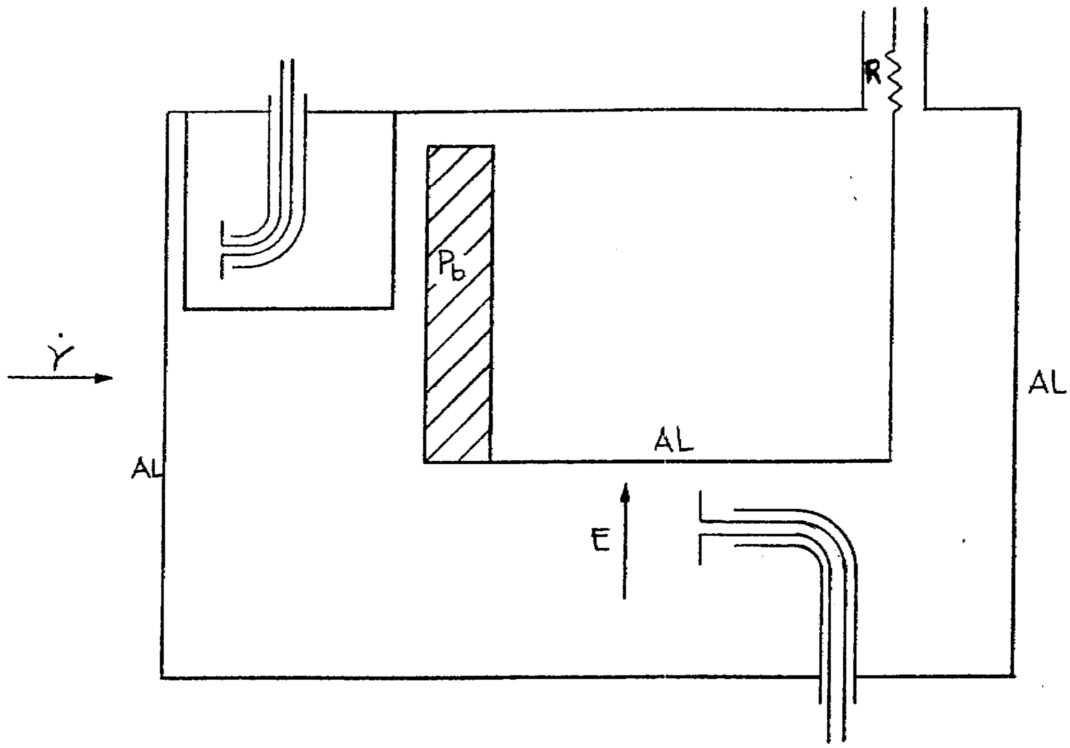


Fig.4 AZIMUTHAL H FIELD

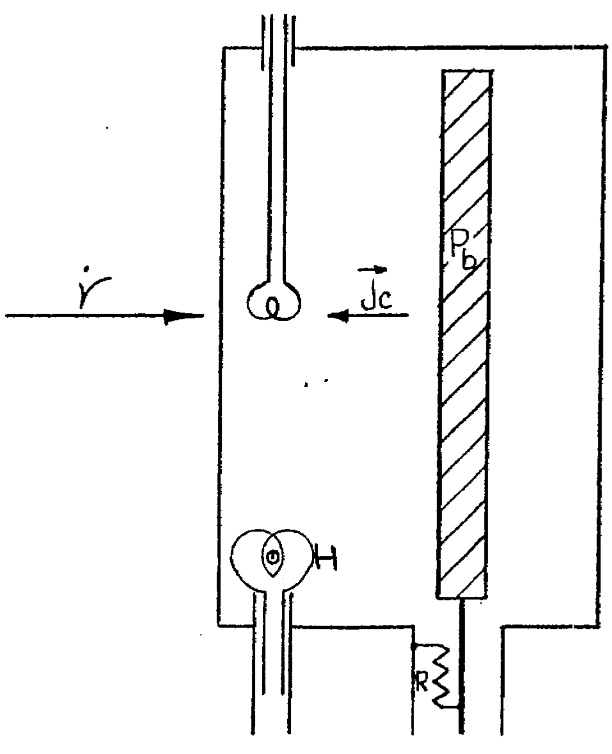
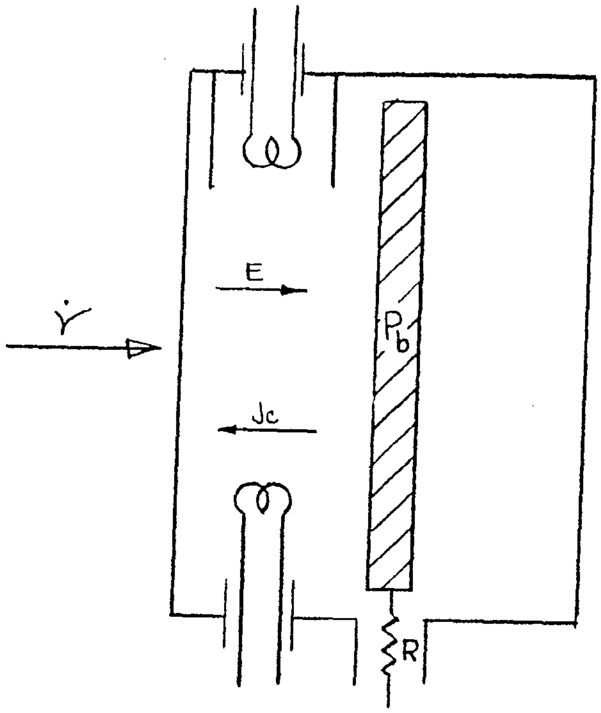


Fig. 5 AZIMUTHAL H FIELD



ELECTRIC FIELD EFFECTS