Variable Sensitivity Automatic Ionization Chamber

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An all quartz electroscope system is described whose sensitivity may be varied over a wide range by changing one potential. Like other previously described systems, it accumulates a definite quantity of electric charge, for given potentials, and then automatically recharges itself. When this recharging occurs an electrical pulse may be taken off for recording purposes. It is possible to change the sensitivity by a factor of 500.

IN two previous communications to this Journal^{1,2} an automatic ionization chamber has been described. The particular advantages to this device are (1) an electrical pulse is given out when a certain amount of charge is collected, thus facilitating telemetering of the information, (2) in securing the data, time measurements only are involved, resulting in a minimum of possible error since time intervals can be measured with great precision, (3) the electrical circuitry needed to accompany the instrument is simple, and (4) the reliability is very high as illustrated by its use for cosmic-ray work over a period of 9 yr.

The sensitivity of the quartz systems used in this instrument is determined by the size of quartz fiber used, its length, and its nearness to the collector. These are fixed when the instrument is made and when the inner electrostatic shield is used² (as is usually the case) there is no control over the sensitivity after the ionization chamber is filled with argon. For a laboratory instrument, where long time stability is not important, the introduction of an auxiliary potential allows the sensitivity to be changed at will over a very wide range.

Consider Fig. 1. Potential V_0 is normally 200 to 300 v. Ion collector C is charged to V_0 when the fiber F touches B. Shield S_1 is connected to the surrounding ion chamber while shield S_2 protects the quartz system from other fields, thus making the sensitivity independent of changes in V_0 . (See reference 2.) The operation of the system is as follows: Let the potential of A be at V_0 plus some small potential. Suppose collector C has just been charged to V_0 by the fiber F having touched the graphite-coated quartz piece B. Now let the potential of conductor A be increased. There will come a time when the attraction of A for fiber F will cause F to touch A. F and C will then become charged to potential $V_0 + \Delta V$, F will be repelled and will then strike B. The fiber will then be repelled back to A. The fiber will thus continue to oscillate in the same manner as does the familiar pith ball when suspended between oppositely charged bells. However, if the potential of A is adjusted to be just under this critical value and the fiber is at potential V_0 , only a small change in charge on C will cause F to fly over to A, whereupon it will be repelled to B and then it

will resume its initial position. Thus the amount of electric charge that needs to be collected by C to result in a pulse being delivered to the amplifier, may be varied by changing one potential. It will be noted that the output pulse is nearly independent of the sensitivity, especially when the sensitivity is high.

In the systems made, the whole device is made of fused quartz and the various parts that need to be electrically conducting are coated with colloidal graphite. Connections to the conducting parts are made by means of fine platinum wires which are cemented to the quartz by means of silver chloride. Fiber F is 8 to 9 μ in diameter and 7 to 8 mm long. The diameter of pieces A and B is 2 mm and the spacing between centers about 4 mm. Under these conditions, the critical potential ΔV_c is about 110 v. The construction allows the ion chamber, with its quartz system, to be baked up to 380°C before filling it with pure argon.

The performance of one of these systems in a 25-cm diam spherical chamber with 8 atm of argon is shown in

FIG. 1. The system is made entirely of fused quartz. Fiber F will oscillate between parts A and B if potential A is sufficiently high with respect to that of B. Just under this critical value, the charge sensitivity is very high.

¹ H. V. Neher, *Rev. Sci. Instr.* **24**, 99 (1953).

² H. V. Neher and A. R. Johnston, *Rev. Sci. Instr.* **27**, 173 (1956).

FIG. 2. The sensitivity of the system may be changed by a factor of about 500 by changing the potential of one electrode.

Fig. 2. Since the intensity of the radiation that causes the ionization is proportional to the reciprocal of the time

interval for constant ΔV , it is convenient to plot $1/t$ vs $1/(\Delta V_0 - \Delta V)$, where ΔV_0 is an arbitrarily chosen potential that corresponds approximately to that potential ΔV to just cause the fiber to oscillate continuously between A and B.

The line in Fig. 2 has a slope of 1.00 as might be expected. Actually this same slope of unity continues over a factor of 200 change in sensitivity. As one approaches the critical value of potential that results in instability of the fiber, the sensitivity continues to increase and the instrument may be used without difficulty until the sensitivity increases another factor of 5 beyond the point "a," in Fig. 2 where linearity ceases. Since the sensitivity of these systems to electric charge is proportional to the change of voltage required to cause a pulse, these adjustable systems may be made something like 500 times as sensitive as those described in the references.

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