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INVESTIGATION OF ATMOSPHERIC IONIC SPECTRA.

By: Seville/Chapman

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The period of this report was given over mostly to construction of a new and longer equipment called 147 cm Ion Mobility Apparatus.

As explained in the previous report the reasoning is that length is the only parameter remaining that can be easily controlled to increase resolution and this length certainly is great enough to reach one percent resolution for dk/k where k is mobility if the limitation is only on dimensions. Thus if lesser resolution is obtained it will most likely be due to a physical spread in mobility, for example as a consequence of the lengthy time of measurement (about 0.2 second).

At least four negative ions are seen in a band 12 percent wide. Although the present resolution is the best reported we would like to improve the resolution still more if possible in order to investigate these ions at something better than close to the resolution limit. It remains to be seen how the apparatus will work.

The figure shows a scale drawing in three dimensions. An eight-inch aluminum channel supplies the rigidity. Supporting insulating rails are made of Delrin, which supposedly has unusually good dimensional stability especially relative to humidity. Equipotential rings are held in place by nylon 6/32 threaded rod, nuts, and washers. In addition to adjustments the function of the threaded rod, half an inch from each support, is to accommodate minor random inaccuracies in spacing of a few thousandths of an inch. There are strictly to be no cumulative inaccuracies. Edges of all rings and other metal parts are rounded. No particular problem is anticipated working at 30000 volts. The maximum voltage at which the gate can be operated is 25000 volts because of the insulation of the isolation transformers, but additional voltage can be used for the aging space. The bleeder resistors between rings are pairs (220K + 270K) matched to one percent.

A new commercial digital voltmeter, accurate to 0.1 percent is now available for high voltage measurement. This tends to match the expected diffusion of ions with 25000 volts on the apparatus (it can be shown that percent uncertainty in mobility due to diffusion is proportional to the square root of voltage across the drift space--for 25000 volts it is 0.12%.

Minor technical improvements are being made in the special electronics which, however, is much more convenient. We discuss one of the electronics packages in the next few paragraphs.

The electrode chamber shown full scale in the drawing is somewhat longer than the earlier chamber, making it possible to accommodate the entire electronics inside except bias for the shield. One of several operational amplifiers is used, normally with a gain of 100X. One chamber of three that are interchangeable has a screwdriver switch inside for changing the gain.

The input resistor R_1 may vary from about 100 megohms to 1000 megohms. Sensitivity is proportional to R_1, noise goes with the square root, and frequency bandwidth inversely. It is not obvious what the optimum value of R_1 is. For example with less than maximum voltage or a longer measuring time, the separate ions are measured in the space between the shield and the teflon insulated electrode at times that are more spread out, requiring a lesser frequency response (permitting a higher R_1). On the other hand more voltage means a shorter measuring time and also greater intensity.

Sensitivity is also influenced by the bias voltage (greater with greater voltage), by pulse length, and by electrode spacing from the shield. The spacing is controlled by two sets of three nylon screws, alternate sets of which pull the shield toward the housing and push it away. When all are tight, the arrangement is rigid. The 100K bias resistor nearest the shield is intended to reduce the chance of burning out the operational amplifier A, if a short circuit occurs. Accoustic noise, which is not as much of a problem in the newer amplifiers, is increased by close spacing of the shield, and by high bias voltage.

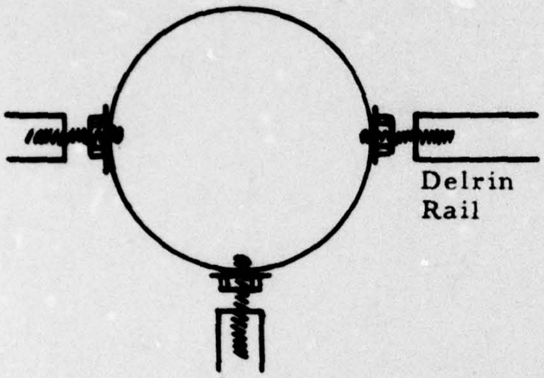
The amplifier which supposedly has an open loop amplification of the order of 90 to 100 db (30000X to 100000X) endeavors to hold the electrode at zero signal volts. Thus all incoming (positive) current goes out through R_1, the lower end of which goes to a (negative) potential which is definite fraction of the output voltage. The greater the amplification factor, and the less the gain controlled by the switch, the lesser the importance of the electr[illegible]nt capacitance (a very desirable aspect of feedback with operational amplifiers).

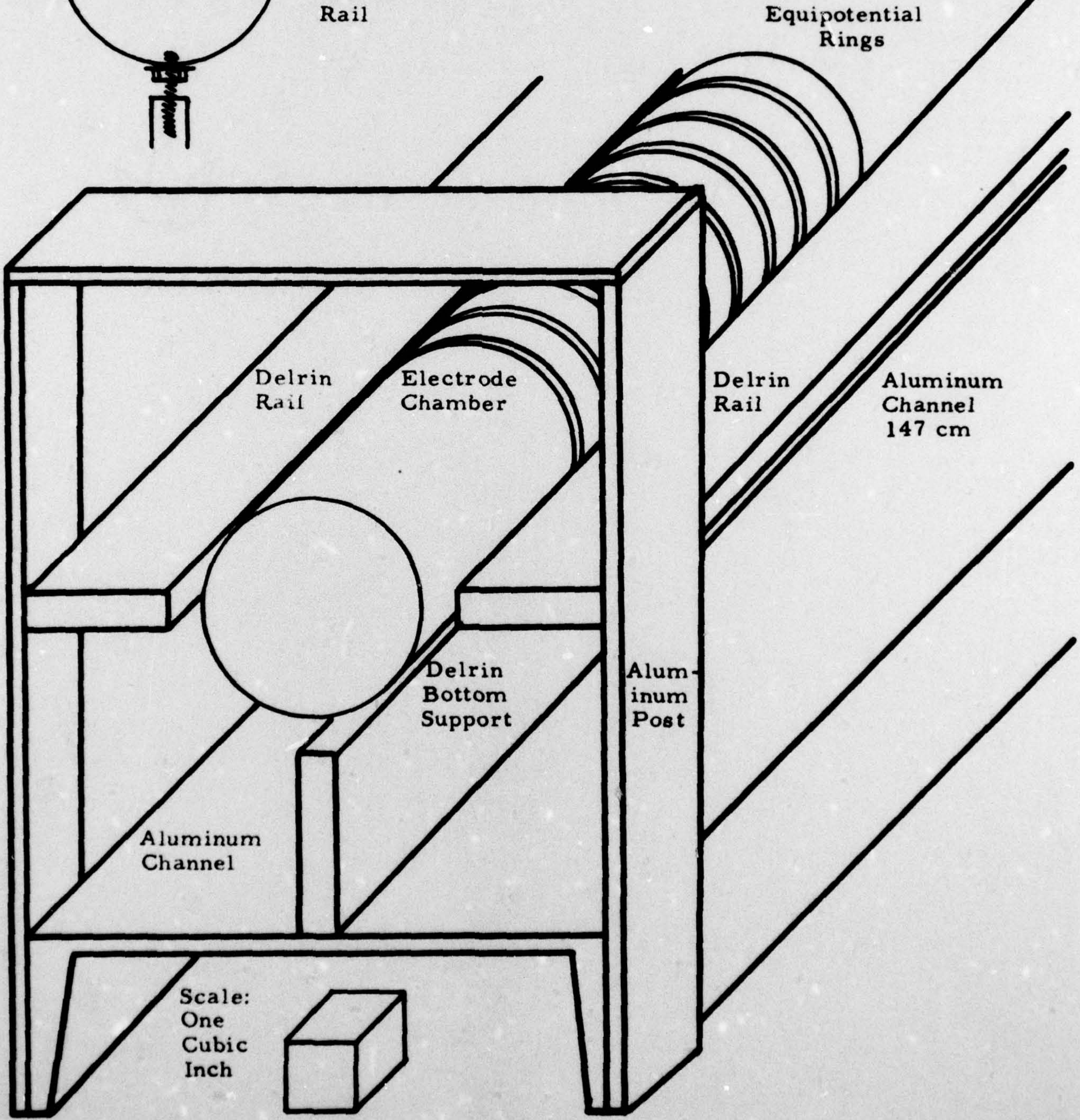
The test signal to the non-inverting (positive) input is useful for determining gain and frequency response. Normally the no. 3 pin is grounded.

The next report will tell how successful the long mobility apparatus is. An unusual difficulty will have been discovered, isolated and overcome.

147 CM ION MOBILITY APPARATUS

Apparatus consists of 3-inch brass rings mounted between 6-32 threaded nylon rod screwed into three Delrin insulating rails mounted on an 8-inch aluminum channel. Nylon nuts and washers adjust position of rings. Rounded ring wall is 1/16 inch thick, to 1/4 inch thick at high voltage end. Drawing is to scale in three dimensions (see example of one-inch cube).





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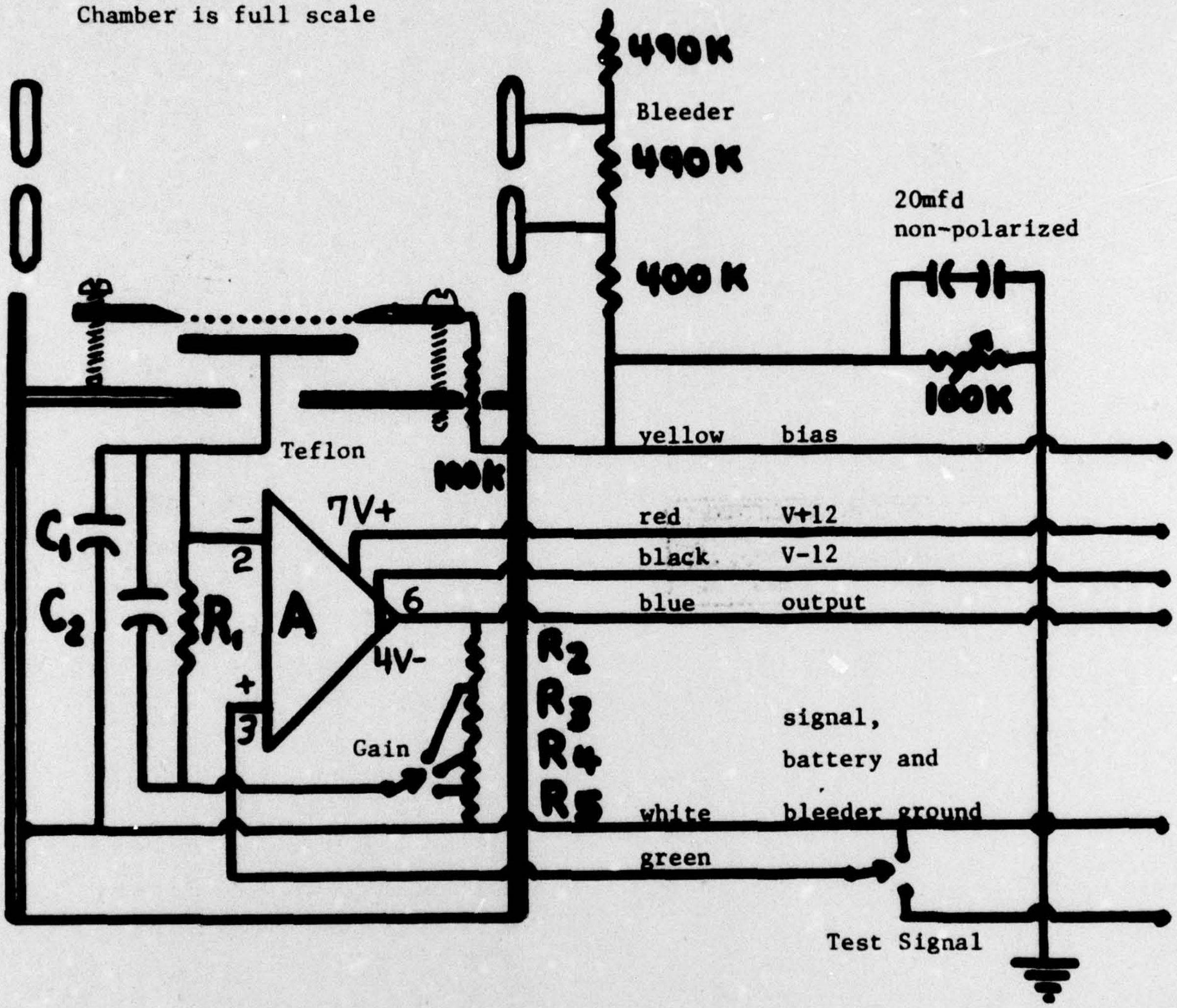
ELECTRODE CHAMBER

Chamber is full scale



R_1	100 to 1000 Megohms	
R_2	usually 10000 ohms	
		Gain 10X
R_3	1000 "	
		Gain 100X
R_4	100 "	
		Gain 1000X
R_5	11 "	

Small shunt capacitances C_1 and C_2 influence frequency response.

Amplifier may be: Analog Devices AD523LH
Burr Brown 3522L
Function Modules 380K

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13. ABSTRACT

The objective of this project is to explore problems of atmospheric ionization and corona discharge by measuring ion mobility under conditions of high resolution. The period covered by this report involved primarily construction of a longer apparatus referred to as 147 cm ion mobility apparatus. Additional electronics was also in work. The intention is that both the existing 24 ring apparatus and the new equipment which will accommodate 72 rings can be operated in essence simultaneously. At the conclusion of the period some essential elements required some additional work.

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