# Automatic Device for Ion Fields Measurement

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***Abstract.*** *Concentration of light negative ions in the atmosphere has a favourable influence on the human health. For better exactness of measurement of ion fields concentration in living and working rooms and for elimination of the influence of a servicing person an automatic measurement device has been designed and completed exploiting the aspiration measurement method. The main emphasis has been put on realisation of the electronic source of polarisation voltage with desired properties. Comparative measurement with use of different types of sources has been carried out and the long-term measurement of light air ions in laboratory has been documented.*
***Keywords****: Air Ion, Measurement, Aspiration Condenser*

## 1. Introduction

An increased amount of light negative ions in the atmosphere has an auspicious influence on the human health [2]. It influences the respiratory organ, blood circulation, central nervous system, and human well-being.

Using the method of the aspiration ionometer (condenser) [1], [2], it is possible to measure the ions concentration with a good resolution in a broad range of their mobility. Until recently, the application of this method was limited by a long measuring time necessary for the attainment of a sufficient resolution, and by a complicated evaluation of the measured data. The exactness of the measurement is significantly dependent on the electric field in the vicinity of the ionometer, on the arrangement of the measurement configuration and elimination of accidental factors (especially noise). The derivation in calculation of spectral characteristics from the saturation characteristics emphasises noise and it is necessary to use effective filtrations of the measured data. Contemporarily the measurement must be carried out for a long time with a record of a bigger number of parameters characterizing the surrounding environment and measurement conditions [3].

## 2. Method

To determine the concentration of different kinds of ions (light, middle and heavy ones) of both polarities and the environmental temperature, an automatic device was developed. It's main goal is to eliminate a spurious electric field in the vicinity of the measurement device caused by the operator and simplify the measurement. An aspiration condenser with a variable electric field and an electrometer were used for the measurement of a low current generated by the impact of ions on the condenser electrode. The principle of the measurement method is obvious from the Fig.1. A known amount of the investigated air *M* passes through a cylindrical condenser to which a variable dc voltage *U* is applied. The ions will be attracted by electrostatic forces toward electrodes and will cause passage of a low current *I* through the circuit with the condenser. From measured data the spectral characteristic were calculated. The concentration of ions will be proportional to the magnitude of this current according to the relation:

$$n_k = \frac{I}{M.e}\cdot\left[I - \frac{dI}{dU}\right]$$

where $e$=1,6 . $10^{-19}$ is the electron charge. The second member of the equations expresses the steady leakage current of the condenser that we try to minimise. The collector of the condenser will not collect ions whose motion is lower than the minimum motion given by the relation:

$$k_m = \frac{v_x.\ln\frac{r_2}{r_1}}{2.l.U}\cdot\left(r_2^2 - r_1^2\right)$$

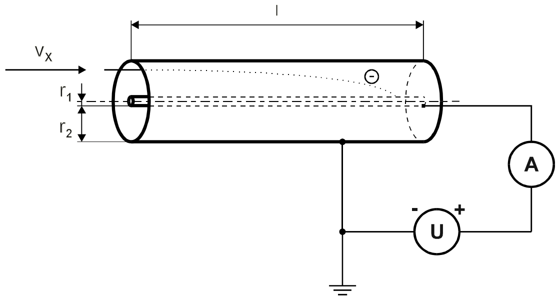


Fig.1. *Principle of the ions measurement by of the aspiration*

The high air humidity in a cave ( >60% ) decreases the measurement accuracy. After a 30 minute measurement, the leakage currents of the aspiration condenser increase to an unacceptable level, owing to the influence of water molecules. As the condenser must be dried prior to next application, the measurement gets disproportionately long. To eliminate the influence of humidity on the measurement accuracy an aspiration condenser of a new design is used. To increase the leak resistance of the aspiration condenser, we used a heated teflon insulator (35°C) that decreases the dew point and, as a result, the condensation of water on the insulator.

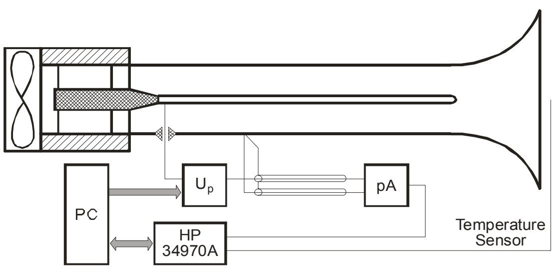


Fig.2. *The configuration of magnetic measurement of ion concentration*

The configuration of magnetic measurement of ion concentration is presented in Fig. 2. The collector of the aspiration condenser is attached through serially connected source of polarization voltage on pico-ampere-meter realized with an impedance transceiver. The impedance transceiver has an input resistance of $10^{11}\Omega$ and an adjustable amplification 1, 10 and 100. Using the measurement central HP34790, it enables measurement of currents in the range of $10^{-13}$ up to $10^{-11}$ A. The time regime of the measurement and data acquisition is adjusted in the control computer using the BenchLink programme. There is a temperature sensor on the second channel HP34790 for recording of temperature changes during the measurement. The processing itself is carried out in the MATLAB program. The source of polarization voltage must have the biggest possible resistance of both output clamps towards the earth potential (>$10^{14}\,\Omega$) and adjustable voltage from 0V to 500 V for measurement of the saturation characteristic in the whole required range. A battery of 15 pieces of 9V cells was used in the first experiments. For the used aspiration condenser a voltage of 135 V matches to the limiting mobility for the measurement of light ions. Heavier ions would require higher voltage. The impossibility of automatic adjustment of voltage is a disadvantage of this configuration. The charged condenser functioning as a source of polarization voltage has similar properties. An advantage of both solutions is big insulation resistance and minimum inducible spurious voltage. The impossibility of program switch-over of polarization voltage is a disadvantage. For automatic measurement a source of subsidiary voltage, whose block diagram is presented in Fig. 3., has been developed. The output voltage is taken after rectification from the first secondary winding of a special transformer. This winding is on an individual Teflon skeleton. Conductors between the transformer and the output connector are self-supporting. The primary winding is induced from a generator (30 kHz) through an amplifier with controlled gain.

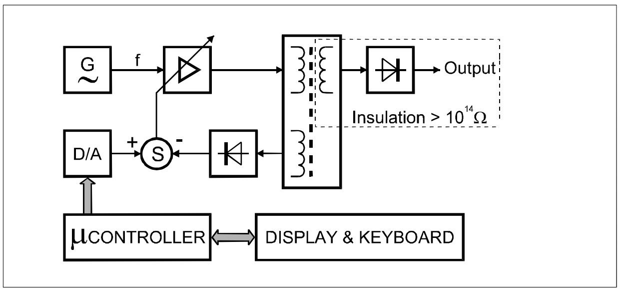


Fig.3. *Block scheme of the polarization source.*

Alternating voltage of the feedback is lead from the second secondary winding and it is compared after rectification with reference voltage on the D/A output of the transceiver. The required reference voltage is adjusted by program in a control computer and micro-controller. The range of the output voltage is 20 – 500 V with a step of 1 V and an accuracy ± 0,5 V. The described connection has an insulation resistance of >$10^{14}$ Ω.

## 3. **Experimental results**

The aspiration condenser had the following parameters: the outer electrode (without aspirating input) has a diameter $r_2$=82 mm and length $l_v$ = 500 mm, the inner electrode has a diameter $r_1$ = 15 mm and has a length l = 460 mm. For the speed of the air flow v = 4,3 m.s$^{-1}$ and capacity of air through-flow $M$ = 2,2.10$^4$ cm$^3$.s$^{-1}$ the ions concentration is given in saturation area by the relation $n = I$ . 2,84.10$^2$ [ions/cm$^3$, pA].

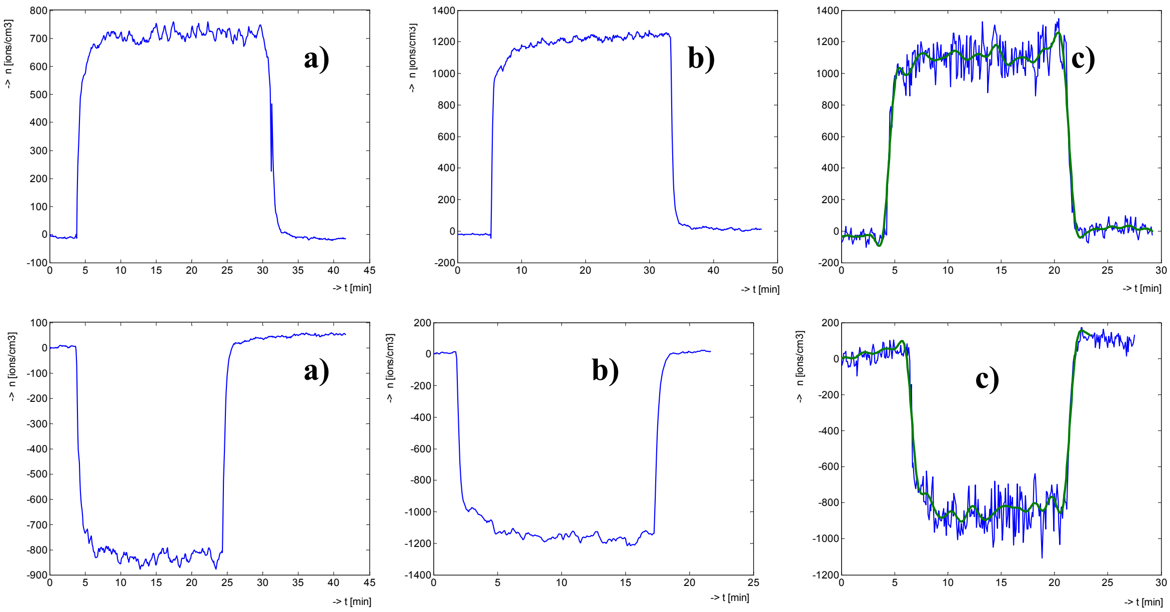


Fig.4. *Measurement of natural ions concentration in the laboratory with use of a source formed with a) batteries, b) condenser or c) electronic source*

From the properties of the source of polarization voltage high insulation resistance against the earth's potential is important as well as the value of spurious voltage induced on it. In Fig. 4 there are time courses of leakage current of the aspiration condenser and measured current for concentration of ions in the laboratory formed without the ionizer with use of a source formed with batteries (50V), condenser or electronic source. As results from the presented comparison, all three sources can be used for measurement of ions concentration by the aspiration technique. The battery and condenser are similar. The discharge of the condenser itself is by several orders longer compared with the measurement time. That is why measurement errors are minimal. The electronic source of polarization voltage causes current noise. It is caused by spurious charges from the vicinity and from the regulation activity. The signal-to-noise ratio for natural concentration in living rooms is approximately 8. It is possible to increase this ratio by filtration of the measured current (the thick line on FIG.4c). Fluctuation of the ion field as well as the measured current is higher than the noise of polarization voltage. The electronic source of polarization voltage is suitable for the measurement.

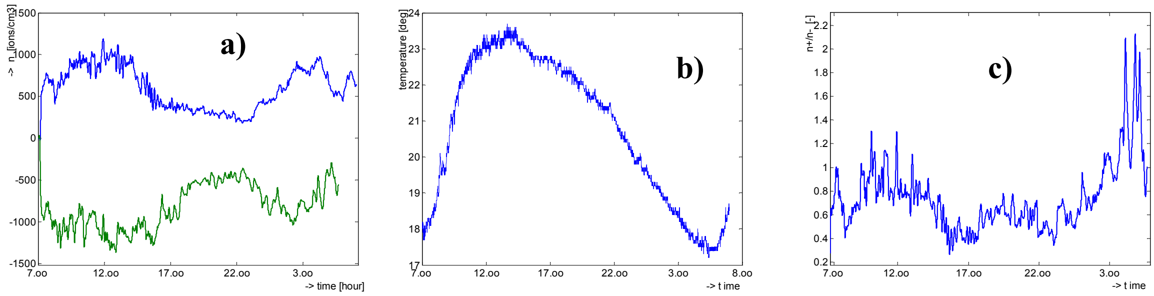


Fig.5a. *Time courses of a) the concentrations of positive and negative light ions, b) the temperature, and c) the ratio of negative and positive light ions in the laboratory ISI measured during the whole day.*

The described device will enable long-term measurements of air ions concentration without need of a present servicing person. There are presented concentrations of positive and negative light ions in Fig. 5a in the laboratory ISI measured on 17th May 2002 during the whole day. It was sunny weather that day, the laboratory widows are oriented to the southeast, the temperature of the room was measured continuously. (Fig. 5b) Relative humidity was 45% (constant during the measurement) and the pressure of 765 mmHg. The concentration of negative ions was higher than that of the positive ones, as seen in Fig. 5c.

## 4. **Conclusion**

The presented automatic device for a precise measurement of ion concentration in the atmosphere makes it possible to determine the light air ions concentration in living or working rooms. Long-term measurements of air ions concentration higher than 100 ions/cm$^3$ can be carried out without the presence of a servicing person. The used electronic source of polarization voltage meets the requirements and does not decrease the exactness of the measurement.

So far, the knowledge about the effect of negative atmospheric ions in the human organism is poor. Despite this fact, we consider the amount of ions of different elements in the human body surroundings and their precise control as one of the most important parameters for the enshrinement of the human health.

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