CONTINUOUS RECORDS OF THE ATMOSPHERIC POTENTIAL GRADIENT AT YENCHING

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Abstract.

Self-recording system is devised and used to measure potential gradient at Yenching. In fine weather the results show two maxima and two minima for a whole day. During raining potential gradient is constant at zero value, except when lightening and thunderstorm occur in which case the potential gradient changes rapidly both in magnitude and direction.

1. Introduction

In recent years several measurements of atmospheric potential gradient[1] and air-earth current[2] have been made in foreign countries; but in China very few such experiments have been performed. During 1931 observations were made at Yenching by Chang Wen Yu on the ionization of the atmosphere, and in the following year preliminary work was done on the potential gradient by Ch'en Jen-lieh. Unfortunately during that period no self recorder was provided so that readings were taken only several times a day.

In the present work a continously recording device has been fitted to the electrometer which can give very reliable photographic records for a whole day. Continous results have been obtained so far for the three months: March, April and May. In this paper the typical results will be presented and discussed according to the weather conditions.

(1) Indian Journal of Physics Vol. 5, Part 7, Dec. 1930.
(2) Physical Review Vol. 37, No. 1, Jan. 1, 1931.

2. Apparatus and Procedure

A. Apparatus.

The essential parts of the apparatus used are: a collector, an electrometer, a source of light, and a rotating camera.

The collector is made of a long piece of wire of good insulation. As an equalizer one end of the wire is sharpened and polonium tubes packed in tin-foils are fastened to it. (The use of these two together is not necessary but it makes the equalizing process more complete in case one is not sufficient). The wire is stretched out from the window of the laboratory and the other end with the equalizer is suspended by another wire insulated from this and attached to a tree. For a long interval during the period of performing this experiment, the equalizer is 15 meters from the Physics Building and 2.8 meters above the ground. But before March 21, the height of the collector was 6.3 meters above the ground, and after May 1, two similar collectors are used. The lower one is about 2.8 meters above the ground, while the higher one is one meter above this, so that the potential to be measured is much lower and the records give directly the potential gradient.

The electrometer is the Dolezalek type. One pair of quadrants is grounded while the other can either be grounded, connected to a battery (for calibration), or to the collector by means of a three-way switch made of paraffin and mercury. A potentil of about 160 volts is applied to the needle through a high resistance and a reversing switch so that the needle potential can be reversed when the potential to be measured is negative. All the connecting wires and keys are well insulated. Fig. 1 shows the arrangement of the electric system.

As the source of light an ordinary flash light bulb is used. The case and socket of this bulb is so designed that when the bulb is in position, the filament is vertical behind a narrow slit. Two lenses, one placed before the slit while the other before the electrometer are employed to condense the light from the source. The rotating camera is at a distance of about 20 cm. from the reflecting mirror of the electrometer. The cylindrical lens, 12 cm. in length, with axis parallel to the axis of

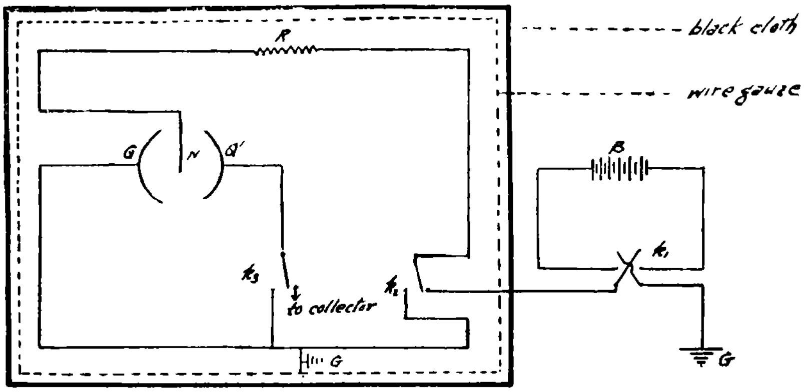


Fig 1 Electrical System

the drum, on the case of the camera has the function of condensing the reflected slit-shaped image into a spot. The drum has a period of 12 hours. The diagramatic arrangement of the whole optical system is given in figure 2.

The electrometer is placed inside an earth connected wire-gauze case so as to be shielded from any electrostatic disturb-

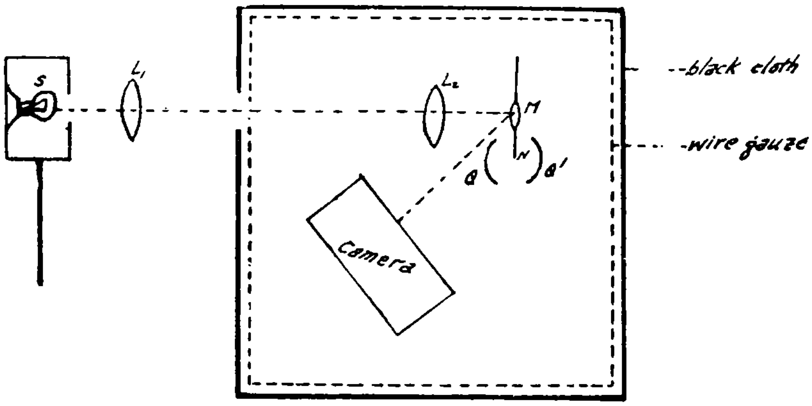


Fig 2 Optical System

ances. In order to insure that no other light besides that from the source can enter the camera the latter is also placed inside the case and the whole case is covered with black cloth except a strip, 3 or 4 cm in width, to permit the entrance of the light from the source.

B. Procedure.

The electrometer is first adjusted both mechanically and electrically so that there is approximately no shift of zero position when the needle is charged and discharged. The reflected image on the drum when both quadrants are grounded is adjusted to a proper position by altering the positions of the source, the condensing lenses, the electrometer, and the camera. The intensity of the image is at the same time observed. The range of the deflection (of the image) on the drum is then tested and the final adjustment of the electrometer made.

Since the period of the drum is 12 hours, the bromide paper has to be changed every 12 hours. This is done every morning and every evening at 7:30. Zero readings are taken right after putting on, and before taking off of the paper, so that the shift of zero, if any, may be noticed as soon as possible. (There is in reality no shift of zero for two weeks or more after an adjustment.) After the zero reading has been taken, the collector is placed in position, clockwork of the drum started, and everything not disturbed till 12 hours have been passed.

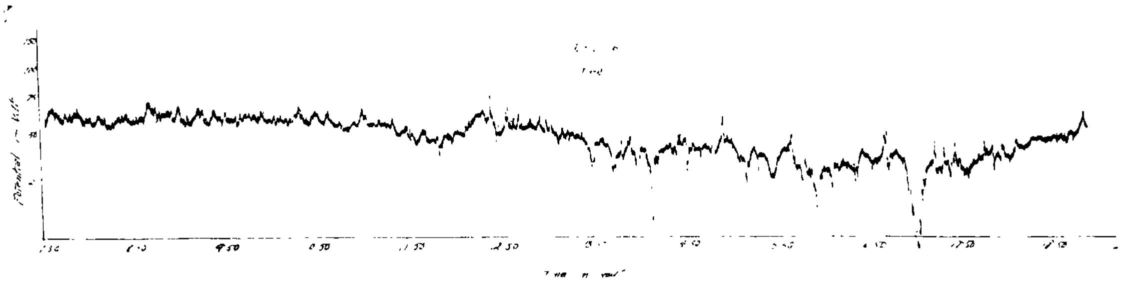
The needle potential is measured frequently and kept nearly constant at 160 ± 10 volts.[3] The calibrations are made on the bromide paper once a week and when necessary at any other time by applying known voltages to the quadrants. After the development of the paper, the deflections are measured by a ruler, and a curve is plotted with deflections against voltages.

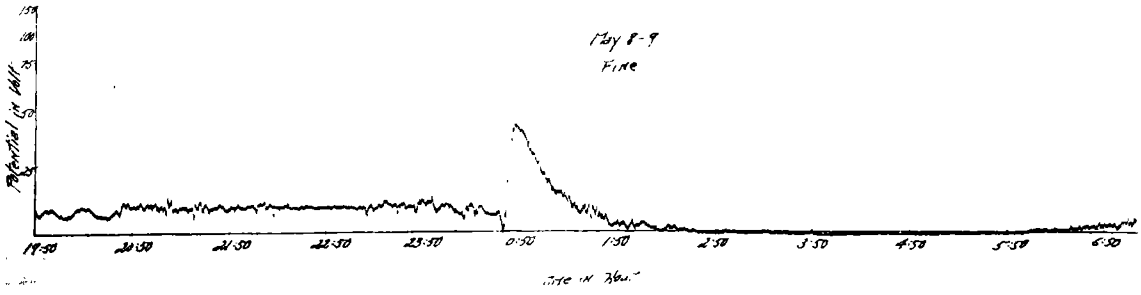
3. Results and Discussion

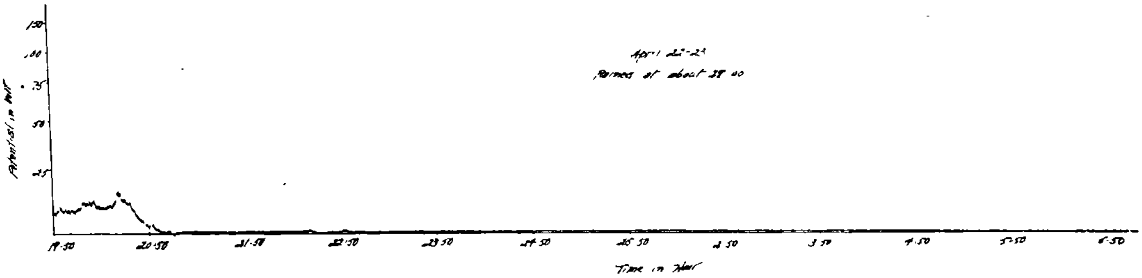
The results are classified into 4 groups according to weather conditions. Since, however, it is not possible to have very close observation and accurate record of the weather condition, the general condition for the whole day is taken as that of the day. The weather condition at night is obtained by combining that of the preceeding evening and the following morning except in case where special changes have been noticed at night.

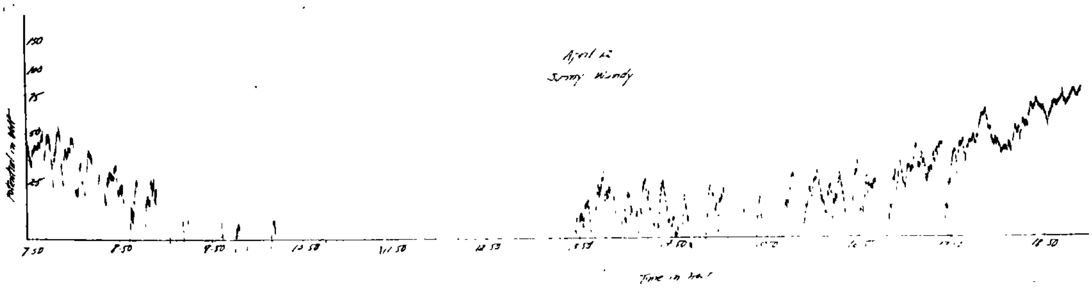
(3) Ten volts difference in the needle potential has not appreciable effect on the calibration.

RECORDS OF THE ATMOSPHERIC POTENTIAL GRADIENT









A. Fine weather.

It is very hard to define what is fine weather. In the present case, if in a day there is no wind, rain, clouds, and other abnormal conditions, then it is taken to be fine. During this period (from March to May) there are usually very few days that satisfy this condition. The first figure of the Plate is a curve which represents the change of potential in the day time. It gives two maxima at about 9 and 19:00, and a minimum at about 15:00. The maximum reaches about 50 volts per meter and the average during the day is about 30 volts per meter. These values are much lower than those obtained in most places (western countries), but it is very nearly the same as that in India[4]. The other minimum occurs at 4 at night. The second figure of the Plate gives a record of a fine day preceeded by rain and wind. It does not give the same shape as the usual ones. This is due mainly to that the weather condition after abnormal cases, though seems to be fine, is really not. Since there are very few days that are of fine weather during this period, very definite conclusions can hardly be drawn.

B. Cloudy weather.

The atmospheric potential gradient does not seem to be affected much by clouds except rain clouds which contain a large amount of water vapor. The variation seems to be smaller than that of fine weather. Detail studies of the effect of clouds on potential gradient requires detail studies on the nature and type of clouds.

What is stated as gloomy weather means that the sky is covered by rain clouds. Under such condition, the potential usually drops to very low value (a few volts per meter only). This may be due to the condensation of water vapor upon free ions in the air as nuclei which reduces the mobilities of these ions, so the conductivity in the upper atmosphere is much smaller, hence the potential gradient in that region is large and that near the surface of the earth lowered.

C. Raining days.

(4) Indian Journal of Physics Vol. 5. Part 7. (Dec. 1930).

The potential gradient during rain is usually zero except when there are lightning and thunderstorms. The potential before raining is either low or normal, according to the condition at that time. When rain falls suddenly, the potential just before raining is normal and drops suddenly to very low value as soon as it begins to rain. The third figure of the Plate is a case where it was very gloomy for a long time, and the potential was low before raining. The constancy of the potential during raining is shown by the third figure of the Plate. The constant zero-value of the potential gradient may be explained by the fact that during raining the conductivity is very high, and continuous currents flow between the atmosphere and ground.

When lightning discharges occur the potential gradient often reaches many hundred volts per meter. The change of potential gradient is so large and rapid that sometimes the needle of the electrometer even attaches to the quadrants.

D. Windy condition.

During windy days the potential gradient fluctuates more quickly than in fine weather. The magnitude of the potential is also not the same as in fine weather. It may be either positive or negative. When heavy dust can be seen in the atmosphere, the fluctuation of the potential gradient is still quicker and larger. The effect of wind may be explained as due to the ionic content at different places being not the same. When there is wind, the air surrounding the equalizer is always changing, so does the ionic content, therefore the potential changes more rapidly. When dust is present, there are more chances for the ions to attach to these particles, so that the mobility and hence the conductivity is largely decreased which results in an increase of the potential gradient. Furthermore the presence of both wind and dust gives another effect which may either increase or decrease the potential gradient depending on the nature of the particles. The effect is due to the friction between the dust particles. This friction gives the surrounding air a charge, and changes the electric condition in the atmosphere. From that the change of the potential gradient follows.

The above results show the general nature of the change of the potential gradient under different weather conditions. But in some cases definite conclusions can not be drawn as comparatively few records have been obtained. It is hoped that in the following years continuous records may be taken, and the relation between the potential gradient and the temperature, pressure, humidity, and radio signals can be studied in detail.

In conclusion, the writers take the pleasure to express their indebtedness to Prof. William Band for the suggestion of the problem as well as for valuable advices in carrying out the experiment.

一量數分米或數厘米電波之陰極射綫波長計

上段 理論研究

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國立中央研究院物理究研所

著者新擬一量數分米或數厘米電波之波長計其法用陰極射綫在極短波長之電場內之特殊偏側.在相當情形下,可由調節其陽極之電壓,而使其偏側之靈敏度或相差成極大或成零。由此計算電場之波長所需各算式均已推出。且按原理及初步實驗,將凡關於此種波長計各節,亦已詳細研究。

大氣電位梯度之連續記錄

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本篇所述,爲在北平燕京大學用靜電計及一連續記錄器測量大氣電位梯度之方法及結果測量方法,乃用一種均位器(eqalizer)將離地面約3至6米高之電位顯示於靜電計上再用照相紙將此電位製成連續記錄。測量所得結果如下: 晴天之電位梯度。一日之中,有二最高値及二最低値雨時梯度卽降至零,且此値非至雨止不變。當閃電及雷颸時,梯度之方向與値,變易極速。且較晴天時爲大.