of sufficiently large opening the radiation loss predominates over the loss at the vertex. In this case, in the steady state of vibration, when the energy input equals the output, the energy input has a constant value independent of the size of the opening of the horn. Thus the amplification or the energy input per unit area of the opening is inversely proportional to the area of the opening.

Thus the two energy losses (1) by abstraction at the vertex and (2) by radiation from the opening of the horn tend to respectively increase and decrease the amplification as the opening of the horn is increased. The former loss predominates for horns of small opening and the latter for horns of large opening. Hence when both losses are operative, there must be an optimum angle of greatest amplication. Mathematical analysis shows that at this angle the energy loss at the open end equals that from the vertex.

XXIX. A ELECTROMETER FOR MEASURING THE RADIOACTIVITY OF GASES FROM OIL AND GAS WELLS

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The ultimate purpose of the problem is to determine whether or not the Helium-bearing earth gases have any radioactivity and to determine the amount of radioactive content of the gases.

It is a well known fact that the gases from many oil and gas fields have an appreciable helium content. This is in itself strong evidence of their radioactivity but cannot at present be accepted as conclusive proof. There has been some work done along this line in the past year or so but is as yet unpublished. This work is being carried out by an oil company operating in Texas. I have, up to the present, been unable to get any information as to the methods they are using and the results obtained. I presume, however, that the gas is collected and its activity measured in some sort of emanation chamber.

The electrometer here described is designed to measure the radioactivity of flowing gas. The order of the effect expected is so small that the instrument used must be of high sensitivity. Portability and compactness are also of prime importance. The instrument therefore selected is an electroscope of low capacity. The electroscope head of the Lind Interchangeable Electroscope is used as a leaf system (this is described fully in Bulletin No. 176 Denver Fire Clay Company). The leaf system is incased in a metal cylinder 10cm. in diameter by 6cm. long. It is suspended from the top of the case by means of an amber plug. A spiral spring at the bottom of the leaf support makes contact with the electrode used. A telescope is rigidly mounted on the case to read the position of the leaf.

The ionization chamber used is a metal cylinder 6cm. in diameter through which the gas flows. The electrode is a metal rod 0.5cm. in diameter and 5 cm. long coaxial with the cylinder and suported by a rod at right angles to it around which is cast a sulfur plug. This plug is cast into a brass ring of such a size that the electroscope head fits over it and is held firmly in place. The rod holding the electrode comes up the insulator far enough to make connection with the leaf system through the spiral spring. The whole leaf system is thus well insulated from the case.

Sulfur was used as an insulator principally because of the ease with which it can be worked. The insulator is easily kept clean by scraping the exposed surface occasionally. It is small enough that the so called "soak" of charge is not a serious factor. This effect can be almost entirely corrected if the electroscope is left charged for some time before it is to be used. It is found that charging an hour at the average potential at which the electroscope is to be used is sufficient to saturate the insulator.

Apart from low capacity there is another factor which makes for sensitivity. The gas under examination is constantly flowing through the ionization chamber. In this way a much larger volume can be examined than would be feasible if the gas were drawn into a chamber and left to stand during examination. Of course most of the radioactive material (gaseous emanation) is carried rapidly past the electrode. But the emanation, upon disintegrating, leaves a short-lived solid deposit of very active material on the walls of the chamber, (half periods range from 3 minutes to half an hour). The principal effect is expected from these active deposits. The effect is therefore cumulative and due to a much larger volume of gas than could be easily examined by methods now in use.

There is another factor to be considered, namely, that the gas will be moist. The insulator must be entirely protected from moisture. This is done by means of a drying tube, at the side and just below the insulator, through which air is forced from a tank outside.

Calibration is carried out by passing air over a preparation containing a known amount of radium. The amount of emanation in the air that goes through the ionization chamber is known. The rate of fall of the electroscope leaf will measure directly the radioactivity. The volume of gas going through the ionization chamber is measured by the time of the test and the pressure in the chamber above atmospheric. The pressure gauge is calibrated with a pitot tube.

The calibration is checked by placing a known amount of uranium oxide in the ionization chamber. A current of air is passed over it carrying the ions formed to the electrode. The rate of fall of the leaf measures directly the radioactivity.

A second check calibration is proposed. The capacity of the electroscope may be determined in the following manner: A parallel plate condenser is constructed with a guard ring. Its capacity may be determined from its dimensions. One plate is movable and a scale is fixed on it so that its distance from the other plate may be accurately determined. The fixed plate of the condenser is attached to the leaf system of the electroscope. The movable plate is attached to the case of the electroscope. The guard ring is around the fixed plate. The leaf system and guard ring are grounded and the movable plate is connected to one side of a battery of known E. M. F. The other side of the battery is grounded

The grounds to the leaf system and guard ring are removed. Then the source of E .M. F. is removed from the movable plate and this plate is grounded. This leaves the electroscope charged. The movable plate is now moved away from the fixed plate and since the capacity of the system is decreased its potential must increase. The leaf of the electroscope rises and its position is read in the telescope.

The telescope scale is at right angles to the leaf support. Consequently, its readings are proportional to the tangent of the angle that the leaf makes with its support. Now the potential of the electroscope is approximately proportional to the tangent of this angle so that positions read for the leaf are directly proportional to the potential of the system.

Consider the capacity C of the electroscope as constant.

The potential V may be represented by V equals kd when d is the position of the leaf read in the telescope and k is a constant for a small variation in d.

The condenser has a capacity A when the leaf reading is a. Then we can say,

Q equals ka(C plus A)

Change the capacity of the condenser to B so that (a minus b) is small.

Then Q equals kb(B plus C)

and a(A plus C) equals b(B plus C)

or C equal (bB minus aA over (a minus b)

A and B may be computed from the dimensions of the variable condensers.

Now let the potential initially on the system be V, i. e., the potential of the battery used. Let the capacity of the condenser at this position be D. Then we may write

Q equals V(D plusC)

Also as above Q equals ka(A plus C)

and V(D plus C) equals ka(A plus C)

k equals V(D plus C) over a(A plus C)

The variation of k can thus be determined over the entire range of the scale and deflections can be read as potentials. This gives the charge associated with any poition of the leaf (since the capacity of the electroscope is known). The rate of fall of the leaf can then be read as rate of loss of charge. This gives the ionization and consequently the radioactivity measured.

Summary

This electroscope has sufficiently high sensitivity to measure the expected radioactivity in gases. It will detect an activity only twenty times as great as that present normally in the atmosphere and will measure with considerable accuracy an activity but little greater than this.

Its construction is simple and all parts are easily accessible for repairs. It is sufficiently rugged and compact to be used for field work.

Measurements may be made with it more rapidly than with types of apparatus now in use. Recalibrations when necessary may be easily and quickly made.

XXX. SOURCES OF DIRECT CURRENT IN HIGH SCHOOL LABORATORIES

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There are a number of experiments both in the laboratory and in the lecture-room that call for direct currents which must be stronger than those which can be furnished by the ordinary primary battery. Since in many schools there are practically no other sources of direct current than that just mentioned, it was thought that it would not be amiss to call attention to some of the methods of producing direct current and, along with the different methods, mention something of the expense involved in each. It should be