**131. *The Application of a Generating Valve Circuit
to the Measurement of Pulsatory Oscillations
and Micro-tremors.***

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Experiments have been carried out with the object to apply a generating valve circuit to the measurement of pulsatory oscillations and micro-tremors. Although much more experimental work is needed before a satisfactory apparatus of measuring such small vibrations may be devised utilizing the entirely new method of measurement, yet it may not be out of place here to publish the results so far obtained.

The electrical connection is shown in Fig. 1. The method of measuring very small motion utilizing such a single valve circuit consists of making the motion produce a corresponding change in the anode current. This change in the anode current is caused either by the change in capacity C or by the change in eddy current loss in the metallic body M placed near the oscillation coil S . Namely, in the former method the motion to be measured is made to produce the change in the capacity C , while in the latter method the motion is made to cause a change in the distance between M and S . The anode current itself is balanced by means of the potentiometer method using the resistances R_A , R_B and R_C as shown in the Fig., and the change in the anode current is measured with a galvanometer G , or if permanent record is needed an Einthoven string galvanometer is employed.

In order to record pulsatory oscillations the capacity method is preferable to the eddy current method on account of its superior sensitivity, so that the former was used throughout the present experiment. Marconi valve D. E. 5. b was employed in the majority of cases.

It is very well known that the surface of mercury in a small cup or dish as looked with a naked eye is a sensitive indicator of very small vibrations. Pulsatory oscillations of short period and micro-tremors can therefore be recorded using a surface of mercury as one of the electrodes of the capacity C . The actual apparatus employed is shown in Fig. 2, a

Fig. 1.

Fig. 2. $\frac{1}{2}$ full size. Fig. 3 I: a porcelain insulator
 $M = 10.58$ kgr.

parallel plate condenser being formed by a steel plate P , dia. 4 cm., and the surface of mercury. The distance and parallelism between the steel plate and mercury surface are adjusted by means of a set of screws s , the air gap being usually about 0.3 mm. The mercury cup was covered with a glass bell jar and protected from wind.

Several records were obtained with this method placing the mercury cup in a laboratory room in a concrete building or directly on the ground. Usually very regular vibrations were recorded in both cases; some typical records are reproduced in Fig. 4.

The Aeronautical Research Institute is situated along the coast of the Tôkyô Bay and is distant about half a mile from any source of disturbance such as city traffic, factories etc.

The record thus obtained with a mercury cup is, however, inevitably affected by the proper oscillation of the mercury, and is far from being accurate with regard to the frequency of vibration. The method being, however, very simple, still extremely sensitive, it may be of value in some cases such as to detect micro-tremors. In such cases a vibration galvanometer may be conveniently used as G , or if tremors having audible frequencies are concerned a telephone receiver may be a suitable instrument.

Further, in order to obtain an accurate record of pulsatory oscillations free from the influence of the proper oscillation of any part of the recording system, a horizontal pendulum was constructed and a parallel plate condenser was formed as shown in Fig. 3, the natural period of the pendulum having been made to be about 20 seconds.

It was tried at the outset to construct the condenser in a vertical position, i.e. to form it with a vertical plane of the mass of the pendulum and the plate held vertically, but the electrostatic attraction between the two electrodes of the condenser rendered it impossible to form the condenser in this position. Fig. 5 shows some records obtained with the horizontal pendulum. Regular vibrations accompanying a kind of beat were usually recorded, the period of the prevailing oscillation being 0.12 second; in some cases a period of 3.4 seconds being also observed (Record P. 9.).

The sensitivity of the method depends upon various factors such as the coupling, filament brightness, plate voltage and the initial distance between the parallel plates of the condenser. Moreover, in the case of mercury cup ripples being formed on the surface of mercury, the sensitivity, i.e. the magnification cannot be simply expressed. The relations between the displacement and galvanometer deflection have been obtain-

Fig. 4. Records obtained with a mercury cup.

Fig. 5. Records obtained with a horizontal pendulum.

$\frac{1}{3}$ full size.

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ed with various initial width of the air gap in the condenser, and it was found with a very narrow air gap, say 0.08 mm., the magnification amounted to several thousands or more. In the actual case with the horizontal pendulum no device was, however, made to measure the width of the air gap, so that the magnification of the record cannot be accurately given.

In order to increase the sensitivity further more so as to be able to measure the tilting of the earth crust an apparatus was constructed and experiments are now in progress. The apparatus consists of a long glass tube, at each end of which a small glass cup is fused. The tube is supported horizontally and filled with mercury, and the minute up-and-down movement of the mercury surface is recorded in a similar manner as in the case of the mercury cup stated above.

Previously the author published the results of a series of experiments¹⁾, which were carried out with the object of applying the methods of measuring very small motion by means of a generating valve circuit to the precise recording of sounds, pressure-variations and vibrations. From the experience obtained therein a new instrument called an "Ultramicrometer" has been constructed, which may be conveniently used for the same purposes as well as other problems requiring the measurement of very small displacement or motion.

The present experiments have been carried out with the instrument, and they were really undertaken as the further application of the instrument. It is, however, a matter of course that any one who has a good experience in manipulating a generating valve circuit may carry out these experiments by combining suitable inductance, resistance etc., and does not require to use any special instrument.

1) J. Obata and Y. Yoshida. Report of the Aeronautical Research Institute, Tôkyô Imperial University No. 11 (1925).