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A New Mercury Vapor Pump.[1]

By Horatio B. Williams.

THERE appeared last year in the Annalen der Physik a paper by Gaede in which was described a new high vacuum pump whose action depends on the difference in the rates of effusion of mercury vapor and gases through a very narrow slit. The writer constructed several of these pumps and a study of their behavior has led to the construction of a very simple pump which is much more rapid in action than the Gaede type and seems to be equally effective in producing extremely low pressures.

The vapor passes through a constriction connected to the vessel to be exhausted. Within the connecting side tube is a small Hopkins condenser (see accompanying sketch), whose cooling effect aided by that of the external air condenses any vapor which enters before it has penetrated far. Diffusion takes place through the annular space between the condenser and outer side tube. This space is 2 mm. wide and has an area of about one sq. cm. A larger Hopkins condenser above condenses the main stream of vapor. The auxiliary pump is connected to it near the top.

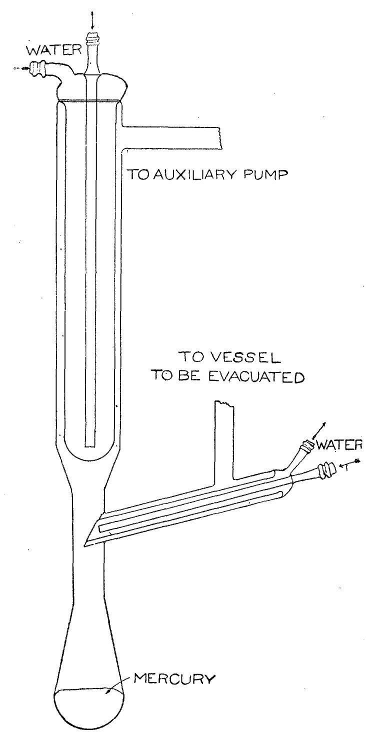

Fig. 1.

By arranging to have the diffusion take place at a constriction in the main vapor flow tube, advantage is taken of the Bernouilli effect. It is thus made possible to have the vapor pass the diffusion point rapidly without reaching a lateral pressure so high as to cause it to pass far into the side tube. A lip

[1] Abstract of a paper presented at the New York meeting of the Physical Society, February 26, 1916.

projecting from the side tube into the main flow tube hinders the direct passage of vapor into the side tube. The eddies in the vapor stream which this obstruction produces probably hasten diffusion. As the gas which diffuses into the stream of vapor is rapidly carried to the upper condensation chamber, the usually slow process of diffusion becomes very rapid. The auxiliary pump should produce a vacuum of something like .1 mm. of mercury; but the pump will operate with a fore vacuum of .25 mm. Its action is then much slower. Two pumps in series operate rapidly with a fore vacuum of .25 mm. The mercury may be heated with a small open flame, or preferably with a small electric oven. Effective action does not depend so critically upon precise regulation of temperature as in the Gaede type. A thermometer built in is unnecessary.

Preliminary experiments indicate that the exhaustion is even more rapid than with the molecular pump. A single pump with a May-Nelson oscillating ring pump as auxiliary exhausted a two-liter bulb with large aluminium electrodes from atmospheric pressure to a point where the alternative spark gap measured 18 cm. in 7 minutes. Two vapor pumps connected in series and sealed directly to a MacLeod gauge reduced the pressure from approximately .25 mm. to 4×10^{-5} mm. in 4 minutes. A short time later the pressure was too low to be measured.

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A Resonance Method for Measuring the Phase Difference of Condensers.[1]

By H. L. Dodge.

It is a well-known fact that when an alternating electromotive force is impressed upon a condenser the resulting current does not lead the electromotive force by the theoretical ninety degrees. This is particularly noticeable in the case of paper condensers of the telephone type so often used in laboratories for experiments in connection with the study of the alternating current circuit. When an attempt is made to interpret such experiments by graphic methods it is sometimes found that the power-factor of the condensers is so great that it must be taken into account. The angle by which the current lags behind the theoretical ninety degree lead is known as the phase difference of the condenser.[2] It is possible to determine this angle from data obtained in the experimental study of current resonance.

A coil of inductance L, resistance r, and impedance z is arranged to be connected in parallel with a number of paper condensers of nominally equal

[1] Abstract of a paper presented at the Columbus meeting of the Physical Society, December 28–30, 1915.

[2] F. W. Grover, Bureau of Standards, Bull., Vol. 7, 495, 1911; Vol. 3, 371, 1907. These papers contain numerous references to other works upon this subject.

capacity. An alternating electromotive force being applied the values of the total current, the coil current, and the condenser current are read as the condensers are introduced one by one. The coil current will remain constant, the condenser current will increase uniformly, while the total current will decrease, pass through a minimum value and then increase.

If one chooses several sets of these values and constructs the vector diagram of currents he will find that if the phase difference of the condensers is to be zero the minimum total current must be exactly equal to the projection of the coil current upon the voltage axis. As a matter of fact the minimum total current will be found to be larger by an amount which varies with the magnitude of the phase difference.

To obtain the phase difference proceed as follows: Draw the voltage axis. From the constants of the coil determine the angle by which the coil current lags behind the voltage and plot to scale the vector representing the coil current. With the origin as a center and a radius equal to the minimum value of the total current describe an arc reaching a short distance each side of the axis of reference. From the extremity of the coil current vector draw a line tangent to this arc. The angle which this line makes with the reference axis is the power-factor angle of the condensers. The difference between this angle and ninety degrees is the phase difference of the condensers. It is also expressed by the formula

$$\text{Phase difference} = \cos^{-1}\frac{r}{z} - \cos^{-1}\frac{I_L}{I_T},$$

in which r and z are constants of the coil, I_L the coil current and I_T the minimum value of the total current. This expression is easily formulated from the vector diagram.

A sine-wave electromotive force has been assumed. If there are higher harmonics their effect will be to increase the apparent value of the phase difference. In the ordinary laboratory experiment this is not a serious matter unless the harmonics are very prominent. The effect of the harmonics may be reduced by the introduction of inductance in series with the parallel circuit.

This method is not proposed as one possessing any great accuracy. It is, however, of some theoretical interest and has proven to be of great practical value in a laboratory where students in studying the alternating current circuit use the commercial paper condenser.

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A SYNCHRONO-PHOSPHOROSCOPE.[1]

BY EDWARD L. NICHOLS AND H. L. HOWES.

IN the study of the phosphorescence of substances the glow of which is of brief duration, particularly where it is desired to investigate the changes of intensity or color due to heating or cooling, it is convenient to be able to deal with substances of considerable size. For this purpose the authors have devised and constructed the apparatus described in this paper.

The object to be examined is viewed through the open sectors of a revolving disk, *WW*, which is mounted on the shaft of a synchronous alternating current motor, *A.C.* The number of open, and of closed sectors equals the number of poles of the alternator and the excitation of the object being examined is by means of a spark or series of sparks *E*, or of a suitable vacuum tube, actuated by means of a step-up transformer *T.T.* on the same alternating circuit. By proper adjustment of the disk, excitation occurs during the intervals when the phosphorescent surface is behind the closed sectors and the surface is visible for successive intermediate intervals. On a 60-cycle circuit with four sectors these intervals are of 1/240 of a second each and may begin one thousandth of a second or less after the excitation ceases.

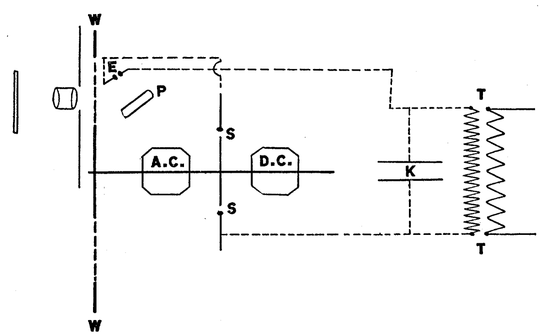

Fig. 1.

By breaking the sparking circuit the subsequent decay of materials of long duration may be observed without stopping the disk.

By means of a direct current motor, *D.C.*, on the same shaft, which ordinarily serves to bring the synchronous motor to speed, the disk may be driven at other speeds, the excitation in these cases being timed by means of a four point star wheel *SS* on the shaft so as to occur regularly during the passage of the closed sectors.

By the use of this device the authors have found it possible to take photographs in color by the Lumière process showing the change of color of various phosphorescent sulphides during decay and the effect of low temperatures on the color and intensity of these substances.[1] They have also made detailed comparisons of the spectra of the uranyl salts during and after the close of excitation and have determined the rate of decay of the phosphorescence of these salts.[2]

CORNELL UNIVERSITY,
April 15, 1916.

[1] Abstract of a paper presented at the Washington Meeting of the Physical Society, April 20–21, 1915.

[2] See Transactions of Am. Philos. Soc., 1916.

[3] See Proceedings of Nat. Acad. of Sci., 1916.