A NEW SPUTTERING APPARATUS

BY RICHARD M. BADGER

The writer, in sputtering a large number of mirrors, has found that the apparatus and methods to be described have several advantages, particularly where very large and perfect mirrors are desired. The accompanying diagram will be self explanatory, and the dimensions given have been found convenient for mirrors up to 10 cm diameter.

The apparatus has been designed to avoid the use of any grease or wax, except shellac, which is not objectionable, and which is used wherever a cement is necessary. The sputtering chamber consists of a large bottle from which the bottom has been cut with a hot wire, the irregular rim being ground flat with moderately fine emery. The ground rim should not exceed 3 mm in width and may be bevelled down to this dimension if necessary. This rim rests on a ring of gasket rubber, 1 cm wide, which is cemented to a thick aluminum plate serving as base, as well as anode of the chamber. We are indebted to Mr. Julius Pearson of the instrument shop of this Institute for this detail of construction.

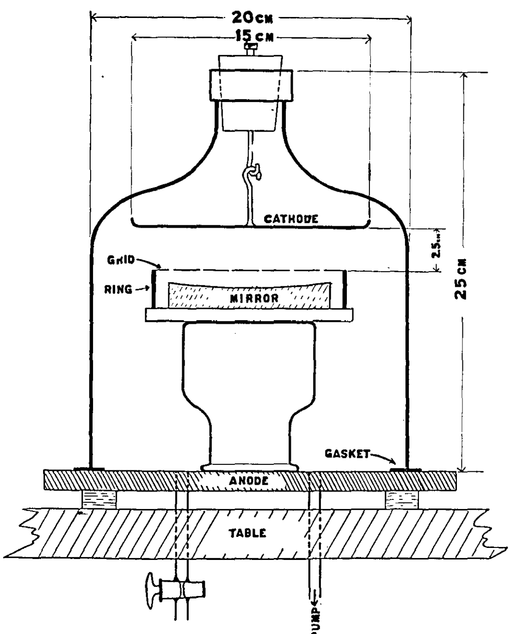

FIG. 1. *Arrangement of sputtering chamber.*

The tapered plug cemented into the neck of the bottle is of iron or aluminum; and the aluminum hook below conveniently supports the cathode of the metal to be sputtered. This should have no sharp edges or corners, and is preferably a disk, larger than the work to be covered, turned up at the edge, and with a hook soldered to the upper side. A disk of copper thickly silver-plated will sputter a number of mirrors before the plating must be renewed.

It is very desirable to use a mercury vapor pump for evacuation, but if a mechanical pump must serve alone, extreme care must be taken to prevent oil mist being carried into the chamber, as this spray often travels through considerable lengths of tubing and invariably causes discolored mirrors. The writer always uses a synchronous rectifier which utilizes both portions of the wave, but good work can be done with alternating current, but at half the rate on account of heating.

The apparatus is operated as follows. The work to be sputtered is supported on a glass mount (as an inverted bottle), so that the surface will be from 3.5 to 4 cm below the cathode. The rim of the chamber is now moistened with water, pressed on the rubber gasket with a slight rotation, and the pumps turned on. A perfect seal should result, but in stubborn cases a little water squirted about the rim will be all that is necessary. Any other liquid or grease must be avoided. The chamber should thereafter be replaced always in the same position.

The chamber should be flushed with a little air two or three times before evacuation is completed, and the discharge should not be allowed to remain on until the dark space is 2 to 2.5 cm wide. The vacuum should be maintained at this value and an opaque coat of silver should be obtained in a little over an hour. With the dimensions given the current should be about 25–30 milliamperes, which requires a potential across the secondary of the transformer of about 5–6000 volts. For all ordinary purposes air is satisfactory as a medium, and no drying or other treatment is necessary.

When sputtering mirrors which have sharp edges or corners, streaks radiating from the corners may often result, or the edges may be bordered by a discolored rim. A little accessory shown in the sketch obviates this difficulty completely. It consists of a section of brass tube about 2.5 cm long and 12 cm in diameter, with a coarse grid (about 2 cm mesh) of fine copper wires, at one end. It is placed about the work with the grid about 1 cm above the surface to be sputtered. In operation the dark space should come not closer than 5 mm from the grid, or the wires may cast shadows. As well as preventing the streaks mentioned, this device seems to assist in keeping the sputtered films clean, and if a trace of organic vapor is present, clean coats may be obtained even though a deposit of carbon is found on the grid.

Other conditions for sputtering have been recommended in the literature; but the writer has found that those described give the most consistently good results, and require a minimum of time.

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Measuring the rate of a tuning fork.—In connection with absolute electrical measurements, it has been necessary to develop a very accurate method of measuring the rate of a tuning fork. In this method the rate of the fork is compared with the period of a gravity pendulum as used by the Coast and Geodetic Survey. The rate of the tuning fork can be determined with an accuracy of 1 part in 100,000 in about 10 seconds.

One of the interesting applications of the method has been in the determination of the effect of amplitude and temperature on the free vibration rate of two tuning forks, one of a good grade of machine steel and the other of a special nickel steel alloy known as "elinvar." The temperature coefficient of the steel fork is about 1 part in 10,000 per degree, whereas with the elinvar fork the temperature coefficient is only 1 part in 100,000 per degree. However, the steel fork showed very little change in frequency with change in amplitude. When the amplitude of the end of the prongs varied from 2 mm to ½ mm, the change in rate was not measureable, which means that it was less than 1 part in a 100,000. With the elinvar tuning fork, however, there was an appreciable change in the rate of the fork as the amplitude changed, there being an increase of about 10 parts in 100,000 when the amplitude decreased from 2 mm to ½ mm. As the forks are practically of identical dimensions, it is difficult to say what caused this difference in behavior. A further study of this question is now in progress. [Technical News Bulletin of the Bureau of Standards, March, 1926.]

Spectrum-Analysis of Striae in Hydrogen.—The striae are produced in rarefied hydrogen, evidently mixed with vapors from stopcock grease, with a voltage of 100 to 150 between a hot filament cathode and cold anode. The length of the spectroscope slit is apparently parallel to the axis of the tube so that from the photographs it is possible to tell where in the stria each particular kind of radiation (Balmer lines, Fulcher bands, continuous band) is emitted with maximum intensity. Thus in the striae obtained at higher pressures, which are blue towards the cathode and red towards the anode, H_α has its maximum near the