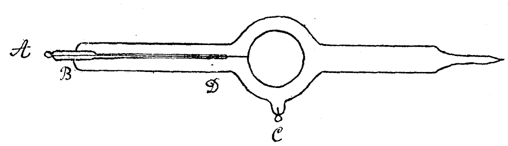
ON THE CONSTRUCTION OF SENSITIVE PHOTOELECTRIC CELLS.

BY JAKOB KUNZ AND JOEL STEBBINS.

THE high sensitiveness of photoelectric cells of alkalihydrides has been discovered by Elster and Geitel. For several years we have tried to apply this cell in stellar photometry. J. G. Kemp[1] and W. F. Schulz[2] have shown that it is possible and advantageous to replace the selenium in stellar photometry by the photoelectric cell. Practically at the same time corresponding measurements have been made in Germany, especially in the observatory of Berlin.

One of us has reported on an astronomical discovery made by the photoelectric cell in the Evanston meeting of the American Astronomical Society in September, 1914. In the last two years we have tried to improve the photometric properties of the cell and we have arrived at a form which seems to be satisfactory with respect to sensitiveness, constancy, absence of the dark current, etc. The final form is indicated by Fig. 1, which is drawn full size. The glass bulb is 3.4 cm. in diameter.



Fg. 1.

It contains a small platinum cathode C, a platinum ring of 1.8 cm. in diameter as an anode A, which passes through a platinum cylinder B; this cylinder was found to be very necessary in order to lead surface and electrolytic currents of the glass to earth. Strips of tinfoil were occasionally wrapped around the glass cylinder at D and the cathode C, in order that dark currents might be suppressed. The tubes are connected to the mercury pump and heated two to three hours to 330° C. to drive off the remaining gases. A small quantity of the pure alkali metal is distilled on the silver mirror of the cell, which is kept cool by cold water or ice, at the same time the end AD of the cell is heated from 160 to 240°, according to the alkali metal, by means of a heating coil.

[1] J. G. Kemp, PHYS. REV., Vol. I., p. 274, 1913.

[2] W. F. Schulz, Astrophysical Journal, Vol. XXXVIII, p. 187.

The most sensitive cells have been obtained when the metal was deposited in a thin uniform layer. Pure hydrogen from palladium was then admitted and its pressure so adjusted that a potential difference of 280 to 400 volts between the electrodes produced a uniform glow discharge. Often a spark or arc appears instead of the bright uniform glow, and the spark is apt to destroy the sensitive layer. By experience one finds the best conditions for the glow to appear. The sensitiveness will be tested during the formation of the hydride. As a rule the formation requires only one to three seconds for the maximum sensitiveness; if continued, the colors of the compound change and the deflection in the galvanometer decreases. During the formation the electrode C is negative and A positive. But in certain gases like ammonia and ethane a sensitive layer is also formed if the current is reversed. After the formation the gas is carefully pumped out and replaced by an inert gas, helium, argon, or neon. The pressure is so chosen as to get a maximum sensitiveness.

Experiments have been made with the object of finding out the influence of the size and shape of the cell on the sensitiveness. The diameter varied from 5 to 2.5 cm. and the sensitiveness rather increased with decreasing diameter. The silver mirror was sometimes deposited on a flat or conical bottom, so that the incident light should be reflected and its action increased; but very little increase in the deflection of the galvanometer was observed, so that the ordinary spherical shape was chosen.

Efforts have been made to replace the hydrogen by other gases, for instance ethane, ammonia and acetylene. With ethane and the current reversed a very dark violet-blue color was obtained of a high sensitiveness, and of a beautiful metallic luster, but unfortunately the sensitiveness proved not to be constant. When dry ammonia vapor was used instead of hydrogen for the formation, a bright blue layer was obtained of high sensitiveness which however decayed also in the course of time. Acetylene finally formed a black layer with potassium under the influence of the electric field, but it was very little sensitive. So far hydrogen seems to give the most sensitive and the most constant cells.

Four alkali metals have been used, viz., sodium, potassium, rubidium and cæsium. The best results have been obtained with rubidium and neon. The metal was distilled in the cell while the silver mirror was cooled with ice. A potential difference of 280 volts produced a glow in the hydrogen and a very beautiful violet reddish sensitive layer with a bright metallic luster. The hydrogen was then replaced by helium, argon or neon. The neon was received from the Bureau of Standards.

The three curves *A*, *B* and *C*, of Fig. 2 show the relative sensitiveness of the rubidium cells filled with these three gases. Helium gives the smallest, neon the best sensitiveness. Nevertheless it is possible that the helium and argon cells are better than the neon cell because the curve for the neon rises much quicker than the other curves, in other words the neon cell is more sensitive to small changes of the potential difference acting between the electrodes than the helium and argon cell. It is very important to use perfectly pure gases.

The sensitiveness of some cells decays slightly during the first few days after the formation and then becomes constant. Some distinct white spots appeared on the surface of some of the very bright violet rubidium metals, and in one or two instances such a spot became wider

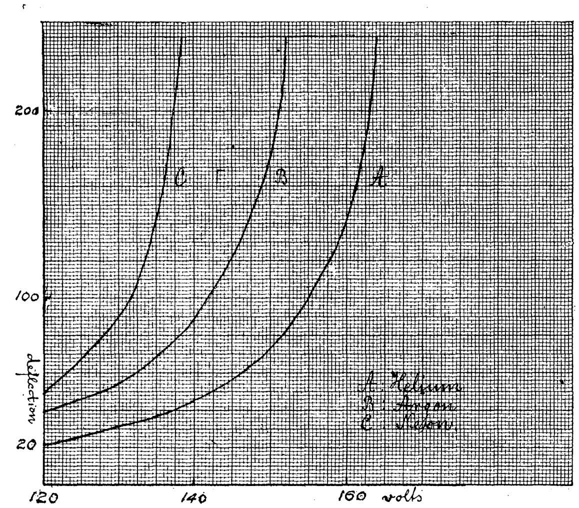


Fig. 2.

in the course of time and covered finally the whole surface, which then appeared bright bluish, and whose sensitiveness was considerably less than that of the original violet surface. When the cells were of a larger size, these bright violet-red surfaces on rubidium were never obtained, but rather sky-blue and blue-green colors which exhibit very beautiful iridescence. The potassium cells were formed with a potential difference of 360 volts. The glow discharge gives almost instantly rise to a most beautiful golden rose color, which is exceedingly sensitive, but not very stable. When the formation is continued for a second or two, a deeper violet-red appears which remains practically constant, but the golden hue gradually fades away. The sensitiveness of the cell when filled with the different gases is shown by the curves of Fig. 3. Neon again shows the greatest sensitiveness, hydrogen the smallest, argon seems to give a curve which lies between *A* and *B*, but this question is not quite settled. A comparison of Figs. 2 and 3 shows that for rubidium we find the same photoelectric current with a potential difference about 40 volts smaller than for potassium. Very striking iridescence can be obtained by the potassium.

Cells have also been formed with sodium and cæsium. The former metal gives very sensitive cells, but their construction is more difficult than that of the potassium and rubidium cells, the sodium seems to act somewhat on the silver mirror, so that the distilled metal does not seem so bright on the silver as on the glass. If however, the metal is distilled on the glass bulb directly, then the contact with the electrode is unsatisfactory. The pure metal seems to give a very sensitive golden

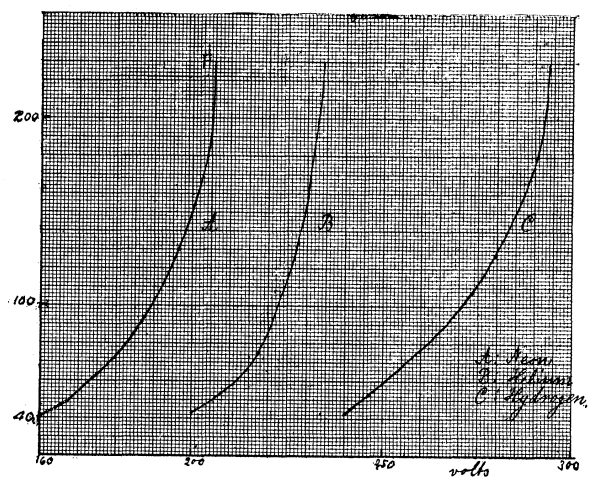


Fig. 3.

layer. The cæsium finally is liquid at 28° and can therefore not be used directly. A solid amalgam of this alkali metal has been formed which was, however, of a rather weak sensitiveness.

The cells described in this article show a very small dark current; if it exists at all, it can be compensated by the application of a convenient small potential at the platinum cylinder between the two electrodes. As far as our present measurements indicate, there is an accurate proportionality between the intensity of the incident light and the photoelectric current. The cells are used in stellar photometry.

Laboratory of Physics,
University of Illinois,
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