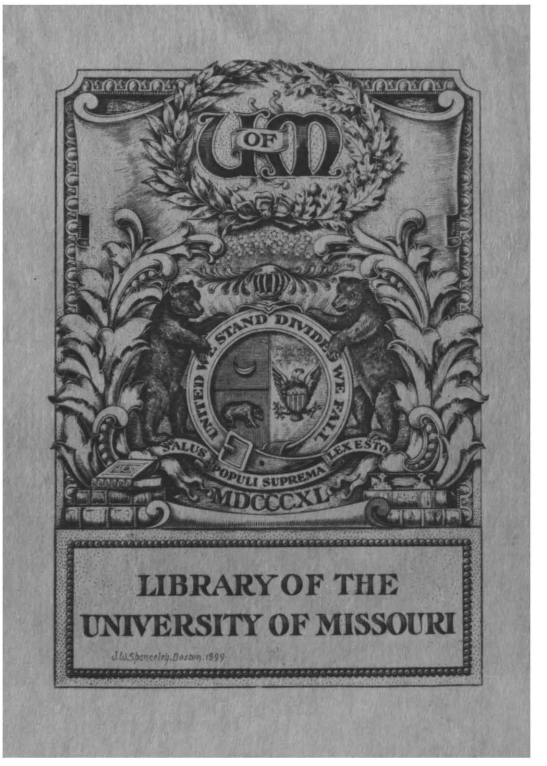

CATHODE DISINTEGRATION

by

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CATHODE DISINTEGRATION.

The use of the disintegration of the cathode in the vacuum discharge for the production of thin metallic films was first proposed by Plücker[1] in 1858. This proposal was first carried out by Wright[2] in 1877. Wright showed that if certain metals, platinum etc., are used as the negative terminal in a vacuum tube, not only are the gaseous molecules shot away from the electrode when the discharge is passed through the tube, but the metal electrode is so affected that the metallic particles are also shot out and that these particles adhere to any object which they happen to strike. In this way he prepared mirrors from a number of metals which were used as cathode.

In 1886 Kundt[3] used this method for preparing thin semi-transparent metallic mirrors to study the polarizing power of metals upon transmitted and also upon reflected light.

The first quantitative work on cathode disintegration was done by Crookes[4] in 1891. He compared the disintegration of a large number of different metals and came to

1 J. Plücker, Pogg. Ann. cv. p. 68 (1858).
2 A. W. Wright, Amer. Journ. of Sc. & Arts, (3) xiii. p. 49 and xiv. p. 169 (1877).
3 A. Kundt, Wied. Ann. xxvii. p. 59 (1886).
4 Crookes, Proceedings of the Royal Society, vol. 15, p. 88, 1891.

the conclusion that the phenomenon is similar to ordinary evaporation. To prove this, he showed that water at atmospheric pressure evaporates faster when a wire connected to the negative terminal of an induction coil dips into the water. He also showed that cadmium in a vacuum when heated to near the temperature at which it vaporizes will vaporize much more rapidly when negatively charged than otherwise. Positive electrification was shown to produce hardly any effect in this respect, and the little effect that was produced was attributed to the leakage of negative electrification from the anode. Silver was experimented with in the same way except that no heat was applied, and practically all the disintegration was found to be produced by the cathode discharge. The observed phosphorescence of the containing glass vessel was found to be produced by the residual gaseous particles of metal shot off from the pole, no metal being deposited in the region of phosphorescence. The order of the metals in descending order of disintegration is given by Crookes. The alloy brass was found to give a deposit which was the same in composition as the original but gold aluminium alloy deposited the gold and left the aluminium behind.

Granquist[1] in 1898 found that the order in which the different metals disintegrate depends upon the pressure of the gas. Thus he found that a platinum cathode lost more

1 G. Granquist, Ofvers. af K. Vetenskaps-Ak. Förhandl. p. 709 (1898).

than a gold electrode at high pressure and less at low pressure. He studied the effect of pressure upon the rate of disintegration and gives a series of curves expressing the effect of pressure upon the rate of disintegration for the metals gold, platinum, silver, and copper. He also found that the amount of disintegration is proportional to the square of the current when the pressure is constant. Furthermore, Granquist found that the metal lost in a few minutes while used as cathode as much as the same metal would in hours when in the form of an incandescent uncharged wire or when used as an anode.

By means of cathodic projection, L. Houllevigue[1] in 1902 prepared thin films of platinum, palladium, iron, cobalt, copper, and bismuth. The receiving substance (glass, metallic plate, & c.), was placed upon a large horizontal anode of aluminium, and 12 mm. above this was placed the cathode which was to be disintegrated. The cathode dark space was allowed to come almost in contact with the plate on which the deposit was formed. The deposits obtained presented all degrees of transparency according to the period of operation. A bismuth film showed no variation of electrical resistance in the magnetic field. Iron when so thin as to be transparent, showed rotation of the plane of polarization when magnetized.

1 Comptes Rendus, 135, pp. 626-627, Oct. 20, 1902.

Holborn and Austin[1] in 1904 made some very interesting experiments on the amount of disintegration of the cathodes of different metals under similar electrical conditions. They used a constant current density of 0.6×10^{-3} amperes per square centimeter of cathode surface. This current density is large enough to make, at the pressures they employed, the cathode fall of potential depend upon the pressure, so that by altering the pressure they could obtain large variations in this fall. The cathode fall was varied from 350 to 2500 volts. The cathodes used consisted of circular disks of metal hung on wires of the same metal (except that iron wire was used to suspend the cathodes of antimony, bismuth, zinc, tin, and lead). A disk of mica was placed over the cathode to prevent disintegrated particles being thrown backward, and the supporting wire was surrounded by a small glass tube.

When the tube was filled with air, they found that y, the loss of weight in 30 minutes could for platinum, silver (one sample), copper, and nickel be represented by the formula

$$y = 0.00163\frac{A}{n}(V - 495) \quad \ldots\ldots\ldots\ldots\ldots\ldots (1);$$

for silver (another sample), bismuth, palladium, antimony, and rhodium the relation was

1 Phil. Mag., Aug. 1904, p. 145.

$$y = 0.00187\frac{A}{n}(V - 495) \quad \ldots\ldots\ldots\ldots\ldots\ldots(2).$$

V is the cathode fall of potential in volts, A the atomic weight of the metal, and n its valency. Other metals such as iron, aluminium, and magnesium do not follow either of these laws, their loss by disintegration being much too small. For those metals which follow the laws (1) and (2) with the same current and cathode fall the weight of the cathode disintegrated is proportional to the weight of those metals which would be deposited in voltameters placed in series with the discharge tube, the weight disintegrated is equal to the amount deposited only for a particular value of the cathode fall. Metals such as zinc, cadmium, lead, and tin, which are readily oxidized, were also investigated, but the oxidation which takes place complicates the results; in the case of zinc, with low potentials, results were obtained which were in approximate agreement with the above equations. In hydrogen the disintegration is less than in air, and the experiments with it did not lead to any regular results.

V. Kohlschütter and R. Müller[1] in 1906, using wire cathodes in pure gases, showed that when the easily fusible metals lead, tin, and cadmium are disregarded, the order of loss of weight by disintegration in air which Crookes had found for these discharges, is approximately - iridium does not follow this law - the inverted voltaic series of the

1 Zeitschr. Elektrochem. 12. pp. 365-377, May 18, 1906. From the Chem. Inst. d. Univ., Strassburg.

metals. But the phenomena are complicated, because the disintegration does not always begin immediately after switching on the current; there may be retardation for many minutes. Aluminium, which has so far been regarded as practically impossible of disintegration, is indeed not disintegrated in the gases hydrogen, oxygen, and nitrogen, but there is some effect in helium, and a strong disintegration is argon and mercury vapor; the retardation in argon lasted in one instance over an hour, after which 0.9 mgm. of aluminium was disintegrated in 25 minutes. It was found that iron could be disintegrated only to a slight extent, which is practically the same for the different gases. Gas pressure in the tube was found to decrease, as a rule, when the disintegrated particles were allowed to be projected only in certain directions, and might increase again and become constant. Each metal gave in each gas a characteristic pressure curve. The increase in pressure was attributed to a generation of hydrogen, produced by the electrolysis of hydrogen layers on cathodes of aluminium, cadmium, iron; there was little disintegration with these three. In nitrogen and oxygen the pressure decreased for all the metals, owing probably to chemical combination; in this case the disintegration is strong. With the noble metals,platinum, gold, silver, and mercury, in inert gases and in hydrogen, the pressure soon became constant while disintegration continued. The researches indi-

cate that the disintegration depends upon the affinity between the metal and the gas, just as, according to Haber, the cathode disintegration in alkaline liquids starts with the formation of a nitride. The vapor density determinations by Crookes of the volatile metals in helium and argon also show that tin and cadmium tend to combine with these inert gases at 1,200 or 1,300 degrees Centigrade. It is therefore concluded by Kohlschütter that the cathode disintegration is due to the formation of endothermic chemical compounds between the metal and the gas, and that these compounds are decomposed on the cold glass walls of the vessel, leaving metallic mirrors. The energy required to form the compounds is the kinetic energy with which the carriers of atomic dimensions in the glow discharge strike the cathode. According to this view, canal rays should produce analogous effects. This was confirmed qualitatively by Kohlschütter[1] in 1906; quantitative experiments could not be made.

The general conclusion, that the cathode disintegration is essentially chemical in nature, and that endothermic, volatile metallic compounds are formed which are subsequently decomposed again is confirmed by further experiments of Kohlschütter and T. Goldschmidt[2] in 1908. The reactions take place between the metal and the positive carriers of the glow discharge which originate in the negative glow

1 Zeitschr. Electrochem. 12. pp. 869-973, Nov. 30, 1906.
2 Zeitschr. Elektrochem. 14. pp. 221-235, April 24, 1908. From the Chem. Inst. d. Univ., Strassburg.

layer, and which strike the cathode with kinetic energy $E = eK$, where e is the positive unit charge and K the fall of potential; this energy is in itself great, compared to the mean kinetic energy of gas molecules, and is all the more powerful because directed. Granquist had already shown for low potentials that the loss of weight of a cathode is proportional to the cathode fall, and Holborn and Austin had demonstrated that the rate of disintegration was related to the atomic weights of the metal. Kohlschütter and Goldschmidt proved that the inert gases helium and argon act in a manner similar to the other gases. The order in which the gases attack the metals is that of the atomic weights of the metals.

The investigation of the chemical nature of disintegration was taken up by F. Fischer and O. Hähnel[1] in 1908. Arranging experiments like those of Kohlschütter and Goldschmidt in a different way, they came to entirely different conclusions. Kohlschütter used one tube in series with a milliameter and a titration coulombmeter for measuring the current in the secondary of an induction apparatus; Fischer and Hähnel placed two equal tubes in series. They found that the order of disintegration is the same for the two gases, helium and argon. When the gases contain air, less metal is disintegrated; argon is particularly sensitive in this respect. The disintegration increases approximately

1 Zeitschr. Elektrochem. 14. pp. 366-367, July 3, 1908. Preliminary communication from the Chem. Inst. d. Univ., Berlin.

as the square of the current intensity, and is inversely proportional to the gas pressure. When the results of Kohlschütter are reduced to equal current intensities, the order of the gases, in which they attack the metals, is by no means that of the atomic weights of the metals. When two tubes are coupled in parallel, however, the argon tube shows a much greater disintegration of metal than the hydrogen tube; that is because the current chiefly passes through the argon; with higher potentials, however, the differences vanish. There is no proof that the noble gases, neon, krypton, xenon, and helium, form any compounds.

Kohlschütter[1] (1908) admits that it is advisable to arrange two tubes is series; the arrangement is inconvenient, however, when several gases are to be tried. Adopting the series grouping for two tubes, charged, the one with hydrogen, and the other with argon, Kohlschütter found in confirmation of his previous results, that 20 times more platinum was disintegrated in argon than in hydrogen. Much depends upon the induction apparatus, however, and it was found that with different induction apparatus of the same mean current intensity both the absolute amount of disintegration and the disintegration ratios for different gases may fluctuate considerably. The probable cause of the discrepancy would be that the disintegration is not proportional

1 Zeitschr. Elektrochem. 14. pp. 417-421, July 31, 1908.

to i, but proportional to i^n, and that n has different values for the different gases. The fluctuations may completely mask the differences in the behavior of different gases. Fischer and Hähnel[1] give particulars of the experiments already noticed, and repeat that they can not accept Kohlschütter's view that the inactive gases become active in the vacuum tubes. Kohlschütter[2] (1908) replies further, and maintains that the differences are due to the different energy consumptions in the two series of experiments; a direct comparison is not possible, as the exact dimensions of the induction apparatus have not been given. He adheres to his opinion that a thermal and a chemical effect overlap; the thermal effect would predominate with the more volatil metals with which Fischer had chiefly experimented.

Fischer and Hähnel[3] (1908) continue the controversy by stating that the cathode disintegration in gases is a purely physical vaporization phenomenon. They worked with weaker currents than Kohlschütter. The disintegration is diminished by the formation of oxides or nitrides on the cathode, but there is no proof of the formation of argon compounds such as would justify a chemical theory. Kohlschütter[4] (1908) points out that his currents were not stronger than those of Fischer; the current curve, not the mean

1 Ibid. pp. 433-437, Aug. 7, 1908.
2 Ibid. pp. 437-439, Aug. 7, 1908.
3 Zeitschr. Elektrochem. 14. pp. 677-681, Oct. 2, 1908. From the Chem. Inst. d. Univ., Berlin.
4 Ibid. pp. 681-683, Oct. 2, 1908.

intensity, is the chief feature. B. Walter[1] (1908) states that the phenomena really depend, not on the quantity of electricity, but on the energy, the product of the quantity by the fall of potential at the cathode, and this fall is smaller in argon than in hydrogen.

Kohlschütter[2] (1908) continues his experiments with constant and somewhat stronger current. The general results previously obtained by Holborn and Austin, by Kohlschütter, and by Goldschmidt are confirmed. The disintegration is proportional to the square of the current intensity and increases with increasing potential in argon and nitrogen. In hydrogen a maximum disintegration is soon reached. The weights of metals disintegrated at the same current intensity vary as the equivalents, but different valencies of the metals have to be assumed for the discharges in argon and nitrogen; in argon the metals appear to have the valencies one or two. Peculiarities are noticed in the behavior of platinum and also of other metals. The disintegration decreases throughout in the order argon, nitrogen, hydrogen. The statement of Fischer and Hähnel that the disintegration would, under equal conditions, become the same in argon and in hydrogen, is not confirmed.

1 Ibid. p. 695, Oct. 9, 1908.
2 Zeitschr. Elektrochem. 15. pp. 318-328, May 15,1909.

The discussion so far has been concerned only with what has been done on the subject of cathode disintegration. There is, however, much left to be done along this line. It has been pointed out that the cathode disintegration depends upon the gas present as well as upon the metal of which the cathode is composed. Hence it was thought interesting to investigate whether the gas in which the mirrors were prepared had any effect upon their reflecting powers for different wave-lengths, especially the short wave-lengths (ultra-violet), owing to the use they might be put to in the construction of interferometers, & c., for the study of this part of the spectrum. The object, therefore, of the present investigation is to test this point and also to find the conditions best suited for the production of the mirrors.

APPARATUS.- A vacuum apparatus was made by cutting a large acid bottle in two with a wire electrically heated and using the upper portion. To make a close joint the bottom of the portion used (the vacuum jar) was emery-ground on a piece of plate glass. The cathode terminal was introduced through the ground joint J (Fig. 1, p. 13), which was mercury-sealed. To prevent discharge taking place along the wire it was covered by a small glass tube inside the outer tube, as shown in the figure. The small neck N was sealed with sealing-wax and the receptacle above was filled with mercury. The cathode was attached to the negative terminal by means of a hook H. The wire immediately attached to the cathode

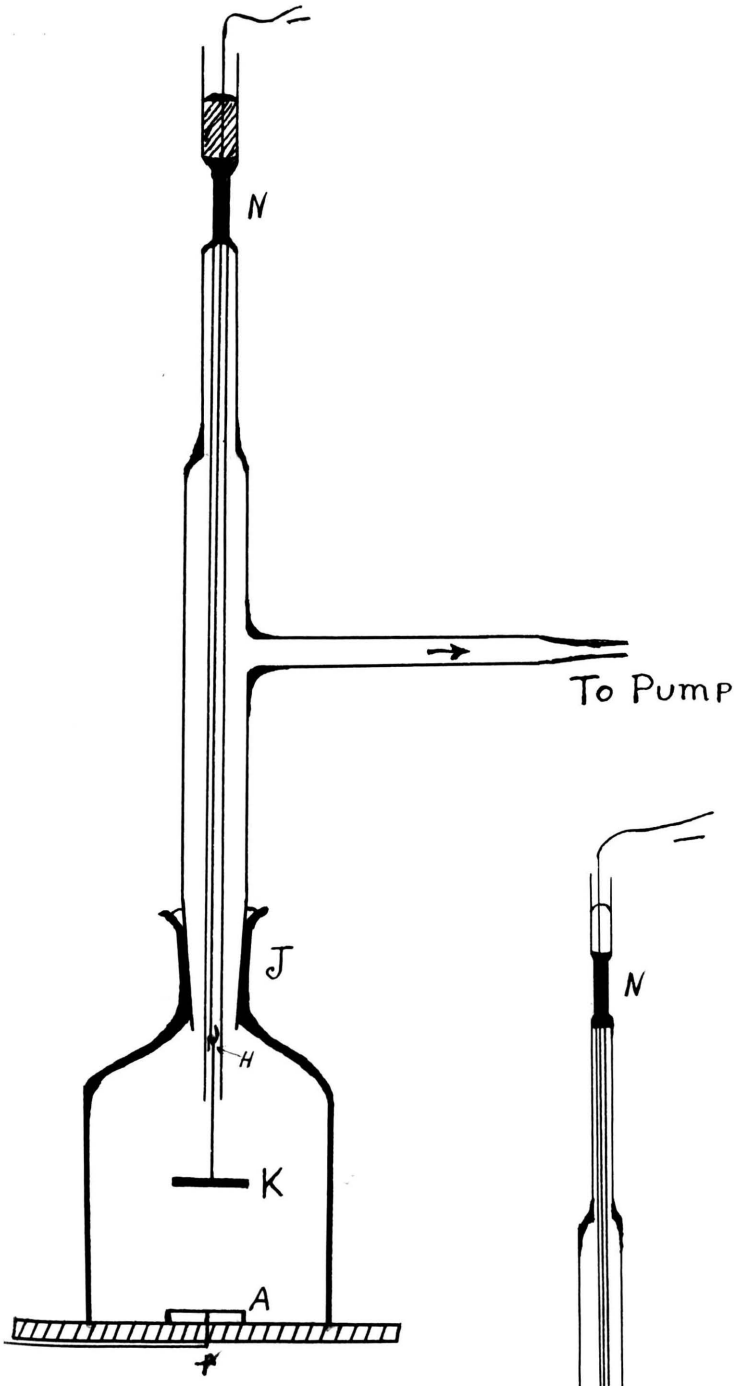


Fig. 1.

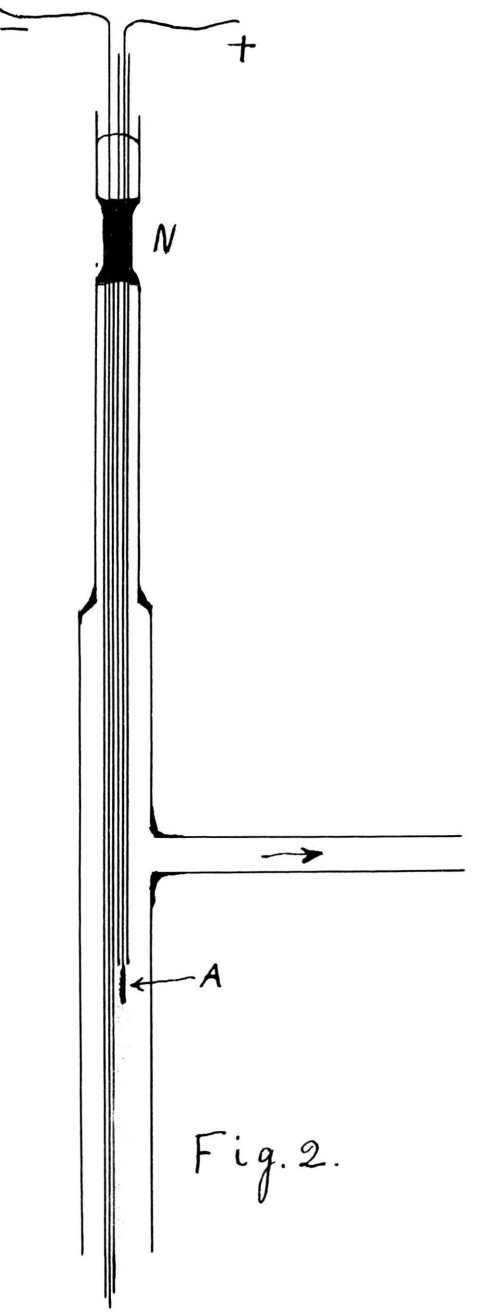


Fig. 2.

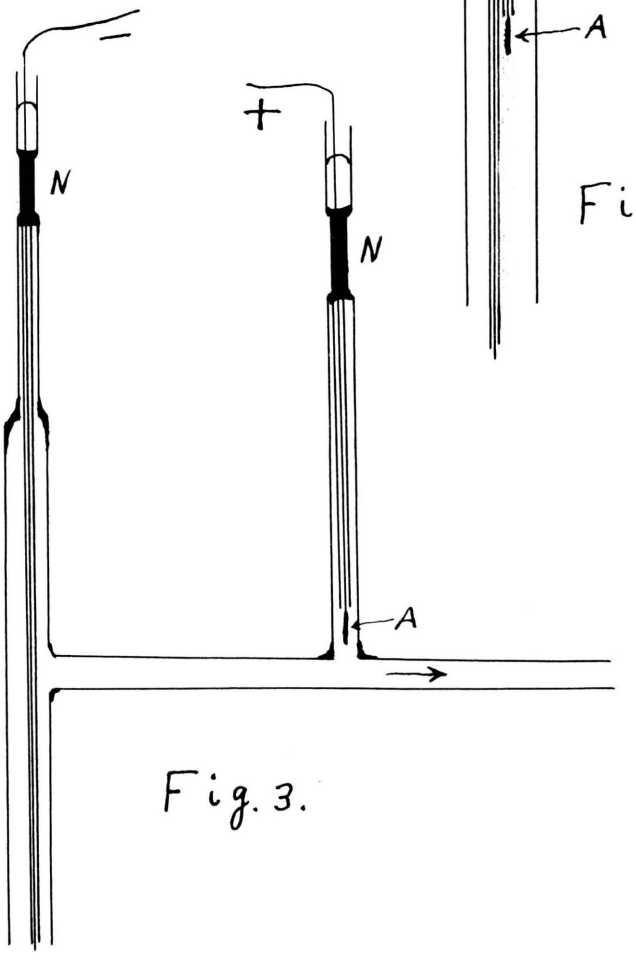


Fig. 3.

was covered by a glass tube which extended back over the tube through which the wire was introduced. Different methods were used in preventing the backward projection of disintegrated particles at different times. As shown in the figure, the anode is situated on the base plate through a hole in which connection is made with the positive terminal, and the seal is made with DeKhotinsky cement. Stop-cock grease was used to make air-tight the joint between the vacuum jar and the base plate. To prevent the possibility of leakage due to the introduction of the positive terminal through the base plate, and to afford means of studying the effect of the position of the anode on the discharge and the character of mirrors formed, two other methods were used in arranging the anode as shown in figures 2 and 3, where the anode is the end of a wire introduced from above through an inner glass tube covering it almost to its end. The vacuum jar in figure 1 is ten cm. in diameter and ten cm. high; the one used with the terminals shown in figure 2 is ten cm. in diameter and thirteen cm. high; that with figure 3 is six cm. in diameter and nine cm. high. A Gaede high vacuum mercury pump was used, and the joint between it and the vacuum apparatus was sealed with sealing-wax. The current was obtained from an induction coil operated in the 110 volt D. C. circuit with a Wehnelt interrupter. In order to have a current through the vacuum apparatus in one direction only, a spark gap about 0.8 cm.

long was kept in series. The electromotive force produced by the induction coil when the circuit was closed was strong enough to force a current across this gap but that produced in the opposite direction when the circuit was broken was not strong enough to do this, hence current resulted in one direction only.

Mirrors from each of the metals silver, tin, copper, zinc, and platinum were prepared in each of the gases air, hydrogen, oxygen, and nitrogen. Hydrogen and oxygen were prepared by electrolysis of water. Nitrogen was prepared by heating sodium nitrite with ammonium chloride. Each gas was collected over water and dried before being introduced into the apparatus by bubbling it through concentrated sulphuric acid.

MANIPULATION.- When air was used as the working gas the apparatus was first exhausted until the cathode dark space came almost down to the glass (the mirror glass) on which the deposit was to be made, and it was kept at this pressure while the discharge was allowed to pass. With the other gases the apparatus was first exhausted to a high vacuum, a little of the gas introduced by means of a three-way stop-cock, and the apparatus exhausted again. Gas was then admitted again to atmospheric pressure and allowed to stand about ten minutes so as to let it wash out the apparatus thoroughly. It was then exhausted again and a little more gas admitted. The next exhaustion was followed by the pas-

sage of the discharge, the pressure being regulated the same as with air. The gas left in the apparatus became contaminated with occluded hydrogen to a slight extent, but there was no way to prevent this.

The apparatus shown in figure 1 was first used in some preliminary experiments and at the last part of the work, as will be explained later. The small vacuum jar was used in the first part of the work of preparing mirrors because of the quickness with which it could be exhausted and because a small amount of gas was required to fill it.

Platinum mirrors were prepared in the small vacuum jar. The disintegrated particles were prevented from being projected backward and to the sides by screening off with glass coverings. The mirror glass was about 1.2 cm. from the cathode. The cathode in this case consisted of an aluminium cathode covered with platinum foil. There was no difficulty in getting good mirrors of platinum in any of the gases.

Copper mirrors prepared in this way were clouded in appearance. The best results with copper were obtained by screening off only the backward projection of the disintegrated particles, by means of a glass plate over the rear of the cathode. The apparatus of figure 2 was found most satisfactory. The copper cathode consisted of sheet copper and was supported by means of a copper wire.

Tin mirrors prepared by this method with the appa-

ratus of figures 2 and 3 were clouded. This work was done with tin-covered iron (such as is used in making tin cans) in an aluminium support for a cathode. Later a cathode was prepared by covering an aluminium cathode with tin foil. With the projection of the disintegrated particles screened off by a covering over the rear of the cathode only, good mirrors were obtained in hydrogen, oxygen, and nitrogen. The one prepared in air was clouded. The apparatus of figure 2 was used in this work. The good results were attributed to the fact that the disintegrated particles were allowed a wider range for projection than was the case with the smaller vacuum jar. The tin foil was found to be not heavy enough to stand the discharge, breaking in the middle when only one layer was used, and being pushed out in the center when more than one layer was used. To obviate this difficulty a tin cathode was prepared by melting some tin foil, making a thick plate of it, and supporting it in an aluminium holder by means of flanges extending from the lower side of the aluminium. A good mirror was obtained in air, but in the other gases and at other times in air it was found difficult and sometimes impossible to get it to disintegrate, the operation being stopped by the melting of the tin. The tin, being an easily fusible metal, showed a plain case of melting. The distance of the mirror glass from the cathode, about 1.8 cm., was greater than in former cases because it was necessary to have a high vacuum (causing the dark space to move out further

from the cathode) in order to get disintegration.

In the case of silver it was found best to screen off only the backward projection, and the apparatus of figure 2 was found most satisfactory. The mirror glass was kept about 1.5 cm. from the cathode.

Many trials were made with zinc with no disintegration. It was finally found necessary to have a high vacuum, when the disintegration was very rapid. In this case the cathode got so hot that a glass covering over it always broke. Mica was tried for a covering but it was found unsatisfactory. The cathode was left uncovered during the rest of the work. with zinc. In all the work before this the mirror glass was placed about 1.2 cm. to 1.8 cm. from the cathode, but it was found necessary to increase this distance considerably in the case of zinc in order to keep the mirror glass outside of the dark space. All the zinc mirrors required polishing but this was required to a less degree when the glass was kept well outside of the cathode dark space. The distance was made about 3 cm. with best results. The side of the deposit next to the glass formed a beautiful mirror, but it could not be used because the glass would absorb the ultra-violet light. The other side had the appearance of fine white powder, due probably to oxidation of the zinc.

To test the reflective power of these mirrors, a photograph of a spectrum given by reflected light from each of them was taken upon a Cramer spectrum plate by means of a

quartz spectrograph. A quartz mercury arc, which is rich in ultra-violet, was used as source. On the plate arranged in suitable positions for comparison with the spectra obtained by reflected light were taken a number of spectra obtained from direct exposure to the source of light. The time of exposure was 40 seconds in each case.

The mercury arc gives a line spectrum. An attempt was also made to get results with a continuous spectrum in the same way. The Nernst lamp and Welsbach burner were tried and found unsatisfactory because the shortest wave-length given by them (the same for both), as shown by the photographic plates, was about 3125. The carbon arc was then tried and was found to give the desired short wave-lengths but the work with it gave undecided results, partly at least, because the photographic films used were unsatisfactory, the supply of spectrum plates having been exhausted before we began work with the carbon arc. Results with the mercury arc only are recorded. The film side of the mirror was always used for the reflector, because the ultra-violet light would be absorbed by the glass if the other side were used.

Each metal was taken up separately and the spectra obtained by reflection from the mirrors prepared in the different gases were compared.

(1) SILVER.- The mirrors prepared in all the gases air, hydrogen, oxygen, and nitrogen are about the same in reflecting wave-lengths equal to and longer than 3650. In reflecting wave-lengths shorter than 3650 the mirror prepared

in nitrogen is the best, showing some reflection of wave-length 2446. The shortest wave-length appreciably reflected by the mirrors prepared in hydrogen and oxygen is about 2500. The mirror prepared in air is decidedly weaker than any of the other three in reflecting wave-lengths shorter than 3650; it shows no appreciable reflection of wave-lengths shorter than about 2875.

(2) TIN.- In the visible spectrum and as far into the ultra-violet as wave-length 3341 the mirror prepared in hydrogen is the best reflector, the one prepared in oxygen is second, the one in air third, and the one in nitrogen fourth. There is, however, only a slight difference between the last two mentioned with these wave-lengths, and in the reflection of shorter wave-lengths than 3341 the order of efficiency is reversed, the mirror prepared in nitrogen being better than that prepared in air. The latter shows no reflection of wave-lengths shorter than about 2875. With wave-lengths shorter than 3341 the mirror prepared in oxygen is a slightly better reflector than the one prepared in hydrogen. The former shows a slight reflection of wave-length 2300 (it gives no appreciable reflection of wave-lengths shorter than this), while the latter does not reflect this wave-length but does reflect wave-length 2446. With wave-lengths shorter than 3341 the mirror prepared in nitrogen is a decidedly weaker reflector than the one prepared in hydrogen. The latter shows reflection of wave-lengths as short as about

2400, while 2446 is the shortest wave-length appreciably reflected by the former.

(3) COPPER.- In the visible spectrum and as far into the ultra-violet as about wave-length 2750 all the mirrors show about equal reflecting powers except that the mirrors prepared in hydrogen and nitrogen simultaneously show slightly weaker reflections in wave-lengths shorter than 3650, the former being the weaker of the two in wave-lengths shorter than about 2900. In reflecting wave-lengths between about 2900 and 2400 the mirrors prepared in air, oxygen, and nitrogen are about the same, none of them showing any reflection of wave-lengths shorter than about 2400. With wave-lengths shorter than about 2750 the mirrors prepared in hydrogen and nitrogen show considerably weaker reflections than the other two, being about equal to each other. The latter shows no reflection of wave-lengths shorter than 2446, while the shortest wave-length apparently reflected by the former is 2536.

(4) ZINC.- The mirrors prepared in air, hydrogen, oxygen, and nitrogen have about equal reflecting powers in the visible spectrum and as far into the ultra-violet as wave-length 2536, and they are only slightly different for wave-lengths shorter than this. They all show a slight reflection of wave-length about 2275, while the mirrors prepared in air and hydrogen are just slightly better reflectors of this wave-length than are the other two. None of them

show any reflection of wave-lengths shorter than about 2275.

(5) PLATINUM.- The mirrors prepared in air, hydrogen, oxygen, and nitrogen have about the same reflecting powers except that the the mirrors prepared in air and nitrogen show slightly weaker reflections of wave-lengths shorter than 2536. All show some reflection of wave-length about 2275 and none of them show any apparent reflection of wave-lengths shorter than this.

Making a general comparison of the mirrors prepared from the different metals, those prepared from platinum and zinc are about equal as reflectors, and are considerably stronger and go further into the ultra-violet than the mirrors prepared from silver, tin, and copper. The spectra of the light from the platinum and zinc mirrors were, however, recorded on one plate and those from the silver, tin, and copper mirrors on another. Hence nothing conclusive can be drawn from this comparison. The mirrors prepared from silver, tin, and copper are about equal as reflectors over most of the spectrum. The tin and copper mirrors are about equal as reflectors of the ultra-violet, while silver is only slightly weaker than these in this part of the spectrum.

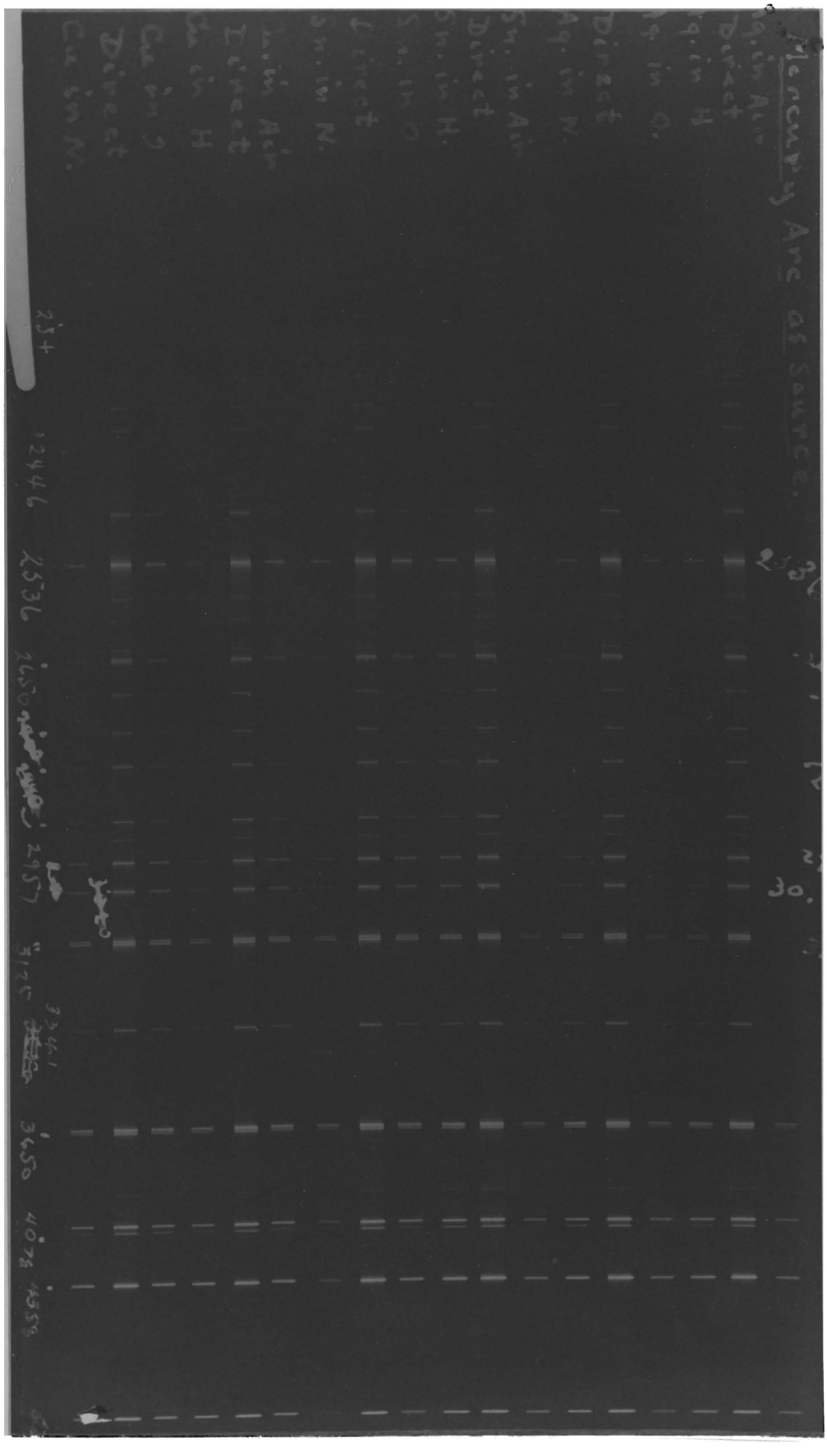
From the above discussion it is seen that the gases in which mirrors are prepared have an appreciable effect upon their reflecting powers in all parts of the spectrum, but especially in the ultra-violet in which we are particularly interested. For reflecting the short wave-lengths it was

found best to prepare silver mirrors in nitrogen, tin in oxygen, copper in air or oxygen (about the same), zinc in air or hydrogen (about the same), and platinum in hydrogen or oxygen (about the same).

On page 24 is mounted a print from the photographic plate upon which were recorded the spectra obtained by reflected light from the silver, tin, and copper mirrors. The faintest lines on the plate do not show on the print. Hence it can give the reader only a general idea of the spectra and of their arrangement on the plate for comparison. The mirror from which each spectrum was obtained by reflected light is marked in line with it.

SUMMARY.

Mirrors were prepared from each of the metals silver, tin, copper, zinc, and platinum by cathode disintegration in the gases air, hydrogen, oxygen, and nitrogen. In preparing them the different metals were found to require different conditions as to screening off the projection of the disintegrated particles, different gas pressure, etc., for best results. Photographs were taken of spectra given by reflected light from them (the quartz mercury arc used as source) and compared, especial attention being given to the relative reflecting powers of the different mirrors for the shorter wave-lengths. For reflecting the shorter wave-lengths it was found best to prepare silver mirrors in nitrogen, tin in oxygen, copper in air or oxygen, and platinum in hydrogen or oxygen, and zinc in air or hydrogen.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This thesis is never to leave this room.

Neither is it to be checked out overnight.