

and frequently painted. Efforts are being made to manufacture glazed earthenware tanks. If successful, these will prove absolutely permanent, and, while their first cost will probably be somewhat higher than lead-lined wooden tanks, the reduced maintenance charge will more than compensate for this increase.

Too much care cannot be taken in seeing that the batteries are properly installed, as proper installation is a large factor in reducing the maintenance expense. The plates should be adequately separated from each other. A new form of plate support is grooved glass, the edges of the battery plates being held in vertical grooves in these glass plates. In this way the plates are kept uniformly spaced and short-circuits around the plates are prevented.

Great care should be taken to secure proper insulation of the battery cells from each other and from the ground. The heating and ventilating of the battery room is also of great importance. The available normal capacity of the battery, at the eight-hour rate of discharge, is reduced 0.56 per cent for each degree F. drop in the temperature below the normal 70 deg.

When the surface of the tanks becomes coated with a film of sulphuric acid, this surface never dries, and the film must be removed by neutralizing with caustic soda. This action is explained by the fact that sulphuric acid, beyond a certain density, is hygroscopic and therefore will absorb water from the air. By using the exhaust system of ventilation, the sulphuric acid spray given off by gassing may be withdrawn so that it will not precipitate, while if a blower is used,

eddies of air will deposit the spray in a thin film over everything in the room.

In order to secure the maximum value from a storage battery installation, the electrical auxiliary apparatus in the way of boosters, switchboards, etc., must be of ample capacity. Attempts to overwork the auxiliary equipment on overload is "penny wise and pound foolish," as this part of the equipment, while it approximates only from 10 to 25 per cent of the total cost of the installation, is absolutely essential to its successful operation.

A storage battery requires periodic, but not excessive, care to secure the best results. Unlike engines, generators, and motors, the storage battery, when abused, gives no audible and seldom any visible signs that it is not working properly, but continues to deliver current until it may be severely injured.

By using the specific gravity method of charging, that is, charging until the specific gravity of the electrolyte returns to the original value that it had at the beginning of the discharge, the efficiency and life of a battery may be much greater than when methods depending upon the voltage only are used. The specific gravity method is based on the fact that for each ampere-hour discharge, a definite amount of sulphuric acid is transferred from the electrolyte to the plates in the form of sulphate. Conversely, this sulphate is returned to the solution on charging. The change of specific gravity of the electrolyte is independent of the rate of discharge, so that knowing the change in specific gravity of the electrolyte for a normal dis-

charge of the battery, the energy taken out at a varying rate of discharge can be determined at any time.

The persistent use of the auxiliary cadmium electrode to determine whether trouble is caused by the positive or negative plates should be encouraged. The use of distilled water for replenishing the loss in the solution due to evaporation and care in preventing impurities from getting into the cells should be insisted upon.

The storage battery, as now installed, is one of the most reliable pieces of apparatus available for the electrical engineer. The life of the negative plates is now indeterminate. The positive plates last from four to eight years, depending upon the service. Storage battery manufacturers make it a practice to enter into maintenance contracts with their customers, guaranteeing that the maintenance cost will not exceed 7 to 10 per cent of the cost of the battery for a period of ten years. Unlike other machinery, at the end of ten years, the installation will have the advantage of the latest developments in the art since, in renewing the plates, the latest types can be used. It is worthy of note that several millions of dollars have been invested in storage batteries by the prominent illuminating companies, these batteries being used simply for insurance against shut-down. They are only discharged when there is something wrong with the regular supply. At all other times they are kept fully charged and floating on the system. This shows the reliability and value of the storage battery of the present day in large power plants.

THE ATOMIC WEIGHT OF RADIUM.*

A NEW DETERMINATION

BY MME. CURIE

THE determination of the atomic weight of radium which I published in 1902 (*Comptes Rendus*, July, 1902) was carried out with 9 centigrammes of radium chloride. Fresh processes having since then furnished some decigrammes of practically pure chloride, I have subjected them to purification, which enabled me to obtain 4 decigrammes of perfectly pure radium chloride, and to determine the atomic weight of radium under far better conditions than before.

The purification processes consisted as before in fractional crystallization in water containing hydrochloric acid, or in fractional precipitation of the aqueous solution by alcohol. The progress of the fractionation was controlled by photographs of the spark spectra, obtained with the spectrograph which formerly belonged to Demarcay. It is convenient to compare the relative values of the lines 4554.4 of barium and 4533.5 of radium. These lines, which are very close together, are very suitable for comparison. The line 4554.4 is the strongest in the barium spectrum, and the line 4533.5 is one of medium importance in the radium spectrum.

When the purification was stopped, the strongest barium line was still faintly visible near the other. Its complete elimination seemed to be very difficult with the quantity of material I had at my disposal. Nevertheless, I shall shortly show that the salt was very pure.

I was confronted with one difficulty during this work. When a clear solution of a radium salt is evaporated in a dish or glass, the dry salt obtained is not generally completely soluble in water, but leaves a residue. I have found that this residue is partly due to the formation of radium sulphate, in consequence of the presence of traces of sulphuric acid in the reagents (traces which could only be detected by barium salts after the concentration of the reagents), and partly to the slow action of the radium salts on the vessels. I therefore decided to prepare specially all the reagents employed. The water was distilled in a platinum still, and received and kept in a platinum flask; this water was used to prepare the hydrochloric acid, which was also kept in a platinum flask. The nitric acid, alcohol, and silver nitrate were also purified. It is not possible to let the radium chloride crystallize in presence of hydrochloric acid in a platinum dish, because it has considerable action on the latter. But if the clear solution is allowed to crystallize rapidly in a porcelain dish, crystals are obtained, which, after being dried, dissolve in the purified water without residue, and hence can be used to determine the atomic weight.

The method employed for this determination was the same as before. It consists in estimating as silver chloride the chlorine contained in a known weight of anhydrous radium chloride. According to my earlier experiments, which were confirmed by new observations, radium chloride, which has just been prepared, loses its water of crystallization when it is heated in a drying oven above 100 deg. C., and its weight is quite constant when it has been subjected

for half an hour to a temperature of 150 deg. C.

The weighings were performed with a Curie's aperiodic balance with direct reading for weights below decigrammes. This rapid balance is accurate to one-tenth of a milligramme, and takes only ten seconds to reach its position of equilibrium. The weighing of the radium chloride is more difficult than that of the silver chloride, because the former salt absorbs water-vapor rather quickly; it is therefore essential to let it cool in a desiccator with phosphoric anhydride before weighing, and not to recommence weighing until after it has been again placed in the drying oven, even if the cage of the balance contains desiccating substances.

After each estimation the radium is present as nitrate with silver nitrate. The silver is eliminated by hydrochloric acid, and the nitric acid by repeated crystallization in presence of hydrochloric acid.

The following table gives the numbers obtained in three consecutive experiments, and the atomic weights P deduced from them, assuming that radium is a divalent metal, and that the atomic weights of silver and chlorine are:

Ag = 107.8, Cl = 35.4.		
Radium Chloride.	Silver Chloride.	P.
0.4052	0.3906—0.00006	226.35
0.4020	0.3879—0.00006	226.04
0.39335	0.3795—0.00006	226.15
Weight of filter ash = 0.00006.		

The weighings of the two chlorides are considered to be exact to about one-tenth milligramme. These three experiments, which agree very closely, give for the atomic weight of radium the mean value 226.18.

The experiments, performed in 1902 with very pure radium chloride, gave less concordant results and a mean of 225. The spectrum of the salt used recently shows a rather greater degree of purity, but the difference of about one unit in the atomic weight could not be ascribed to this cause. I performed a control experiment as follows: I prepared a solution of some milligrammes of pure 1907 salt, and added to it a small quantity of a titrated solution of barium chloride. The amount of barium salt in the mixture was 0.61 per cent. In the spectrum of this salt a great increase of the intensity of the barium spectrum is shown, whereas the change of atomic weight, calculated from the known addition of barium chloride, is only 0.7 unit. From the examination of the spectra it is clear that the difference between the numbers obtained in 1902 and in 1907 should be attributed only to the inferior accuracy of the experiments performed with only 9 centigrammes of radium salt and with less pure reagents.

The above experiment also proves that the spectral reaction of barium in presence of radium is very sensitive and that the radium chloride which was used for the determination must be very pure. It certainly does not contain 0.1 per cent of barium chloride.

I therefore conclude from these experiments that the atomic weight of radium is 226.2 (Ag = 107.8, Cl = 35.4) with a probable error of less than half a unit.

If the values Ag = 107.93, Cl = 35.45 are adopted, the value is Ra = 226.45.

HELION FILAMENTS.*

By WALTER G. CLARK.

THE helion filament is a composite filament in which the base used is a very small carbon filament. It is possible to use other bases, but carbon seems best suited to the requirements. The small carbon base is mounted in a treating jar very similar to the one ordinarily used in treating or flashing the carbon filament. In this treating flask a compound containing silicon is deposited upon the filament. For this purpose has been developed apparatus which is very nearly as automatic as the method used in flashing the carbon filament. The material deposited is, apparently, at first carried into the carbon, but as the process is carried further the filament takes on a surface deposit. As soon as this occurs the emissivity increases very greatly, and the color of the light changes from the characteristic color of a carbon filament to a much whiter light, and this with practically no change in temperature.

The filament is built up with this deposit until the desired resistance is reached, when the current is cut off. The filament is then ready to be mounted in the ordinary glassware as used for a carbon filament. The resistance of the helion filament is sufficiently high to utilize 110 volts in a single corrugated loop, and the filament has sufficient mechanical strength so that it is practically impossible to break it without breaking the glass inclosing the lamp.

The filament may be burned in any position, and in some recent tests a temperature of 3,300 deg. C. was reached before the filament showed any very decided tendency to sag or soften.

It has been found that the helion filament possesses a negative temperature coefficient up to about 1,350 deg. C., at which temperature the coefficient becomes positive, and from there on the filament exhibits a decidedly positive temperature characteristic; so in the helion filament occurs the negative temperature coefficient at starting, and the desirable positive temperature coefficient at the temperature at which the filament is to operate. Another feature possessed by the lamp is that the decrease in candle-power appears to be very slight; experience indicates that the lamp would operate up to a point where the filament parts, with a reduction in efficiency of less than 5 per cent.

The filament, on account of its positive temperature coefficient when incandescent, withstands an overload remarkably well and an excessive voltage usually destroys the leading-in wires or the glass in the stem of the lamp without damaging the filament.

That the lamp is able to operate at an efficiency of better than 1 watt per candle-power in the larger sized lamps is indicated by the fact that a lamp of 400 candle-power at 300 watts burned for about 300 hours in a very imperfect vacuum, after which the filament was taken down and examined; but apart from the oxidation due to the air present when the lamp was started, there was practically no change.

* *Comptes Rendus*, 1907.

* Condensed from the *Electrical Review*.