and a half, then add the sulphites, and continue the boiling until all the salts are dissolved. Three or four minutes will probably be sufficient for this purpose; the solution may then be passed through a sieve, and half a tumbler of acetic tincture of iron added. This acetic tincture of iron may be made by putting small pieces of rusty iron in strong vinegar, leaving them in for a length of time. The longer the iron remains in the vinegar the stronger, of course, will be the solution.

Stone color or lighter gray is made in the same manner and with the same quantity of water, but with half the quantity of all the other substances; but care must be taken to refill the vase in which the liquid is prepared, as the water evaporates by boiling. In order to prepare a red coloring solution, take of pure water, three liters; Brazilian wood, 330 grammes; scotau, five grammes; cream of tartar, one gramme; alum, one gramme.

Boil the mixture until all the color of the wood is extracted, and then pass the solution through the sieve in order to remove therefrom any solid matters that may be held in suspension therein. A yellow color is obtained by adding to three liters of pure water, extract of yellow wood of Cuba, twenty grammes; sulphite of magnesia or alum, ten grammes. The mixture must be boiled until complete solution of extract is effected. In order to obtain a green color dissolve in three liters of pure water, extract of yellow wood of Cuba, twenty grammes; and ten grammes of alum.

Boil the ingredients as above, and then add carefully (by means of a wooden spoon, and keeping at a certain distance) as many drops of acid sulphite of indigo (Saxon blue) as may be necessary to give tone of color desired. To ascertain the depth of color pour a few drops upon white paper, or dip a piece of dry plaster of Paris in the solution. For a blue color dissolve alum, ten grammes; acid sulphite of indigo, twenty grammes, in eight liters of water until the desired color is obtained.

As all the varied colors of aniline penetrate the stone perfectly, they may be used at pleasure. It is only necessary to dissolve the color selected in a little alcohol, which is afterward diluted with warm water, in which alum is dissolved in the proportion of twenty-four grains of alum to every liter of water. The solution of alum may be even stronger; this is for colors which are insoluble in water. For such aniline colors as are soluble in water no alcohol is necessary. They may be dissolved in boiling water in which a little alum or sulphate of magnesia is introduced. Care must be taken to select only those colors which are durable. The same colors which are permanent in cloth are permanent in stone, and in general the same rules which apply to the art of dyeing cloth may be applied to the art of dyeing stone.

After the objects have been taken out of their respective baths they are allowed to dry, during which process the work may be retouched if necessary. When dry they are reduced to a fine surface by means of pumice stone, after which a still finer surface may be given by means of a piece of slate, or, still better, of lead, and then they may be rubbed with oil. When the oil is dry the articles may be rubbed with phosphate of lime, and the luster will be rendered perfect. The ordinary methods of polishing marble will apply to the polishing of petrified marbles prepared by the above improved process.

METHODS OF MEASURING VELOCITY IN RIVER CHANNELS.*

By H. A. PRESSEY.

THERE are in common use a number of methods of measuring the flow of rivers. In general these involve the determination of the mean velocity of the current and the area of the cross section of the stream. The latter is easily computed from soundings made at fre-

quents extending between the points of soundings. The summation of the area of each section gives the total area of the cross section. When the total flow of the river is known and is divided by the area of the cross section the result is called the mean velocity of the river. It is this mean velocity that we try to determine in any method of stream measurement, but, as

feet in length are selected, it is desirable that additional cross sections, at equal intervals from one another, should be measured. As a preliminary step, a base line should be laid out by tape on the bank as nearly as possible parallel with the stream, and points should be marked opposite the cross sections to be used. If the stream is not too wide the soundings in

PRICE ELECTRIC CURRENT METERS.

a matter of fact, it can not be actually determined until the total flow is known.

FLOATS.

General Methods.—Floats are frequently employed to determine the velocity of the current. There are three general types in common use: First, surface floats; second, subsurface or double floats; third, tube or rod floats. The general method of procedure is the same whichever form of float is used. The site for making a float measurement should be on a straight reach, having a fairly uniform cross section. The flow of the water should be regular, without sudden

the cross sections can be taken most conveniently along a tagged rope stretched across the channel at right angles to the base. If the depth does not exceed 4 feet this can be done by wading, the depth being read on a rod graduated to feet and tenths. Should the depth of the channel or the temperature of the water make wading impossible, a boat may be used. On large rivers, where a tagged rope cannot be employed, the boat from which the soundings are to be made should be located by simple triangulation. Soundings should be read to tenths of a foot and be taken preferably at equal distances apart. In deep rivers a tagged rope or chain with lead weight can be substituted for the rod.

Surface Floats.—In reconnaissance work, in which the equipment is as a rule limited by transportation facilities, surface floats consisting of chips will be found most convenient. The use of rod floats, though giving more directly the mean velocity, has many disadvantages, and should not be attempted unless the time and opportunity permit of obtaining floats of the required lengths. In the simplest case but one man is needed to make the observations. The surface floats should be thrown into the stream a considerable distance above the first cross section. The hydrographer should attempt to start the floats, successively, at different distances from the shore, in order to determine the velocity in different parts of the channel. The time of the passage of each float between the upper and lower cross section should be noted, preferably by a stop watch, and also the position of each float with respect to the tags on the ropes. This will enable the hydrographer to determine whether or not he succeeds in covering the different parts of the stream, and it will serve as an aid in the computation. The observations should be continued until all parts of the stream have been covered.

On wide rivers range poles may be established on opposite shores to mark the upper and lower cross sections. The location of each float as it crosses these imaginary lines can readily be recorded by triangulation. A light traverse plane table will be found especially useful in obtaining a graphic record.

The surface floats show approximately the surface velocity of the stream at the point of measurement. The results obtained by this method are subject to errors due to wind and surface currents and eddies. The velocity shown is that of the surface of the river, while that required for computation of discharge is the mean velocity of the cross section. Unfortunately, the relation of the surface to the mean velocity of the vertical is not constant, yet for streams of the same general character of bed, banks, velocity, etc., the ratio is sufficiently constant to allow the mean velocity to be computed with fair precision from the surface velocity observations.

Subsurface or Double Floats.—The double float consists of a small surface float connected by a fine cord to a larger subsurface float, which is so arranged that it shall always remain at the point of mean velocity in the current. The surface float may consist of a

CURRENT METER IN USE, SUSPENDED FROM A BRIDGE.

quent intervals across the channel. These soundings must be taken at intervals so short that the bottom of the river may be considered a straight line between soundings. Usually the velocity of the current is determined in sections of the river channel, the sections

rapids or stretches of still water, and should exhibit no tendencies to form eddies or cross currents caused by irregularities in the channel or resulting from the effect of a sharp bend above the reach. The course of the floats should have a length of from 100 to 300 feet, and the areas of cross section at the upper and lower ends of this course should be carefully determined by soundings. When courses more than 100

* Abstract from a monograph entitled "Observations on the Flow of Rivers," published by the United States Geological Survey.

flat block of wood or a tin water-tight drum, which floats upon the surface of the water with sufficient buoyancy to prevent the larger subsurface float from sinking. The subsurface float may consist of two sheets of galvanized iron set at right angles, weighted at the bottom, with an air-tight cylindrical device at the top, in order that it may at all times keep its vertical position. A round, hollow cylinder of tin also makes an excellent subsurface float. The tension on the connecting cord should be at least 2 or 3 pounds,

should extend nearly to the bottom, as otherwise the velocity, as shown, will be too great, yet the greatest care must be taken that they do not at any time scrape upon the rocks at the bottom or sides so as to retard their movement. Rod floats are free from many of the objections to double floats, as there is no uncertainty as to their position nor as to the point of mean velocity in the channel. They are not, however, suitable for very deep rivers, or for channels where the depth varies considerably, or where weeds grow in the

of the stream to pass over the sharp edge of the weir crest. By observing the head on the weir, computations of the flow can be made. This is probably the most accurate method applicable to small streams. On large rivers, however, the cost of a weir is usually so great as to be prohibitive, so that if there is not a weir or dam already in the stream it is necessary to resort to measurements by floats or current meters.

On many of the rivers of moderate size the conditions are unfavorable for successfully applying either of these methods. For instance, on streams used for manufacturing purposes dams occur at frequent intervals, interrupting the regular flow, and in many cases holding back the night flow for use during the following day, so that the discharge during the night may be either nothing or a very small percentage of the day flow. Then, too, the shutting down of the mill wheels for an hour at noon may have a pronounced effect upon the results of floats or meter measurements made below the mill. Unfortunately these variations are not always apparent to the hydrographer, and surprise and annoyance are caused by finding that the river height differs by several tenths from the gage as read by the regular observer a short time before the hydrographer arrived at the station.

Under the conditions described, better results can undoubtedly be obtained if there exists upon the stream a good dam which can be used as a weir. It should have a level, even crest and a constant cross section, with sufficient pondage to reduce the velocity of approach, and it should be free from leakage. Masonry dams are better for this purpose, for they are more likely to be tight and to have an even crest. Timber dams, although level when first constructed, are likely to settle at various points, thus producing an uneven crest elevation. There are, however, many good timber dams practically free from leakage and with crests sufficiently uniform for accurate work.

Having selected a dam as the proper site for a station a careful survey must be made of the crest line and of the upper and lower slopes, so that it can be compared with other dams or with experimental sections for which the coefficients of flow are known. The experiments of James B. Francis, of Fteley & Stearns and of John R. Freeman, George W. Rafter, and others at Cornell University, have given coefficients upon many sections of various forms. It is probable that the dam selected for the station will not be exactly like any of the experimental forms, but it will resemble some of them so closely that coefficients can be selected for the computations.

When the mill gates are open a part of the flow is diverted from the river through the mill race, the gates, and the tailrace.

The amount of the diversion must of course be measured and added to the quantity flowing over the dam, in order to determine the total discharge of the stream. In many factories the quantity flowing through the wheels varies from day to day, and also during different hours of the day, so that careful records must be kept of gate openings, in order that proper allowance may be made for these variations. The size and the make of the water wheels must be ascertained, and the wheels be used as water meters for the determination of the flow through them. Many of the modern wheels have been carefully rated. Where such ratings have not been made, usually records of wheels of the same type, though possibly of different makes, can be found and the records be compared. Water wheels as meters give fairly accurate records of the discharge.

The Chezy formula or surface-slope method has been extensively employed in gaging large rivers. The proper coefficients to be applied are usually determined

CABLE AND CAR USED TO MEASURE DISCHARGE OF RIVER.

and the cord should be of silk and as fine as possible in order that its resistance to the current should not have a marked effect upon the velocity of the floats. The length of the cord should be so regulated that the lower float may be at the point of mean velocity, and the resistance of the upper float and the cord should be made as small as practicable. A small flag should be placed upon the upper float in order that its position may be easily determined at all times. The chief objection to double floats is the uncertainty as to whether the cord is vertical and the consequent uncertainty as to the position of the subsurface float. Another objection is the modifying effect of the surface float and the cord upon the velocity of the lower float, as in great depth the exposed surface of the cord may exceed that of the float. A third objection is the uncertainty as to the vertical position of the lower float, as, owing to changes in depth of water and local conditions, the point of mean velocity may change, whereas the length of the connecting cord must remain constant in each run. This may introduce a noticeable error if the increase in depth is large, as the retarding effect of the slow velocity near the bottom of the river will not be felt by the float, and the result will show too high a velocity. The lower float may tip slightly, owing to eddies or other causes, thereby changing the exposed surface, or, unknown to the observer, the

bed of the stream. Mr. James B. Francis has stated that the rod floats travel a little faster than the mean velocity of the water even for the depth of immersion. The float will be subject to pressures proportional to the square of the relative velocities of the water at different points, and when it has attained its full speed there will be equilibrium between these different pressures. This equilibrium may exist, however, when the speed of the float is somewhat different from the mean velocity of the water, the latter being the arithmetical mean of all the different velocities throughout the depth of immersion. The following formula for correcting an observed velocity was derived by James B. Francis from his Lowell experiments:

$$V_m = V_o \left[1 - .116 \left(\sqrt{\frac{d-d'}{d}} - 0.1 \right) \right]$$

Where V_m is equal to true mean velocity in vertical, V_o equals observed velocity of tube, d equals mean depth along path of tube, d' equals depth of immersion of tube.

Col. Allan Cunningham* has, however, calculated that such floats move somewhat slower than the water in which they are immersed. The error of assuming that the velocity of the tube represents the mean velocity in the vertical will not be material unless tubes too

GAGING STATION ON HOUSATONIC RIVER AT GAYLORDSVILLE, CONN.

lower float may strike a bowlder, causing its velocity to be checked. In many cases these objections would not be at all serious, but, in general, when floats are to be used better results can be obtained, when the depth is not too great, by the use of rod or tube floats.

Rod or Tube Floats.—These consist of long, cylindrical tin tubes or wooden poles, 2 or 3 inches in diameter, weighted at the bottom, so that they will float vertically with only 2 or 3 inches exposed above the water surface. These rods integrate the velocities in a vertical section and give approximately the mean velocity of the current. It is important that they

short are used, in which case the velocity as shown by the tube should be somewhat reduced.

WEIRS.

By the method of weirs the discharge of the stream is computed by means of an empirical formula, which varies for different types of dams or weirs. On creeks or small rivers it is sometimes practicable to build a timber weir across the channel, causing the total flow

from the auxiliary formula of Gauguillet and Kutter. One difficulty in the application of this method lies in the selection of suitable friction factor or coefficient of roughness.

CURRENT METERS.

The current meter has been found best adapted to the general measurements made by the United States Geological Survey, and is used almost exclusively in its hydrographic investigations. Occasionally, however, either a meter is not available or the conditions are not favorable for its use. In such cases weirs or

* Recent hydraulic experiments: Min. Proc. Inst. Civil Eng., Vol. LXXI, 1883.

floats have been used, though a Pitot's tube, hydro-metric pendulum, or hydrometric balance might in exceptional cases be used to advantage.

The current meter may be used to determine the velocity of a river in four ways: First, by making point measurements at a depth corresponding to the approximate position of the thread of mean velocity; second, by deducing the mean velocity from observations made at other points in the same vertical; third, by the integration method; fourth, by point measurements made at regular intervals throughout cross sections of the river. In the first two of these methods it is important to know the relation between the velocities at various points in the section. In the first method the position of mean velocity must be known, and in the second method the relation between the surface velocity, or the velocity at mean depth, to the mean velocity must be known. In either of these cases the form of the vertical velocity curve will determine the coefficient to be applied to the observations.

VERTICAL VELOCITY CURVES ON STREAMS WITHOUT ICE COVER.

Studies of the vertical velocity curve made on the Mississippi River by Humphreys and Abbott, on the Connecticut by T. G. Ellis, on the Merrimac flume by Wheeler and Lynch, on the Potomac by C. C. Babb, and recent experiments by others, notably those at Cornell University by E. C. Murphy, indicate that the point of mean velocity in a given vertical section is at a depth varying from six-tenths to two-thirds of the total depth of the section, measured from the surface down. The values found in the experiments were as follows:

DEPTH FROM SURFACE OF POINT OF MEAN VELOCITY.

Experimenter.	Stream.	Depths.
Cyrus C. Tabb.....	Potomac River.....	0.58
Humphreys and Abbott.....	Mississippi River.....	.63
T. G. Ellis.....	Connecticut River.....	.64
E. C. Murphy.....	Cornell flume.....	*.65
Wheeler and Lynch.....	Merrimac flume.....	.67

* For depths between 6 and 9 feet, the proportionate depth of point of mean velocity becoming less as the depth of the water decreased, and becoming 0.55 for depths of water between 1 and 2 feet.

The Cornell experiments indicate that measurements made at six-tenths of the depth yield results 3.5 per cent too large, the depth of mean velocity being nearly two-thirds of the depth. The measurements at Cornell were, however, made in the canal, the cross sections of which have a greater ratio of depth to width than most rivers, and decidedly more than the Mississippi, Connecticut, and Potomac, upon which the above coefficients were obtained. There can be no doubt but that the difference in the ratio of the depth to width is a factor likely to affect the position of mean velocity.

The bottom and sides of the channel retard the flow close to them in proportion to their roughness, this retardation being due more to the impeding of the flow by eddies than by friction alone. The retardation of the surface velocity has been attributed to the rising, by vertical motion, of the lower water to the surface after being checked in its flow by striking against the rough bottom and sides of the channel.

Mr. Frederick P. Stearns has attributed the reduction of surface velocity to the general retarding of the layers of water adjacent to the banks of the stream, this water rising to the surface and thereby making the edges of the channel higher than the center and causing a flow of the slowly moving water from the sides toward the middle, thereby decreasing the surface velocity, depressing the point of maximum velocity, and lowering in general the filament of mean velocity. This depression of the maximum velocity is known to become more pronounced with an increase in the roughness of the lining, in the steepness of the banks, and in the ratio of depth to width. In an extreme case of a wide, shallow stream, where the bottom merges imperceptibly into the banks, maximum velocity occurs, under normal conditions, at or very near the surface of the center of the stream. On the other hand, in a deep, narrow channel, as, for instance, in a canal with vertical sides, the maximum velocity occurs a considerable distance below the surface, and, as the Cornell experiments indicate, this depression may amount to as much as one-third and even two-fifths of the total depth. Evidently, then, in such cases a depression of maximum velocity must result in a lowering of the thread of mean velocity, and engineers, in making unit measurements for mean velocity, should bear in mind that while the observations at six-tenths depth give fair values for mean velocity in wide, shallow rivers this ratio should be increased to two-thirds in the case of canals and flumes or narrow natural channels.

The friction of flowing water against the air has a similar influence, and, though in general less marked, it may, in the case of a strong upstream wind, have a decided influence upon the surface velocity and the point in the vertical of the maximum and mean velocity. On account of these resistances on the bed and bank of a stream, the maximum velocity of the river in a straight reach is found in the central portion of the stream, and somewhat below the surface—the actual position depending upon the size and condition of the river and the velocity of flow. The velocity increases from the surface downward for a short distance—say, one-tenth of the depth—and then decreases down to the bottom, where it reaches the minimum.

The mean of 78 velocity curves taken upon rivers in the southern part of New York State shows that the mean velocity was 0.87 of the surface velocity in the vertical section (shown in Fig. 3). This coefficient varied from 0.82 in the case of Catskill Creek to 0.93 in Fishkill Creek. These coefficients apply to the mean velocity in the vertical in which the float is run. If only one surface float is used, and that in the center of the river, or point of maximum velocity, it appears that 0.8 is the proper coefficient to apply, though the chances of error are much greater than when surface floats are used at intervals across the channel.

HOUSATONIC RIVER AT GAYLORDSVILLE, CONN.

A gaging station was established at Gaylordsville, Conn., October 24, 1900. The station is situated 3 miles east of the New York State line and 2 miles below the mouth of Tenmile River. Owing to the unfavorable conditions under the bridge, the discharge measurements are made from a cable of 200 feet span placed across the stream $1\frac{1}{4}$ miles below the bridge. A view of the river at this point is shown in the figure. The cable is supported on the right bank by timber shears 25 feet high and is anchored to a large buried rock. On the left bank a sycamore tree serves as a support for the cable, which is anchored to the base of a large oak.

EXPERIMENTS IN RADIO-ACTIVITY, AND THE PRODUCTION OF HELIUM FROM RADIUM.*

I. EXPERIMENTS ON THE RADIO-ACTIVITY OF THE INERT GASES OF THE ATMOSPHERE.

OF recent years many investigations have been made by Elster and Geitel, Wilson, Strutt, Rutherford, Cooke, Allen, and others on the spontaneous ionization of the gases of the atmosphere and on the excited radio-activity obtainable from it. It became of interest to ascertain whether the inert monatomic gases of the atmosphere bear any share in these phenomena. For this purpose a small electroscope contained in a glass tube of about 20 cubic centimeters capacity, covered in the interior with tin-foil, was employed. After charging, the apparatus if exhausted retained its charge for thirty-six hours without diminution. Admission of air caused a slow discharge. In similar experiments with helium, neon, argon, krypton, and xenon, the last mixed with oxygen, the rate of discharge was proportional to the density and pressure of the gas. This shows that the gases have no special radio-activity of their own, and accords with the explanation already advanced by these investigators that the discharging power of the air is caused by extraneous radio-activity.

Experiments were also made with the dregs left after liquefied air had nearly entirely evaporated, and again with the same result; no increase in discharging power is produced by concentration of a possible radio-active constituent of the atmosphere.

II. EXPERIMENTS ON THE NATURE OF THE RADIO-ACTIVE EMANATION FROM RADIUM.

The word emanation originally used by Boyle ("substantial emanations from the celestial bodies") was resuscitated by Rutherford to designate definite substances of a gaseous nature continuously produced from other substances. The term was also used by Russell ("emanation from hydrogen peroxide") in much the same sense. If the adjective "radio-active" be added, the phenomenon of Rutherford is distinguished from the phenomena observed by Russell. In this section we are dealing with the emanation, or radio-active gas obtained from radium. Rutherford and Soddy investigated the chemical nature of the thorium emanation (Phil. Mag., 1902, p. 580) and of the radium emanation (*ibid.*, 1903, p. 457), and came to the conclusion that these emanations are inert gases which withstand the action of reagents in a manner hitherto unobserved except with the members of the argon family. This conclusion was arrived at because the emanations from thorium and radium could be passed without alteration over platinum and palladium black, chromate of lead, zinc dust, and magnesium powder, all at a red-heat.

We have since found that the radium emanation withstands prolonged sparking with oxygen over alkali, and also, during several hours, the action of a heated mixture of magnesium powder and lime. The discharging power was maintained unaltered after this treatment, and inasmuch as a considerable amount of radium was employed it was possible to use the self-luminosity of the gas as an optical demonstration of its persistence.

In an experiment in which the emanation mixed with oxygen had been sparked for several hours over alkali, a minute fraction of the total mixture was found to discharge an electroscope almost instantly. From the main quantity of the gas the oxygen was withdrawn by ignited phosphorus, and no visible residue was left. When, however, another gas was introduced, so as to come into contact with the top of the tube, and then withdrawn, the emanation was found to be present in it in unaltered amount. It appears, therefore, that phosphorus burning in oxygen and sparking with oxygen have no effect upon the gas so far as can be detected by its radio-active properties.

The experiments with magnesium-lime were more strictly quantitative. The method of testing the gas before and after treatment with the reagent was to take 1-2000 part of the whole mixed with air, and after introducing it into the reservoir of an electroscope to measure the rate of discharge. The magnesium-lime tube glowed brightly when the mixture of emanation and air was admitted; and it was maintained at a red-heat for three hours. The gas was then washed out with a little hydrogen, diluted with air and tested as before. It was found that the discharging power of the gas had been quite unaltered by this treatment.

The emanation can be dealt with as a gas; it can be extracted by aid of a Töpler pump; it can be condensed in a U-tube surrounded by liquid air; and when condensed it can be "washed" with another gas which can be pumped off completely, and which then possesses no luminosity and practically no discharging power. The passage of the emanation from place to place through glass tubes can be followed by the eye in a darkened room. On opening a stop-cock between a tube containing the emanation and the pump, the slow flow through the capillary tube can be noticed; the rapid passage along the wider tubes; the delay caused by the plug of phosphorus pentoxide, and the sudden diffusion into the reservoir of the pump. When compressed, the luminosity increased and when the small bubble was expelled through the capillary it was exceedingly luminous. The peculiarities of the

* By Sir William Ramsay, K.C.B., F.R.S., and Mr. Frederick Soddy. Received at the Royal Society July 28.

excited activity left behind on the glass by the emanation could also be well observed. When the emanation had been left a short time in contact with the glass, the excited activity lasts only a short time; but after the emanation has been stored a long time the excited activity decays more slowly.

The emanation causes chemical change in a similar manner to the salts of radium themselves. The emanation pumped off from 50 milligrammes of radium bromide after dissolving in water, when stored with oxygen in a small glass tube over mercury turns the glass distinctly violet in a single night; if moist the mercury becomes covered with a film of red oxide, but if dry it appears to remain unattacked. A mixture of the emanation with oxygen produces carbon dioxide when passed through a lubricated stop-cock.

III. OCCURRENCE OF HELIUM IN THE GASES EVOLVED FROM RADIUM BROMIDE.

The gas evolved from 20 milligrammes of pure radium bromide (which we are informed had been prepared three months) by its solution in water and which consisted mainly of hydrogen and oxygen (cf. Giesel, Ber., 1903, 347) was tested for helium, the hydrogen and oxygen being removed by contact with a red-hot spiral of copper wire, partially oxidized, and the resulting water vapor by a tube of phosphorus pentoxide. The gas issued into a small vacuum-tube which showed the spectrum of carbon dioxide. The vacuum tube was in train with a small U-tube, and the latter was then cooled with liquid air. This much reduced the brilliancy of the CO₂ spectrum, and the D₂ line of helium appeared. The coincidence was confirmed by throwing the spectrum of helium into the spectroscopic through the comparison prism, and shown to be at least within 0.5 of an Angström unit.

The experiment was carefully repeated in apparatus constructed of previously unused glass with 30 milligrammes of radium bromide, probably four or five months old, kindly lent us by Prof. Rutherford. The gases evolved were passed through a cooled U-tube on their way to the vacuum-tube, which completely prevented the passage of carbon dioxide and the emanation. The spectrum of helium was obtained and practically all the lines were seen, including those at 6677, 5876, 5016, 4932, 4713, and 4472. There were also present three lines of approximate wave-lengths, 6180, 5695, 5455, that have not yet been identified.

On two subsequent occasions the gases evolved from both solutions of radium bromide were mixed, after four days' accumulation which amounted to about 2.5 cubic centimeters in each case, and were examined in a similar way. The D² line of helium could not be detected. It may be well to state the composition found for the gases continuously generated by a solution of radium, for it seemed likely that the large excess of hydrogen over the composition required to form water, shown in the analysis given by Bodländer (Ber., loc. cit.) might be due to the greater solubility of the oxygen. In our analyses the gases were extracted with the pump, and the first gave 28.6, the second 29.2 per cent of oxygen. The slight excess of hydrogen is doubtless due to the action of the oxygen on the grease of the stop-cocks, which has been already mentioned. The rate of production of these gases is about 0.5 cubic centimeter per day for 50 milligrammes of radium bromide, which is more than twice as great as that found by Bodländer.

IV. PRODUCTION OF HELIUM BY THE RADIUM EMANATION.

The maximum amount of the emanation obtained from 50 milligrammes of radium bromide was conveyed by means of oxygen into a U-tube cooled in liquid air, and the latter was then extracted by the pump. It was then washed out with a little fresh oxygen, which was again pumped off. The vacuum tube sealed on to the U-tube, after removing the liquid air, showed no trace of helium. The spectrum was apparently a new one, probably that of the emanation, but this has not yet been completely examined, and we hope to publish further details shortly. After standing from July 17 to 21, the helium spectrum appeared, and the characteristic lines were observed identical in position with those of a helium tube thrown into the field of vision at the same time. On July 22 the yellow, the green, the two blues, and the violet were seen, and in addition the three new lines also present in the helium obtained from radium. A confirmatory experiment gave identical results.

We wish to express our indebtedness to the research fund of the Chemical Society for a part of the radium used in this investigation.

CAUSES OF EXPLOSION OF ACETYLENE AND MEANS OF PREVENTING THEM.

THE density of acetylene is 0.91; its solubility in water, 110 volumes; in salt water, 6 volumes; temperature of ignition under atmospheric pressure, 480 deg. C.; critical temperature, 37 deg. C. under pressure of 67 atmospheres; heat of combustion, 14,340 calories to the cubic meter, or 12,200 calories to the kilogramme.

Under a pressure of less than two atmospheres, the gas will not explode on contact with a red-hot body or a lighted match, but under a stronger pressure, the explosion is produced.

Mixtures of air and acetylene containing from 2.5 to 65 per cent of acetylene explode at 480 deg. C. on contact with an open flame.

According to the experiments of Lewess, if, in order to produce acetylene, water is poured in very slight streams on the carbide, the latter becomes heated, and its temperature may attain 807 deg. C.; if, on the contrary, water is poured on in great quantity, the temperature rises only to 66 deg. C. It is certain that the impurities contained in acetylene may modify these figures and increase the danger of explosion of the gaseous mixture. On this account, phosphoreted and sulphureted hydrogen especially ought to be eliminated, as well as ammonium, which with the copper of the apparatus forms explosive cupric acetylide. Phosphoreted and sulphureted hydrogen are prevented, at least in dangerous quantities, by employing as original material lime of good quality, free from phosphorus and sulphur.

From these observations the following rules may be deduced, which ought to be observed in constructing